RCRA Facility Investigation/Remedial Investigation Report with Baseline Risk Assessment for the Fire Department Hose Training Facility (904-113G)

by
E. Palmer
Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

RECEIVED
JUN 11 1998
OSTI

MASTER

DOE Contract No. DE-AC09-96SR18500

This paper was prepared in connection with work done under the above contract number with the U. S. Department of Energy. By acceptance of this paper, the publisher and/or recipient acknowledges the U. S. Government's right to retain a nonexclusive, royalty-free license in and to any copyright covering this paper, along with the right to reproduce and to authorize others to reproduce all or part of the copyrighted paper.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

WSRC-RP-96-863, REV. 1
April 1997

RCRA FACILITY INVESTIGATION/ REMEDIAL INVESTIGATION REPORT WITH BASELINE RISK ASSESSMENT FOR THE FIRE DEPARTMENT HOSE TRAINING FACILITY (904-113G) (U)

Westinghouse Savannah River Company
Savannah River Site
Aiken, S.C. 29802



Prepared for the US Department of Energy Contract Number DE-AC09-96SR18500

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831; prices available from (615) 576-8401.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

Printed in the United States of America

Prepared for the
U.S. Department of Energy
and
Westinghouse Savannah River Company
Aiken, South Carolina

DISCLAIMER

Portions of this document may be illegible electronic image products. Images are produced from the best available original document.

CERTIFICATION PAGE

RCRA Facililty Investigation/ Remedial Investigation/ Baseline Risk Assessment
for the
Fire Department Hose Training Facility (904-113G) (U)

WSRC-RP-96-863
Revision 1

"I certify under the penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations."

Date: 2MAY97 Signature: _____

Title: R. R. Harbert,
Vice President and General Manager
Environmental Restoration Division
Westinghouse Savannah River Company
Co-operator for the U.S. Department of Energy
Savannah River Operations

Date: 5/6/97 Signature: _____

Title: C. V. Anderson,
Director
Environmental Restoration Division
U.S. Department of Energy
Savannah River Field Office
Owner and Co-operator

areas. Historical groundwater monitoring data indicate that the groundwater pathway has not been impacted by the FDTF; therefore, this pathway was not evaluated.

The FDTF is located on a flat interfluvial area approximately equidistant from Pen Branch to southeast and Fourmile Branch to the northwest. Ground elevations in the vicinity of the FDTF range from 85 to 95 m (290 to 300 ft) above mean sea level (msl). The terrain is essentially level and grassy with a few mature trees. The FDTF is in the Fourmile Branch watershed. There are no surface waters present near the unit, but a small wet weather conveyance northwest of the unit flows in a northerly direction. An unnamed tributary of Fourmile Branch is located approximately 450 m (1,500 ft) to the north, northeast of the FDTF.

The soil sampling activities conducted at the FDTF and background locations in 1996 provided data on the types and extent of constituents present and supplemented soil gas surveys conducted in 1986 and 1992. The primary source of contamination at FDTF would be the soil impacted by oils and associated fuels burned at the facility. This soil was removed in 1984.

During the 1996 site characterization the surface soil was sampled from 0 to 0.3 m (0 to 1 ft) and subsurface soil in the interval from 0 to 1.2 m (0 to 4 ft) at 5 locations in the FDTF. Samples received a full analytical suite: metals/inorganics, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and pesticides/polychlorinated biphenyls (PCBs)/dioxins and furans. There was no indication that radionuclides had ever been disposed of at the FDTF, so samples were only screened for radionuclides. Manganese and two SVOCs, benzo(a)pyrene and benzo(g,h,i)perylene, were identified as unit specific constituents (USCs) in the surface soil. No VOCs, pesticides, PCBs, dioxins, furans or radionuclides were identified as USCs for surface soils.

Eight metals were identified as USCs in the subsurface soil: aluminum, arsenic, beryllium, chromium, iron, manganese, sodium, and vanadium. Two SVOCs, benzo(a)pyrene and benzo(g,h,i)perylene, were identified as USCs in the subsurface soil. The SVOCs were not detected deeper than 0.3 m (1.0 ft). No VOCs, pesticides, PCBs, dioxins, furans or radionuclides were identified as USCs for subsurface soils.

Seven metals were identified as USCs in the deep soil (1.2 to 4.0 m [4 to 13 ft]): aluminum, arsenic, beryllium, chromium, iron, sodium, and vanadium. No VOCs, SVOCs, pesticides, PCBs, dioxins, furans or radionuclides were identified as USCs for the deep soils at FDTF.

The historical groundwater monitoring data has resulted in an analytical suite refined to aluminum, and total recoverable petroleum hydrocarbons (TPH). No TPHs have been detected during the periodic monitoring program, so groundwater sampling was not conducted in the 1996 investigation.

The groundwater migration pathway evaluation determined that no constituents are present in the soil in quantities sufficient to migrate through the soil to cause concentrations above acceptable levels. Previous groundwater monitoring data do not indicate that the groundwater has been impacted by the FDTF or any other source of contaminants. The constituents present in the soil of the FDTF at concentrations above two times their average background concentration were screened against EPA generic soil screening levels (SSLs) using a dilution attention factor of 20 to identify those which would require vadose zone transport modeling. No constituent is present in the FDTF soil at an average concentration exceeding its generic screening level with a DAF of 20.

HUMAN HEALTH RISK ASSESSMENT

A human health baseline risk assessment (BRA) was conducted in order to evaluate the significance of contamination of the soil and groundwater at the FDTF. One soil exposure unit was identified within which human receptors could reasonably average their exposure. Soil monitoring data for this exposure unit was aggregated into exposure groups according to depth in soil.

Summary statistics, including an estimate of the exposure point concentration based on the reasonable maximum exposure (RME), were prepared. The RME is intended to provide a conservative, yet realistic, estimate of exposure. The exposed receptors were based on current and future land uses. The current receptor is identified as an adult, the known on-unit worker. In the future, the most likely receptor is believed to be the on-unit industrial worker. Also considered for the future are the resident child and adult, although residential development of the FDTF is not considered likely and is prohibited under the recently adopted land use plan for SRS (DOE, 1996).

Current Worker

The current worker was evaluated at the 0 to 0.3 m (0 to 1 ft) soil interval only. The total excess lifetime cancer risk level for the current worker is 4E-09 and the hazard index is 7E-05. Therefore, the current worker is not at risk while working at this unit.

Future Industrial Worker

The industrial worker was evaluated at the 0 to 0.3 m (0 to 1 ft) and 0 to 1.2 m (0 to 4 ft) soil intervals. For the 0 to 0.3 m (0 to 1 ft) soil interval, the total excess lifetime cancer risk is 9E-07 and the hazard index is 3E-03. Therefore, the future industrial worker will not be at risk while working at the unit based on the evaluation of the surface soils. For the 0 to 1.2 m (0 to 4 ft) soil interval, the total excess lifetime cancer risk is 4E-06 and the hazard index is 0.2. The pathways which contribute the most to this receptor are soil ingestion and dermal contact, each show a cancer risk of 2E-06. The secondary COCs for these pathways are arsenic (84% of the risk for the ingestion pathway) and beryllium (54 percent of the risk for the dermal contact pathway).

Background Risk to the Future Industrial Worker

The background risk (4E-06) at the 0 to 0.3 m (0 to 1 ft) interval is greater than the unit risk, 9E-07. The pathways which contribute mostly to the total risk are ingestion (arsenic which contributes 92% of the risk) and dermal exposure (risk of 2.3E-06 and beryllium contributes 78%). The background risk at the 0 to 1.2 m (0 to 4 ft) soil interval is 3E-06 which is within the risk range of the unit, 4E-06. The pathways which contribute to the total risk are ingestion (risk of 1.5E-06, arsenic contributes 93%) and dermal (risk of 1.6E-06, beryllium contributes 75%).

Residential Adult/Child

The residential scenario was evaluated at the 0 to 0.3 m (0 to 1 ft) and the 0 to 1.2 m (0 to 4 ft) soil intervals also. At the 0 to 0.3 m (0 to 1 ft) soil interval, the total excess lifetime cancer risk is 1E-05 and the hazard index is 0.5. The secondary COC is benzo(a)pyrene, from ingestion of produce (risk of 1E-05).

For the 0 to 1.2 m (0 to 4 ft) soil interval, the total excess lifetime cancer risk is 8E-05 and the hazard index is 4. The pathways which significantly contribute to this receptor are ingestion

(2E-05), dermal (5E-06), and the ingestion of produce (5E-05). In the ingestion pathway, the cancer secondary COCs are arsenic which contributes 80% of the risk, and benzo(a)pyrene. The hazard index for the ingestion pathway is 2.4 and the secondary COCs are iron, which contributes to 80% of the hazard; arsenic and vanadium. The combined risk for the ingestion of produce is 5E-05, the secondary COCs are arsenic and benzo(a)pyrene, of which arsenic contributes 98% of the risk.

Background Risk to the Resident Adult/Child

The background risk and hazard for the adult/child at the 0 to 0.3 m (0 to 1 ft) soil interval are greater than the unit risk and hazard. The total excess cancer lifetime risk for the background is 7E-05 while the unit risk is 1E-05 and the hazard index for the background is greater than 1.0 while the unit is less than 1.0. The secondary COC for the unit is benzo(a)pyrene, while for the background, the secondary COCs are arsenic and beryllium.

For the 0 to 1.2 m (0 to 4 ft) soil interval, the unit risk and the background risk are the same (2E-05) while the hazard at the unit (3) is greater than the background (1). The secondary COCs for the unit are arsenic, beryllium, vanadium and benzo(a)pyrene. While for the background they are arsenic, beryllium, iron, and vanadium. Again, the difference is benzo(a)pyrene which is present at the unit.

The examination was extended to the individual constituents within a given exposure pathway or route to identify the constituents most attributable to the hazards and risks. In this manner, constituents of concern (COCs) were identified. Table ES-1 provides a summary of human health COCs.

ECOLOGICAL RISK ASSESSMENT

The ecological BRA for FDTF evaluated the likelihood of harmful effects to ecological receptors from exposure to contaminants in soil. The receptors in the FDTF food web that were evaluated include terrestrial plants, earthworms, meadow voles, short-tailed shrews, American robins, and red-tailed hawks. These receptors serve as assessment endpoints for the risk to plant and animal populations and ecosystems at FDTF.

The evaluation of ecological risk was conducted according to relevant EPA headquarters, US EPA Region IV, SCDHEC, and Westinghouse Savannah River Company guidance. The assessment methods follow the EPA Framework for Ecological Risk Assessments (EPA, 1992b) and draft Ecological Risk Assessment Guidance for Superfund (EPA, 1994b).

Ecological Constituents of Potential Concern (COPCs) were identified from among constituents detected at FDTF, and incomplete exposure pathways were eliminated. The risk from COPCs in FDTF surface soil was evaluated only for those pathways resulting in ingestion of soil or those food items exposed directly or indirectly to soil. COPCs are those constituents whose maximum measured concentrations exceeded a toxicity screening value for ecological receptors and 2X the background mean concentration.

Based on field reconnaissance, the principal ecological communities at FDTF were characterized as maintained grassy fields with scattered mature trees. Most receptors, exposure classes, and/or species evaluated in the ecological risk assessment were observed at the unit or potentially reside or forage there. No threatened, endangered and sensitive (TES) species are expected to be exposed to COPCs in surface soil at FDTF.

Six assessment endpoints representing environmental values to be protected in accordance with two policy goals were evaluated at FDTF. The risks to FDTF populations and ecosystems were evaluated by estimating the risk to populations of the six indicator receptors; terrestrial vegetation, earthworms, meadow vole (proxy for herbivorous mammals), short-tailed shrew, American robin, and red-tailed hawk; according to ecological relevance, susceptibility, accessibility to prediction or measurement, and relevance to policy goals.

For the evaluation of risk to FDTF populations and ecosystems, decision rules are stated in terms of hazard quotients (HQs). HQs compare estimates of exposure based on site measurements (e.g., RME concentrations of COPCs in the source media [surface and subsurface soil]) to measures of effect (e.g., test concentrations associated with levels of adverse effect on ecological receptors).

Measured concentrations of ecological COPCs in surface soil are used to estimate the RME concentrations and doses for ecological receptors. Published toxicity-benchmark data are used to derive COPC concentrations associated with levels of adverse effect on ecological receptors at FDTF.

HQs for current and future exposure of ecological receptors to COPCs in surface and subsurface soil were calculated and used to estimate risk. No HQs exceeded one in surface soil (0 - 0.3 m [0 - 1.0 ft]); therefore, there are no ecological risks for current conditions. The five metals (aluminum, cadmium, chromium, selenium, and vanadium) exceeding an HQ of one are the COPCs associated with future conditions at the FDTF.

There are uncertainties in the parameters used to estimate exposure, but reported values for receptors' ingestion rates, size and home range, soil-to-plant uptake factors, and soil-to-animal bioaccumulation factors are unlikely to be biased or severely and consistently over- or underestimate exposure. Exposure may be overestimated for some contaminants because the fraction available for absorption by animals may be overestimated. Extrapolation from studies involving laboratory doses to exposures at FDTF is a major source of uncertainty in the estimate of risk to ecological receptors because the availability of the contaminant under test conditions may be greater than it is to receptors living in field conditions. The weight-of-evidence analysis and evaluation of uncertainty for ecological COPCs with HQs exceeding 1.0 resulted in rejection of all five metals as sources of significant risk to ecological receptors at the exposure unit.

CONCLUSIONS

No human health primary or secondary COCs were identified under current land use assumptions. Secondary COCs were identified for the hypothetical industrial worker and on-unit resident. However, HHRGOs for soil were not developed due to the elimination of the COCs (arsenic, benzo(a)pyrene, beryllium, iron, and vanadium) through the uncertainty analysis process. No ecological remedial goal options (RGOs) were developed because there are no ecological COCs.

The surface and subsurface soil investigation at the FDTF adequately characterized the levels of contamination in soil. This includes both present contamination and the potential for future releases. This investigation has provided an understanding of the nature and extent of contamination, determined there are no potential impacts to groundwater, and identified the human health and ecological risks associated with the unit. SRS believes that sufficient information is available to proceed with a "No Action" Statement of Basis/ Proposed Plan for the FDTF.

Table ES-1. Health-Based COCs for Soil and Produce
Fire Department Hose Training Facility

Media	0 -1 ft Soil Interval	0-4 ft Soil Interval
Soil		
Current On-Unit Worker	--	--
Hypothetical Industrial Worker	--	Arsenic (ELCR = 2 x 10^{-6}) Beryllium (ELCR = 1 x 10^{-6})
Hypothetical On-Unit Resident	-- -- -- Benzo(a)pyrene (ELCR = 3 x 10^{-6})	Arsenic (HQ = 0.3) Arsenic (ELCR = 1 x 10^{-5}) Beryllium (ELCR = 3 x 10^{-6}) Iron (HQ = 2) Vanadium (HQ = 0.3) Benzo(a)pyrene (ELCR = 2 x 10^{-6})
Produce		
Hypothetical Resident	Benzo(a)pyrene (ELCR = 1 x 10^{-5})	Arsenic (ELCR = 4 x 10^{-6}) Benzo(a)pyrene (ELCR = 1 x 10^{-5})

No Constituents of Concern are identified based on exceedances of ARARs.

TABLE OF CONTENTS

EXECUTIVE SUMMARY ES-1
LIST OF FIGURES vii
LIST OF TABLES viii
LIST OF ACRONYMS x

1.0 INTRODUCTION 1-1
1.1 RFI/RI/BRA Report Organization 1-1
1.2 RFI/RI/BRA Purpose 1-2
1.2.1 The RCRA Facility Investigation (RFI) Program 1-2
1.2.2 CERCLA Remedial Investigation (RI) Program 1-3
1.2.3 BRA Objectives 1-4
1.3 Unit Description 1-4
1.3.1 Unit History 1-4
1.3.2 Previous Investigations 1-5
1.3.2.1 Soil 1-5
1.3.2.2 Groundwater 1-6
1.3.3 Unit Status 1-6

2.0 CONCEPTUAL SITE MODEL AND STUDY AREA INVESTIGATION 2-1
2.1 Conceptual Site Model Application 2-1
2.1.1 Primary Sources of Contamination 2-1
2.1.2 Primary Release Mechanisms 2-1
2.1.3 Secondary Sources of Contamination 2-1
2.1.4 Secondary Release Mechanisms 2-2
2.1.5 Exposure Pathways 2-2
2.1.6 Exposure Routes 2-2
2.1.7 Receptors 2-3
2.2 Investigation Objectives 2-3
2.3 Unit Assessment Investigation 2-4
2.3.1 Background Samples 2-4
2.3.2 Primary Source Investigation 2-5
2.3.3 Secondary Source Investigation 2-5
2.3.4 Exposure Pathway Investigation 2-6
2.3.5 Physical Characteristics Investigation 2-6

3.0 PHYSICAL CHARACTERIZATION OF THE STUDY AREA 3-1
3.1 Surface Features 3-1
3.2 Meteorology 3-1
3.3 Surface Water Hydrology 3-1
3.4 Unit Soils 3-2

TABLE OF CONTENTS (Continued)

3.5 Geology 3-2
3.5.1 Regional Geology 3-2
3.5.2 Unit-Specific Geology 3-2
3.6 Hydrogeology 3-3
3.6.1 Regional Hydrogeology 3-3
3.6.2 Unit-Specific Hydrogeology 3-4
3.6.2.1 Upper Aquifer Zone of the Upper Three Runs Aquifer (Water Table Aquifer) 3-4
3.6.2.2 Tan Clay Confining Zone of the Upper Three Runs Aquifer 3-4
3.6.2.3 Lower Aquifer Zone of the Upper Three Runs Aquifer 3-5
3.6.2.4 Gordon Confining Unit 3-5
3.7 Demography and Land Use 3-5
3.7.1 Demographics 3-5
3.7.2 Land Use 3-6

4.0 NATURE AND EXTENT OF CONTAMINATION/UNIT ASSESSMENT INVESTIGATION RESULTS 4-1
4.1 Background Investigation Results 4-2
4.2 Primary Source Investigation Results 4-3
4.2.1 Soil Data Presentation and Interpretation in the FDTF 4-3
4.2.2 Primary Source Uncertainty 4-4
4.3 Secondary Source Investigation Results 4-4
4.3.1 Surface Soil (0 to 0.3 m) Data Presentation and Interpretation 4-5
4.3.1.1 Metals/Inorganics 4-5
4.3.1.2 SVOCs 4-5
4.3.1.3 VOCs 4-5
4.3.1.4 Pesticides/PCBs/Dioxins/Furans 4-5
4.3.1.5 Radionuclides 4-5
4.3.2 Subsurface Soil (0 to 1.2 m) Data Presentation and Interpretation 4-6
4.3.2.1 Metals 4-6
4.3.2.2 SVOCs 4-7
4.3.2.3 VOCs 4-7
4.3.2.4 Pesticides/PCBs/Dioxins/Furans 4-7
4.3.2.5 Radionuclides 4-7
4.3.3 Deep Soil (>1.2 m) Data Presentation and Interpretation 4-7
4.3.3.1 Metals 4-8
4.3.3.2 SVOCs 4-9
4.3.3.3 VOCs 4-9
4.3.3.4 Pesticides/PCBs/Dioxins/Furans 4-9
4.3.3.5 Radionuclides 4-9

TABLE OF CONTENTS (Continued)

4.3.4 Secondary Source Uncertainty 4-9
4.4 Exposure Pathway Investigation Results 4-10

5.0 CONTAMINANT FATE AND TRANSPORT 5-1
5.1 Physical and Chemical Properties 5-1
5.1.1 Metals 5-1
5.1.2 Organic Compounds 5-3
5.2 Conceptual Site Model and Contaminant Migration 5-3
5.2.1 Infiltration and Surface Runoff 5-3
5.2.2 Evapotranspiration 5-4
5.2.3 Subsurface Flow System 5-4
5.2.4 Release Mechanisms 5-4
5.2.4.1 Infiltration with Leaching to Groundwater 5-4
5.2.4.2 Surface Runoff and Erosion 5-6
5.2.4.3 Gaseous Emission and Wind Erosion 5-6
5.3 Soil Leachability Analysis 5-6
5.3.1 Comparison of Unit-Specific CSM to Soil Screening Level 5-6
5.3.1.1 Step 1 5-6
5.3.1.2 Step 2 5-7
5.3.2 Results of Comparison to Soil Screening Levels 5-8
5.4 Summary and Conclusions 5-8

6.0 BASELINE RISK ASSESSMENT 6.0-1
6.1 Selection of Constituents of Potential Concern and Exposure Groups 6.1-1
6.1.1 Media of Potential Concern 6.1-2
6.1.2 COPC Selection Process Description 6.1-3
6.1.2.1 Initial COPC and Exposure Route Processing Steps (Steps A) 6.1-3
6.1.2.2 Human Health COPC and Exposure Route Steps (Steps B) 6.1-4
6.1.2.3 Ecological COPC and Exposure Route Processing Steps (Steps C) 6.1-6
6.1.2.4 Human Health and Ecological COPC Summaries 6.1-8
6.2 Human Health Risk Assessment 6.2-1
6.2.1 Human Health Constituents of Potential Concern and Exposure Pathways 6.2-1
6.2.2 Exposure Assessment 6.2-2
6.2.2.1 Land Use Assumptions and Potentially Exposed Receptors 6.2-3
6.2.2.2 Identification of Potential Human Exposure Pathways 6.2-5

TABLE OF CONTENTS (Continued)

6.2.2.3 Derivation of Exposure Concentrations 6.2-6
6.2.2.4 Development of Constituent Intakes 6.2-7
6.2.3 Toxicity Assessment 6.2-8
6.2.3.1 Chemical Toxicity 6.2-8
6.2.3.2 Constituents Without Toxicity Values 6.2-9
6.2.4 Risk Characterization 6.2-10
6.2.4.1 EPA Methods for Risk Characterization 6.2-10
6.2.4.2 Interpretation of Human Health Risk Assessment Results 6.2-12
6.2.5 Summary of the Human Health Risk Characterization 6.2-12
6.2.5.1 Results for Current Land Use 6.2-13
6.2.6 Uncertainty 6.2-18
6.2.6.1 Provisional Toxicity Value for Iron 6.2-19
6.2.6.2 Constituents Without Toxicity Values 6.2-19
6.2.6.3 Uncertainty in the COPC Selection Process 6.2-20
6.3 Ecological Risk Assessment 6.3-1
6.3.1 Problem Formulation 6.3-2
6.3.1.1 Identification of Ecological Constituents of Potential Concern 6.3-2
6.3.1.2 Characterization of Ecological Communities 6.3-3
6.3.1.3 Ecological Assessment Endpoint(s) 6.3-5
6.3.1.4 Receptor Selection 6.3-7
6.3.1.5 Ecological Conceptual Site Model 6.3-8
6.3.1.6 Analysis Plan 6.3-11
6.3.2 Exposure Assessment 6.3-13
6.3.2.1 Constituent Distribution 6.3-13
6.3.2.2 Receptor Distribution 6.3-14
6.3.2.3 Quantification of Exposure 6.3-15
6.3.3 Effects Assessment 6.3-20
6.3.3.1 Methodology 6.3-20
6.3.4 Risk Characterization 6.3-22
6.3.4.1 Risk Estimation 6.3-23
6.3.4.2 Risk Description 6.3-27

7.0 REMEDIAL GOAL OPTIONS 7-1
7.1 Development of Human Health RGOs for Soil 7-2
7.1.1 Introduction 7-2
7.1.2 Exposure Units and Exposure Scenarios 7-2
7.1.3 Findings 7-3
7.1.4 Summary of Human Health COCs 7-3

TABLE OF CONTENTS (Continued)

7.1.4.1 Current Land Use 7-3
7.1.4.2 Future Land Use 7-4
7.2 Uncertainty Analysis for Human Health COCs 7-4
7.2.1 Current Worker 7-4
7.2.2 Future Industrial Worker 7-4
7.2.3 Resident Adult/Child 7-5
7.2.3.1 Surface Soil 7-5
7.2.3.2 Subsurface Soil 7-7
7.2.4 Other Uncertainties in the RGOs 7-8
7.3 Development of Ecological RGOs for Soil 7-8
7.4 Summary of RGOs 7-9

8.0 SUMMARY AND CONCLUSIONS 8-1
8.1 Summary of Primary Sources 8-1
8.2 Summary of Secondary Sources 8-1
8.2.1 Surface Soil in the FDTF 8-2
8.2.2 Subsurface Soil in the FDTF 8-2
8.2.3 Deep Soils at the FDTF 8-2
8.2.4 Data Interpretation 8-2
8.3 Summary of Exposure Pathways 8-3
8.4 Summary of Baseline Risk Assessment 8-3
8.4.1 Summary of Human Health Risk Assessment 8-4
8.4.2 Summary of Ecological Risk Assessment 8-5
8.5 Summary of Remedial Goal Options 8-7
8.5.1 Human Health Risk-Based RGOs 8-7
8.5.2 Development of Ecological RGOs for Soil 8-8
8.6 Conclusions 8-8

9.0 REFERENCES 9-1

LIST OF APPENDICES

Appendix A-1	1986 Soil Gas Survey
Appendix A-2	1982 Soil Gas Survey
Appendix A-3	Unit Historical Information
Appendix A-4	Data Quality Objectives
Appendix A-5	Groundwater Monitoring Results, Wells CSO-1 and CSO-2
Appendix A-6	Cone Penetrometer Testing
Appendix B	Analytical Results Summary
Appendix C	Human Health Risk Characterization
Appendix D	Ecological Risk Characterization

LIST OF FIGURES

1-1 Fire Department Hose Training Facility Location at SRS 1-7
1-2 Fire Department Hose Training Facility Location in N Area 1-8
2-1 Conceptual Site Model for the Fire Department Hose Training Facility Showing Potential Human and Ecological Receptors and Exposure Pathways 2-7
2-2 FDTF Soil Boring, Background Soil Boring and Cone Penetrometer Test Locations 2-9
3-1 Savannah River Site Watershed Boundaries 3-7
3-2 Topographic Map of the Fire Department Training Facility 3-8
3-3 Map of Soils at FDTF 3-9
3-4 Lithostratigraphic Nomenclature Used at SRS 3-10
3-5 Location of Corehole CPC-1 3-11
3-6 Corehole CPC-1 Lithology with the Hydrostratigraphy and Lithostratigraphic Units (Price et al., 1988) 3-12
3-7 Generalized Lithostratigraphic Column for the Central SRS Area 3-13
3-8 Water Table Map for the FDTF 3-14
4-1 Schematic of Soil Borings with PAH Distribution (µg/kg) 4-11
4-2 Schematic of Soil Borings with Metal Distribution (mg/kg) 4-12
6.1-1 Conceptual Site Model for the Fire Department Hose Training Facility Showing Potential Human and Ecological Receptors and Exposure Pathways 6.1-11
6.2-1 Summary of Chemical Risks and Hazards Across Pathways and Receptors: FDTF 6.2-23
6.3-1 Food Web for FDTF BERA 6.3-33
6.3-2 Summary of Exposure Pathways for FDTF BERA 6.3-34

LIST OF TABLES

ES-1 Health-Based COCs for Soil and Produce Fire Department Hose Training Facility.....ES-8
2-1 Fire Department Hose Training Facility Background Boring Sampling Data..... 2-11
2-2 Fire Department Hose Training Facility Background Boring Sampling Data..... 2-12
3-1 1996 Static Water Level Measurements for Central Shops Area 3-15
4-1 Fire Department Hose Training Facility Unit and Background Soil Sample Information 4-13
4-2 Unit Specific Background Soil Concentrations at the Fire Department Hose Training Facility..... 4-14
4-3 Analytes Not Detected in Fire Department Training Facility Soil Samples..... 4-16
4-4 Summary Statistics for Analytes Detected in Soil Samples from 0 to 1 ft Deep from the Fire Department Hose Training Facility 4-20
4-5 Summary Statistics for Analytes Detected in Soil Samples from 0 to 4 ft Deep from the Fire Department Hose Training Facility 4-22
4-6 Summary Statistics for Analytes Detected in Soil Samples from >4 ft Deep from the Fire Department Hose Training Facility 4-24
4-7 Summary of Results by Borehole for Soil Samples From the Fire Department Hose Training Facility Above Both Background and Human Health Criteria 4-26
5-1 List of Distribution Coefficients (K_d) Used to Describe the Retardation Factors (R_d) for the Inorganic Site-Related Analytes at the FDTF..... 5-9
5-2 Physical and Chemical Properties of Selected Organic Constituents at the FDTF..... 5-10
5-3 Background Soil Screen for Fate and Transport Analysis..... 5-11
5-4 Generic Soil Screening Levels for Exposure Pathways..... 5-12
5-5. Soil Screening Level Summary for Soil Migration Pathway..... 5-13
6.1-1 Summary Statistics for Analytes Detected in Soil Samples from 0-1 ft Deep in the FDTF..... 6.1-12
6.1-2 Summary Statistics for Analytes Detected in Soil Samples from 0 to4 ft Deep in the FDTF 6.1-14
6.1-3 Summary Statistics for Analytes Detected in Soil 4 ft Deep in the FDTF 6.1-16
6.1-4 Summary Statistics for Soil Background Concentrations 0 to 1 ft in the FDTF 6.1-18
6.1-5 Summary Statistics for Soil Background Concentrations 0 to 4 ft in the FDTF 6.1-19
6.1-6 Summary Statistics for Soil Background Concentrations >4 ft in the FDTF 6.1-20
6.1-7 Human Health Risk Assessment COPC Summary: FDTF Surface Soil (0 to 1 ft)... 6.1-22
6.1-8 Human Health Risk Assessment COPC Summary: FDTF Subsurface Soil (0 to 4 ft)6.1-23
6.1-9 Human Health Risk Assessment COPC Summary: Background Surface Soil (0 to 1 ft) 6.1-24
6.1-10 Human Health Risk Assessment COPC Summary: Background Subsurface Soil (0 to 4 ft)..... 6.1-25
6.1-11 Derivation of Toxicity Screening Values for Screening Constituents as Ecological COPCs at FDTF..... 6.1-26

LIST OF TABLES (Continued)

6.1-12 Ecological Risk-Based Screening for Nonradionuclides in FDTF Surface Soil (0 to 1 ft) 6.1-28
6.1-13 Ecological Risk-Based Screening for Nonradionuclides in FDTF Subsurface Soil (0 to 4 ft) 6.1-30
6.1-14 Screening of Food-to-Tissue Bioaccumulation Factors for Constituents at FDTF 6.1-32
6.1-15 COPC Summary: FDTF Surface Soil (0 to 1 ft) 6.1-34
6.1-16 COPC Summary: FDTF Surface Soil (0 to 4 ft) 6.1-35
6.1-17 COPC Summary: Background Surface Soil (0 to 1ft) 6.1-36
6.1-18 COPC Summary: Background Subsurface Soil (0 to 4 ft) 6.1-37
6.2-1 RME Risk Characterization Summary: FDTF Surface Soil (0 to 1 ft) 6.2-24
6.2-2 RME Risk Characterization Summary: FDTF Subsurface Soil (0 to 4 ft) 6.2-25
6.2-3 RME Risk Characterization Summary: Background Surface Soil (0 to 1 ft) 6.2-26
6.2-4 RME Risk Characterization Summary: Background Subsurface Soil (0 to 4 ft) 6.2-27
6.2-5 Health-Based COCs and Rds for Soil and Produce at the FDTF 6.2-28
6.3-1 Threatened, Endangered, and Sensitive Species that Could Potentially Occur in the Area of the FDTF 6.3-35
6.3-2 Policy Goals, Ecological Assessment and Measurement Endpoints, and Decision Rules for the FDTF ERA 6.3-36
6.3-3 Unit Foraging Factors for Ecological Receptors at FDTF 6.3-39
6.3-4 Exposure of Mammals to Ecological COPCs at FDTF Surface Soil (0 to 1 ft) 6.3-40
6.3-5 Exposure of Birds to Ecological COPCs at FDTF Surface Soil (0 to 1 ft) 6.3-41
6.3-6 Exposure of Mammals to Ecological COPCs at FDTF Subsurface Soil (0 to 4 ft) 6.3-42
6.3-7 Exposure of Birds to Ecological COPCs at FDTF Subsurface Soil (0 to 4 ft) 6.3-43
6.3-8 Toxicity Reference Values for Ecological Receptors: Plants and Earthworms 6.3-44
6.3-9 Derivation of Toxicity Reference Values for Ecological Receptors: Mammals 6.3-45
6.3-10 Derivation of Toxicity Reference Values for Ecological Receptors: Birds 6.3-46
6.3-11 Ecological HQs for Plants and Earthworms Exposed to FDTF Surface Soil (0 to 1 ft) 6.3-47
6.3-12 Ecological HQs for Mammals Exposed to FDTF Surface Soil (0 to 1 ft) 6.3-48
6.3-13 Ecological HQs for Birds Exposed to FDTF Surface Soil (0 to 1 ft) 6.3-49
6.3-14 Ecological HQs for Plants and Earthworms Exposed to FDTF Subsurface Soil (0 to 4 ft) 6.3-50
6.3-15 Ecological HQs for Mammals Exposed to FDTF Subsurface Soil (0 to 4 ft) 6.3-51
6.3-16 Ecological HQs for Birds Exposed to FDTF Subsurface Soil (0 to 4 ft) 6.3-52
6.3-17 Qualitative Evaluation of Uncertainty for FDTF Ecological Risk Assessment 6.3-53
6.3-18 Summary of Highest HQs for Ecological COPCs in FDTF Soil 6.3-54

LIST OF ACRONYMS

2X	Two Times
95UCL	95 Percent Upper Confidence Limit
ARAR	Applicable, Relevant, and Appropriate Requirements
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
bgs	Below Ground Surface
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
COC	Constituent of Concern
COPC	Constituent of Potential Concern
CPT	Cone Penetrometer Testing
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
DAF	Dilution Attenuation Factor
DCF	Dose Conversion Factor
DF	Dilution Factor
DOE	U.S. Department of Energy
DQO	Data Quality Objective
DV	Daily Value
ED	Estimated Dose
ELCR	Elevated Lifetime Cancer Risk
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
FDA	Food and Drug Administration
FDTF	Fire Department Hose Training Facility
FFA	Federal Facility Agreement
FS	Feasibility Study
GEL	General Engineering Laboratories
GPR	Ground Penetrating Radar

LIST OF ACRONYMS (Continued)

HEAST	Health Effects Assessment Summary Tables
HHRGO	Human Health Remedial Goal Option
HI	Hazard Index
HIF	Human Intake Factor
HQ	Hazard Quotient
HSWA	Hazardous and Solid Waste Amendments
IRIS	Integrated Risk Information System
LOAEL	Lowest Observed Adverse Effects Level
MCL	Maximum Contaminant Level
msl	Mean Sea Level
NCEA	National Center for Environmental Assessment
NOAEL	No Observed Adverse Effect Level
NPL	National Priorities List
OSWER	Office of Solid Waste and Emergency Response
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene
ppm	Parts per Million
PRG	Preliminary Remedial Goals
QA	Quality Assurance
QC	Quality Control
QCSR	Quality Control Summary Report
RAGS	Risk Assessment Guidance for Superfund
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RDA	Recommended Daily Allowance
RfC	Reference Concentration
RfD	Reference Dose
RFI	RCRA Facility Investigation

LIST OF ACRONYMS (Continued)

RGO	Remedial Goal Option
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
SADI	Safe and Adequate Daily Intake
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act
SCDHEC	South Carolina Department of Health and Environmental Control
SCS	Soil Conservation Service
SHRTSC	Superfund Health Risk Technical Support Center
SRC	Site Related Contaminants
SRFS	Savannah River Forest Service
SRS	Savannah River Site
SSL	Soil Screening Level
SSSL	Site-specific Soil Screening Level
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
T&E	Threatened & Endangered
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
TEDE	Total Effective Dose Equivalent
TES	Threatened, Endangered, and Sensitive
TPH	Total Petroleum Hydrocarbons
TRV	Toxicity Reference Value
UCL	Upper Confidence Limit
UFF	Unit Foraging Factor
USC	Unit Specific Contaminant
VOC	Volatile Organic Compound
WQS	Water Quality Standard
WSRC	Westinghouse Savannah River Company

1.0 INTRODUCTION

This report documents the Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation/Baseline Risk Assessment (RFI/RI/BRA) for the Fire Department Hose Training Facility (FDTF) (904-113G).

1.1 RFI/RI/BRA Report Organization

This RFI/RI/BRA report has nine sections. Section 1 outlines the document organization and purpose, and provides the unit description and history. Section 2 presents the Conceptual Site Model (CSM) based on results of the study area investigation. A detailed description of the unit assessment objectives and activities is also given. Section 3 details the physical characteristics of the unit, as well as the relationship of the unit to the regional physical framework. Data results from the physical characteristics investigation activities are presented in the appropriate subsection discussions.

Section 4 illustrates, tabulates, and interprets the type and horizontal and vertical extent of contaminants that have resulted from the subject unit. Organization in this section follows the CSM, and incorporates exposure units from the BRA.

Section 5 provides a discussion of unit-specific soil contaminants and their potential to contribute to future contamination due to leaching to the groundwater. This section includes a discussion and presentation of the physical and chemical properties that control the behavior of contaminants in the environment. A discussion of contaminant pathways in relation to the CSM is included, as well as the application and underlying assumptions for the leachability analysis. A unit-specific model has been provided for contaminants that exceed their associated soil screening levels.

Section 6 includes the BRA, which determines the potential for adverse effects associated with exposure to constituents present at the unit. The BRA includes both human and ecological receptors, and risk calculations are performed assuming no remediation or institutional controls at the unit.

Section 7 provides remedial goal options (RGOs). RGOs are designed to provide long-term targets for the selection and analysis of remedial alternatives. Human health RGOs are provided to estimate protective cleanup levels based on risk or hazards to human receptors. Similarly, ecological RGOs are provided for ecological receptors. Section 8 presents a summary of the field investigation, nature and extent of contamination, fate and transport modeling, and the risk assessment summary for both human and ecological receptors. References for Sections 1 through 8 are listed in Section 9.

1.2 RFI/RI/BRA Purpose

1.2.1 The RCRA Facility Investigation (RFI) Program

The Savannah River Site (SRS) is located in Aiken, Barnwell, and Allendale Counties in South Carolina. SRS manages certain waste materials which are regulated under RCRA, a comprehensive law requiring stringent management of hazardous wastes. The Hazardous and Solid Waste Amendments (HSWA) were passed in 1984 to augment the 1976 RCRA requirements.

Certain activities conducted at SRS require operating or post-closure permits issued in accordance with RCRA. Disposal units covered under RCRA and HSWA are classified as either regulated or non-regulated. Regulated units are those surface impoundments, landfills, and waste piles (collectively termed "landfill-disposal units") which have received hazardous waste since November 19, 1980 and require RCRA operating or post-closure permits. SRS has received a RCRA permit from the South Carolina Department of Health and Environmental Control (SCDHEC). Part of the permit mandates that SRS establish and implement an RFI program to fulfill the requirement of HSWA Section 3004 (u).

HSWA Section 3004 (u) mandates investigation and corrective action at non-regulated units. These non-regulated units have been termed Solid Waste Management Units (SWMUs) and include units where hazardous constituents are uncontrolled and could be released to the environment. Section V.A.1 of the SRS RCRA Permit lists 65 SWMUs that were identified by the Environmental Protection Agency (EPA) Region IV through the RCRA facility assessment process. The permit mandates that these 65 SWMUs be further investigated to determine the actual or potential impact of each unit to the environment. The FDTF is a non-regulated SWMU that must be investigated in accordance with permit requirements.

1.2.2 CERCLA Remedial Investigation (RI) Program

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act, regulates the investigation and cleanup of hazardous waste sites. CERCLA utilizes a Hazard Ranking System to evaluate the risks that hazardous waste sites pose to human health and the environment. On the basis of Hazard Ranking System scores and state requests, sites are placed on the National Priorities List (NPL). The NPL is a list of hazardous waste sites which pose the most significant risks to human health or the environment.

On December 21, 1989, SRS was included on the NPL. In accordance with Section 120 of CERCLA, the U.S. Department of Energy (DOE) has negotiated a Federal Facility Agreement with the EPA and the SCDHEC to coordinate cleanup activities at SRS.

A detailed remedial investigation/feasibility study (RI/FS) is required for sites listed on the NPL. The RI/FS evaluates the nature and extent of risks posed by hazardous waste sites and evaluates remedial options in order to select the best remedial alternative. The RI serves as a mechanism to collect data to characterize conditions onsite, evaluate the fate of contaminants, and assess the risks to humans and the environment which result from site conditions. The FS uses site-specific information generated during the RI to evaluate remedial alternatives and select an appropriate remedy for the site.

The SRS has recently concluded a surface and subsurface soil investigation at the FDTF located in the Central Shops Area (also known as N Area) of SRS. Based upon preliminary characterization results, SCDHEC concurred with DOE's proposal to separate the operable unit into two operable units and expedite remedial action. SCDHEC also agreed that the investigation at FDTF adequately characterized contamination within that unit and along potential migration pathways. In lieu of a comprehensive RFI/RI Work Plan, SCDHEC has instructed DOE to submit an RFI/RI/BRA Report for the FDTF (Collinsworth, August 1996). This schedule change was acknowledged and approved by the EPA (Froede, August 1996). In support of the Streamlined Approach for Environmental Restoration concept, and Expedited Site Characterizations program, data collected during previous sampling events has been combined with additional samples collected in May through July 1996, to support a comprehensive human health and ecological risk assessment as well as the evaluation of potential remedial technologies.

1.2.3 BRA Objectives

The purpose of the BRA is to assess the potential for adverse effects associated with exposure to contaminants likely to be present at the unit. Baseline risks are those risks to human health and the environment which can be anticipated to be present in the absence of any institutional controls or remedial actions for the unit. The BRA provides the basis for determining whether or not remedial action is necessary and the justification for performing remedial actions.

1.3 Unit Description

The FDTF is located in the Central Shops Area (N Area) of the SRS as shown in Figure 1-1. The unit is approximately 215 m (700 ft) northeast of the intersection of Roads C and 6 and approximately 6 m (20 ft) west and downgradient of a heat exchanger storage pad (Figure 1-2). The area is gently sloping and grassy with a few mature trees. The FDTF is relatively level and revegetated. There are orange markers and a sign identifying the FDTF as a RCRA/CERCLA unit.

1.3.1 Unit History

The FDTF was built between 1975 and March 1979 and operated by the SRS Fire Department between 1979 and 1982 to train personnel in fighting waste oil fires. The training facility consisted of an approximately 6 by 12 m (20 by 40 ft) unlined shallow pit surrounded by an approximately 0.5 m (1.5 ft) high asphalt dike. Training exercised typically included pouring burnable oil into the unit, igniting the oil, and then having the fire department extinguish the fire. No known hazardous wastes were placed in the unit.

The SRS Fire Department discontinued use of the FDTF and recommended the facility for clean up and closure in March 1982. Available documentation indicates clean up activities occurred on November 21, 1982 and 14 loads of oil-contaminated soil were excavated from an area approximately 6 by 6 by 1 m (20 by 20 by 3 ft) and transported to the sanitary landfill. However, the date of this clean up activity could not be verified since an aerial photograph from 1983 shows the FDTF still present. An additional aerial photograph from June 1984 shows the FDTF pit has been removed and the area excavated. The excavated area is approximately 10 to 12 m (30 to 40 ft) wide by 15 to 18 m (50 to 60 ft) long and the pit dikes and visible contaminated soils are removed. An additional area 3 to 5 m (10 to 15 ft) wide by 10 to 12 m (30 to 40 ft)

long, visible on the north side of the main excavation, is an additional remediated area. a pile of the excavated material, or material intended for backfill. The photographs indicate that either existing documentation is incorrect (11/21/82 is actually 11/21/83) or that a more extensive excavation took place between July 1983 and June 1984. Subsequent inspections during 1985 indicated that an additional area approximately 1m by 1 m (3 by 3 ft), of visibly contaminated soil was present, possibly from illegal dumping or a spill. This area was also excavated to a depth of approximately 0.6 m (2 ft) and the soil removed from the site in a manner similar to the 1982/84 clean up activities.

All existing documents, verbal information, pictures, and aerial photographic information concerning the FDTF, which were found during a records search, are presented in Appendix A-3.

In 1986, a soil gas survey was conducted at the FDTF. According to the report, an approximately 6 m by 9 m (20 ft by 30 ft) area of oil stained soil was identified near the center of the study area, although to date, no documentation has been found to indicate soil removal. Differences in the soil gas surveys conducted in 1986 and 1992 (discussed in Section 1.3.2.1) suggest that possible cleanup activities or natural bio-degradation may have occurred.

1.3.2 Previous Investigations

1.3.2.1 Soil

Soil gas and subsurface soil sampling were conducted at the FDTF in November 1986 (Appendix A-1). The soil gas survey consisted of 51 samples taken at a depth of 0.9 m (3 ft). These samples were analyzed for possible breakdown products of oil including methane, ethane, propane, butane, ethylene, and propylene. Total hydrocarbons exceeded 1,000 parts per million (ppm) at two locations and exceeded 100 ppm at three locations. Thirty-four soil samples were obtained from 17 locations between 0.3 and 1.5 m (1 and 5 ft) below ground surface (bgs). These samples were analyzed for pentane, methane, heptane, octane, benzene and toluene, which are breakdown products of oil that are more likely to be found in soil than in soil gas. Results of soil sample analysis indicated the presence of oil to a depth of approximately 1.2 m (4 ft) bgs.

A second soil gas survey was conducted at the FDTF in 1992. The survey consisted of 15 samples analyzed for C1-C14 hydrocarbons, benzene, toluene, ethylbenzene, and xylene, and selected chlorinated hydrocarbons (Appendix A-2). The soil gas survey detected the presence of

pentane, hexane, heptane, octane, xylene, tetrachloroethylene, methane, ethane, propane, butane, ethylene, and propylene above Method Detection Limits. A comparison of the results of this survey to the survey conducted in 1986 reveals a marked decrease in petroleum contaminant concentrations. The maximum recorded concentrations for methane, propane, ethylene, and propylene decreased by an order of magnitude. Maximum concentrations of ethane and butane were less than half of the maximum value reported in 1986.

1.3.2.2 Groundwater

Two monitoring wells are screened across the water table in the vicinity of the FDTF (CSO-1 and CSO-2). From the third quarter of 1994 through the second quarter of 1995, these monitoring wells were sampled twice. Based on prior sampling results, the analytes currently monitored have been reduced to aluminum and total recoverable petroleum hydrocarbons (TPH). No TPH was detected in the subject wells in 1995. Groundwater monitoring results for wells CSO-1 and CSO-2 for the third Quarter 1994 through the second Quarter 1995 are shown in Appendix A-5. During field activities in July 1996, groundwater elevations in monitoring wells throughout N Area were measured. These data are presented in Section 3.6.2.

1.3.3 Unit Status

The FDTF is an inactive unit. After training activities at the facility ceased in 1982, contaminated soil was removed from the area and the pit was backfilled to grade.

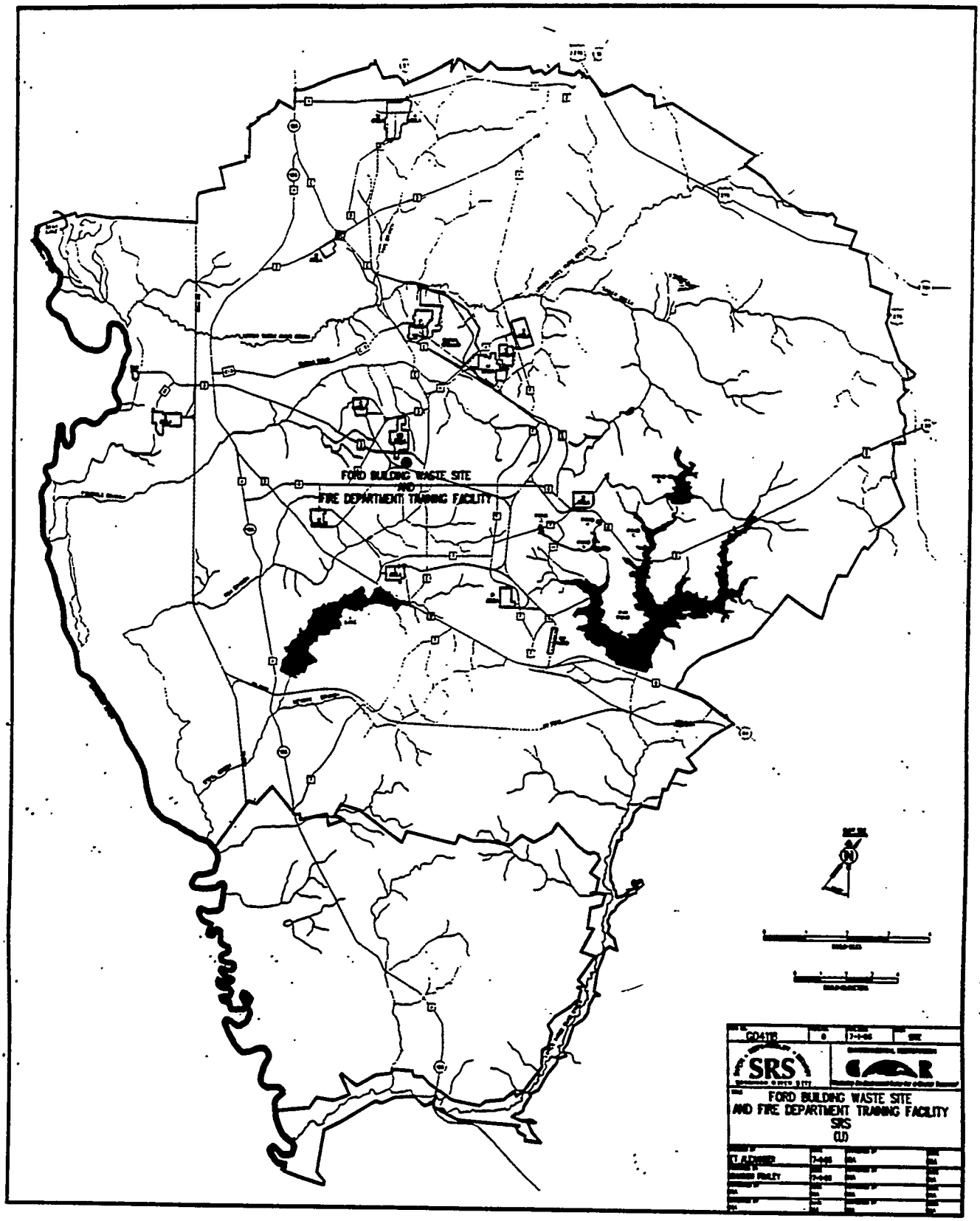


Figure 1-1. Fire Department Hose Training Facility Location at SRS

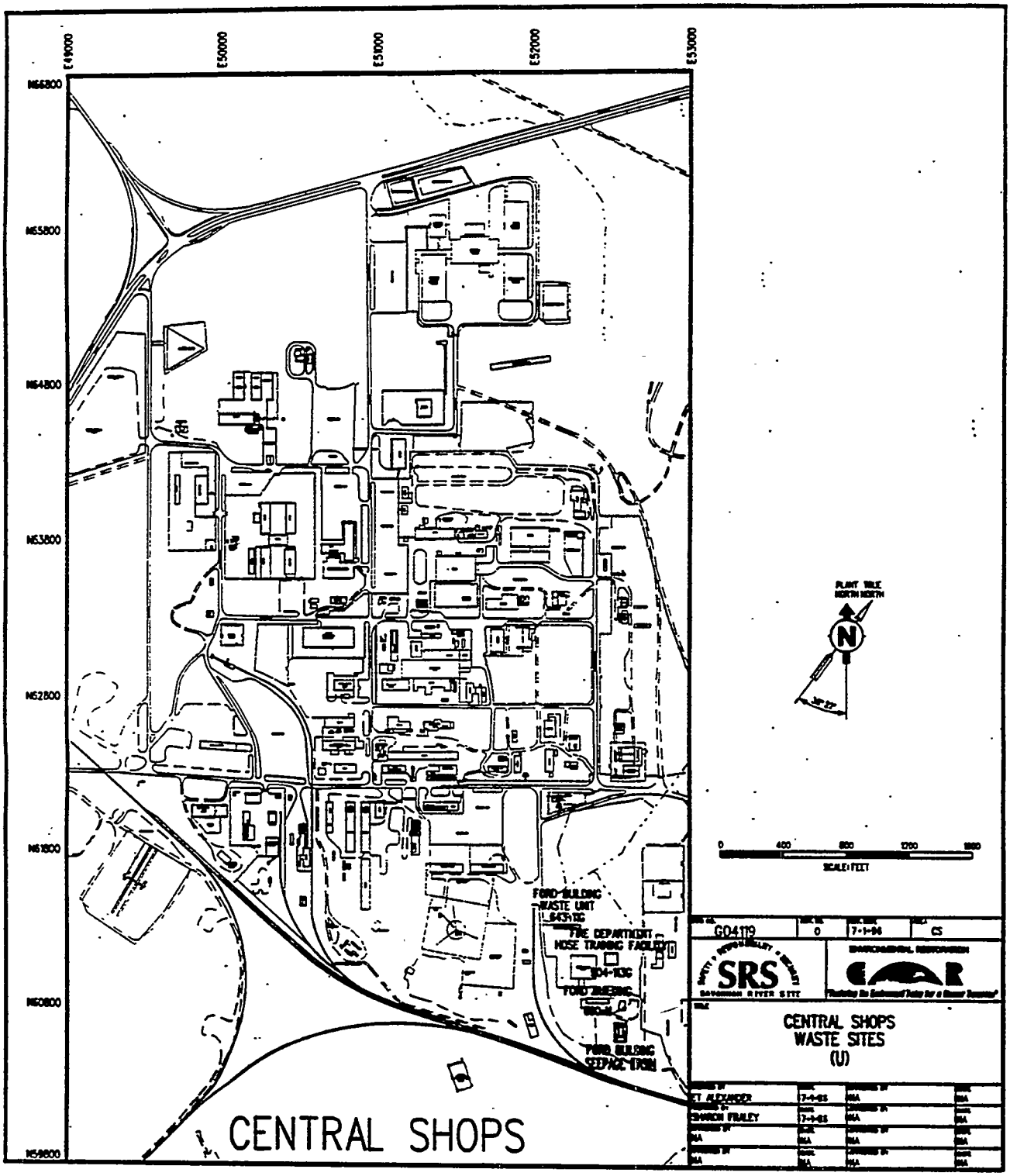


Figure 1-2. Fire Department Hose Training Facility Location in N Area

2.0 CONCEPTUAL SITE MODEL AND STUDY AREA INVESTIGATION

This section presents the Conceptual Site Model (CSM) for the Fire Department Hose Training Facility (FDTF). It includes a discussion of the known and suspected sources of contamination, the types of contaminants and potentially affected media, the known and potential routes of migration, and the known and potential human and ecological receptors.

2.1 Conceptual Site Model Application

Environmental Protection Agency (EPA) guidance (EPA, 1989a) stresses the need for and utility of a conceptual representation of the unit under consideration. The CSM provides an objective framework around which existing information can be organized and synthesized, data gaps can be identified, and sampling programs can be designed to address critical data needs and data quality objectives (DQOs). The CSM presented in Figure 2-1 incorporates information obtained from the unit characterization and contains additional detail used for the Baseline Risk Assessment (BRA) presented in Section 6.

2.1.1 Primary Sources of Contamination

Sources of contamination from FDTF include material from past training activities at the unit. The potential contaminants of concern are the oils and other fuels which were applied to the pit and burned, and the media used to extinguish the fires.

2.1.2 Primary Release Mechanisms

Contaminants may have been released from the primary sources by:

- Deposition of contaminants on the soil during training sessions
- Infiltration/percolation of the waste constituents at the FDTF to subsurface soil

2.1.3 Secondary Sources of Contamination

Environmental media impacted by release of source contamination may include:

- Surface soil on and around the FDTF
- Subsurface soil beneath the FDTF

- Surface soil in adjacent areas
- Subsurface soil in adjacent areas

2.1.4 Secondary Release Mechanisms

Environmental media serve both as a reservoir via chemical bonding and biotic uptake, and as a secondary release mechanism of contaminants. Secondary environmental release mechanisms may include:

- Release of volatile constituents from the soil
- Generation of contaminated fugitive dust by wind or other surface soil disturbance
- Direct contact with contaminated soils
- Biotic uptake occurring at the FDTF
- Leaching

2.1.5 Exposure Pathways

Contact with contaminated environmental media creates the exposure pathways to human and ecological receptors evaluated in the BRA. These include:

- Air in the vicinity of the FDTF
- Direct contact with surface and subsurface soil
- Biota in the vicinity of the FDTF

Historical monitoring data for groundwater (See Appendix A-5) in the vicinity of the FDTF does not indicate contamination from the unit. Therefore, groundwater was not investigated.

2.1.6 Exposure Routes

Exposure routes for human and ecological receptors may include:

- Inhalation of volatile emissions and particulates
- Ingestion of contaminated media, including soil and produce home-grown by future on-unit residents
- Dermal contact with contaminated media

2.1.7 Receptors

Human and ecological receptors are identified below. Human receptors may include:

- Known on-unit workers
- Hypothetical industrial workers
- Hypothetical on-unit residents

Since the FDTF is located near the center of the Savannah River Site, trespassers are not considered to be potential receptors.

Ecological receptors may include:

- Terrestrial ecological receptors (e.g., plants, earthworms, songbirds, and other mid-level and top predators)

Aquatic and semi-aquatic receptors are not considered because there is no surface water at or near the FDTF.

2.2 Investigation Objectives

The DQOs (Appendix A-4) of the investigation at the FDTF were to:

- Screen soil samples from the unit for a wide range of potential contaminants.
- Compare analytical results to site specific background values to derive a list of unit specific contaminants.

The initial site characterization also provided sufficient data to determine the nature and extent of contamination from the FDTF. The site characterization activities in 1996 have been evaluated and are presented in the subsequent sections of this document. Based on the analytical results pursuant to this investigation, the EPA, South Carolina Department of Health and Environmental Control (SCDHEC), and the U.S. Department of Energy (DOE) agreed that a Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) Work Plan was not required for the FDTF. This decision has been documented in correspondence between SCDHEC and U.S. DOE (K. Collinsworth to B. Hennessey, August 16, 1996) and the EPA and DOE (Froede, August 26, 1996).

2.3 Unit Assessment Investigation

This section describes the physical and contaminant investigations conducted at the FDTF between May 13 and July 10, 1996. Sampling activities followed applicable procedures in Westinghouse Savannah River Company (WSRC) Manual 3Q5 (WSRC, 1993b). The study was conducted in several stages, which are listed below:

Background Investigation

- Collection of five background soil samples

Primary Source Investigation

- No primary source investigation was undertaken.

Secondary Source Investigation

- Collection and analysis of soil samples from five locations to characterize secondary sources of contamination

Exposure Pathway Investigation

- Surface soils were collected to determine if these soils are a viable exposure pathway, to assess air and biota as potential exposure pathways, and to evaluate the potential for surface soils to impact the subsurface soil pathway.
- Subsurface soils were collected to identify the potential impact on the groundwater pathway.

Physical Characteristics Investigation

- Collection of lithological data from four cone penetrometer technology (CPT) locations
- Field description of continuous split spoon soil samples to determine lithology beneath the unit to a depth of 4.0 m (13 ft)

2.3.1 Background Samples

Background soil samples were obtained to establish baseline concentrations for evaluation of potential contaminants and pathway information. No groundwater monitoring was conducted.

Locations of the background soil borings are shown on Figure 2-2. Five borings (FBFDBG-01 through FBFDBG-05) were sampled from the following five intervals:

- 0 to 0.3 m (0 to 1 ft)
- 0.3 to 1.2 m (1 to 4 ft)
- 1.2 to 2.1 m (4 to 7 ft)
- 2.1 to 3.0 m (7 to 10 ft)
- 3.0 to 4.0 m (10 to 13 ft)

A stainless steel shovel was used to collect the 0 to 0.3 m (0 to 1 ft) samples, except where surface soils were too hard to dig with a shovel. When a shovel could not be used for surface samples, a drill rig and split spoon were employed. Samples deeper than 0.3 m (1 ft) below ground surface (bgs) were obtained with a split spoon. Table 2-1 summarizes field data obtained from background soil samples. Additional details can be found in the field activity report (WSRC. 1996a).

2.3.2 Primary Source Investigation

According to site records, contaminated soil and the pit dikes were removed from the facility in 1982 and 1985 (Keaton et al, 1985). Therefore, a primary source investigation was not undertaken during the 1996 unit characterization.

2.3.3 Secondary Source Investigation

Potential secondary sources of contamination from the FDTF include surface and subsurface soils. These secondary sources are also the primary media potentially impacted by previous activities at the unit. Soil sampling was conducted to define the nature of contamination at the FDTF.

From May 21 to May 29, 1996, five soil borings (FDTF-01 through FDTF-05) were drilled within the boundaries of the unit. Locations of the borings are shown on Figure 2-2. Five samples were obtained from each boring. The sample intervals for borings FDTF-01, FDTF-02, FDTF-04, and FDTF-05 were analogous to those in the background borings. The upper four

sample intervals from FDTF-03 were the same as those in the other FDTF borings. The fifth sample was obtained from 3.0 to 4 m (10 to 14 ft) bgs.

A stainless steel shovel was used to collect the surface soil samples, except where the soils were too hard to dig with a shovel. When a shovel could not be used for surface samples, a drill rig and split spoon were employed. Samples deeper than 0.3 m (1 ft) bgs were obtained with a split spoon. Table 2-2 presents the field data recorded from each soil boring. Details of field activities can be found in the field activity report (WSRC, 1996a).

2.3.4 Exposure Pathway Investigation

The CSM identifies pathways potentially impacted by previous activities at the FDTF. These pathways include the following: air, surface soil, subsurface soil, biota and groundwater. Historical groundwater monitoring data indicate that the groundwater pathway has not been impacted by the FDTF; therefore, this pathway was not evaluated. Soil sampling activities are described in Section 2.3.3. Air and biota sampling were not conducted as part of the characterization efforts. Surface soil sampling results can be used to estimate volatilization of organics, concentrations of contaminants in fugitive dust, and potential uptake by biota.

2.3.5 Physical Characteristics Investigation

To obtain information about soil characteristics in the vicinity of the FDTF, four CPTs were conducted on July 10, 1996, to a depth of approximately 25 m (80 ft) bgs. CPT locations are shown on Figure 2-2. Data collected during the testing included downhole pore pressure, tip resistance, and sleeve friction. The data indicate interbedded layers of sand, silt, and clay from the ground surface to between 0.9 to 1.5 m (3 to 5 ft) bgs. Below this depth to approximately 11 to 12 m (35 to 40 ft) the soils are predominantly clay with a few interbedded layers of silt and sandy clay. Deeper soils consist of sand interbedded with silty and clayey sand. CPT results are presented in Appendix A-6.

Descriptions from 0 to 4 m (0 to 13 ft) bgs borings taken during field activities indicate fine to medium grained sands occur to a depth of approximately 2 m (7 ft) bgs. These samples are typically underlain by clay to sandy clay. A "very stiff" clay layer was also encountered at a depth of approximately 2 m (7 ft) bgs at a nearby unit (WSRC, 1996a).

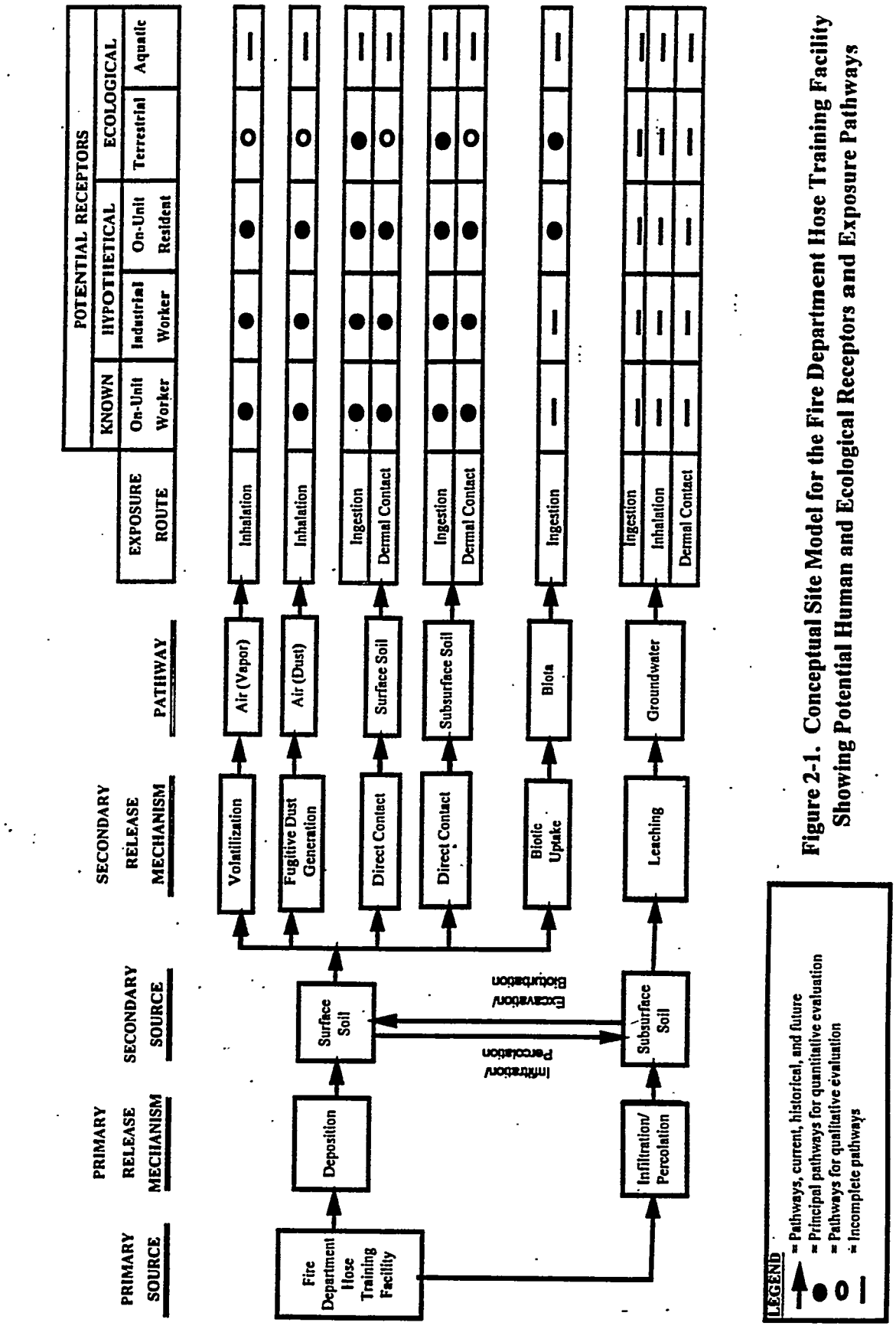


Figure 2-1. Conceptual Site Model for the Fire Department Hose Training Facility Showing Potential Human and Ecological Receptors and Exposure Pathways

(This page intentionally left blank)

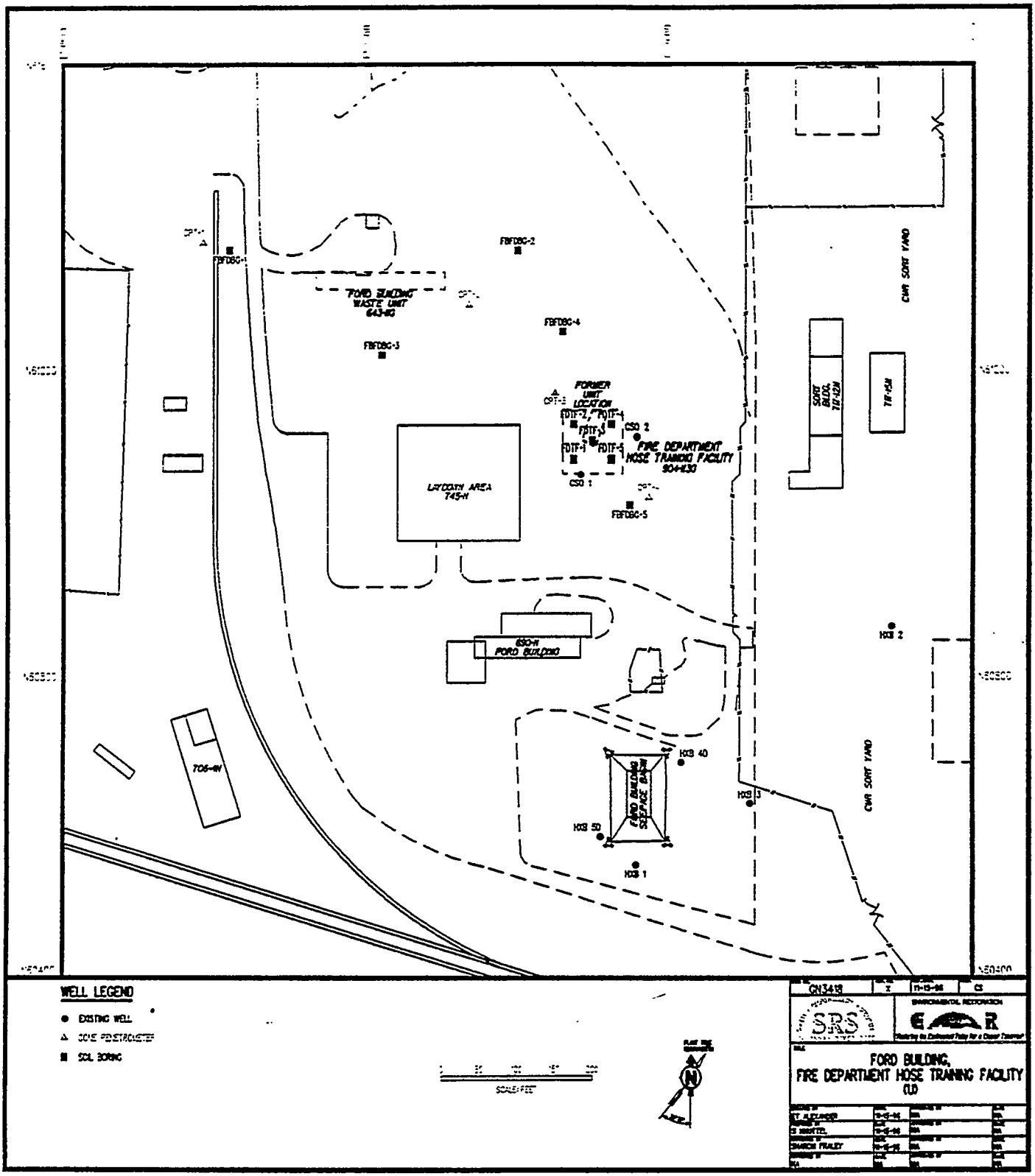


Figure 2-2. FDTF Soil Boring, Background Soil Boring and Cone Penetrometer Test Locations

(This page intentionally left blank)

Table 2-1. Fire Department Hose Training Facility Background Boring Sampling Data

Location	Sample Interval (ft)	Sample Method	H-Nu Headspace Reading (ppm	Dominant Lithology
FBFDBG-01	0.0-1.0	shovel	2.5	Sand, fine grain, moderate yellowish brown
	1.0-4.0	split spoon	2	Sand, fine grain, moderate yellowish brown
	4.0-7.0	split spoon	2.2	Sand, fine grain, light gray, variegated dark yellowish orange
	7.0-10.0	split spoon	3	Sand, fine-course grain, light gray, variegated moderate
				yellowish orange
	10.0-13.0	split spoon	10	Sand, fine-medium grain, light gray, variegated light red
FBFDBG-02	0.0-1.0	shovel	7	Sand, fine-medium grain, light brown
	1.0-4.0	split spoon	6.5	Sand, moderately graded, light gray, variegated dark
				yellowish orange
	4.0-7.0	split spoon	6	Sand, well graded, light gray, variegated moderate
				reddish brown
	7.0-10.0	split spoon	1.8	Clay, light gray, variegated moderate red
	10.0-13.0	split spoon	2.4	Clay, light gray, variegated moderate reddish brown
FBFDBG-03	0.0-1.0	shovel	0.5	Sand, fine-medium grain, trace gravel, moderate
				yellowish brown
	1.0-4.0	split spoon	0.5	Sand, fine-medium grain, variegated moderate
				yellowish brown
	4.0-7.0	split spoon	0.5	Sand, fine-medium grain, trace gravel, variegated moderate
				yellowish brown
	7.0-10.0	split spoon	1.5	Sand, well graded, light gray, variegated moderate reddish
				brown
	10.0-13.0	split spoon	1.75	Sand, well graded, light gray, variegated moderate reddish
				brown
FBFDBG-04	0.0-1.0	shovel	4	Sand, fine grain, trace gravel, dark yellowish orange
	1.0-4.0	split spoon	8	Sand, fine grain, trace gravel, light gray, variegated dark
				yellowish orange
	4.0-7.0	split spoon	4	Sand, fine-course grain, light gray, variegated moderate red
	7.0-10.0	split spoon	3	Clay, light gray, variegated moderate reddish brown
	10.0-13.0	split spoon	6	Clay, light gray, variegated moderate reddish brown
FBFDBG-05	0.0-1.0	shovel	10	Clay, variegated moderate reddish brown
	1.0-4.0	split spoon	4	Sand, fine grain, moderate yellowish brown
	4.0-7.0	split spoon	7.5	Sand, poorly sorted, dark yellowish orange
	7.0-10.0	split spoon	6.8	Clay, dark yellowish orange
	10.0-13.0	split spoon	7	Sand, very light gray, reddish brown

Table 2-2. Fire Department Hose Training Facility Soil Boring Sampling Data

Location	Sample Interval (ft)	Sample Method	H-Nu Headspace Reading (ppm)	Dominant Lithology
FDTF-01	0.0-1.0	shovel	2.2	Clay, some gravel, moderate reddish brown
	1.0-4.0	split spoon	10	Clay, moderate reddish brown
	4.0-7.0	split spoon	11	Clay, light gray, variegated dark red
	7.0-10.0	split spoon	2	Clay, light gray, variegated dark reddish brown
	10.0-13.0	split spoon	2.5	Clay, light gray, pale red purple
FDTF-02	0.0-1.0	shovel	10	Clay, moderate reddish brown
	1.0-4.0	split spoon	10	Clay, reddish brown
	4.0-7.0	split spoon	4	Clay, light gray, variegated pale red purple
	7.0-10.0	split spoon	1	Clay, light gray, variegated moderate reddish brown
	10.0-13.0	split spoon	1	Clay, very light gray, variegated moderate red
FDTF-03	0.0-1.0	split spoon	1.75	Topsoil, sand, medium-course grain, some gravel and
				asphalt, yellowish orange
	1.0-4.0	split spoon	1.75	Sand, moderately graded, moderate reddish brown
	4.0-7.0	split spoon	7	Clay, light gray, pale reddish purple
	7.0-10.0	split spoon	7.5	Sand, course grain, light gray, moderate reddish brown
	10.0-14.0	split spoon	4	Clay, light gray, variegated pale reddish purple
FDTF-04	0.0-1.0	split spoon	0	Sand, moderatly graded, gravel, moderate yellowish brown
	1.0-4.0	split spoon	2	Clay, moderate reddish brown
	4.0-7.0	split spoon	2	Clay, light gray, variegated moderate reddish brown
	7.0-10.0	split spoon	2	Clay, light gray, variegated moderate reddish brown
	10.0-13.0	split spoon	4	Clay, light gray, variegated moderate reddish brown
FDTF-05	0.0-1.0	shovel	1.5	Clay, pale yellowish brown
	1.0-4.0	split spoon	1.5	Clay, moderate reddish brown
	4.0-7.0	split spoon	2.5	Clay, light gray, variegated moderate reddish brown
	7.0-10.0	split spoon	3	Clay, light gray, variegated moderate reddish brown
	10.0-13.0	split spoon	0.5	Clay, light gray, variegated moderate reddish brown

3.0 PHYSICAL CHARACTERIZATION OF THE STUDY AREA

3.1 Surface Features

The Fire Department Hose Training Facility (FDTF) is located on a flat interfluvial area approximately equidistant from Pen Branch to southeast and Fourmile Branch to the northwest (Figure 3-1). Ground elevations in the vicinity of the FDTF range from 88 to 91 m (290 to 300 ft) above mean sea level (msl) (Figure 3-2). The terrain is essentially level and grassy with a few mature trees.

3.2 Meteorology

The Savannah River Site (SRS) region has a temperate climate with short, mild winters and long, humid summers. The region is subject to continental influences, but is protected from the more severe winters in the Tennessee Valley by the Appalachian Mountains to the north and northwest; it is often influenced by warm, moist maritime air masses throughout the year. Gently rolling hills with no unusual topographic features that would significantly influence the general climate characterize the unit and the surrounding area.

The annual average temperature at SRS is 18°C (65°F). The average annual precipitation at SRS is 122 cm (48 in.) and is distributed fairly evenly throughout the year. The greatest observed rainfall for a 24-hour period was about 50 cm (19.6 in.) in October 1990.

Additional details concerning climatology and meteorology of SRS can be found in the Site Characteristics chapter of the Safety Analysis Report for SRS (WSRC, 1995).

3.3 Surface Water Hydrology

The FDTF is in the Fourmile Branch watershed (Figure 3-1). There are no surface waters present near the unit, but a small wet weather conveyance northwest of the unit runs in a northerly direction. An unnamed tributary of Fourmile Branch is located approximately 460 m (1,500 ft) to the north, northeast of the FDTF (Figure 3-2).

3.4 Unit Soils

Soils in the vicinity of the FDTF are shown in Figure 3-3. The soils in the immediate area of the units have been identified as Udorthents with friable substratum (Uo) and Dothan sands (DoB). The Soil Conservation Service (SCS) (1990) has described Udorthents as well-drained soils formed in heterogeneous materials that are derived as spoil or refuse from excavations and major construction operations. SCS (1990) described Dothan sands as well-drained soils found on the broad ridge tops and smooth side slopes of the Coastal Plain and in areas intermingled with the Sand Hills. In the Dothan sands, a perched water table may be present 0.9 to 1.5 m (3 to 5 ft) below ground surface (bgs) for brief periods in winter and early spring.

Soils in the general vicinity of the FDTF are Ogeechee sand loam ponded (Og) and Udorthents, firm substratum (Ud). The Ogeechee is described as poorly drained soil found in low upland depressions and in low areas along stream terraces of the Coastal Plain. The Udorthents are classified as firm substratum, well-drained soils usually associated with borrow pits and areas compacted by traffic.

3.5 Geology

3.5.1 Regional Geology

The Phase I Remedial Investigation Plan for the Ford Building Waste Site (WSRC, 1992) provides a description of the regional and N Area geology. This site is located approximately 120 m (400 ft) to the west of the FDTF, and both units have essentially the same geology. Fallaw and Price (1995) have since revised the stratigraphic nomenclature for the SRS. Figure 3-4 is a comparison of current and previous stratigraphic nomenclature used at the SRS.

3.5.2 Unit-Specific Geology

During field operations, the soil borings from the background locations and from locations within the FDTF were described in the field activities report (WSRC, 1996a). The surface soils included clay and gravel. From 5 to 30 cm (2 to 12 in.) bgs to a depth of approximately 1.2 m (4 ft) bgs, the dominant lithology was a moderate reddish brown (10R4/6) clay with 30 to 40 percent graded sand layers. In most borings, the soils below 1.2 m (4 ft) bgs were described as variegated light gray (N7) and reddish brown (10R4/6) clay with 10 to 30 percent sand. In

boring FDTF-05, this soil type was encountered at approximately 2 m (7 ft) bgs. In boring FDTF-03, a clayey sand predominated from 25 cm (10 in.) to approximately 2 m (7 ft) bgs. From approximately 2 to 2.7 m (7 to 9 ft) bgs a layer of light gray (N7) moderate reddish brown, coarse-grained sand was present. These soil types extended beyond the base of the borings, which were terminated between 4.0 and 4.3 m (13 and 14 ft) bgs.

The soil borings for the background locations (FBFDBG-01, -03, and -05) were dominantly fine to medium grained sands and clayey sands. These soils extended from the ground surface to beyond the base of the borings at 4 m (13 ft) bgs. The sand was moderate yellowish brown (10YR 5/4), moderate reddish brown (10R 4/6) and dark yellowish orange (10YR 6/6). These soils also occurred in background borings FBFDBG-02 and -04 from the ground surface to a depth of 2 m (7 ft) bgs. Below this depth a clay layer was encountered. The clay was described as light gray, variegated with moderate reddish brown (10R 4/6), and very dense. The clay layer continued below the base of borings FBFDBG-02 and -04, which terminated at 4 m (13 ft) bgs. More complete descriptions of the unit and background soil borings are included in Section 2.3 and the field activities report (WSRC, 1996a). These soils are likely part of the Altamaha Formation.

In 1989, a corehole (CPC-1) was drilled in N Area to a depth of 330 m (1,095 ft) bgs (Figure 3-5). The geology of the area is represented in the continuous core taken at that time, which is illustrated in Figure 3-6. The nomenclature shown on this figure has been superseded by that presented in Figure 3-4. A generalized lithostratigraphic column for the central SRS area is shown in Figure 3-7.

3.6 Hydrogeology

3.6.1 Regional Hydrogeology

The SRS is located within the Southeastern Coastal Plain hydrogeological province in west-central South Carolina. The hydrogeological province comprises a multilayered hydraulic complex in which retarding beds are interspersed with more permeable beds. Regional hydrogeology is discussed in Aadland et al. (1995). A description of the hydrogeology beneath N Area and near the FDTF can be found in the Phase I Remedial Investigation Plan for the Ford Building Waste Site (WSRC, 1992).

3.6.2 Unit-Specific Hydrogeology

Because past groundwater monitoring in the vicinity of the FDTF indicated previous activities at the facility did not impact groundwater, a hydrogeological investigation was not conducted during the unit characterization; therefore, the following discussion of the hydrogeology beneath the FDTF is limited. On July 1 and 2, 1996 the water levels were measured in monitoring wells throughout N Area (Table 3-1). As indicated in the table, the groundwater level in the two wells, CSO 001 and CSO 002, near the FDTF is at an elevation of 77.755 m (255.1 ft) and 77.846 m (255.4 ft) , respectively, which is 14.295 m (46.9 ft) and 13.503 m (44.3 ft) below the ground surface. Figure 3-8 shows the elevation of the water table beneath N Area at that time. The groundwater flow direction is to the southwest.

The Upper Three Runs Aquifer consists of the water-bearing sediment from the water table to the top of the Gordon confining unit (Figure 3-7). The Upper Three Runs Aquifer generally demonstrates lower transmissivity values than the underlying Gordon Aquifer (Aadland et al., 1995). In the central SRS, the "tan clay" confining zone separates the Upper Three Runs Aquifer into the "upper" and "lower" aquifer zones (Figure 3-7) (Aadland et al., 1995).

3.6.2.1 "Upper" Aquifer Zone of the Upper Three Runs Aquifer (Water Table Aquifer)

The "upper" aquifer zone of the Upper Three Runs Aquifer includes the water-bearing sediment assigned to the Altamaha Formation, Tobacco Road Sand and upper part of the Dry Branch Formation (Figure 3-7). The "upper" aquifer zone includes the material below the water table and above the "tan clay" confining zone. The overall transmissivity of this part of the unit is somewhat less than the "lower" aquifer zone due to the relatively large amounts of interbedded and interstitial silt and clay (Aadland et al., 1995).

3.6.2.2 "Tan Clay" Confining Zone of the Upper Three Runs Aquifer

Beneath N Area, the "tan clay" confining zone is located at a depth of approximately 37 to 40 m (120 to 130 ft) (Figure 3-6). The "tan clay" confining zone separates the Upper Three Runs Aquifer into the "upper" and "lower" aquifer zones (Figure 3-7).

3.6.2.3 "Lower" Aquifer Zone of the Upper Three Runs Aquifer

The "lower" aquifer zone of the Upper Three Runs Aquifer includes the water-bearing sediment from the base of the "tan clay" confining zone to the top of the Gordon confining unit. Lithologic variations within the "lower" aquifer zone commonly result in significant vertical variations in transmissivity (Aadland et al., 1995). The "lower" aquifer zone is therefore commonly differentiated by upper and lower parts for the purposes of designing well screens.

3.6.2.4 Gordon Confining Unit

The Gordon confining unit separates the Upper Three Runs Aquifer from the Gordon Aquifer across much of the SRS region. The Gordon confining unit consists of an interval of clayey sand and clay. Boundaries between the Upper Three Runs and Gordon Aquifers are defined by the vertical extent of the confining units. A confining unit is differentiated from an aquifer by a relative increase in silt and clay content that is consistent over a large area. The hydrogeologic changes do not always correspond with boundaries between stratigraphic units. Geologic formations therefore remain implicit in the hydrostratigraphy.

3.7 Demography and Land Use

3.7.1 Demographics

SRS is located approximately 40 km (25 mi) southeast of Augusta, Georgia, and 32 km (20 mi) south of Aiken, South Carolina. According to 1990 census data, the average population densities (in people per square mile) for the surrounding South Carolina counties are 111 for Aiken County, 36 for Barnwell County, and 28 for Allendale County. For the surrounding Georgia counties, the densities are 228 for Columbia County, 524 for Richmond County, 25 for Burke County and 21 for Screven County. The population within an 80 km (50 mi) radius of SRS is 634,784 people.

The estimated population for the area in the year 2000 is projected to be 852,000. This estimate was calculated utilizing the 1970 to 1980 growth rate of each county in an 80 km (50 mi) radius, assuming that the same rate of growth would continue into the future. The calculation assumed that the population would remain constant for counties that experienced a negative population growth between 1970 and 1980.

Additional details on demography can be found in the Site Characteristics chapter of the Safety Analysis Report for SRS (WSRC, 1995).

3.7.2 Land Use

The Savannah River Site Future Use Project Report (DOE, 1996) presents SRS stakeholder-preferred future use recommendations. This report recommends that the FDTF area be designated for future industrial use.

General public access to SRS is prohibited, with access limited by guards and security fences. Access to the FDTF area is by a road. The area is not fenced and is not routinely mowed. Monitoring wells in the area are sampled periodically.

Less than 5 percent of the existing land in the area surrounding SRS is devoted to urban and developed uses (DOE, 1990). Most of the urbanized development in the area has occurred in and around the cities of Augusta, Georgia, and Aiken, South Carolina. Agriculture accounts for 24 percent of total land use; forests, wetlands, water bodies, and unclassified land that is predominantly rural accounts for about 70 percent of the total land use. A projected 2 percent increase in the development of urban land surrounding SRS is expected by the year 2000.

Less than 5 percent of the total SRS land area is used by facilities engaged in the production of special nuclear materials. Reservoirs and ponds comprise approximately 13 km^2 (5 mi^2) of SRS. The remainder of the more than 780 km^2 (300 mi^2) is comprised of natural vegetation and pine plantations. The proposed future land use for the SRS is expected to remain industrial.

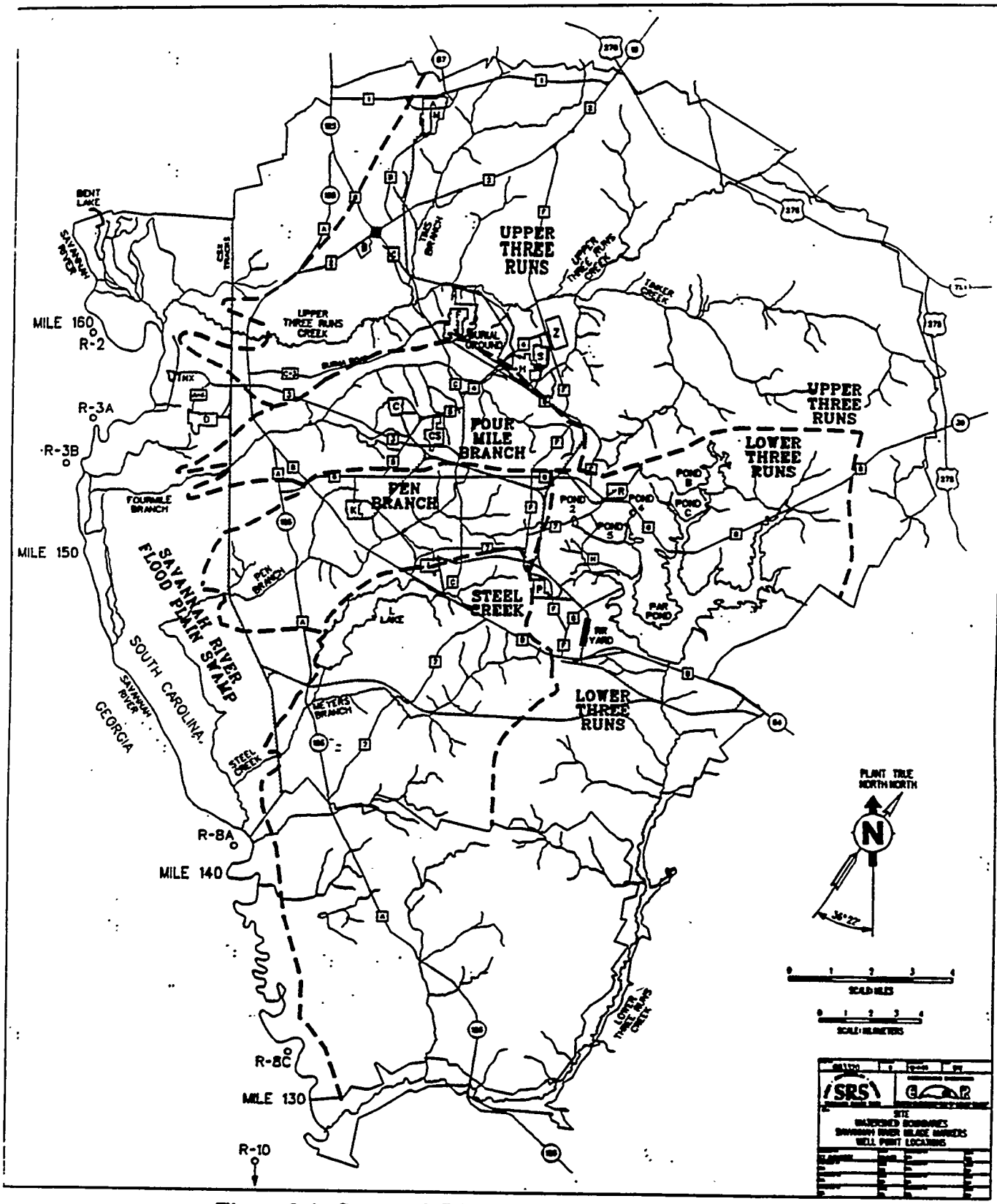


Figure 3-1. Savannah River Site Watershed Boundaries

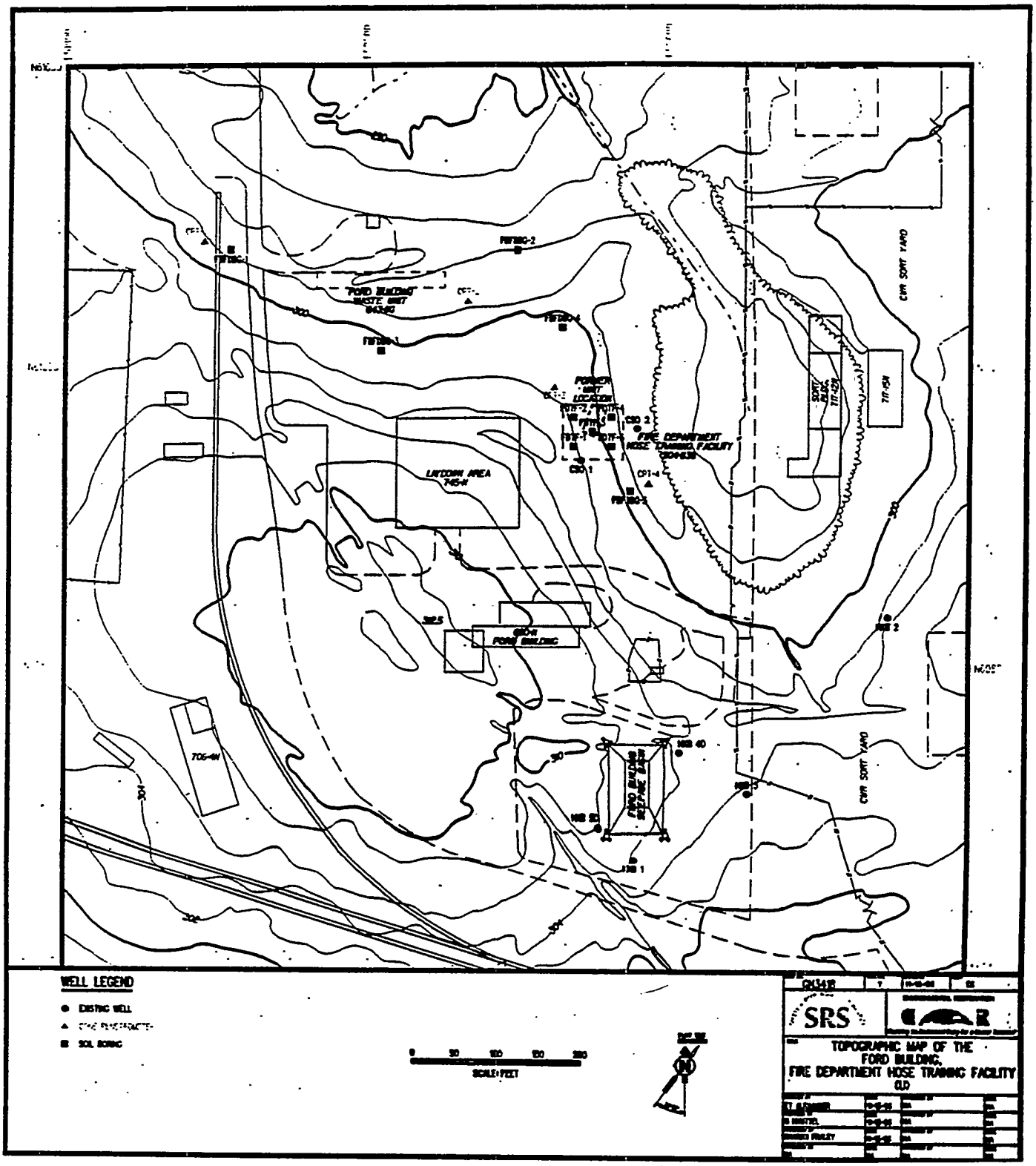


Figure 3-2. Topographic Map of the Fire Department Training Facility

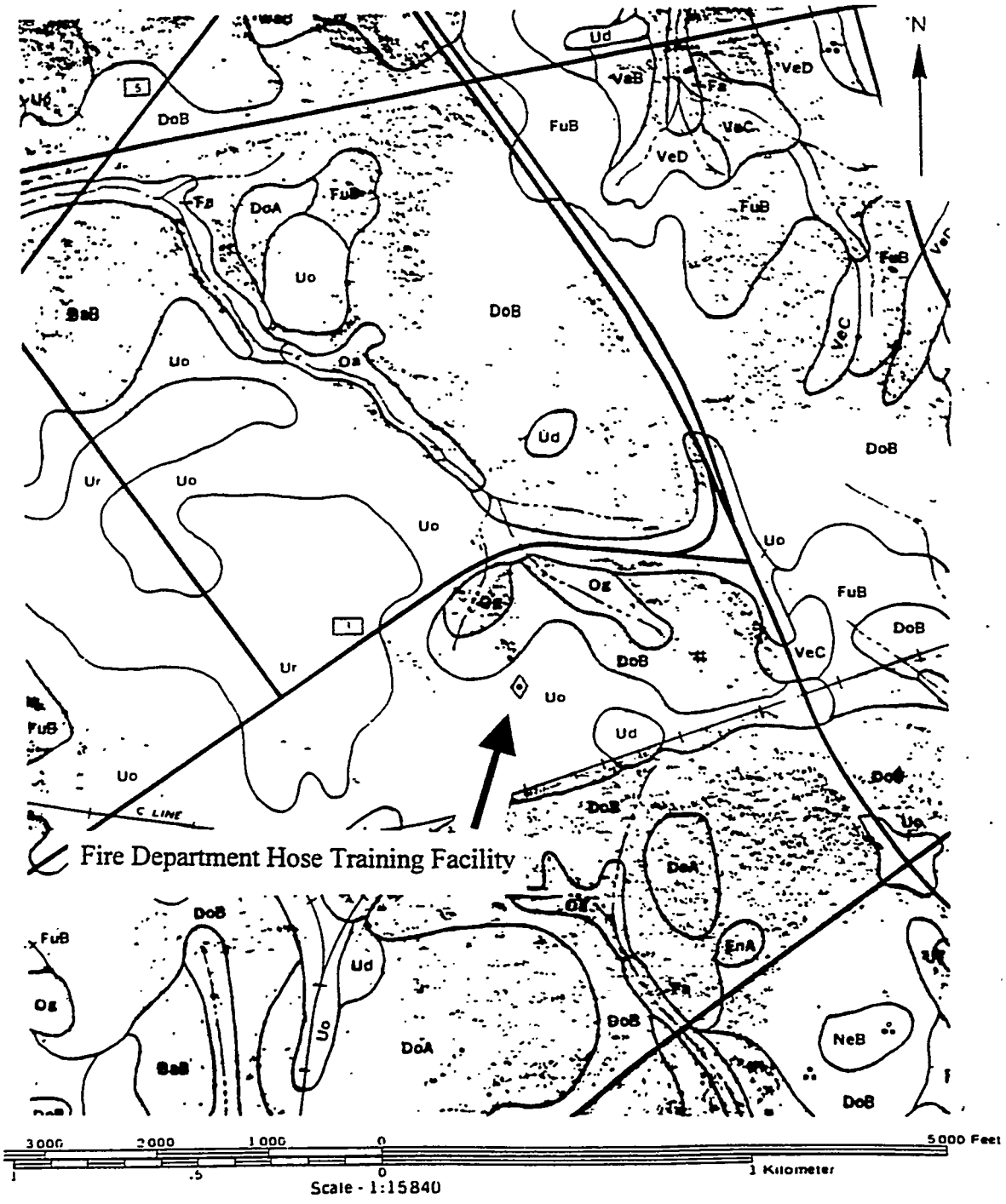


Figure 3-3. Map of Soils at FDTF

CHRONOSTRATIGRAPHIC UNITS		LITHOSTRATIGRAPHIC UNITS (Price et al., 1988)		LITHOSTRATIGRAPHIC UNITS (Fallaw and Price, 1995)	
System	Series	Group	Formation	Group	Formation
Miocene		Burnwell Group	"Upland Unit"		Altamaha Formation
Eocene	Upper		Tobacco Road Formation		Tobacco Road Sand
			Dry Branch Formation: Irwinton Sand Member, Twiggs Clay Member, Griffins Landing Member		Dry Branch Formation: Irwinton Sand Member, Griffins Landing Member
			Clinchfield Formation		Clinchfield Formation: Albion Member, "Orangeburg District Bed", Riggins Mill Member, Utley Limestone Member
	Middle	Orangeburg Group	Santee Formation: Median Member, Cau Cau Member		Tinker Formation: Santee Limestone, "Blue Bluff Unit"
			Warley Hill Formation		Warley Hill Formation
			Congaree Formation		Congaree Formation
	Lower	Black Mingo Group	Fishburne Fm., Fourmile Member		Fourmile Branch Formation
Paleocene	Upper		Williamsburg Fm., Snapp Member		Snapp Formation
	Lower		Ellenton Formation		Lang Syne Formation
					Sawdust Landing Formation
Cretaceous	Upper	Lumbee Group	Peedee Formation, Steel Creek Member		Steel Creek Formation
			Black Creek Formation		Black Creek Group
			Middendorf Formation		Middendorf Formation
			Cape Fear Formation		Cape Fear Formation
Triassic		Newark Supergroup	Sedimentary Rock (Dunbarton Basin)	Newark Supergroup	Sedimentary Rock (Dunbarton Basin)
Precambrian			Crystalline Basement Rock		Crystalline Basement Rock

Figure 3-4: Lithostratigraphic Nomenclature Used at SRS

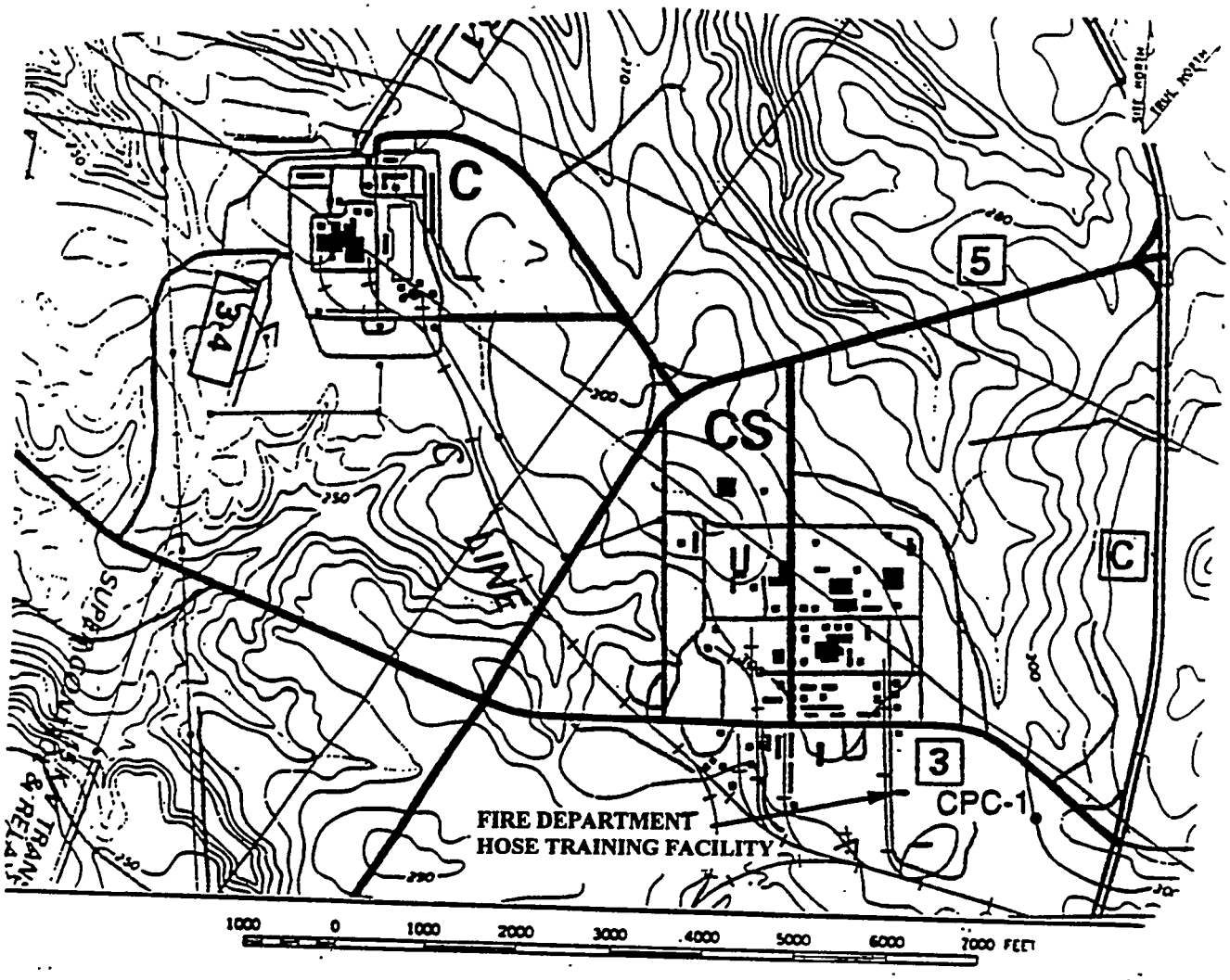


Figure 3-5. Location of Corehole CPC-1

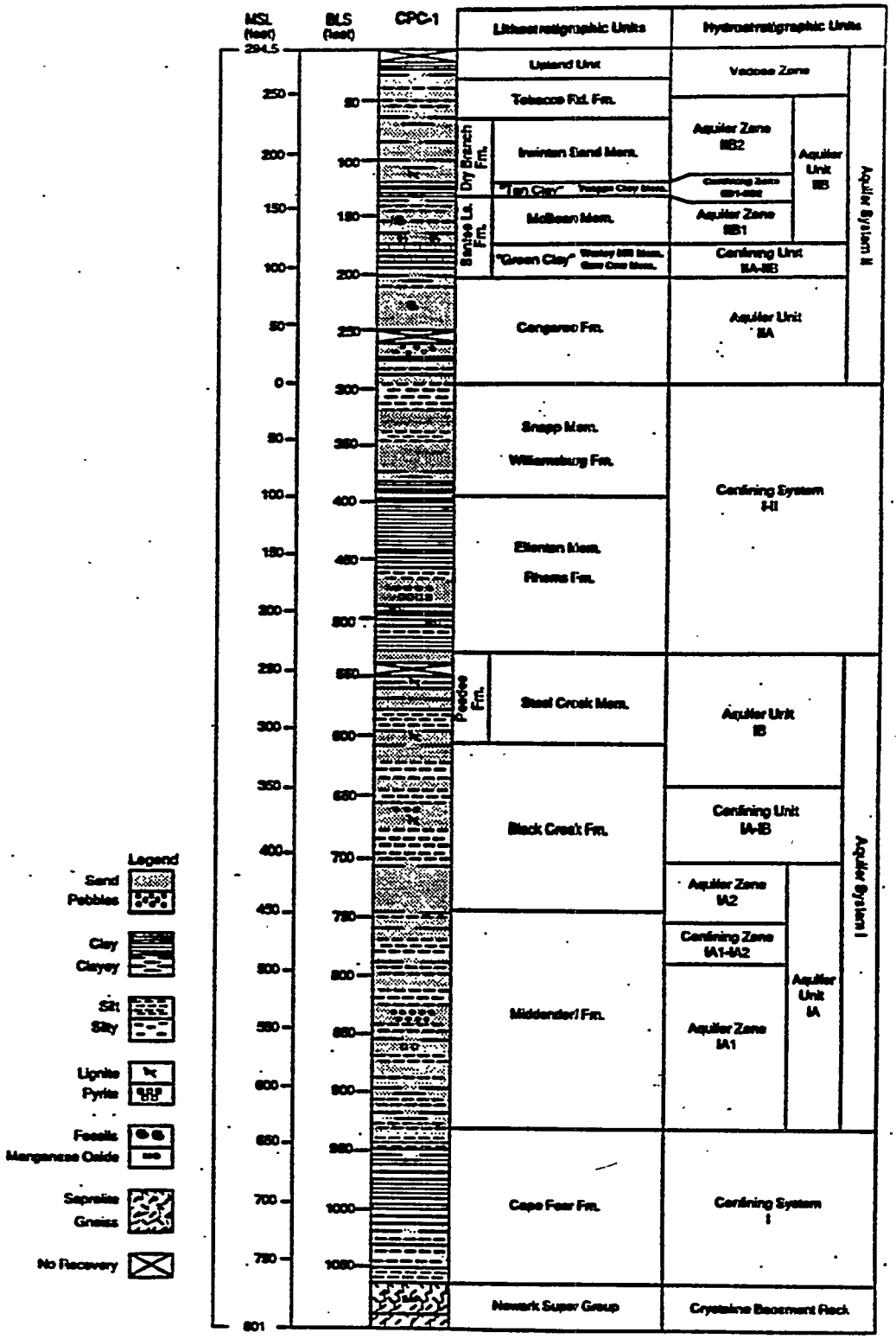


Figure 3-6. Corehole CPC-1 Lithology with the Hydrostratigraphy and Lithostratigraphic Units (Price et al., 1988)

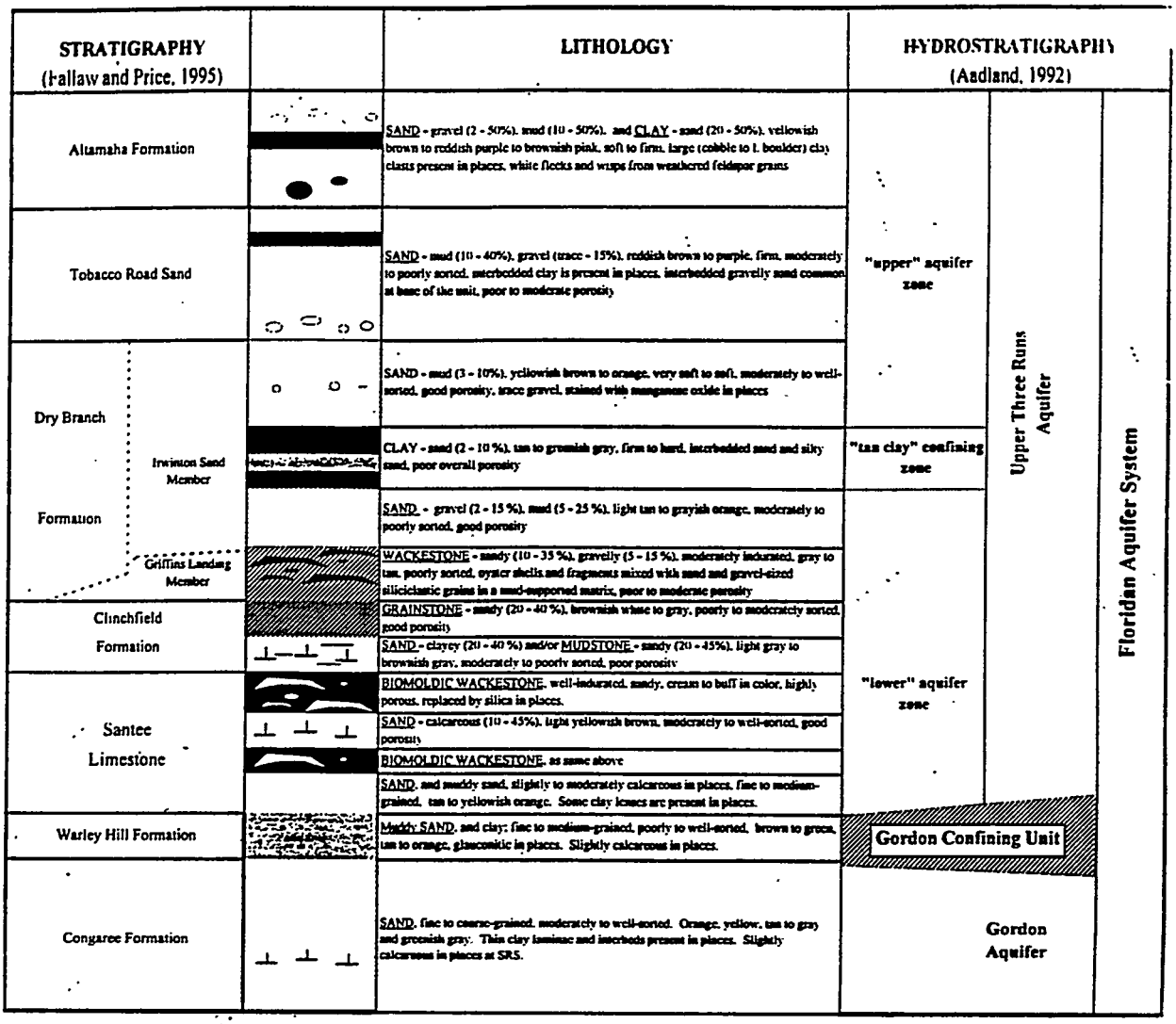


Figure 3-7. Generalized Lithostratigraphic Column for the Central SRS Area

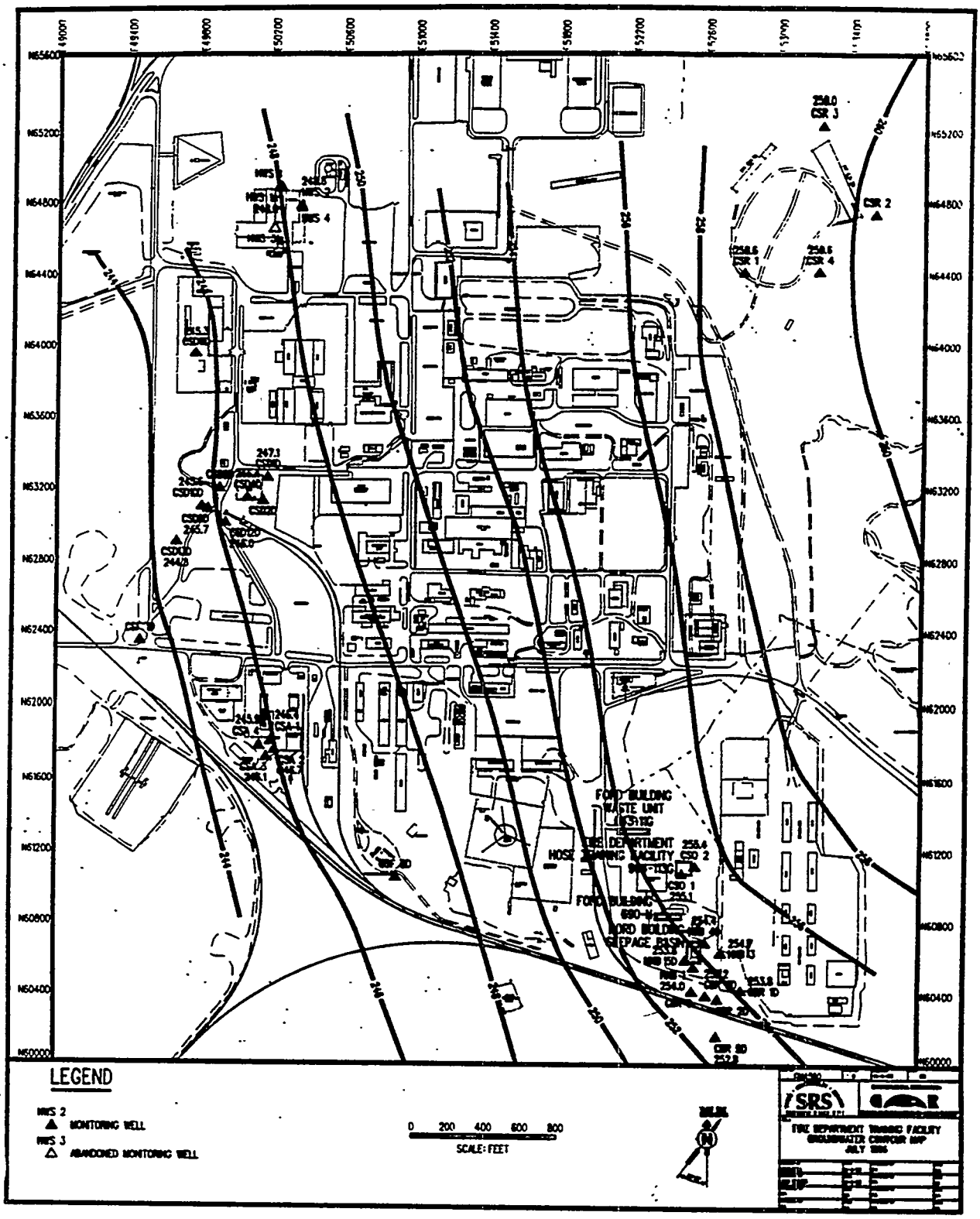


Figure 3-8. Water Table Map for the FDTF

Table 3-1. 1996 Static Water Level Measurements for Central Shops Area

Well ID			Elevation (ft MSL)			Depth to Water (ft)*	WL Measured Time-Day	Elevation WL (ft)	Comments
ID	NO	SUB	Ground	TOC	TOS				
CBR	001	D	298 5	300 6	300 8	47 04	1038-07/01/96	253 8	
CBR	002		ND	ND	ND	NT			Could not locate well (probably abandoned)
CBR	002	D	298 8	300 9	301 2	56 08	1019-07/01/96	245 1	
CBR	003		299 6	301 8	302 0	48 81	1022-07/01/96	253.2	
CBR	004		293 4	295 8	ND	NT			Probe blocked at 39 64' below TOC
CBR	005		293 3	295 9	ND	43 06	1506-07/01/96	252.8	Measured from TOC
CBR	006		301 4	303 9	ND	41 11	1521-07/01/96	262 8	Measured from TOC--No label on well
CSA	001		289 0	290 8	290 9	44.55	0920-07/02/96	246 4	
CSA	002		288 2	290 1	290.2	43.51	0923-07/02/96	246.7	
CSA	003		287 6	289 4	289.5	43 41	0925-07/02/96	246.1	
CSA	004		288 4	290 4	290.5	44.58	0912-07/02/96	245.9	
CSD	001	D	313 4	315 4	ND	68.26	1710-07/01/96	247.1	Measured from TOC
CSD	002	D	308 8	310.8	311.1	NT			Could not open lock on wellhead
CSD	004	D	306 5	308 5	308.7	62.32	1701-07/01/96	246.4	
CSD	008	D	301 8	303.9	304.1	NT			Purge water containment required
CSD	009	D	296.2	298.2	298.4	52.75	1643-07/01/96	245.7	
CSD	010	D	294 5	296.6	296.9	51.35	1647-07/01/96	245.6	
CSD	011	D	290 9	293.0	293.3	47.97	1636-07/01/96	245.3	
CSD	012	D	299.5	301.6	301.8	55.82	1652-07/01/96	246.0	
CSD	013	D	287 4	289.5	289.6	44.85	1632-07/01/96	244.8	
CSO	001		302 0	303.9	304.0	48.88	1121-07/02/96	255.1	
CSO	002		299.7	301.9	302.1	46.74	1118-07/02/96	255.4	
CSR	001		272.2	274.1	274.2	15.57	1030-07/02/96	258.6	
CSR	002		295.5	297.7	297.8	NT	1023-07/02/96		Probe blocked at 20.15' below TOS
CSR	003		283.1	285.2	285.7	26.68	1019-07/02/96	259.0	
CSR	004		282 6	284.7	284.8	25.25	1027-07/02/96	259.6	
HWS	001		323.2	325.2	ND	NT			Could not locate well (possibly abandoned?)
HWS	001	A	323 2	324.6	324.7	76.71	0950-07/02/96	248.0	
HWS	002		320 3	323.2	323.4	74.62	0942-07/02/96	248.8	
HWS	003		323 5	323.5	ND	NT			Abandoned
HWS	004		ND	ND	ND	NT			Listed as "unknown well"--Could not locate
HXB	001		304.2	306.2	306.5	52.55	1114-07/02/96	254.0	
HXB	002		302.1	304.4	304.6	NT	1051-07/02/96		Probe would not fit into standpipe
HXB	003		302.2	304.2	304 4	49.68	1059-07/02/96	254.7	
HXB	004	D	304 4	307 0	307 1	52.68	1350-07/01/96	254.4	
HXB	005	D	306 2	308 8	309 0	55.23	1048-07/01/96	253.8	
PW	071	N	290 0	292.8	ND	NT			Could not get water level with 300' tape
PW	072	N	312 9	315.4	ND	NT			Abandoned
PW	083	N	294 0	ND	ND	NT			Could not get water level with 300' tape
CSF	001	D	ND	ND	ND	51.97	1623-07/01/96		No well construction data available

*Except where noted, all water level measurements were taken with respect to the Top of Standpipe
TOC = Top of Casing
TOS = Top of Standpipe
ND = No Data
NT = Water level for the well was not taken

NOTE:
Well CBR-2 was listed in the well inventory as having grout contamination problems and was scheduled for abandonment
Wells CBR-4D and CBR-6 were improperly identified (transposed) on the map provided for N-Area.
Well CSD-11D was improperly located on the map provided for N-Area.
Well HWS-1 was unable to be located at the Haz Waste Facility It may have been abandoned when HWS-1A was installed
Well HWS-4 is listed in the well inventory as an "unknown well" It was unable to be located during this series of water level measurements

(This page intentionally left blank)

4.0 NATURE AND EXTENT OF CONTAMINATION/UNIT ASSESSMENT INVESTIGATION RESULTS

This section illustrates, tabulates, and interprets the type and horizontal and vertical extent of contaminants resulting from training exercises at the Fire Department Hose Training Facility (FDTF). The assessment is presented in the context of the Conceptual Site Model (CSM) (Figure 2-1).

A single exposure unit has been identified in the Baseline Risk Assessment (BRA) (Section 6.0). Data for this exposure unit are grouped by primary source and secondary source. Each source is further categorized by type of contaminant as follows: (1) metals, (2) volatile organic compounds (VOCs), (3) semivolatile organic compounds (SVOCs), (4) pesticides/polychlorinated biphenyls (PCBs)/dioxins/furans, and (5) radionuclide indicators.

The FDTF (904-113G) is comprised of a single unit with no associated ditches or drainage areas. The primary source of contamination identified in the CSM was the material used during past training activities at this unit. Through deposition and infiltration/percolation of the primary source, surface and subsurface soils in the unit may have become initially impacted media. These primary media may then have become secondary sources. Through secondary release mechanisms, air, surface and subsurface soils, biota, and groundwater may become potential exposure pathways to human and ecological receptors. Records indicate that the primary source has been removed from the unit. Groundwater monitoring data collected from wells in the vicinity of the unit do not indicate that the unit has impacted groundwater. Biota and air exposure pathways are typically estimated utilizing surface soil data. Therefore, only surface and subsurface soils at the FDTF were evaluated.

Through these evaluations, the quantities of constituents released via each secondary release mechanism can be estimated. For example, surface soil samples could be used to estimate the volatilization of organic constituents, the concentration of constituents in fugitive dust, the potential for biotic uptake, and the constituents available for transport via direct contact. Surface and subsurface soil sample data could be used to evaluate the potential for transporting constituents to groundwater.

Soil samples were collected from five soil borings within the FDTF unit. Each boring was sampled over five depth intervals for a total of 25 unit samples (Table 4-1). In addition, five samples were taken from each of the five background borings located in the vicinity of the FDTF (Figure 2-2). Samples were analyzed for Target Compound List (TCL) volatiles, semivolatiles, pesticides/PCBs, Target Analyte List (TAL) inorganics, and the radionuclide indicators gross alpha, nonvolatile beta, and gamma spectroscopy. Results of the soil samples collected for this project are discussed in the following section.

The analytical soil data for the 1996 investigation were compared to Environmental Protection Agency (EPA) Region III residential risk-based concentrations (RBCs) and to two times (2X) the corresponding unit-specific average background concentrations as an initial screening (Table 4-2). Constituents not present in detectable quantities in any soil sample are shown in Table 4-3. The results of the screenings and the summary statistics are presented in a series of tables (Tables 4-4, 4-5, and 4-6). Table 4-7 shows the summary for the FDTF soil intervals from 0 to 0.3 m (0 to 1 ft), 0 to 1.2 m (0 to 4 ft), 1.2 to 2.1 m (4 to 7 ft), 2.1 to 3.1 m (7 to 10 ft), 3.1 to 4.0 m (10 to 13 ft), and 3.1 to 4.3 m (10 to 14 ft). Constituents that exceeded both the RBC and the 2X average background concentration criteria were retained as unit specific contaminants (USCs). If an RBC has not been established for a constituent, then it is considered a USC if its maximum concentration exceeds twice the average background concentration. Figures 4-1 and 4-2 are schematic cross-sections which depict the distribution of various USCs in the soil column.

4.1 Background Investigation Results

Background soil samples were collected from five boring locations (FBFDBG-01 through FBFDBG-05) in order to determine unit specific background soil concentrations. Samples were collected from five depth intervals, as follows: 0.0 to 0.3 m (0 to 1 ft), 0.3 to 1.2 m (1 to 4 ft), 1.2 to 2.1 m (4 to 7 ft), 2.1 to 3.1 m (7 to 10 ft), and 3.1 to 4.0 m (10 to 13 ft).

Unit specific background values were computed over three depth intervals that complemented the sampling strategy of the associated unit. Surface soil background concentrations were determined for the 0 to 0.3 m (0 to 1 ft) interval. This value was used to screen soil data for the human health risk assessment for current exposure scenarios and for the ecological risk assessment.

Subsurface background concentrations correspond to the interval from 0 to 1.2 m (0 to 4 ft) and were used to determine the human health risk and ecological risk for future land use. These concentrations were computed using the data from the first two sampling intervals at each of the five background soil sampling locations.

Unit-specific background soil concentrations for deep soil were calculated at depths greater than 1.2 m (4 ft) to support the evaluation of the nature and extent of contamination. The measured concentrations from 1.2 to 4 m (4 to 13 ft) were averaged to calculate a mean background concentration for these intervals. The background concentrations presented in Table 4-2 represent the mean of all results from each of the background locations for the surface, subsurface, and deep soil.

4.2 Primary Source Investigation Results

The FDTF was used from 1979 to 1982 as an area to extinguish oil fires for fire department training exercises. During this time, the unit consisted of a shallow, unlined pit which measured approximately 6 m by 12 m (20 ft by 40 ft) and was surrounded by a 45 cm (18 in) high asphalt dike. No known hazardous or radioactive wastes were placed in the unit.

The primary sources of contamination at FDTF are the oils and associated fuels burned at the facility. According to site records, approximately 0.3 m (1 ft) of soil from the pit bottom, the asphalt dike, and other visibly contaminated soils in the vicinity of the pit were excavated in 1982, and the pit was returned to grade with clean fill. A second soil removal activity was documented in 1985 (discussed in Section 1.3.1).

4.2.1 Soil Data Presentation and Interpretation in the FDTF

Information and data obtained during the field characterization activity are consistent with historical information about past activities at this location. No saturated soil, separate phases, or sludge were observed on the surface or encountered in any of the borings in the unit. The analytical data collected from the borings provide further evidence that there is no longer a primary source at this unit. Volatile and semivolatile compounds were detected in only one of five samples in the interval from 0.0 to 0.3 m (0 to 1 ft) and in fewer than two of 10 samples in the interval from 0.0 to 1.2 m (0 to 4 ft) (Tables 4-4 and 4-5). Of these, only the SVOCs benzo(a)pyrene and benzo(g,h,i)perylene were detected above screening levels. These polycyclic

aromatic hydrocarbons are a major constituent of asphalt and can be attributed to bits of asphalt remaining after the dike was removed. Volatile and semivolatile compounds were also detected in the sampling intervals greater than 1.2 m (4 ft); however, each was detected in fewer than eight of 15 samples and at low concentrations (Table 4-6). None of these compounds was detected in the interval between 0.3 and 1.2 m (1 to 4 ft). The paucity of VOCs detected in the unit borings suggests that the primary source was successfully removed from the unit and that only secondary sources remain.

4.2.2 Primary Source Uncertainty

No physical or analytical evidence indicates the presence of any source material at FDTF. Samples collected from the five boring locations should adequately describe the conditions across the unit. Borings were placed in areas where visibly contaminated soil was previously identified, and intervals where contamination was detected in previous investigations were resampled.

According to the Quality Control Summary Report (QCSR) for the N-Area Ford Building Waste Unit (WSRC, 1996b), one of the 25 samples collected for the FDTF was flagged for questionable data. Headspace was present in a VOC sample collected from 3.1 to 4.0 m (10 to 13 ft) due to difficulty in packing the hard soil in the sample jars. Volatiles which may have been present would have dissipated once the sample container was opened, biasing the data toward lower concentrations. Although the validity of this data is uncertain, the lack of significant volatile constituents in the overlying or adjacent intervals suggests that low VOC concentrations would be anticipated. Because the sampling problem involved only one VOC sample, the results of the data for the other analyses conducted for this sample were not affected.

4.3 Secondary Source Investigation Results

Four borings were placed along the FDTF perimeter and one boring was placed in the center of the unit for a total five soil borings. These borings were located along the unit boundaries delineated during the 1986 investigation, and in areas where surface soil contamination was previously identified.

4.3.1. Surface Soil (0 to 0.3 M) Data Presentation and Interpretation

The analysis of the baseline risk to humans and ecological receptors considers two intervals: 0 to 0.3 m (0 to 1 ft) and 0 to 1.2 m (0 to 4 ft). The surface soil sampled from 0 to 0.3 m (0 to 1 ft) at each of the five locations at FDTF is discussed below (Tables 4-4 and 4-7).

4.3.1.1 Metals/Inorganics

Manganese was the only metal identified as a USC in the surface soils at FDTF. Manganese was detected in each of the soil borings. Concentrations ranged from 28 mg/kg in boring FDTF-03 to 65.3 mg/kg in boring FDTF-04. Of the five samples, only the sample from FDTF-04 exceeded the sample screening criteria.

4.3.1.2 SVOCs

Two SVOCs, benzo(a)pyrene and benzo(g,h,i)perylene, were retained as potential USCs in surface soils at the unit. These compounds were detected in one boring, FDTF-01, at concentrations of 144 µg/kg and 121 µg/kg, respectively (Figure 4-1). These samples were obtained in the area where pieces of asphalt have been identified (WSRC, 1996a). The SVOCs may be attributed to these bits of asphalt material.

4.3.1.3 VOCs

No VOCs were identified as USCs in surface soils at FDTF (Table 4-4).

4.3.1.4 Pesticides/PCBs/Dioxins/Furans

No pesticides/PCBs, dioxins, or furans were retained as USCs for surface soils at the unit (Table 4-4).

4.3.1.5 Radionuclides

No radionuclides were retained as USCs for surface soils at the unit (Table 4-4).

4.3.2 Subsurface Soil (0 to 1.2 M) Data Presentation and Interpretation

Subsurface soil is the interval from 0.0 to 1.2 m (0 to 4 ft) and includes the surface soil discussed in Section 4.3.1 and the underlying interval sampled from 0.3 to 1.2 m (1.0 to 4.0 ft). The summary of data at this depth is shown in Table 4-5, and the results for each boring are presented in Table 4-7.

4.3.2.1 Metals

Eight metals were identified as USCs for FDTF subsurface soil: aluminum, arsenic, beryllium, chromium, iron, manganese, sodium, and vanadium. Each of these constituents was detected in at least eight of the 10 samples and exceeded screening levels in at least one soil boring. With the exception of manganese, all exceedances occurred in the interval between 0.3 and 1.2 m (1 to 4 ft).

Aluminum was detected in all 10 samples with concentrations ranging from 1,670 to 12,500 mg/kg. Chromium, iron, and vanadium were also detected in each of the 10 samples with the lowest concentrations for each metal identified in FDTF-04 and maximum concentrations reported in FDTF-02. A comparison of the chromium, iron, and vanadium values across the unit shows that concentrations of these constituents are highly variable. The difference between the maximum and minimum values reported for each metal is at least one order of magnitude. Chromium was detected above screening levels in boring FDTF-02. Aluminum, iron, and vanadium exceeded screening criteria in borings FDTF-02 and FDTF-03, which are located in the northwest and central parts of the unit, respectively. The only other metal detected in each of the 10 samples was sodium. Concentrations of this metal are generally consistent across the unit and are within +/- 30 mg/kg of background. Sodium exceedances were identified in borings FDTF-02, FDTF-03, and FDTF-05.

Arsenic was present in nine of the 10 samples collected for this interval. Concentrations for arsenic range from 1.2 to 7.3 mg/kg, with one exceedance of screening criteria identified in boring FDTF-02. Beryllium was detected in eight samples with values ranging from 0.05 mg/kg in boring FDTF-05 to 0.201 mg/kg in FDTF-03. The only sample in excess of screening levels was collected from boring FDTF-03. Manganese was detected in all of the samples, but was the only metal identified in excess of screening levels in both the 0.0 to 0.3 m (0 to 1 ft) and 0.3 to 1.2 m (1 to 4 ft) intervals. These exceedances were recorded in boring FDTF-04.

In general, no trend was identified across the unit, although a general increase in metal concentrations can be seen with depth (Figure 4-2). This vertical trend is anticipated since the interval from 0.0 to 0.3 m (0 to 1 ft) is comprised of clean fill. Lower concentrations of aluminum, arsenic, beryllium, chromium, sodium, and vanadium were also noted in borings FDTF-04 and FDTF-05, located on the eastern edge of the pit. Metal concentrations in these borings are approximately half those reported for borings in the center and along the western edge of the unit. This may be an artifact of the previous soil removal activities, which targeted areas that exhibited impact.

4.3.2.2 SVOCs

Two SVOCs, benzo(a)pyrene and benzo(g,h,i)perylene, were retained as potential USCs in the 0.0 to 1.2 m (0 to 4 ft) depth interval. These constituents were not detected in samples collected from the 0.3 to 1.2 m (1.0 to 4.0 ft) interval, but were retained because of their presence in the 0.0 to 0.3 m (0.0 to 1 ft) interval in boring FDTF-01.

4.3.2.3 VOCs

No VOCs were identified as USCs for subsurface soils at FDTF (Table 4-5).

4.3.2.4 Pesticides/PCBs/Dioxins/Furans

No constituents in this analytical suite were determined to be USCs in subsurface soil at FDTF (Table 4-5).

4.3.2.5 Radionuclides

No radionuclides were identified as USCs for subsurface soils at FDTF (Table 4-5).

4.3.3 Deep Soil (>1.2 M) Data Presentation and Interpretation

The deep soil interval represents all sample depths greater than 1.2 m (4 ft), and includes 1.2 to 2.1 m (4 to 7 ft), 2.1 to 3.1 m (7 to 10 ft), and 3.1 to 4.3 m (10 to 14 ft). A summary of the analytical data for this interval is shown in Table 4-6. Results for each sampled interval are summarized by boring in Table 4-7.

4.3.3.1 Metals

Seven metals were retained as USCs for this interval at FDTF: aluminum, arsenic, beryllium, chromium, iron, sodium, and vanadium. These results concur with the data from the previous interval, which indicate the presence of these constituents in each of the soil borings. Aluminum concentrations exceeded both screening criteria in all borings except FDTF-05. Concentrations for this metal ranged from 2,960 mg/kg in FDTF-05 to 12,600 mg/kg in FDTF-01. In general, aluminum concentrations decrease with depth within the deep soil interval. However, a comparison of subsurface sample results to the results for the deep soil reveals an increase in concentration in the interval from 1.2 to 2.1 m (4 to 7 ft) in borings FDTF-01, FDTF-04, and FDTF-05 (Table 4-7). Aluminum concentrations in borings FDTF-02 and FDTF-03 are generally consistent with those reported in the preceding interval.

Arsenic, iron, chromium, and vanadium were each present at concentrations at or above the screening criteria in borings FDTF-01 and FDTF-02, with maximum concentrations of 11.1 mg/kg, 76,200 mg/kg, 59.4 mg/kg, and 166 mg/kg, respectively. Iron was also detected above screening levels in FDTF-04 and FDTF-05. Metals concentrations within each sampled interval are generally consistent across the unit, and a comparison of results reveals no distinctive lateral trends. Like aluminum, the concentrations of each of these metals in the interval from 1.2 to 2.1 m (4 to 7 ft) are generally elevated when compared to the subsurface soil interval.

Sodium was identified above screening levels in four of the five borings, with values ranging from 60.6 mg/kg in FDTF-04 to 86.8 mg/kg in FDTF-02. In borings where the concentration was below the screening criteria, reported values ranged from 27.5 mg/kg to 57.3 mg/kg. Beryllium was detected in 11 of 15 samples, and exceeded the screening criteria in samples collected from borings FDTF-01, FDTF-02, FDTF-03, and FDTF-04. Concentrations of this metal ranged from 0.0695 mg/kg in FDTF-05 to 0.201 mg/kg in FDTF-02. Sodium and beryllium concentrations in deep soil samples show little lateral or vertical variability. When compared to the analytical results from the subsurface interval, sodium and beryllium concentrations are generally consistent.

These results concur with data from the subsurface soil interval. With the exception of manganese, each of the metals identified as a USC in the 0.0 to 1.2 m (0 to 4 ft) interval was retained as a USC in this interval and was present in detectable quantities across the unit. The vertical increase in metals concentration from the subsurface soil samples to the samples in the

1.2 to 4.0 m (4 to 7 ft) interval suggests that the samples from the 0.0 to 1.2 m (0 to 4 ft) interval are composed of a mixture of clean fill and contaminated soil (Figure 4-2). The samples from the 1.2 to 4.0 m (4 to 7 ft) interval are probably representative of contaminated soils that were undisturbed during the removal activities. The general decrease in metals concentration with depth and the lack of a discernible lateral trends suggest that metal contaminants have adsorbed to soil particles and been immobilized in the soil environment.

4.3.3.2 SVOCs

No SVOCs were identified as USCs for this interval at FDTF (Table 4-6).

4.3.3.3 VOCs

No VOCs were identified as USCs for this interval at FDTF (Table 4-6).

4.3.3.4 Pesticides/PCBs/Dioxins/Furans

No constituents in this analytical suite were identified as USCs in the deep soil interval at FDTF (Table 4-6).

4.3.3.5 Radionuclides

No radionuclides were determined to be USCs in this interval at FDTF (Table 4-6).

4.3.4 Secondary Source Uncertainty

There is no documented or physical evidence indicating that materials other than burnable oil were applied to the FDTF. Asphalt was the only material identified during field sampling. No oil stained soils or metal debris was observed. The asphalt bits may account for the SVOCs detected in excess of the screening levels in surface soil samples. The potential that surface and subsurface soils are secondary sources for metal contaminants is also not certain. The consistency of the metals concentration across the unit and with depth, particularly in the deeper sampled intervals, suggests that some of the metals detected may be naturally occurring.

As discussed in Section 4.2.3, the greatest uncertainty associated with the data from the deeper soils is the improper preparation of one VOC sample from the 3.1 to 4.0 m (10 to 13 ft) interval.

The uncertainty associated with this sample has minimal impact on the data interpretation because there is no evidence to substantiate the presence of high VOC concentrations in this interval.

4.4 Exposure Pathway Investigation Results

From the results of historical groundwater monitoring data, the analytical suite for groundwater monitoring wells (CSO-1 and CSO-2) in the vicinity of the FDTF was refined to target metals, and total recoverable petroleum hydrocarbons (TPH). The results of groundwater monitoring from wells CSO-1 and CSO-2 conducted from the third quarter 1994 through the second quarter 1995 are presented in Appendix A-5. No TPH was detected during the 1995 sampling event. Because no hydrocarbon components were detected during the 1995 sampling event, groundwater sampling was not conducted in this investigation.

Air and biota in the vicinity of the FDTF were also identified in the CSM as exposure pathways. The impact on these secondary media via secondary release mechanisms can be evaluated using the results of surface soil sampling. Therefore, no ecological samples (biota, fish tissue, vegetation, etc.) or air samples were collected during this investigation. Groundwater monitoring results for wells CSO-2 and CSO-2 for periods 3rd Quarter 94 through 3rd Quarter 95 are shown is Appendix A-5.

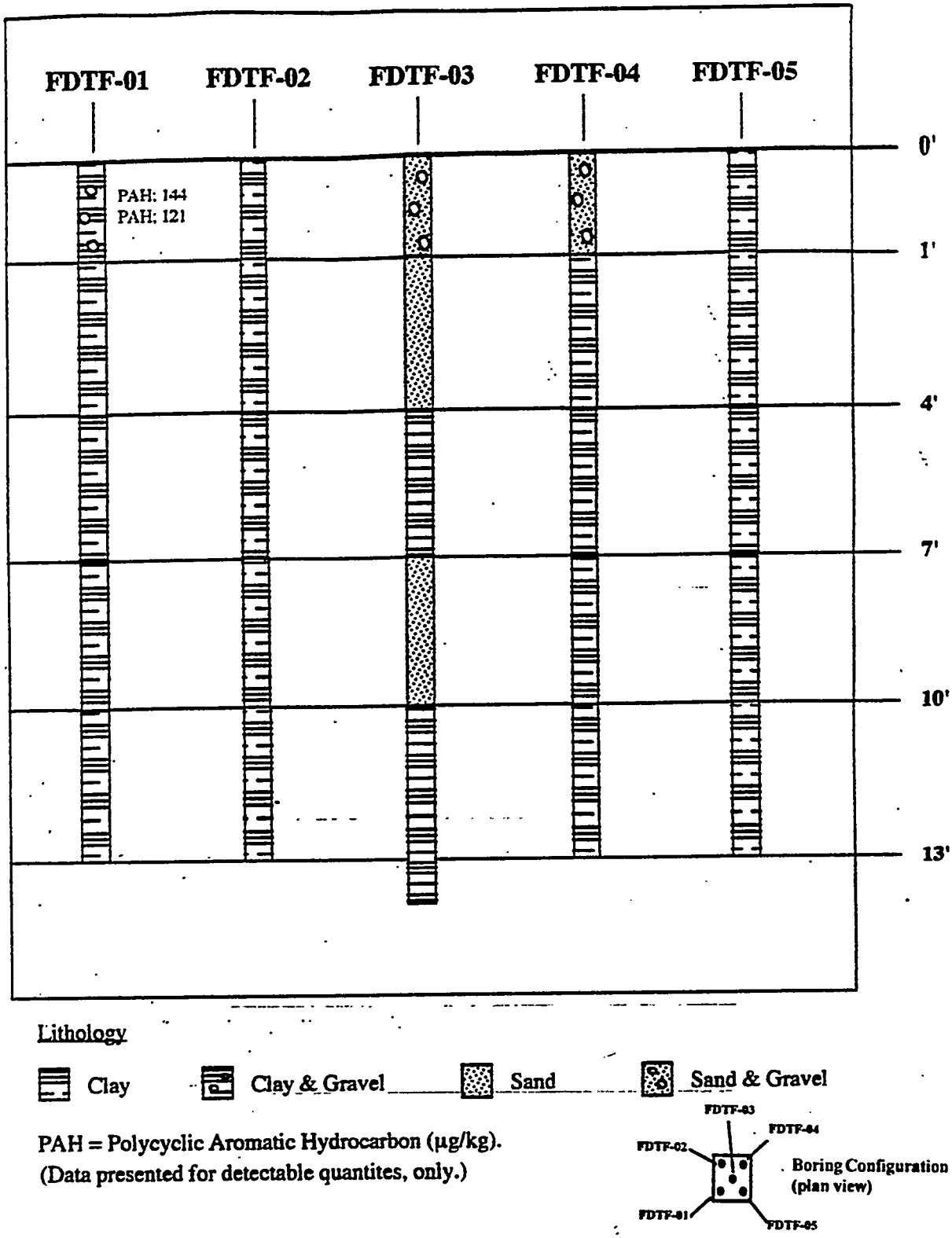


Figure 4-1. Schematic of Soil Borings with PAH Distribution (µg/kg)
(no scale implied)

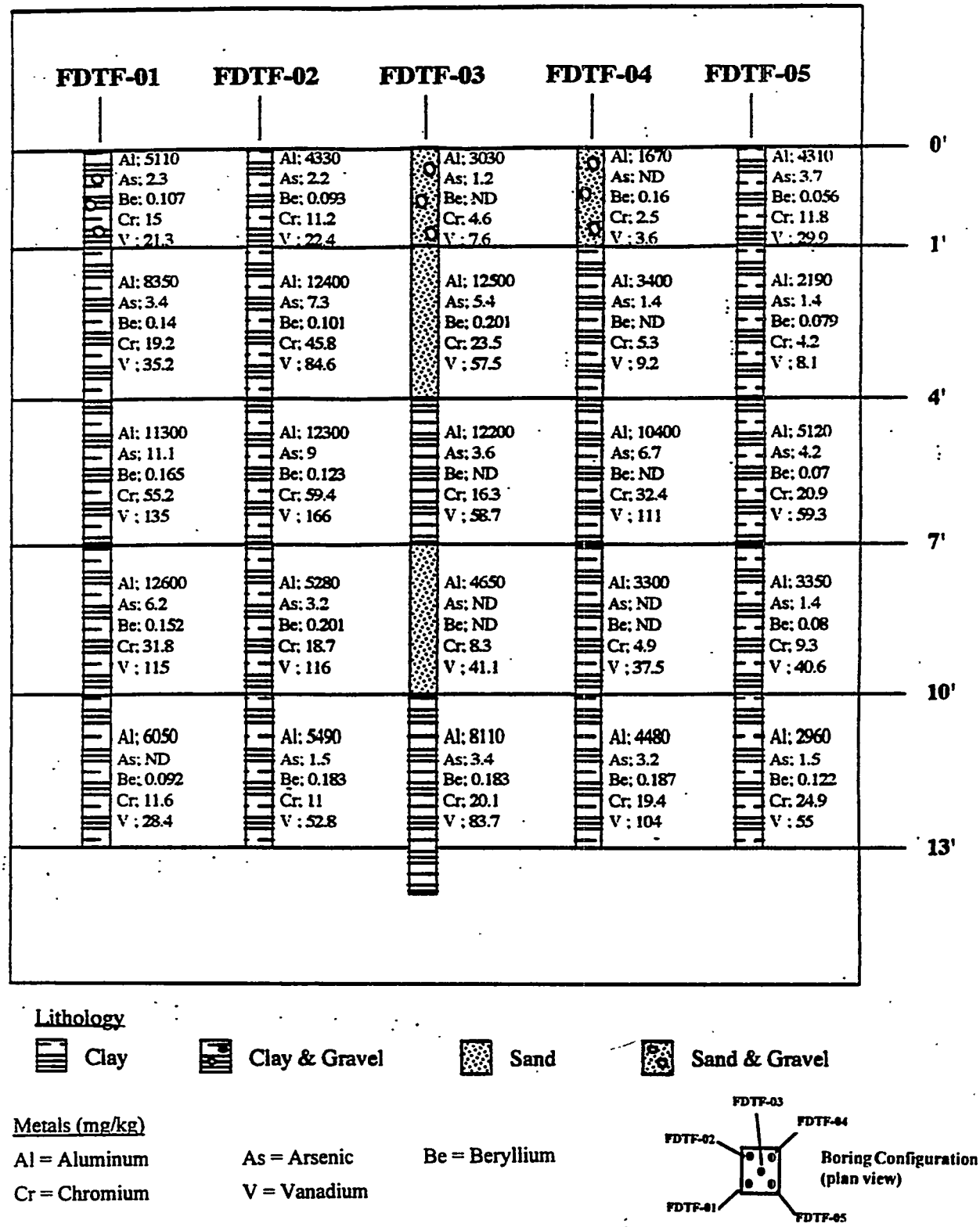


Figure 4-2. Schematic of Soil Borings with Metals Distribution (mg/kg) (no scale implied)

Table 4-1. Fire Department Hose Training Facility Unit and Background Soil Sample Information

Depth Range (ft)	FDTF-01	FDTF-02	FDTF-03	FDTF-04	FDTF-05	FBFDBG-01	FBFDBG-02	FBFDBG-03	FBFDBG-04	FBFDBG-05
0- 1	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5	1,2,3,4,5
1- 4	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5	1,2,3,4,5
4- 7	1,2,3,4,5	1,2,3,4,5,	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5	1,2,3,4,5
7- 10	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5	1,2,3,4,5
10- 13	1,2,3,4,5	1,2,3,4,5		1,2,3,4,5	1,2,3,4,5	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5,6	1,2,3,4,5	1,2,3,4,5
10- 14			1,2,3,4,5							

* Analysis suite codes:
  1-Target Analyte List (TAL) Inorganics with Cyanide
  2-Target Compound List (TCL) Semi-volatiles
  3-TCL Volatiles
  4-TCL Pesticides/PCBs
  5-Radionuclide Indicators (Gross Alpha, Non-volatile Beta, Gamma Spec)
  6-Detailed radionuclide speciation (background samples only, as requied).
  Alpha Speciation - U Series, Pu Series, Th Series, Am-241, Ru-226
  Beta Speciation - I-129, C-14, Tc-99, Sr-90, Pm-147, Ra-228

Table 4-2. Unit Specific Background Soil Concentrations at the Fire Department Hose Training Facility*

Analyte (Units)	Surface Bkgd (0-1 ft)	2X Surface Bkgd	Subsurface Bkgd (0-4 ft)	2X Subsurface Bkgd	Deep Soil Bkgd (>4 ft)	2X Deep Bkgd
Metals/Inorganics (mg/kg)						
Aluminum	6300	12600	5890	11800	4700	9400
Antimony	0.663	1.33	0.579	1.16	0.801	1.6
Arsenic	3.26	6.52	2.87	5.74	3.52	7.04
Barium	12.9	25.8	13.3	26.6	5.73	11.5
Beryllium	0.103	0.206	0.0972	0.194	0.0754	0.151
Cadmium	0.27	0.54	0.307	0.614	0.64	1.28
Calcium	155	310	152	304	88.4	177
Chromium	14.2	28.4	12.5	25	15.9	31.8
Cobalt	0.512	1.02	0.49	0.98	0.232	0.464
Copper	11.2	22.4	6.95	13.9	4.15	8.3
Cyanide	0.16	0.32	0.183	0.366	0.181	0.362
Iron	11200	22400	10500	21000	18200	36400
Lead	7.68	15.4	6.04	12.1	6.38	12.8
Magnesium	78.7	157	79.4	159	74.3	149
Manganese	21.7	43.4	19.7	39.4	2.42	4.84
Mercury	0.0435	0.087	0.0412	0.0824	0.035	0.07
Nickel	1.94	3.88	1.66	3.32	0.844	1.69
Potassium	71	142	69.1	138	48.1	96.2
Selenium	ND	ND	0.489	0.978	1:74	3.48
Sodium	35.2	70.4	29.8	59.6	29.9	59.8
Vanadium	30.4	60.8	27.2	54.4	67.7	135
Zinc	6.28	12.6	4.52	9.04	2.17	4.34
SVOCs (µg/kg)						
Di-n-octyl phthalate	ND	ND	ND	ND	229	458
Phenol	ND	ND	ND	ND	44.9	89.8

* The background concentration is the mean of all results above the detection limit for samples from stations FBFDB-01, FBFDB-02, FBFDB-03, FDFDB-04 and FBFDB-05. "ND" indicates that the analyte was not detected in any background samples in that depth interval.

Table 4-2. Unit Specific Background Soil Concentrations at the Fire Department Hose Training Facility* (Continued)

Analyte (Units)	Surface Bkgd (0-1 ft)	2X Surface Bkgd	Shallow Bkgd (0-4 ft)	2X Shallow Bkgd	Deep Bkgd (>4 ft)	2X Deep Bkgd
Radionuclides (pCi/g)						
Actinium-228	1.07	2.14	1.14	2.28	1.28	2.56
Americium-241	0.865	1.73	0.795	1.59	0.842	1.68
Antimony-124	0.06	0.12	0.06	0.12	ND	ND
Antimony-125	ND	ND	ND	ND	0.15	0.3
Barium-133	ND	ND	ND	ND	0.07	0.14
Cesium-134	ND	ND	ND	ND	0.06	0.12
Cesium-137	0.175	0.35	0.175	0.35	ND	ND
Cobalt-60	ND	ND	0.06	0.12	ND	ND
Europium-152	0.33	0.66	0.34	0.68	0.302	0.604
Europium-155	0.263	0.526	0.377	0.754	0.253	0.506
Gross Alpha	14.7	29.4	16.7	33.4	18.1	36.2
Iodine-129	5.05	10.1	5.05	10.1	ND	ND
Lead-212	1.47	2.94	1.48	2.96	1.55	3.1
Manganese-54	ND	ND	ND	ND	0.06	0.12
Neptunium-239	ND	ND	ND	ND	0.87	1.74
Non-volatile Beta	14.6	29.2	13.7	27.4	16.9	33.8
Plutonium-238	0.32	0.64	0.23	0.46	0.295	0.59
Potassium-40	1.16	2.32	1.26	2.52	1.65	3.3
Promethium-146	ND	ND	ND	ND	0.05	0.1
Promethium-147	ND	ND	ND	ND	1.12	2.24
Radium-226	0.22	0.44	0.273	0.546	0.257	0.514
Radium-228	1.69	3.38	1.36	2.72	2.83	5.66
Ruthenium-106	ND	ND	ND	ND	2.1	4.2
Strontium-90	ND	ND	0.47	0.94	0.78	1.56
Technetium-99	0.215	0.43	0.148	0.296	0.176	0.352
Thorium-228	1.44	2.88	1.37	2.74	1.56	3.12
Thorium-232	0.967	1.93	1.08	2.16	1.45	2.9
Thorium-234	1.49	2.98	1.35	2.7	1.63	3.26
Tin-113	ND	ND	ND	ND	0.08	0.16
Uranium-235	ND	ND	0.13	0.26	0.14	0.28
Yttrium-88	ND	ND	0.05	0.1	ND	ND
Zinc-65	ND	ND	ND	ND	0.08	0.16

* The background concentration is the mean of all results above the detection limit for samples from stations FBFDB-01, FBFDB-02, FBFDB-03, FDFDB-04 and FBFDB-05. "ND" indicates that the analyte was not detected in any background samples in that depth interval.

Table 4-3. Analytes Not Detected in Fire Department Hose Training Facility Soil Samples

Analyte (Units)	Number of Measurements	Minimum Sample Detection Limit	Average Sample Detection Limit	Maximum Sample Detection Limit
1,2,4-Trichlorobenzene (µg/kg)	50	340.00	430.000	1720.00
1,2-Dichlorobenzene (µg/kg)	50	340.00	430.000	1720.00
1,3-Dichlorobenzene (µg/kg)	50	340.00	430.000	1720.00
1,4-Dichlorobenzene (µg/kg)	50	340.00	430.000	1720.00
2,4,5-Trichlorophenol (µg/kg)	50	1700.00	2150.000	8620.00
2,4,6-Trichlorophenol (µg/kg)	50	340.00	430.000	1720.00
2,4-Dichlorophenol (µg/kg)	50	340.00	430.000	1720.00
2,4-Dimethyl phenol (µg/kg)	50	340.00	430.000	1720.00
2,4-Dinitrophenol (µg/kg)	50	1700.00	2150.000	8620.00
2,4-Dinitrotoluene (µg/kg)	50	340.00	430.000	1720.00
2,6-Dinitrotoluene (µg/kg)	50	340.00	430.000	1720.00
2-Chloronaphthalene (µg/kg)	50	340.00	430.000	1720.00
2-Chlorophenol (µg/kg)	50	340.00	430.000	1720.00
2-Methyl-4,6-dinitrophenol (µg/kg)	50	1700.00	2150.000	8620.00
2-Methylnaphthalene (µg/kg)	50	340.00	430.000	1720.00
2-Nitroaniline (µg/kg)	50	1700.00	2150.000	8620.00
2-Nitrophenol (µg/kg)	50	340.00	430.000	1720.00
3,3'-Dichlorobenzidine (µg/kg)	50	680.00	860.000	3450.00
3-Nitroaniline (µg/kg)	50	1700.00	2150.000	8620.00
4-Bromophenyl phenyl ether (µg/kg)	50	340.00	430.000	1720.00
4-Chloro-3-methylphenol (p-chloro-m-cresol) (µg/kg)	50	340.00	430.000	1720.00
4-Chloroaniline (µg/kg)	50	340.00	430.000	1720.00
4-Chlorophenyl phenyl ether (µg/kg)	50	340.00	430.000	1720.00
4-Nitroaniline (µg/kg)	50	1700.00	2150.000	8620.00
4-Nitrophenol (µg/kg)	50	1700.00	2150.000	8620.00
Acenapthene (µg/kg)	50	340.00	430.000	1720.00
Acenapthylene (µg/kg)	50	340.00	430.000	1720.00
Anthracene (µg/kg)	50	340.00	430.000	1720.00
Benzyl alcohol (µg/kg)	50	340.00	430.000	1720.00
Bis(2-chloroethoxy) methane (µg/kg)	50	340.00	430.000	1720.00
Bis(2-chloroethyl) ether (µg/kg)	50	340.00	430.000	1720.00
Bis(2-chloroisopropyl) ether (µg/kg)	50	340.00	430.000	1720.00

Table 4-3. Analytes Not Detected in Fire Department Hose Training Facility Soil Samples (Continued)

Analyte (Units)	Number of Measurements	Minimum Sample Detection Limit	Average Sample Detection Limit	Maximum Sample Detection Limit
Butyl benzyl phthalate (µg/kg)	50	340.00	430.000	1720.00
Dibenzo(a,h)anthracene (µg/kg)	50	340.00	430.000	1720.00
Dibenzofuran (µg/kg)	50	340.00	430.000	1720.00
Diethyl phthalate (µg/kg)	50	340.00	430.000	1720.00
Dimethyl phthalate (µg/kg)	50	340.00	430.000	1720.00
Fluorene (µg/kg)	50	340.00	430.000	1720.00
Hexachlorobenzene (µg/kg)	50	340.00	430.000	1720.00
Hexachlorobutadiene (µg/kg)	50	340.00	430.000	1720.00
Hexachlorocyclopentadiene (µg/kg)	50	340.00	430.000	1720.00
Hexachloroethane (µg/kg)	50	340.00	430.000	1720.00
Isophorone (µg/kg)	50	340.00	430.000	1720.00
N-Nitrosodi-n-propylamine (µg/kg)	50	340.00	430.000	1720.00
N-Nitrosodiphenylamine (µg/kg)	50	340.00	430.000	1720.00
Naphthalene (µg/kg)	50	340.00	430.000	1720.00
Nitrobenzene (µg/kg)	50	340.00	430.000	1720.00
Pentachlorophenol (µg/kg)	50	1700.00	2150.000	8620.00
Phenanthrene (µg/kg)	50	340.00	430.000	1720.00
o-cresol (2-methylphenol) (µg/kg)	50	340.00	430.000	1720.00
p-cresol (4-methylphenol) (µg/kg)	50	340.00	430.000	1720.00
Aldrin (µg/kg)	50	1.70	1.920	2.40
Aroclor-1016 (µg/kg)	50	34.00	38.400	48.00
Aroclor-1221 (µg/kg)	50	68.00	76.800	95.90
Aroclor-1232 (µg/kg)	50	34.00	38.400	48.00
Aroclor-1242 (µg/kg)	50	34.00	38.400	48.00
Aroclor-1248 (µg/kg)	50	34.00	38.400	48.00
Aroclor-1254 (µg/kg)	50	34.00	38.400	48.00
Aroclor-1260 (µg/kg)	50	34.00	38.400	48.00
Dieldrin (µg/kg)	50	3.40	3.840	4.80
Endosulfan I (µg/kg)	50	1.70	1.920	2.40
Endosulfan II (µg/kg)	50	3.40	3.840	4.80
Endosulfan sulfate (µg/kg)	50	3.40	3.840	4.80
Endrin (µg/kg)	50	3.40	3.840	4.80
Endrin ketone (µg/kg)	50	3.40	3.840	4.80
Heptachlor (µg/kg)	50	1.70	1.920	2.40

Table 4-3. Analytes Not Detected in Fire Department Hose Training Facility Soil Samples (Continued)

Analyte (Units)	Number of Measurements	Minimum Sample Detection Limit	Average Sample Detection Limit	Maximum Sample Detection Limit
Heptachlor epoxide (µg/kg)	50	1.70	1.920	2.40
Methoxychlor (Mariate) (µg/kg)	50	17.00	19.200	24.00
Toxaphene (µg/kg)	50	170.00	192.000	240.00
alpha-Benzene hexachloride (µg/kg)	50	1.70	1.920	2.40
alpha-Chlordane (µg/kg)	50	1.70	1.920	2.40
beta-Benzene hexachloride (µg/kg)	50	1.70	1.920	2.40
delta-Benzene hexachloride (µg/kg)	50	1.70	1.920	2.40
gamma-Benzene hexachloride (Lindane) (µg/kg)	50	1.70	1.920	2.40
gamma-Chlordane (µg/kg)	50	1.70	1.920	2.40
p,p'-DDD (µg/kg)	50	3.40	3.840	4.80
p,p'-DDE (µg/kg)	50	3.40	3.840	4.80
p,p'-DDT (µg/kg)	50	3.40	3.840	4.80
Carbon-14	18	-1.21	-0.177	1.10
Cerium-144	50	-0.42	-0.071	0.23
Cobalt-57	50	-0.03	-0.003	0.03
Plutonium-239/240	18	0.00	0.009	0.05
Promethium-144	50	-0.03	-0.001	0.04
Sodium-22	50	-0.04	0.000	0.04
Thorium-230	18	0.73	1.020	1.29
Uranium-234	18	0.72	0.976	1.30
Uranium-238	18	0.73	0.930	1.20
Thallium (mg/kg)	50	8.47	9.750	12.20
1,1,1-Trichloroethane (µg/kg)	50	5.00	5.740	7.50
1,1,2,2-Tetrachloroethane (µg/kg)	50	5.00	5.740	7.50
1,1,2-Trichloroethane (µg/kg)	50	5.00	5.740	7.50
1,1-Dichloroethane (µg/kg)	50	5.00	5.740	7.50
1,1-Dichloroethene (µg/kg)	50	5.00	5.740	7.50
1,2-Dichloroethane (µg/kg)	50	5.00	5.740	7.50
1,2-Dichloroethene (total) (µg/kg)	50	5.00	5.740	7.50
1,2-Dichloropropane (µg/kg)	50	5.00	5.740	7.50
2-Butanone (MEK) (µg/kg)	50	10.00	11.500	15.00

Table 4-3. Analytes Not Detected in Fire Department Hose Training Facility Soil Samples (Continued)

Analyte (Units)	Number of Measurements	Minimum Sample Detection Limit	Average Sample Detection Limit	Maximum Sample Detection Limit
2-Hexanone (µg/kg)	50	10.00	11.500	15.00
4-Methyl-2-pentanone (µg/kg)	50	10.00	11.500	15.00
Benzene (µg/kg)	50	5.00	5.740	7.50
Bromodichloromethane (µg/kg)	50	5.00	5.740	7.50
Bromoform (µg/kg)	50	5.00	5.740	7.50
Bromomethane (Methyl bromide) (µg/kg)	50	10.00	11.500	15.00
Carbon disulfide (µg/kg)	50	5.00	5.740	7.50
Carbon tetrachloride (µg/kg)	50	5.00	5.740	7.50
Chlorobenzene (µg/kg)	50	5.00	5.740	7.50
Chlorodibromomethane (µg/kg)	50	5.00	5.740	7.50
Chloroethane (µg/kg)	50	10.00	11.500	15.00
Chloroform (µg/kg)	50	5.00	5.740	7.50
Chloromethane (methyl chloride) (µg/kg)	50	10.00	11.500	15.00
Ethylbenzene (µg/kg)	50	5.00	5.740	7.50
Styrene (µg/kg)	50	5.00	5.740	7.50
Tetrachloroethene (µg/kg)	50	5.00	5.740	7.50
Trichloroethene (TCE) (µg/kg)	50	5.00	5.740	7.50
Vinyl acetate (µg/kg)	50	10.00	11.500	15.00
Vinyl chloride (µg/kg)	50	10.00	11.500	15.00
Xylenes (total) (µg/kg)	50	5.00	5.740	7.50
cis-1,3-Dichloropropene (µg/kg)	50	5.00	5.740	7.50
trans-1,3-Dichloropropene (µg/kg)	50	5.00	5.740	7.50

Table 4-4. Summary Statistics for Analytes Detected in Soil Samples from 0 to 1 ft Deep from the Fire Department Hose Training Facility[1]

Analyte (Units)	Freq. of Detection	Minimum Detected	Mean Result	Maximum Detected	Human Health Criteria Source	Human Health Criteria	>Human Health Criteria	2X Bkgd	Maximum Detect > 2X Bkgd	Unit Specific Contaminant
Metals/Inorganics (mg/kg)										
Aluminum	5/5	1670	3690	5110	RBC*0.1	7800		12600		
Antimony	1/5	0.556	1.58	0.556	RBC*0.1	3.1		1.33		
Arsenic	4/5	1.2	3.01	3.7	RBC	0.43	YES	6.52		
Barium	5/5	9	13.5	19.4	RBC*0.1	550		25.8		
Beryllium	3/5	0.0558	0.0719	0.107	RBC	0.15		0.206		
Cadmium	3/5	0.051	0.0847	0.119	RBC*0.1	3.9		0.54		
Calcium	5/5	78.8	156	302	RDA	1000000		310		
Chromium	5/5	2.5	9.02	15	RBC*0.1	39		28.4		
Cobalt	5/5	0.405	0.61	0.822	RBC*0.1	470		1.02		
Copper	4/5	4.3	4.12	5.2	RBC*0.1	310		22.4		
Cyanide	1/5	0.091	0.338	0.091	RBC*0.1	160		0.32		
Iron	5/5	1480	6820	11100	RBC*0.1	2300	YES	22400		
Lead	5/5	4.7	9.58	12.9	RBC*0.1	40		15.4		
Magnesium	5/5	41.9	72	93.6	RDA	1000000		157		
Manganese	5/5	28	37.1	65.3	RBC*0.1	39	YES	43.4	YES	YES
Mercury	1/5	0.03	0.0607	0.03	RBC*0.1	0.78		0.087		
Nickel	5/5	0.74	1.73	3.3	RBC*0.1	160		3.88		
Potassium	5/5	54.8	74.3	90.3	RDA	393273		142		
Silver	3/5	0.267	0.715	1.9	RBC*0.1	39		ND	YES	
Sodium	5/5	33.5	54.9	69.1		NA	YES	70.4		
Vanadium	5/5	3.6	17	29.9	RBC*0.1	55		60.8		
Zinc	5/5	2.5	10.7	22.8	RBC*0.1	2300		12.6	YES	

Table 4-4. Summary Statistics for Analytes Detected in Soil Samples from 0 to 1 ft Deep from the Fire Department Hose Training Facility[1] (Continued)

Analyte (Units)	Freq. of Detection	Minimum Detected	Mean Result	Maximum Detected	Human Health Criteria Source	Human Health Criteria	>Human Health Criteria	2X Bkgd	Maximum Detect > 2X Bkgd	Unit Specific Contaminant
SVOCs (µg/kg)										
Benzo(a)anthracene	1 / 5	94.6	296	94.6	RBC	880		ND	YES	
Benzo(a)pyrene	1 / 5	144	306	144	RBC	88	YES	ND	YES	YES
Benzo(b)fluoranthene	1 / 5	317	340	317	RBC	880		ND	YES	
Benzo(g,h,i)perylene	1 / 5	121	301	121		NA	YES	ND	YES	YES
Benzo(k)fluoranthene	1 / 5	219	321	219	RBC	8800		ND	YES	
Benzoic acid	1 / 5	60.3	1390	60.3	RBC*0.1	31000000		ND	YES	
Bis(2-ethylhexyl) phthalate	1 / 5	465	233	465	RBC	46000		ND	YES	
Chrysene	1 / 5	180	313	180	RBC	88000		ND	YES	
Fluoranthene	1 / 5	112	299	112	RBC*0.1	310000		ND	YES	
Indeno(1,2,3-c,d)pyrene	1 / 5	125	302	125	RBC	880		ND	YES	
Pyrene	1 / 5	99.8	297	99.8	RBC*0.1	230000		ND	YES	
VOCs (µg/kg)										
Dichloromethane (methylene chloride)	1 / 5	6.84	4.7	6.84	RBC	85000		ND	YES	
Toluene	1 / 5	2.36	2.57	2.36	RBC*0.1	1600000		ND	YES	

[1] Mean includes all results with no detects set to one half the sample quantitation limit except for radionuclides which were included at the full reported value.
ND indicates an analyte that was not detected in the background samples for this depth class.
NA indicates an analyte that does not have a human health screening criteria.

Table 4-5. Summary Statistics for Analytes Detected in Soil Samples from 0 to 4 ft Deep from the Fire Department Hose Training Facility[1]

Analyte (Units)	Freq. of Detection	Minimum Detected	Average Result	Maximum Detected	Human Health Criteria Source	Human Health Criteria	>Human Health Criteria	2X Bkgd	Maximum Detect > 2X Bkgd	Unit Specific Contaminant
Metals/Inorganics (mg/kg)										
Aluminum	10 / 10	1670	5730	12500	RBC*0.1	7800	YES	11800	YES	YES
Antimony	3 / 10	0.549	1.56	1.4	RBC*0.1	3.1		1.16	YES	
Arsenic	9 / 10	1.2	3.4	7.3	RBC	0.43	YES	5.74	YES	YES
Barium	10 / 10	9	19.5	41	RBC*0.1	550		26.6	YES	
Beryllium	8 / 10	0.0558	0.104	0.201	RBC	0.15	YES	0.194	YES	YES
Cadmium	7 / 10	0.051	0.165	0.638	RBC*0.1	3.9		0.614	YES	
Calcium	10 / 10	78.1	247	735	RDA	1000000		304	YES	
Chromium	10 / 10	2.5	14.3	45.8	RBC*0.1	39	YES	25	YES	YES
Cobalt	10 / 10	0.405	0.699	1	RBC*0.1	470		0.98	YES	
Copper	7 / 10	4.3	4.25	8.1	RBC*0.1	310		13.9		
Cyanide	2 / 10	0.091	0.365	0.115	RBC*0.1	160		0.366		
Iron	10 / 10	1480	12600	44000	RBC*0.1	2300	YES	21000	YES	YES
Lead	10 / 10	3.8	8.07	12.9	RBC*0.1	40		12.1	YES	
Magnesium	10 / 10	41.9	117	248	RDA	1000000		159	YES	
Manganese	10 / 10	8	31.2	65.3	RBC*0.1	39	YES	39.4	YES	YES
Mercury	3 / 10	0.02	0.0594	0.052	RBC*0.1	0.78		0.0824		
Nickel	10 / 10	0.74	1.98	3.6	RBC*0.1	160		3.32	YES	
Potassium	10 / 10	54.8	109	224	RDA	393273		138	YES	
Selenium	1 / 10	2.1	5.28	2.1	RBC*0.1	39		0.978	YES	
Silver	4 / 10	0.11	0.583	1.9	RBC*0.1	39		ND	YES	
Sodium	10 / 10	25.9	58.8	89.8		NA	YES	59.6	YES	YES
Vanadium	10 / 10	3.6	27.9	84.6	RBC*0.1	55	YES	54.4	YES	YES
Zinc	10 / 10	2.5	7.35	22.8	RBC*0.1	2300		9.04	YES	

Table 4-5. Summary Statistics for Analytes Detected in Soil Samples from 0 to 4 ft Deep from the Fire Department Hose Training Facility[1] (Continued)

Analyte (Units)	Freq. of Detection	Minimum Detected	Average Result	Maximum Detected	Human Health Criteria Source	Human Health Criteria	>Human Health Criteria	2X Bkgd	Maximum Detect > 2X Bkgd	Unit Specific Contaminant
SVOCs (µg/kg)										
Benzo(a)anthracene	1 / 10	94.6	246	94.6	RBC	880		ND	YES	
Benzo(a)pyrene	1 / 10	144	251	144	RBC	88	YES	ND	YES	YES
Benzo(b)fluoranthene	1 / 10	317	268	317	RBC	880		ND	YES	
Benzo(g,h,i)perylene	1 / 10	121	249	121		NA	YES	ND	YES	YES
Benzo(k)fluoranthene	1 / 10	219	259	219	RBC	8800		ND	YES	
Benzoic acid	1 / 10	60.3	1190	60.3	RBC*0.1	31000000		ND	YES	
Bis(2-ethylhexyl) phthalate	2 / 10	386	233	465	RBC	46000		ND	YES	
Chrysene	1 / 10	180	255	180	RBC	88000		ND	YES	
Di-n-butyl phthalate	1 / 10	194	234	194	RBC*0.1	780000		ND	YES	
Di-n-octyl phthalate	2 / 10	39.9	252	335	RBC*0.1	160000		ND	YES	
Fluoranthene	1 / 10	112	248	112	RBC*0.1	310000		ND	YES	
Indeno(1,2,3-c,d) pyrene	1 / 10	125	249	125	RBC	880		ND	YES	
Pyrene	2 / 10	90.2	235	99.8	RBC*0.1	230000		ND	YES	
VOCs (µg/kg)										
Dichloromethane (methylene chloride)	2 / 10	6.84	5.47	9.55	RBC	85000		ND	YES	
Toluene	1 / 10	2.36	2.79	2.36	RBC*0.1	1600000		ND	YES	

[1] Mean includes all results with nondetects set to one half the sample quantitation limit
ND indicates an analyte that was not detected in the background samples for this depth class.
NA indicates an analyte that does not have a human health screening criteria.

Table 4-6. Summary Statistics for Analytes Detected in Soil Samples from >4 ft Deep from the Fire Department Hose Training Facility[1]

Analyte (Units)	Freq. of Detection	Minimum Detected	Average Result	Maximum Detected	Human Health Criteria Source	Human Health Criteria	>Human Health Criteria	2X Background	Maximum Detect > 2X Bkgd	Unit Specific Contaminant
Metals/Inorganics (mg/kg)										
Aluminum	15 / 15	2960	7170	12600	RBC*0.1	7800	YES	9400	YES	YES
Antimony	9 / 15	0.482	1.31	1.9	RBC*0.1	3.1		1.6	YES	
Arsenic	12 / 15	1.4	5.06	11.1	RBC	0.43	YES	7.04	YES	YES
Barium	15 / 15	2.4	7.67	26.9	RBC*0.1	550		11.5	YES	
Beryllium	11 / 15	0.0695	0.12	0.201	RBC	0.15	YES	0.151	YES	YES
Cadmium	14 / 15	0.169	0.455	0.938	RBC*0.1	3.9		1.28		
Calcium	15 / 15	44.1	188	1190	RDA	1000000		177	YES	
Chromium	15 / 15	4.9	22.9	59.4	RBC*0.1	39	YES	31.8	YES	YES
Cobalt	11 / 15	0.163	0.365	0.538	RBC*0.1	470		0.464	YES	
Copper	15 / 15	3.4	6.59	13	RBC*0.1	310		8.3	YES	
Cyanide	4 / 15	0.104	0.387	0.306	RBC*0.1	160		0.362		
Iron	15 / 15	10200	33400	76200	RBC*0.1	2300	YES	36400	YES	YES
Lead	15 / 15	6.4	11.9	24.6	RBC*0.1	40		12.8	YES	
Magnesium	15 / 15	44.8	142	574	RDA	1000000		149	YES	
Manganese	15 / 15	1.2	11.8	32.8	RBC*0.1	39		4.84	YES	
Mercury	2 / 15	0.02	0.0717	0.03	RBC*0.1	0.78		0.07		
Nickel	15 / 15	0.27	1.17	2.9	RBC*0.1	160		1.69	YES	
Potassium	15 / 15	39.8	98.8	198	RDA	393273		96.2	YES	
Selenium	8 / 15	1.4	4.32	5.5	RBC*0.1	39		3.48	YES	
Sodium	15 / 15	27.5	65.5	86.8		NA	YES	59.8	YES	YES
Vanadium	15 / 15	28.4	80.3	166	RBC*0.1	55	YES	135	YES	YES
Zinc	9 / 15	2.2	6.15	5.2	RBC*0.1	2300		4.34	YES	

Table 4-6. Summary Statistics for Analytes Detected in Soil Samples from >4 ft Deep from the Fire Department Hose Training Facility[1] (Continued)

Analyte (Units)	Freq. of Detection	Minimum Detected	Average Result	Maximum Detected	Human Health Criteria Source	Human Health Criteria	>Human Health Criteria	2X Background	Maximum Detect > 2X Bkgd	Unit Specific Contaminant
SVOCs (µg/kg)										
Benzoic acid	4 / 15	44.6	756	84.7	RBC*0.1	31000000		ND	YES	
Bis(2-ethylhexyl) phthalate	3 / 15	63.5	178	110	RBC	46000		ND	YES	
Di-n-octyl phthalate	8 / 15	69	234	462	RBC*0.1	160000		458	YES	
VOCs (µg/kg)										
Acetone	1 / 15	17.5	6.91	17.5	RBC*0.1	780000		ND	YES	
Dichloromethane (methylene chloride)	3 / 15	10.5	5.79	13.2	RBC	85000		ND	YES	

[1] Mean includes all results with nodetects set to one half the sample quantitation limit reported value.
ND indicates an analyte that was not detected in the background samples for this depth class.
NA indicates an analyte that does not have a human health screening criteria.

Table 4-7. Summary of Results by Borehole for Soil Samples From the Fire Department Hose Training Facility Above Both Background and Human Health Criteria

		Location				
Analyte	Depth(ft)	FDTF-01	FDTF-02	FDTF-03*	FDTF-04	FDTF-05
Metals (mg/kg)						
Aluminum	0-1	5110	4330	3030	1670	4310
	1-4	8350	12400	12500	3400	2190
	4-7	11300	12300	12200	10400	5120
	7-10	12600	5280	4650	3300	3350
	10-13	6050	5490	8110	4480	2960
Arsenic	0-1	2.3	2.2	1.2	ND	3.7
	1-4	3.4	7.3	5.4	1.4	1.4
	4-7	11.1	9	3.6	6.7	4.2
	7-10	6.2	3.2	ND	ND	1.4
	10-13	ND	1.5	3.4	3.2	1.5
Beryllium	0-1	0.107	0.0926	ND	ND	0.0558
	1-4	0.14	0.101	0.201	0.16	0.079
	4-7	0.165	0.123	ND	ND	0.0695
	7-10	0.152	0.201	ND	ND	0.0797
	10-13	0.0921	0.183	0.183	0.187	0.122
Chromium	0-1	15	11.2	4.6	2.5	11.8
	1-4	19.2	45.8	23.5	5.3	4.2
	4-7	55.2	59.4	16.3	32.4	20.9
	7-10	31.8	18.7	8.3	4.9	9.3
	10-13	11.6	11	20.1	19.4	24.9
Iron	0-1	9560	8960	3020	1480	11100
	1-4	15900	44000	24900	3830	3740
	4-7	76200	53400	20100	51000	26700
	7-10	39800	48300	18700	11800	24200
	10-13	10200	18200	29500	35900	37000
Manganese	0-1	31.6	28.7	28	65.3	32.1
	1-4	14.1	8	18.8	50.8	34.3
	4-7	7.8	9.2	3.3	3.5	14.8
	7-10	22	32.8	6.3	1.2	19.7
	10-13	4.1	11.8	10.1	10	19.8

Table 4-7. Summary of Results by Borehole for Soil Samples From the Fire Department Hose Training Facility Above Both Background and Human Health Criteria (Continued)

		Location				
Analyte	Depth(ft)	FDTF-01	FDTF-02	FDTF-03*	FDTF-04	FDTF-05
Sodium	0-1	33.5	61.8	57.1	53.2	69.1
	1-4	25.9	89.8	87.1	53.7	56.8
	4-7	27.5	86.8	69.7	60.6	64.8
	7-10	73.3	73	81.7	66.7	51.9
	10-13	74.8	57.3	77.4	65.6	51.5
Vanadium	0-1	21.3	22.4	7.6	3.6	29.9
	1-4	35.2	84.6	57.5	9.2	8.1
	4-7	135	166	58.7	111	59.3
	7-10	115	116	41.1	37.5	40.6
	10-13	28.4	52.8	83.7	104	55
B/N/A Extractables (including PAH and Phenols) (mg/kg)						
Benzo(a)pyrene	0-1	144	ND	ND	ND	ND
	1-4	ND	ND	ND	ND	ND
	4-7	ND	ND	ND	ND	ND
	7-10	ND	ND	ND	ND	ND
	10-13	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	0-1	121	ND	ND	ND	ND
	1-4	ND	ND	ND	ND	ND
	4-7	ND	ND	ND	ND	ND
	7-10	ND	ND	ND	ND	ND
	10-13	ND	ND	ND	ND	ND

* Boring location of FDTF-03 total depth = approx. 14 ft
ND indicates an analyte that was not detected.
NA indicates an analyte that was not analyzed.
Shading indicates value exceeds screening criteria.

(This page intentionally left blank)

5.0 CONTAMINANT FATE AND TRANSPORT

This chapter describes the potential migration pathways and mechanisms for transport of chemical substances found in soils at the Fire Department Hose Training Facility (FDTF). Using the information presented in previous chapters, contaminant fate and transport analyses are typically performed to identify the unit specific contaminant migration constituents of concern (CMCOCs), predict the rate of contaminant migration, and project contaminant concentrations to receptor locations via various media. A simple tiered approach is used to develop the CMCOCs, and analytical models are used to define transport of these CMCOCs from source areas to receptor locations. The overall objectives of these analyses are to evaluate potential future impact to human health and the environment.

Section 5.1 discusses the persistence, mobility, and other physical and chemical properties of the metals and organic compounds found at the FDTF at the Savannah River Site (SRS). Section 5.2 provides a discussion of contaminant migration pathways in relation to the conceptual site model and describes contaminant release mechanisms through various transport media. Section 5.3 presents a soil leachability analysis describing the application and underlying assumptions for the soil screening analysis. Section 5.4 summarizes the conclusions drawn from the results of the analyses.

5.1 Physical and Chemical Properties

The fate and transport of metals and organic compounds are functions of both site characteristics and the physical and chemical interactions between the contaminants and the site media. The physical and chemical properties of the contaminants that influence these interactions include, but are not limited to, solubility in water, tendency to transform or degrade (usually described by an environmental half-life in a given medium), and chemical affinity for solids or organic matter (usually described by a partitioning coefficient such as K_d, K_{oc}, or K_{ow}). These properties and how they affect the behavior of detected analytes at the FDTF are described below.

5.1.1 Metals

Inorganic analytes detected at the FDTF include the metals which are present above two times (2X) the average background concentration listed in Table 5-1. When associated with the aqueous phase

in a soil, these metals are subject to movement with soil water. Aqueous transport mechanisms may result in metal migration through the vadose zone to groundwater. Metals, unlike organic compounds, cannot be degraded. However, some metals, such as arsenic and chromium which are present at the FDTF in detectable concentrations, can be transformed to other oxidation states in soil, reducing their mobility and toxicity. Metals may also react with soil particles or other solid surfaces by ion exchange, adsorption, precipitation, or complexation. Such reactions are affected by pH, oxidation-reduction conditions, and the type and amount of organic matter, clay, and hydrous oxides present. These reactions are typically reversible, resulting in dynamic metals' solubility in immature or poorly developed soils. In general, ion exchange, adsorption, precipitation, and complexation cause an element's mobility to be retarded. The retardation factor (R_d) describes numerically the extent to which the velocity of the contaminant migration is slowed. It is largely derived from the partitioning coefficient (K_d), as expressed by the following equation:

$$R_d = 1 + (K_d \rho_b) / \theta \qquad \text{(Eq. 5.1-1)}$$

where:

ρ_b = the soil bulk density (g/cm^3)

θ = soil moisture content (%)

Table 5-1 presents the range of K_ds for metals for the two types of soil (sandy soil and loam). The K_ds of metals vary widely in the same soil type and may vary by orders of magnitude between samples from the same site. However, for the purpose of transport modeling typically only the average K_d values are used.

In soil, metals are found in one or more of several "pools" of the soil, as described by Shuman (1991): (1) dissolved in soil solution; (2) occupying exchange sites on inorganic soil constituents; (3) specifically adsorbed on inorganic soil constituents; (4) associated with insoluble soil organic matter; (5) precipitated as pure or mixed solids; (6) present in the structure of secondary minerals; and (7) present in the structure of primary minerals. In situations where metals have been introduced into the environment through human activities, they are typically associated with the first five pools. The dissolved/aqueous fraction and its equilibrium fraction are of primary importance when considering the migration potential of metals associated with soils. The dissolved fraction is the more mobile and bioavailable fraction. Of the compounds that are most likely to be present in soils, the chlorides, nitrates, and nitrites are the most soluble. Sulfates, carbonates, and

hydroxides have low to moderate solubility. Soluble compounds are transported in aqueous forms that are subject to retardation. Metals form both soluble and insoluble compounds in soil. The insoluble compounds remain as precipitates and limit the overall dissolution of a metal.

5.1.2 Organic Compounds

The organic constituents detected at the FDTF include volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs). These contaminants may be degraded in the environment by various processes including hydrolysis, oxidation/reduction, photolysis, or biodegradation. Environmental half-lives of organic compounds in different media can vary from minutes to years, depending on the chemical and on environmental conditions. Degradation usually reduces the toxicity, but may not completely eliminate the threat to human health and the environment. Biodegradation rates for organic compounds of interest are presented in Table 5-2.

5.2 Conceptual Site Model and Contaminant Migration

The Conceptual Site Model (CSM) presents known or expected unit conditions that serve as a paradigm within which an investigation is developed, and against which new data can be compared and interpreted. The CSM incorporates all the waste unit characteristics that combine to constitute the problem being addressed (e.g., hydrogeologic features, primary contaminants and their properties, potential human and ecological exposure scenarios, etc.). The predictive function of the CSM relies on known information and informed assumptions about the waste unit. The better the information and the greater the accuracy of the assumptions, the more accurately the site CSM describes the unit, resulting in more reliable predictions.

The expected unit conditions and components of the CSM at the FDTF are briefly discussed in the following paragraphs.

5.2.1 Infiltration and Surface Runoff

The potential for contaminant transport begins with precipitation. The degree to which the processes of infiltration and runoff occur across SRS is variable and dependent primarily upon the density of vegetation. Much of the area surrounding the FDTF is vegetated, and infiltration is expected to be high. Average annual percolation to the water table at this site is expected to be 36 cm (14 in.).

5.2.2 Evapotranspiration

All infiltrated water does not recharge to groundwater; much of it is lost from the subsurface via evapotranspiration. The amount lost is variable, depending largely on the extent and type of vegetative cover. At SRS, a large percentage of the average annual precipitation is consumed by evapotranspiration.

5.2.3 Subsurface Flow System

The infiltrated water that is not lost to evapotranspiration enters the subsurface flow system. The subsurface flow system is comprised of the vadose zone and the saturated zone. The vadose zone at the FDTF is composed of dirty to moderately clean, cross bedded sands with clay lenses representing the Clinchfield and Tinker Formations. The vadose zone is approximately 15 m (50 ft) thick.

The water table aquifer is known as the "upper" aquifer zone of the Upper Three Runs Aquifer. Although many factors influence groundwater flow, topography, surface cover, geologic structure, and lithology exhibit strong influence on the hydrogeology. Variations in these features result in water flux variations. Groundwater movement in the water table beneath the FDTF is predominantly to the southwest from the unit.

5.2.4 Release Mechanisms

The primary release mechanisms at the unit are infiltration with leaching to groundwater, surface runoff and erosion, and gaseous emission and wind erosion.

5.2.4.1 Infiltration with Leaching to Groundwater

Precipitation that does not leave the waste unit as surface runoff infiltrates into the subsurface. Some of this infiltrating water leaves the subsurface environment via evapotranspiration after little or no subsurface flow. The remainder of the water percolates into the subsurface flow system. The rate of percolation is controlled by soil cover, ground slope, saturated conductivity of the soil, and meteorological conditions.

Water infiltrating through contaminated surface and subsurface soils may leach contaminants into the groundwater. The factors that affect the leaching rate include a contaminant's solubility and K_d and the amount of percolation. Whether it is the contaminant's partition coefficient or solubility that controls leaching depends on whether leaching is solubility-controlled or sorption-controlled. Compounds with low solubility will precipitate out of solution in the subsurface or remain in their insoluble form with little leaching. However, the contaminants detected at the FDTF generally do not form insoluble compounds in the natural environment, so sorption processes and the K_d will have the greatest effect on leaching. Since the retardation factor describes numerically how the velocity of contaminant migration is slowed, the larger the retardation factor, the slower the velocity of a constituent in the soil. The R_d is directly proportional to the K_d, so those contaminants with small K_ds will be leached more effectively than those with larger K_ds.

Another factor that affects whether a contaminant will reach the water table is the contaminant's rate of decay. Most organic compounds decay or break down at characteristic rates that are described by the substance's half-life. For a given percolation rate, those contaminants with longer half-lives have a greater potential for contaminating groundwater than do those contaminants with shorter half-lives.

Flow and contaminant transport processes in the subsurface are conceptualized from the hydrogeology of the site, saturated-unsaturated flow characteristics (such as hydraulic conductivity, thickness of the vadose zone, Darcy and seepage velocity), and a constituent's chemical behavior in a specific medium. The hydrogeology of the unit has already been discussed in Section 3. The principal release mechanism at the FDTF is infiltration and leaching to groundwater. Water is introduced to contaminants buried in the soils by infiltration of rainwater. Contaminants would then be leached from contaminated soils and migrate downward through the vadose zone to the water table. The water table is located in the "upper" aquifer zone of the Upper Three Runs Aquifer. In the saturated zone, the contaminants may be carried laterally to receptor locations in solution or in fine particulates or colloids. As the contaminants migrate downward, they could pass from the "upper" aquifer zone of the Upper Three Runs Aquifer through the "tan clay" confining zone and into the underlying "lower" aquifer zone of the Upper Three Runs Aquifer. The depth to groundwater is approximately 15 m (50 ft).

5.2.4.2 Surface Runoff and Erosion

Contaminants that are sorbed onto surface soils can be released by desorption in surface runoff or captured with particulate matter by soil erosion during a rainstorm. Surface water runoff from the FDTF flows in a north, northeast direction toward an unnamed tributary of Fourmile Branch.

5.2.4.3 Gaseous Emission and Wind Erosion

Organic compounds in surface soil are emitted to air via volatilization. The rate of emission is controlled by the vapor pressure of the organic compounds. It decreases rapidly over a short period of time as the volatiles are depleted by release to the atmosphere. VOCs in subsurface soils are emitted to the atmosphere via vertical diffusion through soil pores. Depending on how extensively diffusion has occurred, gaseous emissions from subsurface soils may be significant.

Particulate matter from contaminated surface soil can become airborne (fugitive dust) as a result of wind erosion. This process is controlled by vegetative cover, wind speed, and moisture and other fluids in the surface soils.

5.3 Soil Leachability Analysis

Soil and groundwater are the principal media of contaminant transport. Contaminant fate and transport analyses involve conducting a series of screening steps to define what constituents are present at concentrations that warrant vadose zone modeling. The screening process did not identify the presence of any constituents in concentrations high enough to warrant evaluation using a vadose zone contaminant transport model. The screening process is discussed in the following sections.

5.3.1 Comparison of Unit-Specific CSM to Soil Screening Level

5.3.1.1 Step 1

The first step of the screening process was comparison of the maximum detected concentrations of all the analytes measured in the soils with 2X their respective average background concentrations. As discussed previously (Section 4), soil samples were collected from five soil borings (FDTF-01 through FDTF-05) drilled within the FDTF. For this screen, all background samples were

grouped into one set and samples from the FDTF were grouped into another set. There was no distinction in either set according to sample depth. Each analyte in the FDTF group was compared with 2X its average background concentration. The results of this background screen are presented in Table 5-3. The constituents exceeding 2X their average background concentration are evaluated for their potential leachability from the waste unit soil to the groundwater. Essential nutrients (calcium, chloride, iodine, magnesium, phosphorus, potassium, and sodium) are not included in this screening process, because they are not considered to be toxic and do not have health based limits.

5.3.1.2 Step 2

The second step of the screening process for this unit compared the average concentration of each constituent with the Environmental Protection Agency (EPA) generic soil screening level (SSL) for Superfund Sites for migration to the groundwater pathway (EPA, 1996a). When the average concentration was higher than the maximum concentration detected, the maximum concentration was used. (This occurs when the detection limit for one or more samples is much higher than the maximum concentration detected.) The SSL is the concentration of a contaminant in soil that represents a level of contamination below which there is generally no concern under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), provided conditions associated with SSLs are met. The generic SSLs for the migration to groundwater exposure pathway are presented in Table 5-4.

Using the average soil concentration of a constituent is appropriate for the fate and transport screening process, because it provides the best estimate of the concentration of contaminants distributed homogeneously throughout the source. This is one of the simplifying assumptions used when SSL models are applied. The natural processes that reduce constituent concentrations in the subsurface are also considered in the migration screen. The effect of this natural process is accounted for by using a dilution attenuation factor (DAF). For this unit a DAF of 20 was used for the migration to groundwater pathway. The DAF of 20 is the value appropriate for the size of the unit (approximately 7,800 ft^2) according to EPA guidance (EPA, 1996a).

Generally, if contaminant concentrations in soil fall below the SSL with DAF, and there is no significant ecological receptor of concern, then no further study or action is warranted for that area. If no generic SSL was available for a chemical for the migration to groundwater pathway, the chemical was carried through the screening.

5.3.2 Results of Comparison to Soil Screening Levels

The screening process shows that no constituent with an established SSL is present above the SSL when the DAF = 20. Only iron, which does not have an established SSL, is present above 2X its average background concentration. There are no SVOCs or VOCs present above their respective SSLs when the DAF = 20. The results of the screen are shown in Table 5-5.

5.4 Summary and Conclusions

The constituents present in the soil of the FDTF at concentrations above 2X their average background concentration were screened against EPA generic SSLs for the migration to groundwater, ingestion and inhalation pathways to identify those which present a potential current hazard (inhalation of ingestion) or which would require vadose zone transport modeling (migration to groundwater). To be consistent with the EPA screening guidelines which assume a homogeneous soil concentration, the average concentration of the constituents was compared with the generic SSLs promulgated by EPA (EPA, 1996a) using a DAF of 20. This screening process would identify constituents to be considered for vadose zone transport modeling. Constituents which do not have established, generic SSLs were carried through the screening process.

No constituent with an established, generic SSL for migration to groundwater is present in the FDTF soil at an average concentration exceeding its generic screening level. Iron, which does not have an established generic SSL and which is sometimes considered an essential nutrient, is the only constituent which is not screened out. Iron is not associated with any known previous activity at the FDTF. This suggests it is naturally occurring. There are no VOCs or SVOCs present at average concentrations above their SSLs with DAF = 20.

The results of this analysis show that no constituents are present in the soil from previous activities at the FDTF at concentrations sufficient to leach to the groundwater in concentrations of concern.

Table 5-1. List of Distribution Coefficients (K_d) Used to Describe the Retardation Factors (R_d) for the Inorganic Site-Related Analytes at the FDTF

Site Related Analytes	K_d[a] in Sandy Soil (mL/kg)	K_d[a] in Loam (mL/kg)
Aluminum	1500[b]	1500[b]
Antimony	45	150 (100 to 10000)[c]
Arsenic	2.0E+02[b]	2.0E+02[b]
Barium	50[b]	50[b]
Beryllium	2.5E+02	8.0E+02
Cadmium	80 (1.7 to 6.25E+02)	40 (7 to 9.6E+02)
Chromium	70 (1.7 to 1.73E+03)	30 (2.2 to 1.0E+03)
Cobalt	60 (0.07 to 9.0E+03)	1,300 (1.0E+02 to 9.7E+03)
Copper	3.5E+01[b]	3.5E+01[b]
Iron	220 (5 to 6000)	800 (290 to 2240)
Lead	270 (19 to 1,405)	1.6E+04 (100[a] to 5.9E+04)
Manganese	50 (6.4 to 5.0E+03)	750 (40 to 7.7E+04)
Nickel	400 (60 to 3.6E+03)	3.0E+02
Silver	90 (2.7 to 1.0E+03)	120 (28 to 3.33E+02)
Selenium	(150 to 1800)[c]	300[c]
Vanadium	1.0E+03[b]	1.0E+03[b]
Zinc	200 (0.1 to 8,000)	1,300 (3.6 to 11,000)

[a] K_d values taken from Sheppard and Thibault (1990) unless otherwise noted; the range is provided in parentheses if available.
[b] K_d values obtained from Baes et al. (1984)
[c] Source: EPA (1996)

Table 5-2. Physical and Chemical Properties of Selected Organic Constituents at the FDTF

Constituents	Mol. Wt.	Solubility S_w (mg/L)	S_w @ Temp. (°C)	K_{ow} (mL/mL)	Henry's Constant (K_h) (atm.m³/mol)	K_h @ Temp. (°C)	Air Diff. Coeff. (cm²/s)		K_{oc} mL/g	BDR λ (1/day)	Biodeg. half-life (day)	Log (K_{ow})
Volatile Organic Compounds												
Acetone	58.1	1.00E+06		5.75E-01	5.14E-07	25#	0.110	s	3.63E-01	2.48E-02	28	-0.24
Methylene chloride	84.9	1.67E+04	25	1.78E+01	3.19E-03	25	0.104	s	1.12E+01	6.19E-03	112	1.25
Toluene	92.1	5.15E+02	20	4.90E+02	5.92E-03	25	0.087		3.09E+02	3.30E-03	210	2.69
Semivolatile Organic Compounds												
Benzo (a) anthracene	228.3	1.00E-02	24	4.07E+05	2.94E-08	25#	0.051		2.57E+05	2.55E-04	2720	5.61
Benzo (a) pyrene	252.3	3.80E-03	25	9.55E+05	4.90E-07	25	0.043		6.02E+05	3.27E-04	2120	5.98
Benzo (b) fluoranthene	252.3	1.00E-03	#	3.72E+06	2.94E-07	25#	0.044	#	2.34E+06	2.84E-04	2440	6.57
Benzo (k) fluoranthene	252.3	3.00E-04	#	6.92E+06	2.54E-05	25#	0.044		4.36E+06	8.10E-05	8560	6.84
Bis-(2-Ethylhexyl)phthalate	390.6	1.30E+00	25	2.00E+05	3.00E-07	20	0.032	s	1.26E+05	1.78E-03	389	5.30
Chrysene	228.3	6.00E-03	25	4.07E+05	1.05E-06	25	0.046		2.57E+05	1.73E-04	4000	5.61
Di-n-butylphthalate	278.4	4.00E+02	25	1.58E+05	2.80E-07	25	0.042		9.98E+04	3.01E-02	23	5.20
Fluoranthene	202.3	2.65E-01	25	2.14E+05	6.50E-06	25	0.069	s	1.35E+05	3.94E-04	1760	5.33
Phenol	94.1	8.00E+04	25	2.88E+01	1.30E-06	25	0.087	s	1.81E+01	2.48E-02	28	1.46
Pyrene	202.3	1.60E-01	26	1.51E+05	5.10E-06	25	0.051		9.54E+04	9.12E-05	7600	5.18

Solubilities, Henry's Constant and Log (Kow) have been taken from RREL Treatability Data Base (EPA, 1994a) except as otherwise indicated.
Biodegradation half-lives are taken from Handbook of Environmental Degradation Rates (Howard et al., 1991) except as otherwise indicated.
Air diffusion coefficients are obtained from EPA (1987), except as otherwise indicated.
[#] indicates STF Data Base (EPA, 1992a) as the source, and [s] indicates Shen et al. (1993) as the source.

Table 5-3. Background Soil Screen for Fate and Transport Analysis

Analyte	Average Result (0-4.0 m)	Maximum Conc. Detected (0-4.0 m)	2X Mean Bkgd (0-4.0 m)	Maximum Conc. Greater Than 2X Mean Bkgd
Metals/Inorganics (mg/kg)				
Aluminum	6,940	12,500	10.352	YES
Antimony	1.4	1.9	1.4	YES
Arsenic	4.8	11	6.5	YES
Barium	9.6	41	17.5	YES
Beryllium	0.117	0.201	0.168	YES
Cadmium	0.408	0.938	1.0	NO
Chromium	22	59	29.1	YES
Cobalt	0.418	1.0	0.670	YES
Copper	5.7	13	11	YES
Cyanide	0.356	0.306	0.364	NO
Iron	30,072	76,200	30,240	YES
Lead	11	25	12	YES
Manganese	15	65	19	YES
Mercury	0.060	0.052	0.075	NO
Nickel	1.3	3.6	2.3	YES
Selenium	4.5	5.5	2.48	YES
Silver	0.551	1.9	ND	YES
Vanadium	72	166	103	YES
Zinc	6.3	23	6.2	YES
SVOCs (ug/kg)				
Benzo(a)anthracene	204	95	ND	YES
Benzo(a)pyrene	205	144	ND	YES
Benzo(b)fluoranthene	208	317	ND	YES
Benzo(g,h,i)perylene	204	121	ND	YES
Benzo(k)fluoranthene	206	219	ND	YES
Benzoic acid	825	60	ND	YES
Bis(2-ethylhexyl) phthalate	187	465	ND	YES
Chrysene	205	180	ND	YES
Di-n-butyl phthalate	202	194	ND	YES
Di-n-octyl phthalate	237	335	229	YES
Fluoranthene	204	112	ND	YES
Indeno(1,2,3-c,d) pyrene	204	125	ND	YES
Pyrene	202	100	ND	YES
VOCs (ug/kg)				
Acetone	6.9	18	ND	YES
Methylene chloride	5.7	9.6	ND	YES
Toluene	3.0	2.36	ND	YES

Table 5-4. Generic Soil Screening Levels for Exposure Pathways

Constituents	Ingestion	Inhalation	Migration to Groundwater SSL DAF=20
Metals/Inorganics (mg/kg)			
Aluminum	#	#	110.0E+3
Antimony	31	#	5
Arsenic	0.4	750	29
Barium	5.5E+3	6.90E+05	1.600
Beryllium	0.1	1300	63
Cadmium	78	1800	8
Chromium	390	270	38
Cobalt	#	#	2.640
Copper	#	#	9.2E+3
Iron	#	#	#
Lead	400	400	400
Manganese	#	#	5.0E+3
Nickel	1.6E+3	13.0E+3	130
Selenium	390	#	5
Silver	390	#	34
Vanadium	550	#	6.0E+3
Zinc	23.0E+3	#	12.0E+3
SVOCs (ug/kg)			
Benzo(a)anthracene	900	#	2.0E+3
Benzo(a)pyrene	90	#	8.0E+3
Benzo(b)fluoranthene	900	#	5.0E+3
Benzo(g,h,i)perylene	#	#	50.0E+3
Benzo(k)fluoranthene	9,000	#	49.0E+3
Benzoic acid	3.10E+05	#	400.0E+3
Bis(2-ethylhexyl) phthalate	46.0E+3	31.0E+6	3.6E+6
Chrysene	88.0E+3	#	160.0E+3
Di-n-butyl phthalate	7.8E+6	2.3E+6	240.0E+3
Di-n-octyl phthalate	1.6E+6	10.0E+6	10.0E+6
Fluoranthene	3.1E+6	#	4.3E+6
Indeno(1,2,3-c,d) pyrene	900	#	14.0E+3
Pyrene	2.3E+6	#	4.2E+6
VOCs (ug/kg)			
Acetone	7.8E+6	1.00E+05	1.6E+3
Methylene chloride	85.0E+3	13.0E+3	20
Toluene	16.0E+6	650.0E+3	12.0E+3

No soil screening level established for this substance for this pathway
Source: EPA (1996a)

Table 5-5. Soil Screening Level Summary for Soil Migration Pathway

Analyte	Average Conc. [1] (0-4.0 m)	Maximum Conc. [1] Detected (0-4.0m)	SSL (DAF=20)	Average Conc. > SSL (DAF=20)
Metals/Inorganics (mg/kg)				
Aluminum	6,940	12,500	110,000	NO
Antimony	1.4	1.4	5	NO
Arsenic	4.8	7.3	29	NO
Barium	9.6	41	1,600	NO
Beryllium	0.117	0.201	63	NO
Cadmium	0.408	0.638	8	NO
Chromium	22	46	38	NO
Cobalt	0.418	1.0	2,640	NO
Copper	5.66	13	9,160	NO
Iron	30,072	44,000		YES
Lead	11	13	400	NO
Manganese	15	65	5,020	NO
Nickel	1.3	3.6	130	NO
Selenium	4.5	2.1	5	NO
Silver	0.551	1.9	34	NO
Vanadium	72	85	6,000	NO
Zinc	6.3	23	12,000	NO
SVOCs (ug/kg)				
Benzo(a)anthracene	204	95	2,000	NO
Benzo(a)pyrene	205	144	8,000	NO
Benzo(b)fluoranthene	208	317	5,000	NO
Benzo(g,h,i)perylene	204	121	50,000	NO
Benzo(k)fluoranthene	206	219	49,000	NO
Benzoic acid	825	60	400,000	NO
Bis(2-ethylhexyl) phthalate	187	465	3,600,000	NO
Chrysene	205	180	160,000	NO
Di-n-butyl phthalate	202	194	240,000	NO
Di-n-octyl phthalate	237	335	10,000,000	NO
Fluoranthene	204	112	4,300,000	NO
Indeno(1,2,3-c,d) pyrene	204	125	14,000	NO
Pyrene	202	100	4,200,000	NO
VOCs (ug/kg)				
Acetone	6.9	18	1600	NO
Methylene chloride	5.7	9.6	20	NO
Toluene	3.0	2.36	12,000	NO

[1] The concentrations are for the entire depth sampled, 0-4.0 m (0-13 ft)

(This page intentionally left blank)

6.0 BASELINE RISK ASSESSMENT

The purpose of the Baseline Risk Assessment (BRA) is to assess the potential for adverse effects associated with exposure to constituents present at the Fire Department Hose Training Facility (FDTF). Baseline risks are those risks to human health and the environment that can be anticipated to be present in the absence of any institutional controls or remedial actions for the FDTF. The BRA provides the basis for determining whether or not remedial action is necessary and the justification for performing remedial actions.

(This page intentionally left blank)

6.1 Selection of Constituents of Potential Concern and Exposure Groups

The objective of constituent identification is to screen the available information on hazardous substances at the waste unit, identify constituents of potential concern (COPCs), and focus subsequent efforts in the risk assessment process. COPCs are defined as constituents that are potentially unit-related, which are present in concentrations that may impact human health and/or the environment. COPCs are selected in accordance with guidance from the Environmental Protection Agency (EPA) Headquarters (EPA, 1989a), EPA Region IV (EPA, 1995c), and the South Carolina Department of Health and Environmental Control (SCDHEC); they are quantitatively carried through the risk assessment.

Two terms are frequently used throughout the risk assessment: exposure unit and exposure group. An exposure unit is a geographical area in which receptors are likely to average their exposure. The exposure unit is defined on the basis of observed or assumed patterns of receptor behavior and the nature and extent of contamination. An exposure group is the particular array of sample data that is used to represent exposures within the exposure unit. The COPCs identified for each exposure unit (Section 6.1.2) are carried through the risk assessment process and are statistically represented by the samples in the exposure group. Only one unit-related exposure unit, soil, is defined for the Fire Department Hose Training Facility (FDTF). There are two unit-related exposure groups for soil: shallow (0 to 0.3 m [0 to 1 ft]) and subsurface (0 to 1.2 m [0 to 4 ft]). Data are also available for soil in the background. Groundwater is not included in this investigation. (For a discussion of why groundwater is not included, see Section 4.4)

Based on the results of the risk assessment, COPCs contributing significantly to a pathway that have a significant human cancer risk or human noncarcinogenic hazard, or that are determined to pose unacceptable ecological risk are designated as constituents of concern (COCs). For human health, COCs are substances associated with risks or hazards exceeding targets for the protection of human health, as defined in the National Contingency Plan and under the Comprehensive Environmental Response, Compensation, and Liability Act. For ecological resources, a weight-of-evidence approach is conducted to identify ecological COCs. The COCs become the basis of and the focus for remediation.

A multiple-step approach has been adopted for identifying COPCs for the risk assessment, and for eliminating incomplete exposure pathways. The Conceptual Site Model (CSM) for the FDTF

is presented in Figure 6.1-1. The CSM summarizes the credible exposure pathways and media of potential concern for both human and ecological receptors.

6.1.1 Media of Potential Concern

Media of potential concern are defined as any medium through which human or ecological receptors may be exposed to constituents or through which constituents may be transported to potential receptors. During the unit investigation, constituent concentrations were determined for one medium: soil. There are no surface water or sediment features at the FDTF, and groundwater is not included in the investigation. The data for soil were sorted and grouped in order to provide a set of values for further processing; the available data for soil were assigned to either a shallow soil or subsurface soil exposure group.

The shallow soils were to assess exposures under current conditions, whereas both the shallow and subsurface soils were used to assess exposures under future conditions (two separate calculations). The 0 to 1.2 m (0 to 4 ft) soil interval was used in a hypothetical scenario in which the subsurface soils are excavated and brought to the surface. Generally, 1.2 m (4 ft) is considered a reasonable depth for excavation of a footing to support a small structure. The 1.2 m (4 ft) depth is also appropriate for use by burrowing animals found in the area.

For the FDTF, the following exposure groups are identified for both human and ecological receptors:

- Surface soil from 0 to 0.3 m (0 to 1 ft)
- Subsurface soil from 0 to 1.2 m (0 to 4 ft)

There are no "hot spots" or areas of elevated contamination within the FDTF that warrant a separate analysis. The FDTF is small in area, and the top 0 to 1.2 m (0 to 1 ft) is currently comprised of clean fill. For these reasons, the entire subsurface soil layer (0 to 1.2 m [0 to 4 ft]) may be considered to be a hot spot, relative to the surface soil layer (0 to 0.3 m [0 to 1 ft]).

Appendix B provides all environmental data used in the risk assessment, including the sample interval, sample location, and sample identification numbers.

6.1.2 COPC Selection Process Description

The following paragraphs describe the process applied to select the media exposure groups and COPCs for use in the Baseline Risk Assessment (BRA). Note that no radionuclide constituents were evaluated in this investigation since none was detected. Note too that a somewhat different process for determining constituents of potential concern was used in previous sections of this report to document the nature and extent of contamination. Summary statistics for all intervals sampled are presented in Tables 6.1-1 through 6.1-6.

6.1.2.1 Initial COPC and Exposure Route Processing Steps (Steps A)

A.1 The data for the detected analytes in soil are sorted for each constituent as described in Section 6.1.1 (soil data from 0 to 0.3 m [0 to 1 ft] or soil data from 0 to 1.2 m [0 to 4 ft]). The background data for soil in the appropriate exposure group is then identified. For the 0 to 0.3 m (0 to 1 ft) soil exposure group, only background samples corresponding to the 0 to 0.3 m (0 to 1 ft) soil interval will be used to calculate average background concentrations. Furthermore, only 0 to 1.2 m (0 to 4 ft) soil from the unit will be compared to 0 to 1.2 m (0 to 4 ft) soil in the background. Data that have qualifiers are evaluated to determine whether the qualified data should be retained and how it should be treated.

All qualifiers are addressed before the constituent is used or deleted from the quantitative risk assessment. Qualifiers used by the laboratory may differ from those used in the data validation process in both identity and meaning. Therefore, definitions for all qualifiers are reviewed in the Quality Control Summary Report (QCSR) (WSRC, 1996b) prior to data evaluation.

A.2 For each constituent in a soil exposure group, constituents that have no detects are eliminated.

A.3 For each constituent in a soil exposure group, constituents are eliminated as COPCs based on comparisons to blanks, as follows:

a. All analytes -- COPC is eliminated if the maximum constituent concentration is less than 5 times the maximum concentration detected in the blank.

b. Common laboratory contaminants -- Common laboratory contaminants, such as acetone and methylene chloride, are eliminated as COPCs if the maximum

constituent concentration is less than 10 times the maximum concentration detected in the blank.

A.4 For each constituent in each medium and exposure group, the following parameters are determined:

a. Maximum detected concentrations
b. Frequency of detection
c. Arithmetic average background concentration
d. Range of detected values (minimum and maximum)

Appendix C provides a statistical summary of all data evaluated for the risk assessment.

6.1.2.2 Human Health COPC and Exposure Route Steps (Steps B)

B.1 A screening is performed against the most current EPA Region III risk-based concentration (RBC) levels by comparing the maximum detected concentration of each soil analyte to its relevant screening value. The constituent is retained as a COPC if it exceeds the screening level or if a screening level is not available.

In accordance with EPA Region IV guidance (EPA, 1995d), residential soil RBCs rather than industrial soil RBCs are used in the selection of COPC for soil and sediment analytes at a risk level of 1×10^{-6} or a hazard quotient (HQ) of 0.1. The RBCs for soil that are used to conduct the screen are presented in the Tables 6.1-7 through 6.1-10.

In accordance with EPA Region IV guidance (EPA, 1995d), the screening is performed against an HQ level of 0.1, which is accomplished by multiplying the Region III RBC screening value for noncarcinogenic effects by 0.1 (RBC screening levels for Region III are based on an HQ level of 1.0 rather than 0.1). Noncarcinogenic constituents are retained as COPCs if they exceed the HQ screening level of 0.1.

B.2 The following is a list of essential nutrients for human health that were detected at the unit but are not considered to be toxic and do not have health based limits: calcium, chloride, iodine, magnesium, phosphorous, and potassium.

For the constituents listed above, the chronic daily intake value is determined and compared to the recommended daily allowance (RDA) or the safe and adequate daily intake (SADI). The chronic daily intake is calculated by converting concentrations in soil to intake concentrations (mg/day). The constituent is eliminated as a COPC if the intake value is calculated to be below the RDA or SADI (Tables 6.1-7 through 6.1-10).

To perform this step, daily intakes for essential nutrients are calculated by multiplying the maximum detected concentration in soil by an ingestion rate for soil of 200 mg/day.

B.3 For the naturally occurring and anthropogenic inorganics and radionuclides that exceed a screening level in steps B.1 or B.2, the maximum concentration in soil at the unit is compared to 2 times (2X) the average background concentration for soil. The comparison is made for each exposure group (i.e., soil depth interval). Since the majority of organic compounds are manmade, screening of organics to background is not evaluated. To avoid potential bias of the data, nondetected values are not used to calculate the average background concentration for use in the background comparison. The constituent is eliminated as a COPC if the maximum is less than 2X the average background concentration in soil (Tables 6.1-7 through 6.1-10).

For information only, background risk is calculated for any constituent that exceeds the 1×10^{-6} RBC screening-level or the 0.1 HQ level, but is eliminated when compared to 2X the average background concentration (Appendix C).

The estimation of future groundwater concentrations from soil constituents potentially leaching to the groundwater is considered in Section 5. Those results are meant to support speculation regarding the fate and transport of contaminants in the soil. The uncertainty of the model results is considered to be too great to carry into the risk assessment.

B.4 Previously eliminated constituents, media, or exposure groups are considered for re-inclusion based on historical information or considerations such as mobility, bioaccumulation, persistence, or toxicity.

B.5 For each medium and/or exposure group, it is determined whether any COPCs remain. If no COPCs remain, the medium and/or exposure group is removed from further consideration in the human health risk assessment.

B.6 The constituents and exposure groups that are retained after the application of this process are the starting points of the human health risk assessment analysis. Tables 6.1-7 through 6.1-10 present the human health-related COPCs identified by the screening process.

6.1.2.3 Ecological COPC and Exposure Route Processing Steps (Steps C)

C.1 The appropriate ecological receptors are identified for the screening process. For each receptor and constituent, the maximum detected concentration is compared to the appropriate ecological screening value that includes the following:

a. Soil screening of nonradionuclides using no observed adverse effect levels (NOAELS) for wildlife species (based on dietary exposure).

The maximum concentration of each analyte detected in the soil intervals used for risk assessment is incorporated into a dietary intake equation, and is then compared to a risk-based dietary benchmark. The screening intake equation, based on *EPA Region IV Guidance for Wildlife Screening Values* (EPA, 1995e), conservatively assumes that the entire diet of the receptor consists of soil, all of which contains the maximum detected concentration of the analyte. Receptors for nonradionuclides are not unit-specific but, instead, are the animals used in the analyte-specific toxicity studies, as shown in Table 6.1-11. There were no radionuclides detected at the FDTF. The screening intake equation for nonradionuclides is:

$$SI = (Cs_{max})\ (f)\ (I/w) \qquad \text{(Eq. 6.1-1)}$$

where:

SI = screening intake in milligrams per kilogram body weight per day (mg/kg/d)

Cs_{max} = maximum soil concentration in mg/kg

f = feeding rate of test animal in kg/d dry weight ingested
w = body weight of test animal in kg

Maximum concentrations of the nonradiological soil analytes are shown in Tables 6.1-12 and 6.1-13. Toxicity benchmarks reflecting a chronic dietary NOAEL were sought for benchmarks in the soil screening. Where chronic NOAEL tests could not be found, other tests with endpoints of lowest observed adverse effect level (LOAEL) were used, with appropriate uncertainty factors to equate the test to a NOAEL. Chronic NOAEL benchmarks were derived from the subchronic NOAEL by dividing by 10, and NOAELs were estimated by dividing the LOAEL by 10 (Opresko et al., 1995).

Toxicity tests and test endpoints used to develop the preliminary screening values for soil constituents are shown in Table 6.1-11. Feeding rates and body weights of the animals used in the toxicity tests, as well as results of the toxicity screening for nonradionuclides, are shown in Tables 6.1-12 and 6.1-13. Note that the receptor with the lower NOAEL was used to screen each constituent.

C.2 For each constituent, the maximum concentration is compared to 2X the average background concentration. This comparison is made only for naturally occurring and non-anthropogenic inorganics. The comparison is made for each medium and exposure group. The constituent is eliminated as a COPC if the maximum is less than 2X the average background concentration in each medium.

C.3 Previously eliminated constituents, media, or exposure groups are evaluated to determine whether they should be re-included based on historical information or considerations such as mobility, bioaccumulation, persistence, or toxicity. Bioaccumulation factors for the transfer of constituents from soil to animal tissue are reported in Table 6.1-14. Only di-n-octylphthalate is included as an ecological COPC due to its reported bioaccumulation factor (BAF) of $2.4 \times 10^{+3}$. Mercury and cadmium have BAFs greater than 10, but they are not included as COPCs because they were not present above 2X the average background concentrations, nor did they exceed the toxicity screening benchmarks. Considerations of bioaccumulation are discussed below.

Bioaccumulation is the process of absorption and retention of a substance by an organism due to both uptake from water (or other surrounding medium) and uptake from ingested residues in food, soil and/or sediment. It is quantified by the calculation of a BAF. Bioconcentration is a component of bioaccumulation, accounting only for the process of uptake from the surrounding medium (i.e., water for aquatic organisms, soil for terrestrial plants and burrowing invertebrates, such as earthworms). It is quantified by the calculation of a bioconcentration factor (BCF). Both BAFs and BCFs are proportionality constants, relating the concentration of a constituent in the tissues of an organism to the concentration in the surrounding environment and/or the concentration in an animal's diet (Amdur et al., 1991; EPA, 1989b). Professional judgment is used to evaluate the relative biological persistence of the COPCs, as well as their potential to pose ecological risk based on their propensity to bioaccumulate. Based on these considerations, COPCs may be re-included for further evaluation in the ecological risk assessment.

C.4 For each medium and/or exposure group, it is determined whether there are any COPCs remaining. If no COPCs remain, the medium and/or exposure group is dropped from further consideration in the ecological risk assessment. COPCs remain in both FDTF exposure groups.

C.5 The constituents and exposure routes that are retained after the application of this process are then selected for use as the starting point of the ecological risk assessment analysis. The COPCs exceeding the human health and ecological screening values, as well as the maximum detect and Reasonable Maximum Exposure (RME) concentration of each, are shown in Tables 6.1-15 through 6.1-18. There are two ecological COPCs in surface soil at FDTF (1 inorganic, 1 organic) and 16 COPCs in subsurface soil (14 inorganics, 2 organics).

6.1.2.4 Human Health and Ecological COPC Summaries

Summaries of COPCs for the various media are presented in Tables 6.1-15 through 6.1-18. Summary tables also include the RME concentrations for the human health and ecological COPCs that will be further evaluated in the risk assessment. RME concentrations are given in the same units used in Section 4 tables: mg/kg for inorganics, µg/kg for organics. Detailed statistical summary tables are included in Appendix C. The constituents and exposure routes that

are retained after applying the screening process are then used as the starting point for the human health and ecological risk assessment analyses presented in Sections 6.2 and 6.3, respectively. Since ecological and/or human health-related COPCs or exposure routes remain upon completion of the screening process, the development of Sections 6.2 and 6.3 is warranted.

(This page intentionally left blank)

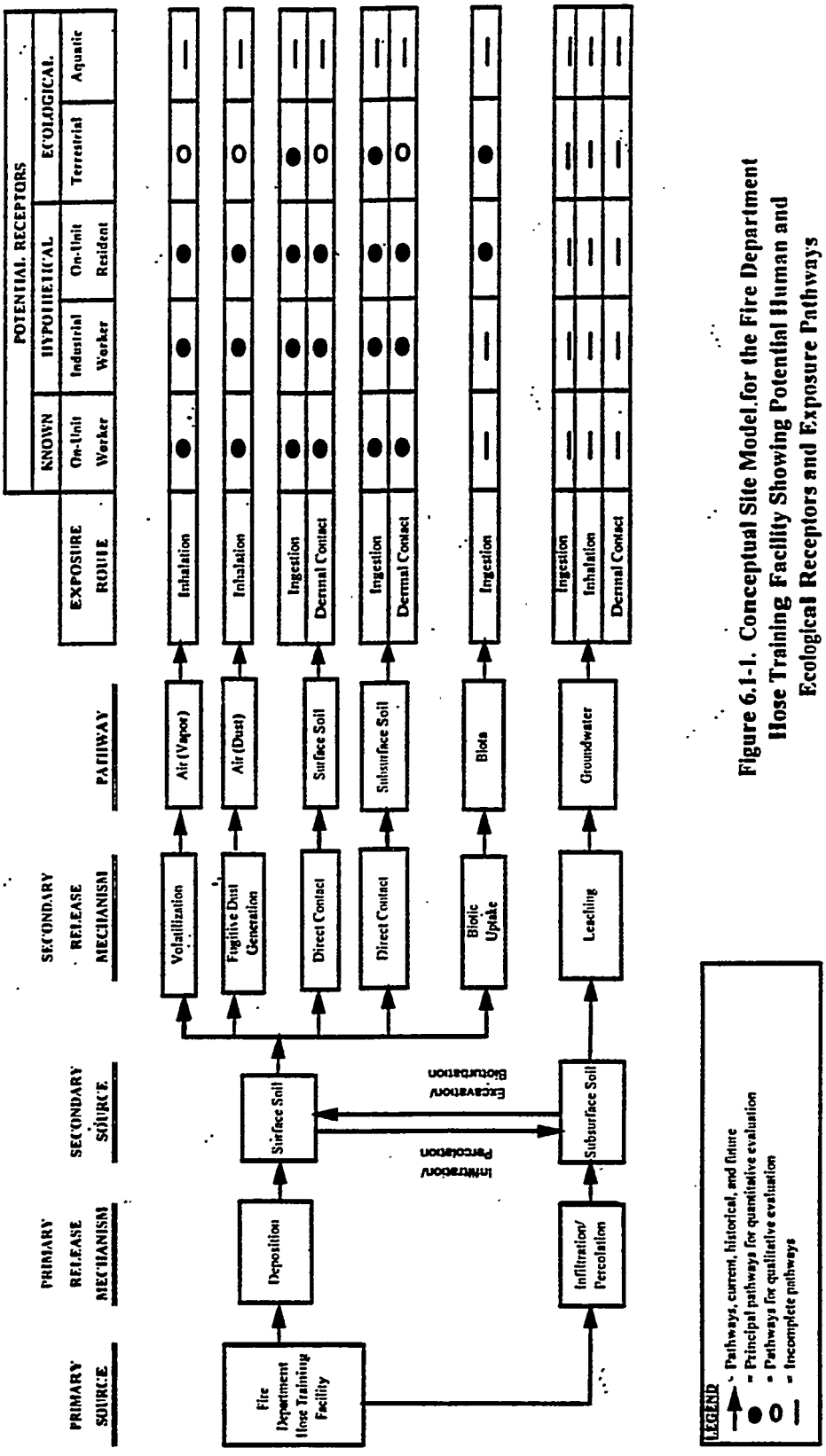


Figure 6.1-1. Conceptual Site Model for the Fire Department Hose Training Facility Showing Potential Human and Ecological Receptors and Exposure Pathways

Table 6.1-1. Summary Statistics for Analytes Detected in Soil Samples from 0 to 1 ft Deep in the FDTF*

Analyte (Units)	Proportion Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detect	Average Result	Maximum Detect	Dist. Type	95% UCL	Exposure Concentration
Total Metals and Cyanide (mg/kg)									
Aluminum	5/ 5	19	20.3	1670	3690	5110	N	4980	4980
Antimony	1/ 5	3.57	3.83	0.556	1.58	0.556	D	2.13	0.556
Arsenic	4/ 5	11.3	12.1	1.2	3.01	3.7	D	4.65	3.7
Barium	5/ 5	1.12	1.2	9	13.5	19.4	L	21.8	19.4
Beryllium	3/ 5	0.263	0.328	0.0558	0.0719	0.107	D	0.0968	0.0968
Cadmium	3/ 5	0.408	0.438	0.051	0.0847	0.119	D	0.108	0.108
Calcium	5/ 5	17.1	18.4	78.8	156	302	L	393	302
Chromium	5/ 5	0.918	0.985	2.5	9.02	15	N	14	14
Cobalt	5/ 5	0.816	0.875	0.405	0.61	0.822	L	0.918	0.822
Copper	4/ 5	1.02	1.09	4.3	4.12	5.2	D	5.76	5.2
Cyanide	1/ 5	0.78	0.83	0.091	0.338	0.091	D	0.47	0.091
Iron	5/ 5	22.3	24	1480	6820	11100	N	10900	10900
Lead	5/ 5	6.02	6.45	4.7	9.58	12.9	N	13	12.9
Magnesium	5/ 5	8.87	9.52	41.9	72	93.6	N	95.9	93.6
Manganese	5/ 5	0.204	0.219	28	37.1	65.3	X	52.2	52.2
Mercury	1/ 5	0.133	0.142	0.03	0.0607	0.03	D	0.0771	0.03
Nickel	5/ 5	1.73	1.86	0.74	1.73	3.3	L	4.48	3.3
Potassium	5/ 5	68.3	73.3	54.8	74.3	90.3	N	91.2	90.3
Silver	3/ 5	0.918	0.985	0.267	0.715	1.9	D	1.35	1.35
Sodium	5/ 5	132	141	33.5	54.9	69.1	N	67.7	67.7
Vanadium	5/ 5	0.714	0.766	3.6	17	29.9	N	27.4	27.4
Zinc	5/ 5	16.4	17.6	2.5	10.7	22.8	L	87.8	22.8

Table 6.1-1. Summary Statistics for Analytes Detected in Soil Samples from 0 to 1 ft Deep in the FDTF* (Continued)

Analyte (Units)	Proportion Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detect	Average Result	Maximum Detect	Dist. Type	95% UCL	Exposure Concentration
B/N/A Extractables (including PAH and Phenols) (µg/kg)									
Benzo(a)anthracene	1/ 5	340	1720	94.6	296	94.6	D	598	94.6
Benzo(a)pyrene	1/ 5	340	1720	144	306	144	D	601	144
Benzo(b)fluoranthene	1/ 5	340	1720	317	340	317	D	623	317
Benzo(g,h,i)perylene	1/ 5	340	1720	121	301	121	D	600	121
Benzo(k)fluoranthene	1/ 5	340	1720	219	321	219	D	609	219
Benzoic acid	1/ 5	1700	8620	60.3	1390	60.3	D	2980	60.3
Bis(2-ethylhexyl) phthalate	1/ 5	340	1720	465	233	465	D	357	357
Chrysene	1/ 5	340	1720	180	313	180	D	604	180
Fluoranthene	1/ 5	340	1720	112	299	112	D	599	112
Indeno(1,2,3-c,d)pyrene	1/ 5	340	1720	125	302	125	D	600	125
Pyrene	1/ 5	340	1720	99.8	297	99.8	D	599	99.8
Volatile Organic Compounds (µg/kg)									
Dichloromethane (methylene chloride)	1/ 5	5	5.5	6.84	4.7	6.84	D	6.43	6.43
Toluene	1/ 5	5	5.5	2.36	2.57	2.36	D	2.74	2.36

* Average result includes all results with nondetects set to one half the sample quantification limit except for radionuclides which were included at the full reported value.

Population Distribution Codes:

D Fewer than 5 or 50% detects. Treated as normal.

L Log-normal distribution.

N Normal distribution.

Z Population includes zero or negative results, treated as normal.

X Significantly different from normal and log-normal. Use arithmetic mean and t-distribution for 95% UCL.

Table 6.1-2 Summary Statistics for Analytes Detected in Soil Samples from 0 to 4 ft Deep in the FDTF*

Analyte (Units)	Proportion Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detect	Average Result	Maximum Detect	Dist. Type	95% UCL	Exposure Concentration
Total Metals and Cyanide (mg/kg)									
Aluminum	10/ 10	19	26.1	1670	5730	12500	L	10400	10400
Antimony	3/ 10	3.57	4.91	0.549	1.56	1.4	D	1.88	1.4
Arsenic	9/ 10	11.3	15.6	1.2	3.4	7.3	L	6	6
Barium	10/ 10	1.12	1.54	9	19.5	41	L	28.4	28.4
Beryllium	8/ 10	0.263	0.421	0.0558	0.104	0.201	L	0.15	0.15
Cadmium	7/ 10	0.408	0.561	0.051	0.165	0.638	L	0.448	0.448
Calcium	10/ 10	17.1	23.6	78.1	247	735	L	512	512
Chromium	10/ 10	0.918	1.26	2.5	14.3	45.8	L	38.5	38.5
Cobalt	10/ 10	0.816	1.12	0.405	0.699	1	N	0.808	0.808
Copper	7/ 10	1.02	1.4	4.3	4.25	8.1	N	5.62	5.62
Cyanide	2/ 10	0.78	1.07	0.091	0.365	0.115	D	0.448	0.115
Iron	10/ 10	22.3	30.7	1480	12600	44000	L	48500	44000
Lead	10/ 10	6.02	8.28	3.8	8.07	12.9	L	11.3	11.3
Magnesium	10/ 10	8.87	12.2	41.9	117	248	L	202	202
Manganese	10/ 10	0.204	0.281	8	31.2	65.3	L	54	54
Mercury	3/ 10	0.133	0.187	0.02	0.0594	0.052	D	0.071	0.052
Nickel	10/ 10	1.73	2.39	0.74	1.98	3.6	L	3.04	3.04
Potassium	10/ 10	68.3	94	54.8	109	224	L	163	163
Selenium	1/ 10	10.6	14.6	2.1	5.28	2.1	D	5.95	2.1
Silver	4/ 10	0.918	1.26	0.11	0.583	1.9	D	0.864	0.864
Sodium	10/ 10	132	181	25.9	58.8	89.8	N	70.5	70.5
Vanadium	10/ 10	0.714	0.982	3.6	27.9	84.6	L	85.7	84.6
Zinc	10/ 10	16.4	22.6	2.5	7.35	22.8	L	14.6	14.6

Table 6.1-2 Summary Statistics for Analytes Detected in Soil Samples from 0 to 4 ft Deep in the FDTF* (Continued)

Analyte (Units)	Proportion Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detect	Average Result	Maximum Detect	Dist. Type	95% UCL	Exposure Concentration
B/N/A Extractables (including PAH and Phenols) (µg/kg)									
Benzo(a)anthracene	1/ 10	340	1720	94.6	246	94.6	D	373	94.6
Benzo(a)pyrene	1/ 10	340	1720	144	251	144	D	376	144
Benzo(b)fluoranthene	1/ 10	340	1720	317	268	317	D	392	317
Benzo(g,h,i)perylene	1/ 10	340	1720	121	249	121	D	374	121
Benzo(k)fluoranthene	1/ 10	340	1720	219	259	219	D	382	219
Benzoic acid	1/ 10	1700	8620	60.3	1190	60.3	D	1850	60.3
Bis(2-ethylhexyl) phthalate	2/ 10	340	1720	386	233	465	D	294	294
Chrysene	1/ 10	340	1720	180	255	180	D	378	180
Di-n-butyl phthalate	1/ 10	340	1720	194	234	194	D	365	194
Di-n-octyl phthalate	2/ 10	340	1720	39.9	252	335	D	383	335
Fluoranthene	1/ 10	340	1720	112	248	112	D	374	112
Indeno(1,2,3-c,d)pyrene	1/ 10	340	1720	125	249	125	D	375	125
Pyrene	2/ 10	340	1720	90.2	235	99.8	D	365	99.8
Volatile Organic Compounds (µg/kg)									
Dichloromethane (methylene chloride)	2/ 10	5	7.5	6.84	5.47	9.55	D	6.79	6.79
Toluene	1/ 10	5	7.5	2.36	2.79	2.36	D	3.02	2.36

*Average result includes all results with nondetects set to one half the sample quantification limit except for radionuclides which were included at the full reported value.

Population Distribution Codes:

D Fewer than 5 or 50% detects. Treated as normal.

L Log-normal distribution.

N Normal distribution.

Z Population includes zero or negative results, treated as normal.

X Significantly different from normal and log-normal. Use arithmetic mean and t-distribution for 95% UCL.

Table 6.1-3. Summary Statistics for Analytes Detected in Soil Samples > 4 ft Deep in the FDTF*

Analyte (Units)	Proportion Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detect	Average Result	Maximum Detect	Dist. Type	95% UCL	Exposure Concentration
Total Metals and Cyanide (mg/kg)									
Aluminum	15/ 15	21	26.8	2960	7170	12600	L	9790	9790
Antimony	9/ 15	3.95	5.04	0.482	1.31	1.9	X	1.64	1.64
Arsenic	12/ 15	12.5	16	1.4	5.06	11.1	N	6.39	6.39
Barium	15/ 15	1.24	1.58	2.4	7.67	26.9	L	11.3	11.3
Beryllium	11/ 15	0.299	0.432	0.0695	0.12	0.201	L	0.16	0.16
Cadmium	14/ 15	0.452	0.576	0.169	0.455	0.938	L	0.7	0.7
Calcium	15/ 15	19	24.2	44.1	188	1190	X	317	317
Chromium	15/ 15	1.02	1.3	4.9	22.9	59.4	L	35.9	35.9
Cobalt	11/ 15	0.903	1.15	0.163	0.365	0.538	N	0.43	0.43
Copper	15/ 15	1.13	1.44	3.4	6.59	13	L	7.88	7.88
Cyanide	4/ 15	0.86	1.09	0.104	0.387	0.306	D	0.452	0.306
Iron	15/ 15	24.7	131	10200	33400	76200	L	47500	47500
Lead	15/ 15	6.66	8.49	6.4	11.9	24.6	L	15	15
Magnesium	15/ 15	9.82	12.5	44.8	142	574	L	210	210
Manganese	15/ 15	0.226	0.288	1.2	11.8	32.8	L	23.5	23.5
Mercury	2/ 15	0.147	0.192	0.02	0.0717	0.03	D	0.0806	0.03
Nickel	15/ 15	1.92	2.45	0.27	1.17	2.9	L	1.76	1.76
Potassium	15/ 15	75.6	96.4	39.8	98.8	198	L	134	134
Selenium	8/ 15	11.7	15	1.4	4.32	5.5	X	5.31	5.31
Sodium	15/ 15	146	186	27.5	65.5	86.8	N	72.2	72.2
Vanadium	15/ 15	0.79	1.01	28.4	80.3	166	L	111	111
Zinc	9/ 15	18.2	23.2	2.2	6.15	5.2	L	8.87	5.2

Table 6.1-3. Summary Statistics for Analytes Detected in Soil Samples > 4 ft Deep in the FDTF* (Continued)

Analyte (Units)	Proportion Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detect	Average Result	Maximum Detect	Dist. Type	95% UCL	Exposure Concentration
B/N/A Extractables (including PAH and Phenols) (µg/kg)									
Benzoic acid	4/ 15	1880	2400	44.6	756	84.7	D	954	84.7
Bis(2-ethylhexyl) phthalate	3/ 15	376	480	63.5	178	110	D	201	110
Di-n-octyl phthalate	8/ 15	376	480	69	234	462	L	345	345
Volatile Organic Compounds (µg/kg)									
Acetone	1/ 15	11	15	17.5	6.91	17.5	D	8.57	8.57
Dichloromethane (methylene chloride)	3/ 15	5.5	7.5	10.5	5.79	13.2	D	7.39	7.39

* Average result includes all results with nondetects set to one half the sample quantification limit except for radionuclides which were included at the full reported value.

Population Distribution Codes:

D Fewer than 5 or 50% detects. Treated as normal.

L Log-normal distribution.

N Normal distribution.

Z Population includes zero or negative results, treated as normal.

X Significantly different from normal and log-normal. Use arithmetic mean and t-distribution for 95% UCL.

Table 6.1-4. Summary Statistics for Soil Background Concentrations from 0 to 1 ft in the FDTF*

Analyte (Units)	Proportion Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detect	Average Result	Maximum Detect	Dist. Type	95% UCL	Exposure Concentration
Total Metals and Cyanide (mg/kg)									
Aluminum	5/ 5	11	21.9	1410	6300	9900	N	9520	9520
Antimony	3/ 5	3.04	4.12	0.442	1.11	0.798	D	1.71	0.798
Arsenic	5/ 5	12	13.1	0.821	3.26	6.9	L	22.8	6.9
Barium	5/ 5	1.19	1.29	5.1	12.9	26.6	L	35.3	26.6
Beryllium	5/ 5	0.325	0.461	0.0529	0.103	0.204	L	0.252	0.204
Cadmium	5/ 5	0.419	0.47	0.0737	0.27	0.444	N	0.398	0.398
Calcium	5/ 5	14	19.8	63.6	155	219	N	215	215
Chromium	5/ 5	0.838	1.06	2.7	14.2	27	L	158	27
Cobalt	4/ 5	0.866	1.04	0.244	0.44	0.749	D	0.672	0.672
Copper	5/ 5	0.734	1.18	1	11.2	30.7	L	2090	30.7
Cyanide	3/ 5	0.83	0.9	0.11	0.268	0.223	D	0.414	0.223
Iron	5/ 5	23.7	25.8	1700	11200	22700	N	19400	19400
Lead	5/ 5	6.39	6.94	3.6	7.68	14.6	L	19	14.6
Magnesium	5/ 5	9.42	10.2	23.2	78.7	144	N	121	121
Manganese	5/ 5	0.217	0.235	7.5	21.7	47.9	L	75.5	47.9
Mercury	4/ 5	0.146	0.158	0.02	0.0502	0.094	D	0.0817	0.0817
Nickel	5/ 5	1.84	2.07	0.708	1.94	2.9	N	2.8	2.8
Potassium	5/ 5	72.6	78.8	32.3	71	118	L	150	118
Sodium	3/ 5	140	152	12.8	50.3	79	D	82.7	79
Vanadium	5/ 5	0.758	0.823	4.3	30.4	59.3	L	938	59.3
Zinc	5/ 5	17.4	18.9	1.5	6.28	13.4	L	44.8	13.4

* Average result includes all results with nondetects set to one half the sample quantification limit except for radionuclides which were included at the full reported value.

Population Distribution Codes:

D Fewer than 5 or 50% detects. Treated as normal.

L Log-normal distribution.

N Normal distribution.

Z Population includes zero or negative results, treated as normal.

X Significantly different from normal and log-normal. Use arithmetic mean and t-distribution for 95% UCL

N/A Statics not calculated because less than 2 samples.

Table 6.1-5. Summary Statistics for Soil Background Concentrations 0 to 4 ft in the FDTF*

Analyte (Units)	Proportion Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detect	Average Result	Maximum Detect	Dist. Type	95% UCL	Exposure Concentration
Total Metals and Cyanide (mg/kg)									
Aluminum	10/ 10	11	21.9	1410	5890	9900	N	7630	7630
Antimony	5/ 10	2.82	4.12	0.442	1.15	0.798	N	1.52	0.798
Arsenic	10/ 10	11.1	13.1	0.821	2.87	6.9	L	5.32	5.32
Barium	10/ 10	1.1	1.29	5.1	13.3	26.6	L	20.4	20.4
Beryllium	10/ 10	0.299	0.461	0.0529	0.0972	0.204	L	0.133	0.133
Cadmium	9/ 10	0.39	0.47	0.0737	0.284	0.662	L	0.605	0.605
Calcium	10/ 10	13	19.8	50.4	152	219	N	185	185
Chromium	10/ 10	0.779	1.06	2.7	12.5	27	L	25.7	25.7
Cobalt	9/ 10	0.797	1.04	0.221	0.456	0.756	N	0.576	0.576
Copper	10/ 10	0.682	1.18	1	6.95	30.7	L	24.2	24.2
Cyanide	5/ 10	0.8	0.9	0.11	0.304	0.289	X	0.383	0.289
Iron	10/ 10	21.8	25.8	1700	10500	22700	L	25100	22700
Lead	10/ 10	5.88	6.94	2.8	6.04	14.6	L	8.51	8.51
Magnesium	10/ 10	8.67	10.2	23.2	79.4	144	N	101	101
Manganese	10/ 10	0.199	0.235	2.6	19.7	47.9	L	49.7	47.9
Mercury	9/ 10	0.14	0.158	0.02	0.0448	0.094	L	0.0681	0.0681
Nickel	10/ 10	1.69	2.07	0.708	1.66	2.9	L	2.37	2.37
Potassium	10/ 10	66.7	78.8	32.3	69.1	118	L	99.3	99.3
Selenium	1/ 10	10.4	12.2	0.489	5.23	0.489	D	6.21	0.489
Sodium	7/ 10	129	152	12.8	41.9	79	X	59.3	59.3
Vanadium	10/ 10	0.697	0.823	4.3	27.2	59.3	L	67.1	59.3
Zinc	9/ 10	16	18.9	1.4	4.87	13.4	L	10.2	10.2

* Average result includes all results with nondetects set to one half the sample quantification limit except for radionuclides which were included at the full reported value.

Population Distribution Codes:

D Fewer than 5 or 50% detects. Treated as normal.

L Log-normal distribution.

N Normal distribution.

Z Population includes zero or negative results, treated as normal

X Significantly different from normal and log-normal. Use arithmetic mean and t-distribution for 95% UCL

Table 6.1-6. Summary Statistics for Soil Background Concentrations from >4 ft in the FDTF*

Analyte (Units)	Proportion Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detect	Average Result	Maximum Detect	Dist. Type	95% UCL	Exposure Concentration
Total Metals and Cyanide (mg/kg)									
Aluminum	15/ 15	12	22.6	2040	4700	7970	N	5580	5580
Antimony	9/ 15	3.09	4.26	0.473	1.24	1.5	L	1.72	1.5
Arsenic	13/ 15	12.4	13.5	0.603	3.91	6.3	N	4.82	4.82
Barium	15/ 15	1.23	1.34	1.7	5.73	21.7	L	8.29	8.29
Beryllium	12/ 15	0.336	0.469	0.04	0.0955	0.134	L	0.129	0.129
Cadmium	12/ 15	0.427	0.487	0.0897	0.536	1.3	L	1.53	1.3
Calcium	15/ 15	14	20.4	38.8	88.4	287	X	119	119
Chromium	15/ 15	0.854	1.1	2	15.9	42.8	N	21	21
Cobalt	4/ 15	0.895	1.06	0.122	0.253	0.468	D	0.335	0.335
Copper	13/ 15	0.747	1.22	1.3	3.73	8.8	L	5.84	5.84
Cyanide	7/ 15	0.87	0.92	0.12	0.323	0.257	D	0.388	0.257
Iron	15/ 15	24.5	26.7	635	18200	53900	L	64600	53900
Lead	15/ 15	6.6	7.18	2	6.38	17.8	L	9.34	9.34
Magnesium	15/ 15	9.74	10.6	40.1	74.3	132	L	89.4	89.4
Manganese	15/ 15	0.224	0.243	0.313	2.42	8.8	L	4.07	4.07
Mercury	8/ 15	0.152	0.162	0.02	0.0554	0.083	X	0.0678	0.0678
Nickel	15/ 15	1.9	2.11	0.333	0.844	1.7	L	1.05	1.05
Potassium	15/ 15	75	81.5	19.5	48.1	93.2	N	57	57
Selenium	5/ 15	11.6	12.7	0.416	4.59	2.9	D	5.58	2.9
Sodium	8/ 15	144	157	10.2	50.9	72.2	X	64	64
Vanadium	15/ 15	0.783	0.852	8	67.7	148	N	86.3	86.3
Zinc	8/ 15	18	19.6	0.64	5.51	5.8	X	7.3	5.8

Table 6.1-6. Summary Statistics for Soil Background Concentrations from >4 ft in the FDTF* (Continued)

Analyte (Units)	Proportion Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detect	Average Result	Maximum Detect	Dist. Type	95% UCL	Exposure Concentration
B/N/A Extractables (including PAH and Phenols) (µg/kg)									
Di-n-octyl phthalate	13/ 15	380	405	95.4	224	425	L	279	279
Phenol	1/ 15	380	405	44.9	186	44.9	D	204	44.9

* Average result includes all results with nondetects set to one half the sample quantification limit except for radionuclides which were included at the full reported value.

Population Distribution Codes:

D Fewer than 5 or 50% detects. Treated as normal.

L Log-normal distribution.

N Normal distribution.

Z Population includes zero or negative results, treated as normal.

X Significantly different from normal and log-normal. Use arithmetic mean and t-distribution for 95% UCL.

Table 6.1-7. Human Health Risk Assessment COPC Summary: FDTF Surface Soil (0 to 1 ft)

Parameter	Maximum Detect	Human Health Criteria	Human Health Criteria Source	Exceeds Human Health Criteria	2X Average Background	Maximum Detect >2X Background	COPC
INORGANICS (mg/kg)							
Aluminum	5.110	7.800	RBC*0.1	NO	12.600	NO	
Antimony	0.56	3.10	RBC*0.1	NO	1.33	NO	
Arsenic	3.7	0.43	RBC	YES	6.52	NO	
Barium	19.4	550.00	RBC*0.1	NO	25.8	NO	
Beryllium	0.11	0.15	RBC	NO	0.21	NO	
Cadmium	0.12	3.90	RBC*0.1	NO	0.54	NO	
Calcium	302	1,000.000	RDA	NO	310	NO	
Chromium, hexavalent	15	39	RBC*0.1	NO	28.4	NO	
Cobalt	0.82	470	RBC*0.1	NO	1.02	NO	
Copper	5.2	310	RBC*0.1	NO	22.4	NO	
Cyanide	0.09	160	RBC*0.1	NO	0.32	NO	
Iron	11,100	2,300	RBC*0.1	YES	22,400	NO	
Lead	12.9	400	OSWER	NO	15.4	NO	
Magnesium	93.6	1,000,000	RDA	NO	157	NO	
Manganese	65.3	39	RBC*0.1	YES	43.4	YES	COPC
Mercury	0.03	1	RBC*0.1	NO	0.09	NO	
Nickel	3.3	160	RBC*0.1	NO	3.88	NO	
Potassium	90.3	393,273	RDA	NO	142	NO	
Silver	1.9	39	RBC*0.1	NO		YES	
Sodium	69.1			NONE	70.4	NO	
Vanadium	29.9	55	RBC*0.1	NO	60.8	NO	
Zinc	22.8	2.300	RBC*0.1	NO	12.6	YES	
ORGANICS (µg/kg)							
Benzo(a)anthracene	94.6	880	RBC	NO	NA	NA	
Benzo(a)pyrene	144	88	RBC	YES	NA	NA	COPC
Benzo(b)fluoranthene	317	880	RBC	NO	NA	NA	
Benzo(g,h,i)perylene	121			NONE	NA	NA	COPC
Benzo(k)fluoranthene	219	8,800	RBC	NO	NA	NA	
Benzoic acid	60.3	31,000.000	RBC*0.1	NO	NA	NA	
bis(2-Ethylhexyl)phthalate	465	46,000	RBC	NO	NA	NA	
Chrysene	180	88.000	RBC	NO	NA	NA	
Fluoranthene	112	310.000	RBC*0.1	NO	NA	NA	
Indeno(1,2,3-cd)pyrene	125	880	RBC	NO	NA	NA	
Pyrene	99.8	230,000	RBC*0.1	NO	NA	NA	
Methylene Chloride	6.84	85.000	RBC	NO	NA	NA	
Toluene	2.36	1.600.000	RBC*0.1	NO	NA	NA	

BKG - background criteria
COPC - constituent of potential concern
NA - not applicable
OSWER - EPA Office of Solid Waste and Emergency Response criterion for lead (EPA, 1994c)
RBC - risk based concentration
RDA - recommended daily allowance

Table 6.1-8. Human Health Risk Assessment COPC Summary: FDTF Subsurface Soil (0 to 4 ft)

Parameter	Maximum Detect	Human Health Criteria	Human Health Criteria Source	> Human Health Criteria	2X Average Background	Maximum Detect >2X Background	COPC
INORGANICS (mg/kg)							
Aluminum	12.500	7.800	RBC*0.1	YES	11.800	>BKG	COPC
Antimony	1.4	3.1	RBC*0.1	NO	1.16	>BKG	
Arsenic	7.3	0.43	RBC	YES	5.74	>BKG	COPC
Barium	41	550	RBC*0.1	NO	26.6	>BKG	
Beryllium	0.2	0.15	RBC	YES	0.19	>BKG	COPC
Cadmium	0.64	3.90	RBC*0.1	NO	0.61	>BKG	
Calcium	735	1.000.000	RDA	NO	304	>BKG	
Chromium. hexavalent	45.8	39	RBC*0.1	YES	25	>BKG	COPC
Cobalt	1	470	RBC*0.1	NO	0.98	>BKG	
Copper	8.1	310	RBC*0.1	NO	13.9		
Cyanide	0.12	160	RBC*0.1	NO	0.37		
Iron	44.000	2.300	RBC*0.1	YES	21.000	>BKG	COPC
Lead	12.9	400	OSWER	NO	12.1	>BKG	
Magnesium	248	1,000.000	RDA	NO	159	>BKG	
Manganese	65.3	39	RBC*0.1	YES	39.4	>BKG	COPC
Mercury	0.05	0.78	RBC*0.1	NO	0.08		
Nickel	3.6	160.00	RBC*0.1	NO	3.32	>BKG	
Potassium	224	393.273	RDA	NO	138	>BKG	
Selenium	2.1	39	RBC*0.1	NO	0.98	>BKG	
Silver	1.9	39	RBC*0.1	NO		>BKG	
Sodium	89.8			YES	59.6	>BKG	COPC
Vanadium	84.6	55	RBC*0.1	YES	54.4	>BKG	COPC
Zinc	22.8	2.300	RBC*0.1	NO	9.04	>BKG	
				NO			
ORGANICS (µg/kg)				NO			
Benzo(a)anthracene	94.6	880	RBC	NO		>BKG	
Benzo(a)pyrene	144	88	RBC	YES		>BKG	COPC
Benzo(b)fluoranthene	317	880	RBC	NO		>BKG	
Benzo(g.h.i)perylene	121			YES		>BKG	COPC
Benzo(k)fluoranthene	219	8.800	RBC	NO		>BKG	
Benzoic acid	60.3	31.000.000	RBC*0.1	NO		>BKG	
bis(2-Ethylhexyl)phthalate	465	46.000	RBC	NO		>BKG	
Chrysene	180	88.000	RBC	NO		>BKG	
di-N-Butyl phthalate	194	780.000	RBC*0.1	NO		>BKG	
di-N-Octyl phthalate	335	160.000	RBC*0.1	NO		>BKG	
Fluoranthene	112	310.000	RBC*0.1	NO		>BKG	
Indeno(1,2,3-cd)pyrene	125	880	RBC	NO		>BKG	
Pyrene	99.8	230,000	RBC*0.1	NO		>BKG	
Methylene Chloride	9.55	85.000	RBC	NO		>BKG	

BKG - background criteria
COPC - constituent of potential concern
NA - not applicable
OSWER - EPA Office of Solid Waste and Emergency Response criterion for lead (EPA. 1994c)
RBC - risk based concentration
RDA - recommended daily allowance

Table 6.1-9. Human Health Risk Assessment COPC Summary: Background Surface Soil (0 to 1 ft)

Parameter	Maximum Detect	Human Health Criteria	Human Health Criteria Source	> Human Health Criteria	2X Average Background	Maximum Detect >2X Background	COPC
INORGANICS (mg/kg)							
Aluminum	9,900	7,800	RBC*0.1	YES	12,600	NA	COPC
Antimony	0.8	3.1	RBC*0.1	NO	1.33	NA	
Arsenic	6.9	0.43	RBC	YES	6.52	NA	COPC
Barium	26.6	550	RBC*0.1	NO	25.8	NA	
Beryllium	0.2	0.15	RBC	YES	0.21	NA	COPC
Cadmium	0.44	3.90	RBC*0.1	NO	0.54	NA	
Calcium	219	1,000,000	RDA	NO	310	NA	
Chromium	27	39	RBC*0.1	NO	28.4	NA	
Cobalt	0.75	470	RBC*0.1	NO	1.02	NA	
Copper	30.7	310	RBC*0.1	NO	22.4	NA	
Cyanide	0.22	160	RBC*0.1	NO	0.32	NA	
Iron	22,700	2,300	RBC*0.1	YES	22,400	NA	COPC
Lead	14.6	400	OSWER	NO	15.4	NA	
Magnesium	144	1,000,000	RDA	NO	157	NA	
Manganese	47.9	39	RBC*0.1	YES	43.4	NA	COPC
Mercury	0.09	0.78	RBC*0.1	NO	0.09	NA	
Nickel	2.90	160	RBC*0.1	NO	3.88	NA	
Potassium	118	393,273	RDA	NO	142	NA	
Sodium	79			YES	70.4	NA	COPC
Vanadium	59.3	55	RBC*0.1	YES	60.8	NA	COPC
Zinc	13.4	2,300	RBC*0.1	NO	12.6	NA	

BKG - background criteria
COPC - constituent of potential concern
NA - not applicable
OSWER - EPA Office of Solid Waste and Emergency Response criterion for lead (EPA, 1994c)
RBC - risk based concentration
RDA - recommended daily allowance

Table 6.1-10. Human Health Risk Assessment COPC Summary: Background Subsurface Soil (0 to 4 ft)

Parameter	Maximum Detect	Human Health Criteria	Human Health Criteria Source	> Human Health Criteria	2X Average Background	Maximum Detect >2X Background	COPC
INORGANICS (mg/kg)							
Aluminum	9,900	7,800	RBC*0.1	YES	11.800	NA	COPC
Antimony	0.8	3.1	RBC*0.1	NO	1.16	NA	
Arsenic	6.9	0.43	RBC	YES	5.74	NA	COPC
Barium	26.6	550	RBC*0.1	NO	26.6	NA	
Beryllium	0.2	0.15	RBC	YES	0.19	NA	COPC
Cadmium	0.66	3.90	RBC*0.1	NO	0.61	NA	
Calcium	219	1.000.000	RDA	NO	304	NA	
Chromium	27	39	RBC*0.1	NO	25	NA	
Cobalt	0.76	470	RBC*0.1	NO	0.98	NA	
Copper	30.7	310	RBC*0.1	NO	13.9	NA	
Cyanide	0.29	160	RBC*0.1	NO	0.37	NA	
Iron	22.700	2.300	RBC*0.1	YES	21.000	NA	COPC
Lead	14.6	400	OSWER	NO	12.10	NA	
Magnesium	144	1,000,000	RDA	NO	159	NA	
Manganese	47.9	39	RBC*0.1	YES	39.4	NA	COPC
Mercury	0.09	0.78	RBC*0.1	NO	0.08	NA	
Nickel	2.9	160	RBC*0.1	NO	3.32	NA	
Potassium	118	393.273	RDA	NO	138	NA	
Selenium	0.49	39	RBC*0.1	NO	0.98	NA	
Sodium	79			YES	59.6	NA	COPC
Vanadium	59.3	55	RBC*0.1	YES	54.4	NA	COPC
Zinc	13.4	2.300	RBC*0.1	NO	9.04	NA	

BKG - background criteria
COPC - constituent of potential concern
NA - not applicable
OSWER - EPA Office of Solid Waste and Emergency Response criterion for lead (EPA, 1994x)
RBC - risk based concentration
RDA - recommended daily allowance

Table 6.1-11. Derivation of Toxicity Screening Values for Screening Constituents as Ecological COPCs at FDTF

Constituent	Mammal Test Receptor	NOAEL (mg/kg/d)	Bird Test Receptor	NOAEL (mg/kg/d)	TSV Receptor	TSV (mg/kg/d)
Inorganics						
Aluminum	Mouse	1.93E+00 a	Ringed dove	1.10E+02 a	Mouse	1.93E+00
Antimony	Mouse	1.25E-01 a			Mouse	1.25E-01
Arsenic	Mouse	1.26E-01 a	Mallard duck	5.14E+00 a	Mouse	1.26E-01
Barium	Rat	5.10E+00 a	Chick	2.08E+01 a	Rat	5.10E+00
Beryllium	Rat	6.60E-01 a			Rat	6.60E-01
Cadmium	Rat	8.00E-03 a	Mallard duck	1.45E+00 a	Rat	8.00E-03
Calcium						None
Chromium	Rat	2.74E+03 a	Black duck	1.00E+00 a	Black duck	1.00E+00
Cobalt	Mouse	2.06E+01 c			Mouse	2.06E+01
Copper	Mink	1.17E+01 a	Chick	4.70E+01 a	Mink	1.17E+01
Cyanide	Rat	6.87E+01 a			Rat	6.87E+01
Iron						None
Lead	Rat	8.00E+00 a	Quail	1.13E+00 a	Quail	1.13E+00
Magnesium						None
Manganese	Rat	8.80E+01 a	Quail	9.77E+02 a	Rat	8.80E+01
Mercury	Mink	1.00E+00 a	Quail	4.50E-01 a	Quail	4.50E-01
Nickel	Rat	4.00E+01 a	Mallard duckling	7.74E+01 a	Rat	4.00E+01
Potassium						None
Selenium	Mouse	7.60E-02 a	Mallard duck	5.00E-01 a	Mouse	7.60E-02
Silver						None
Sodium						None
Vanadium	Rat	2.10E-01 a	Mallard duck	1.14E+01 a	Rat	2.10E-01
Zinc	Rat	1.60E+02 a	Leghorn chicken	1.45E+01 a	Leghorn chicken	1.45E+01

Table 6.1-11. Derivation of Toxicity Screening Values for Screening Constituents as Ecological COPCs at FDTF (Continued)

Constituent	Mammal test receptor	NOAEL (mg/kg/d)	Bird test receptor	NOAEL (mg/kg/d)	TSV receptor	TSV (mg/kg/d)
Organics						
PAHs						
Benzo(a)anthracene	Mouse	1.00E+00 b			Mouse	1.00E+00
Benzo(a)pyrene	Mouse	1.00E+00 a			Mouse	1.00E+00
Benzo(b)fluoranthene	Mouse	1.00E+00 b			Mouse	1.00E+00
Benzo(g,h,i)perylene	Mouse	1.00E+00 b			Mouse	1.00E+00
Benzo(k)fluoranthene	Mouse	1.00E+00 b			Mouse	1.00E+00
Chrysene	Mouse	4.76E+02 c			Mouse	4.76E+02
Fluoranthene	Mouse	1.32E+01 c			Mouse	1.32E+01
Indeno(1,2,3-c,d)pyrene	Mouse	1.00E+00 b			Mouse	1.00E+00
Pyrene	Mouse	7.50E+01 c			Mouse	7.50E+01
Phthalates						
Bis(2-ethylhexyl)phthalate	Mouse	1.83E+01 a	Ringed dove	1.10E+00 a	Ringed dove	1.10E+00
Di-n-butylphthalate	Mouse	5.50E+02 a	Ringed dove	1.10E-01 a	Ringed dove	1.10E-01
Di-n-octylphthalate	Mouse	5.50E+02 b			Mouse	5.50E+02
SVOCs						
Benzoic acid						None
VOCs						
Dichloromethane	Rat	5.85E+00 a			Rat	5.85E+00
Toluene	Mouse	2.60E+01 a			Mouse	2.60E+01

TSV = Toxicity Screening Value = NOAEL (mg/kg body wt/day) for mammal or bird test receptors, whichever is lower

a Opresko et al. 1996 (February data base); Note, rat is incorrectly listed as test species for toluene in database.

b NOAELs for mammals based on measurement for similar or related chemical species

c NOAELs from EPA (1996b)

Table 6.1-12. Ecological Risk-based Screening for Nonradionuclides in FDTF Surface Soil (0 to 1 ft)

Analyte (Units)	Maximum Detected Conc.[a]	Test Species Name[b]	Test Species Feeding Rate (kg/d)	Test Species Body Weight (kg)	Screening Intake Value (mg/kg bw/d)	Toxicity Screening Value (mg/kg bw/d)	2X Average Background Conc.[c]	COPC?[d]	Screening Results Basis for Rejection
Inorganics (mg/kg)									
Aluminum	5.11E+03	Mouse	5.50E-03	3.00E-02	9.37E+02	1.93E+00	1.26E+04	No	< 2x Bkg
Antimony	5.56E-01	Mouse	5.50E-03	3.00E-02	1.02E-01	1.25E-01	1.33E+00	No	< TSV
Arsenic	3.70E+00	Mouse	5.50E-03	3.00E-02	6.78E-01	1.26E-01	6.52E+00	No	< 2x Bkg
Barium	1.94E+01	Rat	2.80E-02	3.50E-01	1.55E+00	5.10E+00	2.58E+01	No	< TSV
Beryllium	1.07E-01	Rat	2.80E-02	3.50E-01	8.56E-03	6.60E-01	2.06E-01	No	< TSV
Cadmium	1.19E-01	Rat	2.80E-02	3.50E-01	9.52E-03	8.00E-03	5.40E-01	No	< 2x Bkg
Calcium	3.02E+02	None	--	--	None	None	3.10E+02	No	< 2x Bkg
Chromium	1.50E+01	Black duck	1.25E-01	1.25E+00	1.50E+00	1.00E+00	2.84E+01	No	< 2x Bkg
Cobalt	8.22E-01	Mouse	5.50E-03	3.00E-02	1.51E-01	2.06E+01	1.02E+00	No	< TSV
Copper	5.20E+00	Mink	1.37E-01	1.00E+00	7.12E-01	1.17E+01	2.24E+01	No	< TSV
Cyanide	9.10E-02	Rat	2.80E-02	3.50E-01	7.28E-03	6.87E+01	3.20E-01	No	< TSV
Iron	1.11E+04	None	--	--	None	None	2.24E+04	No	< 2x Bkg
Lead	1.29E+01	Japanese quail	1.69E-02	1.50E-01	1.45E+00	1.13E+00	1.54E+01	No	< 2x Bkg
Magnesium	9.36E+01	None	--	--	None	None	1.57E+02	No	< 2x Bkg
Manganese	6.53E+01	Rat	2.80E-02	3.50E-01	5.22E+00	8.80E+01	4.34E+01	No	< TSV
Mercury	3.00E-02	Japanese quail	1.69E-02	1.50E-01	3.38E-03	4.50E-01	8.70E-02	No	< TSV
Nickel	3.30E+00	Rat	2.80E-02	3.50E-01	2.64E-01	4.00E+01	3.88E+00	No	< TSV
Potassium	9.03E+01	None	--	--	None	None	1.42E+02	No	< 2x Bkg
Silver	1.90E+00	None	--	--	None	None	ND	Yes	
Sodium	6.91E+01	None	--	--	None	None	7.04E+01	No	< 2x Bkg
Vanadium	2.99E+01	Rat	2.80E-02	3.50E-01	2.39E+00	2.10E-01	6.08E+01	No	< 2x Bkg
Zinc	2.28E+01	Leghorn chicken	1.23E-01	1.94E+00	1.45E+00	1.45E+01	1.26E+01	No	< TSV

Table 6.1-12. Ecological Risk-based Screening for Nonradionuclides in FDTF Surface Soil (0-1 foot) (Continued)

Analyte	Maximum Detected Conc.[a]	Test Species Name[b]	Test Species Feeding Rate (kg/d)	Test Species Body Weight (kg)	Screening Intake Value (mg/kg bw/d)	Toxicity Screening Value (mg/kg bw/d)	2X Average Background Conc.[g]	Screening Results COPC?[h]	Screening Results Basis for Rejection
Organics (µg/kg)									
PAHs									
Benzo(a)anthracene	9.46E+01	Mouse	5.50E-03	3.00E-02	1.73E-02	1.00E+00	--	No	< TSV
Benzo(a)pyrene	1.44E+02	Mouse	5.50E-03	3.00E-02	2.64E-02	1.00E+00	--	No	< TSV
Benzo(b)fluoranthene	3.17E+02	Mouse	5.50E-03	3.00E-02	5.81E-02	1.00E+00	--	No	< TSV
Benzo(g,h,i)perylene	1.21E+02	Mouse	5.50E-03	3.00E-02	2.22E-02	1.00E+00	--	No	< TSV
Benzo(k)fluoranthene	2.19E+02	Mouse	5.50E-03	3.00E-02	4.02E-02	1.00E+00	--	No	< TSV
Chrysene	1.80E+02	Mouse	5.50E-03	3.00E-02	3.30E-02	4.76E+02	--	No	< TSV
Fluoranthene	1.12E+02	Mouse	5.50E-03	3.00E-02	2.05E-02	1.32E+01	--	No	< TSV
Indeno(1,2,3-c,d)pyrene	1.25E+02	Mouse	5.50E-03	3.00E-02	2.29E-02	1.00E+00	--	No	< TSV
Pyrene	9.98E+01	Mouse	5.50E-03	3.00E-02	1.83E-02	7.50E+01	--	No	< TSV
Phthalates									
Bis(2-ethylhexyl)phthalate	4.65E+02	Ringed dove	1.70E-02	1.55E-01	5.10E-02	1.10E+00	--	No	< TSV
SVOCs									
Benzoic acid	6.03E+01	None	--	--	None	None	--	Yes	
VOCs									
Dichloromethane	6.84E+00	Rat	2.80E-02	3.50E-01	5.47E-04	5.85E+00	--	No	< TSV
Toluene	2.36E+00	Mouse	5.50E-03	3.00E-02	4.33E-04	2.60E+01	--	No	< TSV

[a] Data from summary statistics tables in Section 6.1, where units also reported as mg/kg for inorganics and µg/kg for organics

[b] Test species from Opresko et al. 1996 (February data base); Note, rat is incorrectly listed as test species for toluene in database.

[c] Feeding rates from Opresko et al. (1994), except Leghorn chicken, which is from Sample et al. (1996)

[d] Body weights from Opresko et al. 1996 (February data base); where published values vary, one body weight chosen as standard

[e] Screening Intake Value = Cs_{max} x Feeding Rate x (1/Bodyweight), where Cs_{max} = maximum detected concentration

[f] TSV = Toxicity Screening Value = lower of NOAEL (mg/kg body-weight/day) for mammal and bird test species from Opresko et al. (1995) and other sources

[g] The average background concentration in screen is calculated using only detected concentrations, as in Section 4.

[h] Constituent is not an ecological COPC if TSV > SIV or 2 x average background > maximum detected concentration

-- = Not applicable; ND = Not detected

Table 6.1-13. Ecological Risk-based Screening for Nonradionuclides in FDTF Subsurface Soil (0 to 4 ft)

Analyte	Maximum Detected Conc.[a]	Test Species Name[b]	Test Species Feeding Rate (kg/d)	Test Species Body Weight (kg)[d]	Screening Intake Value (mg/kg bw/d)	Toxicity Screening Value (mg/kg bw/d)[f]	2X Average Background Conc.[g]	Screening Results	
								COPC?[h]	Basis for Rejection
Inorganics (mg/kg)									
Aluminum	1.25E+04	Mouse	5.50E-03	3.00E-02	2.29E+03	1.93E+00	1.18E+04	Yes	
Antimony	1.40E+00	Mouse	5.50E-03	3.00E-02	2.57E-01	1.25E-01	1.16E+00	Yes	
Arsenic	7.30E+00	Mouse	5.50E-03	3.00E-02	1.34E+00	1.26E-01	5.74E+00	Yes	
Barium	4.10E+01	Rat	2.80E-02	3.50E-01	3.28E+00	5.10E+00	2.66E+01	No	< TSV
Beryllium	2.01E-01	Rat	2.80E-02	3.50E-01	1.61E-02	6.60E-01	1.94E-01	No	< TSV
Cadmium	6.38E-01	Rat	2.80E-02	3.50E-01	5.10E-02	8.00E-03	6.14E-01	Yes	
Calcium	7.35E+02	None	--	--	None	None	3.04E+02	Yes	
Chromium	4.58E+01	Black duck	1.25E-01	1.25E+00	4.58E+00	1.00E+00	2.50E+01	Yes	
Cobalt	1.00E+00	Mouse	5.50E-03	3.00E-02	1.83E-01	2.06E+01	9.80E-01	No	< TSV
Copper	8.10E+00	Mink	1.37E-01	1.00E+00	1.11E+00	1.17E+01	1.39E+01	No	< TSV
Cyanide	1.15E-01	Rat	2.80E-02	3.50E-01	9.20E-03	6.87E+01	3.66E-01	No	< TSV
Iron	4.40E+04	None	--	--	None	None	2.10E+04	Yes	
Lead	1.29E+01	Japanese quail	1.69E-02	1.50E-01	1.45E+00	1.13E+00	1.21E+01	Yes	
Magnesium	2.48E+02	None	--	--	None	None	1.59E+02	Yes	
Manganese	6.53E+01	Rat	2.80E-02	3.50E-01	5.22E+00	8.80E+01	3.94E+01	No	< TSV
Mercury	5.20E-02	Japanese quail	1.69E-02	1.50E-01	5.86E-03	4.50E-01	8.24E-02	No	< TSV
Nickel	3.60E+00	Rat	2.80E-02	3.50E-01	2.88E-01	4.00E+01	3.32E+00	No	< TSV
Potassium	2.24E+02	None	--	--	None	None	1.38E+02	Yes	
Selenium	2.10E+00	Mouse	5.50E-03	3.00E-02	3.85E-01	7.60E-02	9.78E-01	Yes	
Silver	1.90E+00	None	--	--	None	None	ND	Yes	
Sodium	8.98E+01	None	--	--	None	None	5.96E+01	Yes	
Vanadium	8.46E+01	Rat	2.80E-02	3.50E-01	6.77E+00	2.10E-01	5.44E+01	Yes	
Zinc	2.28E+01	Leghorn chicken	1.23E-01	1.94E+00	1.45E+00	1.45E+01	9.04E+00	No	< TSV

Table 6.1-13. Ecological Risk-based Screening for Nonradionuclides in FDTF Subsurface Soil (0 to 4 ft) (Continued)

Analyte	Maximum Detected Conc.[a]	Test Species Name[b]	Test Species Feeding Rate (kg/d)	Test Species Body Weight (kg)[d]	Screening Intake Value (mg/kg bw/d)	Toxicity Screening Value (mg/kg bw/d)[f]	2X Average Background Conc.[g]	Screening Results	
								COPC?[h]	Basis for Rejection
Organics (µg/kg)									
PAHs									
Benzo(a)anthracene	9.46E+01	Mouse	5.50E-03	3.00E-02	1.73E-02	1.00E+00	--	No	< TSV
Benzo(a)pyrene	1.44E+02	Mouse	5.50E-03	3.00E-02	2.64E-02	1.00E+00	--	No	< TSV
Benzo(b)fluoranthene	3.17E+02	Mouse	5.50E-03	3.00E-02	5.81E-02	1.00E+00	--	No	< TSV
Benzo(g,h,i)perylene	1.21E+02	Mouse	5.50E-03	3.00E-02	2.22E-02	1.00E+00	--	No	< TSV
Benzo(k)fluoranthene	2.19E+02	Mouse	5.50E-03	3.00E-02	4.02E-02	1.00E+00	--	No	< TSV
Chrysene	1.80E+02	Mouse	5.50E-03	3.00E-02	3.30E-02	4.76E+02	--	No	< TSV
Fluoranthene	1.12E+02	Mouse	5.50E-03	3.00E-02	2.05E-02	1.32E+01	--	No	< TSV
Indeno(1,2,3-c,d)pyrene	1.25E+02	Mouse	5.50E-03	3.00E-02	2.29E-02	1.00E+00	--	No	< TSV
Pyrene	9.98E+01	Mouse	5.50E-03	3.00E-02	1.83E-02	7.50E+01	--	No	< TSV
Phthalates									
Bis(2-ethylhexyl)phthalate	4.65E+02	Ringed dove	1.70E-02	1.55E-01	5.10E-02	1.10E+00	--	No	< TSV
Di-n-butylphthalate	1.94E+02	Ringed dove	1.70E-02	1.55E-01	2.13E-02	1.10E-01	--	No	< TSV
Di-n-octylphthalate	3.35E+02	Mouse	5.50E-03	3.00E-02	6.14E-02	5.50E+02	--	No	< TSV
SVOCs									
Benzoic acid	6.03E+01	None	--	--	None	None	--	Yes	
VOCs									
Dichloromethane	9.55E+00	Rat	2.80E-02	3.50E-01	7.64E-04	5.85E+00	--	No	< TSV
Toluene	2.36E+00	Mouse	5.50E-03	3.00E-02	4.33E-04	2.60E+01	--	No	< TSV

[a] Data from summary statistics tables in Section 6.1, where units also reported as mg/kg for inorganics and µg/kg for organics
[b] Test species from Opresko et al. 1996 (February data base); Note, rat is incorrectly listed as test species for toluene in database.
[c] Feeding rates from Opresko et al. (1994), except Leghorn chicken, which is from Sample et al. (1996)
[d] Body weights from Opresko et al. 1996 (February data base); where published values vary, one body weight chosen as standard
[e] Screening Intake Value = Cs_{max} x Feeding Rate x (1/Bodyweight), where Cs_{max} = maximum detected concentration
[f] TSV = Toxicity Screening Value = lower of NOAEL (mg/kg body weight/day) for mammal and bird test species from Opresko et al. (1995) and other sources
[g] The average background concentration in screen is calculated using only detected concentrations, as in Section 4.
[h] Constituent is not an ecological COPC if TSV > SIV or 2 x average background > maximum detected concentration
-- = Not applicable; ND = Not detected

Table 6.1-14. Screening of Food-to-Tissue Bioaccumulation Factors for Constituents at FDTF

Constituent	Soil-to-Animal Transfer		BAF > 10?
	BAF_{inv}	BAF_{mamm}	COPC?
Inorganics			
Aluminum	7.50E-02 a	7.50E-02 a	No
Antimony	5.00E-02 a	5.00E-02 a	No
Arsenic	6.60E-03 a	1.00E-01 a	No
Barium	7.50E-03 a	7.50E-03 a	No
Beryllium	5.00E-02 a	5.00E-02 a	No
Cadmium	1.10E+01 a	2.80E-02 a	Yes
Calcium	3.50E-02 c	3.50E-02 c	No
Chromium	1.60E-01 a	2.80E-01 a	No
Cobalt	1.00E+00 a	1.00E+00 a	No
Copper	1.60E-01 a	5.00E-01 a	No
Cyanide	0.00E+00 a	0.00E+00 a	No
Iron	1.00E+00 d	1.00E+00 d	No
Lead	see note b	1.50E-02 a	No
Magnesium	2.50E-01 c	2.50E-01 c	No
Manganese	2.00E-02 a	2.00E-02 a	No
Mercury	3.40E-01 a	1.30E+01 a	Yes
Nickel	2.30E-01 a	3.00E-01 a	No
Potassium	1.00E+00 d	1.00E+00 d	No
Selenium	7.60E-01 a	7.50E-01 a	No
Silver	1.50E-01 a	1.50E-01 a	No
Sodium	2.75E+00 c	2.75E+00 c	No
Vanadium	1.30E-01 a	1.30E-01 a	No
Zinc	1.80E+00 a	5.00E+00 a	No
Organics			
PAHs			
Benzo(a)anthracene	5.00E-02 a	7.60E-01 a	No
Benzo(a)pyrene	5.00E-02 a	1.50E+00 a	No
Benzo(b)fluoranthene	5.00E-02 a	1.90E+00 a	No
Benzo(g,h,i)perylene	5.00E-02 a	6.00E+00 a	No
Benzo(k)fluoranthene	5.00E-02 a	1.90E+00 a	No
Chrysene	5.00E-02 a	7.60E-01 a	No
Fluoranthene	5.00E-02 a	1.30E-01 a	No
Indeno(1,2,3-c,d)pyrene	5.00E-02 a	6.00E+00 a	No
Pyrene	5.00E-02 a	3.00E-01 a	No

Table 6.1-14. Screening of Food-to-Tissue Bioaccumulation Factors for Constituents at FDTF (Continued)

Constituent	Soil-to-Animal Transfer		BAF > 10?
	BAF_{inv}	BAF_{mamm}	COPC?
Phthalates			
Bis(2-ethylhexyl)phthalate	5.00E-02 a	1.90E-01 a	No
Di-n-butylphthalate	5.00E-02 a	2.40E-01 a	No
Di-n-octylphthalate	5.00E-02 a	2.40E+03 a	Yes
SVOCs			
Benzoic acid	5.00E-02 c	1.86E-06 c	No
VOCs			
Dichloromethane	5.00E-02 a	3.00E-05 a	No
Toluene	5.00E-02 a	7.60E-04 a	No

BAF= Bioaccumulation Factor (unitless); inv = invertebrate, mamm = mammal

a HAZWRAP (1994)

b Calcium-dependent (HAZWRAP 1994): see footnote to Appendix D-2

c Travis and Arms (1988); for K_{ow}s see Table D-2

d Inorganic default value = 1.0, organic default value = 0.05 (HAZWRAP 1994)

Table 6.1-15. COPC Summary: FDTF Surface Soil (0 to 1 ft)

Parameter	Exceeds Human Healt Screening	Exceeds Ecological Screening	Maximum Detect	RME Concentration
INORGANICS (mg/kg)				
Aluminum			5.110	4.980
Antimony			0.56	0.56
Arsenic			3.7	3.7
Barium			19.4	19.4
Beryllium			0.11	0.10
Cadmium			0.12	0.11
Calcium			302	302
Chromium. hexavalent			15	14
Cobalt			0.82	0.82
Copper			5.2	5.2
Cyanide			0.09	0.09
Iron			11,100	10.900
Lead			12.9	12.9
Magnesium			93.6	93.6
Manganese	x		65.3	52.2
Mercury			0.03	0.03
Nickel			3.30	3.30
Potassium			90.3	90.3
Silver		x	1.90	1.35
Sodium			69.1	67.7
Vanadium			29.9	27.4
Zinc			22.8	22.8
ORGANICS (mg/kg)				
Benzo(a)anthracene			94.6	94.6
Benzo(a)pyrene	x		144	144
Benzo(b)fluoranthene			317	317
Benzo(g.h.i)perylene	x		121	121
Benzo(k)fluoranthene			219	219
Benzoic acid		x	60.3	60.3
bis(2-Ethylhexyl)phthalate			465	357
Chrysene			180	180
Fluoranthene			112	112
Indeno(1,2,3-cd)pyrene			125	125
Pyrene			99.8	99.8
Methylene Chloride			6.84	6.43
Toluene			2.36	2.36

COPC - constituent of potential concern
RME - reasonable maximum concentration; this concentration was used in the risk assessments

Table 6.1-16. COPC Summary: FDTF Surface Soil (0 to 4 ft)

Parameter	Exceeds Human Healt Screening	Exceeds Ecological Screening	Maximum Detect	RME Concentration
INORGANICS (mg/kg)				
Aluminum	x	x	12.500	10.400
Antimony		x	1.4	1.4
Arsenic	x	x	7.3	6
Barium			41	28.4
Beryllium	x		0.20	0.15
Cadmium		x	0.64	0.45
Calcium		x	735	512
Chromium. hexavalent	x	x	45.8	38.5
Cobalt			1	0.81
Copper			8.10	5.62
Cyanide			0.12	0.12
Iron	x	x	44,000	44.000
Lead		x	12.9	11.3
Magnesium		x	248	202
Manganese	x		65.3	54
Mercury			0.05	0.05
Nickel			3.60	3.04
Potassium		x	224	163
Selenium		x	2.1	2.1
Silver		x	1.9	0.86
Sodium	x	x	89.8	70.5
Vanadium	x	x	84.6	84.6
Zinc			22.8	14.6
ORGANICS (mg/kg)				
Benzo(a)anthracene			94.6	94.6
Benzo(a)pyrene	x		144	144
Benzo(b)fluoranthene			317	317
Benzo(g.h.i)perylene	x		121	121
Benzo(k)fluoranthene			219	219
Benzoic acid		x	60.3	60.3
bis(2-Ethylhexyl)phthalate			465	294
Chrysene			180	180
di-N-Butyl phthalate			194	194
di-N-Octyl phthalate			335	335
Fluoranthene			112	112
Indeno(1,2,3-cd)pyrene			125	125
Pyrene			99.8	99.8
Methylene Chloride			9.55	6.79

COPC - constituent of potential concern
RME - reasonable maximum concentration; this concentration was used in the risk assessments

Table 6.1-17. COPC Summary: Background Surface Soil (0 to 1 ft)

Parameter	Exceeds Human Health Screening	Maximum Detect	RME Concentration
INORGANICS (mg/kg)			
Aluminum	x	9,900	9,520
Antimony		0.8	0.8
Arsenic	x	6.9	6.9
Barium		26.6	26.6
Beryllium	x	0.2	0.2
Cadmium		0.44	0.4
Calcium		219	215
Chromium		27	27
Cobalt		0.75	0.67
Copper		30.7	30.7
Cyanide		0.22	0.22
Iron	x	22,700	19,400
Lead		14.6	14.6
Magnesium		144	121
Manganese	x	47.9	47.9
Mercury		0.09	0.08
Nickel		2.9	2.8
Potassium		118	118
Sodium	x	79	79
Vanadium	x	59.3	59.3
Zinc		13.4	13.4

COPC - constituent of potential concern
RME - reasonable maximum concentration; this concentration was used in the risk assessments

Table 6.1-18. COPC Summary: Background Subsurface Soil (0 to 4 ft)

Parameter	Exceeds Human Health Screening	Maximum Detect	RME Concentration
INORGANICS (mg/kg)			
Aluminum	x	9900.00	7630.00
Antimony		0.80	0.80
Arsenic	x	6.90	5.32
Barium		26.60	20.40
Beryllium	x	0.20	0.13
Cadmium		0.66	0.61
Calcium		219.00	185.00
Chromium		27.00	25.70
Cobalt		0.76	0.58
Copper		30.70	24.20
Cyanide		0.29	0.29
Iron	x	22700.00	22700.00
Lead		14.60	8.51
Magnesium		144.00	101.00
Manganese	x	47.90	47.90
Mercury		0.09	0.07
Nickel		2.90	2.37
Potassium		118.00	99.30
Selenium		0.49	0.49
Sodium	x	79.00	59.30
Vanadium	x	59.30	59.30
Zinc		13.40	10.20

COPC - constituent of potential concern
RME - reasonable maximum concentration; this concentration was used in the risk assessments

(This page intentionally left blank)

6.2 Human Health Risk Assessment

The human health risk assessment characterizes both the potential risk from exposure to carcinogenic substances and adverse health effects from noncarcinogens to human receptors exposed to unit-related constituents under current and future land use conditions. The Environmental Protection Agency (EPA) *Risk Assessment Guidance for Superfund* (RAGS) (EPA, 1989a) and Region IV *Supplemental Guidance to RAGS* (EPA, 1995d) are used as primary guidance for the human health risk assessment. Using this process, the human health risk assessment has been organized into the following sections:

- Human Health Constituents of Potential Concern and Exposure Pathways (Section 6.2.1)
- Exposure Assessment (Section 6.2.2)
- Toxicity Assessment (Section 6.2.3)
- Risk Characterization (Section 6.2.4)
- Summary of the Human Health Risk Characterization (Section 6.2.5)
- Uncertainty (Section 6.2.6)

6.2.1 Human Health Constituents of Potential Concern and Exposure Pathways

The human health constituent of potential concern (COPC) selection process described in Part B of Section 6.1.2 is used to screen the initial COPCs identified in each exposure group. The human health COPCs remaining from the selection process are identified below.

Data for each exposure group are evaluated with respect to the data qualifiers identified in the Quality Control Summary Report (QCSR) (WSRC, 1996b). A description of the relevant data qualifiers and their associated interpretation for use in the risk assessment is provided in the QCSR. Tables 6.1-7 through 6.1-10 list constituents eliminated because their maximum concentrations are less the risk-based concentration (RBC) levels. Developed by the EPA, the RBCs include constituent concentrations in soil that produce threshold risk (i.e., cancer risk of 1E-06 or a hazard quotient [HQ] of 1). An HQ of 0.1 is used in the screening process to account for potential additive effects of noncarcinogenic constituents.

Tables 6.1-7 through 6.1-10 list essential nutrients that are eliminated because their maximum concentration is less than the recommended daily allowance (RDA) or safe and

adequate daily intake (SADI). Daily intakes for essential nutrients are calculated based on an ingestion rate of 200 mg/kg soil.

The maximum concentration of naturally occurring and anthropogenic inorganics that exceeded the RBC and essential nutrient screens is compared to two times (2X) the average background concentration. A constituent is eliminated as a COPC if the maximum concentration is less than 2X the background average concentration in each medium. To avoid potential bias of the data, nondetected values are not used to calculate the average background concentration.

Tables 6.1-7 through 6.1-10 list all constituents that were eliminated because the maximum detected concentration is less than 2X the average background concentrations. Tables 6.1-15 through 6.1-18 present the COPCs to be used in the human health risk assessment that are identified for soil as a result of the screening process. Tables 6.1-1 through 6.1-6 provide the statistical summary information including frequency of detection, detection limits, minimum detected value, maximum detected value, 95 percent upper confidence limit (95 UCL), and the exposure concentration for the COPCs remaining in soil after the screening process.

6.2.2 Exposure Assessment

The objective of the exposure assessment is to estimate the type and magnitude of the potential human exposures to the COPCs identified in Section 6.2.1. For a given receptor group (i.e., workers, residents), this result is an estimate of chronic daily intake or dose that may occur from exposure to the COPCs in the soil. In identifying primary pathways of exposure, current and future land uses of the unit and surrounding area are considered.

The exposure assessment, in conjunction with the subsequent toxicity assessment (discussed in Section 6.2.3), supports the characterization of potential risks to human health (discussed in Section 6.2.4). Information developed in this section includes land use assumptions, potential receptors, exposure pathways, the concentration of the COPCs at points of human exposure, and receptor intakes (doses). Reasonable maximum exposure (RME) estimates are presented for chemical intakes within each scenario. Uncertainties of the exposure assessment are discussed in Section 6.2.6.

6.2.2.1 Land Use Assumptions and Potentially Exposed Receptors

This section describes land uses at the Fire Department Hose Training Facility (FDTF) and the human receptors that may be exposed to unit-related constituents. Potential receptors are expected to differ for the current and future land use scenarios. The possible receptor under the current land use scenario includes the known on-unit worker. The possible receptors under the future land use scenario include the on-unit industrial worker and the on-unit resident (adult and child).

6.2.2.1.1 Current Land Use

Currently, the FDTF is inactive; it was formerly a fire training area where flammable materials were ignited and then extinguished. The top 0 to 0.3 m (0 to 1 ft) of soil has been removed and replaced with clean fill, and the samples used in the risk assessment represent this condition. Access to the Savannah River Site (SRS) is controlled by the Department of Energy (DOE). Once within the SRS boundaries, access to the FDTF is not restricted. Paved roads exist near the FDTF, and access on foot is easy and unrestricted. The surrounding area is partially developed, and there are wooded areas nearby. Because the area is developed, there is human activity in the area (e.g., grass is mowed; there are nearby structures and roads). Based on a recent unit visit, there is no evidence to suggest that there is any appreciable activity or potential for exposure within the FDTF area itself. Signs of casual trespassing (e.g., people, litter, campsites) were not observed during the unit visit.

Groundwater in the vicinity of the FDTF is not currently being used for consumption by on-unit workers. The potentially exposed receptors that are evaluated for the current land use scenario are known on-unit workers. An on-unit worker may be a researcher, a groundwater sampler, or personnel in close proximity to the unit.

The receptor population that is considered for current exposure to constituents at the FDTF is the on-unit worker. Known on-unit workers are defined as SRS-related individuals who visit the unit under actual land use conditions on an infrequent or occasional basis (e.g., a researcher associated with SRS who uses the unit as an outdoor laboratory). These receptors may be involved in the excavation or collection of contaminated media; however, they would be using SRS procedures and protocols for sampling at hazardous waste units.

6.2.2.1.2 Future Land Use

According to the Savannah River Site: Future Use Project Report (DOE, 1996), "residential uses of SRS land should be prohibited:" In this report, the FDTF is identified as a "current industrial (with buffer)" area. The future use recommendation contained in the Future Use Project Report is for "future industrial (non-nuclear)". In the future, this unit is most likely to remain as it is currently: an open grassy area. No residential use of the FDTF is anticipated for the future.

If land use conditions remain industrial, the only future human receptors are considered to be industrial workers. However, until deed notifications are established, the possibility exists that new buildings could be constructed, and the area at or near the FDTF could be converted to residential use in the future. Although residential development is unlikely, a hypothetical residential exposure scenario for both adults and children is presented for comparative purposes. This is in accordance with EPA Region IV guidance (EPA, 1995d) which states that residential development cannot be entirely ruled out. However, the future use of the land is not likely to change from current use.

Because institutional controls preventing the excavation of contaminated soils cannot be guaranteed, the future scenario assumes the possible excavation of soils from depths of 0 to 1.2 m (0 to 4 ft) and subsequent spreading of those soils on the surface as the result of construction activities. Approximately 1.2 m (4 ft) is considered a reasonable depth for a residential contractor to excavate during typical construction in the SRS area.

The potentially exposed receptors that are evaluated for the future land use scenario include:

- Hypothetical on-unit industrial worker
- Hypothetical on-unit resident (age adjusted adult/child)

6.2.2.1.2.1 Hypothetical On-Unit Industrial Worker

The hypothetical on-unit industrial exposure scenario addresses long-term risks to workers who are exposed to unit-related constituents while working within an industrial setting. The hypothetical on-unit industrial worker is an adult who works in an outdoor industrial setting for the majority of his time.

6.2.2.1.2.2 Hypothetical On-Unit Resident (Adult & Child)

The hypothetical on-unit resident exposure scenario evaluates long term risks to individuals expected to have unrestricted use of the unit. It assumes that residents live on-unit and are chronically exposed (both indoors and outdoors) to unit-related constituents. The hypothetical on-unit resident includes adults and children who are exposed to all the contaminated media.

6.2.2.2 Identification of Potential Human Exposure Pathways

Exposure pathways describe "the course a chemical or physical agent takes from the source to the exposed individual" (EPA, 1989a). Four components comprise an exposure pathway:

- A source and mechanism of constituent release
- A retention or transport medium (or media)
- A point of potential human contact with the contaminated medium (the exposure point)
- An exposure route (e.g., ingestion, dermal contact, and inhalation)

If any of these elements is missing, the pathway is incomplete and is not considered further in the risk assessment. A pathway is complete when all four elements are present to permit potential exposure of a receptor to a source of contamination. Quantification of some potentially complete pathways may not be warranted because of minimal contribution to risk relative to other major pathways. The dominant pathways from constituent sources and exposure media to human receptors potentially exposed to COPCs at the unit are presented in a graphical form as a Conceptual Site Model (CSM) (Figure 6.1-1). As shown in the model, only soil and produce pathways are considered in the human health risk assessment.

The primary source of contamination from the FDTF is soil that is contaminated as a result of past fire training activities. The potential on-unit exposure points for soil constituents are surface soil or subsurface soil that has been excavated and redistributed onto the surface. Constituents may be released from the soil via windblown dust and vegetative uptake. The potential for leaching to groundwater is considered to be minimal, as discussed in Section 5. Volatile emissions from soil are not evaluated further, since there are no volatile COPCs in the soil at the FDTF. As noted, there are no surface water or sediment features at or in the immediate vicinity of the FDTF, and groundwater is not included in this investigation.

6.2.2.2.1 Known On-Unit Worker

The following are the primary pathways proposed for the evaluation of exposures to the known on-unit worker:

- Exposure via direct contact with contaminated soils through ingestion, dermal contact, and inhalation of windblown dust

6.2.2.2.2 Hypothetical On-Unit Industrial Worker

The primary pathways proposed for the evaluation of exposures to the hypothetical on-unit industrial worker include:

- Exposure via direct contact with contaminated soils through ingestion, dermal contact, and inhalation of windblown dust

6.2.2.2.3 Hypothetical On-Unit Resident (Adult & Child)

The primary pathways proposed for the evaluation relative to the hypothetical on-unit resident include:

- Exposure via direct contact with contaminated soils through ingestion, dermal contact, and inhalation of windblown dust, and ingestion of homegrown produce

6.2.2.3 Derivation of Exposure Concentrations

Exposure concentrations are the concentrations of constituents in a given medium to which human receptors are exposed at the point of contact. Exposure concentrations are used to calculate the constituent intakes or doses for human receptors based on methodology provided in EPA risk assessment guidance (EPA, 1989a and 1991). The calculation of constituent intakes or doses for the human receptors is discussed in Section 6.2.2.4.

Because of the uncertainty associated with any estimate of exposure concentration, the 95 UCL of the mean or the maximum constituent concentration (whichever is lower) is used to determine the exposure concentration in each medium (EPA, 1989a). This exposure concentration is the RME concentration. Appendix C presents the procedure and summary statistics for calculating the 95 UCL and the RME concentrations for each medium. Tables 6.1-7 through 6.1-10 present the statistical data used to evaluate the COPCs in the risk assessment.

6.2.2.4 Development of Constituent Intakes

Human intake factors (HIFs) are calculated based on the RME concentrations for each principal complete pathway. The RMEs represent the highest exposure that is reasonably expected to occur in a small, but definable "high-end" segment of the potentially exposed population. Constituent-specific intakes, or doses, are calculated for the receptors and exposure pathways identified for quantitative evaluation in Sections 6.2.2.1 and 6.2.2.2, respectively. The development of constituent intakes is based on EPA methodology presented in EPA's *Risk Assessment Guidance for Superfund* (EPA, 1989a) and the Office of Solid Waste and Emergency Response (OSWER) Directive 9285.6-03 (EPA, 1991).

Under the current and future land use scenarios, estimated intakes are calculated for the known on-unit worker, hypothetical on-unit industrial worker, and hypothetical on-unit resident for exposure to constituents in the soil previously described in Section 6.2.2.2. The constituent-specific intakes are developed for the principal complete exposure pathways (EPA, 1992b) and are presented with risk calculations in Appendix C. RME exposure point concentrations upon which the intake and dose are based are presented in Tables 6.1-15 through 6.1-18. The exposure parameters and intake equations are discussed below and are provided in Appendix C.

6.2.2.4.1 Exposure Equations

Appendix C presents the equations used to calculate constituent-specific RME intake or dose. The appendix includes equations for exposure to soil (dermal contact, ingestion, and inhalation of particulates) and ingestion of homegrown produce grown in the unit soil.

6.2.2.4.2 Exposure Parameters

The RME intakes or doses are calculated by using parameters that represent the 95th percentile for a population or by using best professional judgment in the absence of unit-specific data (EPA, 1995a). Exposure parameters are provided for each complete exposure pathway as defined above. Appendix C presents the values used for the exposure parameters and the technical basis on which parameter values are based. Additional input parameters required to calculate intake or dose include the RME concentrations that are described in

Section 6.2.2.3 are presented in Appendix C (e.g., dermal permeability coefficients and soil-to-plant transfer factors).

6.2.3 Toxicity Assessment

The toxicity assessment presents and discusses constituent-specific quantitative dose-response data for the COPCs identified in Section 6.2.1. The objectives of the toxicity assessment are to evaluate the inherent toxicity of the substances under investigation and to identify and select toxicity values for use in risk characterization. For the assessment of human health risks from exposure to chemicals and radionuclides, the following toxicity values are of principal importance:

- Reference doses (RfDs) for oral exposure; acceptable intake values for chronic exposure (noncancer effects)
- Reference concentrations (RfCs) for inhalation exposure; acceptable intake values for chronic exposure (noncancer effects); these have been converted to inhalation RfDs by multiplying by 20 m^3/day and dividing by 70 kg
- Cancer slope factors (CSFs) for oral and inhalation exposure routes

Toxicity information is preferably obtained from the Integrated Risk Information System (IRIS) (EPA, 1996b). If values are not available from IRIS, the Health Effects Assessment Summary Tables (HEAST) (EPA, 1995a) or provisional toxicity values developed by the EPA's Superfund Health Risk Technical Support Center-National Center for Environmental Assessment (SHRTSC-NCEA) are used.

Appendix C presents the toxicological data used in the risk assessment for the COPCs, and abbreviated toxicity profiles for COPCs. Appendix C includes a table of toxicity values that briefly summarizes carcinogenic toxicity data for each of the COPCs, including weight-of-evidence classifications, Cancer Slope Factors (CSFs), and target organs.

6.2.3.1 Chemical Toxicity

6.2.3.1.1 Noncarcinogens

All three COPCs for surface soil, and eight of the ten COPCs for subsurface soil are toxicants that are assigned an RfD for evaluating noncancer effects. An RfD, reported as a chemical intake (mg/kg-day), is the toxicity value used most often in evaluating noncarcinogenic

effects. RfDs are developed and verified for specific chemicals by the EPA, and are defined as "an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime" (EPA, 1989a). Reference concentrations (RfCs), which are reported as a concentration in air (in mg/m^3), are also used to evaluate noncarcinogenic effects. Derivation and/or conversion from an RfC (concentration) to an RfD (dose) is employed. Appendix C presents the RfD, confidence level, critical effects, and uncertainty/modifying factors for each of the noncarcinogenic COPCs. The uncertainty introduced by the lack of an RfD for two constituents is discussed in Section 6.2.6.

6.2.3.1.2 Carcinogens

One COPC in surface soil and three COPCs in subsurface soil at the FDTF are potential carcinogens that have CSFs assigned to them by the EPA: arsenic, benzo(a)pyrene, and beryllium. Of these, arsenic is assigned the greatest weight-of-evidence classification of A, a known human carcinogen. Benzo(a)pyrene and beryllium are classified as type B2 carcinogens, and are considered to be probable human carcinogens.

6.2.3.2 Constituents Without Toxicity Values

EPA toxicity values are available only for the oral and inhalation routes. As discussed below for the dermal contact route, it is sometimes necessary to convert the administered dose toxicity value to an absorbed dose in order to calculate risk for the dermal pathway. In addition, when a constituent has no chronic toxicity values, the toxicity value of a constituent that is related both chemically and toxicologically may be used. Except for aluminum and sodium, all of the COPCs in this investigation have either noncancer or cancer toxicity values.

In accordance with RAGS (EPA, 1989a), absorbed-dose toxicity values are derived from the oral administered-dose toxicity values to estimate risk associated with the dermal contact route. Adjustment of the oral administered-dose toxicity values from absorbed-dose toxicity values requires sufficient data from the principal laboratory studies on oral absorption efficiency (i.e., gastrointestinal absorption factors) in the species on which the toxicity values are based.

Using these data, the administered-dose toxicity value is multiplied (if it is an RfD) or divided (if it is a CSF) by a gastrointestinal absorption factor to derive a toxicity value based on the absorbed dose. In cases where constituent-specific absorption factors are not available, EPA Region IV provides default absorption factors of 80 percent for volatile organic compounds (VOCs), 50 percent for semivolatile organic compounds (SVOCs), and 20 percent for inorganic substances (EPA, 1995d). Appendix C presents the dermal permeability coefficients, dermal absorption factors, and gastrointestinal absorption factors used in this risk assessment.

6.2.4 Risk Characterization

Risk characterization combines the exposure intake values and toxicity assessment values to determine a quantitative risk for all human receptors defined in the human health risk assessment. The objective of the human health risk characterization is to determine whether exposure to constituents associated with the unit poses risks that exceed target levels for human health effects. The results of the human health baseline risk assessment support the determination of need for unit remediation.

This section presents the human health cancer risks and constituent hazard estimates for the current land use and hypothetical scenarios for the unit. Quantitative evaluations of exposure pathways for human receptors include a known on-unit worker, a hypothetical on-unit (industrial) worker, and a hypothetical on-unit resident. Appendix C presents constituent-specific RME risks for each receptor and pathway. Figure 6.2-1 summarizes risks and hazards across pathways and media for nonradiological chemicals.

6.2.4.1 EPA Methods for Risk Characterization

This risk characterization presents a separate evaluation of noncancer and cancer effects. EPA methods distinguish cancer from noncancer effects because organisms typically respond differently following exposure to noncarcinogenic or carcinogenic agents. The outcome of this comparison is used to determine whether the constituent concentrations detected in environmental media at the unit may be associated with adverse effects on the health of humans potentially exposed to unit-related constituents.

The risk characterization requires that the potentially toxic effects associated with exposures to each of the COPCs be combined across environmental media and exposure pathways. As described in the exposure assessment, the current and/or future receptors could be concurrently exposed to the COPCs through direct contact exposure to unit soils (i.e., ingestion, dermal contact and inhalation of dust). In the case of the resident, the soil exposures could also be combined with ingestion exposure to produce grown in unit soil. In general, the hazards and risks are combined across exposure pathways to develop a reasonable total risk estimate for each receptor.

The potential noncarcinogenic hazards and carcinogenic risks are assessed quantitatively by evaluating exposure estimates with respect to available toxicity values for the constituents of potential concern.

6.2.4.1.1 Evaluation of Noncarcinogenic Hazards

The risk of adverse noncarcinogenic effects from constituent exposure is expressed in terms of the HQ. The HQ is the ratio of the estimated chronic daily intake of a COPC to the reference dose level (RfD). RfDs are described in Section 6.2.3 and are provided in Appendix C.

To evaluate exposure from more than one noncarcinogen, the constituent-specific HQs are summed for each environmental medium and exposure pathway to obtain the hazard index (HI). After individual pathway risks are calculated, HIs may be combined across pathways to estimate total unit risk for each receptor. An HI greater than 1.0 has been defined as the level of potential concern for adverse noncarcinogenic health effects (EPA, 1989a).

6.2.4.1.2 Evaluation of Carcinogenic Risks

Cancer risks are estimated as the incremental excess probability of an individual developing cancer over a lifetime as a result of pathway-specific exposure to radionuclides and chemical carcinogens (i.e., incremental or excess individual lifetime risk over the course of a 70-year lifetime for chemicals and a 50-year lifetime for radionuclides). This value is calculated by multiplying the average daily intake over a lifetime by the CSF for the constituent. In order to account for simultaneous exposure to multiple carcinogens through a given pathway, the

risks calculated for each individual carcinogen in that medium are summed to obtain an estimate of the total cancer risk for the pathway.

Cancer risks less than 1×10^{-6} are considered to be adequately protective of human health. Cancer risks greater than 1×10^{-6} are generally considered to represent exposure levels requiring a risk management decision regarding the need for remediation.

6.2.4.2 Interpretation of Human Health Risk Assessment Results

Human health primary (COCs) are constituents in a total exposure pathway (media/receptor/route) with a cumulative noncancer hazard greater than 3 or a cumulative ELCR greater than 1×10^{-4}. Primary COCs have a constituent-specific noncancer hazard greater than or equal to 0.1 or a cancer risk greater than 1×10^{-6}.

Human Health secondary COCs are chemicals in a total exposure pathway (media/receptor/route) with a cumulative noncancer hazard between 1 and 3 or a cumulative Excess Lifetime Cancer Risk (ELCR) between 1×10^{-6} and 1×10^{-4}. Secondary COCs have a constituent-specific noncancer hazard greater than or equal to 0.1 or a cancer risk greater than or equal to 1×10^{-6}.

6.2.5 Summary of the Human Health Risk Characterization

To evaluate the risks to human receptors due to the contamination at the FDTF, unit-specific analytical data are used to identify COCs. RME concentrations are determined for each COC to estimate the potential exposure for various receptors and exposure scenarios. Receptors are selected based a single current land use (known on-unit worker) and two potential future scenarios (hypothetical on-unit industrial worker, and a hypothetical on-unit resident).

Following the selection of individual receptors, chemical cancer risks and health hazards are estimated for each COC for pathway/receptor combinations based on EPA guidance (EPA, 1989a). Carcinogenic risks and noncarcinogenic hazards are summarized across pathways and media for each receptor at the FDTF. For example, the risks to the known on-unit worker resulting from the ingestion of, dermal contact with, and inhalation of soil COCs are combined to estimate a total risk for nonradioactive carcinogens from soil. The totals for

each medium are then summed to obtain a total risk value that includes all reasonable pathways for each receptor.

The RME risk estimates for current and future land use for human receptors at the FDTF are discussed in the following sections. Tables 6.2-1 and 6.2-2 and Figure 6.2-1 provide summaries of unit-related carcinogenic risk and noncarcinogenic hazard for the pathways and receptors identified for quantitative evaluation. Tables 6.2-3 and 6.2-4 provide the hazard and risk estimates for exposures in the background.

In order to help ascertain the significance of the hazard and risk estimates, the background hazards and risks for the same soil intervals are provided. In addition, the hazards and risks for the substances that were screened out in the background comparison have been calculated and are presented in the discussion of uncertainties (Section 6.2.6.3). Note that for the 0 to 1.2 m (0 to 4 ft) soil interval, no constituents were screened out in the background comparison.

6.2.5.1 Results for Current Land Use

Under the current land use scenario, carcinogenic risks and noncarcinogenic hazards are characterized for exposure of an on-unit worker to soil.

6.2.5.1.1 Known On-Unit Worker

6.2.5.1.1.1 Noncarcinogenic Hazard

Noncarcinogenic HIs for the known on-unit worker exposure pathways are presented in Tables 6.2-1 and 6.2-3. None of the HIs exceeded 1.0, indicating that under current conditions, noncarcinogenic constituents at the unit do not pose a toxic hazard of concern for human health. Estimates of the HI by pathway for the nonradioactive noncarcinogens are summarized for the known on-unit worker in Figure 6-2.1.

0 to 0.3 m (0 to 1 ft) Soil Interval

- For the 0 to 0.3 m (0 to 1 ft) soil interval, the total HI for the known on-unit worker is 0.00007.
- By comparison, exposures to the 0 to 0.3 m (0 to 1 ft) soil interval in the background also resulted in a total HI for the known on-unit worker of 0.002.

6.2.5.1.1.2 Carcinogenic Risk

Estimates of total risk by pathway for nonradioactive carcinogens are summarized for the known on-unit worker in Figure 6.2-1. All of the estimated total cancer risks are less than 1×10^{-6}, indicating that under current conditions carcinogenic risk is insignificant at the unit. Carcinogenic risk for the known on-unit worker exposure pathways are presented in Tables 6.2-1 through 6.2-4.

0 to 0.3 m (0 to 1 ft) Soil Interval

- For the 0 to 0.3 m (0 to 1 ft) soil interval, the total site cancer risk for the known on-unit worker is 4×10^{-9}.
- By comparison, exposures to the 0 to 0.3 m (0 to 1 ft) soil interval in the background also resulted in a total cancer risk for the known on-unit worker of 2×10^{-8}.

6.2.5.1.2 Future Land Use

Under the future land use scenario, carcinogenic risks and noncarcinogenic hazards are calculated for exposure of the hypothetical on-unit resident (adult and child) to surface and redistributed subsurface soils, and homegrown produce. For the hypothetical on-unit industrial worker, exposures are to surface soil and redistributed subsurface soil (but not produce). The summary of carcinogenic risks and noncarcinogenic hazards is shown in Figure 6.2-1.

6.2.5.1.2.1 Noncarcinogenic Hazard for the Hypothetical On-Unit Industrial Worker

Noncarcinogenic HIs for the hypothetical on-unit industrial worker exposure pathways are presented in Tables 6.2-1 through 6.2-4. None of the HIs exceed 1.0, indicating that under current conditions, noncarcinogenic constituents at the unit are not of concern for human health.

0 to 0.3 m (0 to 1 ft) Soil Interval

- For the 0 to 0.3 m (0 to 1 ft) soil interval, the total HI for the hypothetical on-unit industrial worker is 0.003.
- By comparison, exposures to the 0 to 0.3 m (0 to 1 ft) soil interval in the background resulted in a higher total HI of 0.1 for the hypothetical on-unit industrial worker.

0 to 1.2 m (0 to 4 ft) Soil Interval

- For the 0 to 1.2 m (0 to 4 ft) soil interval, the total HI for the hypothetical on-unit industrial worker is 0.2. This is below the limit of 1 for noncancer effects, indicating that under these exposure assumptions the noncancer hazards are not of concern. Although the HI is greater than 0.1, this is the result of the combination of the ingestion and dermal contact pathways, each with an HI of about 0.1. All of the constituent HQs are less than 0.1; therefore, there are no COCs.
- By comparison, exposures to the 0 to 1.2 m (0 to 4 ft) soil interval in the background resulted in a similar total HI of 0.1 for the hypothetical on-unit industrial worker.

6.2.5.1.2.2 Noncarcinogenic Hazard for the Hypothetical On-Unit Resident

Noncarcinogenic HIs for the hypothetical on-unit resident exposure pathways are presented in Tables 6.2-1 through 6.2-4.

0 to 0.3 m (0 to 1 ft) Soil Interval

- The total HI (soil and produce exposures combined) for the hypothetical on-unit resident exposed to this soil is 0.5, which is below the limit of 1. The HI for the soil exposures is 0.03 (i.e., excluding the produce exposures).
- By comparison, exposures to the same soil interval in the background resulted in a higher total HI of 2 for the hypothetical on-unit resident. The HIs for the soil exposure and produce ingestion in the background are each 1.

0 to 1.2 m (0 to 4 ft) Soil Interval

- For this soil interval, the total HI for the hypothetical on-unit resident is 4. This is primarily due to the soil exposures (HI = 3), of which soil ingestion is most important (HI = 2). The HI for produce ingestion is 1.

The secondary COCs for soil exposure are:

- Arsenic (11 percent of the HI for soil ingestion, HQ = 0.3)

- Iron (78 percent of the HI for soil ingestion; HQ = 2)
- Vanadium (6 percent of the HI for soil ingestion, and 72 percent of the HI for dermal contact; HQ = 0.3)

- By comparison, exposures to this soil interval in the background resulted in a total HI of 2 for the hypothetical on-unit resident. This exceeds the upper limit of 1 for noncancer effects.

6.2.5.1.2.3 Carcinogenic Risk Hypothetical On-Unit Industrial Worker

Estimates of total risk by pathway for carcinogens are summarized for the hypothetical on-unit industrial worker in Figure 6.2-1.

0 to 0.3 m (0 to 1 ft) Soil Interval

- For the 0 to 0.3 m (0 to 1 ft) soil interval, the total cancer risk for the hypothetical on-unit industrial worker is 9×10^{-7}. This is below 1×10^{-6}, the initial level of concern for cancer risk.
- By comparison, exposures to the 0 to 0.3 m (0 to 1 ft) soil interval in the background resulted in a higher total cancer risk of 4×10^{-6} for the hypothetical on-unit industrial worker. The finding of a slightly higher cancer risk in the background is most likely due to natural variation in the concentration of metals (i.e., arsenic and beryllium) in soil.

0 to 1.2 m (0 to 4 ft) Soil Interval

- For the 0 to 1.2 m (0 to 4 ft) soil interval, the total cancer risk for the hypothetical on-unit industrial worker is 4×10^{-6}. The cancer risk is attributable to the ingestion (ELCR = 2×10^{-6}) and dermal contact (ELCR = 2×10^{-6}) pathways.

The secondary COCs for exposure to soil in this interval are:

- Arsenic (84 percent of the ELCR for soil ingestion; ELCR = 2×10^{-6})
- Beryllium (54 percent of the ELCR for soil dermal contact, ELCR = 1×10^{-6})

- By comparison, exposures to the 0 to 1.3 m (0 to 4 ft) soil interval in the background also resulted in a total cancer risk for the hypothetical on-unit industrial worker of 3×10^{-6}.

6.2.5.1.2.4 Carcinogenic Risk for the Hypothetical On-Unit Resident

Estimates of total risk by pathway for nonradioactive carcinogens are summarized for the hypothetical on-unit resident in Figure 6.2-1.

0 to 0.3 m (0 to 1 ft) Soil Interval

- For this soil interval, the total cancer risk for the hypothetical on-unit resident is 1×10^{-5}. This is above 1×10^{-6}, the initial level of concern for cancer risk. Media with cancer risks of greater than 1×10^{-6} are soil and ingestion of produce grown in the soil (1×10^{-5}).

  The secondary COC for exposure to soil in this interval is:

  - Benzo(a)pyrene (100 percent of the ELCR for soil ingestion and 100 percent for dermal contact; ELCR = 3×10^{-6})

  The secondary COC for exposure to produce in this interval is:

  - Benzo(a)pyrene (100 percent of the ELCR for tuberous vegetables; ELCR = 1×10^{-5})

- By comparison, exposures to the same soil interval in the background resulted in a higher total cancer risk for the hypothetical on-unit resident of 7×10^{-5}. The finding of a higher cancer risk in the background is most likely due to natural variation in the concentration of metals (i.e., arsenic and beryllium) in soil.

0 to 1.2 m (0 to 4 ft) Soil Interval

- For this soil interval, the total cancer risk for the hypothetical on-unit resident is 8×10^{-5}. This exceeds the initial level of concern of 1×10^{-6}. Media with cancer risks of greater than 1×10^{-6} are soil and produce grown in the soil.

  The secondary COCs for exposure to soil in this interval are:

  - Arsenic (84 percent of the ELCR for soil ingestion; ELCR = 1×10^{-5})
  - Beryllium (6 percent of the ELCR for soil ingestion and 54 percent of the dermal contact pathway; ELCR = 3×10^{-6})
  - Benzo(a)pyrene (10 percent of the ELCR for soil ingestion and 28 percent of the dermal contact pathway; ELCR = 3×10^{-6})

  The secondary COCs for exposure to produce are:

  - Arsenic (98 percent of the ELCR for leafy vegetables, 42 percent of the ELCR for tuberous vegetables; 98 percent of the ELCR for fruit; ELCR = 4×10^{-5})
  - Benzo(a)pyrene (58 percent of the ELCR for tuberous vegetables; ELCR = 1×10^{-5})

- By comparison, exposures to the 0 to 1.3 m (0 to 4 ft) soil interval in the background resulted in a total cancer risk for the hypothetical on-unit resident of 5×10^{-5}. The cancer risk in the background is attributable to arsenic and beryllium in the soil.

6.2.5.1.3 Constituents of Concern

Table 6.2-5 provides a summary of the human health secondary COCs. The following briefly summarizes the findings:

- For current land use, there are no primary or secondary COCs.
- For the future industrial land use, there are two secondary COCs.
- For the future residential land use, there are five secondary COCs.
- For the 0 to 0.3 m (0 to 1 ft) soil interval, there is one secondary COC, benzo(a)pyrene, for the on-unit resident.
- For the 0 to 1.2 m (0 to 4 ft) soil interval, there are five secondary COCs for the hypothetical on-unit resident. There are two secondary COCs for the future industrial worker.
- There are no ARAR-driven COCs because there are no ARARs for constituents detected in the FDTF soil.

6.2.6 Uncertainty

Uncertainty will always surround estimates of environmental concentrations at waste units. Uncertainty in the analytical data may be linked to sample density and distribution, collection procedures in the field, seasonal fluctuations, and accuracy of the sample analyses.

Sample collection procedures are established to reduce uncertainty surrounding the sample results. Standard Quality Assurance/Quality Control measures (e.g., proper decontamination of equipment and collection of trip blanks, field blanks, and matrix spike/matrix spike duplicates) are followed to reduce uncertainty associated with the analytical data. The uncertainty associated with sample collection procedures has the potential for either overestimating or underestimating risks to receptors.

Uncertainty also may be introduced at the laboratory. Standardized procedures are followed by the laboratory to reduce this uncertainty. For example, procedures include the use of surrogate spikes to monitor constituent recovery, internal standards to monitor instrument sensitivity, and laboratory blanks to determine whether laboratory preparation has introduced contamination to the sample. These measures are explained in the data quality assessment for the FDTF (WSRC, 1996b)

6.2.6.1 Provisional Toxicity Value for Iron

The designation of iron as a COC is highly uncertain. There is no EPA-verified toxicity value for iron, and a provisional toxicity value for iron was used. The provisional toxicity value was developed for use by the EPA in their risk assessments, and is not included in either IRIS or HEAST because the value has not been verified by the EPA's RFD Workgroup. Conclusions based on the use of the provisional toxicity value should be cautiously viewed in light of the weakness of the available provisional toxicity value. Note that neither arsenic nor vanadium would have been designated as RDs if iron had not been designated a COC.

Note that the U.S. Food and Drug Administration (FDA) dietary value (DV) for iron is 18 mg/day, which for a 70 kg adult corresponds to a recommended daily dose of 0.26 mg/kg/day. This is the daily dose of iron that is recommended as part of a healthy diet. In order to ingest this amount of iron from soil, the concentration of iron in the soil would have to be very high, on the order of 180,000 mg/kg. This assumes 350 days per year of exposure at a rate of 100 mg/day for 30 years to a 70 kg adult who gets all his or her iron from the soil (which is unlikely). The concentrations in soil at the FDTF are typically an order of magnitude lower than 180,000 mg/kg, indicating that iron in the soil is very unlikely to be of concern at the FDTF. This discussion is very simple, since there are other important sources of iron, particularly in the diet. The point is, however, that there is a large discrepancy between the findings based on the provisional toxicity value for iron versus the findings based on the DV. When determining the need for remediation at the FDTF, this large degree of uncertainty should be considered.

6.2.6.2 Constituents Without Toxicity Values

The number of COPCs included in the investigation of the FDTF is small; there are three COPCs in the surface 0 to 0.3 m (0 to 1 ft) soil interval, and 10 in the subsurface 0 to 1.2 m (0 to 4 ft) soil interval. Of these, only aluminum and sodium were included as COPCs without EPA-verified toxicity values.

The FDA has developed a DV of 2,400 mg/day for the dietary intake of sodium. Note that the DVs were formerly called RDAs by the FDA. The DV for sodium does not vary for differing intake levels or for different age groups. Based on the DV for sodium and a body weight of 70 kg, the upper limit of sodium intake for use in the risk assessment is 34 mg/kg-day ([2,400

mg/day]/70 kg = 34 mg/kg-day). Using the same methods to derive an upper acceptable concentration in soil for screening other nutrients, the upper acceptable concentration in soil for sodium is greater than 1,000,000 mg/kg. This value is greater than could exist in soil, and is so because the DV has been theoretically applied to the ingestion of small amounts of soil containing sodium. The relevance of the finding is that it would be acceptable to consume up to the full DV of soil ingested in a day as dietary sodium. The effect of not quantitatively evaluating sodium is thus likely to be negligible.

Although the degree of uncertainty resulting from the lack of a quantitative evaluation of aluminum makes it difficult to assess, the direction of the bias is likely to be toward underestimation of the noncancer effects.

6.2.6.3 Uncertainty in the COPC Selection Process

There is inherently some uncertainty introduced by screening constituents out before the risk assessment. The screening consists of a health-based screening and a background comparison. The health-based screen is very conservative, and for this reason it is unlikely to result in appreciable uncertainty in the risk estimates for the remaining constituents. The background comparison is important, since it is designed to identify and eliminate naturally-occurring levels of constituents from the risk assessment. Naturally-occurring levels of constituents may, however, represent significant hazards or cancer risks.

The document was prepared according to the protocol in the SRS FFA Implementation Plan (FIP) (WSRC-RP-94-1200, December 1996), which was appropriate at the time the document was generated. Since then, SRS has reviewed the analytes which were eliminated as a result of the 2 times average background rule. Tables 6.1-7 (0 to 0.3 m [0 to 1 ft] interval) and 6.1-8 (0 to 1.2 m [0 to 4 ft] interval) are COPC summaries for the unit and Tables 6.1-9 and 6.1-10 are COPC summaries for background. All four tables are affected by the 2 times average background rule. However, the unit-specific tables, Tables 6.1-7 and 6.1-8, are the issue at hand. The remaining two tables, Tables 6.1-9 and 6.1-10 are provided for risk management decisions.

In Table 6.1-7 (0 to 0.3 m [0 to 1 ft] interval) there were three constituents which were eliminated as a result of the 2 times average background rule: arsenic, iron, and sodium. Table 6.1-4 provides the frequency of detection for all analytes which were detected in the

background for the soil interval 0 to 0.3 m (0 to 1 ft). The frequency of detection for arsenic and iron was 5/5 which means that surrogate values are not required since there were not any non-detects. Sodium frequency of detection is 3/5 which means that surrogate values are required based on the new protocol. The method detection limit is 12.9 mg/kg for sodium and to include it as a surrogate for the two non-detects will reduce the average background concentration to 23.68 mg/kg or 47.36 for 2 times the average background concentration. Therefore, the maximum unit value (69.1 mg/kg) for sodium will be greater than the revised 2 times average background value and it would be identified as a COPC. Under the new protocol, sodium would be carried through the entire risk assessment process without a risk or hazard quotient determination because there is no toxicity data available for it. Sodium is considered an essential human nutrient and the recommended dietary allowance or benchmark value for a child is 400 mg/day and for an adult it is 500 mg/day. If one assumes that the daily soil intake for a child is 200 mg/day and the adult is 100 mg/day, then the concentration range that one can intake on a daily basis is 2E+06 to 5E+06 mg/kg. The unit maximum concentration for sodium (69.1 mg/kg) is therefore insignificant to the daily intake concentration range.

While reviewing Table 6.1-8 (0 to 4 ft soil interval), it was determined that none of the constituents were eliminated due to the comparison of 2 times the average background.

As mentioned earlier, Tables 6.1-9 and 6.1-10 are provided for risk management decisions. These tables provide a summary of the background analytes being screened against the COPC selection protocol as the unit analytes. As a result, background risk was determined on the remaining analytes.

Based on these observations, implementation of the new protocol will not affect this unit and the outcome of the risk or hazard.

The direction of the bias introduced by screening out constituents before the risk assessment would always be toward underestimating the hazard or risk, since the screened constituents are not included in the risk assessment. In order to assess the significance of the screening process, risk estimates have been calculated for the chemicals that were screened out in the COPC selection process. The findings are as follows:

On-Unit Worker

- For the 0 to 0.3 m (0 to 1 ft) soil interval, the total HI for exposures to the constituents that were screened out is 0.0006 for the known on-unit worker, and the total cancer risk is 6×10^{-9}. This is well below the upper limit of 1 for noncancer hazards, and is also well below the initial level of concern of 1×10^{-6} for cancer risk.

Hypothetical On-Unit Industrial Worker

- For the 0 to 0.3 m (0 to 1 ft) soil interval, the total HI for exposures to the screened constituents is 0.03 for the hypothetical on-unit industrial worker, and the total cancer risk is 1×10^{-6}. The HI is well below 1, and the cancer risk is at the lowest level of concern.
- For the 0 to 1.2 m (0 to 4 ft) soil interval, there were no constituents screened out in the COPC selection process.

Hypothetical On-Unit Resident

- The total HI (soil and produce combined) for exposures to the screened constituents from the 0 to 0.3 m (0 to 1 ft) soil interval is 0.8, and the cancer risk is 5×10^{-5}. The HI for the soil exposures (not including produce) to the screened constituents from the 0 to 0.3 m (0 to 1 ft) soil interval for the hypothetical on-unit resident is 0.6, and the cancer risk is 9×10^{-6}. There is only one constituent with a cancer risk of greater than 1×10^{-6}, as follows:
- Arsenic (ELCR = 9×10^{-6} for soil ingestion, 7×10^{-6} for leafy vegetables, 5×10^{-6} for tuberous vegetables, and 1×10^{-5} for fruits)
- For the 0 to 1.2 m (0 to 4 ft) soil interval, there were no constituents screened out in the COPC selection process.

These findings indicate that there is minimal uncertainty in the risk estimates that may be attributable to the COPC selection process. In case of the highest hazards or risks for the screened constituents (e.g., the cancer risk of 5×10^{-5}), the estimates appear to be entirely attributable to naturally-occurring levels of arsenic and beryllium in the soil. Note that the background comparison used in the COPC selection process is very simple, increasing the uncertainty of whether naturally-occurring substances are carried through to the risk assessment. In particular, although arsenic and beryllium were not always screened out in the COPC selection process, these naturally-occurring substances do not appear to be site-related and may still be present at naturally-occurring levels.

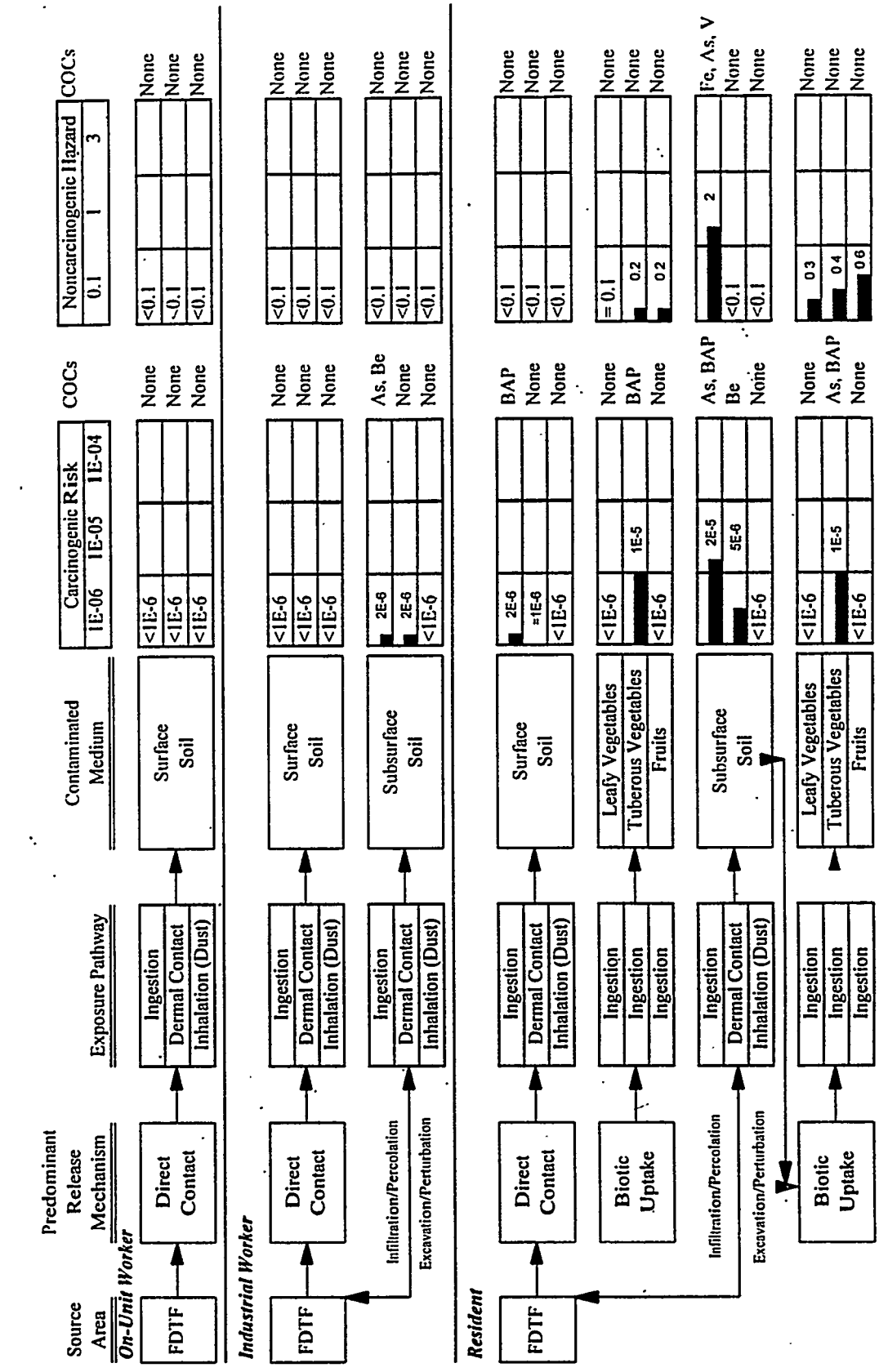


Figure 6.2-1. Summary of Chemical Risks and Hazards Across Pathways and Receptors: FDTF

Table 6.2-1. RME Risk Characterization Summary: FDTF Surface Soil (0 to 1 foot)

Medium	Exposure Route	Current		Future			
		Noncancer HI	Cancer Risk	Noncancer HI		Cancer Risk	
		On-Unit Worker	On-Unit Worker	Resident	Industrial Worker	Resident	Industrial Worker
Soil	Ingestion	3E-05	9E-10	3E-02	1E-03	2E-06	2E-07
	Dermal/External	4E-05	3E-09	3E-03	1E-03	1E-06	7E-07
	Inhalation	4E-06	3E-14	8E-04	2E-04	2E-11	7E-12
Leafy Vegetables	Ingestion	NA	NA	1E-01	NA	3E-12	NA
Tuberous Vegetables	Ingestion	NA	NA	2E-01	NA	1E-05	NA
Fruits	Ingestion	NA	NA	2E-01	NA	6E-13	NA
Combined Hazard Index:		7E-05		5E-01	3E-03		
Combined Cancer Risk:			4E-09			1E-05	9E-07

NA - pathway not evaluated

Table 6.2-2. RME Risk Characterization Summary: FDTF Subsurface Soil (0 to 4 feet)

Medium	Exposure Route	Current		Future			
		Noncancer HI	Cancer Risk	Noncancer HI		Cancer Risk	
		On-Unit Worker	On-Unit Worker	Resident	Industrial Worker	Resident	Industrial Worker
Soil	Ingestion	NA	NA	2E+00	9E-02	2E-05	2E-06
	Dermal/External	NA	NA	2E-01	9E-02	5E-06	2E-06
	Inhalation	NA	NA	8E-04	2E-04	7E-08	3E-08
Leafy Vegetables	Ingestion	NA	NA	3E-01	NA	1E-05	NA
Tuberous Vegetables	Ingestion	NA	NA	4E-01	NA	2E-05	NA
Fruits	Ingestion	NA	NA	6E-01	NA	2E-05	NA
Combined Hazard Index:		0E+00		4E+00	2E-01		
Combined Cancer Risk:			0E+00			8E-05	4E-06

NA - pathway not evaluated
0E+00 - pathway evaluated but no risks could be calculated due to lack of EPA-approved toxicity values

Table 6.2-3. RME Risk Characterization Summary: Background Surface Soil (0 to 1 foot)

Medium	Exposure Route	Current		Future			
		Noncancer HI	Cancer Risk	Noncancer HI		Cancer Risk	
		On-Unit Worker	On-Unit Worker	Resident	Industrial Worker	Resident	Industrial Worker
Soil	Ingestion	1E-03	9E-09	1E+00	5E-02	2E-05	2E-06
	Dermal/External'	1E-03	1E-08	1E-01	5E-02	4E-06	2E-06
	Inhalation	3E-06	3E-11	7E-04	1E-04	1E-08	5E-09
Leafy Vegetables	Ingestion	NA	NA	3E-01	NA	1E-05	NA
Tuberous Vegetables	Ingestion	NA	NA	3E-01	NA	1E-05	NA
Fruits	Ingestion	NA	NA	4E-01	NA	3E-05	NA
Combined Hazard Index:		2E-03		2E+00	1E-01		
Combined Cancer Risk:			2E-08			7E-05	4E-06

NA - pathway not evaluated

Table 6.2-4. RME Risk Characterization Summary: Background Subsurface Soil (0 to 4 feet)

Medium	Exposure Route	Current		Future			
		Noncancer HI	Cancer Risk	Noncancer HI		Cancer Risk	
		On-Unit Worker	On-Unit Worker	Resident	Industrial Worker	Resident	Industrial Worker
Soil	Ingestion	NA	NA	1E+00	5E-02	1E-05	1E-06
	Dermal/External	NA	NA	1E-01	5E-02	3E-06	2E-06
	Inhalation	NA	NA	7E-04	1E-04	1E-08	4E-09
Leafy Vegetables	Ingestion	NA	NA	2E-01	NA	1E-05	NA
Tuberous Vegetables	Ingestion	NA	NA	3E-01	NA	8E-06	NA
Fruits	Ingestion	NA	NA	4E-01	NA	2E-05	NA
Combined Hazard Index:		0E+00		2E+00	1E-01		
Combined Cancer Risk:			0E+00			5E-05	3E-06

NA - pathway not evaluated
0E+00 - pathway evaluated but no risks could be calculated due to lack of EPA-approved toxicity values

Table 6.2-5. Health-Based COCs for Soil and Produce
Fire Department Hose Training Facility

Media	0 -1 ft Soil Interval	0-4 ft Soil Interval
Soil		
Current On-Unit Worker	--	--
Hypothetical Industrial Worker	--	Arsenic (ELCR = 2 x 10^{-6}) Beryllium (ELCR = 1 x 10^{-6})
Hypothetical On-Unit Resident	-- -- -- Benzo(a)pyrene (ELCR = 3 x 10^{-6})	Arsenic (HQ = 0.3) Arsenic (ELCR = 1 x 10^{-5}) Beryllium (ELCR = 3 x 10^{-6}) Iron (HQ = 2) Vanadium (HQ = 0.3) Benzo(a)pyrene (ELCR = 2 x 10^{-6})
Produce		
Hypothetical Resident	Benzo(a)pyrene (ELCR = 1 x 10^{-5})	Arsenic (ELCR = 4 x 10^{-6}) Benzo(a)pyrene (ELCR = 1 x 10^{-5})

No Constituents of Concern are identified based on exceedances of ARARs.

6.3 Ecological Risk Assessment

The purpose of the Ecological Risk Assessment (ERA) component of the Baseline Risk Assessment (BRA) is to evaluate the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to unit-related constituents based on a weight-of-evidence approach. An ecological risk does not exist unless a given constituent has the ability to cause one or more adverse effects and it either co-occurs with, or is contacted by, an ecological receptor for a sufficient length of time, or at a sufficient intensity to elicit the identified adverse effect(s) (EPA, 1994b).

The methodology used in this assessment is based on and complies with the intent of the Risk Assessment Guidance for Superfund, Volume II, *Environmental Evaluation Manual* (EPA, 1989b); *Framework for Ecological Risk Assessment* (EPA, 1992c), the draft *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA, 1994b), and the draft Supplemental Guidance to Risk Assessment Guidance: Region 4 Bulletins, Ecological Risk Assessment (EPA, 1995d). These documents do not provide a detailed step-by-step approach to ERAs. Instead, they discuss an overall approach to considering ecological effects and identify sources of information for ERAs. Thus, professional knowledge and experience are important in performing ERAs to compensate for the limited specific guidance and established methods.

The ecological assessment methodology consists of four interrelated steps: problem formulation (Section 6.3.1), exposure assessment (Section 6.3.2), effects assessment (Section 6.3.3), and risk characterization (Section 6.3.4).

Included in the ERA is a decision regarding the need to conduct additional field studies in order to complete the assessment. This decision is based on the quality of information about the unit already available from previous studies, including the following: the constituents of potential concern (COPCs) identified; ecological, physical, and other characteristics of the unit; the ability to estimate exposures of assessment endpoints; and the ability to predict possible effects on assessment endpoints that may result from such exposures. This decision is discussed in Section 6.3.4.1.3.

6.3.1 Problem Formulation

Problem formulation establishes the goals, breadth, and focus of the ERA through the following:

- Identification of the ecological COPCs
- Characterization of ecological communities
- Selection of assessment endpoints
- Presentation of an ecological Conceptual Site Model (CSM)
- Selection of an analysis plan (including measures of effects)

6.3.1.1 Identification of Ecological Constituents of Potential Concern

Ecological COPCs are identified for each exposure group and medium following qualification and evaluation of analytical data and comparison to ecological risk-based screening values and unit-specific background concentrations as described in Section 6.1.2. The COPCs (including their basis for designation) are presented in Tables 6.1-12 and 6.1-14, along with the analytes' maximum detected concentrations, reasonable maximum exposure (RME) concentrations, and risk-based screening values.

Table 6.1-11 presents the toxicity data and derivation of toxicity screening benchmarks used to screen nonradioactive constituents in soil. Soil screening is done by calculating a screening intake dose, as described in Section 6.1.2.3. As shown in Tables 6.1-12 and 6.1-13, the intake dose is compared to the toxicity screening benchmark. Radionuclides were not detected at the unit (see Section 4); therefore, they are not included in the ecological BRA.

There are no sediment and surface water at these units; therefore, there is no screen for non-radioactive and radioactive constituents in sediment or surface water.

Comparison of concentrations of constituents in unit samples with background concentrations is conducted for the medium of soil (as shown in Tables 6.1-12 and 6.1-13).

The ecological COPCs identified through this screening process serve as the constituents for quantitative ecological risk assessment for all media of concern. Tables 6.1-1 through 6.1-6 contain detailed summary statistics for all constituents evaluated. The ecological COPCs

remaining after the selection process are presented below by exposure group and listed in Tables 6.1-12 through 6.1-14 with their associated RME concentrations.

6.3.1.2 Characterization of Ecological Communities

The following paragraphs discuss the methods for ecological characterization of the exposure groups, including field reconnaissance and habitat mapping if applicable. The ecosystem potentially at risk comprises only a few plant community types. The most prevalent is a community consisting of maintained grass with scattered mature trees; a pine plantation community is also present in the area. The immediate vicinity of the exposure unit is maintained as a grassy field with scattered mature trees nearby (WSRC, 1996a). The exposure unit occupies a total of approximately 0.01 hectare (0.025 acre).

Overall habitat quality appears low. There are no visual indications of vegetative stress, nor are there any observable indicators of stress to the wildlife community.

6.3.1.2.1 Vegetation

A brief site visit was conducted by Science Applications International Corporation (SAIC) personnel. As noted in a previous study that describes the major plant communities of the Savannah River Site (SRS) (Workman and McLeod, 1990), vegetative community type patterns are found to be dependent on topography, soil type, moisture, and degree of disturbance. No previous studies describing the vegetative communities of the Fire Department Hose Training Facility (FDTF) are known. Based on the brief site visit, the following three vegetative communities have been identified in the immediate area.

Community Type No. 1: *Maintained grassy field with scattered mature trees.* This vegetative community occupies the area surrounding the FDTF, and extends for some distance in all directions. This community is typified by a limited variety of grass species, with a limited number of mature trees present as individuals or small clumps. There are essentially no herbaceous, mid-level, or canopy layers present.

Community Type No. 2: *Transportation, transmission line/pipeline right-of-way.* This vegetative community occurs along the rights-of-way associated with transportation and utility corridors. The habitat is open and ranges from grassy to more weedy in nature. Species

frequently found in the community type include bahia grass (*Paspalum notatum*), lespedeza (*Lespedeza capitata*), sericea (*Lespedeza sericea*), and broom sedge (*Andropogon* spp.). The canopy level is completely absent due to periodic mowing.

Community Type No. 3: *Pine plantation.* This vegetative community is represented nearby (a few hundred feet away) by areas that have been planted to monoculture stands of either loblolly pine (*Pinus taeda*) or longleaf pine (*P. palustris*). The canopy level displays little diversity in species present. The mid-level is poorly developed, as is the herbaceous layer, due to forestry maintenance practices.

6.3.1.2.2 Wildlife

No site visits specifically for the purpose of wildlife observations are known to have been made. As discussed above, one brief site visit by SAIC personnel has taken place.

6.3.1.2.2.1 Mammals

No mammals were observed during the site visit by SAIC personnel. Based on observations of the area. white-tailed deer (*Odocoileus virginianus*) and raccoon (*Procyon lotor*) are likely inhabitants of the area. Additionally, some areas within the mowed grass areas would offer potential habitat for smaller mammals such as the cotton mouse (*Peromyscus gossypinus*) and shrews (*Blarina brevicauda*).

6.3.1.2.2.2 Avifuana

Although no birds were observed during the site visit, the area could offer potential habitat for several species, including the American robin (*Turdus migratorius*), red-bellied woodpecker (*Melanerpes carolinus*), northern cardinal (*Cardinalis cardinalis*), and eastern bluebird (*Sialia sialis*).

6.3.1.2.2.3 Herpetofauna

Although the possible presence of small mammal species increases the likelihood that reptilian predators are present, no species were observed during the site visit.

6.3.1.2.2.4 Aquatic Life

Due to the upland location of the study area, no water bodies are present; thus, no forms of aquatic life are present.

6.3.1.2.3 Threatened and Endangered Species

No surveys, literature reviews, or other studies concerning the presence of threatened, endangered, or sensitive (TES) species are known to have been carried out close to the unit. However, in May, June, and July 1994, Savannah River Forest Station (SRFS) personnel carried out a TES survey at the CS-Area Burning/Rubble Pit, located approximately 365 m (400 yards) south of the FDTF (SRFS, 1994). Most findings of that survey would be generally applicable to the FDTF.

No individuals of federally-listed TES species were observed during that survey. However, it is possible that two such species could occur in the area. Smooth purple coneflower (*Echinacea laevigata*) occurs in open sandhill habitat, some of which is present in the area. Potential habitat also exists for the red-cockaded woodpecker (*Picoides borealis*). The nearest known active colony of this species, however, is several miles east of the unit. Timber management plans for the area do not include attempts to recruit the species (SRFS, 1994). It is also possible that individual bald eagles (*Haliaeetus leucocephalus*) may move briefly through the area. These individuals would not be permanent residents, however, due to their requirement for aquatic habitats for foraging and nesting (Table 6.3-1).

6.3.1.3 Ecological Assessment Endpoint(s)

EPAs draft *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA, 1994b) states that the selection of assessment endpoints depends on the following:

1. The constituents present and their concentrations
2. Mechanisms of toxicity to different groups of organisms
3. Potential species present
4. Potential complete exposure pathways

The constituents and concentrations are discussed in detail in Section 4. Mechanisms of toxicity are evaluated conceptually in the analysis plan in Section 6.3.1.6.1. Potential species present are discussed in Section 6.3.1.2 and receptor selection is presented in Section 6.3.1.4. Potential complete exposure pathways are part of the ecological conceptual site model in Section 6.3.1.5.

To assess whether significant adverse ecological effects have occurred or may occur at the FDTF as a result of ecological receptors' exposure to COPCs, ecological endpoints were selected. An assessment endpoint is an ecological component that may be affected by exposure to a stressor (e.g., a constituent). Assessment endpoints represent environmental values to be protected and generally refer to characteristics of populations and ecosystems (EPA, 1994b). Unlike the human health risk assessment process, which focuses on individual receptors, the ERA focuses on populations or groups of interbreeding non-human, non-domesticated receptors, In the ERA process, risks to individuals are assessed only if they are protected under the Endangered Species Act, or if they are species that are candidates for protection or are considered rare.

Given the diversity of the biological world and the multiple values placed on it by society, there is no universally applicable list of assessment endpoints. Therefore, EPA, in the *Proposed Guidelines for Ecological Risk Assessment* (EPA, 1996c) has suggested three criteria that should be considered in selecting assessment endpoints suitable for a specific ERA. These criteria are ecological relevance. susceptibility to the constituent(s), and representation of management goals.

- Ecological relevance. The assessment endpoint should have biological/ecological significance to a higher level of the ecological hierarchy. Relevant endpoints help sustain the natural structure, function, and biodiversity of an ecosystem. For example, an increase in mortality or a decrease in fecundity of individuals is ecologically significant if it affects the size or productivity of the population. Likewise, a decrease in the size of a population is ecologically significant if it affects the number of species, the productivity, or some other property of the ecosystem.
- Susceptibility to the constituent(s). The assessment endpoint should be susceptible to exposure to the constituent(s) and should be responsive/sensitive to such exposure. That is, assessment endpoints should be chosen that are likely to be exposed to constituents at the unit, either directly or indirectly (e.g., through the food chain), and they should be sensitive enough that such exposure may elicit an adverse response. Ideally, this sensitivity should be at such a level that other unit-related receptors of potential concern are adequately protected under the selected endpoints response threshold.

- Representation of management goals. The value of a risk assessment depends on whether it can support quality management decisions. Therefore the assessment is based on values and organisms that reflect management goals. The protection of ecological resources (e.g., habitats and species of plants and animals) is a principal motivation for conducting ERAs. Key aspects of ecological protection are presented as policy goals, which are general goals established by legislation or agency policy based on societal concern for the protection of certain environmental resources. For example, environmental protection is mandated by a variety of legislation and government agency policies (e.g., Comprehensive Environmental Response, Compensation, and Liability Act, National Environmental Policy Act). Other legislation includes the Endangered Species Act 16 U.S.C. 703-711 (1993, as amended). Table 6.3-2 shows the policy goals established for the unit. To determine whether these protection goals are met at the unit, assessment and measurement endpoints are formulated that define the specific ecological values to be protected and the degree to which each may be protected.

Because of the small size of the unit and its low habitat quality, it does not provide habitat for many species. The TES survey of the CS Area Burning/Rubble Pit concluded that the area does not provide habitat for any such species; therefore, the assessment endpoint of no reduction in numbers of any TES is met. However, the field surveys concluded that the unit is likely to be used by small mammal populations. Accordingly, the assessment endpoint that has been selected to represent the policy goal of protection of terrestrial populations and ecosystems is "no substantial adverse effect on survival, growth, and reproduction of resident mouse populations."

Selection of measurement endpoints, or measures of effects, is discussed in Section 6.3.1.6.1.

6.3.1.4 Receptor Selection

Potential receptor species likely to be exposed to unit-related constituents are judged by the criteria identified in Section 6.3.1.3 as part of the assessment endpoint selection process. That is, receptors are selected to represent assessment endpoints based principally on their importance in the community food web, their susceptibility (through exposure and sensitivity) to the unit-related constituents, the amount of available data describing their potential for exposure, the toxicological effects that may result from exposure, and the extent to which they are valued by society or are important to another species valued by society. The results of this analysis indicate that the most appropriate assessment endpoint species are those described below.

- Vegetation or plants
  - trees (pine)

- vines (honeysuckle)
- Soil dwelling invertebrates
  - earthworms
- Herbivorous animals
  - voles (proxy)
- Worm-eating and/or insectivorous mammals and birds
  - short-tailed shrews
  - American robins
- Terrestrial top predator
  - red-tailed hawks

These receptors or their ecological equivalents are likely to be present and were selected in accordance with the Environmental Protection Agency Framework Document (EPA, 1992c). All are ecologically and socially relevant because they represent major groups of receptors exposed along the pathways leading from the identified source media. All are susceptible to unit contaminants, and there are toxicity data for each to evaluate effects and predict risk. These receptors have been defined in clear operational terms, and their relationship to policy goals is indicated in Table 6.3-2. The receptors and their major exposure routes are explained below. Figure 6.1-1 provides a summary.

6.3.1.5 Ecological Conceptual Site Model

The CSM will serve as a conceptual hypothesis for the exposure characterization, the objective of which is to gather information from which to determine the pathways and media through which ecological receptors may be exposed to COPCs. The exposure characterization typically involves determining the following:

1. The ecological setting of the unit
2. The inventory of constituents that are or may be present at the unit
3. The extent and magnitude of the constituent concentrations present, along with spatial and temporal variability of those concentrations
4. The environmental fate and transport of the constituents

The ecological setting is described in Section 6.3.1.2, and the inventory of constituent extent and magnitude is presented in Section 4, Nature and Extent of Contamination. The environmental fate of the COPCs and the potential exposure pathways is discussed in the following paragraphs.

The CSM presents the ecological receptors at the unit that are potentially exposed to hazardous substances in soil across several pathways (Figure 6.1-2). A complete exposure pathway consists of the following four elements:

- A source and mechanism of constituent release to the environment
- An environmental transport mechanism for the released constituents
- A point of contact with the contaminated medium
- A route of constituent entry into the receptor at the exposure point

If any of these elements is missing, the pathway is incomplete and is not considered further in the ERA. A pathway is complete when all four elements are present, permitting potential exposure of a receptor to a source of contamination. Quantification of some potentially complete pathways may not be warranted because of minimal contribution to risk relative to other major pathways. The dominant pathways from constituent sources and exposure media, through the food web, to ecological receptors potentially exposed to ecological COPCs at the unit are presented in Figure 6.3-1.

The principal sources of contaminants are the constituents placed on the FDTF. Primary release mechanisms are deposition to surface soil and infiltration to subsurface and deeper soils. From there, a variety of secondary release mechanisms (e.g., volatilization, biotic uptake, direct contact, and leaching) place the constituents in pathways and potential receptor exposure routes. Because this part of the remedial investigation deals with ecological resources, the following discussion on receptors is provided.

6.3.1.5.1 Vegetation

Trees and forbs are exposed to ecological COPCs primarily by direct contact with soil. It is assumed that they are exposed to the full soil concentration.

6.3.1.5.2 Soil-Dwelling Invertebrates

Earthworms and other soil-dwelling invertebrates are exposed to ecological COPCs in surface soil by ingestion and direct contact. It is assumed that earthworms ingest only soil and are exposed to the full-measured concentration.

6.3.1.5.3 Herbivorous Mammals

Herbivorous mammals (e.g., voles, *Microtus pennsylvanicus*, which serve as a proxy) are exposed primarily through ingestion of plant material and incidental ingestion of contaminated surface soil and direct radiation. Exposure by dermal contact with soil and inhalation is assumed to be negligible for small mammals at the FDTF exposure unit and background location. Receptor exposure is the sum of ingested soil and plant matter plus absorbed material. Small mammals at each exposure unit are assumed to obtain everything they ingest from that exposure unit.

6.3.1.5.4 Worm-Eating and/or Insectivorous Mammals and Birds

Insectivorous mammals (e.g., short-tailed shrew, *Blarina brevicauda)* and birds (e.g., American robin, *Turdus migratorius*) are primarily exposed by ingestion of potentially contaminated prey (e.g.. earthworms, insect larvae, slugs) as well as ingestion of soil. Robins are also exposed by ingestion of seeds and fruit. For the FDTF exposure unit, the exposure for this class of receptors is the sum of soil absorption from the plants and animals they ingest. The soil fraction of their diet includes soil from the intestinal tracts of their prey. Exposure by direct contact and inhalation was not evaluated. This class of receptors may also be exposed to soil contaminants by dermal contact and inhalation of volatile and semivolatile organic compounds and particulates. However, exposure by dermal contact with soil is assumed to be negligible for small mammals and birds at the FDTF exposure unit and background location. There are few data on inhalation toxicity or toxicity by direct contact with contaminated soil (or the parameters required to model contaminant absorption). Instead, conservative values for soil ingestion and dietary composition were used for shrews and robins.

6.3.1.5.5 Terrestrial Top Predators

Top predators are exposed primarily to ecological COPCs that have accumulated in their prey. Terrestrial top predators (e.g., red-tailed hawk, *Buteo jamaicensis*) feed primarily on terrestrial prey. Some terrestrial predators also may incidentally consume soil; hawks do not. Hawks are assumed to forage over an area that is large in relation to that of the FDTF exposure unit, so their exposure includes only the fraction of their diet that comes from the contaminated area. This is estimated as a function of the size of home range relative to the size of exposure unit.

6.3.1.6 Analysis Plan

The analysis plan is the final stage of problem formulation. In this step, risk hypotheses presented in the CSM are evaluated to determine how these hypotheses will be assessed using unit-specific data. The analysis plan includes three categories of measures to evaluate the risk hypotheses identified in the CSM: measures of effect (also termed measurement endpoints), measures of exposure, and measures of ecosystem and receptor characteristics.

6.3.1.6.1 Measures of Effect

Measurement endpoints are measurable responses to a stressor that are related to the valued characteristics chosen as assessment endpoints (EPA, 1992c). Assessment endpoints generally refer to characteristics of populations and ecosystems. It is usually impractical to measure changes in these characteristics as part of an assessment (Suter, 1993). Consequently, measurement endpoints are selected that can be measured and extrapolated to predict effects on assessment endpoints (EPA, 1992c). The most appropriate measurement endpoint(s) relating to the assessment endpoint(s) are the exposure point concentrations (RME) for each COPC. For each assessment endpoint, there are one or more measurement endpoints. Every endpoint evaluation begins with the RME concentration and is then modified. Typical modifications are uptake factors, ingestion rates, unit foraging factors, and body weight conversions. These modifications are intended to make the exposure at the receptor more realistic. This class of receptors may also be exposed to soil contaminants by direct contact and inhalation of volatile and semivolatile organic compounds and particulates. For example, the assessment endpoint for protection of terrestrial animals has the measurement endpoint of the RME concentration in the soil for each COPC.

Reliable measures of effects are not available for each exposure route for each constituent. Effects from exposure through inhalation and dermal contact are not well developed for ecological receptors; consequently, these exposure routes are analyzed qualitatively.

The measures of ecosystem and receptor characteristics include such characteristics as the behavior and location of the receptor and the distribution of a constituent, both of which may affect the receptor's exposure to the constituent. The typical foraging area of the receptor, as well as the quality of the habitat in the unit, have been considered in the estimation of exposure, as discussed in Sections 6.3.2.2 and 6.3.2.3.

6.3.1.6.2 Measures of Exposure

Measures of exposure are the amounts, in dosage or concentration, that the receptors are hypothesized to receive. These include concentrations of constituents in the impacted media (presented in Tables 6.3-3 through 6.3-15, and summarized in Section 6.3.2.1) and concentrations or dosages of the constituents to which the receptor is exposed (discussed in Section 6.3.2.3).

Decision rules are specified for evaluating effects on the assessment endpoints. Table 6.3-2 shows the decision rules that describe the logical basis for choosing among alternative actions for the assessment endpoints based on the results of the measurement endpoints. Together, the assessment endpoint, measurement endpoint, and decision rules define the following:

- An entity (e.g., terrestrial community)
- A characteristic of the entity (e.g., health of the individuals in the population)
- An acceptable amount of change in the entity (e.g., loss of no more than 20 percent of a population)
- A decision on whether the policy goal is or is not met

The results of the assessment are presented in terms of hazard quotients (HQs). The HQ is the ratio of the measured or predicted concentration of an ecological COPC to which the receptors are exposed in an environmental medium, and the measured concentration that adversely affects an organism based on a toxicity threshold. If the measured concentration or estimated dose is less than the concentration or dose expected to have the potential to produce an adverse effect (i.e., the ratio of the two is less than 1), the risk is considered acceptable (protective of the ecological receptor). Any quotient greater than or equal to 1 indicates that the ecological COPC warrants further evaluation to determine the actual likelihood of harm. COCs are selected only after an additional weight-of-evidence evaluation of the conservatism of the exposure assumptions, toxicity values, and uncertainties is conducted.

6.3.1.6.3 Measures of Ecosystem and Receptor Characteristics

Section 6.1.2.3 discusses the measured concentrations of ecological COPCs. Section 6.3.3 discusses the toxicity values associated with these COPCs. Endpoints stated in terms of specific ecological receptors or exposure classes (groups of species exposed by similar pathways) often

require data on the processes that increase or decrease the exposure concentration above or below the measured or predicted environmental concentration. Thus, some quotients incorporate exposure factors (e.g., dietary soil fractions and bioaccumulation factors). Section 6.3.2 discusses exposure factors for the unit.

6.3.2 Exposure Assessment

The exposure assessment evaluates potential exposures of ecological receptors to unit-related constituents and consists of the following:

- Description of the spatial distribution of COPCs (Section 6.3.2.1)
- Description of the spatial and temporal distribution of ecological receptors (Section 6.3.2.2)
- Quantification of receptor exposures that may result from overlap of these distributions (Section 6.3.2.3)

6.3.2.1 Constituent Distribution

The nature and extent of contamination at the FDTF are discussed in detail in Section 4.

The FDTF encompasses approximately 0.01 hectare (0.025 acres). Data aggregates for FDTF include samples taken at depths of 0 to 0.3 m (0 to 1 ft) and depths of 0 to 1.2 m (0 to 4 ft). Background data aggregates were also computed for each of the two depth intervals in soil that had not been contaminated by unit operations.

Exposures were evaluated by using RME concentrations. The RME concentration of each constituent in soil was the lower of the 95th-percentile upper confidence limit of the mean and the maximum detected concentration for that data aggregate. RME soil concentrations were used to calculate daily exposures (ED_{soil}) for each receptor by methods discussed in Section 6.3.2.3.

The magnitude of the contaminant exposures that may be experienced by ecological receptors is affected by the degree of their spatial and temporal associations with the unit. These associations are discussed in Sections 6.3.2.2 and 6.3.2.3.

6.3.2.2 Receptor Distribution

The approximately 0.01 hectare (0.025 acre) study area is characterized in terms of ecological communities and receptors that could potentially be exposed to unit-related constituents (see Section 6.3.1.2 and Figure 6.3-2). All three of the plant communities identified (Section 6.3.1.2.1) overlap the areas of contamination identified at the unit. All receptors and exposure classes in the food web could regularly use the exposure units for foraging and/or shelter.

The receptors selected for evaluation were vegetation, earthworms, short-tailed shrews (*Blarina brevicauda*), meadow voles (*Microtus pennsylvanicus*, a proxy for small mammal herbivores), American robins (*Turdus migratorius*), and red-tailed hawks (*Buteo jamaicensis*). These receptors are appropriate for evaluation of risks to the ecosystem for the following reasons: (1) conditions are favorable for vegetation growth throughout the area, which is an essential component of the food web; (2) single-chemical toxicity data are available for many COPCs; (3) there are standard techniques for determining site-specific toxicity of soils; and (4) for each endpoint, the receptors are present at the unit or potentially occur based on habitat availability. Earthworms are abundant and are likely to occur at the unit. Earthworms are important because their feeding and burrowing activities help maintain soil fertility. There are single-chemical toxicity data available for many COPCs, and there are standard techniques for determining site-specific toxicity to earthworms. Shrews are highly exposed to soil COPCs because they live and burrow in the soil, have small home ranges, and consume large quantities of soil and soil-dwelling organisms. Because voles are potentially exposed to soil contaminants, predominantly through ingestion of plants, their diet may subject them to high exposure to COPCs that are bioaccumulated by plants. Voles also have a small home range that may restrict them to areas of high contamination by COPCs. Also, single-chemical toxicity data for small mammals are available for many COPCs. Robins are abundant and provide an evaluation of exposure from a mixed diet comprised of earthworms and other soil invertebrates along with associated soil and fruits and berries. The hawk was selected since some hawks are protected species; they are also top predators that may be highly exposed, because they consume wildlife which may have bioaccumulated COPCs. However, because hawks have a large home range, they may feed at the unit only infrequently. Single-chemical toxicity data for birds and small mammals are available for many COPCs.

FDTF exposures to all six receptor groups were evaluated. Because the FDTF represents a small unit of landscape where only a few organisms interact, a food web, where many organisms interact, is evaluated as a conservative approach to the potential for exposures at this unit.

A variety of factors may affect the extent and significance of potential exposures. Receptor exposures are affected by the degree of spatial and temporal association with the unit. For example, the receptors' mobility may significantly affect their potential exposures to unit-related constituents. Many species may only inhabit the study area during seasonal periods (e.g., breeding season, non-migratory periods). Non-migratory species may remain in the vicinity throughout the year. These species, particularly those with longer life spans (and usually larger home ranges), have the greatest potential duration of exposure. However, species with small home range sizes have the greatest potential frequency of exposure. Other factors affecting exposures include habitat preference, behavior (e.g., burrowing, rooting, foraging), individual home range size (larger home ranges correspond to far less frequent use of study area), and diet. Diet is of particular importance in exposure as related to food source availability (larger amounts of preferred food sources equal a greater potential for receptor usage) and bioaccumulative constituents. Constituents that bioaccumulate may also tend to biomagnify in the food chain. As a result, predatory species at higher trophic levels may receive their most significant exposures through their prey. However, the possibility of a population, or even an individual predator, utilizing the unit as a primary source of food is considered extremely remote.

Table 6.3-3 presents typical home range areas of the selected receptor species. It also presents the fraction of each home range that each exposure unit and all units combined would comprise if the receptors made maximal use of the exposure units. The FDTF is smaller than the home range of shrews, voles, robins, and the red-tailed hawk. The unit foraging factor (UFF) for each receptor is also shown in Table 6.3-3 (see Section 6.3.2.3).

6.3.2.3 Quantification of Exposure

Evaluation of the degree to which constituent and receptor distributions (described in the previous two sections) coincide at the exposure units indicated that plants, earthworms, short-tailed shrews, meadow voles, American robins, and red-tailed hawks are the receptors (exposure classes and species) likely to have the greatest potential exposures to COPCs in soil.

To quantify exposures of terrestrial receptors to each COPC, a daily intake of each constituent was calculated. Conversion of the environmental concentration of each COPC to an estimated daily intake for a receptor at the unit is necessary prior to evaluation of potentially toxic effects. Exposure rates for short-tailed shrews, meadow voles, American robins, and red-tailed hawks were based upon ingestion of constituents from these media and also from consumption of other organisms. The ecological risk assessment did not attempt to measure potential risk from dermal and/or inhalation exposure pathways given the insignificance of these pathways relative to the major exposure pathways (e.g., ingestion) and due to the scarcity of data available.

The first step in measuring exposure rates for terrestrial wildlife is the calculation of food ingestion rates for short-tailed shrews, meadow voles, American robins, and red-tailed hawks. The EPA's *Wildlife Exposure Factors Handbook* (EPA, 1993) includes a variety of exposure information for a number of avian, herptile, and mammalian species. Information regarding body weights, food ingestion rates, and dietary composition is available for the selected receptor species. For example. the information in EPA (1993) includes the average total daily dietary intake, with separate measures of daily ingestion of animal matter, ingestion of vegetable matter, and incidental ingestion of soil, as well as other life history information on the receptors. Average body weights and food intake rates for the receptors are presented in Appendix Table D-1.

The *Wildlife Exposure Factors handbook* (EPA, 1993) also presents average values for intake of animal matter and vegetable matter for the selected receptors, as well as incidental soil ingestion. Food and soil ingestion rates for each receptor are presented in Appendix Table D-1.

A unit-specific exposure dose of each constituent was calculated using a food chain uptake model consistent with EPA Region IV guidance (EPA, 1995c). This algorithm accounts for exposure via incidental ingestion of contaminated soil, ingestion of plants grown in contaminated soil, and ingestion of lower trophic level animals associated with contamination. The soil exposure equation for shrews, voles, and robins is as follows:

$$ED_{soil} = [(C_s \times SP \times CF \times I_p) + (C_s \times BAF \times I_a) + (C_s \times I_s)] \times UFF / BW \qquad \text{(Eq. 6.3-1)}$$

where:

ED_{soil} = Soil exposure dose for terrestrial receptor (mg/kg/day)

C_s = RME concentration in soil (mg/kg)

SP	=	Soil-to-plant uptake factor (unitless)
CF	=	Plant wet-weight-to-dry-weight conversion factor (unitless) = 0.2 (used if SP values are based on dry weight)
I_p	=	Receptor-specific ingestion rate of plant material (kg/day)
BAF	=	Constituent-specific bioaccumulation factor (unitless)
I_a	=	Receptor-specific ingestion rate of animal material (kg/day)
I_s	=	Receptor-specific ingestion rate of soil (kg/day)
UFF	=	Unit foraging factor (unitless) (see explanation below)
BW	=	Body weight (kg)

For the exposure of hawks to COPCs from soil in their diet, an algorithm similar to the exposure equation for shrews, voles, and robins was used. However, bioaccumulation by shrews (the most highly contaminated diet potential diet items for hawks) was included in the calculation as follows:

$$ED_{soil} = [(C_S \times SP \times CF \times I_{p(hawk)}) + (C_{shrew} \times I_{a(hawk)}) + (C_S \times I_{s(hawk)})] \times UFF / BW \quad \text{(Eq. 6.3-2)}$$

where:

ED_{soil}	=	Soil exposure dose for terrestrial receptor (mg/kg/day)
C_s	=	RME concentration in soil (mg/kg)
SP	=	Soil-to-plant uptake factor (kg soil/kg tissue)
CF	=	Plant wet-weight-to-dry-weight conversion factor (unitless) = 0.2 (used if SP values are based on dry weight)
$I_{p(hawk)}$	=	Ingestion rate of plant material by hawk (kg/day)
C_{shrew}	=	Concentration in shrew tissue (mg/kg)
$I_{a(hawk)}$	=	Ingestion rate of animal material by hawk (kg/day)
$I_{s(hawk)}$	=	Ingestion rate of soil by hawk (kg/day)
UFF	=	Unit foraging factor (unitless)
BW	=	Body weight of hawk (kg)

The concentration of a COPC in shrew tissue was calculated using a bioaccumulation factor for ingested contaminants to tissue (BAF_{mamm}) derived from studies of cattle (Ng et al., 1982). This factor relates contaminant concentration in tissue to daily contaminant intake rather than to concentration in soil and has units of d/kg [concentration in tissue (mg/kg) divided by daily intake (mg/d)]. The equation for concentration in shrew tissue is:

$$C_{shrew} = C_s \times (SP \times I_{p(shrew)} + BAF_{inv} \times I_{a(shrew)} + I_s) \times BAF_{mamm} \qquad \text{(Eq. 6.3-3)}$$

where:

$I_{p(shrew)}$ = Ingestion rate of plant material by shrew (kg/d)

BAF_{inv} = Constituent-specific bioaccumulation factor for earthworms (kg soil/kg tissue)

$I_{a(shrew)}$ = Ingestion rate of animal material by shrew (kg/d)

BAF_{mamm} = Bioaccumulation factor of constituent ingested by shrew (d/kg)

Therefore, the following equation was used to calculate the indirect exposure of hawks to soil COPCs:

$$ED_{soil} = [(C_s \times SP_v \times I_{p(shrew)}) + (C_s \times BAF_{inv} \times I_{a(shrew)}) + (C_s \times I_{s\ (shrew)})] \times BAF_{mamm} \times I_{a(hawk)} \times UFF/BW \qquad \text{(Eq. 6.3-4)}$$

because hawks ingest no plant matter ($I_{p(hawk)} = 0$) and no soil ($I_{s(hawk)} = 0$).

Bioaccumulation is the process by which constituents are absorbed from ingested soil or sediment, food, and water and retained in tissues. It is quantified by the calculation of a bioaccumulation factor (BAF), which is a proportionality constant relating the concentration of a constituent in tissue to the concentration in the exposure medium (Amdur et al., 1991; EPA, 1989b).

Bioaccumulation may be a significant component of exposure to COPCs for the receptors. For the terrestrial receptors, bioaccumulation was evaluated by means of specific soil-to-plant and soil-to-invertebrate tissue BAFs. Soil-to-plant uptake factors (termed SPs) were obtained from Baes et al. (1984) for inorganics. Values presented by Baes et al. (1984) are calculated on a dry-weight basis for plant tissue and were adjusted to a wet-weight basis by assuming a moisture content of 80 percent and, therefore, multiplying the BAFs by 0.2. BAFs for organic

constituents were calculated by using an empirical equation presented by Travis and Arms (1988). This equation is based on the observed relationship of constituent uptake rate to octanol-water partitioning coefficients of the constituents. Adjusted BAFs (wet weight basis) for vegetative (leaf and stem) and reproductive (seed and fruit) parts of plants (SPv and SPr, respectively) are presented in Appendix Table D-2. Therefore, the wet-weight-to-dry weight conversion factor, CF, is not used to calculate ED_{soil}. BAFs for earthworms were taken from HAZWRAP (1994). BAFs for diet-to-tissue uptake by mammals were taken from Ng et al (1982) and Baes et al. (1984) as reported in HAZWRAP (1994). Values for soil-to-invertebrate and diet-to-tissue uptake factors are presented in Appendix Table D-2. When COPC-specific values were not available, surrogate values were substituted (e.g., BAF_{inv} of 0.2 for most organics [HAZWRAP, 1994], and values for polychlorinated byphenyls (PCBs) were used for dioxins and furans [Table D-2]).

Terrestrial soil-to-plant transfer factors (Bioconcentration Factors [BCFs]) and plant-to-animal BAFs for organic COPCs were estimated using regression equations from Travis and Arms (1988) when observed values were unavailable from the literature. The equation for calculating soil-to-plant BCFs is:

$$\text{Log BCF} = 1.588 - 0.578 \log K_{ow} \qquad \text{(Eq. 6.3-5)}$$

The equation for calculating plant-to-animal BAFs is:

$$\text{Log BAF} = (-7.6 + \log K_{ow}) \times 8 \qquad \text{(Eq. 6.3-6)}$$

The calculated BAF is multiplied by a factor of 8 to adjust for the feeding rate used in the study Travis and Arms (1988). BAFs reported in HAZWRAP (1994) and used here result from multiplying the calculated BAF by a factor of 12 (HAZWRAP, 1994). A default value of 1 was used for BAF_{inv} of metals when data were not available. These are thought to be conservative default values.

A UFF was calculated to account for the reasonably expected use of an exposure unit. Because of the small home range area and year-round residence, shrews, voles, other small mammals, and non-migratory songbirds living on or near the unit potentially would use the contaminated areas only a fraction of the time. Hawks, with their large feeding range, are likely to be exposed even less frequently to contaminants derived from FDTF soils. UFFs for each receptor are shown in Table 6.3-3.

Because it was assumed that the vegetation consumed by shrews and voles comprises largely leaves, stems, and roots of plants (EPA, 1993), values of SPv were used to calculate their exposure to COPCs. Because robins consume predominantly berries and fruits when they eat plant matter (EPA, 1993), values of SPr were used to calculate their exposure to COPCs. BAF_{inv} was used to calculate the exposure of shrews and robins to COPCs by ingestion of soil invertebrates. BAF_{mamm} was used to calculate the tissue concentration of shrews as the most highly contaminated potential diet of hawks.

Daily exposures of small mammals and birds to COPCs were calculated using the RME exposure concentration at each exposure unit and for each depth aggregate. Exposures were not calculated for plants and earthworms because their toxicity benchmarks are direct measurements of soil constituent concentrations rather than dietary exposures. The daily exposures of small mammals and birds to COPCs (ED_{soil}) at each exposure unit are presented in Tables 6.3-4 through 6.3-7.

6.3.3 Effects Assessment

The effects assessment defines and evaluates the potential ecological response to ecological COPCs in terms of the selected and measurement endpoints. The effects assessment includes the derivation of toxicity reference values (TRVs) that are the basis of the evaluation. Section 6.3.4 uses the results of the effects assessment to identify ecological COCs and characterize ecological risk.

6.3.3.1 Methodology

This section describes the methods used in assessing potentially toxic effects of COPCs to ecological receptors exposed to soil at FDTF.

6.3.3.1.1 Nonradioactive Constituents

The methods for assessing the potentially toxic effects of nonradioactive COPCs was based on the derivation of a TRV for each COPC in each medium. The TRVs were derived to represent reasonable estimates of the constituent concentrations that, if exceeded in an environmental medium, may produce toxic effects in ecological receptors exposed to that medium. Ideally, TRV values are based on unit-specific toxicity data. However, in the absence of unit-specific data, toxicity data from the literature are used by establishing data selection criteria such that

background for the soil interval 0 to 0.3 m (0 to 1 ft). The frequency of detection for arsenic and iron was 5/5 which means that surrogate values are not required since there were not any non-detects. Sodium frequency of detection is 3/5 which means that surrogate values are required based on the new protocol. The method detection limit is 12.9 mg/kg for sodium and to include it as a surrogate for the two non-detects will reduce the average background concentration to 23.68 mg/kg or 47.36 for 2 times the average background concentration. Therefore, the maximum unit value (69.1 mg/kg) for sodium will be greater than the revised 2 times average background value and it would be identified as a COPC. Under the new protocol, sodium would be carried through the entire risk assessment process without a risk or hazard quotient determination because there is no toxicity data available for it. Sodium is considered an essential human nutrient and the recommended dietary allowance or benchmark value for a child is 400 mg/day and for an adult it is 500 mg/day. If one assumes that the daily soil intake for a child is 200 mg/day and the adult is 100 mg/day, then the concentration range that one can intake on a daily basis is 2E+06 to 5E+06 mg/kg. The unit maximum concentration for sodium (69.1 mg/kg) is therefore insignificant to the daily intake concentration range.

While reviewing Table 6.1-8 (0 to 4 ft soil interval), it was determined that none of the constituents were eliminated due to the comparison of 2 times the average background.

As mentioned earlier, Tables 6.1-9 and 6.1-10 are provided for risk management decisions. These tables provide a summary of the background analytes being screened against the COPC selection protocol as the unit analytes. As a result, background risk was determined on the remaining analytes.

Based on these observations, implementation of the new protocol will not affect this unit and the outcome of the risk or hazard.

The direction of the bias introduced by screening out constituents before the risk assessment would always be toward underestimating the hazard or risk, since the screened constituents are not included in the risk assessment. In order to assess the significance of the screening process, risk estimates have been calculated for the chemicals that were screened out in the COPC selection process. The findings are as follows:

On-Unit Worker

- For the 0 to 0.3 m (0 to 1 ft) soil interval, the total HI for exposures to the constituents that were screened out is 0.0006 for the known on-unit worker, and the total cancer risk is 6×10^{-9}. This is well below the upper limit of 1 for noncancer hazards, and is also well below the initial level of concern of 1×10^{-6} for cancer risk.

Hypothetical On-Unit Industrial Worker

- For the 0 to 0.3 m (0 to 1 ft) soil interval, the total HI for exposures to the screened constituents is 0.03 for the hypothetical on-unit industrial worker, and the total cancer risk is 1×10^{-6}. The HI is well below 1, and the cancer risk is at the lowest level of concern.
- For the 0 to 1.2 m (0 to 4 ft) soil interval, there were no constituents screened out in the COPC selection process.

Hypothetical On-Unit Resident

- The total HI (soil and produce combined) for exposures to the screened constituents from the 0 to 0.3 m (0 to 1 ft) soil interval is 0.8, and the cancer risk is 5×10^{-5}. The HI for the soil exposures (not including produce) to the screened constituents from the 0 to 0.3 m (0 to 1 ft) soil interval for the hypothetical on-unit resident is 0.6, and the cancer risk is 9×10^{-6}. There is only one constituent with a cancer risk of greater than 1×10^{-6}, as follows:
- Arsenic (ELCR = 9×10^{-6} for soil ingestion, 7×10^{-6} for leafy vegetables, 5×10^{-6} for tuberous vegetables, and 1×10^{-5} for fruits)
- For the 0 to 1.2 m (0 to 4 ft) soil interval, there were no constituents screened out in the COPC selection process.

These findings indicate that there is minimal uncertainty in the risk estimates that may be attributable to the COPC selection process. In case of the highest hazards or risks for the screened constituents (e.g., the cancer risk of 5×10^{-5}), the estimates appear to be entirely attributable to naturally-occurring levels of arsenic and beryllium in the soil. Note that the background comparison used in the COPC selection process is very simple, increasing the uncertainty of whether naturally-occurring substances are carried through to the risk assessment. In particular, although arsenic and beryllium were not always screened out in the COPC selection process, these naturally-occurring substances do not appear to be site-related and may still be present at naturally-occurring levels.

magnitude of risk from ecological COPCs at each exposure unit and assess the risk to ecological receptors. Risk characterization includes two main steps: risk estimation and risk description. Risk estimation (Section 6.3.4.1) uses the results of the exposure and effects assessments to calculate an HQ for each COPC. The HQs are based on relevant measurement endpoints and are indicative of the COPCs' potential to pose ecological risk to receptors. Risk assessment-related uncertainties are also analyzed and discussed. Section 6.3.4.2, Risk Description, summarizes the conclusions of the risk estimation and discusses confidence in the risk estimates based on a weight-of-evidence evaluation. Any COPCs for a given exposure unit and medium that were identified as likely to pose significant risk to receptors are classified as ecological constituents of concern (COCs).

6.3.4.1 Risk Estimation

Estimation of the potential of COPCs to pose significant risk to receptors is based on the magnitude of the HQ value calculated for each contaminant, as well as other factors such as the bioaccumulation/biomagnification potential, mechanism of toxicity, physicochemical characteristics, environmental fate, and ecological relevance of each contaminant. Tables 6.3-11 through 6.3-16 present the calculation of HQs for COPCs in surface and subsurface soil at the exposure unit. An HQ is a ratio of the estimated exposure dose (for small mammals and birds) or exposure concentration (for plants and earthworms) of a contaminant to the TRV. Generally, the greater this ratio, or quotient, the greater the likelihood of the effect. A quotient of 1.0 is considered the threshold level at which effects may occur. The TRVs on which the HQs were based were derived to be conservative and representative of chronic exposures, as described previously in Section 6.3.3. A Hazard Index (HI) is calculated by summing two or more HQs if the constituents exhibit consistent modes of toxicity and effect endpoints (EPA, 1995e).

The calculated HQs were used to assess the potential that toxicological effects will occur among the unit's receptors. The HQs were compared to HQ guidelines for assessing the risk posed from contaminants (Menzie et al., 1993). These guidelines suggest that HQs less than or equal to 1.0 present no probable risk, HQs greater than 1.0 but less than 10 present a small potential for environmental effects, HQs greater than 10 but less than 100 present a significant potential for ecological effects, and HQs greater than 100 present the highest potential for expected effects. The likelihood that terrestrial plants, earthworms, small mammals, songbirds, and hawks could be significantly impacted by the toxicological effect(s) produced by a given COPC was a major

factor in the subsequent determination (in Section 6.3.4.2) of whether that contaminant should be classified as an ecological COC.

Ecological risk from nonradioactive contaminants was characterized for both current and potential future land use conditions at the unit (Sections 6.3.4.1.1 and 6.3.4.1.2, respectively). Under current conditions, ecological receptors are unlikely to be exposed to soils deeper than 0.3 m (1 ft). while under hypothetical future land uses involving trenches for construction. deeper soils could be excavated and distributed on the surface. Therefore, samples for the FDTF were taken to depths of 0.3 m (1 ft) and 1.2 m (4 ft). Soil data from the surface down to 0.3 m (1 ft) were used for current conditions. Soil data to a depth of 1.2 m (4 ft) were used in characterizing future risk associated with the FDTF.

6.3.4.1.1 Current Land Use

HQs for exposure of ecological receptors to surface soil at FDTF are presented in Tables 6.3-11 through 6.3-13. No HQs exceeded 1.0.

For all six receptors, HQs could not be calculated for the two COPCs, silver and benzoic acid, because there are no toxicity benchmarks for these COPCs.

6.3.4.1.2 Future Land Use

In the future, excavation is possible and, therefore, soil exposure can change. Chemical concentrations in soil depths of 0 to 1.2 m (0 to 4 ft) would be used to compute HQs. The computations for future ecological risk were done using soil concentration data for that depth. Projected land uses (e.g., residential, industrial, other) also influence the specific receptors, but not necessarily the receptor exposure classes. Therefore, future estimated risks to the plants and animals at the exposure units can be considered to be very similar to current risks from exposure at that depth in the soil. Changes in habitat type or ecological succession could occur, and exposure of large trees and burrowing animals could increase; computations were made only for future conditions.

HQs for exposure of plants and earthworms in deeper soil (0 to 1.2 m [0 to 4 ft]) at FDTF are presented in Table 6.3-14. For plants, HQs that are greater than 1 were calculated for aluminum (208), chromium (38.5), selenium (2.1) and vanadium (42.3). For plants, HQs could not be

calculated for calcium, iron, magnesium, potassium, sodium, and benzoic acid because there are no toxicity data for the COPCs and receptors. For earthworms, the only HQ greater than 1 was calculated for chromium (1.2). HQs could not be calculated for earthworms for aluminum, antimony, calcium, iron, magnesium, potassium, silver, sodium, vanadium, and benzoic acid because there are no toxicity data for the COPCs and receptors.

HQs for small mammals and birds are presented in Tables 6.3-15 and 6.3-16. For shrews, HQs that are greater than 1 are for aluminum (1.28) and cadmium (2.32). For voles, there were no HQs greater than 1. For mammals, HQs could not be calculated for calcium, iron, magnesium, potassium, silver, sodium, and benzoic acid because there are no toxicity data for the COPCs and receptors. For birds, there are no HQs greater than 1. For birds, HQs could not be calculated for antimony, calcium, iron, magnesium, potassium, silver, sodium, and benzoic acid.

6.3.4.1.3 Uncertainty

Uncertainty is inherent in each step of the ERA process. Major factors contributing to uncertainty in this risk assessment are discussed qualitatively in the following sections.

- Problem formulation
- Exposure assessment
- Effects assessment
- Risk characterization

These are identified and evaluated in Table 6.3-17, where the effect of uncertainty on the risk assessment is indicated in terms of the likelihood of overestimating or underestimating risk.

6.3.4.1.3.1 Uncertainties in Problem Formulation

There is uncertainty about which analytes in environmental media at FDTF qualify as ecological COPCs. For instance, some substances are undetectable at contract-required detection limits, but may be present at or accumulate to toxic concentrations in biota. There is also uncertainty about what organisms potentially exposed at FDTF are most at risk and are not adequately recognized in the assessment endpoints evaluated in the ERA.

6.3.4.1.3.2 Uncertainties in Exposure Assessment

The primary uncertainties in the exposure assessment concern unit-specific and receptor-specific exposure factors. There is uncertainty about the unit-specific properties of soil that determine the availability of ecological COPCs to ecological receptors. There is also uncertainty about the receptor-specific exposure parameters that determine the magnitude of their exposure to contaminated media (e.g., dietary composition and time spent at unit). In general, the ERA is designed to conservatively overestimate exposure.

6.3.4.1.3.3 Uncertainties in Effects Assessment

The major uncertainties in the effects assessment include the consequences of extrapolating from published toxicity thresholds for test organisms, the lack of toxicity data for some receptors for some ecological COPCs, the lack of toxicity data for chemical mixtures, and the ecological relevance of organismal toxicity for characterizing risks to populations and communities. The weight-of-evidence indicates that the effects assessment is conservative and thus likely overestimates risk.

6.3.4.1.3.4 Uncertainties in Risk Characterization

The uncertainty in the risk characterization is the uncertainty about the actual HQ values and, thus, their interpretation in terms of current and future risks to plants and animals at FDTF. In general, the HQs are more likely to overestimate than underestimate risk to ecological receptors at this unit. Also, ecological COPCs with no threshold data show uncertainty. It is not possible to evaluate risks of toxicity of silver, benzoic acid, bromomethane, carbon disulfide, and phenol to wildlife. However, concentrations of phenol were well below toxicity benchmarks for plants and earthworms. This indicates that risks from phenol to wildlife are likely to be low as well. Four additional areas of uncertainty in risk characterization are off-unit risk, cumulative risk, future risk, and background risk. If more certainty is needed, then field and laboratory studies will be required.

Off-unit risk. Off-unit receptors can be exposed to contaminants via physical and organismal transport processes; evaluating the magnitude of this exposure would require additional studies. There is little reason to expect that contaminants migrating off-unit would be concentrated above measured concentrations at the FDTF unless they bioconcentrate in organisms with extensive

mobility. In general, the risk to most off-unit receptors is likely to be overestimated by the risk estimate for on-unit receptors.

Cumulative risk. The ERA estimates the risk to populations of ecological receptors from individual contaminants. Generally, the methods used are sufficiently conservative so risk from individual COPCs is overestimated. Nevertheless, cumulative risk is possible when plants and animals are exposed to multiple COPCs simultaneously. Risks from radionuclides are summed because they have similar modes of action, while risks for inorganic and organic COPCs do not. Ecological risk characterization for FDTF is unlikely to overestimate actual risks to plants and animals because of cumulative risks.

Future risk. A third area of uncertainty in ecological risk characterization is future risk to plants and animals from FDTF contamination. The baseline ERA characterizes current risk based on chronic exposure to measured concentrations of toxicants with potential to persist in the environment for extended periods of time. Risk quotients for ecological receptors estimate the risk to plants and animal species that would be natural parts of future successional stages. Nevertheless, mechanisms exist that could increase (e.g., erosion, leaching to groundwater, excavation) or decrease (e.g., enhanced microbial degradation) risk to future plants and animals at the unit.

Background risk. Another source of uncertainty is ecological risk relative to background conditions. Some ecological COPCs are likely above background only by a statistically insignificant amount, such that concentrations at the exposure unit are actually less than the background concentration. This conservative approach to comparing unit concentrations to background likely overestimates the risk from ecological COPCs not associated with The FDTF exposure unit.

The primary sources of uncertainty in the four steps of the FDTF ERA do not seriously affect the credibility of the risk characterization.

6.3.4.2 Risk Description

The risk description has two main elements: (1) the ecological risk summary, which summarizes the results of the risk estimation and uncertainty analysis and assesses confidence in the risk

estimates based on weight of evidence; and (2) the interpretation of ecological significance, which describes the magnitude of the identified risks to the assessment endpoint(s).

6.3.4.2.1 Ecological Risk Summary

The current and future risks to ecological receptors at each exposure unit are characterized by evaluating ecological assessment endpoints using HQs. HQs were calculated for different receptors for every ecological COPC for which a toxicity threshold concentration was available from published information on toxicity tests. Each HQ compares two concentrations: (1) the estimated exposure for a given receptor at a particular exposure unit based on the measured environmental concentration in soil; and (2) the toxicity threshold concentration for the ecological COPC and receptor. The toxicity threshold concentration is the concentration expected to cause no harm to the receptor, minimal harm with no ecological significance, or minimal harm to a community of organisms (i.e., assemblage of species) exposed to the ecological COPC in the appropriate medium. Thus, the toxicity threshold is a safe or protective concentration as required by the decision criteria associated with the assessment endpoints. The HQ benchmark was set at 1.0, and several COPCs exceeded that number. These COPCs are further evaluated based on weight-of-evidence, and a determination is made as to whether any have a high likelihood of being a significant risk to the receptor population analyzed for this risk assessment or the ecological community that encompasses the study area.

Table 6.3-18 shows the highest HQs for each COPC with an HQ greater than 1 at the exposure unit. Neither of the two COPCs has an HQ greater than 1 in surface soil (0 to 0.3 m [0 to 1 ft]) at the FDTF. Aluminum, cadmium, chromium, selenium, and vanadium have HQs greater than 1 in subsurface soil (0 to 1.2 m [0 to 4 ft]) at the FDTF.

The COPCs with HQs exceeding 1.0 were evaluated to determine whether the COPC has a high probability of being a COC at FDTF. This evaluation considered whether the variables that were used to derive the estimated dose (ED) and TRV resulted in an HQ that is too conservative, that is, overestimates the risk to ecological receptors. For both the ED and TRV, receptor properties, contaminant properties, and properties of the relationship between receptor and contaminant were considered.

Properties of the ecological receptors that influence the magnitude of the EDs include the dietary intake rates (Ip, Ia, and Is), the UFFs, and body weight. The values used for these parameters,

including the home ranges used to calculate UFFs, are those published in EPA (1993) and Sample and Suter (1994). They are unlikely to either greatly underestimate or overestimate the exposure of ecological receptors at the FDTF.

The chemical property of COPCs that most influences the exposure of ecological receptors to a COPC in soil is the COPC's tendency to adsorb to soil particles. If the adsorptive tendency of a COPC is great enough, then the COPC may not be fully available for absorption by the ecological receptor as soil particles pass through the receptor's digestive system. Here the absorption of COPC from soil particles is modeled at 100 percent. Absorption from soil is likely to be less for most, if not all, COPCs, but especially strongly adsorptive COPCs, such as aluminum. Aluminum, for example, is a structural component of clay particles in soil and is unlikely to be available for uptake by ecological receptors at even 15 percent of the measured concentration. The HQs for soil ingesting receptors (shrew, vole, and robin) likely overestimate the risk from aluminum, resulting in EDs for aluminum that are too high.

The uptake and bioaccumulation of COPCs in organisms is a property of the organisms, the COPC, and the unit-specific conditions. The uptake and bioaccumulation factors (SPv, SPr, and BAFs) that are used to estimate EDs for animals at the FDTF are published values from one or more sites. Because these values represent various organisms and unit-specific conditions, these factors are equally likely to either overestimate or underestimate uptake and bioaccumulation by ecological receptors at FDTF. There is at present no reason to conclude that HQs are consistently overestimated as a result of the uptake and bioaccumulation factors used to estimate EDs at the FDTF.

One parameter of the receptors that can influence the magnitude of the TRVs is body weight. Published toxicity benchmarks (mg/kg bw/d) for test species are adjusted by the body weight of the FDTF ecological receptors. There is no reason to expect that body weights used to calculate TRVs for FDTF ecological receptors are not representative of receptors at the unit.

Properties of COPCs that influence the magnitude of the TRVs include the chemical form of the contaminant and the mode of delivery (i.e, exposure medium). The methods used to measure the concentration of COPCs in soil do not distinguish among the different forms of inorganic compounds, primarily metal salts. Although it is not known whether the form of contaminant used in the published toxicity test is the same as that which occurs in FDTF soils, in some cases

it is likely that the form used in the test is more mobile and available for uptake by organisms than is the naturally-occurring form. This is most likely the case for aluminum and cadmium. For example, the TRV for aluminum is based on the toxicity benchmark for aluminum chloride. but aluminum chloride adsorbs less strongly than aluminum oxides, which are likely to be the more prevalent unbound form in soil. The TRV for cadmium is based on the toxicity of cadmium chloride, which is unlikely to be the prevalent form of cadmium in soil. The HQs for aluminum and cadmium at the FDTF may be overestimated due to differences between the chemical forms of these COPCs that were used to derive TRVs and those occurring at the unit.

Another important factor for the evaluation of HQs is the difference between the exposure medium used to deliver the contaminant to the receptor in the published toxicity test and the exposure medium at the unit, that is, natural soil and plant or animal tissues of various types. The HQs for aluminum for short-tailed shrews and for chromium and selenium for plants at FDTF likely overestimate the risk slightly. The TRVs for the COPCs are derived from studies where the animal tests species was exposed to the contaminant in drinking water, or sandy soil in the case of plants. The availability of these contaminants is likely to be lower in natural soil with higher clay and silt content than water or sandy soils. For example, the LOAEL for chromium (VI) with an endpoint of fresh shoot weight (30 percent reduction) was 30 mg/kg in a loam soil. The NOAEL for chromium (VI) was 4 in a loamy sand compared to an LOAEL of 1 for a more acidic. sandy soil. The TRVs based on these data would be correspondingly higher, which would reduce the magnitude of the HQs. Given this fact, coupled with the low HQs, aluminum is not judged to be a COC for shrews, and chromium and selenium are not considered to be COCs for plants at FDTF.

Aluminum (plants and mammals), cadmium (mammals), chromium (earthworms), and vanadium (plants) were also evaluated with respect to their toxicity, which is the most important factor influencing the magnitude of HQs.

The toxicity of a substance to a receptor is a property of both the receptor and the COPC. LOAELs were used as the basis for TRVs for plants and earthworms, as well as for mammals and birds. The LOAELs for plants and earthworms are briefly evaluated below.

There is low confidence in the plant LOAEL benchmarks reported for toxicity of aluminum and vanadium because of the lack of data (Will and Suter, 1996). The authors reviewed one study on aluminum. There were no primary reference data for vanadium. Aluminum toxicity to plants is

likely to be dependent on soil acidity because of the effect of acidity on aluminum binding capacity of soil. Based on this one published toxicity value for a soil with pH = 5, the benchmark for aluminum is not enough to warrant considering aluminum a COC at the FDTF. Likewise, there is sufficient uncertainty about the threshold concentration for significant ecological effects of vanadium on plants to disregard vanadium as a COC for plants at FDTF.

Examination of the toxicity data for chromium leads to the conclusion that chromium is not a COC for earthworms at the FDTF. The TRV of 32 mg/kg for chromium (III), based on a 30 percent reduction in growth, is questionable considering that a comparable effect on reproduction occurred at 100 mg/kg. The LOAEL for chromium (III) based on reproduction effects is, thus, greater by a factor of 3.0. There is sufficient uncertainty in the relevance of the TRV endpoint that chromium should not be considered a COC for earthworms at the FDTF when the HQ is less than 3.0, as it is for earthworms in subsurface soil at the FDTF (Table 6.3-14).

Aluminum and cadmium have HQs greater than 1 for mammals. The toxicity data on which the TRVs for these COPCs were based are evaluated below.

The endpoint of the observed LOAEL for mammals exposed to aluminum in drinking water was detrimental growth effects on offspring, not survival or reproduction. No LOAEL is available for birds. The LOAEL is estimated to be 10 times the No Observed Adverse Effects Level (NOAEL). Combined with the lower availability of aluminum in natural soil and the higher LOAELs necessary for ecologically significant effects on mammals and birds, aluminum is unlikely to be a COC for animals at FDTF. Aluminum should not be considered to be a COC without additional toxicity data.

Cadmium is not considered to be a COC for mammals at the FDTF. The observed LOAEL for cadmium was associated with 28 percent lower fetal survivorship. Given the high reproductive capacity of small mammals, this level of effect is unlikely to be significant to the maintenance of populations. Given the form of cadmium tested (cadmium chloride), the questionable significance to natural populations of the observed effect, and the magnitude of the HQs, cadmium is judged not to be a COC at FDTF. Cadmium should not be considered a COC for small mammals without additional toxicity data.

In addition, background risk was computed (Appendix Tables D-3 through D-12). It was found that background risks were lower (less than an HQ of 1.0) for all animal (earthworm, small

mammal and bird) receptors. There were HQs greater than 1.0 for plants for aluminum (118), chromium (12.5) and vanadium (13.6). The high plant HQs support the weight-of-evidence analysis that these COPCs are not COCs.

In summary, following examination of the data used to estimate EDs and TRVs for ecological receptors at the FDTF, all COPCs with HQs greater than 1.0 were eliminated from further consideration as COCs. Aluminum, chromium, selenium, and vanadium are not judged to be COCs for plants growing in FDTF soil because of the low confidence in the published phytotoxicity values. Nevertheless, there is uncertainty about whether aluminum and chromium should be considered COCs for plants exposed to subsurface soils at FDTF because of the high HQs there. There are no COCs for earthworms at FDTF. There is sufficient published evidence on the toxicity of chromium to conclude that the levels of these COPCs in soil at FDTF do not pose much risk to earthworms. The risk to mammals and birds from aluminum and cadmium is sufficiently overestimated by conservative HQs that these are not considered COCs at the FDTF without additional experimental evidence of toxicity of FDTF soil.

The weight-of-evidence includes habitat information about the FDTF. All four terrestrial exposure units are small, occupying 0.01 hectare (0.025 acres) total. This area is not large enough to encompass an entire home range of individual endpoint receptors: populations of wildlife species require more space than this for their combined home ranges. Therefore, exposure and ecological risk are limited due to a small number of organisms.

The small units consist of disturbed (e.g., weedy and grassy) vegetation and scattered trees. This type of habitat provides (1) limited cover for protection, (2) limited food, and (3) limited additional resources necessary to sustain an active multiple individual food web. The few species that do live there, such as plant species, earthworms, small birds, and small mammals, are typical of inhabitants of many other small patches of disturbed vegetation at SRS. There is nothing unique about the commonly encountered habitat and species at this unit.

6.3.4.2.2 Interpretation of Ecological Significance

There are no ecological COCs present in surface and subsurface soils at the FDTF.

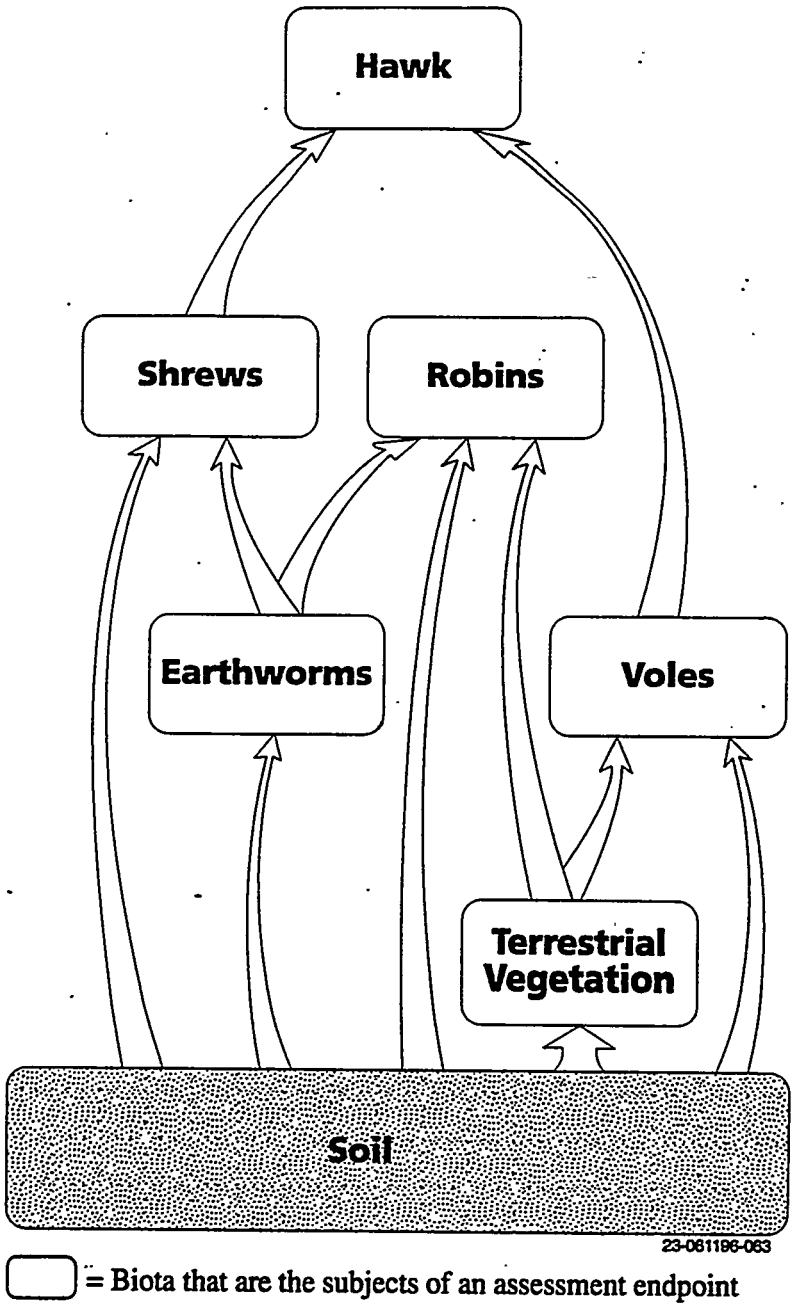


Figure 6.3-1. Food Web for the FDTF BERA

Exposure Unit	Exposure Route	Receptor					
Terrestrial Units		Terrestrial Vegetation (AE2)	Soil-dwelling Invertebrates (AE3)	Herbivorous Mammals (AE4)	Worm-eating and/or Insectivorous Mammals and Birds (AE5)	Hawk (AE6)
FDTF	Ingestion of Terrestrial Plants	—	—	●	—	—
FDTF Soil Background	Ingestion of Terrestrial Animals	—	—	—	●	●
	Soil Ingestion	—	●	●	●	—
	Inhalation	—	○	○	○	—
	Direct Soil Contact	●	●	○	○	—
	External Radiation	—	—	●	●	●

AE - Assessment Endpoint
● Evaluated quantitatively
○ Evaluated qualitatively
— Not applicable

Figure 6.3-2. Summary of Exposure Pathways for FDTF BERA

Table 6.3-1. Threatened, Endangered, and Sensitive Species that Could Potentially Occur in the Area of the FDTF

Common Name	Scientific Name	Federal Status	Preferred Habitat
Bald eagle	*Haliaeetus leucocephalus*	Endangered	Only as transient; prefers aquatic habitat for feeding and nesting
Red-cockaded woodpecker	*Picoides borealis*	Endangered	Requires savannah-like areas of mature pine with open midstory. Currently there is no intent to manage stands in the area for recruitment of red-cockaded woodpecker
Smooth purple coneflower	*Echinacea laevigata*	Endangered	Potential habitat is open areas with sandy soil

Table 6.3-2. Policy Goals, Ecological Assessment and Measurement Endpoints, and Decision Rules for the FDTF ERA

Policy Goals	Assessment Endpoint	Measurement Endpoint	Decision Rule
Policy Goal 1: The conservation of threatened and endangered species.	**Assessment Endpoint 1:** No reduction in numbers of any state- or federally-designated threatened or endangered species	**Measurement Endpoint 1:** COPC concentrations in physical media and predicted concentrations in prey species	**Decision Rule for Assessment Endpoint 1:** If T&S are not present, or COPC RME concentrations in the media do not exceed lower toxicity thresholds or dietary NOAELs (i.e., HQs <1), the assessment endpoint is met and T&E species are not at risk.
Policy Goal 2: The protection of terrestrial populations and ecosystems	**Assessment Endpoint 2:** No substantial adverse effect on terrestrial plant community	**Measurement Endpoint 2:** Concentrations of COPCs in surface soil	**Decision Rule for Assessment Endpoint 2:** If the ratios of COPC RME concentrations in surface soil to phytotoxicity benchmarks (HQs) are <1, then Assessment Endpoint 2 has been met and terrestrial plants are not at risk. If the HQ >1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk.
	Assessment Endpoint 3: No substantial adverse effect on populations of soil-dwelling invertebrates, e.g., earthworms	**Measurement Endpoint 3:** Concentrations of COPCs in surface soil	**Decision Rule for Assessment Endpoint 3:** If the ratios of COPC RME concentrations in surface soil to benchmarks for adverse effects on soil invertebrates (HQs) are <1, then Assessment Endpoint 3 has been met and soil-dwelling invertebrates are not at risk. If the HQ > 1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk.

Table 6.3-2. Policy Goals, Ecological Assessment and Measurement Endpoints, and Decision Rules for the FDTF ERA (Continued)

Policy Goals	Assessment Endpoint	Measurement Endpoint	Decision Rule
	Assessment Endpoint 4: No substantial adverse effect on populations of herbivorous animals, e.g., voles	**Measurement Endpoint 4:** Concentration of COPCs in surface soil and vegetation predicted from soil concentrations	**Decision Rule for Assessment Endpoint 4:** If ratios of estimated exposure concentrations predicted from COPC RME concentrations in surface soil to dietary limits corresponding to LOAEL benchmarks for adverse effects on herbivorous animals (HQs) are <1, then Assessment Endpoint 4 is met, and herbivorous animals are not at risk. If the HQ > 1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk.
	Assessment Endpoint 5: No substantial adverse effect on populations of worm-eating and/or insectivorous animals, e.g., shrew, robin	**Measurement Endpoint 5:** Concentration of COPCs in surface soil and soil-dwelling invertebrate prey predicted from soil concentrations	**Decision Rule for Assessment Endpoint 5:** If ratios of estimated exposure concentrations predicted from COPC RME concentrations in surface soil to dietary limits corresponding to LOAEL benchmarks for adverse effects on insectivorous animals (HQs) are <1, then Assessment Endpoint 5 is met, and insectivorous animals are not at risk. If the HQ > 1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk.

Table 6.3-2. Policy Goals, Ecological Assessment and Measurement Endpoints, and Decision Rules for the FDTF ERA (Continued)

Policy Goals	Assessment Endpoint	Measurement Endpoint	Decision Rule
	Assessment Endpoint 6: No substantial adverse effect on populations of terrestrial predators, e.g., hawk	**Measurement Endpoint 6:** Concentrations of COPCs in prey predicted from concentrations in surface soil	**Decision Rule for Assessment Endpoint 6:** If ratios of estimated exposure concentrations predicted from COPC RME concentrations in surface soil to dietary limits corresponding to LOAEL benchmarks for adverse effects on terrestrial top predators (HQs) are <1, then Assessment Endpoint 6 is met, and terrestrial predators are not at risk. If the HQ > 1, a weight-of-evidence evaluation will be conducted to determine the potential for ecological risk.

COPC = Constituent of potential concern
TES = Threatened and endangered species
LOAEL = Lowest observed adverse effects level
NOAEL = No observed adverse effects level
RME = Reasonable maximum exposure
HQ = Hazard quotient

Table 6.3-3. Unit Foraging Factors for Ecological Receptors at FDTF

Receptor	Home Range (ha)[a]	Home Range (acres)a	UFF Area = 0.01 ha (0.025 acres)
Short-tailed shrew	3.90E-01	(0.97)	2.56E-02
Meadow vole	8.30E-02	(0.21)	1.20E-01
American robin	4.20E-01	(1.0)	2.38E-02
Red-tailed hawk	2.33E+02	(580)	4.29E-05

[a]Data from Sample and Suter (1994)
FDTF = Fire Department Training Facility
UFF = Unit Foraging Factor, the smaller of 1.0 and the ratio of the area of the FDTF exposure unit and the Receptor Home Range

Table 6.3-4. Exposure of Mammals to Ecological COPCs at FDTF Surface Soil (0 to 1 ft)

COPC	C_S	ED_{soil}[a] (mg/kg bw/d) Short-Tailed Shrew	Meadow Vole
Inorganics (mg/kg)			
Silver	1.35E+00	5.61E-03	1.92E-03
Organics (µg/kg)			
SVOCs			
Benzoic acid	6.03E+01	1.63E-04	3.63E-05

[a] $ED_{soil} = [(C_S \times SP_V \times I_p) + (C_S \times BAF_{inv} \times I_a) + (C_S \times I_S)] \times UFF / BW$

C_S = RME soil concentration (mg/kg for inorganics, µg/kg for organics)

SP_V = Soil-to-plant uptake factor for vegetative parts (Table D-2)

I_p = Daily plant ingestion rate (1.24E-03 kg/d for shrews, 5.00E-03 kg/d for voles

BAF_{inv} = Soil-invertebrate uptake factor (Table D-2)

I_a = Daily animal ingestion rate (7.76E-03 kg/d for shrews, 0 for voles)

I_S = Daily soil ingestion rate (1.17E-03 kg/d for shrews, 1.20E-04 kg/d for voles)

UFF = Unit foraging factor (Table 6.3-3)

BW = Body weight (0.015 kg for shrews, 0.044 kg for voles)

Table 6.3-5. Exposure of Birds to Ecological COPCs at FDTF Surface Soil (0 to 1 ft)

COPC	C_S	ED_{soil} (mg/kg bw/d) American Robin[a]	ED_{soil} (mg/kg bw/d) Red-Tailed Hawk[b]
Inorganics (mg/kg)			
Silver	1.35E+00	4.09E-03	2.05E-09
Organics (µg/kg)			
SVOCs			
Benzoic acid	6.03E+01	9.61E-05	7.38E-16

[a] $ED_{soil} = [(C_S \times SP_r \times CF \times I_p) + (C_S \times BAF_{inv} \times I_a) + (C_S \times I_S)] \times UFF / BW$

C_S = RME soil concentration (mg/kg for inorganics, µg/kg for organics)
SP_r = Soil-to-plant uptake factor for reproductive parts (Table D-2)
CF = Plant wet to dry weight conversion factor (unitless), 0.2 for dry weight SP values
I_p = Daily plant ingestion rate (4.65E-02 kg/d)
BAF_{inv} = Soil-invertebrate uptake factor (Table D-2)
I_a = Daily animal ingestion rate (4.65E-02 kg/d)
I_S = Daily soil ingestion rate (1.90E-03 kg/d)
UFF = Unit foraging factor (Table 6.3-3)
BW = Body weight (7.70E-02 kg)

[b] $ED_{soil} = [(C_S \times SP_V \times CF \times I_{p(shrew)}) + (C_S \times BAF_{inv} \times I_{a(shrew)}) + (C_S \times I_{S(shrew)})] \times BAF_{mamm} \times I_{a(hawk)} \times UFF / BW$ (See Eq. 6.3-4)

C_S = RME soil concentration (mg/kg for inorganics, ug/kg for organics)
SP_V = Soil-to-plant uptake factor for vegetative parts (Table D-2)
CF = Plant wet to dry weight conversion factor (unitless), 0.2 for dry weight SP values
$I_{p(shrew)}$ = Daily plant ingestion rate by shrews (1.24E-03 kg/d)
BAF_{inv} = Soil-invertebrate uptake factor (Table D-2)
$I_{a(shrew)}$ = Daily animal ingestion rate by shrews (7.76E-03 kg/d)
BAF_{mamm} = Mammal intake-to-tissue uptake factor (Table D-2)
$I_{S(shrew)}$ = Daily soil ingestion rate by shrews (1.17E-03 kg/d)
$I_{a(hawk)}$ = Daily animal ingestion rate by hawks (1.09E-01 kg/d)
UFF = Unit foraging factor (Table 6.3-3)
BW = Body weight (1.13 kg)

Table 6.3-6. Exposure of Mammals to Ecological COPCs at FDTF Subsurface Soil (0 to 4 ft)

COPC	C_S	ED_{soil}[a] (mg/kg bw/d) Short-Tailed Shrew	ED_{soil}[a] (mg/kg bw/d) Meadow Vole
Inorganics (mg/kg)			
Aluminum	1.04E+04	3.12E+01	3.53E+00
Antimony	1.40E+00	3.85E-03	1.23E-03
Arsenic	6.00E+00	1.26E-02	2.63E-03
Cadmium	4.48E-01	6.64E-02	8.22E-04
Calcium	5.12E+02	2.02E+00	5.08E+00
Chromium	3.85E+01	1.59E-01	1.34E-02
Iron	4.40E+04	6.72E+02	1.49E+01
Lead	1.13E+01	2.54E-01	5.11E-03
Magnesium	2.02E+02	1.16E+00	6.19E-01
Potassium	1.63E+02	2.56E+00	5.00E-01
Selenium	2.10E+00	2.54E-02	8.34E-04
Silver	8.64E-01	3.59E-03	1.23E-03
Sodium	7.05E+01	2.71E+00	3.76E-02
Vanadium	8.46E+01	3.15E-01	2.91E-02
Organics (µg/kg)			
SVOCs			
Benzoic acid	6.03E+01	1.63E-04	3.63E-05
Phthalates			
Di-n-octylphthalate	3.35E+02	8.92E-04	1.10E-04

[a] $ED_{soil} = [(C_S \times SP_V \times CF \times I_P) + (C_S \times BAF_{inv} \times I_a) + (C_S \times I_S)] \times UFF / BW$

C_S = RME soil concentration (mg/kg for inorganics, µg/kg for organics)

SP_V = Soil-to-plant uptake factor for vegetative parts (Table D-2)

CF = Plant wet to dry weight conversion factor (unitless), 0.2 for dry weight SP values

I_P = Daily plant ingestion rate (1.24E-03 kg/d for shrews, 5.00E-03 kg/d for voles)

BAF_{inv} = Soil-invertebrate uptake factor (Table D-2)

I_a = Daily animal ingestion rate (7.76E-03 kg/d for shrews, 0 for voles)

I_S = Daily soil ingestion rate (1.17E-03 kg/d for shrews, 1.20E-04 kg/d for voles)

UFF = Unit foraging factor (Table 6.3-3)

BW = Body weight (0.015 kg for shrews, 0.044 kg for voles)

Table 6.3-7. Exposure of Birds to Ecological COPCs FDTF Subsurface Soil (0 to 4 ft)

COPC	C_S	ED_{soil} (mg/kg bw/d) American Robin[a]	ED_{soil} (mg/kg bw/d) Red-Tailed Hawk[b]
Inorganics (mg/kg)			
Aluminum	1.04E+04	1.73E+01	5.68E-06
Antimony	1.40E+00	1.95E-03	4.68E-10
Arsenic	6.00E+00	4.20E-03	3.07E-09
Cadmium	4.48E-01	7.13E-02	4.52E-09
Calcium	5.12E+02	1.07E+00	1.72E-07
Chromium	3.85E+01	1.12E-01	1.08E-07
Iron	4.40E+04	6.59E+02	1.63E-03
Lead	1.13E+01	2.58E-01	9.26E-09
Magnesium	2.02E+02	1.16E+00	7.05E-07
Potassium	1.63E+02	2.70E+00	6.21E-06
Selenium	2.10E+00	2.43E-02	4.63E-08
Silver	8.64E-01	2.62E-03	1.31E-09
Sodium	7.05E+01	2.84E+00	1.81E-05
Vanadium	8.46E+01	2.09E-01	9.96E-08
Organics (µg/kg)			
SVOCs			
Benzoic acid	6.03E+01	9.61E-05	7.38E-16
Phthalates			
Di-n-octylphthalate	3.35E+02	4.38E-04	5.20E-06

[a] $ED_{soil} = [(C_S \times SP_r \times CF \times I_p) + (C_S \times BAF_{inv} \times I_a) + (C_S \times I_S)] \times UFF / BW$

C_S = RME soil concentration (mg/kg for inorganics, µg/kg for organics)
SP_r = Soil-to-plant uptake factor for reproductive parts (Table D-2)
CF = Plant wet to dry weight conversion factor (unitless), 0.2 for dry weight SP values
I_p = Daily plant ingestion rate (4.65E-02 kg/d)
BAF_{inv} = Soil-invertebrate uptake factor (Table D-2)
I_a = Daily animal ingestion rate (4.65E-02 kg/d)
I_S = Daily soil ingestion rate (1.90E-03 kg/d)
UFF = Unit foraging factor (Table 6.3-3)
BW = Body weight (7.70E-02 kg)

[b] $ED_{soil} = [(C_S \times SP_V \times CF \times I_{p(shrew)}) + (C_S \times BAF_{inv} \times I_{a(shrew)}) + (C_S \times I_{s(shrew)})] \times BAF_{mamm} \times I_{a(hawk)} \times UFF / BW$ (See Eq. 6.3-4)

C_S = RME soil concentration (mg/kg for inorganics, µg/kg for organics)
SP_V = Soil-to-plant uptake factor for vegetative parts (Table D-2)
CF = Plant wet to dry weight conversion factor (unitless), 0.2 for dry weight SP values
$I_{p(shrew)}$ = Daily plant ingestion rate by shrews (1.24E-03 kg/d)
BAF_{inv} = Soil-invertebrate uptake factor (Table D-2)
$I_{a(shrew)}$ = Daily animal ingestion rate by shrews (7.76E-03 kg/d)
BAF_{mamm} = Mammal intake-to-tissue uptake factor (Table D-2)
$I_{s(shrew)}$ = Daily soil ingestion rate by shrews (1.17E-03 kg/d)
$I_{a(hawk)}$ = Daily animal ingestion rate by hawks (1.09E-01 kg/d)
UFF = Unit foraging factor (Table 6.3-3)
BW = Body weight (1.13 kg)

Table 6.3-8. Toxicity Reference Values for Ecological Receptors: Plants and Earthworms

COPC	LOAEL	
	Plants (mg/kg soil)	Earthworms (mg/kg soil)
Inorganics		
Aluminum	50	None
Antimony	5	None
Arsenic	10	60
Cadmium	3	20
Calcium	None	None
Chromium	1	32
Iron	None	None
Lead	50	500
Magnesium	None	None
Potassium	None	None
Selenium	1	70
Silver	2	None
Sodium	None	None
Vanadium	2	None
Organics		
SVOCs		
Benzoic acid	None	None
Phthalates		
Di-n-octylphthalate	100[a]	200[b]

LOAEL = Lowest Observed Adverse Effect Level
Plant LOAELs are from Will and Suter (1995), LOAEL for chromium is for total chromium.
Earthworm LOAELs are from Will and Suter (1996); Note, LOAEL for chromium is for chromium (III).
[a] Surrogate value, LOAEL for diethylphthalate
[b] Surrogate value, LOAEL for dimethylphthalate

Table 6.3-9. Derivation of Toxicity Reference Values for Ecological Receptors: Mammals

COPC	Test Species	Test Species Body Weight (kg)	Toxicity Benchmark LOAEL (mg/kg/d)	Source	Short-Tailed Shrew		Meadow Vole	
					Body-Weight Conversion Factor[d]	TRV (mg/kg/d)	Body-Weight Conversion Factor[d]	TRV (mg/kg/d)
Inorganics								
Aluminum	Mouse	3.00E-02	1.93E+01	a	1.26E+00	2.43E+01	8.80E-01	1.70E+01
Antimony	Mouse	3.00E-02	1.25E+00	a	1.26E+00	1.57E+00	8.80E-01	1.10E+00
Arsenic	Mouse	3.00E-02	1.26E+00	a	1.26E+00	1.59E+00	8.80E-01	1.11E+00
Cadmium	Rat	3.50E-01	1.00E-02	a	2.86E+00	2.86E-02	2.00E+00	2.00E-02
Calcium			None		None	None	None	None
Chromium	Rat	3.50E-01	2.74E+04	b	2.86E+00	7.82E+04	2.00E+00	5.46E+04
Iron			None		None	None	None	None
Lead	Rat	3.50E-01	8.00E+01	a	2.86E+00	2.29E+02	2.00E+00	1.60E+02
Magnesium	None		None		None	None	None	None
Potassium	None		None		None	None	None	None
Selenium	Mouse	3.00E-02	7.60E-01	a	1.26E+00	9.58E-01	8.80E-01	6.69E-01
Silver	None		None		None	None	None	None
Sodium	None		None		None	None	None	None
Vanadium	Rat	2.60E-01	2.10E+00	a	2.59E+00	5.43E+00	1.81E+00	3.80E+00
Organics								
SVOCs								
Benzoic acid	None		None		None	None	None	None
Phthalates								
Di-n-octylphthalate	Mouse	3.00E-02	5.50E+02	c	1.26E+00	6.93E+02	8.80E-01	4.84E+02

LOAEL = Lowest Observed Adverse Effect Level
TRV = Toxicity Reference Value
a Opresko 1996 (February database)
b Opresko 1996 (February database); NOAEL x 10
c Surrogate, value for di-n-hexylphthalate; Opresko 1996 (February database)
d Body weight conversion factor = (test species body weight/receptor body weight)$^{0.33}$: See equation (4) in Opresko et al. (1995)

Table 6.3-10. Derivation of Toxicity Reference Values for Ecological Receptors: Birds

COPC	Test Species	Test Species Body Weight (kg)	Toxicity Benchmark LOAEL (mg/kg/d)	Source	American Robin Body-Weight Conversion Factor[d]	American Robin TRV (mg/kg/d)	Red-Tailed Hawk Body-Weight Conversion Factor[d]	Red-Tailed Hawk TRV (mg/kg/d)
Inorganics								
Aluminum	Ringed dove	1.55E-01	1.10E+03	a	1.26E+00	1.39E+03	5.16E-01	5.66E+02
Antimony			None		None	None	None	None
Arsenic	Mallard duck	1.00E+00	1.28E+01	b	2.35E+00	3.02E+01	9.61E-01	1.23E+01
Cadmium	Mallard duck	1.15E+00	2.00E+01	a	2.46E+00	4.93E+01	1.01E+00	2.02E+01
Calcium			None		None	None	None	None
Chromium	Black duck	1.25E+00	5.00E+00	b	2.53E+00	1.27E+01	1.04E+00	5.18E+00
Iron			None		None	None	None	None
Lead	Japanese quail	1.50E-01	1.13E+01	b	1.25E+00	1.41E+01	5.11E-01	5.77E+00
Magnesium			None		None	None	None	None
Potassium			None		None	None	None	None
Selenium	Mallard duck	1.00E+00	1.00E+00	a	2.35E+00	2.35E+00	9.61E-01	9.61E-01
Silver			None		None	None	None	None
Sodium			None		None	None	None	None
Vanadium	Mallard duck	1.17E+00	1.14E+02	a	2.48E+00	2.82E+02	1.01E+00	1.15E+02
Organics								
SVOCs								
Benzoic acid			None		None	None	None	None
Phthalates								
Di-n-octylphthalate	Ringed dove	1.55E-01	1.10E+00	c	1.26E+00	1.39E+00	5.16E-01	5.68E-01

LOAEL = Lowest Observed Adverse Effect Level
TRV = Toxicity Reference Value
a Opresko 1996 (February database)
b Opresko 1996 (February database) NOAEL x 10
c Surrogate, value for di-n-butylphthalate; Opresko 1996 (February database)
d Body weight conversion factor = (test species body weight/receptor body weight)$^{0.33}$; See equation (4) in Opresko et al. (1995)

Table 6.3-11. Ecological HQs for Plants and Earthworms Exposed to FDTF Surface Soil (0 to 1 ft)

COPC	C_s	Plants TRV	Plants HQ	Earthworms TRV	Earthworms HQ
Inorganics (mg/kg)					
Silver	1.35E+00	2.00E+00	6.75E-01	None	
Organics (ug/kg)					
SVOCs					
Benzoic acid	6.03E+01	None		None	

C_s = RME soil concentration (mg/kg for inorganics, ug/kg for organics) (See Table 6.3-4)
TRV = Toxicity Reference Value (See Table 6.3-8)
HQ = Hazard Quotient = C_s/TRV
Cells with heavy outlines = HQs >1

Table 6.3-12. Ecological HQs for Mammals Exposed to FDTF Surface Soil (0 to 1 ft)

COPC	Short-Tailed Shrew ED_{soil} (mg/kg/d)	Short-Tailed Shrew TRV (mg/kg/d)	Short-Tailed Shrew HQ	Meadow Vole ED_{soil} (mg/kg/d)	Meadow Vole TRV (mg/kg/d)	Meadow Vole HQ
Inorganics						
Silver	5.61E-03	None		1.92E-03	None	
Organics						
SVOCs						
Benzoic acid	1.63E-04	None		3.63E-05	None	

ED_{soil} = Estimated dose from soil (See Table 6.3-4)
TRV = Toxicity Reference Value (See Table 6.3-9)
HQ = Hazard Quotient = ED/TRV
Cells with heavy outlines = HQs >1

Table 6.3-13. Ecological HQs for Birds Exposed to FDTF Surface Soil (0 to 1 ft)

COPC	American Robin			Red-Tailed Hawk		
	ED_{soil} (mg/kg/d)	TRV (mg/kg/d)	HQ	ED_{soil} (mg/kg/d)	TRV (mg/kg/d)	HQ
Inorganics						
Silver	4.09E-03	None		2.05E-09	None	
Organics						
SVOCs						
Benzoic acid	9.61E-05	None		7.38E-16	None	

ED_{soil} = Estimated dose from soil (See Table 6.3-5)
TRV = Toxicity Reference Value (See Table 6.3-10)
HQ = Hazard Quotient = ED/TRV
Cells with heavy outlines = HQs >1

Table 6.3-14. Ecological HQs for Plants and Earthworms Exposed to FDTF Subsurface Soil (0 to 4 ft)

COPC	C_s	Plants		Earthworms	
		TRV	HQ	TRV	HQ
Inorganics (mg/kg)					
Aluminum	1.04E+04	5.00E+01	**2.08E+02**	None	
Antimony	1.40E+00	5.00E+00	2.80E-01	None	
Arsenic	6.00E+00	1.00E+01	6.00E-01	6.00E+01	1.00E-01
Cadmium	4.48E-01	3.00E+00	1.49E-01	2.00E+01	2.24E-02
Calcium	5.12E+02	None		None	
Chromium	3.85E+01	1.00E+00	**3.85E+01**	3.20E+01	**1.20E+00**
Iron	4.40E+04	None		None	
Lead	1.13E+01	5.00E+01	2.26E-01	5.00E+02	2.26E-02
Magnesium	2.02E+02	None		None	
Potassium	1.63E+02	None		None	
Selenium	2.10E+00	1.00E+00	**2.10E+00**	7.00E+01	3.00E-02
Silver	8.64E-01	2.00E+00	4.32E-01	None	
Sodium	7.05E+01	None		None	
Vanadium	8.46E+01	2.00E+00	**4.23E+01**	None	
Organics (µg/kg)					
SVOCs					
Benzoic acid	6.03E+01	None		None	
Phthalates					
Di-n-octylphthalate	3.35E+02	1.00E+05	3.35E-03	2.00E+05	1.68E-03

C_s = RME soil concentration (mg/kg for inorganics, µg/kg for organics) (See Table 6.3-6)
TRV = Toxicity Reference Value (See Table 6.3-8)
HQ = Hazard Quotient = C_s/TRV
Cells with heavy outlines = HQs >1

Table 6.3-15. Ecological HQs for Mammals Exposed to FDTF Subsurface Soil (0 to 4 ft)

COPC	Short-Tailed Shrew			Meadow Vole		
	ED_{soil} (mg/kg/d)	TRV (mg/kg/d)	HQ	ED_{soil} (mg/kg/d)	TRV (mg/kg/d)	HQ
Inorganics						
Aluminum	3.12E+01	2.43E+01	**1.28E+00**	3.53E+00	1.70E+01	2.08E-01
Antimony	3.85E-03	1.57E+00	2.44E-03	1.23E-03	1.10E+00	1.12E-03
Arsenic	1.26E-02	1.59E+00	7.95E-03	2.63E-03	1.11E+00	2.37E-03
Cadmium	6.64E-02	2.86E-02	**2.32E+00**	8.22E-04	2.00E-02	4.12E-02
Calcium	2.02E+00	None		5.08E+00	None	
Chromium	1.59E-01	7.82E+04	2.03E-06	1.34E-02	5.46E+04	2.46E-07
Iron	6.72E+02	None		1.49E+01	None	
Lead	2.54E-01	2.29E+02	1.11E-03	5.11E-03	1.60E+02	3.20E-05
Magnesium	1.16E+00	None		6.19E-01	None	
Potassium	2.56E+00	None		5.00E-01	None	
Selenium	2.54E-02	9.58E-01	2.65E-02	8.34E-04	6.69E-01	1.25E-03
Silver	3.59E-03	None		1.23E-03	None	
Sodium	2.71E+00	None		3.76E-02	None	
Vanadium	3.15E-01	5.43E+00	5.80E-02	2.91E-02	3.80E+00	7.66E-03
Organics						
SVOCs						
Benzoic acid	1.63E-04	None		3.63E-05	None	
Phthalates						
Di-n-octylphthalate	8.92E-04	6.93E+02	1.29E-06	1.10E-04	4.84E+02	2.28E-07

ED_{soil} = Estimated dose from soil (See Table 6.3-6)
TRV = Toxicity Reference Value (See Table 6.3-9)
HQ = Hazard Quotient = ED/TRV
Cells with heavy outlines = HQs >1

Table 6.3-16. Ecological HQs for Birds Exposed to FDTF Subsurface Soil (0 to 4 ft)

COPC	American Robin			Red-Tailed Hawk		
	ED_{soil} (mg/kg/d)	TRV (mg/kg/d)	HQ	ED_{soil} (mg/kg/d)	TRV (mg/kg/d)	HQ
Inorganics						
Aluminum	1.73E+01	1.39E+03	1.25E-02	5.68E-06	5.66E+02	1.00E-08
Antimony	1.95E-03	None		4.68E-10	None	
Arsenic	4.20E-03	3.02E+01	1.39E-04	3.07E-09	1.23E+01	2.49E-10
Cadmium	7.13E-02	4.93E+01	1.45E-03	4.52E-09	2.02E+01	2.24E-10
Calcium	1.07E+00	None		1.72E-07	None	
Chromium	1.12E-01	1.27E+01	8.82E-03	1.08E-07	5.18E+00	2.09E-08
Iron	6.59E+02	None		1.63E-03	None	
Lead	2.58E-01	1.41E+01	1.83E-02	9.26E-09	5.77E+00	1.60E-09
Magnesium	1.16E+00	None		7.05E-07	None	
Potassium	2.70E+00	None		6.21E-06	None	
Selenium	2.43E-02	2.35E+00	1.04E-02	4.63E-08	9.61E-01	4.81E-08
Silver	2.62E-03	None		1.31E-09	None	
Sodium	2.84E+00	None		1.81E-05	None	
Vanadium	2.09E-01	2.82E+02	7.39E-04	9.96E-08	1.15E+02	8.63E-10
Organics						
SVOCs						
Benzoic acid	9.61E-05	None		7.38E-16	None	
Phthalates						
Di-n-octylphthalate	4.38E-04	1.39E+00	3.15E-04	5.20E-06	5.68E-01	9.16E-06

ED_{soil} = Estimated dose from soil (See Table 6.3-7)
TRV = Toxicity Reference Value (See Table 6.3-10)
HQ = Hazard Quotient = ED/TRV
Cells with heavy outlines = HQs >1

Table 6.3-17. Qualitative Evaluation of Uncertainty for FDTF Ecological Risk Assessment

Source or Area of Uncertainty	Effect on Risk Estimates[1]		
	Potential for Underestimating Risk	Potential for Either Under or Overestimating Risk	Potential for Overestimating Risk
Problem Formulation			
Identification of COPCs		Medium	
Identification of sensitive receptors	Low		
Exposure Assessment			
Site-specific bioavailability of COPCs			Medium
Receptor-specific exposure factors		Low	
Toxicity Assessment			
Use of published toxicity values			Medium
No toxicity values for some contaminants	Medium		
No data on chemical interactions	Medium		
Organismal toxicity used for higher levels of ecological organization			Medium
Risk Characterization			
Ecological risk quotient values			Low
Off-unit ecological risk	Low		
Cumulative ecological risk	Low		
Future ecological risk		Low	
Background ecological risk		Medium	

[1] Evaluation given only for potential effect with most serious consequences for ecological risk management decisions.

Table 6.3-18. Summary of Highest HQs for Ecological COPCs in FDTF Soil

HQ Range	FDTF	
	(0 to 1 ft)	(0 to 4 ft)
>100	None	Aluminum (208) plants
>10, <100	None	Chromium (38.5) plants Vanadium (42.3) plants
>1, <10	None	Cadmium (2.32) shrews Selenium (2.1) plants

HQ = Hazard Quotient

7.0 REMEDIAL GOAL OPTIONS

Remedial Goal Options (RGOs) are cleanup concentrations for contaminated environmental media that are designed to provide conservative, long-term targets for the selection and analysis of remedial alternatives. The Baseline Risk Assessment (BRA) is used to determine the potential for adverse health effects to human and ecological receptors. The Remedial Investigation (RI) and BRA are used to support the risk management decision-making process. Risk management decisions may be based on a variety of information, including the site-specific findings of the RI and BRA. The intention of the RI and BRA is to provide a scientific and technically sound foundation of information that allows for informed decision-making. The RI and BRA should be unprejudiced regarding such decisions.

An important risk management decision, based on the findings of the RI and BRA, is to decide whether there is a need to remediate the contamination. If the RI indicates that there is a need to consider remediation, cleanup targets are developed for the Constituents of Concern (COCs). The initial step in the development of the cleanup targets is calculation of human health and ecological RGOs. RGOs represent a range of potential protective cleanup levels based on risk to human and ecological receptors. The RGOs are carried through to the Feasibility Study (FS), where final remediation goals are selected from the RGOs and applied to the detailed analysis of remedial alternatives.

The RGOs are multiple cleanup targets representing a range of health protection. Based on the findings of the RI/FS, the risk managers make decisions that will lead to the selection of the final cleanup levels, which will be presented in the Proposed Plan and formalized in the Record of Decision for the Fire Department Hose Training Facility (FDTF). The final cleanup levels are to be protective of both human and ecological health, and must comply with federal and state applicable and relevant and appropriate requirements (ARARs). If remediation is found to be necessary, remedial activity at the waste unit will be conducted to meet the final cleanup levels.

This section describes the process used to develop the RGOs for the soil at the FDTF. Food chain exposures were projected in the BRA by means of transport models. There is a high level of uncertainty in the models used to project the uptake of contaminants in soil into plants, and for this reason RGOs are not developed for the food chain.

7.1 Development of Human Health RGOs for Soil

7.1.1 Introduction

The Environmental Protection Agency (EPA) has published guidance (EPA, 1991) on the determination of Preliminary Remediation Goals (PRGs) for human health. PRGs are similar to Human Health RGOs (HHRGOs), except that the original guidance did not explicitly state that a range of cleanup options should be generated. Furthermore, PRGs are normally determined during the early part of the RI before the COCs are known. They are calculated using an equation that is similar to the risk equation, setting the noncancer Hazard Index (HI) or cancer risk to the appropriate target, and solving the equation for the concentration term.

Federal guidance is not available for the determination of HHRGOs. However, EPA Region IV has provided guidance (EPA, 1995e) that can be used in conjunction with the federal guidance to develop HHRGOs. In accordance with EPA Region IV guidance, HHRGOs are calculated using noncancer target HIs of 0.1, 1, and 3 and target cancer risks of 10^{-6}, 10^{-5}, and 10^{-4}. Therefore, multiple HHRGOs are calculated for a given receptor and medium.

The purpose of determining multiple HHRGOs for a single medium is to provide the risk manager with a range of possible risk-based cleanup levels. This range also allows flexibility in the determination of remedial alternatives. The selection of the final remediation level is made by the risk manager and will be presented in the Record of Decision for the FDTF.

7.1.2 Exposure Units and Exposure Scenarios

Under current land use assumptions, the risk assessment evaluated surface soil exposures for known on-unit workers who are occasionally in close proximity to the FDTF. Only one exposure unit for soil and produce was defined for the FDTF.

Under current land use, human health effects were projected to be below EPA targets for noncancer and cancer effects. No primary or secondary COCs were identified under current land use assumptions. Secondary COCs were identified for hypothetical industrial worker and on-unit resident.

Residential and industrial exposure scenarios were evaluated in the human health risk assessment under future land use assumptions. The same exposure unit that was used under current land use assumptions was applied to the future scenarios.

Although the future industrial exposure scenario is more likely, the future residential scenario was included as a conservative measure. An evaluation of the residential scenario is normally included in the BRA, even if it is not a likely future use of the unit. In this situation, the future residential scenario, although unlikely, may be useful as a point of comparison for decision makers. The default residential assumptions used in the evaluation provide a common frame of reference to other similar sites. The residential scenario is also useful if the non-residential use of the unit cannot be assured over time.

The HHRGOs are not unique to a given exposure area, that is, they are not dependent on the concentrations of constituents at the unit. Rather, they are estimates of the upper acceptable concentration for a given receptor exposed to soil. They take into consideration exposure from multiple exposure routes evaluated in the risk assessment. For example, a soil HHRGO takes into account risks from soil ingestion, dermal contact with soil, and inhalation of suspended particulates.

7.1.3 Findings

HHRGOs were not calculated for chemical COCs as defined and identified in the human health risk assessment because an uncertainty analysis was performed (Section 7.2) and all the constituents were eliminated.

7.1.4 Summary of Human Health COCs

Human health COCs are defined and presented in this section.

- Primary COCs in the human health risk assessment are defined as constituents that either individually produce or significantly contribute to risk estimates that exceed a 1×10^{-4} risk or and HI of 3 by selecting individual COCs equal to or greater than a cancer risk of 1×10^{-6} or a noncancer hazard of 0.1 in any pathway.
- Secondary COCs are defined as constituents in each medium with a cancer risk equal to or greater than 1×10^{-6} or an HI equal to or greater than 0.1 by selecting individual COCs with a cancer risk equal to or greater than 1×10^{-6} or a noncancer hazard equal to or greater than 0.1 in any pathway.

7.1.4.1 Current Land Use

Under current land use there are no primary or secondary COCs identified for the surface soil.

7.1.4.2 Future Land Use

Under future industrial land use, arsenic and beryllium were identified as secondary COCs for the subsurface soil.

Under future residential land use, the following human health secondary COCs for soil have been identified:

- Arsenic
- Beryllium
- Iron
- Vanadium
- Benzo(a)pyrene

7.2 Uncertainty Analysis for the Human Health COCs

The risk and hazard to the current worker, future on-unit industrial worker, and the future on-unit resident are summarized below. Key uncertainties are examined to determine whether it is appropriate to develop an RGO for each COC identified.

7.2.1 Current Worker

The current worker was evaluated at the 0 to 0.3 m (0 to 1 ft) soil interval only. The total excess lifetime cancer risk level for the current worker is 4×10^{-9} and the hazard index is 7×10^{-5}. Therefore, the current worker is at an insignificant risk while working at this unit.

7.2.2 Future Industrial Worker

The industrial worker was evaluated at the 0 to 0.3 m (0 to 1 ft) and 0 to 1.2 m (0 to 4 ft) soil intervals. For the 0 to 0.3 m (0 to 1 ft) soil interval, the total excess lifetime cancer risk is 9×10^{-7} and the hazard index is 3×10^{-3}. The hazard and risk to future industrial worker will be insignificant while working at the unit, based on the evaluation of the surface soils. For the

0 to 1.2 m (0 to 4 ft) soil interval, the total excess lifetime cancer risk is 4×10^{-6} and the hazard index is 0.2. The soil exposure pathways that contribute the most to this receptor are ingestion and dermal, each with a cancer risk of 2×10^{-6}. The secondary COCs for these pathways are arsenic (84% of the cancer risk for the soil ingestion pathway) and beryllium (54 % of the cancer risk for the soil dermal contact pathway.

Background Risk- The background cancer risk (4×10^{-6}) at the 0 to 0.3 m (0 to 1 ft) soil interval is greater than the unit cancer risk (9×10^{-7}). The background risk at the 0 to 1.2 m (0 to 4 ft) soil interval is 3×10^{-6} which is similar to the cancer risk for the unit, 4×10^{-6}. The pathways contributing most to the total risk are soil ingestion (cancer risk of 2×10^{-6}, arsenic is 93% of the total) and dermal contact with soil (cancer risk of 2×10^{-6}, beryllium is 75% of the total). The results below show that the unit risk for this receptor is equivalent to the background risk for the same pathway.

Industrial Worker - 0 to 1.2 m (0 to 4 ft) Soil Interval

Soil Pathway	Unit Cancer Risk	Background Cancer Risk
Ingestion	2×10^{-6} /Arsenic	2×10^{-6} /Arsenic
Dermal Contact	1×10^{-6} /Beryllium	2×10^{-6} /Beryllium

7.2.3 Resident Adult/Child

The residential scenario was evaluated separately for the 0 to 0.3 m (0 to 1 ft) and the 0 to 1.2 m (0 to 4 ft) soil intervals. Food chain exposures were projected in the BRA by means of uptake (partitioning) models. There is a high level uncertainty in the models used to project the uptake of contaminants in soil into plants, and for this reason RGOs are not developed for the food chain.

7.2.3.1 Surface Soil

For the 0 to 0.3 m (0 to 1 ft) soil interval, the total excess lifetime cancer risk is 1×10^{-5} and the hazard index is 0.5. Benzo(a)pyrene is the significant contributor to risk. The most important

pathways for this contaminant are ingestion (cancer risk is 2×10^{-6}) and dermal (cancer risk is 1×10^{-6}).

Frequency of Detection

RGOs should be calculated for any constituent that exceeds a cancer risk of greater than 1×10^{-6} or a hazard index of 1.0. However, professional judgment should be used to exclude constituents that may not be clearly site-related for which risks may be overestimated. In particular, the cancer risk for benzo(a)pyrene (3×10^{-6} for the unlikely residential land use) is based on the maximum detected concentration value, because in this case the exposure point concentration is the maximum observed value. Benzo(a)pyrene was detected in only 1 out of 25 on-unit samples. Because of the low (< 5%) frequency of detection, benzo(a)pyrene should not be considered for RGO determination.

Background Risk

The background cancer risk and hazard for the adult/child at the 0 to 0.3 m (0 to 1 ft) soil interval are greater than the cancer risk and hazard at the unit. The total excess cancer lifetime risk for the 0 to 0.3 m (0 to 1 ft) soil in the background is 7×10^{-5} while the cancer risk for the same soil interval at the unit is 1×10^{-5}. The hazard index for the 0 to 0.3 m (0 to 1 ft) soil in the background is greater than 1.0 while at the unit it is less than 1.0. The secondary COCs for the unit are arsenic, beryllium, benzo(a)pyrene, iron, and vanadium. By comparison, the secondary COCs for the background are arsenic, beryllium, and iron. The difference between the secondary COCs at the unit and in the background are vanadium and benzo(a)pyrene.

Resident (Adult/Child) - 0 to 0.3 m (0 to 1 ft) Soil Interval

Pathway	Unit Cancer Risk	Hazard	Bkg Cancer Risk	Bkg Hazard
Soil Ingestion	2E-06 Benzo (a) pyrene	<1.0	2E-05 Arsenic	1
Soil Dermal	1E-06 Benzo (a) pyrene	<1.0	4E-06 Beryllium	<0.1
Total	**3E-06**	**<1.0**	**2E-05**	**1**

7.2.3.2 Subsurface Soil

For the 0 to 1.2 m (0 to 4 ft) soil interval, the total excess lifetime cancer risk is 2×10^{-5} and the hazard index is 2. The pathways that significantly contribute to this receptor are ingestion (2×10^{-5}) and dermal contact (5×10^{-6}). For the soil ingestion pathway, arsenic is a secondary COC that contributes 84% of the cancer risk and benzo(a)pyrene is a COC that contributes 10% of the cancer risk. The hazard index for the ingestion pathway is 2 and the secondary COCs are iron, which contributes to 78% of the hazard; arsenic, which contributes 11% of the hazard; and vanadium, which contributes 6% of the hazard. In the dermal pathway there is one secondary COC based on cancer risk, beryllium which contributes 54% of the cancer risk.

Background Risk

For the 0 to 1.2 m (0 to 4 ft) soil interval, the cancer risk at the unit and the in the background are basically the same while the hazard index at the unit is greater than in the background. In both cases, the major contribution to the hazard is iron. The secondary COCs for the unit are arsenic, beryllium, and benzo(a)pyrene. Once again, the only notable difference between the unit and the background is the benzo(a)pyrene that is present at the unit.

Resident (Adult/Child) - 0 to 1.2 m (0 to 4 ft) Soil Interval

Pathway	Unit Cancer Risk	Hazard	Bkg Cancer Risk	Bkg Hazard
Soil Ingestion	2E-05 Arsenic, Benzo (a) pyrene	2 Iron, Vanadium, Arsenic	1.3E-05 Arsenic	1 Iron, Arsenic, Vanadium
Soil Dermal	5E-06 Beryllium	0.2 Vanadium	3.0E-06 Beryllium	0.1 Vanadium
Total	**2E-05**	**3**	**2E-05**	**1**

7.2.4 Other Uncertainties in the RGOs

Several factors should be considered in selecting the appropriate use of the RGOs. There is no EPA-verified toxicity value for iron. The designation of iron as a secondary COC is based on the use of a provisional toxicity value for iron. The provisional reference dose (RfD) for iron has not been verified or approved for use in risk assessments by EPA's RfD Workgroup. The provisional toxicity value was developed for use by the EPA in their risk assessments, and is not included in either IRIS or HEAST.

There are indications that the provisional RfD for iron is extremely conservative. The USFDA daily value (DV) for iron is 18 mg per day. For a 70 kg adult, this corresponds to a recommended daily dose of 0.26 mg/kg/day. This is the daily dose of iron that is recommended as part of a healthy diet. In order to ingest this amount of iron from soil, the concentration of iron in the soil would have to be very high, on the order of 180,000 mg/kg. This assumes 350 days per year of exposure at a rate of 100 mg/day for 30 years to a 70 kg adult who gets all his or her iron from the soil (which is unlikely). The exposure point concentration for 0 to 1.2 m (0 to 4 ft) soil at the FDTF is 44,000 mg/kg, and 22,700 mg/kg for the background. These are both more than an order of magnitude lower than 180,000 mg/kg, indicating that iron in the soil is very unlikely to be of concern at the FDTF.

Although there are other important sources of iron, particularly in the diet, there is a large discrepancy between the findings based on the provisional toxicity value for iron versus the findings based on the DV. When determining the need for remediation at the FDTF, this large degree of uncertainty should be considered.

The designation of iron as a secondary COC is thus highly uncertain. Note that arsenic and vanadium would not have been designated secondary COCs for noncancer effects, had iron not been designated as a secondary COC. Conclusions based on the use of provisional toxicity value should be viewed cautiously in light of the weakness of the available provisional toxicity value.

7.3 Development of Ecological RGOs for Soil

There are no ecological COCs and, therefore, there is no need for RGOs. The surface soil (0 to 0.3 m [0 to 1 ft]) has a small amount of risk to ecological receptors, but the risk is so small that

the decision criteria are not exceeded. Subsurface soil (0 to 1.2 m [0 to 4 ft]) exhibits HQs greater than 1.0, but the COPCs do not pass the weight-of-evidence analysis. Further, the unit occupies a very small piece of grassy habitat.

7.4 Summary of RGOs

RGOs were not calculated for chemical COCs as defined and identified in the human health risk assessment based on the uncertainty analysis. As a result of this finding, it is recommended that a "No Action" be considered for the Fire Department Hose Training Facility.

(This page intentionally left blank)

8.0 SUMMARY AND CONCLUSIONS

The soil sampling activities conducted at the Fire Department Hose Training Facility (FDTF) and background locations provided data on the types and extent of constituents present. These data were used to evaluate the human health and ecological risks associated with any residual contamination remaining at the waste units.

8.1 Summary of Primary Sources

The FDTF was used between 1979 and 1982 by the Savannah River Site (SRS) Fire Department to train personnel in fighting waste oil fires. The training facility consisted of a shallow, unlined pit surrounded by a 50 cm (18 in.) high asphalt dike. The dimensions of the pit were approximately 6 by 12 m (20 by 40 ft). Training exercises typically included pouring burnable oil into the basin, igniting it, and then having fire department personnel extinguish the fire. No known hazardous wastes were placed in the unit.

The primary source of contamination would be soil impacted by the oils and associated fuels burned at the facility. The soil was removed to a depth of 1.2 m (4 ft) between November 1982 and June 1994. The exact date is not known. An additional one meter square (3 by 3 ft) area was cleaned up in 1985. This was attributed to a small petroleum product spill. A soil gas survey conducted in 1986 identified organic contaminants at a depth of 1 m (3 ft) below ground surface (bgs). This finding was supported by data from soil samples collected in conjunction with the soil gas survey. Field observations at the time of this sampling identified oil saturated soil in the northeast corner of the unit. This soil was apparently removed between 1982 and 1985. Following soil removal, the site was returned to grade with clean fill. The results of a second soil gas survey performed in 1992 again showed petroleum contaminants, but at markedly lower concentrations than those reported in the 1986 survey. Therefore, it is concluded the primary source has been removed.

8.2 Summary of Secondary Sources

Surface and subsurface soils are the primary media impacted by past operations conducted at the FDTF. Therefore, they are also the secondary source of contaminants. The surface soil was

sampled from 0 to 0.3 m (0 to 1 ft), and subsurface soil was sampled in the interval from 0 to 1.2 m (0 to 4 ft) at five locations in the FDTF.

8.2.1 Surface Soil in the FDTF

Manganese and two semivolatile organic compounds (SVOCs), benzo(a)pyrene, and benzo-(g,h,i)perylene, are the USCs in the surface soil. No volatile organic compounds (VOCs), pesticides, polychlorinated biphenyls (PCBs), dioxins, furans or radionuclides were identified as USCs for surface soils.

8.2.2 Subsurface Soil in the FDTF

Eight metals were identified as USCs in the subsurface soil: aluminum, arsenic, beryllium, chromium, iron, manganese, sodium, and vanadium. With the exception of manganese, all exceedances occurred in the interval between 0.3 and 1.2 m (1 to 4 ft). No trend was identified across the unit, although a general increase in concentrations occurred with depth. Two SVOCs, benzo(a)pyrene and benzo(g,h,i)perylene, are USCs in the subsurface soil. These constituents were not detected in the 0.3 to 1.2 m (1.0 to 4.0 ft) interval. No VOCs, SVOCs, pesticides, PCBs, dioxins, furans, or radionuclides were identified as USCs for subsurface soils at the FDTF.

8.2.3 Deep Soils at the FDTF

The deep soil interval is comprised of depths greater than 1.2 m (4 ft). Samples were collected to a depth of 4.0 m (13 ft). Seven metals were identified as USCs for the deep soil: aluminum, arsenic, beryllium, chromium, iron, sodium, and vanadium. With the exception of manganese, each metal identified as a USC in the 0 to 1.2 m (0 to 4 ft) interval is a USC in the deep soil. The concentrations of the metals generally decrease with depth, which suggests the metals have adsorbed to soil particles and been immobilized in the soil. No VOCs, SVOCs, pesticides, PCBs, dioxins, furans, or radionuclides were identified as USCs for the deep soils.

8.2.4 Data Interpretation

The soil characterization identified only metals as USCs in all three soil intervals; surface, subsurface and deep soils. The two SVOCs identified as USCs in the surface and subsurface

soils were detected only in the uppermost interval sampled, 0 to 0.3 m (0 to 1 ft). The available records indicate that only petroleum products were placed in the FDTF. It is also probable that soils containing hydrocarbon residues were removed (and clean backfill placed) three times over a 4 to 10 year period.

Based upon the unit history and the results of the soil characterization, the metals and SVOCs identified as USCs do not appear to be the result of fire hose training activities.

8.3 Summary of Exposure Pathways

The groundwater has been monitored in the vicinity of the FDTF for many years. Prior to the start of this characterization (and unrelated to it), SRS evaluated the historical groundwater monitoring data and reduced the analytical suite to aluminum and total recoverable petroleum hydrocarbons (TPHs). Since TPHs have not been detected in the groundwater, groundwater sampling was not conducted in this investigation. The potential for constituents present in the soil to migrate to groundwater was evaluated. Only iron was present in concentrations above its generic soil screening level with a dilution attenuation factor of 20.

Air and biota in the vicinity of the FDTF were also identified in the Conceptual Site Model (CSM) as exposure pathways. The impact on these secondary media via secondary release mechanisms can be evaluated using the results of surface soil sampling. Therefore, no ecological samples (biota, fish tissue, vegetation, etc.) or air samples were collected during this investigation.

The characterization data analysis and unit history indicate there is no exposure pathway impacted by the FDTF.

8.4 Summary of Baseline Risk Assessment

A Baseline Risk Assessment (BRA) was conducted to assess the potential for adverse effects associated with exposure to contaminants at the FDTF in the absence of any institutional controls or remedial actions for the units. The BRA provides the basis for determining whether or not remedial action is necessary and the justification for performing remedial action.

8.4.1 Summary of Human Health Risk Assessment

A human health BRA was conducted in order to evaluate the significance of contamination of the soil and groundwater at the FDTF. One soil exposure unit was identified within which human receptors could reasonably average their exposure. Soil monitoring data for this exposure unit were aggregated into exposure groups according to depth in soil.

Summary statistics, including an estimate of the exposure point concentration based on the reasonable maximum exposure (RME), were prepared. The RME is intended to provide a conservative, yet realistic, estimate of exposure. The exposed receptors were based on current and future land uses. The current receptor is identified as an adult, the known on-unit worker. In the future, the most likely receptor is believed to be the on-unit industrial worker. Also considered for the future are the resident child and adult, although residential development of the FDTF is not considered likely and is prohibited under the recently adopted land use plan for SRS (DOE, 1996).

Exposure parameters were developed to define the intensity of exposure to each receptor and to develop an RME estimate of intake by the receptor. Noncancer hazards and cancer risks were estimated for all exposures encountered by the receptor. If the total hazard index was greater than 1.0, or if the total cancer risk was greater than 1×10^{-6}, then the exposure pathways and routes were examined to determine the source of the excessive hazard or risk.

The examination was extended to the individual constituents within a given media to identify the constituents most attributable to the hazards and risks. In this manner, constituents of concern (COCs) were identified. Table 6.2-5 provides a summary of human health COCs.

The BRA for human health did not identify any primary or secondary COCs for the known on-unit worker from exposures to the surface soil (0 - 0.3 m [0 - 1 ft]). The BRA for the scenario of the hypothetical on-unit worker identified two cancer COCs, arsenic and beryllium, from the exposure to soil. The BRA for the future use scenario of the on-unit resident identified three noncancer secondary COCs; arsenic, iron, and vanadium; from the exposure to soil. It also identified arsenic, beryllium and benzo(a)pyrene as cancer secondary COCs from exposure to soil.

8.4.2 Summary of Ecological Risk Assessment

The ecological BRA for the FDTF evaluated the likelihood of harmful effects to ecological receptors from exposure to contaminants in soil. The receptors in the FDTF food web that were evaluated include terrestrial plants, earthworms, meadow voles, short-tailed shrews, American robins, and red-tailed hawks. These receptors serve as assessment endpoints for the risk to plant and animal populations and ecosystems at the FDTF.

The evaluation of ecological risk was conducted according to relevant EPA Headquarters, U.S. EPA Region IV, South Carolina Department Health and Environmental Control, and Westinghouse Savannah River Company guidance. The assessment methods follow the EPA Framework for Ecological Risk Assessments (EPA, 1992b).

Ecological Constituents of Potential Concern (COPCs) were identified from constituents detected at FDTF, and incomplete exposure pathways were eliminated. The risk from COPCs in FDTF surface soil was evaluated only for those pathways resulting in ingestion of soil or those food items exposed directly or indirectly to soil. COPCs are those constituents whose maximum measured concentrations exceeded a toxicity screening value for ecological receptors and 2X the background mean concentration. The toxicity screening value was the lower of the benchmark doses associated with no observed adverse effect on test species of mammals and birds reported by Opresko et al. (1995).

Based on field reconnaissance, the principal ecological communities at the FDTF were characterized as maintained grassy fields with scattered mature trees; transportation, transmission line/pipeline right-of-way; and pine plantation. The dominant habitat on the FDTF is a grassy field. A Savannah River Forestry Service inventory in 1994 (SRFS, 1994) documented the animals in habitats at the CS Area Burning/Rubble Pit located about 400 yards south of the FDTF. Most receptors, exposure classes, and/or species evaluated in the ecological risk assessment (ERA) were observed at the unit or potentially reside or forage there. No threatened, endangered and sensitive (TES) species are expected to be exposed to COPCs in surface soil at FDTF; however, three TES species (one plant and two animal) could occur in the area.

Six assessment endpoints representing environmental values to be protected in accordance with two policy goals were evaluated at FDTF. The risks to FDTF populations and ecosystems were evaluated by estimating the risk to populations of the six indicator receptors (terrestrial

vegetation, earthworms, meadow vole [proxy for herbivorous mammals], short-tailed shrew, American robin, and red-tailed hawk) according to ecological relevance, susceptibility, accessibility to prediction or measurement, and relevance to policy goals.

The CSM, represented by the six assessment endpoints and the exposure pathways diagram, shows the links between the source media (surface and subsurface soil) and the six ecological receptors. The exposure routes that are evaluated for each receptor and the food web indicating feeding relationships among biota are also specified.

For the evaluation of risk to FDTF populations and ecosystems, decision rules are stated in terms of hazard quotients (HQs). HQs compare estimates of exposure based on site measurements (e.g., RME concentrations of COPCs in the source media [surface and subsurface soil]) to measures of effect (e.g., test concentrations associated with levels of adverse effect on ecological receptors).

Measured concentrations of ecological COPCs in surface soil are used to estimate the RME concentrations and doses for ecological receptors. The RME concentration for plants and earthworms is the RME soil concentration. The reasonable maximum estimated dose (ED_{soil}) for animals that are exposed by ingestion is the RME soil concentration adjusted for reported daily ingestion rates, body weights, bioaccumulation and soil-to-plant uptake factors, estimates of absorption from soil, and the degree of overlap of receptor home range and the exposure unit.

Published toxicity-benchmark data are used to derive COPC concentrations associated with levels of adverse effect on ecological receptors at FDTF. Toxicity reference values (TRVs) for plants and earthworms are published soil concentrations with the lowest observed adverse effect on the test species of plant or earthworm. TRVs for mammals and birds are concentrations of COPCs in ingested matter associated with lowest observed adverse effect levels (LOAELs) on the mammal and bird test species.

HQs for current and future exposure of ecological receptors to COPCs in surface and subsurface soil were calculated and used to estimate risk. No HQs exceeded 1.0 in surface soil (0 to 0.3 m [0 to 1.0 ft]); therefore, there are no ecological risks for current conditions. For future conditions in deeper soil (0 to 1.2 m [0 to 4 ft]), five metals (aluminum, cadmium, chromium, selenium, and vanadium) had an HQ greater than 1.0. No organics had an HQ greater than 1.0. The COPCs are aluminum, cadmium, chromium, selenium, and vanadium.

There are uncertainties in the parameters used to estimate exposure, but reported values for receptors' ingestion rates, size and home range, soil-to-plant uptake factors, and soil-to-animal bioaccumulation factors are unlikely to be biased or to severely and consistently overestimate or underestimate exposure. Exposure may be overestimated for some contaminants because the fraction available for absorption by animals may be overestimated. Extrapolation from studies involving laboratory doses to exposures at the FDTF is a major source of uncertainty in the estimate of risk to ecological receptors, because the availability of the contaminant under test conditions may be greater than it is to receptors living in field conditions.

The weight-of-evidence analysis and evaluation of uncertainty for ecological COPCs with HQs exceeding 1.0 resulted in rejection of all five metals as sources of significant risk to ecological receptors at the exposure unit.

No remedial goal options (RGOs) were developed because there were no ecological COCs.

8.5 Summary of Remedial Goal Options

8.5.1 Human Health Risk-Based RGOs

RGOs are cleanup concentrations for contaminated environmental media that are designed to provide conservative, long-term targets for the selection and analysis of remedial alternatives. RGOs were not developed for the COCs at the FDTF.

No primary or secondary COCs were identified under current land use assumptions.

Residential and industrial exposure scenarios were evaluated in the human health risk assessment under future land use assumptions. Although the future industrial exposure scenario is more likely, the future residential scenario was included as a conservative measure. Secondary COCs were identified for the hypothetical industrial worker and on-unit resident.

Human health RGOs (HHRGOs) are not unique to a given exposure area; they are estimates of the upper acceptable concentration for a given receptor exposed to soil. The following briefly summarizes the findings of the BRA as it pertains to the development and application of the HHRGOs:

- For current land use, there are no primary or secondary COCs.
- For the future industrial land use, there are two secondary COCs.
- For the future residential land use, there are five secondary COCs.
- For the 0 to 0.3 m (0 to 1 ft) soil interval, there is one COC, benzo(a)pyrene, for the on-unit resident:
- For the 0 to 1.2 m (0 to 4 ft) soil interval, there are five secondary COCs for the hypothetical on-unit resident. There are two secondary COCs for the future industrial worker.
- There are no ARAR-driven COCs because there are no ARARs for soil.

For the future residential land use scenario, HHRGOs for soil were not developed for arsenic, benzo(a)pyrene, beryllium, iron, or vanadium because they were eliminated through the uncertainty analysis process. Most important in this regard are the following findings discussed in detail in Sections 6 and 7:

- Iron was designated as a COC based on an uncertain provisional toxicity value, which is not meant to be used in the general risk assessment community.
- An upper limit on the concentration of iron in soil can be estimated using the U.S. Food and Drug Administration Dietary Value for iron. This upper limit is an order of magnitude greater than the exposure point concentrations for iron in soil at the FDTF.
- The hazards and cancer risks at the FDTF are generally similar to background. The hazard at the unit is greater than background for the 0 to 1.2 m (0 to 4 ft) soil interval, due to iron.
- Benzo(a)pyrene was detected at a frequency of less than 5 percent.

8.5.2 Development of Ecological RGOs for Soil

There are no ecological COCs and, therefore, there are no ecological RGOs.

8.6 Conclusions

The surface and subsurface soil investigation at the FDTF adequately characterized the levels of contamination in soil. This includes both present contamination and the potential for future releases. This investigation has provided an understanding of the nature and extent of contamination, determined there are no potential impacts to groundwater, and identified the human health and ecological risks associated with the unit. Based on the results of the

uncertainty analysis presented in Sections 6 and 7, all analytes are dropped from the HHRGO list. There are no ecological COCs and, therefore, no ecological RGOs. As a result of these findings, SRS believes that sufficient information is available to proceed with a "No Action" Statement of Basis/Proposed Plan and eliminate the Corrective Measures Study/Feasibility Study for the FDTF.

(This Page intentionally left blank)

9.0 REFERENCES

Aadland, R.K., Thayer, P.A., and Smits, A.D. 1992. *Hydrogeologic Atlas of West-Central South Carolina (U).* WSRC-RP-92-632, Savannah River Technology Center, Westinghouse Savannah River Company, Aiken, SC.

Aadland, R.K., Gellici, J.A., and Thayer, P.A. 1995. *Hydrogeologic Framework of West-Central South Carolina.* Report 5. Department of Natural Resources, State of South Carolina. Water Resources Division.

Amdur, MO, J. Doull, and C.D. Klaassen (eds.). 1991. *Casarett and Doull's Toxicology: The Basic Science of Poisons.* Fourth Edition, Pergamon Press, New York, NY.

Baes, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. *A Review of Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture.* ORNL-5786, Oak Ridge National Laboratory, Oak Ridge, TN.

Collinsworth, K.A. 1996. *Document Submittals for the Ford Building Waste Unit (643-11G) and the Fire Department Hose Training Facility (904-113G).* Letter from K.A. Collinsworth (SCDHEC) to B.T. Hennessey (U.S. DOE), August 16, 1996.

DOE. 1990. *Final Environmental Impact Statement, Continued Operation of K-, L-, and P-Reactors, Savannah River Site.* DOE/EIS-0147, Savannah River Operations Office, Aiken, SC.

DOE. 1996. *Savannah River Site: Future Use Project Report.* Stakeholder Recommendations for SRS Land and Facilities. January 1996. Cover letter: Fiori, Mario P., "SRS Future Use Project Report (Reference: Transmittal of Final Draft "Forging the Missing Link: A Resource Document for Identifying Future Use Options," Grumbly/Pearlman letter, 1-12-94)", USDOE Letter EB-96-015, Savannah River Site, Aiken, SC, January 29, 1996.

EPA. 1987. *Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF) - Air Emission Models.* United States Environmental Protection Agency, Office of Air and Radiation Research Triangle Park, NC, 1987.

EPA. 1989a. *Risk Assessment Guidance for Superfund (RAGS) Volume I, Human Health Evaluation Manual (Part A).* EPA/540/1-89/002, Office of Emergency and Remedial Response, Washington, DC.

EPA. 1989b. *Risk Assessment Guidance for Superfund (RAGS), Volume II: Environmental Evaluation Manual.* EPA/540/1-89/001, Washington, DC.

EPA. 1991. *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual. Supplemental Guidance "Standard Default Exposure Factors"* OSWER Directive 9285.6-03, Interim Final, Office of Emergency & Remedial Response, Toxics Integration Branch, Washington, DC.

EPA. 1992a. Soil Transport and Fate (STF) Database and Model Management System. ver. 2.0. United States Environmental Protection Agency, R.S. Kerr Environmental Research Laboratory Ada, OK.

EPA. 1992b. "*Guidance on Risk Characterization for Risk Managers and Risk Assessors.*" Memorandum from F.H. Habicht to Assistant and Regional Administrators, Washington, DC.

EPA. 1992c. *Framework for Ecological Risk Assessment.* EPA/630/R-92/001, Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC.

EPA. 1993. *Wildlife Exposure Factors Handbook.* EPA/600/R-93/187a & b, Office of Research and Development, Washington, DC.

EPA. 1994a. *Risk Reduction Engineering Laboratory (RREL) Treatability Database.* Ver. 4.0, United States Environmental Protection Agency, Office of Research and Development Cincinnati, OH.

EPA. 1994b. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments.* Review Draft, Environmental Response Team, Edison, NJ.

EPA. 1994c. *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities.* OSWER Directive 9355.4-12, Office of Solid Waste and Emergency Response.

EPA. 1995a. *Health Effects Assessment Summary Tables, FY-95 Annual (May 1995).* EPA/540/R-95/036, Office of Research and Development, Office of Solid Waste and Emergency Response.

EPA. 1995b. *Final Water Quality Guidance for the Great Lakes System.* 40 CFR Parts 9, 122, 123, 131, and 132.

EPA. 1995c. *Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment.* Draft, Office of Health Assessment, EPA Region IV, Atlanta, GA.

EPA. 1995d. *Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment.* Interim, Office of Health Assessment, EPA Region IV, Atlanta, GA.

EPA. 1995e. *EPA Region IV Guidance for Wildlife Screening Values.* Atlanta. Georgia.

EPA. 1996a. *Soil Screening Guidance: Technical Background Document.* 9355.4-17A. EPA/540/R-95/128, May 1996, Office of Solid Waste Emergency Response, Washington. DC.

EPA. 1996b. *Integrated Risk Information System (IRIS) On-Line Database.* Office of Environmental Criteria and Assessment Office, Cincinnati, OH.

EPA. 1996c. *Proposed Guidelines for Ecological Risk Assessment.* Washington. DC.

Fallaw, W.C. and Price, V. 1995. "Stratigraphy of the Savannah River Site and Vicinity" *Southeastern Geology* 35(1): 21-58.

Froede, C.R. to B.T. Hennessey. 1996. *Ford Building Waste Unit (643-11G) and the Fire Department Hose Training Facility (904-113G) Document Submittals.* EPA Region 4, August 26, 1996.

HAZWRAP. 1994. *Loring Air Force Base Ecological Risk Methodology.* Draft, Martin Marietta Energy Systems, Inc.

Howard, P.H., R.S. Boethling, W.F. Jarvis, W.M. Meylan, and E.M. Michalenko. 1991. *Handbook of Environmental Degradation Rates.* Lewis Publishers, Inc. Chelsea, MI.

Looney, B.B., M.W. Grant, and C.M. King, 1987. *Estimation of Geochemical Parameters for Assessing Subsurface Transport at the Savannah River Plant.* E.I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC.

Menzie, C., J. Cura, J. Freshman, and S. Svirsky. 1993. "Evaluating Ecological Risks and Developing Remedial Objectives at Forested Wetland Systems in New England". pp. 89-100 in: *Application of Ecological Risk Assessment to Hazardous Waste Site Remediation.* Workshop Proceedings, USEPA Science Advisory Board.

Ng, Y.C. et.al. 1982. "A Review of Transfer Factors for Assessing the Dose from Radionuclides in Agricultural Products." *Nuclear Safety* 23:57-71.

Opresko, D.M., B.E. Sample, and G.W. Suter, II. 1994. *Toxicological Benchmarks for Wildlife; 1994 Revision.* ES/ER/TM-86/R1, Oak Ridge National Laboratory, Oak Ridge, TN.

Opresko, D.M., B.E. Sample, and G.W. Suter II. 1995. *Toxicological Benchmarks for Wildlife; 1995 Revision.* ES/ER/TM-86/R2, Oak Ridge National Laboratory, Oak Ridge, TN.

Opresko, D.M., B.E. Sample, and G.W. Suter, II. 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision.* ES/ER/TM-86/R3, Oak Ridge National Laboratory, Oak Ridge. TN.

Price, V., S.J. Bohannon, J. Marsh, W.C. Fallow, and K.A. Sargent, 1988. *Geology and Hydrology of the F-Area Seepage Basins,* Draft, Westinghouse Savannah River Company. Aiken, S.C.

Sample. B.E., and G.W. Suter, II. 1994. *Estimating Exposure of Terrestrial Wildlife to Contaminants.* ER/ES/TM-125, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision.* ES/ER/TM-86/R3, Risk Assessment Program, Health Sciences Research Division, Oak Ridge, TN.

Shen, T.T., C.E. Schmidt, and T.R. Card. 1993. *Assessment and Control of VOC Emissions from Waste Treatment and Disposal Facilities.* Van Nostrand Reinhold, New York, NY.

Sheppard, M.I. and D.H. Thibault. 1990. "Default Soil Solid/Liquid Partition Coefficients for Four Major Soil Types: A Compendium." *Health Physics* 59(4): 471-482.

Shuman, L.M. 1991. "Chemical Forms of Micronutrients in Soils." in J.J. Montvedt (ed.), *Micronutrients in Agriculture.* Book Series No. 4, Soil Science Society of America Inc., Madison, WI.

Soil Conservation Service. 1990. *Soil Survey of Savannah River Plant Area, Parts of Aiken, Barnwell and Allendale Counties, South Carolina.* United States Department of Agriculture.

SRFS. 1994. *Threatened, Endangered and Sensitive Species Listing: 1994 Savannah River Forest Station Site 19 Central Shops Burning Rubble Pit (Waste Site #90).* Written by S.D. Bumpus and S.J. Garner, November.

Suter, G. W. II. 1993. *Ecological Risk Assessment.* Lewis Publishers, Chelsea, MI.

Suter, G.W., II, R.N. Hull, and B.E. Sample. 1994. *Ecological Risk Assessment for Comprehensive Environmental Response, Compensation, and Liability Act Sites on Federal*

Facilities: An Introductory Guide for Facility Managers. DOE/HWP-152. U.S. Department of Energy.

Suter, G.W.. II, 1996. *Guide for Developing Conceptual Models for Ecological Risk Assessments.* ES/ER/TM-186, Oak Ridge National Laboratory, Oak Ridge, TN.

Travis, C.C. and A.D. Arms. 1988. "Bioconcentration of Organics in Beef, Milk, and Vegetation". *Environ. Sci. Technol.* 22(3): 271-274.

Will, M.E. and G.W. Suter II. 1995. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1995 Revision.* ES/ER/TM-126/R2. Oak Ridge National Laboratory, Oak Ridge, TN.

Will, M.E., and G.W. Suter II. 1996. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes: 1995 Revision.* ES/ER/TM-126/R2, Martin Marietta Energy Systems, Oak Ridge National Laboratory, Oak Ridge, TN.

Workman, S.W. and K.W. McLeod. 1990. *Vegetation of the Savannah River Site: Major Community Types.* Publication SRO-NERP-19, Savannah River Ecology Laboratory, Aiken, SC.

WSRC. 1992. *Phase I Remedial Investigation Plan for the Ford Building Waste Site (Building 643-11G).* WSRC-RP-92-983, Rev. 0, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

WSRC. 1993a. *Site Evaluation Report for the Fire Department Hose Training Facility (904-113G)(U).* WSRC-RP-93-119, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

WSRC. 1993b. *WSRC Hydrogeologic Data Collection Procedures and Specifications,* Manual 3Q5, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

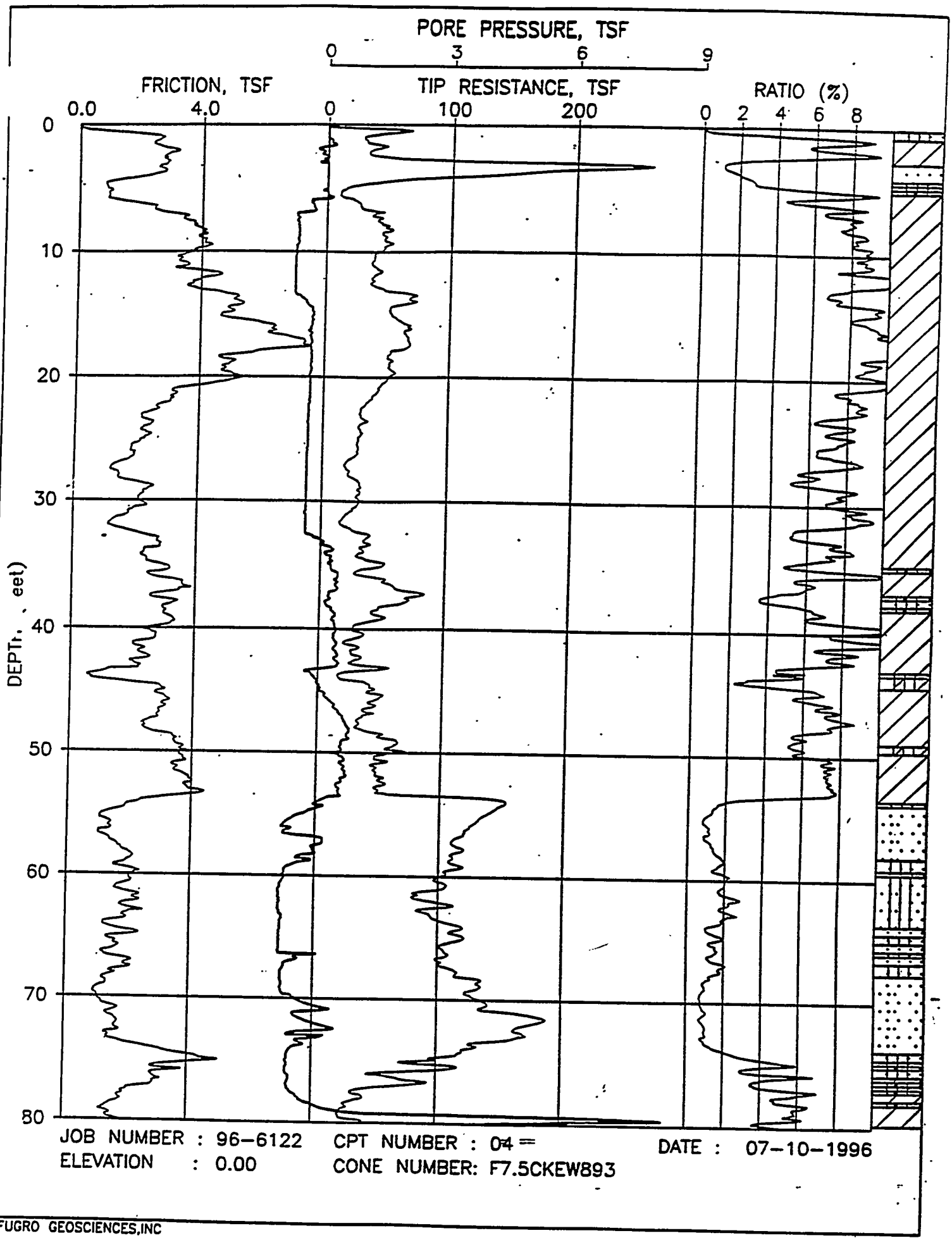
WSRC. 1995. *Safety Analysis Report, Savannah River Site, Generic Chapter 1, Site Characteristics.* WSRC-SA-19, Rev. 0, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

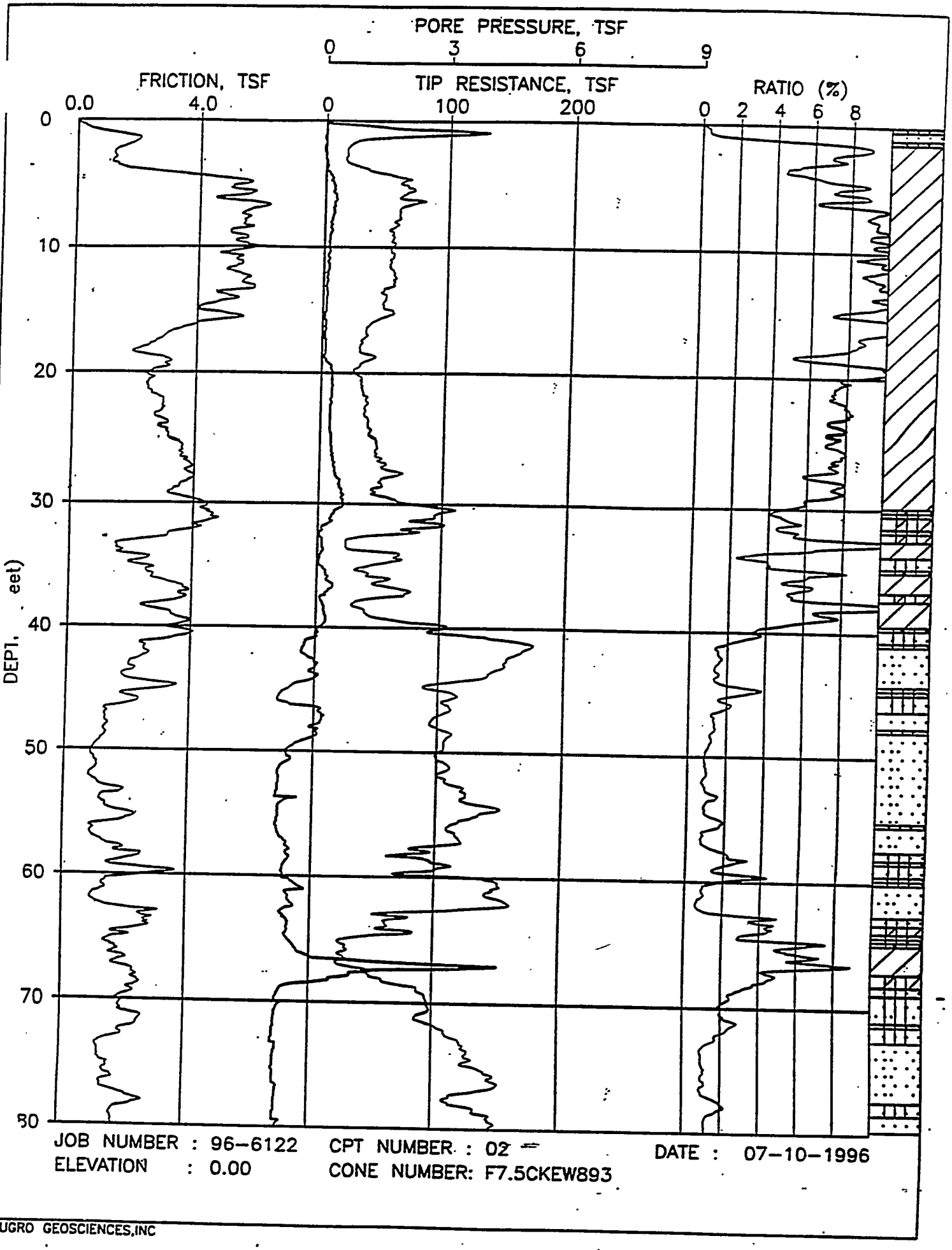
WSRC. 1996a. *Technical Oversight for the N-Area Ford Building Waste Unit (643-11G) and Fire Department Hose Training Facility (904-113G).* WSRC-RP-96-856, Rev. 0, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

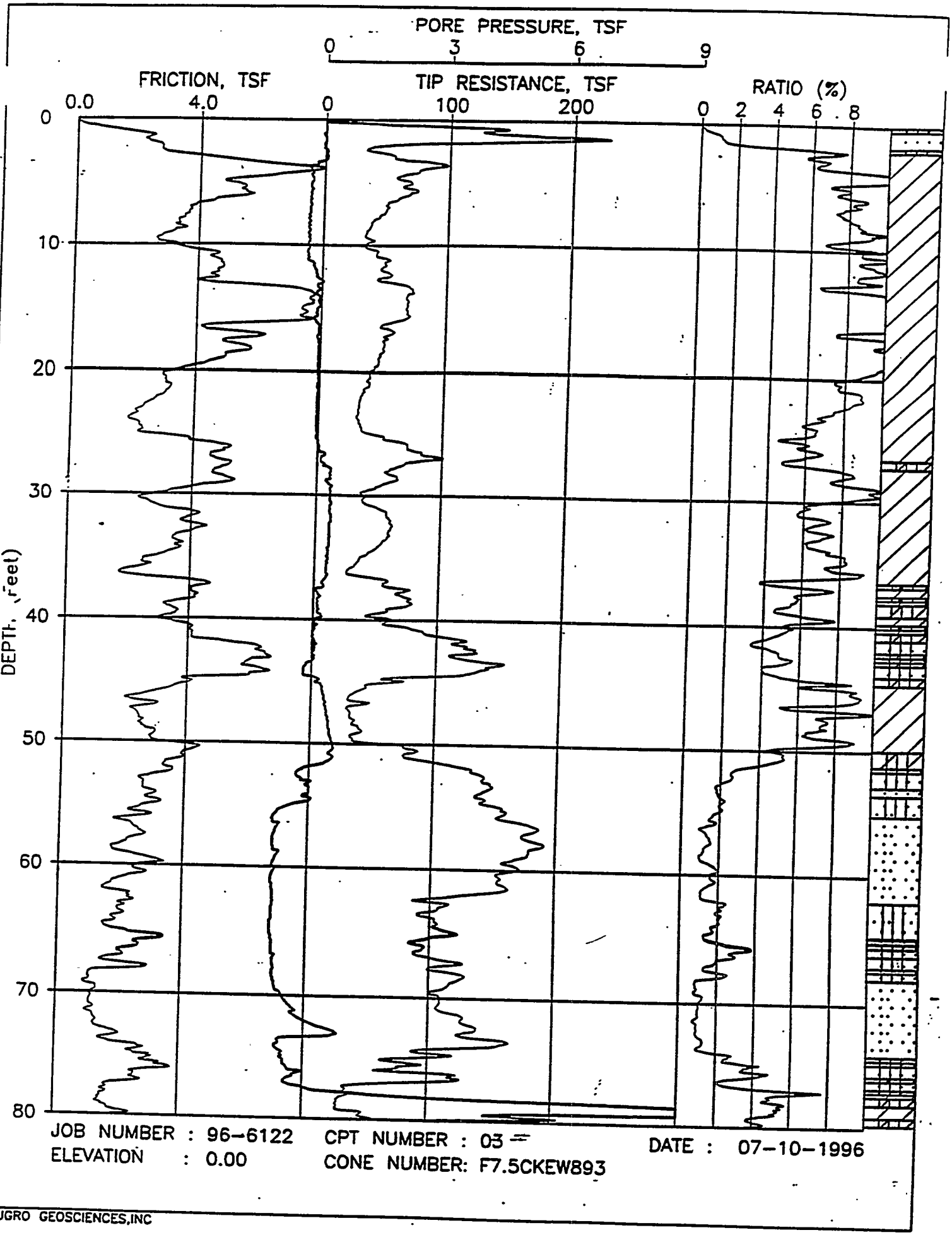
WSRC. 1996b. *Quality Control Summary Report for the N-Area Ford Building Waste Unit, Phase I.* ESH-EMS-960457, July 1996, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

APPENDIX A-1

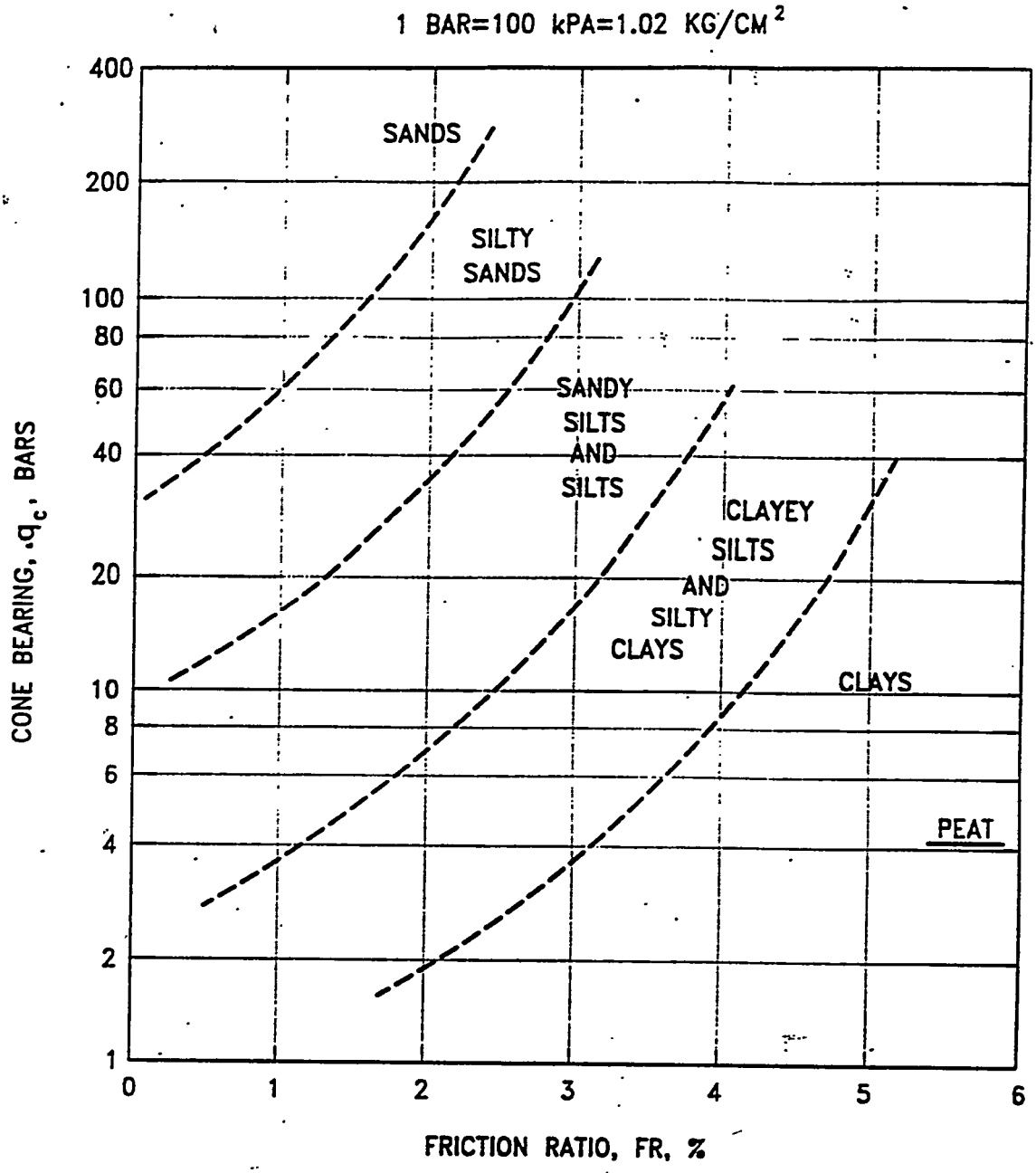
1986 SOIL GAS SURVEY


PORE PRESSURE, TSF
0
3
6
9
FRICTION, TSF
0.0
4.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
0
10
20
30
40
50
60
70
80
DEPTH (Feet)
JOB NUMBER : 96-6122
ELEVATION : 0.00
CPT NUMBER : 04
CONE NUMBER: F7.5CKEW893
DATE : 07-10-1996
FUGRO GEOSCIENCES,INC

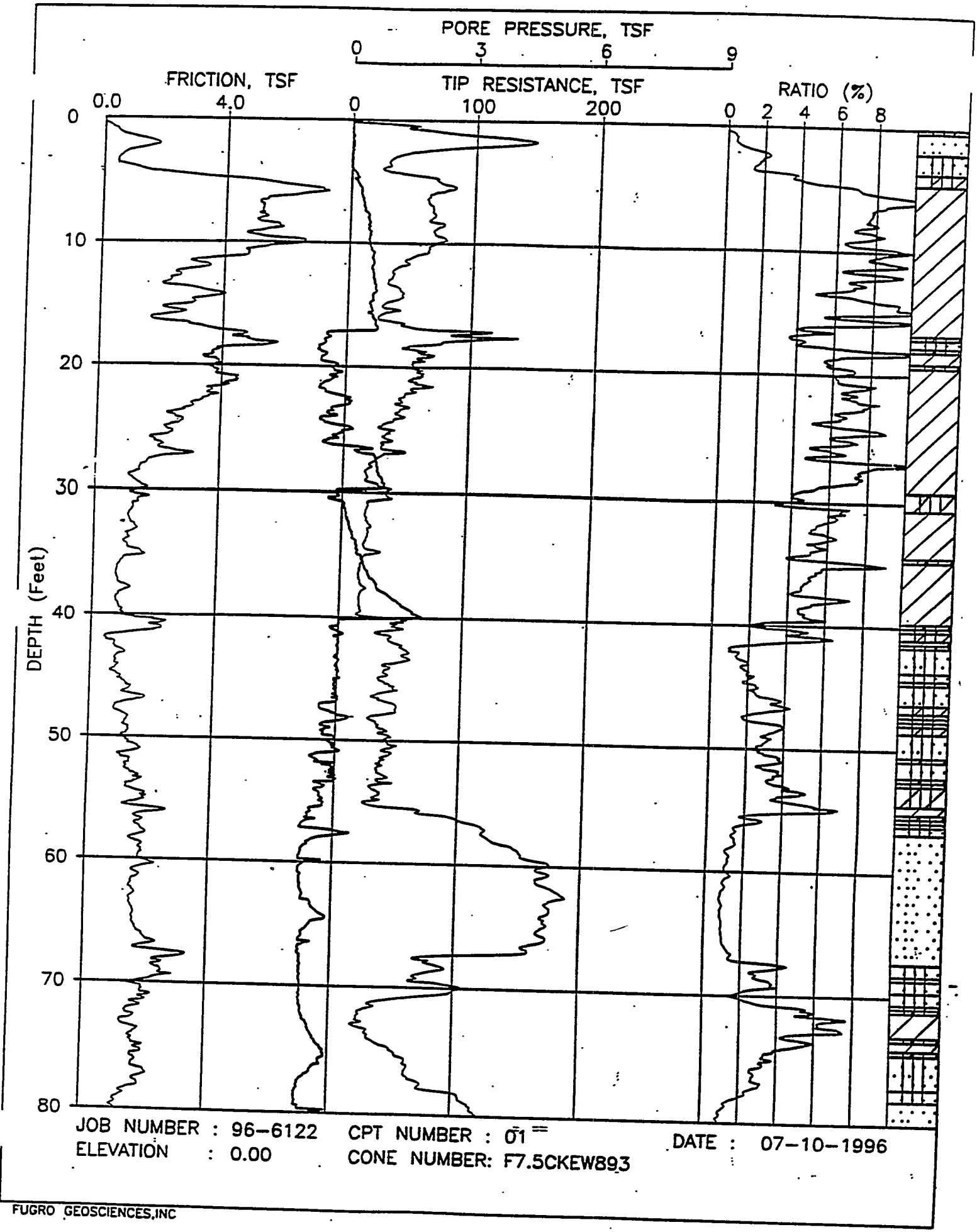

PORE PRESSURE, TSF
0
3
6
9
FRICTION, TSF
0.0
4.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
0
10
20
30
40
50
60
70
80
DEPTH (Feet)
JOB NUMBER : 96-6122
ELEVATION : 0.00
CPT NUMBER : 02
CONE NUMBER: F7.5CKEW893
DATE : 07-10-1996
FUGRO GEOSCIENCES,INC



FUGRO GEOSCIENCES,INC



CAMPANELLA AND ROBERTSON CLASSIFICATION CHART (1983)


PORE PRESSURE, TSF
0
3
6
9
FRICTION, TSF
0.0
4.0
TIP RESISTANCE, TSF
0
100
200
RATIO (%)
0
2
4
6
8
DEPTH (Feet)
0
10
20
30
40
50
60
70
80
JOB NUMBER : 96-6122
CPT NUMBER : 01
DATE : 07-10-1996
ELEVATION : 0.00
CONE NUMBER: F7.5CKEW893
FUGRO GEOSCIENCES,INC

FUGRO GEOSCIENCES, INC.

6105 Rookin
Houston, TX 77074
Phone : 713-778-5580
Fax : 713-778-5501

August 6, 1996
Report Number 0301-6122

Westinghouse Savannah River Company
Building 772-7B, Room 2
1000 Brookhaven Drive
Aiken, SC 29803-6105

Attention: Ms. Jannelle Janssen

CONE PENETROMETER TESTING
AND RELATED SERVICES
FBW / FDTF CENTRAL SHOPS
SAVANNAH RIVER SITE

Dear Ms. Janssen:

Please find enclosed herewith the final results of the cone penetrometer tests conducted at the above referenced location.

For your information, the soil stratigraphy was identified using Campanella and Robertson's Simplified Soil Behavior Chart. Please note that because of the empirical nature of the soil behavior chart, the soil identification should be verified locally.

Fugro Geosciences appreciates the opportunity to be of service to your organization. If you should have any questions, or if we can be of further assistance, please do not hesitate to contact us. We look forward to working with you in the future.

Very truly yours,
FUGRO GEOSCIENCES, INC.

Recep Yilmaz
President

RY/rsp
1 Diskette(s) Enclosed

Key To Soil Classification and Symbols

SOIL TYPE
(Shown in Symbol Column)



Predominant Type Shown Heavy

SAMPLE TYPE
(Shown in Samples Column)



TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (Major portion Retained on No. 200 Sieve)
Includes (1) clean gravels and sand described as fine, medium or course, depending on distribution of grain sizes (2) silty or clayey gravels and sands and (3) fine grained low plasticity soils (PI < 10) such as sandy silts. Condition is rated according to relative density, as determined by lab tests or estimated from resistance to sampler penetration.

Descriptive Term	Penetration Resistance*	Relative Density
Loose	0 - 10	0 to 40%
Medium Dense	10 - 30	40 to 70%
Dense	30 - 50	70 to 90%
Very Dense	Over 50	90 to 100%

* Blows/Foot, 140# Hammer, 30" Drop

FINE GRAINED SOILS (Major Portion Passing No. 200 Sieve)
Includes (1) inorganic and organic silts and clays, (2) sandy, gravelly or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings or by unconfined compression tests for soils with PI $\geq$ 10.

Descriptive Term	Cohesive Shear Strength Tons/Square Foot
Very Soft	Less Than 0.125
Soft	0.125 to 0.25
Firm	0.25 to 0.50
Stiff	0.50 to 1.00
Very Stiff	1.00 to 2.00
Hard	2.00 and Higher

Note: Slickensided and fissured clay may have lower unconfined compressive strengths than shown above because of planes of weakness or shrinkage cracks; consistency ratings of such soils are based on hand penetrometer readings.

TERMS CHARACTERIZING SOIL STRUCTURE

Parting:	paper thin in size
Seam:	1/8" to 3" thick
Layer:	greater than 3"
Fissured:	containing shrinkage cracks, frequently filled with fine sand or silt, usually more or less vertical
Sensitive:	pertaining to cohesive soils that are subject to appreciable loss of strength when remolded
Interbedded:	composed of alternate layers of different soil types
Laminated:	composed of thin layers of varying color and texture
Calcareous:	containing appreciable quantities of calcium carbonate
Well Graded:	having wide range in grain sizes and substantial amounts of all intermediate particle sizes
Poorly Graded:	predominantly of one grain size, or having a range of sizes with some intermediate size missing
Flocculated:	pertaining to cohesive soils that exhibit a loose knit or flakey structure
Slickensided:	having inclined planes of weakness that are slick and glossy in appearance.

Degree of Slickensided Development

Slightly Slickensided:	slickensides present at intervals of 1' to 2', soil does not easily break along these plates
Moderately Slickensided:	slickensides spaced at intervals of 1' to 2', soil breaks easily along these planes
Extremely Slickensided:	continuous and interconnected slickensides spaced at intervals of 4" to 12", soil breaks along the slickensides into pieces 3" to 6" in size
Intensely Slickensided:	slickensides spaced at intervals of less than 4", continuous in all directions; soil breaks down along planes into nodules 1/4" to 2" in size.

APPENDIX A-2

1992 SOIL GAS SURVEY

MICROSEEPS LTD.

CLIENT: SRS / Lynn Mart
LOCATION: Fire Dept Hosting
PROJECT(S): 904-113G
PAGE: __ OF: __

********** SAMPLE COLLECTION LOG **********

SAMPLER NAME(S): CDE & KGG

SAMPLE ID#	DATE	TIME	SEQ.#	SAMPLE DEPTH	SAMPLE TYPE G	S	V	SAMPLE SIZE	COMMENTS
904-113G-10	4-30-91	1153	94	3'	✓			185	
904-113G-20		1159	95					22	
113G-20		1200	96						
20A		1205	97						
20A		1208	98	↓					
SB-3		1211	99	-0-					
S-3	↓	1213	50	-0-	↓			↓	Last Sample Visit

* A NEW SHEET WHEN REGARDING SOURCE

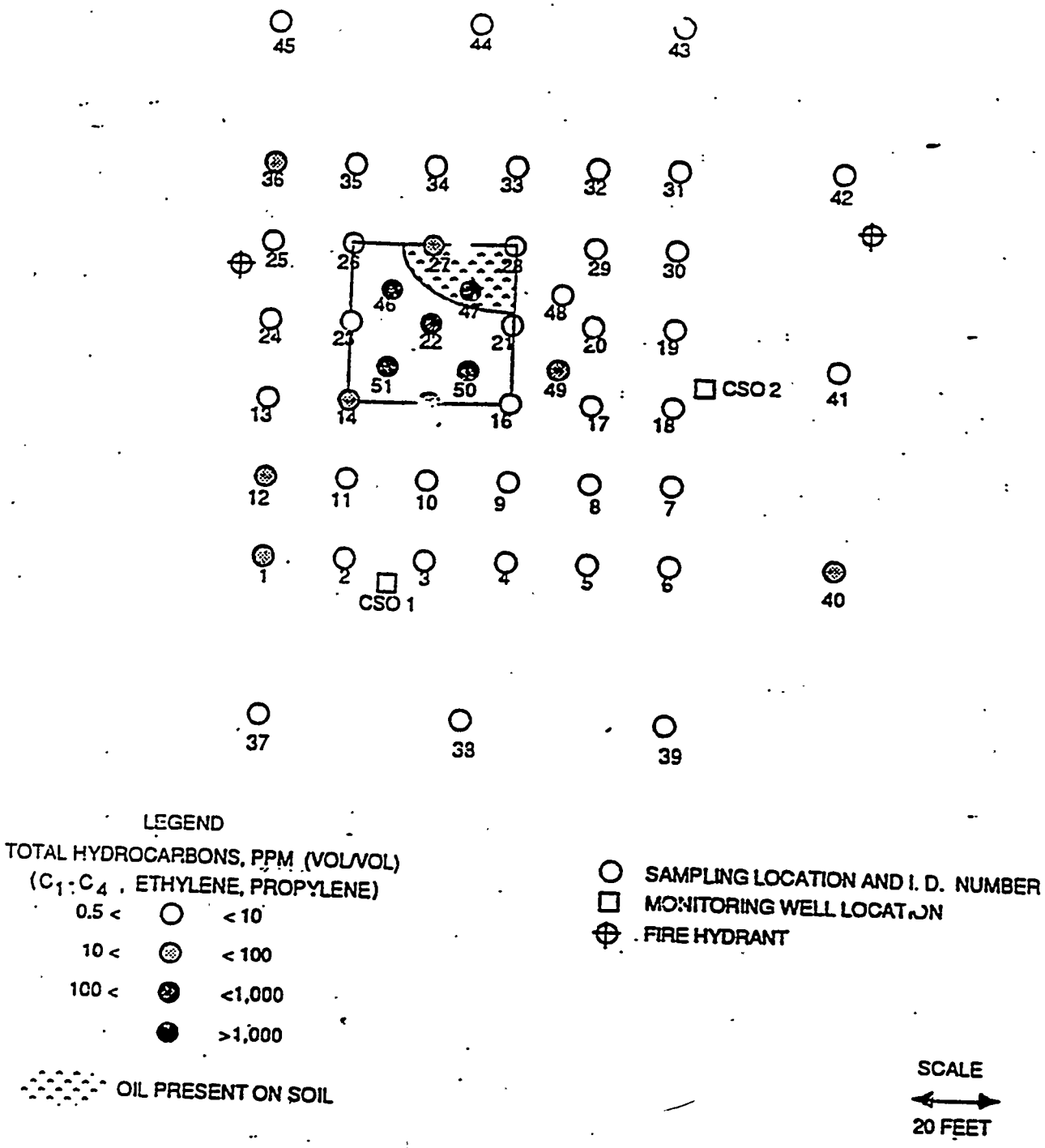


Figure 2. Total Hydrocarbons in Soil Gas at the Fire Department Hose Training Facility

XICROSEEPS LTD.

CLIENT: SBS/Lynn MacTir
LOCATION: Fire Dept Hall Twp F
PROJECT(S): 904-113G
PAGE: ___ OF: ___

########## SAMPLE COLLECTION LOG ##########

SAMPLER NAME(S): VGG & CDS

SAMPLE ID#	DATE	TIME	SEQ.#	SAMPLE DEPTH	SAMPLE TYPE G	S	V	SAMPLE SIZE	COMMENTS
904-1136-SB-1	4-30-92	1000	1	0-	✓			22	
904-1136-SB-1		1001	2	-0-				125	
1136-1		1003	3	3'					
1136-1		1004	4						
2		1005	5						
2		1007	6						
3		1008	7						
3		1010	8						
4		1012	9						
4		1014	10						
5		1016	11						
5		1018	12						
6		1020	13						
6		1023	14						
7		1025	15						
7		1027	16						
8		1029	17						
8		1030	18						
9		1034	19						
9		1035	20						
10		1039	21						
10		1040	22						
10A		1042	23						
10A		1044	24						
S-2		1047	25	0-					
S-2		1048	26	-3-					
11		1051	27	3'					
11		1053	28						
12		1910	29						
12		1111	30						
13		1115	31						
13		1116	32						
14		1120	33						
14		1121	34						
15		1125	35						
15		1126	36						
16		31	37						
16		1132	38						
17		1136	39						
17		1137	40						
18		1142	41						
18		1145	42						
19	↓	1152	43	↓			↓		

Table 2

—— E. I. DUPONT DE NEMOURS CO. INC., S.R.P., AIKEN S.C. ——
—— FIRE TRAINING AREA — SOIL SAMPLES — OCT. , ——
—— SOIL CORRECTED RATIO BY WEIGHT ——

SAMPLE NUMBER	DEPTH	PENTANE PPB	HEXANE PPB	BENZENE PPB	OCTANE PPB	TOLUENE PPB	TOTAL AREA	SAMPLE NUMBER	DEPTH
FT 1	1.0	-	-	-	-	-	785	FT 1	1.0
FT 1	2.0	-	-	-	-	-	8302	FT 1	2.0
FT 1R	2.0	-	-	-	-	-	11205	FT 1R	2.0
FT 1	3.0	-	-	-	-	-	10155	FT 1	3.0
FT 1	4.0	-	-	-	-	-	6246	FT 1	4.0
FT 1	5.0	-	-	-	-	-	14291	FT 1	5.0
FT 12	2.0	-	-	-	-	-	10737	FT 12	2.0
FT 14	2.0	-	-	-	-	-	13275	FT 14	2.0
FT 15	2.0	-	-	-	-	-	29902	FT 15	2.0
FT 16	2.0	-	-	-	-	-	11268	FT 16	2.0
FT 17	2.0	-	-	-	-	-	17002	FT 17	2.0
FT 20	2.0	-	-	-	-	-	17223	FT 20	2.0
FT 21	2.0	-	-	-	-	-	20730	FT 21	2.0
FT 22	2.0	2.4	-	-	7.5	9.5	681970	FT 22	2.0
FT 23	2.0	-	-	-	-	-	26617	FT 23	2.0
FT 26	2.0	-	-	-	-	-	34288	FT 26	2.0
FT 27	2.0	-	-	-	-	-	14678	FT 27	2.0
FT 28	2.0	-	-	-	-	-	16043	FT 28	2.0
FT 29	2.0	-	-	-	-	-	44576	FT 29	2.0
FT 41	1.0	-	-	-	-	-	7201	FT 41	1.0
FT 41	2.0	-	-	-	-	-	6982	FT 41	2.0
FT 41	3.0	-	-	-	-	-	9416	FT 41	3.0
FT 41	4.0	-	-	-	-	-	7822	FT 41	4.0
FT 41	5.0	-	-	-	-	-	7688	FT 41	5.0
FT 47	1.0	-	-	2.3	6.4	6.6	959610	FT 47	1.0
FT 47	2.0	-	-	3.3	10.1	59.5	1303900	FT 47	2.0
FT 47	3.0	-	-	-	6.0	19.5	397400	FT 47	3.0
FT 47	4.0	-	-	-	3.7	3.9	398220	FT 47	4.0
FT 47	5.0	-	-	-	-	-	88959	FT 47	5.0
FT 51	1.0	-	-	-	-	-	7940	FT 51	1.0
FT 51	2.0	-	-	-	2.5	5.4	438260	FT 51	2.0
FT 51	3.0	-	-	-	-	2.6	173130	FT 51	3.0
FT 51	4.0	-	-	-	-	2.5	13	FT 51	4.0
FT 51	5.0	-	-	-	-	-	01	FT 51	5.0

below mdl

below mdl

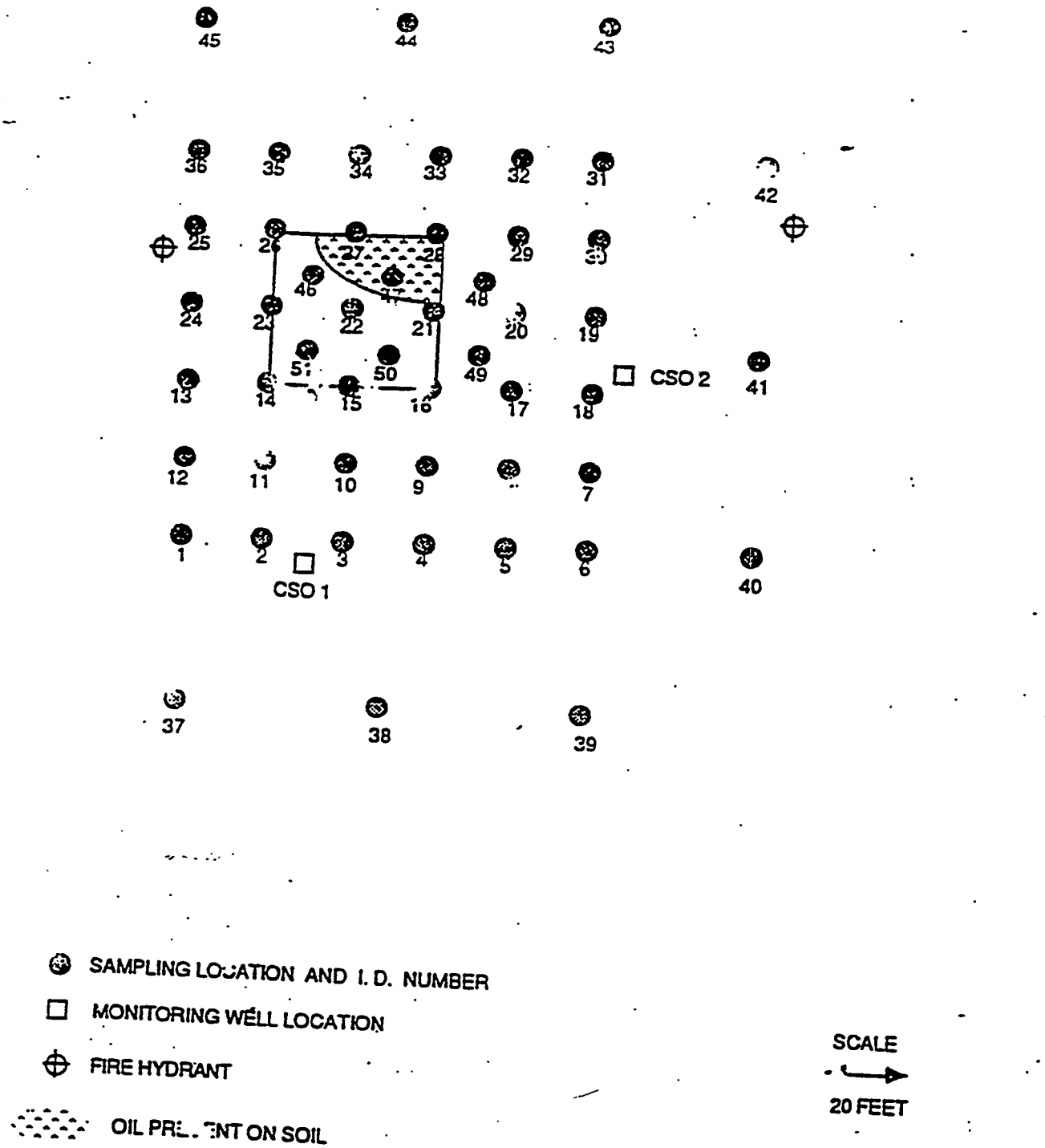


Figure 1. Soil and Soil Gas Sampling Locations at the Fire Department Hose Training Facility.

Table 1 —— E. I. DUPONT DE NEMOURS CO. INC., S.R.P., AIKEN, S.C. ——
—— FIRE TRAINING AREA — PROBE SURVEY, OCT. 1986 ——
—— SOIL GAS CONCENTRATIONS ——

SAMPLE #	METHANE PPB	ETHANE PPB	PROPANE PPB	I-BUTANE PPB	N-BUTANE PPB	ETHYLENE PPB	PROPYLENE PPB	TOTAL HYDCARB
F. 1	20714	706	210	243	86	441	429	22829
FT 2	6003	310	99	169	40	210	222	7053
FT 3	4078	224	76	141	34	159	176	4888
FT 4	2[illegible]8	118	39	71	-	83	82	2851
FT 5	1843	45	15	29	-	27	30	1989
FT 6	1366	79	29	62	-	64	77	1677
FT 7	924	23	9	23	-	20	22	1021
FT 8	1113	30	11	31	-	23	25	1233
FT 9	1233	167	63	41	26	114	124	1768
FT 10	4024	224	73	148	40	168	177	4854
FT 11	1[illegible]2	124	44	50	13	91	107	2071
FT 12	16401	363	89	240	40	234	218	17585
FT 13	2908	391	108	175	42	216	239	3[illegible]39
FT 14	9547	714	246	246	96	534	557	11[illegible]10
FT 15	47505	502	126	53	75	424	429	49[illegible]14
FT 15-1	3398	94	32	61	-	150	98	[illegible]33
FT 15-2	15520	228	64	43	-	183	143	1[illegible]81
FT 16	1593	123	43	76	-	95	102	[illegible]032
FT 17	698	27	10	23	-	22	24	804
FT 18	1316	58	21	38	-	41	45	1519
FT 19	2675	160	55	93	14	107	121	3225
FT 20	869	30	11	18	-	22	25	975
FT 21	5479	497	170	182	65	331	348	7072
FT 22	302630	482	147	108	113	567	722	304769
FT 23	1170	142	57	18	19	81	87	1574
FT 24	7100	913	305	203	108	514	539	9682
FT 25	2049	55	25	24	-	42	54	2249
FT 26	2781	365	144	70	60	206	247	3873
FT 27	25864	3466	1[illegible]9	187	331	1441	1442	33760
FT 28	5791	622	1	30	59	304	370	7266
FT 29	990	98	35	20	-	56	59	1258
FT 30	2575	327	136	123	58	248	293	3760
FT 31	4916	153	53	84	27	137	148	5518
FT 32	1419	60	21	39	-	45	48	1632
FT 33	2030	116	43	39	-	93	97	2418
FT 34	4471	259	103	118	51	194	204	5400
FT 35	2741	209	72	68	27	159	175	3451
FT 36	10158	698	245	433	101	666	643	12944
FT 37	8561	356	105	80	40	190	207	9609
FT 38	1096	53	16	22	-	31	34	1252
FT 39	1652	64	21	33	-	42	45	1857
FT 40	14301	199	43	20	-	55	61	14679
FT 41	514	37	14	-	-	28	29	622
FT 42	1877	83	25	22	-	53	53	2113
FT 43	731	48	17	-	-	32	36	864
FT 44	5517	352	45	43	-	89	96	5952
FT 45	6673	391	128	170	49	288	311	8010
FT 46	306540	1358	398	130	137	2267	1778	312608
FT 47	6131601	1190	234	449	569	3994	3841	6141878

Table 1 continued

---- E. I. DUPONT DE NEMOURS CO. INC., S.R.P., AIKEN, S.C. ----
---- FIRE TRAINING AREA -- PROBE SURVEY, OCT. 1986 ----
---- SOIL GAS CONCENTRATIONS ----

SAMPLE #	METHANE PPB	ETHANE PPB	PROPANE PPB	I-BUTANE PPB	N-BUTANE PPB	ETHYLENE PPB	PROPYLENE PPB	TOTAL HYDROCARB
FT 48	887	43	17	-	-	33	31	1011
FT 49	14427	290	57	51	-	127	94	15046
FT 50	102[illegible]0	1096	290	192	322	1821	16[illegible]	103C808
FT 51	228300	396	113	87	81	658	6[illegible]	230443

NOTE:

FT XX - 3 FT. SAMPLE
FT XX-1 - 1 FT. SAMPLE
FT XX-2 - 2 FT. SAMPLE

TECHNICAL DIVISION
SAVANNAH RIVER LABORATORY

CC: C. A. Palmiotto, 773-42A
C. R. Sherman, 703-A
A. M. Nowicki, 703-A

November 5, 1986

MEMORANDUM

TO: D. E. GORDON

FROM: P. CORBO

SOIL GAS SURVEY OF FIRE DEPARTMENT HOSE TRAINING FACILITY

A soil gas survey of the Fire Department Hose Training Facility (Building 904-113G) was conducted recently to determine whether any contamination was present from waste oil that was burned when the facility was used to train fire department personnel. The results of the survey suggest that some organic residue has been left in the area of the Training Facility. The survey and results are described below.

The grid used in performing the soil survey is given in Figure 1. The area in the center square is where the pit appears to have been located based on field inspection. Pieces of asphalt were also observed in the center section. The shaded area in the center indicates where oil was present on the soil. Both soil samples and soil gas samples were used in this study. Soil gas samples were taken at a three-foot depth at all locations. Soil samples were taken at several locations at a two-foot depth. Five-foot cores were taken at four locations and analyzed every foot to determine a depth profile.

The soil gas was analyzed for methane, ethane, propane, butane, ethylene, and propylene. These compounds were chosen as possible breakdown products of oil. The data are presented in Table 1 and summarized in Figure 2. Most of the high concentrations of total hydrocarbons were found within in the outlined area in Figure 2. At five of these locations, greater than 100 ppm of total hydrocarbons were observed.

Soil samples were taken at locations listed in Table 2 at several two-foot depths and at four five-foot depths which were analyzed at one-foot intervals. Soil samples were analyzed for pentane, hexane, heptane, octane, benzene, and toluene. These compounds were chosen as potential breakdown products of oil, and are more likely to be associated with soil rather than soil gas since they are heavier compared to the compounds measured in the soil gas.

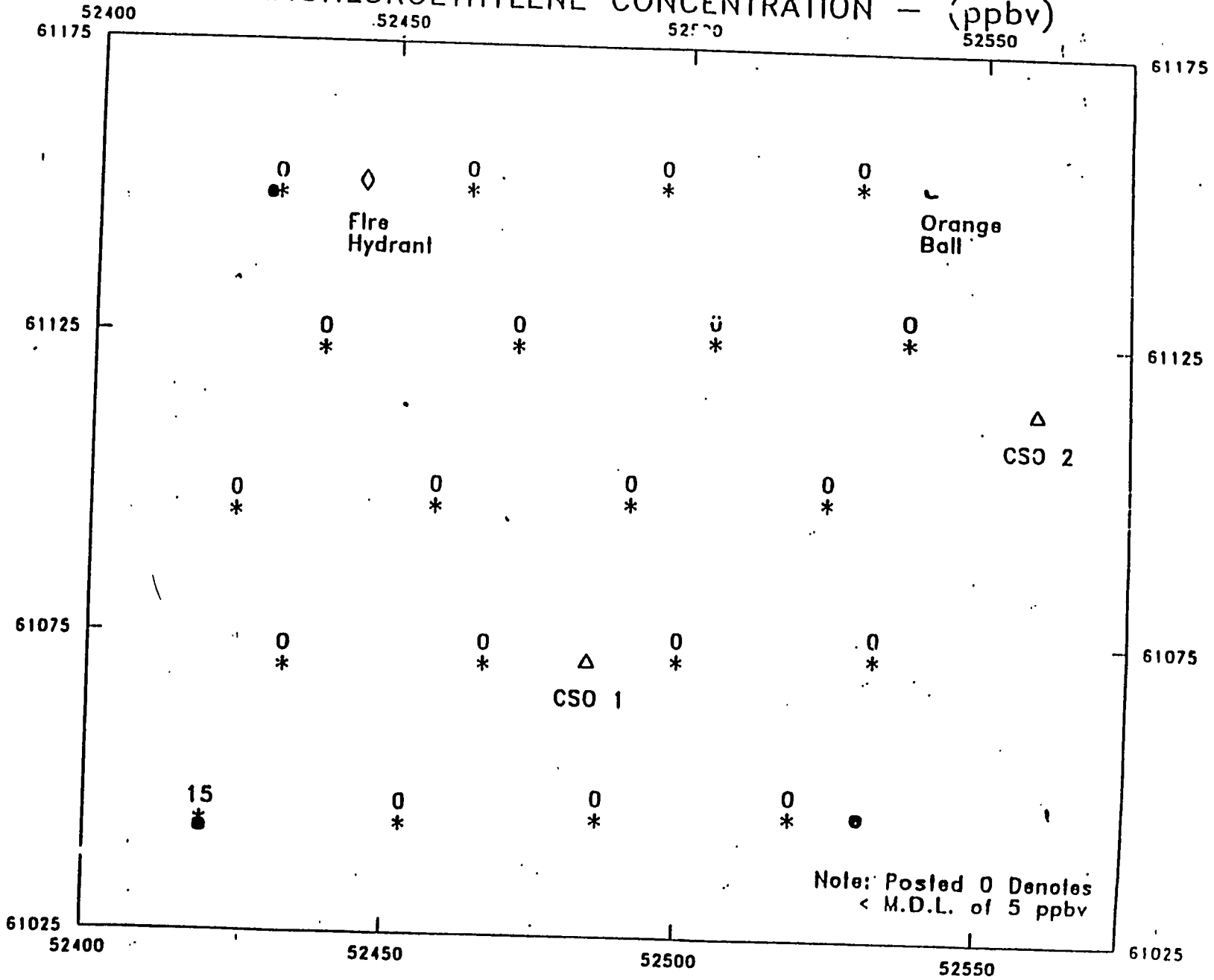
Several of the heavier hydrocarbon compounds were observed at a two-foot depth for sample locations 22, 41, and 51. Locations 1 and 41, which showed low levels of total hydrocarbons in the soil gas, did not contain any of the compounds throughout the five-foot sample depth. Location 47 showed the presence of the heavier compounds in the first four feet of the five-foot core. Location 51 showed the presence of the heavier compounds in the two, three, and four-foot sections. Locations 47 and 51 both had high concentrations of total hydrocarbons in the soil gas. These results suggest that waste oil may be present to a depth of four feet.

The results of the soil gas survey can be used a screening for contamination at the Fire Department Hose Training Facility. Further testing is needed to determine whether this area contains any hazardous materials.

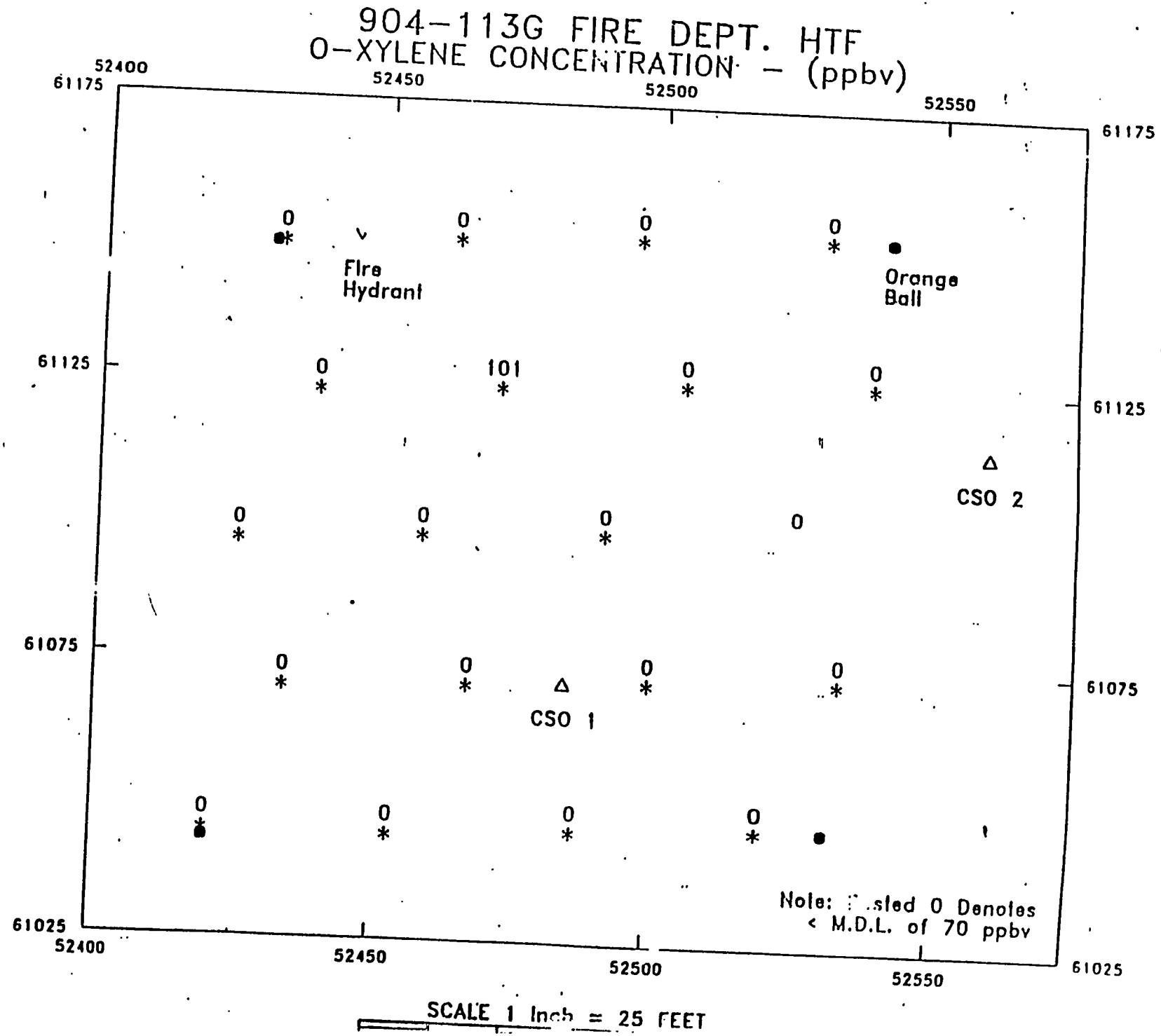
APPENDIX A-3

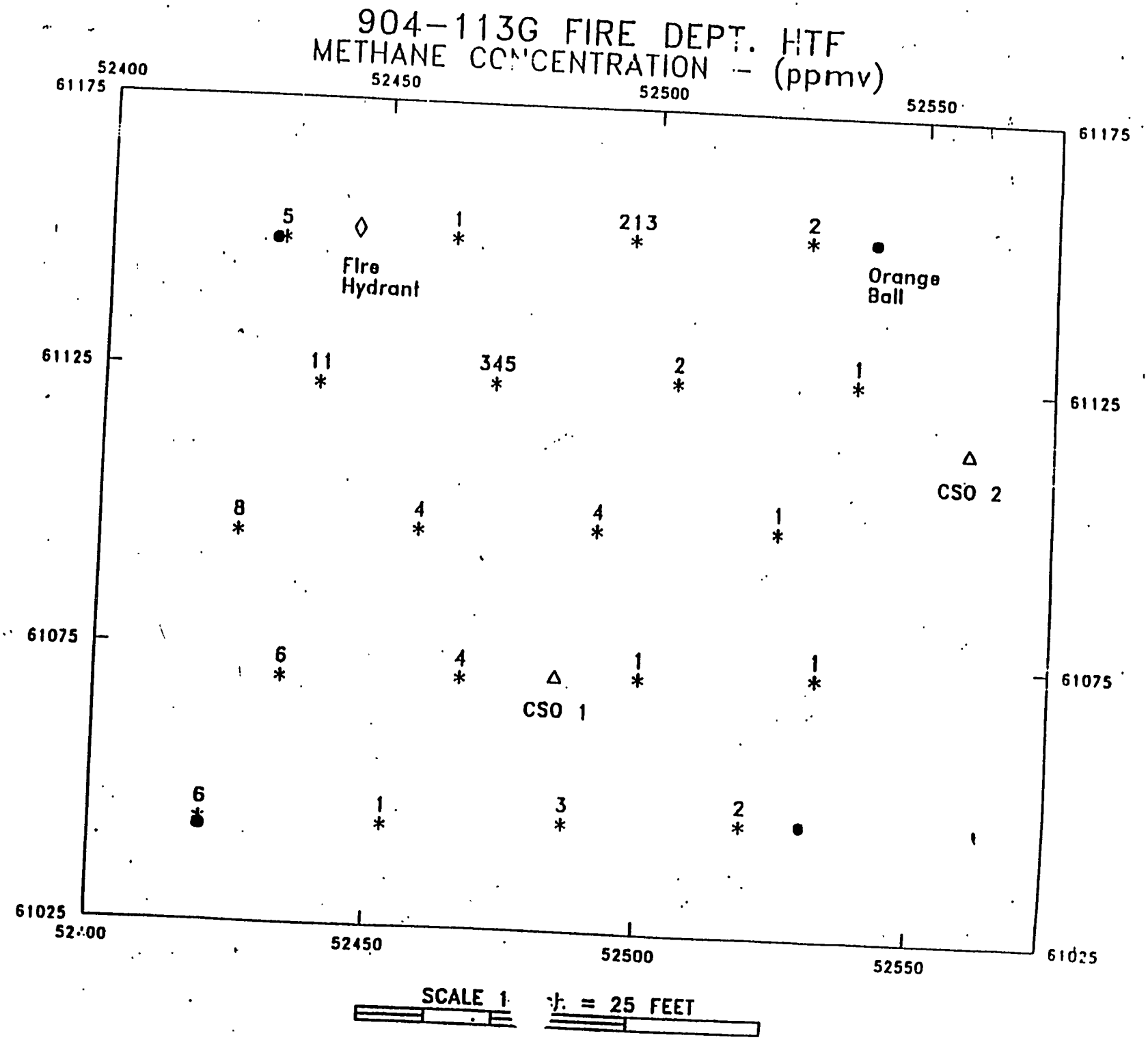
UNIT HISTORICAL INFORMATION

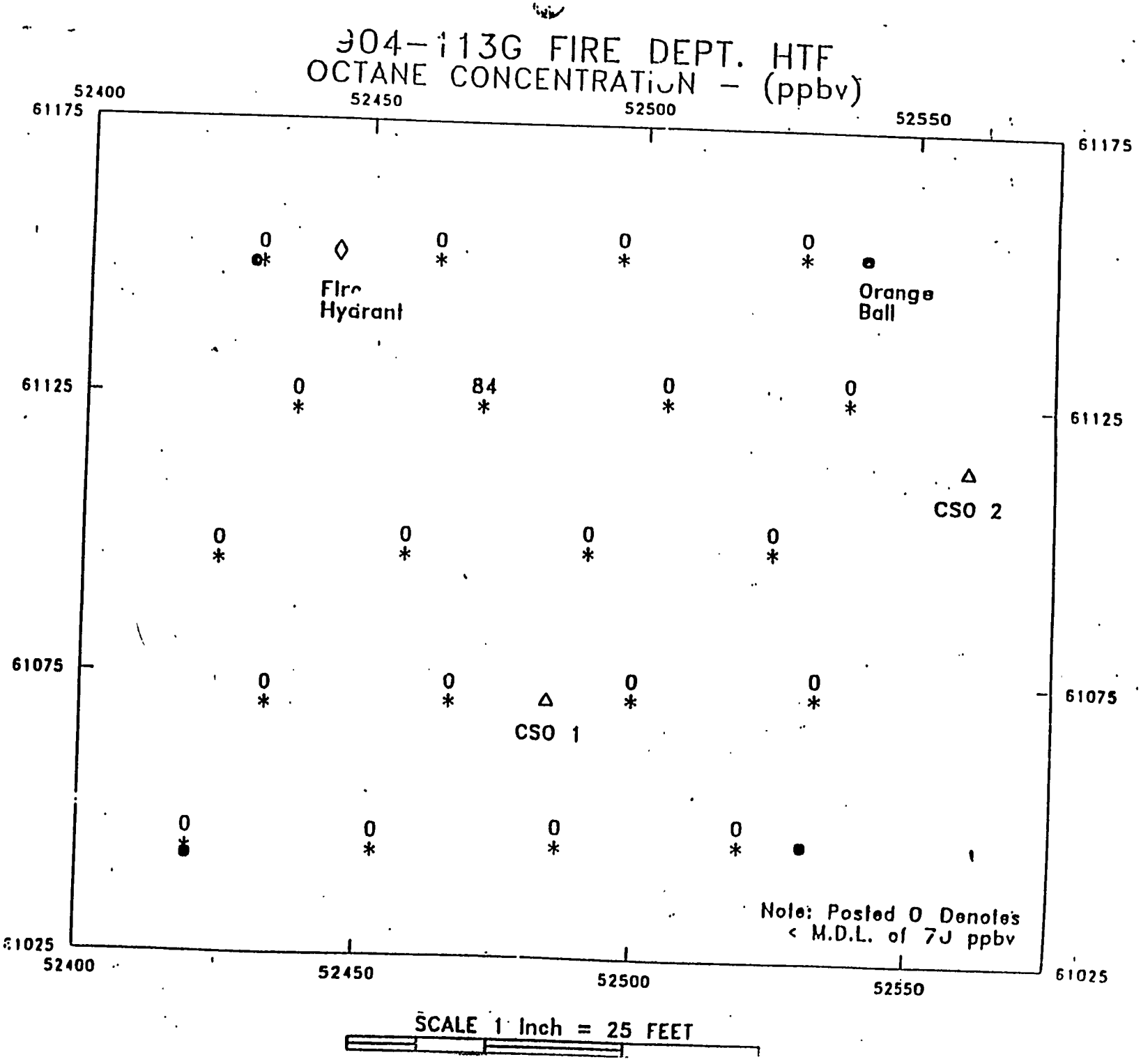
904-113G FIRE DEPT. HTF
TETRACHLOROETHYLENE CONCENTRATION - (ppbv)



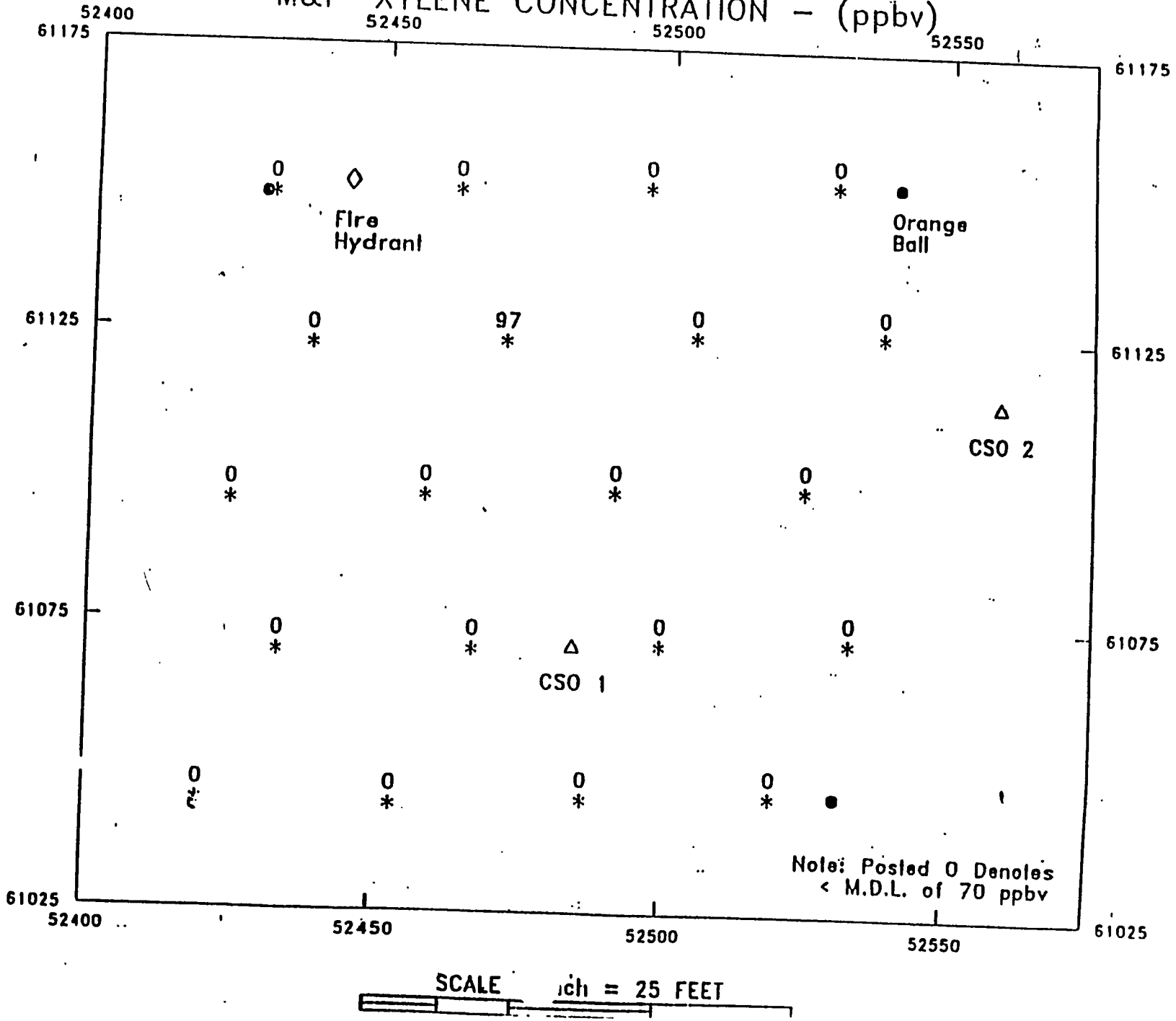
SCALE 1 Inch = 25 FEET

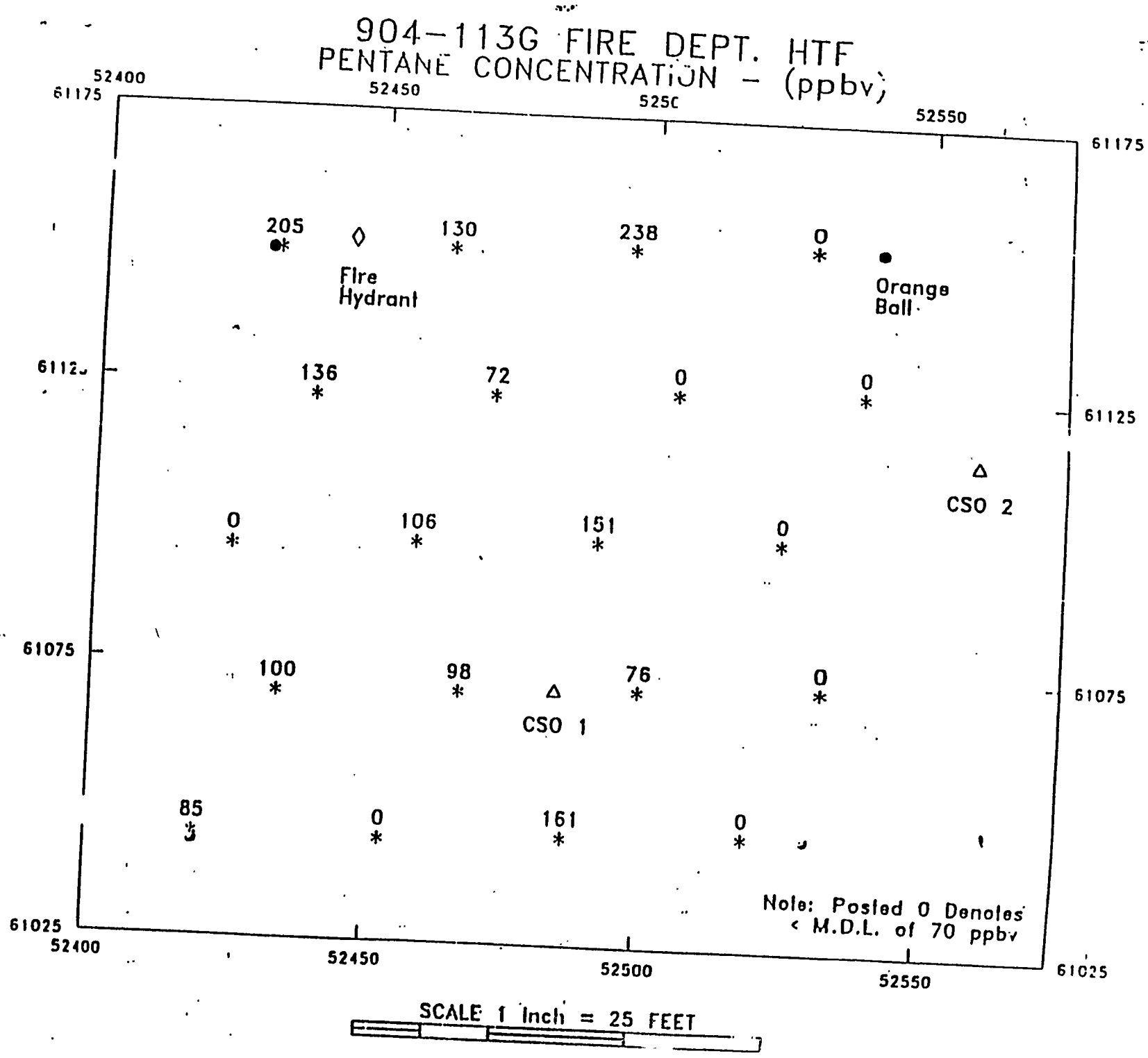

904-113G FIRE DEPT. HTF
O-XYLENE CONCENTRATION - (ppbv)
52400
52450
52500
52550
61175
61125
61075
61025
Fire Hydrant
Orange Ball
CSO 1
CSO 2
0
101
Note: Circled 0 Denotes < M.D.L. of 70 ppbv
SCALE 1 Inch = 25 FEET


904-113G FIRE DEPT. HTF
METHANE CONCENTRATION - (ppmv)
52400
52450
52500
52550
61175
61125
61075
61025
5
1
213
2
Fire Hydrant
Orange Ball
11
345
2
1
CSO 2
8
4
4
1
6
4
1
1
CSO 1
6
1
3
2
SCALE 1" = 25 FEET

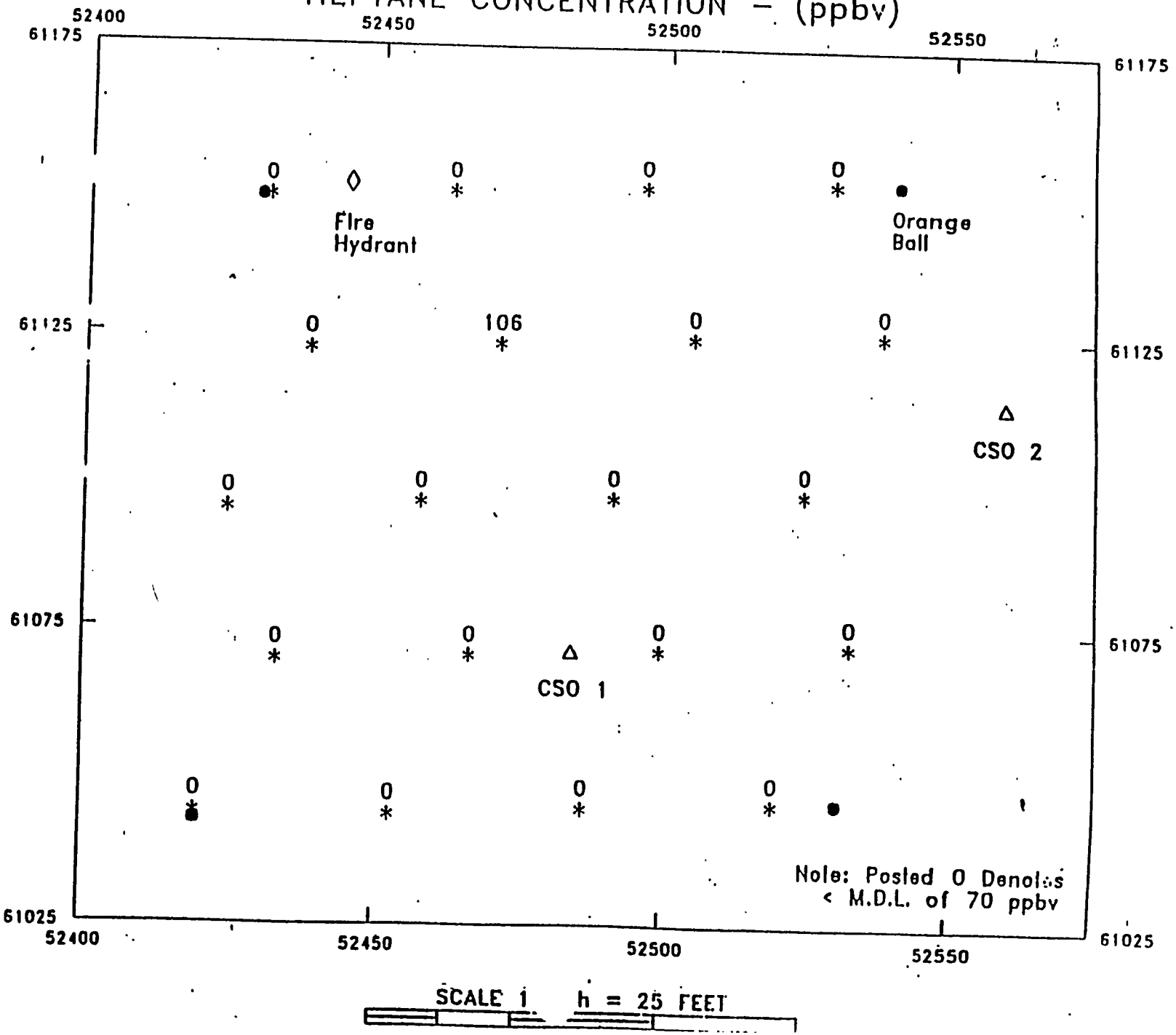

904-113G FIRE DEPT. HTF
OCTANE CONCENTRATION - (ppbv)
52400
52450
52500
52550
61175
61125
61075
61025
Fire Hydrant
Orange Ball
CSO 1
CSO 2
84
Note: Posted 0 Denotes < M.D.L. of 70 ppbv
SCALE 1 Inch = 25 FEET

904-113G FIRE DEPT. HTF
M&P-XYLENE CONCENTRATION - (ppbv)




904-113G FIRE DEPT. HTF
PENTANE CONCENTRATION - (ppbv)
52400
52450
52500
52550
61175
61125
61075
61025
205
130
238
0
Fire Hydrant
Orange Ball
136
72
0
0
CSO 2
0
106
151
0
100
98
76
0
CSO 1
85
0
161
0
Note: Posted 0 Denotes < M.D.L. of 70 ppbv
SCALE 1 Inch = 25 FEET

901-113G FIRE DEPT. HTF
HEPTANE CONCENTRATION - (ppbv)

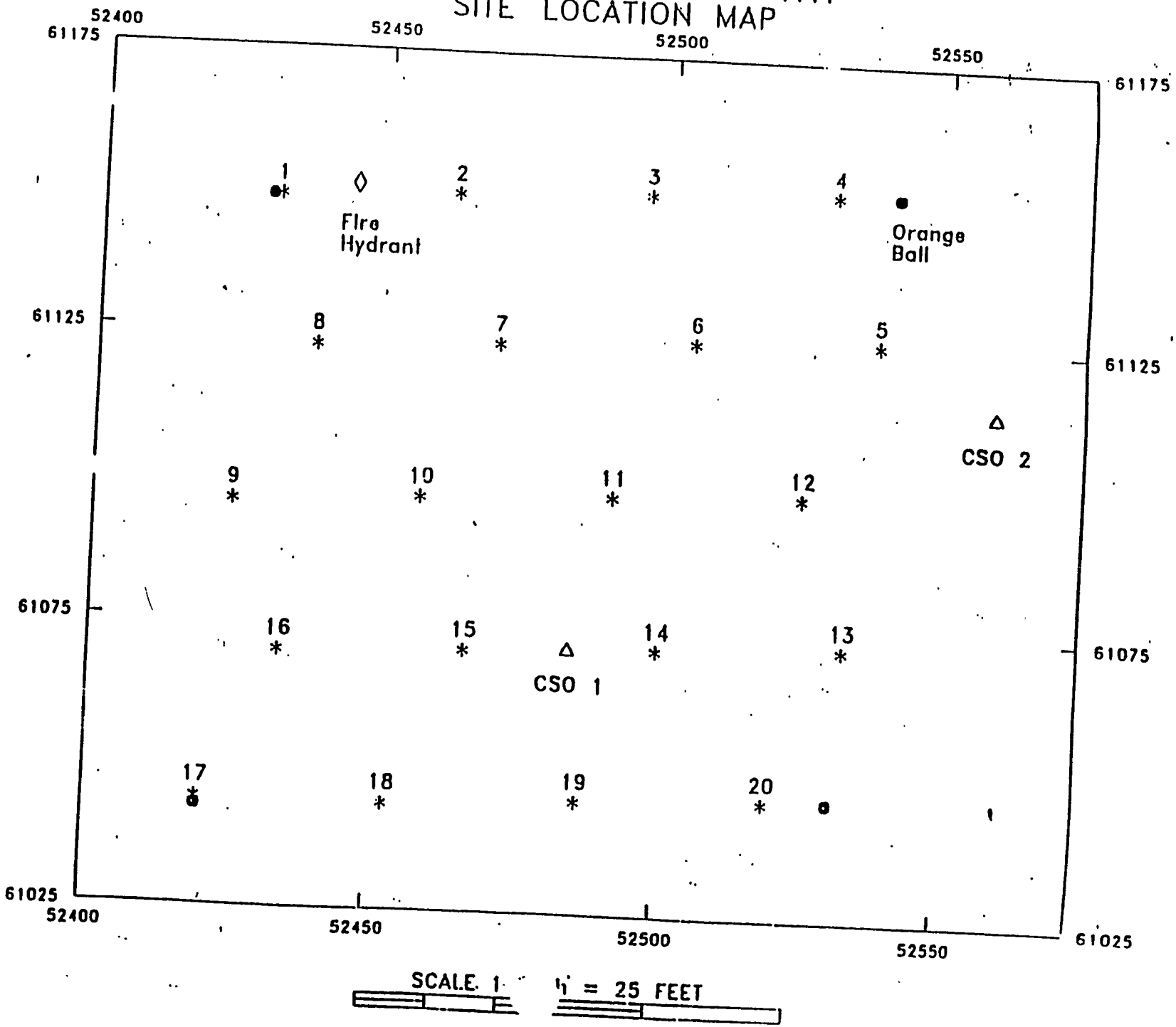


----- SAVANNAH RIVER SITE -----
----- 904-113G " FIRE DEPT. TRAINING AREA" -----
----- SOIL GAS CONCENTRATIONS -----

SAMPLE NAME	METHANE PPBV	ETHANE PPBV	PROPANE PPBV	I-BUTANE PPBV	N-BUTANE PPBV	ETHYLENE PPBV	PROPYLENE PPBV	SAMPLE NAME
904-113G-1	4521	310	135	97	56	223	243	904-113G-1
904-113G-2	1162	113	45	29	11	84	96	904-113G-2
904-113G-3	212950	370	146	137	72	474	440	904-113G-3
904-113G-4	1878	90	36	34	<5	64	68	904-113G-4
904-113G-5	715	45	19	31	<5	36	45	904-113G-5
904-113G-6	2482	75	30	23	<5	67	96	904-113G-6
904-113G-7	345324	136	[illegible]	30	28	133	208	904-113G-7
904-113G-8	10908	425	[illegible]	199	65	342	336	904-113G-8
904-113G-9	8451	239	[illegible]6	25	<5	184	169	904-113G-9
904-113G-10	4143	1001	37	60	<5	93	93	904-113G-10
904-113G-10A	3203	164	[illegible]7	70	<5	131	149	904-113G-10A
904-113G-11	3575	2[illegible]8	107	79	31	177	202	904-113G-11
904-113G-12	624	39	12	345	<5	31	43	904-113G-12
904-113G-13	855	29	20	8	<5	22	26	904-113G-13
904-113G-14	593	62	23	15	<5	44	85	904-113G-14
904-113G-15	3899	151	55	105	20	118	127	904-113G-15
904-113G-16	5903	231	84	102	30	146	198	904-113G-16
904-113G-17	6366	220	74	108	19	179	164	904-113G-17
904-113G-18	1235	86	38	68	<5	65	113	904-113G-18
904-113G-19	3424	230	104	33	20	187	181	904-113G-19
904-113G-20	1596	115	72	47	47	70	76	904-113G-20
904-113G-20A	1012	79	51	22	<5	54	70	904-113G-20A
904-113G"SB1	3157	9	7	<5	<5	<5	<5	904-113G"SB1
904-113G"SB2	3173	5	6	<5	<5	<5	<5	904-113G"SB2
904-113G"SB3	3101	7	<5	<5	<5	<5	<5	904-113G"SB3

05-Jun-92

S04-113G FIRE DEPT. HTF
SITE LOCATION MAP



----- SAVANNAH RIVER SITE -----
----- 904-113G " FIRE DEPT. TRAINING : EA" -----
----- SOIL GAS CONCENTRATIONS (PPHV) -----

SAMPLE NAME	PENTANE	HEXANE	HEPTANE	BENZENE	OCTANE	TOLUENE	NONANE	ETHYL BENZENE	M&P-XYLENE	O-XYLENE	DECANE
904-113G-1	0.21	0.08	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-2	0.13	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-3	0.24	0.08	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-4	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-5	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-6	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-7	0.07	<.07	0.11	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-8	0.14	<.07	<.07	<.07	0.08	<.07	<.07	<.07	0.10	0.10	<.07
904-113G-9	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-10	0.11	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-10A	0.09	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-11	0.15	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-12	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-13	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-14	0.08	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-15	0.10	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-16	0.10	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-17	0.09	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-18	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-19	0.16	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-20	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G-20A	<.07	.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G*SB1	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G*SB2	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
904-113G*SB3	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07	<.07
								<.07	<.07	<.07	<.07

MICROSEEPS

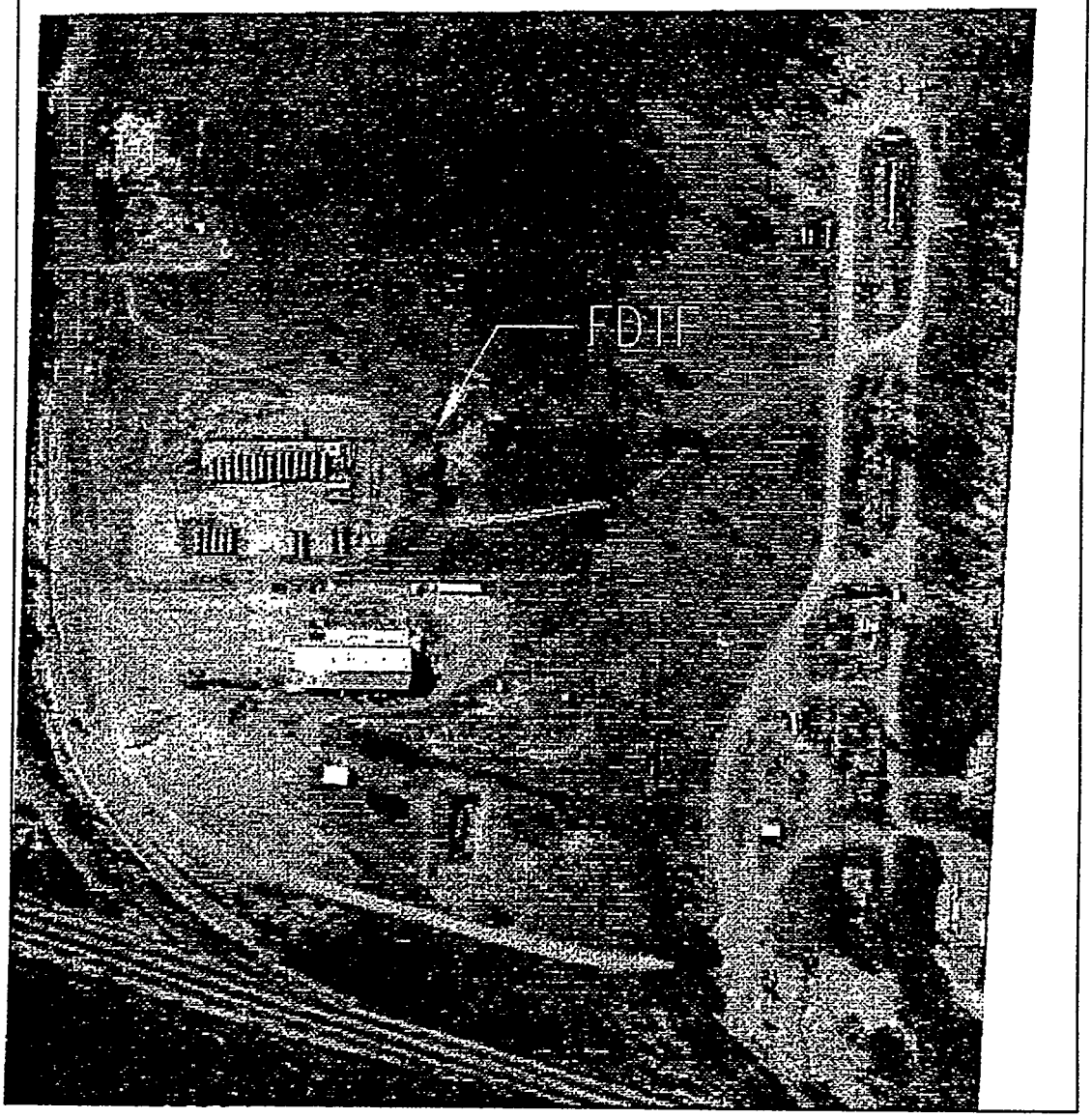
----- SAVANNAH RIVER SITE -----
----- 904-113G "FIRE DEPT. TRAINING AREA" -----
----- SOIL GAS CONCENTRATIONS (PPMV) -----

SAMPLE NAME	VINYL CHLORIDE	METHYLENE CHLORIDE	TRANS 1,2 DICHLORO ETHYLENE	CHLORO FORM	111 TRI CHLORO ETHANE	CARBON TETRA CHLORIDE	TRI CHLORO ETHYLENE	TETRA CHLORO ETHYLENE	FILE #
904-113G-1	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 155
904-113G-2	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 156
904-113G-3	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 157
904-113G-4	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 158
904-113G-5	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 159
904-113G-6	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 160
904-113G-7	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 161
904-113G-8	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 162
904-113G-9	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 163
904-113G-10	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 164
904-113G-10A	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 165
904-113G-11	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 168
904-113G-12	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 169
904-113G-13	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 170
904-113G-14	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 171
904-113G-15	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 172
904-113G-16	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 173
904-113G-17	<3	<2	<.10	<.005	<.005	<.005	<.005	0.015	W20 174
904-113G-18	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 175
904-113G-19	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 176
904-113G-20	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 177
904-113G-20A	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 178
904-113G-SB1	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 153
904-113G-SB2	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 166
904-113G-SB3	<3	<2	<.10	<.005	<.005	<.005	<.005	<.005	W20 179

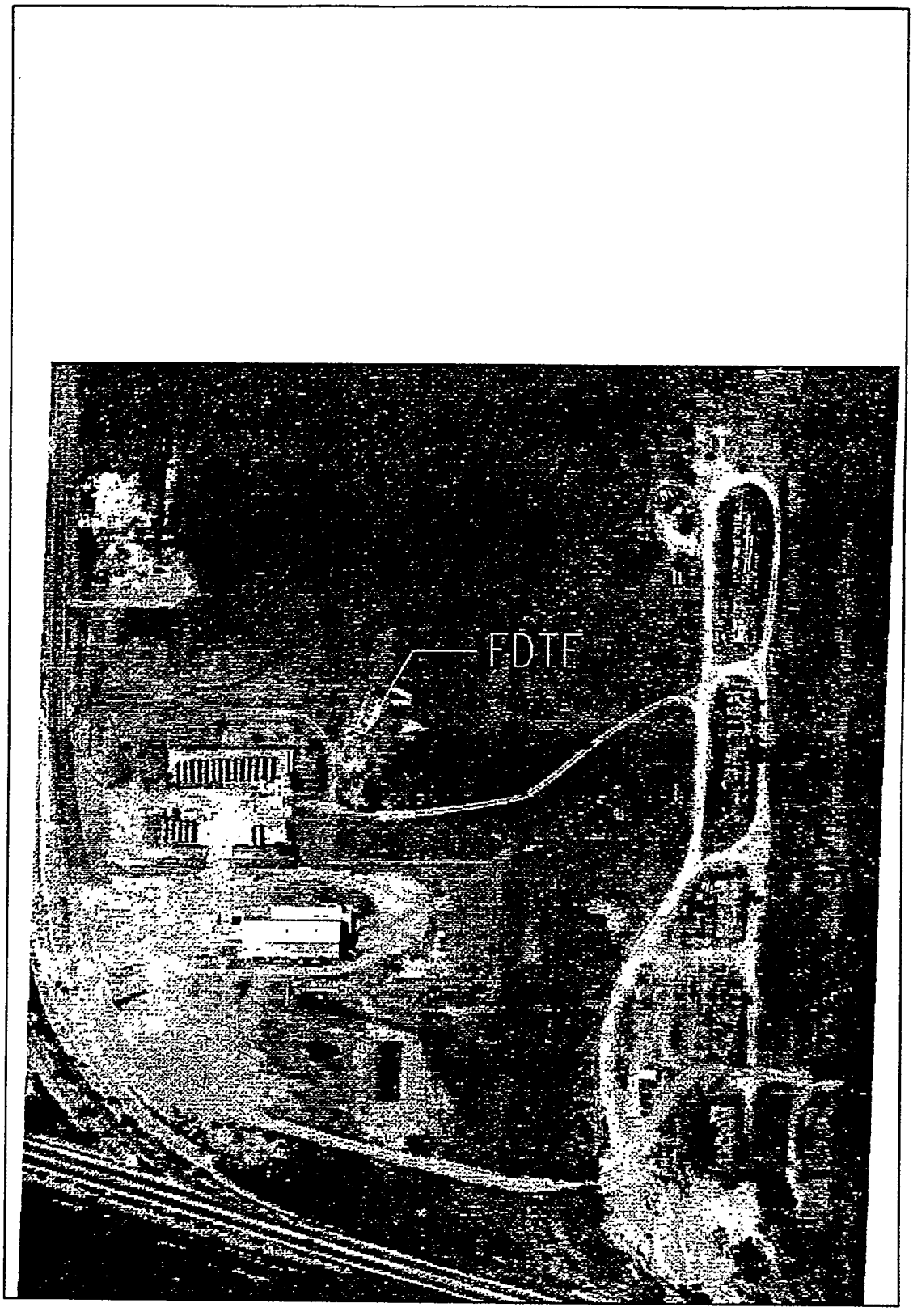
12-May-92

APPENDIX A-4

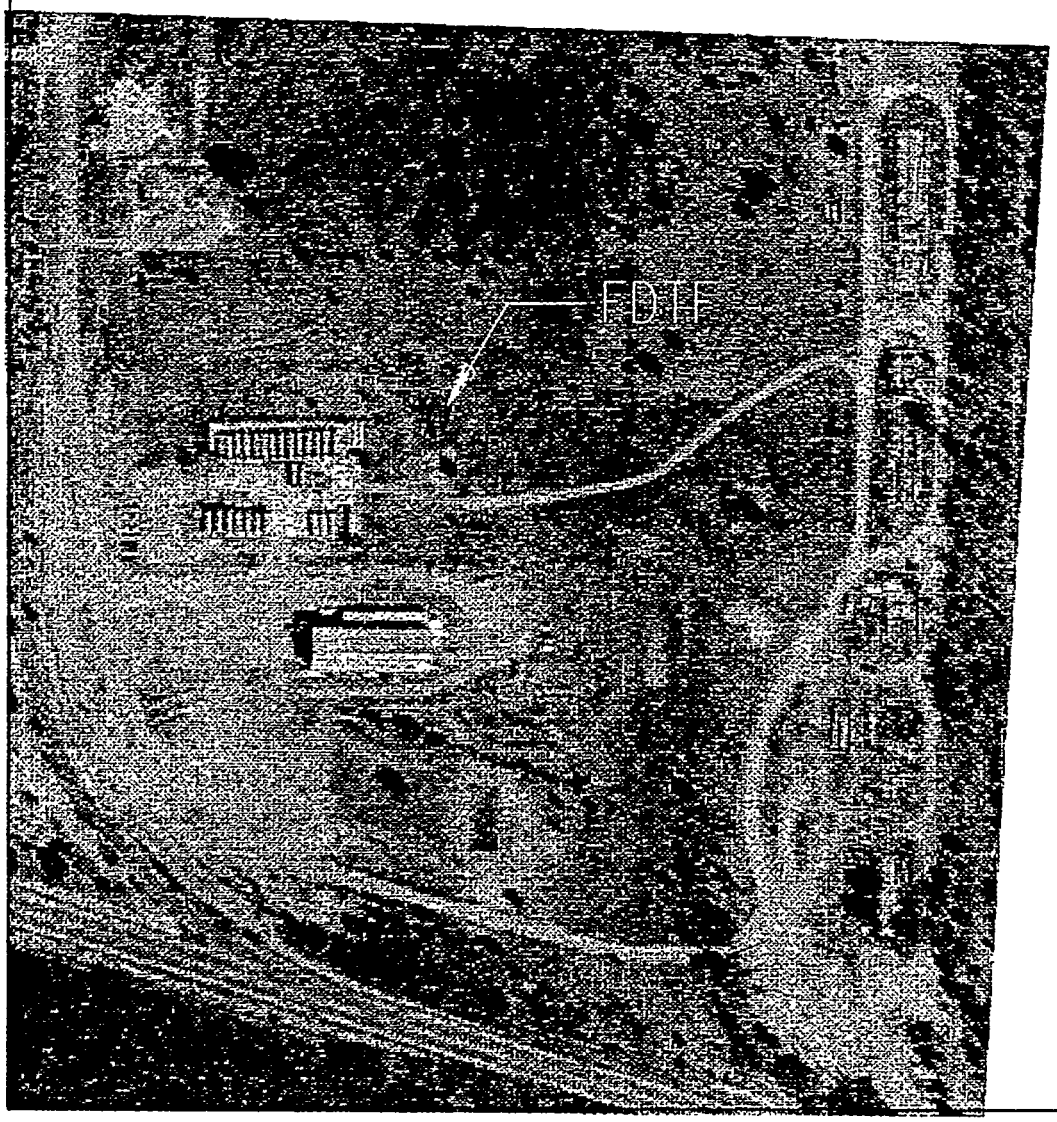
DATA QUALITY OBJECTIVES



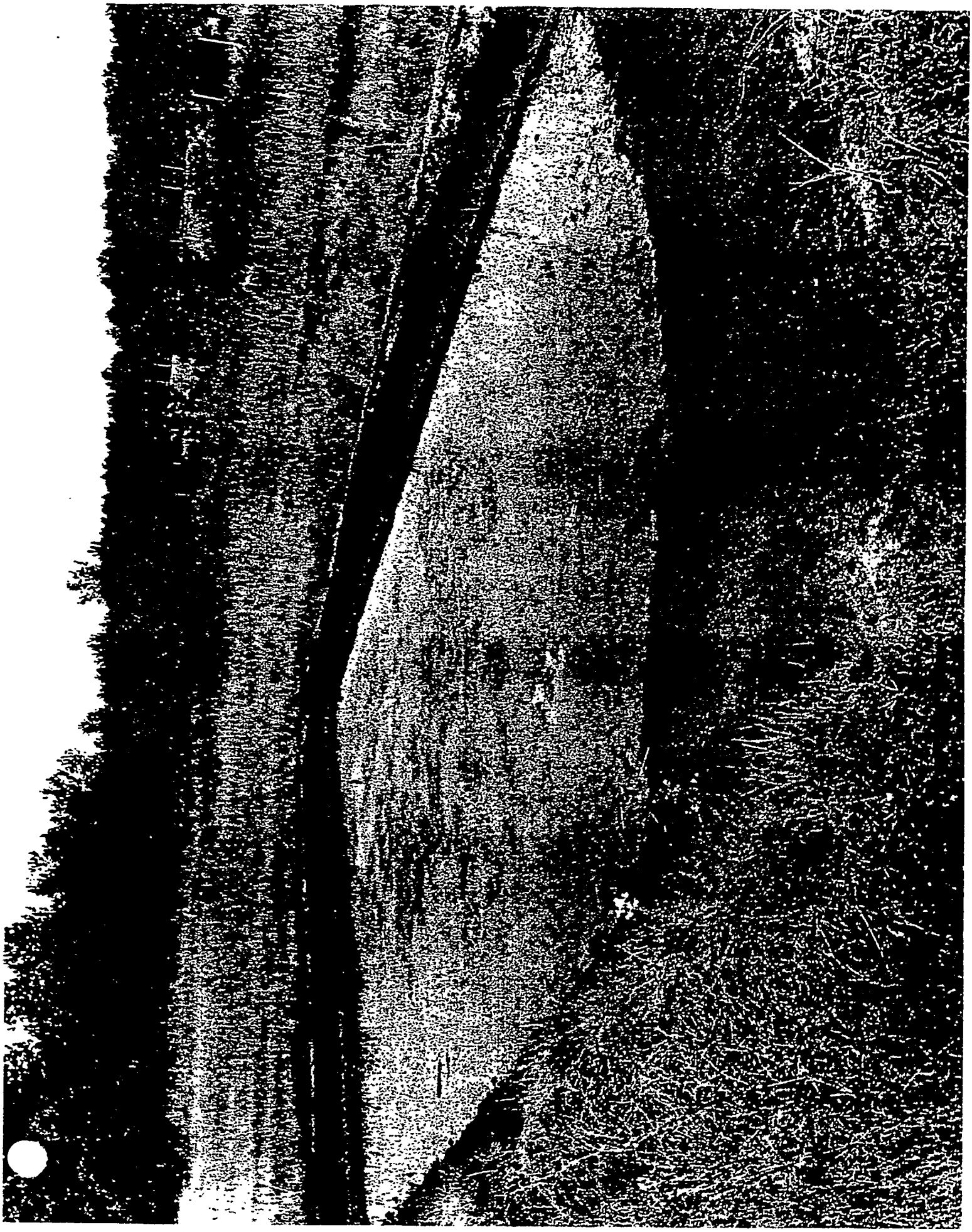
AERIAL PHOTOGRAPH, EG&G, 4997-107, 05-19-1985



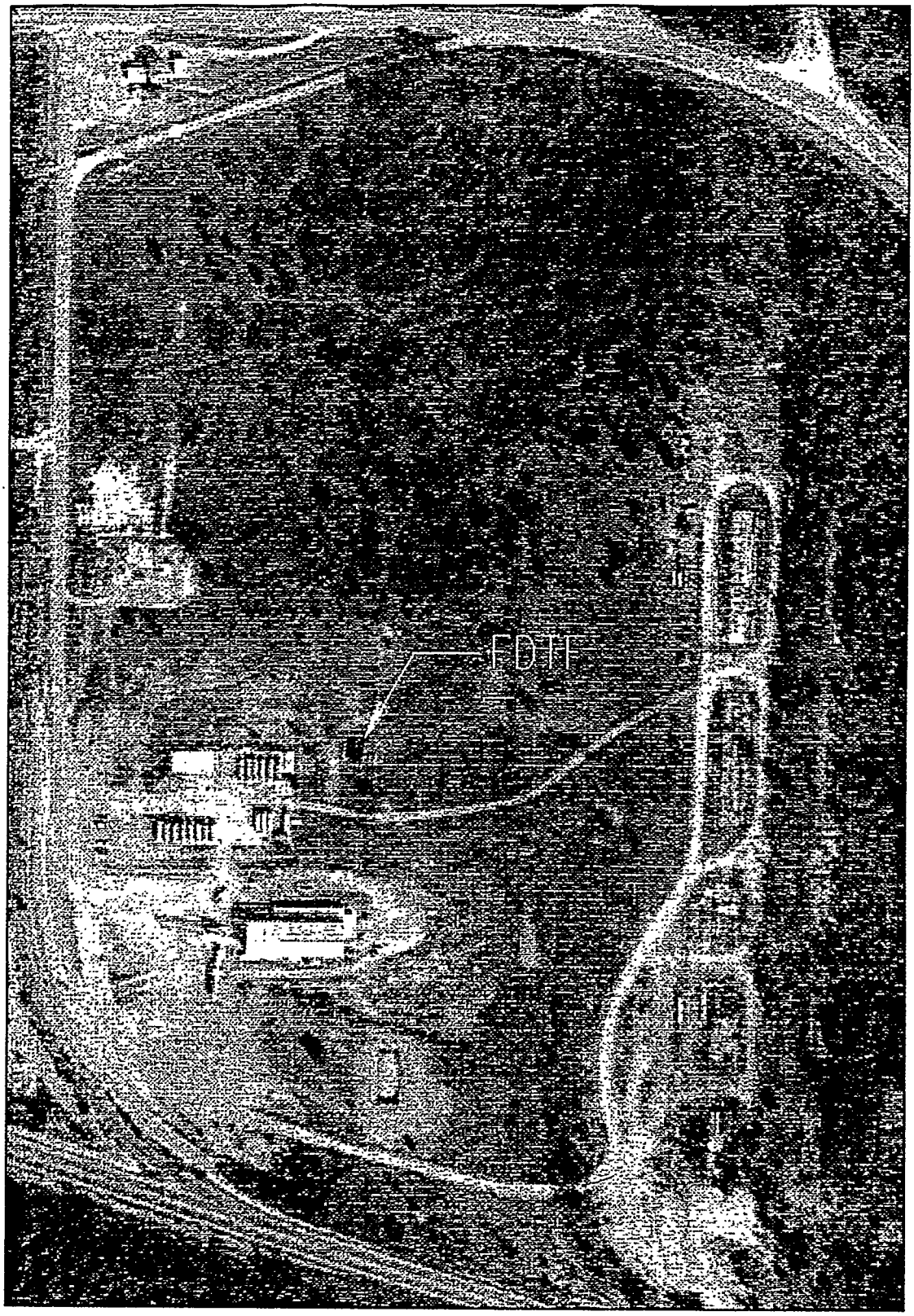
AERIAL PHOTOGRAPH, EG&G, 4736-084, 06-09-1984



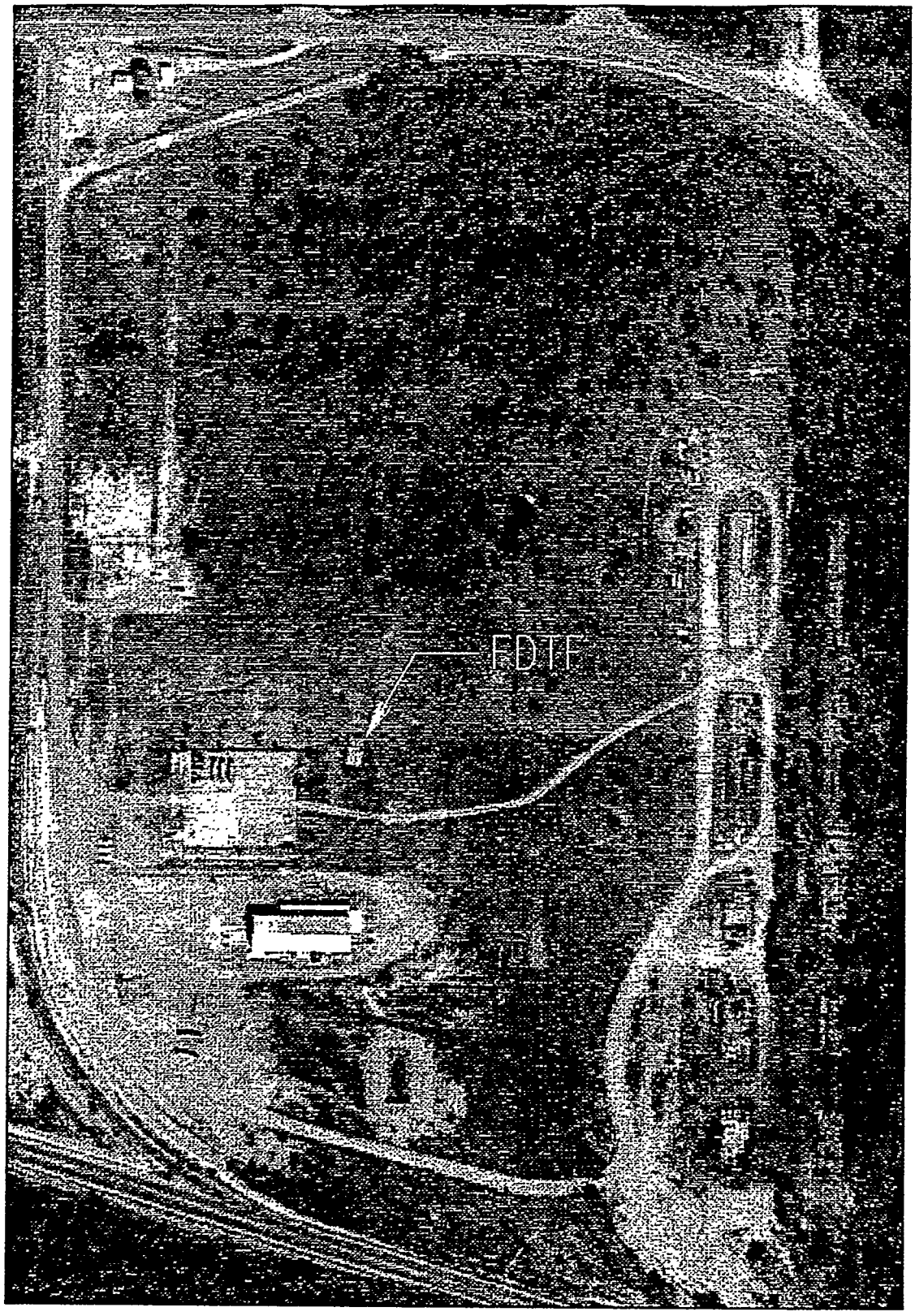
AERIAL PHOTOGRAPH, EG&G, 4375-138, 07-29-1983



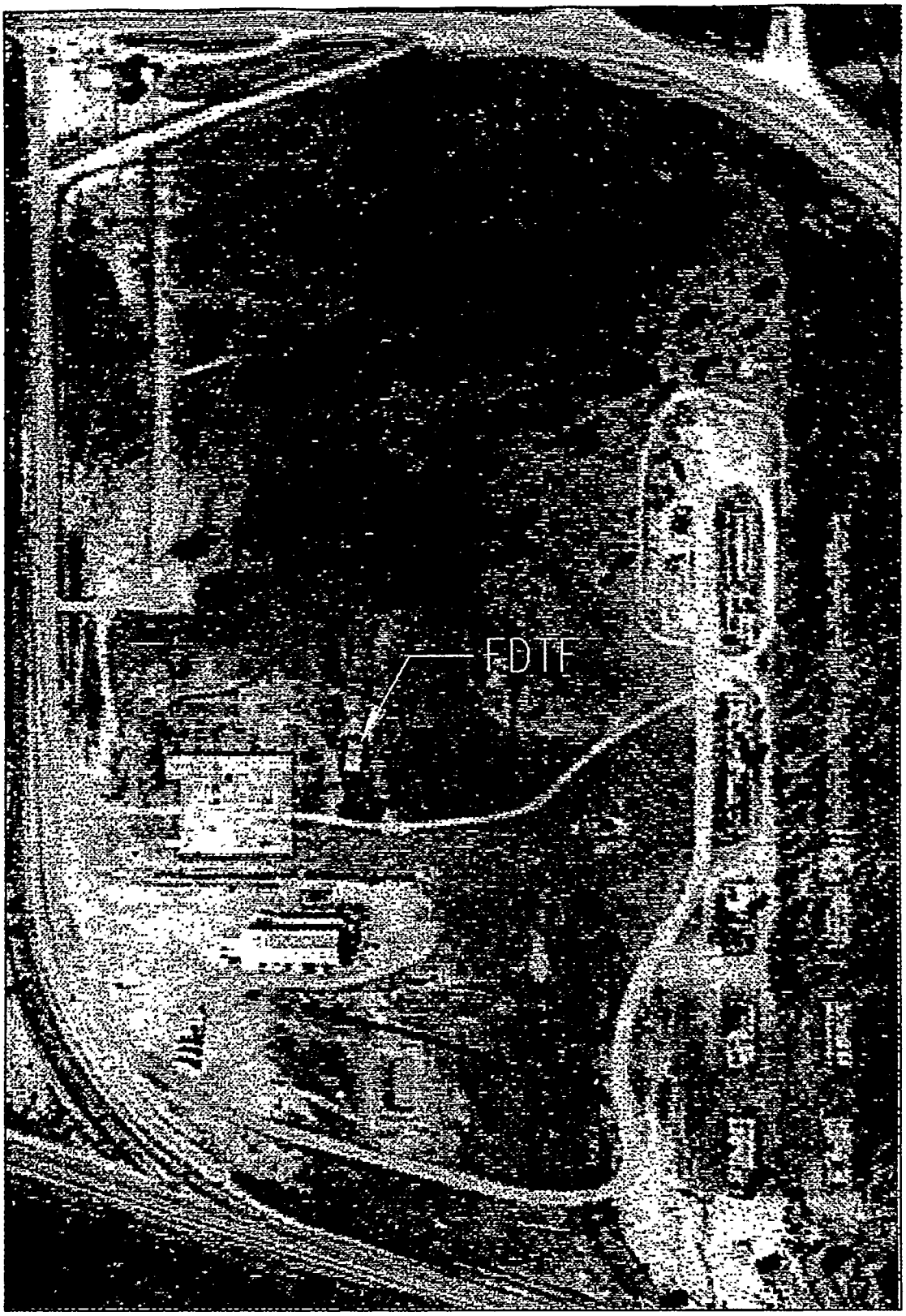
Fire Department Hose Training Facility; Photograph 35199-28 taken on 11/16/82.



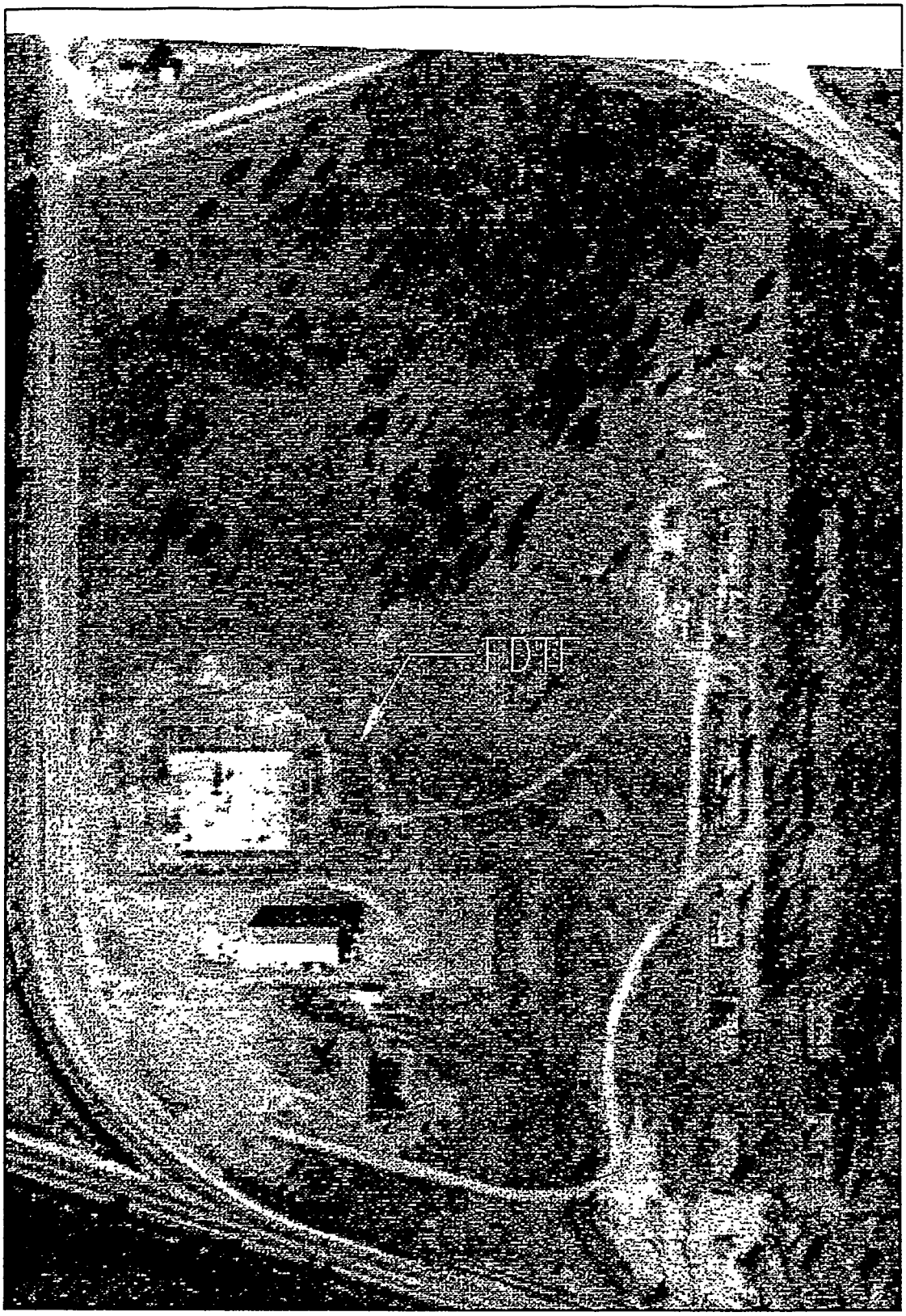
AERIAL PHOTOGRAPH, EG&G, 4126-078, 08-26-1982



AERIAL PHOTOGRAPH, EG&G, 3388-050, 09-02-1980



AERIAL PHOTOGRAPH, SRP SC, F16, 279-21, 03-07-1979



AERIAL PHOTOGRAPH, EG&G, 892-015,12-11-1975



Fire Department Hose Training Facility; Aerial Photograph, AEC, FS2-181, 2-13-74

DSR 3-4A

DUPONT

INTER-OFFICE MEMORANDUM

SAVANNAH RIVER PLANT

December 5, 1984

TO: M. B. HUGHES, 703-A
CHAIRMAN, WASTE SITE CLOSURE TASK FORCE

FROM: P. F. BECK, 709-4A
LIAISON, FIRE PROTECTION

FIRE PROTECTION'S ABANDONED HOSE TRAINING FACILITY

Prior to the waste site closure meeting on July 13, 1984 we had discussed the Fire Protection's abandoned hose training facility, 904-113G, near the Ford Building. In our discussion you said that the facility would be treated as a "spill" and would only need DEHEC's approval for us to have T & T excavate the small area, haul the spoil to the sanitary landfill and backfill with clean dirt.

Would you check with DEHEC and see if they have approved our plan. If so, I will issue a MIAC to T & T to proceed.

PFB:rs
Att

CC: R. B. Jewell, 742-A

OSR 3-4A

DUPONT

INTER-OFFICE MEMORANDUM

SAVANNAH RIVER PLANT

October 17, 1985

TO: M. B. HUGHES, 703-A
CHAIRMAN, WASTE SITE CLOSURE TASK FORCE

FROM: K. E. KEATON, 709-4A
SAFETY AND FIRE PROTECTION

FIRE DEPARTMENT HOSE TRAINING FACILITY 904-113G

As a Waste Site Closure Plan this memo would list proposed clean-up and closure recommendations, however in writing the closure plan for 904-1136 it was noted that clean up and closure was requested by the Fire Division in March of 1982, and then T & T Department completed the following:

- Removal of all oil contaminated soil, approximate size 20'x20'x3';
- Clean soil was backfilled;
- Disposal of oil contaminated soil at burial ground.

Inspections during April, July and September 1985 revealed that vegetation had recovered and the appearance of the training area was similar to that of the surrounding area with the exception of an area in size 3'x3'x2". This area has been dumped on illegally. The clean up for this 3'x3'x2" area was the same as the 1982 clean-up procedure.

Documentation concerning clean up is limited to:

- MIAC #BG 676 IDP #66390506 11/21/82
- T & T Log Book Entry: 11/21/82 14 loads of oil-contaminated soil were excavated and sent to burial ground.

KEK:rs

WESTINGHOUSE SAVANNAH RIVER COMPANY

INTEROFFICE MEMORANDUM

PROJECTS ENGINEERING AND CONSTRUCTION DIVISION
SITE GEOTECHNICAL SERVICES DEPARTMENT

PE&CD-SGS-97-0089

April 15, 1997

TO: Sharon Fraley

FROM: Stephen Knüttel

RE: Fire Department Hose Training Facility (FDTF) (#904-113G) - Update on Document Search

The following is a rewrite of my November 15, 1996 interoffice memorandum which includes new information obtained from aerial photographs received on March 6, 1997.

A document search was conducted to locate information concerning clean up activities and disposal of materials at the Fire Department Hose Training Facility (Building #904-113G). Documentation of clean up activities are limited due to the dates of clean up (1982 - 1984) and the subsequent removal of the facility from the SRS database.

From the available information, the following history of the unit can be made:

> The FDTF was build between 1975 and March 1979 and operated by the SRS Fire Department between 1979 and 1982 to train personnel in fighting waste oil fires. The training facility consisted of an approximately 6 x 12 m (20 x 40 ft) unlined shallow pit surrounded by an approximately 0.5 m (1.5 ft) high asphalt dike. Training exercises typically included pouring burnable oil into the unit, igniting it, and then having the fire department extinguish the fire. No known hazardous wastes were placed in the unit.
>
> The SRS Fire Department discontinued uses of the FDTF and recommended the facility for clean up and closure in March of 1982. Available documentation indicates that clean up activities occurred on 11/21/82 and that 14 loads of oil-contaminated soil were excavated from an approximately 6 x 6 x 1 M (20 x 20 x 3 ft) area and sent to the sanitary landfill. However, the date of this clean up activity could not be verified since an aerial photograph from 1983 shows the FDTF still present. An additional aerial photograph from June 1984 shows the FDTF pit has been removed and the area excavated. The excavated area is approximately 10-12 M (30-40 ft) wide by 15-18 M (50-60 ft) long and the pit dikes and visible contaminated soils are removed. An additional 3 x 5 M (10-15 ft) wide by 10-12 M (30-40 ft) long area is visible on the north side of the main excavation which either an additional remediated area, a pile of the excavated material, or material intended for backfill. The photographs indicate that either existing documentation is incorrect (11/21/82 is actually 11/21/83) or that a subsequent more extensive excavation took place between July of 1983 and June of 1984. Subsequent inspections during 1985 indicated that an additional approximately 1 x 1 M (3 x 3 ft) area of visibly contaminated soil was present, possibly from illegal dumping or a spill. This area was also excavated to a depth of approximately 0.5 M (2 ft) and the soil removed from the site similar to the 1982/84 clean up activities.

The existing documents, verbal information, pictures, and aerial photographic information concerning the FDTF are discussed below.

OSR 3-4A

DUPONT

INTER-OFFICE MEMORANDUM

SAVANNAH RIVER PLANT

July 16, 1984

TO: M. B. HUGHES, 703-A

FROM: P. F. BECK, 709-4A P F Beck/RBJ

FIRE PROTECTION DIVISION HOSE TRAINING FACILITY 904-113G

This pit was used as a hose training site from 1979 to February 1983 when it was abandoned. It is approximately 20 feet by 40 feet with one-foot dikes on all sides and has oil-saturated soil about three inches deep in the bottom. Our plans for cleanup are listed below.

1. The pit dikes or walls and one foot of soil on the floor will be removed and sent to the Plant Sanitary Landfill by T & T Department.

2. Sufficient clean topsoil will be hauled in to refill and level the pit, again by T & T Department.

If you feel that DEHEC-Aiken would like to inspect the pit before, during or after the job, please call me on X1897, and I will arrange for badge and escort.

PFB:rs

CC: J. C. Morris, 703-A
P. E. McBeath, 703-2A
R. B. Jewell, 742-A

APPENDIX A-5

GROUNDWATER MONITORING DATA

FD1
DQO WORKSHEET
PATHWAY

Pathway Media	Probable Conditions	Exposure Pathway and/or Release Mechanisms	Data Needs and DQOs Including Engineering/Physical Processes	Sampling and Field Activities Including Removal and Characterization	Parameters	Potential Remedial Action Alternatives
Groundwater	Not impacted.	Infiltration	Empirical soil data to predict leaching potential.	Soil samples. Cone Penetrometer Testing. Evaluate pre-existing soil data for Central Shops Area soil samples collected to determine unit specific contaminants.	Gamma spectroscopy (PHA) radionuclides, gross alpha, non volatile beta, speciation when required. TCL/TAL with TICs. Pore pressure, tip and sleeve resistance.	No further action. RFI/RI/Focused BRA Report.

FD1F

DQO WORKSHEET
SECONDARY SOURCE MEDIA
(0 TO 4 FEET)

Secondary Source Media	Probable Conditions	Exposure Pathways and/or Release Mechanism	Data Needs and DQOs Including Engineering/Physical Processes	Sampling and Field Activities Including Removal and Characterization	Parameters	Potential Remedial Action Alternatives
Contaminated Soil 0-4 ft	Natural processes, such as infiltration, wind erosion, surface water runoff, and bioturbation, may be dispersing contaminants.	Potential exposure pathways for 0-1 ft are incidental ingestion of contaminated soil, dermal contact, inhalation, and potential uptake by biota. For 1-4 ft zone, exposure is driven by future excavation scenario. Potential leaching to groundwater could occur over time.	Determine the nature and extent/ fate and transport of contamination at the 0-4 ft interval. Definitive data for risk assessment needs. Leaching potential with empirical data and/or EPA SSL guidance. Physical parameters for leachability evaluation. Verification that contaminated material was removed.	0-4 ft Soil samples. Cone Penetrometer Testing. Evaluate pre-existing soil data for Central Shops Area. (PHASE I)	Gamma spectroscopy (PHA) radionuclides, gross alpha, non volatile beta, speciation when required. TCL/TAL with TICs. Pore pressure, tip and sleeve resistance. (PHASE I)	No further action. RFI/RI/Focused BRA Report. (PHASE I)

FDTF
DQO WORKSHEET
SECONDARY SOURCE MEDIA
(> 4 FEET)

Secondary Source Media	Probable Conditions	Exposure Pathways and/or Release Mechanism	Data Needs and DQOs Including Engineering/Physical Processes	Sampling and Field Activities Including Removal and Characterization	Parameters	Potential Remedial Action Alternatives
Soils > 4.	Potential impact from mobilization of contaminants	Potential threat of leaching to groundwater of contaminants causing exposure to future residents through groundwater ingestion.	Determine the nature and extent/ fate and transport of contamination at the 0-4 ft interval. Leaching potential with empirical data and/or EPA SSL guidance. Physical parameters for leachability evaluation. Verification that contaminated material was removed.	>4 ft Soil samples. Cone Penetrometer Testing. Evaluate pre-existing soil data for Central Shops Aren soil samples collected to determine unit specific contaminants. (PHASE I)	Gamma spectroscopy (PHA) radionuclides, gross alpha, non volatile beta, speciation when required. TCL/TAL with TICs. Pore pressure, tip and sleeve resistance. (PHASE I)	No further action. RFI/RI/Focused BRA Report. (PHASE I)

FDTF

DQO WORKSHEET
PRIMARY SOURCE MATERIAL

Primary Source Material	Probable Conditions	Exposure Pathway and/or Release Mechanisms	Data Needs and DQOs Including Engineering/Physical Processes	Field Activities Including Removal and Characterization	Parameters	Potential Remedial Action Alternatives
Oil in the FDTF	The primary sources at the FDTF have been removed, and the unit backfilled to level conditions with clean fill.	N/A	N/A	N/A	N/A	N/A

FDTF
DQO WORKSHEET
SECONDARY SOURCE MEDIA
(0 TO 1 FOOT)

Secondary Source Media	Probable Conditions	Exposure Pathways and/or Release Mechanism	Data Needs and DQOs Including Engineering/Physical Processes	Sampling and Field Activities Including Removal and Characterization	Parameters	Potential Remedial Action Alternatives
Soil 0-1 ft	Backfill material. Some bioturbation may have caused intermix of potential contamination from below 1 ft	Potential exposure pathways for 0-1 ft are incidental ingestion of contaminated soil, inhalation, dermal contact, and potential uptake by biota.	Determine the nature and extent/ fate and transport of contamination at the 0-1 ft interval. Definitive data for risk assessment needs. Verification that contaminated material was removed.	0-1 ft soil samples (PHASE I)	Gamma spectroscopy (PHA) radionuclides, gross alpha, non-volatile beta, speciation when required. TCL/TAL with TICs (PHASE I)	No further action. RFI/RI/Focused BRA Report. (PHASE I)

APPENDIX A-6

CONE PENETROMETER TESTING LOGS

2nd Quarter 1995

WELL CSO 1

MEASUREMENTS CONDUCTED IN THE FIELD

Sample date: 04/18/95
Depth to water: 46.74 ft (14.25 m) below TOC
Water elevation: 257.16 ft (78.38 m) msl
pH: 4.7
Sp. conductance: 28 µS/cm
Turbidity: 1 NTU
Water evacuated from the well prior to sampling: 80 gal

Time: 11:15
Water temperature: 20.2 °C
Air temperature: 26 °C
Alkalinity: 0 mg/L
Phenolphthalein alkalinity: 0 mg/L

LABORATORY ANALYSES

F	Analyte	Result	R	A	B	SQL	Unit	Lab	Method
0	Total petroleum hydrocarbons	<1,670				1,670	µg/L	GE	EPA418 1

The Savannah River Site's Groundwater Monitoring Program
Second Quarter 1995 (U)
ESH-EMS-950394

1st Quarter 1995

WELL CSO 1

MEASUREMENTS CONDUCTED IN THE FIELD

Sample date: 02/17/95
Depth to water: 59.41 ft (18.11 m) below TOC
Water elevation: 244.49 ft (74.52 m) msl
Sp. conductance: 26 µS/cm
Turbidity: 2 NTU
Water evacuated before sampling: 78 gal

Time: 14:58
pH: 5.0
Alkalinity: 0 mg/L
Water temperature: 19.6°C
Air temperature: 10.9°C

LABORATORY ANALYSES

F	Analyte	Result	Mod	Unit	Lab
1	Aluminum, total recoverable	33		µg/L	GE

WELL CSO 2

MEASUREMENTS CONDUCTED IN THE FIELD

Sample date: 02/17/95
Depth to water: 46.52 ft (14.18 m) below TOC
Water elevation: 255.38 ft (77.84 m) msl
Sp. conductance: 28 µS/cm
Turbidity: 1 NTU
Water evacuated before sampling: 115 gal

Time: 14:28
pH: 4.9
Alkalinity: 0 mg/L
Water temperature: 19.4°C
Air temperature: 11.9°C

LABORATORY ANALYSES

F	Analyte	Result	Mod	Unit	Lab
1	Aluminum, total recoverable	29		µg/L	GE

The Savannah River Site's Groundwater Monitoring Program
First Quarter 1995 (U)
ESH-EMS-950393

3rd Quarter 1994

WELL CSO 1

MEASUREMENTS CONDUCTED IN THE FIELD

Sample date: 06/29/94
Depth to water: 49.42 ft (15.06 m) below TOC
Water elevation: 254.48 ft (77.57 m) msl
Sp. conductance: 31 µS/cm
Turbidity: 1 NTU
Water evacuated before sampling: 76 gal

Time: 8:19
pH: 5.0
Alkalinity: 1 mg/L
Water temperature: 20.2°C
Air temperature: 22.6°C

LABORATORY ANALYSES

F	Analyte	Result	Mod	Unit	Lab
2	Aluminum, total recoverable	60	/Y	µg/L	WA

WELL CSO 2

MEASUREMENTS CONDUCTED IN THE FIELD

Sample date: 06/29/94
Depth to water: 47.37 ft (14.44 m) below TOC
Water elevation: 254.53 ft (77.58 m) msl
Sp. conductance: 32 µS/cm
Turbidity: 1 NTU
Water evacuated before sampling: 90 gal

Time: 7:36
pH: 4.8
Alkalinity: 0 mg/L
Water temperature: 20.0°C
Air temperature: 21.2°C

LABORATORY ANALYSES

F	Analyte	Result	Mod	Unit	Lab
1	Aluminum, total recoverable	40	/Y	µg/L	WA

The Savannah River Site's Groundwater Monitoring Program
Third Quarter 1994 (U)
ESH-EMS-940516

APPENDIX B

ANALYTICAL RESULTS SUMMARY

FIRE DEPARTMENT HOSE TRAINING FACILITY
BACKGROUND SAMPLES
ANALYSIS RESULTS SUMMARY

Sample Name		FBFDB0101	FBFDB0102	FBFDB0103	FBFDB0104	FBFDB0105
Station		FBFDB0101	FBFDB0102	FBFDB0103	FBFDB0104	FBFDB0105
Sample ID		107595	107597	107598	107599	107800
Date		35216	35216	35216	35216	35216
Depth (ft)		0 - 1	1 - 4	4 - 7	7 - 10	10 - 13
Analysis	Units					
Aluminum	mg/kg	1410	3120	6210	2150	3260
Antimony	mg/kg	<3.34	<2.82	0.807	<3.34	<3.27
Arsenic	mg/kg	0.821	1	6.3	0.603	1.3
Barium	mg/kg	9.5	20.8	8.2	2.1	1.7
Beryllium	mg/kg	0.0703	0.127	0.0645	0.0598	0.0576
Cadmium	mg/kg	0.0737	0.16	0.697	0.0897	0.176
Calcium	mg/kg	63.6	172	124	46.5	51.9
Chromium	mg/kg	2.7	4.6	22.6	9.1	12.8
Cobalt	mg/kg	0.244	0.487	<1.06	<1.04	<1.02
Copper	mg/kg	1	1.4	3.5	1.3	2.7
Cyanide	mg/kg	<0.88	<0.8	<0.92	<0.88	<0.89
Iron	mg/kg	1700	4030	19300	2700	4710
Lead	mg/kg	3.6	2.8	4.3	2	2.8
Magnesium	mg/kg	23.2	73.6	96.5	56.1	55.6
Manganese	mg/kg	47.9	29.3	1.9	1.4	1.5
Mercury	mg/kg	<0.154	0.038	0.083	<0.155	<0.157
Nickel	mg/kg	0.708	0.987	0.967	0.598	0.846
Potassium	mg/kg	32.3	53	60.3	23.5	23
Selenium	mg/kg	<12	<10.9	0.416	<12.1	<12.2
Sodium	mg/kg	12.8	13.8	17.3	10.2	12.7
Vanadium	mg/kg	4.3	9.1	68.2	56.9	102
Zinc	mg/kg	1.5	1.6	0.782	0.773	0.64
Di-n-octyl phthalate	ug/kg	ND	ND	<402	235	119
Phenol	ug/kg	ND	ND	<402	<387	<391
Actinium-228	pCi/g	0.72	1.18	1.44	1.27	1.75
Americium-241	pCi/g	ND	ND	0.64	0.52	0.45
Antimony-124	pCi/g	<-0.02	<0	ND	ND	ND
Antimony-125	pCi/g	ND	ND	<0.01	<0.04	<-0.02
Barium-133	pCi/g	ND	ND	<0.02	<0.03	0.07
Cesium-134	pCi/g	ND	ND	0.06	<0	<0.01
Cesium-137	pCi/g	<0.04	<0.01	ND	ND	ND
Cobalt-60	pCi/g	<-0.02	<0.01	ND	ND	ND
Europium-152	pCi/g	<-0.07	<0.02	<-0.21	<0.21	<-0.1
Europium-155	pCi/g	0.22	0.35	0.18	0.17	<0.55
Manganese-54	pCi/g	ND	ND	<0	<0.03	<0.01
Neptunium-239	pCi/g	ND	ND	<0.53	<0.5	<0.49
Plutonium-238	pCi/g	<0.84	<0.73	<0.99	<0.7	<0.81
Potassium-40	pCi/g	<0.63	1.36	1.15	0.94	0.98
Promethium-146	pCi/g	ND	ND	<-0.03	<0.01	<0.05

FIRE DEPARTMENT HOSE TRAINING FACILITY
BACKGROUND SAMPLES
ANALYSIS RESULTS SUMMARY

Sample Name		FBFDB0101	FBFDB0102	FBFDB0103	FBFDB0104	FBFDB0105
Station		FBFDB0101	FBFDB0102	FBFDB0103	FBFDB0104	FBFDB0105
Sample ID		107595	107597	107598	107599	107800
Date		35216	35216	35216	35216	35216
Depth (ft)		0 - 1	1 - 4	4 - 7	7 - 10	10 - 13
Analysis	Units					
Promethium-147	pCi/g	ND	ND	1.12	<0.13	<0.38
Radium-226	pCi/g	0.11	0.27	0.24	0.12	0.31
Radium-228	pCi/g	<1.52	<0.94	<1.22	<1.65	6.75
Ruthenium-106	pCi/g	ND	ND	<-0.35	<0.13	<0.14
Strontium-90	pCi/g	<0	<0	<0.02	<0	0.78
Technetium-99	pCi/g	<0.06	0.11	0.37	0.37	<0.07
Thorium-228	pCi/g	<0.48	1.16	1.53	1.59	1.85
Thorium-232	pCi/g	0.43	1.05	1.65	1.68	1.7
Thorium-234	pCi/g	<0.21	<0.06	<1.52	<0.65	<0.62
Tin-113	pCi/g	ND	ND	<-0.02	<0	<0.02
Uranium-235	pCi/g	<0.05	<0	0.14	<0.03	<0.05
Yttrium-88	pCi/g	<-0.01	<0.01	ND	ND	ND
Zinc-65	pCi/g	ND	ND	<-0.04	<0.06	<0

FIRE DEPARTMENT HOSE TRAINING FACILITY
BACKGROUND SAMPLES
ANALYSIS RESULTS SUMMARY

Sample Name		FBFDB0201	FBFDB0202	FBFDB0203	FBFDB0204	FBFDB0205
Station		FBFDB0201	FBFDB0202	FBFDB0203	FBFDB0204	FBFDB0205
Sample ID		107582	107583	107584	107585	107586
Date		35214	35214	35214	35214	35214
Depth (ft)		0 - 1	1 - 4	4 - 7	7 - 10	10 - 13
Analysis	Units					
Aluminum	mg/kg	9900	6670	5990	2690	2040
Antimony	mg/kg	0.798	0.445	0.612	<4.15	<4.05
Arsenic	mg/kg	6.9	3.1	3.6	<13.2	<12.8
Barium	mg/kg	11.6	20.1	7.9	3.7	3.1
Beryllium	mg/kg	0.0709	0.109	<0.352	<0.356	<0.347
Cadmium	mg/kg	0.312	<0.155	<0.164	<0.474	<0.0833
Calcium	mg/kg	169	196	53.8	55.6	54.2
Chromium	mg/kg	27	12	13.4	2.1	.2
Cobalt	mg/kg	0.568	0.756	<0.266	<0.209	<0.178
Copper	mg/kg	17.3	3.5	5	<1.9	<2
Cyanide	mg/kg	0.147	0.144	0.185	<0.9	0.146
Iron	mg/kg	22700	11100	13200	635	2660
Lead	mg/kg	9	5.6	5.7	2.4	3.5
Magnesium	mg/kg	75.5	112	62.3	55.2	57
Manganese	mg/kg	16	11.6	0.972	0.313	0.979
Mercury	mg/kg	0.03	0.038	0.03	0.03	0.02
Nickel	mg/kg	1.5	1.6	0.86	0.333	0.484
Potassium	mg/kg	84.2	101	71.3	39.2	39.1
Selenium	mg/kg	<12.1	<11.9	<12.2	<12.3	<12
Sodium	mg/kg	79	60.1	52.8	45.8	72.2
Vanadium	mg/kg	59.3	27.4	38.8	8	9.9
Zinc	mg/kg	7.9	3.4	5.8	4.1	<18.6
Di-n-octyl phthalate	ug/kg	ND	ND	241	194	<386
Phenol	ug/kg	ND	ND	<391	<395	<386
Actinium-228	pCi/g	1.53	1.37	1.46	1.58	1.22
Americium-241	pCi/g	ND	ND	<1.09	<1.17	<0.67
Antimony-124	pCi/g	0.06	<0.01	ND	ND	ND
Antimony-125	pCi/g	ND	ND	<-0.02	<0.08	<0.01
Barium-133	pCi/g	ND	ND	<0.02	<0.02	<0.03
Cesium-134	pCi/g	ND	ND	<-0.02	<0	<0
Cesium-137	pCi/g	0.19	<-0.02	ND	ND	ND
Cobalt-60	pCi/g	<0.01	0.06	ND	ND	ND
Europium-152	pCi/g	<0.06	<-0.22	0.3	<0.01	0.3
Europium-155	pCi/g	0.41	0.74	<0.17	0.22	0.34
Manganese-54	pCi/g	ND	ND	0.06	0.06	<0.03
Neptunium-239	pCi/g	ND	ND	<0.33	<0.33	<-0.01
Plutonium-238	pCi/g	0.32	0.14	0.31	<0.14	0.28
Potassium-40	pCi/g	0.91	2.2	1.07	2.78	1.33
Promethium-146	pCi/g	ND	ND	<-0.02	<-0.04	<0.01

FIRE DEPARTMENT HOSE TRAINING FACILITY
BACKGROUND SAMPLES
ANALYSIS RESULTS SUMMARY

Sample Name		FBFDB0201	FBFDB0202	FBFDB0203	FBFDB0204	FBFDB0205
Station		FBFDB0201	FBFDB0202	FBFDB0203	FBFDB0204	FBFDB0205
Sample ID		107582	107583	107584	107585	107586
Date		35214	35214	35214	35214	35214
Depth (ft)		0 - 1	1 - 4	4 - 7	7 - 10	10 - 13
Analysis	Units					
Promethium-147	pCi/g	ND	ND	<-0.81	<-0.14	<-0.1
Radium-226	pCi/g	0.33	0.38	0.3	0.29	0.28
Radium-228	pCi/g	2.21	1.28	1.98	<1.02	3.65
Ruthenium-106	pCi/g	ND	ND	<0.06	<-0.21	<0.11
Strontium-90	pCi/g	<0.19	<0	<0.05	<0	<0.11
Technetium-99	pCi/g	0.28	0.11	0.16	0.09	0.1
Thorium-228	pCi/g	1.57	1.41	1.76	1.51	1.65
Thorium-232	pCi/g	1.54	1.43	1.38	1.51	1.11
Thorium-234	pCi/g	<1.18	<1.3	<-1.48	<0.94	<1.36
Tin-113	pCi/g	ND	ND	<0.03	<0.01	0.08
Uranium-235	pCi/g	<0.11	<0.06	<0	<0.1	<0.08
Yttrium-88	pCi/g	<0	0.05	ND	ND	ND
Zinc-65	pCi/g	ND	ND	<-0.01	<0	<-0.06

FIRE DEPARTMENT HOSE TRAINING FACILITY
BACKGROUND SAMPLES
ANALYSIS RESULTS SUMMARY

Sample Name		FBFDB0301	FBFDB0302	FBFDB0303	FBFDB0304	FBFDB0305
Station		FBFDB0301	FBFDB0302	FBFDB0303	FBFDB0304	FBFDB0305
Sample ID		107588	107589	107590	107591	107592
Date		35215	35215	35215	35215	35215
Depth (ft)		0 - 1	1 - 4	4 - 7	7 - 10	10 - 13
Analysis	Units					
Aluminum	mg/kg	8230	9540	5680	3670	3790
Antimony	mg/kg	<3.79	<3.84	0.66	0.564	<3.92
Arsenic	mg/kg	2	3	4.4	3.7	1.5
Barium	mg/kg	26.6	12.3	5.7	4.4	2.7
Beryllium	mg/kg	0.204	0.0954	0.05	0.04	0.0593
Cadmium	mg/kg	0.225	0.486	0.586	1.2	0.308
Calcium	mg/kg	219	151	38.8	84.5	52.6
Chromium	mg/kg	8.6	15.2	18.3	20	5.4
Cobalt	mg/kg	0.749	0.441	0.122	<0.895	0.168
Copper	mg/kg	2.8	3.5	2.8	2.3	2.4
Cyanide	mg/kg	0.11	<0.86	0.12	<0.91	<0.88
Iron	mg/kg	6810	12200	14800	28100	7980
Lead	mg/kg	5.3	4.7	3.9	6.7	3.8
Magnesium	mg/kg	144	114	40.1	69.8	64.1
Manganese	mg/kg	17.7	8.3	2.5	2.7	1.8
Mercury	mg/kg	0.094	0.055	0.02	0.02	<0.154
Nickel	mg/kg	2.9	2.1	1.1	0.57	0.643
Potassium	mg/kg	118	104	45.7	49.5	39.5
Selenium	mg/kg	<11.3	<11.4	<12.4	<11.6	<11.6
Sodium	mg/kg	<140	15.9	<154	<144	<144
Vanadium	mg/kg	15.3	31.1	63.5	96.4	30.9
Zinc	mg/kg	5.2	2.9	<19.2	<18	<18
Di-n-octyl phthalate	ug/kg	ND	ND	210	151	425
Phenol	ug/kg	ND	ND	<398	<399	<384
Actinium-228	pCi/g	1.13	1.52	1.43	1.25	1.22
Americium-241	pCi/g	ND	ND	0.69	1.12	1.63
Antimony-124	pCi/g	<0.01	<-0.01	ND	ND	ND
Antimony-125	pCi/g	ND	ND	<0.04	<-0.03	<-0.03
Barium-133	pCi/g	ND	ND	<0.03	<0	<0.02
Cesium-134	pCi/g	ND	ND	<-0.02	<0	<-0.02
Cesium-137	pCi/g	<0.02	<0	ND	ND	ND
Cobalt-60	pCi/g	<0	<0.01	ND	ND	ND
Europium-152	pCi/g	<0.11	<-0.13	<-0.01	<-0.08	0.32
Europium-155	pCi/g	0.18	0.5	0.34	<0.18	0.36
Manganese-54	pCi/g	ND	ND	<-0.01	<0.01	<0
Neptunium-239	pCi/g	ND	ND	<0.16	<0.66	<0.89
Plutonium-238	pCi/g	<0.62	<0.57	<0.56	<0.59	<0.57
Potassium-40	pCi/g	1.6	0.58	1	2.86	1.75
Promethium-146	pCi/g	ND	ND	<0.03	<0.01	<0.02

FIRE DEPARTMENT HOSE TRAINING FACILITY
BACKGROUND SAMPLES
ANALYSIS RESULTS SUMMARY

Sample Name		FBFDB0301	FBFDB0302	FBFDB0303	FBFDB0304	FBFDB0305
Station		FBFDB0301	FBFDB0302	FBFDB0303	FBFDB0304	FBFDB0305
Sample ID		107588	107589	107590	107591	107592
Date		35215	35215	35215	35215	35215
Depth (ft)		0 - 1	1 - 4	4 - 7	7 - 10	10 - 13
Analysis	Units					
Promethium-147	pCi/g	ND	ND	<-0.15	<-0.52	<-0.53
Radium-226	pCi/g	<0.13	<0.29	<0.25	<0.19	<0.22
Radium-228	pCi/g	1.16	0.77	2.68	0.76	1.15
Ruthenium-106	pCi/g	ND	ND	<0.13	<-0.06	2.1
Strontium-90	pCi/g	<0.26	0.47	<0	<0	<0
Technetium-99	pCi/g	0.15	0.09	0.12	0.1	0.1
Thorium-228	pCi/g	1.3	1.42	1.31	1.67	1.21
Thorium-232	pCi/g	0.93	1.08	1.66	0.93	1.44
Thorium-234	pCi/g	1.95	<1.63	<0.91	<-0.07	<-0.01
Tin-113	pCi/g	ND	ND	<0.01	<0	<0.01
Uranium-235	pCi/g	<0.02	0.13	<0.07	<0	<0.02
Yttrium-88	pCi/g	<0.03	<-0.03	ND	ND	ND
Zinc-65	pCi/g	ND	ND	<0.03	<0.01	<-0.03

FIRE DEPARTMENT HOSE TRAINING FACILITY
BACKGROUND SAMPLES
ANALYSIS RESULTS SUMMARY

Sample Name		FBFDB0401	FBFDB0402	FBFDB0403	FBFDB0404	FBFDB0405
Station		FBFDB0401	FBFDB0402	FBFDB0403	FBFDB0404	FBFDB0405
Sample ID		107801	107802	107803	107805	107806
Date		35216	35216	35216	35219	35219
Depth (ft)		0 - 1	1 - 4	4 - 7	7 - 10	10 - 13
Analysis	Units					
Aluminum	mg/kg	4440	5820	5680	7420	5440
Antimony	mg/kg	0.442	0.462	0.473	1	<4.1
Arsenic	mg/kg	2	4	3.9	4.8	1.6
Barium	mg/kg	11.8	7.9	5.8	5	5.3
Beryllium	mg/kg	0.117	0.0657	0.048	0.134	0.117
Cadmium	mg/kg	0.293	0.662	0.929	1.1	0.28
Calcium	mg/kg	201	179	96.4	98.3	52.1
Chromium	mg/kg	9.2	16.8	18.9	30.9	4.6
Cobalt	mg/kg	0.488	0.221	0.168	<0.305	0.468
Copper	mg/kg	30.7	3.2	4.9	8.8	6
Cyanide	mg/kg	<0.84	<0.87	<0.87	<0.91	0.257
Iron	mg/kg	7330	17600	23200	48000	11300
Lead	mg/kg	14.6	4.4	6.6	17.8	6.1
Magnesium	mg/kg	93	70.1	75.8	110	81.4
Manganese	mg/kg	19.3	2.6	1.6	1.9	4.9
Mercury	mg/kg	0.03	0.046	0.03	<0.16	<0.158
Nickel	mg/kg	1.9	1.2	0.964	0.864	1.1
Potassium	mg/kg	53.6	44.9	43.9	67.2	50.6
Selenium	mg/kg	<11.4	0.489	1	2.9	<12.2
Sodium	mg/kg	13.7	13.3	12	<152	16.2
Vanadium	mg/kg	18.4	41.7	63	138	42
Zinc	mg/kg	13.4	1.4	0.957	<18.9	2.2
Di-n-octyl phthalate	ug/kg	ND	ND	142	308	268
Phenol	ug/kg	ND	ND	<380	<400	44.9
Actinium-228	pCi/g	0.84	1.12	0.98	1.33	1.16
Americium-241	pCi/g	ND	ND	ND	ND	ND
Antimony-124	pCi/g	<0.04	<0.03	ND	ND	ND
Antimony-125	pCi/g	ND	ND	<-0.08	<-0.01	0.16
Barium-133	pCi/g	ND	ND	<-0.03	<0.05	<0.01
Cesium-134	pCi/g	ND	ND	<-0.02	<-0.03	<0
Cesium-137	pCi/g	0.16	<0	ND	ND	ND
Cobalt-60	pCi/g	<-0.02	<0	ND	ND	ND
Europium-152	pCi/g	0.33	<0.22	<0.1	<0.05	0.3
Europium-155	pCi/g	0.24	<0.32	0.15	0.27	0.2
Manganese-54	pCi/g	ND	ND	<0.03	<0.01	<0
Neptunium-239	pCi/g	ND	ND	<0.45	<0.67	0.87
Plutonium-238	pCi/g	ND	ND	ND	ND	ND
Potassium-40	pCi/g	0.76	1.72	0.84	1.76	2.45
Promethium-146	pCi/g	ND	ND	<0.01	0.05	<-0.02

FIRE DEPARTMENT HOSE TRAINING FACILITY
BACKGROUND SAMPLES
ANALYSIS RESULTS SUMMARY

Sample Name		FBFDB0401	FBFDB0402	FBFDB0403	FBFDB0404	FBFDB0405
Station		FBFDB0401	FBFDB0402	FBFDB0403	FBFDB0404	FBFDB0405
Sample ID		107801	107802	107803	107805	107806
Date		35216	35216	35216	35219	35219
Depth (ft)		0 - 1	1 - 4	4 - 7	7 - 10	10 - 13
Analysis	Units					
Promethium-147	pCi/g	ND	ND	ND	ND	ND
Radium-226	pCi/g	ND	ND	ND	ND	ND
Radium-228	pCi/g	ND	ND	ND	ND	ND
Ruthenium-106	pCi/g	ND	ND	<0.08	<0.09	<0.23
Strontium-90	pCi/g	ND	ND	ND	ND	ND
Technetium-99	pCi/g	ND	ND	ND	ND	ND
Thorium-228	pCi/g	ND	ND	ND	ND	ND
Thorium-232	pCi/g	ND	ND	ND	ND	ND
Thorium-234	pCi/g	1.02	1.08	<0.91	<-0.23	1.63
Tin-113	pCi/g	ND	ND	<0	<0.02	<-0.03
Uranium-235	pCi/g	ND	ND	ND	ND	ND
Yttrium-88	pCi/g	<-0.03	<0	ND	ND	ND
Zinc-65	pCi/g	ND	ND	<0	<0	<-0.06

FIRE DEPARTMENT HOSE TRAINING FACILITY
BACKGROUND SAMPLES
ANALYSIS RESULTS SUMMARY

Sample Name		FBFDB0501	FBFDB0502	FBFDB0503	FBFDB0504	FBFDB0505
Station		FBFDB0501	FBFDB0502	FBFDB0503	FBFDB0504	FBFDB0505
Sample ID		107807	107809	107813	107814	107815
Date		35219	35219	35220	35220	35220
Depth (ft)		0 - 1	1 - 4	4 - 7	7 - 10	10 - 13
Analysis	Units					
Aluminum	mg/kg	7540	2200	7970	6040	2430
Antimony	mg/kg	0.749	<3.49	0.826	1.5	0.769
Arsenic	mg/kg	4.6	1.3	5	5.9	3.1
Barium	mg/kg	5.1	6.8	21.7	5.5	3.1
Beryllium	mg/kg	0.0529	0.0598	0.0959	0.0913	0.0875
Cadmium	mg/kg	0.444	0.109	0.602	1.3	0.416
Calcium	mg/kg	123	50.4	287	185	45
Chromium	mg/kg	23.4	5.5	22.4	42.8	13
Cobalt	mg/kg	<0.299	0.456	<0.394	<0.15	<0.226
Copper	mg/kg	4.3	1.8	4.9	5.7	3.7
Cyanide	mg/kg	0.223	0.289	0.15	0.156	0.254
Iron	mg/kg	17500	3890	25300	53900	17900
Lead	mg/kg	5.9	4.5	6.1	16.3	7.7
Magnesium	mg/kg	57.8	30.9	132	113	45.8
Manganese	mg/kg	7.5	37.2	8.8	2	3.1
Mercury	mg/kg	0.02	0.02	0.047	<0.162	<0.156
Nickel	mg/kg	2.7	0.967	1.7	0.926	0.704
Potassium	mg/kg	66.8	32.8	93.2	55.5	19.5
Selenium	mg/kg	<12.2	<10.4	1.5	2.9	<11.8
Sodium	mg/kg	<152	<129	<151	<157	<147
Vanadium	mg/kg	54.8	10.5	64.8	148	84.4
Zinc	mg/kg	3.4	<16	2.1	<19.6	<18.3
Di-n-octyl phthalate	ug/kg	ND	ND	95.4	294	291
Phenol	ug/kg	ND	ND	<390	<405	<390
Actinium-228	pCi/g	1.14	0.89	1.23	1.06	0.76
Americium-241	pCi/g	ND	ND			
Antimony-124	pCi/g	<-0.01	<-0.01	ND	ND	ND
Antimony-125	pCi/g	ND	ND	0.14	<0.03	<-0.03
Barium-133	pCi/g	ND	ND	<0.02	<0.03	<0.02
Cesium-134	pCi/g	ND	ND	<0	<-0.01	<-0.01
Cesium-137	pCi/g	<0.02	<-0.02	ND	ND	ND
Cobalt-60	pCi/g	<0.01	<0	ND	ND	ND
Europium-152	pCi/g	<0.06	0.35	<0	<0.16	0.29
Europium-155	pCi/g	<-0.11	<0.16	0.42	0.26	0.13
Manganese-54	pCi/g	ND	ND	<0.03	<-0.01	<0
Neptunium-239	pCi/g	ND	ND	<-0.34	<0.64	<0.22
Plutonium-238	pCi/g	ND	ND			
Potassium-40	pCi/g	1.38	0.86	1.31	3.5	0.97
Promethium-146	pCi/g	ND	ND	<0.01	<0.02	<-0.02

FIRE DEPARTMENT HOSE TRAINING FACILITY
BACKGROUND SAMPLES
ANALYSIS RESULTS SUMMARY

Sample Name		FBFDB0501	FBFDB0502	FBFDB0503	FBFDB0504	FBFDB0505
Station		FBFDB0501	FBFDB0502	FBFDB0503	FBFDB0504	FBFDB0505
Sample ID		107807	107809	107813	107814	107815
Date		35219	35219	35220	35220	35220
Depth (ft)		0 - 1	1 - 4	4 - 7	7 - 10	10 - 13
Analysis	Units					
Promethium-147	pCi/g	ND	ND			
Radium-226	pCi/g	ND	ND			
Radium-228	pCi/g	ND	ND			
Ruthenium-106	pCi/g	ND	ND	<-0.12	<0.11	<-0.1
Strontium-90	pCi/g	ND	ND			
Technetium-99	pCi/g	ND	ND			
Thorium-228	pCi/g	ND	ND			
Thorium-232	pCi/g	ND	ND			
Thorium-234	pCi/g	<1.58	<-0.44	<0.88	<-0.34	<0.34
Tin-113	pCi/g	ND	ND	<0	<0	<0
Uranium-235	pCi/g	ND	ND			
Yttrium-88	pCi/g	<0.01	<-0.02	ND	ND	ND
Zinc-65	pCi/g	ND	ND	0.08	<0.04	<0

FIRE DEPARTMENT HOSE TRAINING FACILITY
WASTE UNIT
ANALYSIS RESULTS SUMMARY

Sample Name		FDTF0101	FDTF0102	FDTF0103	FDTF0104	FDTF0105	FDTF0201
Station		FDTF0101	FDTF0102	FDTF0103	FDTF0104	FDTF0105	FDTF0201
Sample ID		107539	107541	107542	107548	107549	107550
Date		5/21/96	5/21/96	5/21/96	5/21/96	5/21/96	5/22/96
Depth (ft)		0 - 1	1 - 4	4 - 7	7 - 10	10 - 13	0 - 1
Analysis	Units						
Aluminum	mg/kg	5110	8350	11300	12600	6050	4330
Antimony	mg/kg	<3.69	<3.98	1.2	0.578	0.583	0.556
Arsenic	mg/kg	2.3	3.4	11.1	6.2	16	2.2
Barium	mg/kg	18	26.4	7.1	10.5	5.1	11.5
Beryllium	mg/kg	0.107	0.14	0.165	0.152	0.0921	0.0926
Cadmium	mg/kg	0.119	0.075	0.409	0.518	0.17	<0.177
Calcium	mg/kg	302	308	219	176	74.2	169
Chromium	mg/kg	15	19.2	55.2	31.8	11.6	11.2
Cobalt	mg/kg	0.822	0.825	0.491	0.43	1.15	0.501
Copper	mg/kg	5	4.5	13	8.9	4.7	5
Cyanide	mg/kg	<0.8	<0.86	<0.91	<0.920	1.09	<0.78
Iron	mg/kg	9560	15900	76200	39800	10200	8960
Lead	mg/kg	11	5.4	11.1	24.6	6.8	12.9
Magnesium	mg/kg	86.7	171	168	204	89.4	93.6
Manganese	mg/kg	31.6	14.1	7.8	22	4.1	28.7
Mercury	mg/kg	0.03	0.02	0.02	<0.162	0.192	<0.137
Nickel	mg/kg	3.3	2.3	1.4	1.6	1.2	2
Potassium	mg/kg	90.3	156	105	158	82.4	82.6
Selenium	mg/kg	<11	<11.8	5.5	2.6	15	<10.7
Silver	mg/kg	1.9	0.11	<1.08	<1.09	1.3	0.454
Sodium	mg/kg	33.5	25.9	27.5	73.3	74.8	61.8
Vanadium	mg/kg	21.3	35.2	135	115	28.4	22.4
Zinc	mg/kg	15	3.5	<19.2	5	23.2	8.8
Benzo(a)anthracene	ug/kg	94.6	<379	<398	<405	<480	<343
Benzo(a)pyrene	ug/kg	144	<379	<398	<405	<480	<343
Benzo(b)fluoranthene	ug/kg	317	<379	<398	<405	<480	<343
Benzo(g,h,i)perylene	ug/kg	121	<379	<398	<405	<480	<343
Benzo(k)fluoranthene	ug/kg	219	<379	<398	<405	<480	<343
Benzoic acid	ug/kg	<1760	<1900	<1990	<2020	<2400	<1720
Bis(2-ethylhexyl) phthalate	ug/kg	<351	<379	<398	<110	<480	<343
Chrysene	ug/kg	180	<379	<398	<405	<480	<343
Di-n-butyl phthalate	ug/kg	<351	<379	<398	<405	<480	<343
Di-n-octyl phthalate	ug/kg	<351	39.9	69	391	462	<343
Fluoranthene	ug/kg	112	<379	<398	<405	<480	<343
Indeno(1,2,3-c,d)pyrene	ug/kg	125	<379	<398	<405	<480	<343
Pyrene	ug/kg	99.8	<379	<398	<405	<480	<343
Methylene chloride	ug/kg	<9.03	<15.8	<13.5	13.2	10.5	6.84
Toluene	ug/kg	<5.5	<6	<5.5	<6	<7.5	<5

FIRE DEPARTMENT HOSE TRAINING FACILITY
WASTE UNIT
ANALYSIS RESULTS SUMMARY

Sample Name		FDTF0202	FDTF0203	FDTF0204	FDTF0205	FDTF0301	FDTF0302
Station		FDTF0202	FDTF0203	FDTF0204	FDTF0205	FDTF0301	FDTF0302
Sample ID		107551	107552	107554	107555	107557	107558
Date		5/22/96	5/22/96	5/22/96	5/22/96	5/23/96	5/23/96
Depth (ft)		1 - 4	4 - 7	7 - 10	10 - 13	0 - 1	1 - 4
Analysis	Units						
Aluminum	mg/kg	12400	12300	5280	5490	3030	12500
Antimony	mg/kg	1.4	1.9	0.482	<4.1	<3.62	0.549
Arsenic	mg/kg	7.3	9	3.2	1.5	1.2	5.4
Barium	mg/kg	27.1	26.9	3.7	6.3	19.4	41
Beryllium	mg/kg	0.101	0.123	0.201	0.1883	<0.109	0.201
Cadmium	mg/kg	0.638	0.846	0.797	0.283	0.0849	0.436
Calcium	mg/kg	735	1190	91.1	67.6	144	455
Chromium	mg/kg	45.8	59.4	18.7	11	4.6	23.5
Cobalt	mg/kg	0.551	0.362	0.465	0.457	0.78	1
Copper	mg/kg	8.1	7.8	5.1	5.7	5.2	6.7
Cyanide	mg/kg	<1.07	0.98	0.176	0.104	<0.79	<0.93
Iron	mg/kg	44000	53400	48300	18200	3020	24900
Lead	mg/kg	9.2	16.5	17.1	10.2	12.4	9.1
Magnesium	mg/kg	239	574	101	119	90.1	248
Manganese	mg/kg	8	9.2	32.8	11.8	28	18.8
Mercury	mg/kg	0.052	0.03	<.153	<.152	<0.135	<0.158
Nickel	mg/kg	2.5	1.3	0.583	1.1	1.4	3.6
Potassium	mg/kg	192	198	74.4	99.2	88.4	224
Selenium	mg/kg	2.1	2.8	1.9	<12.2	<10.8	<12.7
Silver	mg/kg	<1.26	<1.16	<1.06	<1.05	0.267	<1.1
Sodium	mg/kg	89.8	86.8	73	57.3	57.1	87.1
Vanadium	mg/kg	84.6	166	116	52.8	7.6	57.5
Zinc	mg/kg	3.1	20.8	<18.9	4.1	22.8	6.6
Benzo(a)anthracene	ug/kg	<467	<430	<392	<390	<1720	<406
Benzo(a)pyrene	ug/kg	<467	<430	<392	<390	<1720	<406
Benzo(b)fluoranthene	ug/kg	<467	<430	<392	<390	<1720	<406
Benzo(g,h,i)perylene	ug/kg	<467	<430	<392	<390	<1720	<406
Benzo(k)fluoranthene	ug/kg	<467	<430	<392	<390	<1720	<406
Benzoic acid	ug/kg	<2340	72.9	<1960	44.6	<8620	<2030
Bis(2-ethylhexyl) phthalate	ug/kg	<467	<430	<392	<390	465	386
Chrysene	ug/kg	<467	<430	<392	<390	<1720	<406
Di-n-butyl phthalate	ug/kg	194	<430	<392	<390	<1720	<406
Di-n-octyl phthalate	ug/kg	<467	100	459	457	<1720	335
Fluoranthene	ug/kg	<467	<430	<392	<390	<1720	<406
Indeno(1,2,3-c,d)pyrene	ug/kg	<467	<430	<392	<390	<1720	<406
Pyrene	ug/kg	<467	<430	<392	<390	<1720	90.2
Methylene chloride	ug/kg	9.55	11.6	<10.5	<10.7	<8.13	<13
Toluene	ug/kg	<7.5	<6.5	<6	<5.5	2.36	<6

FIRE DEPARTMENT HOSE TRAINING FACILITY
WASTE UNIT
ANALYSIS RESULTS SUMMARY

Sample Name		FDTF0303	FDTF0304	FDTF0305	FDTF0401	FDTF0402	FDTF0403
Station		FDTF0303	FDTF0304	FDTF0305	FDTF0401	FDTF0402	FDTF0403
Sample ID		107559	107560	107561	107564	107566	107568
Date		5/23/96	5/23/96	5/23/96	5/24/96	5/24/96	5/24/96
Depth (ft)		4 - 7	7 - 10	10 - 13	0 - 1	1 - 4	4 - 7
Analysis	Units						
Aluminum	mg/kg	12200	4650	8110	1670	3400	10400
Antimony	mg/kg	0.51	<4.19	<4.14	<3.57	<3.76	0.759
Arsenic	mg/kg	3.+6	<13.3	3.4	<11.3	1.4	6.7
Barium	mg/kg	11.7	3.1	6.5	9	20.1	7.9
Beryllium	mg/kg	<.13	<.147	0.183	<0.0989	0.16	<.125
Cadmium	mg/kg	0.312	0.291	0.527	0.051	0.0548	0.938
Calcium	mg/kg	213	68	105	78.8	118	211
Chromium	mg/kg	16.3	8.3	20.1	2.5	5.3	32.4
Cobalt	mg/kg	0.447	0.26	0.538	0.405	0.819	0.351
Copper	mg/kg	7.6	6.3	7.7	<2.2	<2.8	7.4
Cyanide	mg/kg	<.94	0.91	<.9	0.091	<0.82	<.9
Iron	mg/kg	20100	187200	29500	1480	3830	51000
Lead	mg/kg	8.9	6.9	12.7	6.9	5.3	12.6
Magnesium	mg/kg	221	65.7	111	47.6	96.5	147
Manganese	mg/kg	3.3	6.3	10.1	65.3	50.8	3.5
Mercury	mg/kg	<.161	<.156	<.154	<0.133	<0.14	<.155
Nickel	mg/kg	2.2	0.511	2.9	0.74	1.8	1.2
Potassium	mg/kg	162	68.9	129	54.8	85.9	126
Selenium	mg/kg	1.4	<12.4	<12.3	<10.6	<11.2	3.8
Silver	mg/kg	<1.12	<1.08	<1.06	<0.918	<0.968	<1.07
Sodium	mg/kg	69.7	81.7	77.4	53.2	53.7	60.6
Vanadium	mg/kg	58.7	41.1	83.7	3.6	9.2	111
Zinc	mg/kg	4.4	3	5.2	4.6	4.1	3.1
Benzo(a)anthracene	ug/kg	<414	<399	<394	<340	<358	<396
Benzo(a)pyrene	ug/kg	<414	<399	<394	<340	<358	<396
Benzo(b)fluoranthene	ug/kg	<414	<399	<394	<340	<358	<396
Benzo(g,h,i)perylene	ug/kg	<414	<399	<394	<340	<358	<396
Benzo(k)fluoranthene	ug/kg	<414	<399	<394	<340	<358	<396
Benzoic acid	ug/kg	<2070	84.7	46.1	<1700	<1790	<1980
Bis(2-ethylhexyl) phthalate	ug/kg	<414	<399	<394	<340	<358	63.5
Chrysene	ug/kg	<414	<399	<394	<340	<358	<396
Di-n-butyl phthalate	ug/kg	<414	<399	<394	<340	<358	<396
Di-n-octyl phthalate	ug/kg	98.9	<399	<394	<340	<358	<396
Fluoranthene	ug/kg	<414	<399	<394	<340	<358	<396
Indeno(1,2,3-c,d)pyrene	ug/kg	<414	<399	<394	<340	<358	<396
Pyrene	ug/kg	<414	<399	<394	<340	<358	<396
Methylene chloride	ug/kg	<13.8	<8.26	<7.8	<4.23	<6.89	<6.77
Toluene	ug/kg	<6	<5.5	<6	<5	<5.5	<6

FIRE DEPARTMENT HOSE TRAINING FACILITY
WASTE UNIT
ANALYSIS RESULTS SUMMARY

Sample Name		FDTF0404	FDTF0405	FDTF0501	FDTF0502	FDTF0503	FDTF0504
Station		FDTF0404	FDTF0405	FDTF0501	FDTF0502	FDTF0503	FDTF0504
Sample ID		107569	107570	107573	107575	107576	107577
Date		5/24/96	5/24/96	5/28/96	5/28/96	5/28/96	5/28/96
Depth (ft)		7 - 10	10 - 13	0 - 1	1 - 4	4 - 7	7 - 10
Analysis	Units						
Aluminum	mg/kg	3300	4480	4310	2190	5120	3350
Antimony	mg/kg	<3.95	<4.14	<3.83	<3.74	0.68	<4.04
Arsenic	mg/kg	<12.5	3.2	3.7	1.4	4.2	1.4
Barium	mg/kg	2.8	7.6	9.8	13.1	9.2	4.3
Beryllium	mg/kg	<.0858	0.187	0.0558	0.079	0.0695	0.0797
Cadmium	mg/kg	0.169	0.604	<0.16	<0.047	0.302	0.28
Calcium	mg/kg	44.1	55.7	85.5	78.1	187	65.7
Chromium	mg/kg	4.9	19.4	11.8	4.2	20.9	9.3
Cobalt	mg/kg	0.163	0.424	0.544	0.743	<0.373	<0.282
Copper	mg/kg	4	6.7	4.3	<2.4	5.1	3.4
Cyanide	mg/kg	<.86	<0.900	<0.83	0.115	<0.910	0.306
Iron	mg/kg	11800	35900	11100	3740	26.7	24200
Lead	mg/kg	7.2	18.4	4.7	3.8	6.4	8.9
Magnesium	mg/kg	47.7	89.6	41.9	58.2	98.8	55.1
Manganese	mg/kg	1.2	10	32.1	34.3	14.8	19.7
Mercury	mg/kg	<0.147	<0.154	<0.142	<0.139	<0.156	<0.150
Nickel	mg/kg	0.27	1.3	1.2	0.984	0.779	0.526
Potassium	mg/kg	40.7	80	55.4	62.8	73.4	45
Selenium	mg/kg	<11.7	<12.3	<11.4	<11.1	1.4	<12.0
Silver	mg/kg	<1.02	<1.06	<0.985	<0.961	<1.08	<1.04
Sodium	mg/kg	66.7	65.6	69.1	56.8	64.8	51.9
Vanadium	mg/kg	37.5	104	29.9	8.1	59.3	40.6
Zinc	mg/kg	2.2	3.1	2.5	2.5	2.2	<18.6
Benzo(a)anthracene	ug/kg	<376	<394	<365	<356	<400	<385
Benzo(a)pyrene	ug/kg	<376	<394	<365	<356	<400	<385
Benzo(b)fluoranthene	ug/kg	<376	<394	<365	<356	<400	<385
Benzo(g,h,i)perylene	ug/kg	<376	<394	<365	<356	<400	<385
Benzo(k)fluoranthene	ug/kg	<376	<394	<365	<356	<400	<385
Benzoic acid	ug/kg	<1880	<1970	60.3	<1780	<2000	<1920
Bis(2-ethylhexyl) phthalate	ug/kg	<376	<394	<365	<356	<400	<385
Chrysene	ug/kg	<376	<394	<365	<356	<400	<385
Di-n-butyl phthalate	ug/kg	<376	<394	<47.6	<356	<400	<385
Di-n-octyl phthalate	ug/kg	<376	<394	<365	<356	<400	<385
Fluoranthene	ug/kg	<376	<394	<365	<356	<400	<385
Indeno(1,2,3-c,d)pyrene	ug/kg	<376	<394	<365	<356	<400	<385
Pyrene	ug/kg	<376	<394	<365	<356	<400	<385
Methylene chloride	ug/kg	<2.55	<3.31	<11.9	<7.59	<9.7	<11
Toluene	ug/kg	<5.5	<5.5	<5.5	<5	<6	<6

FIRE DEPARTMENT HOSE TRAINING FACILITY
WASTE UNIT
ANALYSIS RESULTS SUMMARY

Sample Name		FDTF0505
Station		FDTF0505
Sample ID		107580
Date		5/28/96
Depth (ft)		10 - 13
Analysis	**Units**	
Aluminum	mg/kg	2960
Antimony	mg/kg	0.716
Arsenic	mg/kg	1.5
Barium	mg/kg	2.4
Beryllium	mg/kg	0.122
Cadmium	mg/kg	0.462
Calcium	mg/kg	47.9
Chromium	mg/kg	24.9
Cobalt	mg/kg	<0.360
Copper	mg/kg	5.4
Cyanide	mg/kg	0.113
Iron	mg/kg	37000
Lead	mg/kg	9.8
Magnesium	mg/kg	44.8
Manganese	mg/kg	19.8
Mercury	mg/kg	<0.158
Nickel	mg/kg	0.702
Potassium	mg/kg	39.8
Selenium	mg/kg	1.4
Silver	mg/kg	<1.07
Sodium	mg/kg	51.5
Vanadium	mg/kg	55
Zinc	mg/kg	<19.1
Benzo(a)anthracene	ug/kg	<395
Benzo(a)pyrene	ug/kg	<395
Benzo(b)fluoranthene	ug/kg	<395
Benzo(g,h,i)perylene	ug/kg	<395
Benzo(k)fluoranthene	ug/kg	<395
Benzoic acid	ug/kg	<1980
Bis(2-ethylhexyl) phthalate	ug/kg	<395
Chrysene	ug/kg	<395
Di-n-butyl phthalate	ug/kg	<395
Di-n-octyl phthalate	ug/kg	103
Fluoranthene	ug/kg	<395
Indeno(1,2,3-c,d)pyrene	ug/kg	<395
Pyrene	ug/kg	<395
Methylene chloride	ug/kg	<4.99
Toluene	ug/kg	<6

APPENDIX C

HUMAN HEALTH RISK CHARACTERIZATION

Appendix C

C.1. SCREENING LEVELS FOR COPC SELECTION

Health-based screening levels were used in the selection of chemicals of potential concern (COPCs) for the human health risk assessment. The COPC selection process is discussed in Section 6.1 of the report. The purpose of this section is to identify the sources for the levels against which the data were screened for use in the risk assessment. Tables in Section 6.1 present the summary statistics as well as the chemicals that were screened out as a result of the comparison with these health-based screening levels. Table C-1 presents the health-based screening levels used in the COPC selection process.

USEPA Region III risk based concentrations (RBCs) (EPA, 1996) served as the primary source for screening levels. Since RBCs are not available for all the chemicals detected at the site, other sources provided screening levels and methods for determining screening levels. Note that if screening levels are not available, even after using the methods presented in the following paragraphs, the chemicals were included in the risk assessment.

For screening of essential nutrients (i.e., calcium, chloride, iodine, magnesium, phosphorous, potassium, and sodium), RBCs are not available. Instead, the Food and Drug Administration (FDA) recommended daily allowances (RDAs) were used in conjunction with residential exposure assumptions to determine screening levels. Table C-2 presents the RDAs that were used to determine the screening levels. The following equations were used to determine the screening level for essential nutrients in soil and groundwater using the U.S. FDA RDAs.

Essential nutrient screening levels for soil:

$$Nu_{Soil} = \frac{RDA}{Soil_{Ing} + Soil_{Derm} + Soil_{Inh}}$$

where:

Nu_{Soil}	=	Chemical concentration of essential nutrient in soil (mg/kg soil)
RDA	=	Recommended Daily Allowance (mg/kg BW/day)
$Soil_{Ing}$	=	Soil intake for the ingestion pathway, excluding the concentration term (kg soil/day/kg BW) (Section C.3.1.1)
$Soil_{Der}$	=	Soil contact for the dermal pathway, excluding the concentration term (kg soil/day/kg BW) (Section C.3.1.2)
$Soil_{Inh}$	=	Soil intake for the inhalation pathway, excluding the concentration term (kg soil/day/kg BW) (Section C.3.1.3)

C.2. DERIVATION OF EXPOSURE POINT CONCENTRATIONS

Exposure point concentrations for the risk estimates will be developed from sampling and analytical data. In accordance with EPA's *Supplemental Guidance to RAGS: Calculating the Concentration Term* (EPA 1992b), the 95-percent upper-confidence limit on the arithmetic mean should be used as the exposure point concentration. Note that if the UCL_{95} exceeds the maximum detected concentration, the maximum detected concentration will replace the UCL_{95} as the exposure point concentration used in the risk assessment.

The methods used to derive exposure point concentrations will depend upon the underlying shape of the distribution of the data set. The Shapiro-Wilk W test (Gilbert 1987) was used to determine if the data are normally or lognormally distributed. The following equation has been used for normally distributed data:

$$UCL_{95} = \bar{x} + t\left(\frac{s}{\sqrt{n}}\right)$$

where:

UCL_{95}	=	95% upper confidence limit of arithmetic mean
$\bar{x}$	=	arithmetic mean for normally distributed data

t	=	Student-t statistic at 95th percentile and n-1 degrees of freedom
s	=	standard deviation for normally distributed data
n	=	number of samples

The following equation has been used for normally distributed data:

$$UCL_{95} = e^{(\bar{x}+0.5s^2+\frac{sH}{\sqrt{n-1}})}$$

where:

UCL_{95} = 95% upper confidence limit of mean of lognormal distribution

$\bar{x}$	=	mean of log-transformed data for lognormally distributed data
s	=	standard deviation of log-transformed data
H	=	H-statistic at 95th percentile (Gilbert 1987)
n	=	number of samples

C.3. CHEMICAL INTAKE EQUATIONS

Intake equations for evaluating chemical exposures are presented in the following sections. Table C-3 provides the values for each of the parameters included in the following equations.

C.3.1. Exposure to Soil

Direct soil contact exposure pathways include ingestion, dermal contact, and inhalation of fugitive dust. Potential receptors that have been evaluated include on-unit workers, residents, and industrial workers. The following sections describe the methods that were used to quantify exposures resulting from direct soil contact.

C.3.1.1. Soil Ingestion

For the soil ingestion pathway, on-unit worker and industrial worker exposures were evaluated using the first equation presented below. For the residential pathway, exposures have been evaluated separately for noncarcinogenic and carcinogenic effects. Therefore, two different equations are presented. The equation used to determine intakes for evaluating noncarcinogenic effects is presented first (note that this is the same equation that is used in the evaluation of worker exposures). The equation that is used to calculate intakes for evaluating chemical carcinogenicity is presented second. Note that intakes were calculated for all chemicals and for both toxicological endpoints.

Children ages 1 through 6 (i.e., 15 kg) have been evaluated for noncarcinogenic effects. For the integrated receptor, age-adjusted intake factors have been used to generate excess lifetime cancer risk estimates that are considered to be more protective than adult-only risks. These risks are calculated and account for the differences in the age-specific contact rates, exposure durations, and body weights for children and adults over the expected duration of 30 year of exposure.

Soil Ingestion (On-unit Visitors and Workers; Residents for Noncarcinogenic Effects Only):

$$\text{Intake} = \frac{C_{so} \times CF \times IR \times BAF \times EF \times ED}{BW \times AT}$$

where:

C_{so}	=	Chemical concentration in soil (mg/kg)
CF	=	Conversion factor (10^{-6} kg soil/mg soil)
IR	=	Ingestion rate (mg/day)
BAF	=	Bioavailability factor (1 unitless)
EF	=	Exposure frequency (days/year)

ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time - noncarcinogenic effects (10,950 days)
		Averaging time - carcinogenic effects (25,550 days)

Soil Ingestion (Residents for Carcinogenic Effects Only):

$$\text{Intake} = C_{so} \times CF \times \left\{ \left[\left(\frac{IR_c \times BAF \times EF \times ED_c}{BW_c} \right) + \left(\frac{IR_a \times BAF \times EF \times ED_a}{BW_a} \right) \right] / AT_c \right\}$$

where:

C_{so}	=	Chemical concentration in soil (mg/kg)
IR_c	=	Ingestion rate - child (mg/day)
IR_a	=	Ingestion rate - adult (mg/day)
BAF	=	Bioavailability factor (unitless)
EF	=	Exposure frequency (days/year)
ED_c	=	Exposure duration - child (years)
ED_a	=	Exposure duration - adult (years)
CF	=	Conversion factor (10^{-6} kg soil/mg soil)
BW_c	=	Body weight - child (kg)
BW_a	=	Body weight - adult (kg)
AT_c	=	Averaging time - carcinogenic effects (25,550 days)

Bioavailability is a function of both compound-specific physical/chemical properties and the properties of the soil matrix itself. When soil is inadvertently ingested, not all of the contaminants in the ingested soil are available to be absorbed across the gut lining. In accordance with EPA Region IV guidance (EPA, 1995), a default value of 1.0 was used in the risk assessment. Use of an oral bioavailability factor (BAF) of 1.0 for chemicals in soil may

result in an inaccurate estimate of dose if there are differences in the uptake levels under the laboratory study conditions versus environmental exposure conditions. Because chemical-specific data are not available to support the use of a bioavailability factor other than 1, the Region IV default value was used.

C.3.1.2. Soil Dermal Contact

Dermal exposure is assumed to occur simultaneously with soil ingestion exposure. Soil dermal exposures have been evaluated using the following equations:

Soil Dermal Contact (On-unit Visitors and Workers; Residents for Noncarcinogenic Effects Only):

$$\text{Intake} = \frac{C_{so} \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

where:

C_{so}	=	Chemical concentration in soil (mg/kg)
CF	=	Conversion factor (10^{-6} kg soil/mg soil)
SA	=	Skin surface available for contact (cm^2/day)
AF	=	Soil to skin adherence factor (1 mg/cm^2)
ABS	=	Dermal absorption factor (0.001 for inorganics; 0.01 for organics)
EF	=	Exposure frequency (350 days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time - noncarcinogenic effects (10,950 days)
		Averaging time - carcinogenic effects (25,550 days)

Soil Dermal Contact (Residents for Carcinogenic Effects Only):

$$\text{Intake} = C_{so} \times CF \times \left\{ \left[\left(\frac{SA_c \times AF \times ABS \times EF \times ED_c}{BW_c} \right) + \left(\frac{SA_a \times AF \times ABS \times EF \times ED_a}{BW_a} \right) \right] / AT_c \right\}$$

where:

C_{so}	=	Chemical concentration in soil (mg/kg)
CF	=	Conversion factor (10^{-6} kg soil/mg soil)
SA_c	=	Skin surface available for contact - child (cm^2/day)
SA_a	=	Skin surface available for contact - adult (cm^2/day)
AF	=	Soil to skin adherence factor (mg/cm^2)
ABS	=	Dermal absorption factor (0.001 for inorganics; 0.01 for organics)
EF	=	Exposure frequency (days/year)
ED_c	=	Exposure duration - child (years)
ED_a	=	Exposure duration - adult (years)
BW_c	=	Body weight - child (kg)
BW_a	=	Body weight - adult (kg)
AT_c	=	Averaging time - carcinogenic effects (25,550 days)

C.3.1.3. Fugitive Dust Inhalation

Intake of soil (fugitive dust) via inhalation has been evaluated for all receptors. The intake equations follow:

Soil Inhalation (On-unit Visitors and Workers; Residents for Noncarcinogenic Effects Only):

$$\text{Intake} = \frac{C_{so} \times IR \times EF \times ED}{PEF \times BW \times AT}$$

where:

C_{so}	=	Chemical concentration in soil (mg/kg)
IR	=	Inhalation rate (m^3/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
PEF	=	Particulate emission factor (4.63×10^9 m^3/kg)
AT	=	Averaging time - noncarcinogenic effects (10,950 days)
	=	Averaging time - carcinogenic effects (25,550 days)

Soil Inhalation (Residents for Carcinogenic Effects Only):

$$\text{Intake} = C_{so} \times \left\{ \left[\left(\frac{IR_c \times EF \times ED_c}{BW_c} \right) + \left(\frac{IR_a \times EF \times ED_a}{BW_a} \right) \right] / PEF \times AT_c \right\}$$

where:

C_{so}	=	Chemical concentration in soil (mg/kg)
IR_c	=	Inhalation rate - child (m^3/day)
IR_a	=	Inhalation rate - adult (m^3/day)
EF	=	Exposure frequency (days/year)
ED_c	=	Exposure duration - child (years)
ED_a	=	Exposure duration - adult (years)
BW_c	=	Body weight - child (kg)
BW_a	=	Body weight - adult (kg)
PEF	=	Particulate emission factor (4.63×10^9 m^3/kg)
AT_c	=	Averaging time - carcinogenic effects (25,550 days)

C.3.2. Produce Ingestion Exposure Pathways

The produce ingestion pathway was included in the risk assessment for residents. Chemical intakes are assumed to result from ingesting leafy vegetables (e.g., kale and lettuce), tuberous vegetables (e.g., potatoes and carrots), and fruits (e.g., tomatoes). The equations are the same for all plant parts, however, the values for two of the parameters differ: ingestion rate and fraction ingested from the contaminated area. Table C-3 presents the values for both of these parameters, as well as all the others, for each of the plant parts. Section C.4 discusses the values used for the soil-to-plant biotransfer factors (BTFs).

Produce Ingestion Exposure (Residents for Noncarcinogenic Effects Only):

$$\text{Intake} = \frac{C_{Soil} \times BTF \times IR_c \times FI \times EF \times ED_c}{BW_c \times AT_{nc}}$$

where:

C_{Soil}	=	Chemical concentration in soil (mg/kg)
BTF	=	Soil-to-plant biotransfer factor - chemical specific (mg/kg plant)/(mg/kg soil)
IR_c	=	Ingestion rate - child (kg/day)
FI	=	Fraction ingested from contaminated area (unitless)
EF	=	Exposure frequency (days/year)
ED_c	=	Exposure duration - child (years)
BW_c	=	Body weight - child (kg)
AT_{nc}	=	Averaging time - noncarcinogenic effects (10,950 days)

Produce Ingestion Exposure (Residents for Carcinogenic Effects Only):

$$\text{Intake} = C_{Soil} \times BTF \times FI \times \left\{ \left[\left(\frac{IR_c \times EF \times ED_c}{BW_c} \right) + \left(\frac{IR_a \times EF \times ED_a}{BW_a} \right) \right] / AT_c \right\}$$

where:

C_{Soil}	=	Chemical concentration in soil (mg/kg)
BTF	=	Soil-to-plant biotransfer factor - chemical specific (mg/kg plant)/(mg/kg soil)
FI	=	Fraction ingested from contaminated area (unitless)
IR_c	=	Ingestion rate - child (kg/day)
IR_a	=	Ingestion rate - adult (kg/day)
EF	=	Exposure frequency (days/year)
ED_c	=	Exposure duration - child (years)
ED_a	=	Exposure duration - adult (years)
BW_c	=	Body weight - child (kg)
BW_a	=	Body weight - adult (kg)
AT_c	=	Averaging time - carcinogenic effects (25,550 days)

C.4. SOIL TO PLANT BIOTRANSFER

Direct measurement of site related chemicals in biota or other food chain items has not been conducted. In order to evaluate the potential effect of chemical releases on the food chain, ingestion of garden-grown produce has been evaluated in the risk assessment. In the evaluation, uptake of inorganic and organic chemicals into the edible portions of vegetation (i.e., leafy vegetables, tuberous vegetables, and fruits) has been considered.

Since monitoring data for chemical concentrations in produce are not available, these concentrations were calculated using an equilibrium partitioning model for inorganics (Travis and Arms, 1988; Belcher and Travis, 1989; and National Council on Radiation Protection and Measurements [NCRP], 1989). In this model, biotransfer factors (BTF) are used to derive concentrations of substances in foods from measured concentrations in soil. The equation for uptake into produce is shown below:

$$C_{PRO} = C_{So} \times BTF_{PRO}$$

where:

C_{PRO} = Chemical concentration in produce (mg/kg produce tissue)

C_{SO} = Chemical concentration in soil (mg /kg soil)

BTF_{PRO} = Biotransfer factor from soil to plant for vegetation ([mg pollutant/kg plant] per [mg pollutant/kg soil]).

The BTF in the above equation is a multiplier representing the uptake of contaminants into produce. For inorganics, published BTFs were used. A review of the number of surveys published in scientific literature was conducted to identify produce- and chemical-specific soil to plant biotransfer factors for inorganics. These include the *Technical Support Document for Land Application of Sewage Sludge: Volumes I and II* (EPA, 1992), *Environmental Profiles and Hazard Indices for Constituents of Municipal Sludge* (EPA, 1985); Belcher and Travis (1989); Baes et al. (1984); Hoffman and Baes (1979); Ng et al. (1977); Ng (1982); NCRP (1989 and 1991); and, NUREG (1994). In addition, a model to assess acute radionuclide fallout on agricultural systems was reviewed (Idaho National Engineering Laboratory [INEL], 1993; Abbott and Rood, 1994). BTFs published in NUREG (1994) were used in this risk assessment. For the remaining inorganics, BTFs were presented in the NCRP reports, Numbers 3 and 20 (NCRP, 1989 and 1991). If BTFs were still not available from these sources, the values presented in Baes et al. (1984) were used.

For organic chemicals, however, there are far fewer published values and models available. EPA (1991a) indicates that in the absence of sampling data for produce, uptake into plants can be estimated using procedures developed by Briggs et al. (1982). A computer-based model was developed by Trapp et al. (1994) and Trapp and Matthies (1995) based upon the study conducted by Briggs. The computer model is based on mass balance and estimates chemical concentrations in plant roots, stems, leaves, and fruits. This model requires chemical-specific inputs of log K_{ow}, dimensionless Henry's Law constant, and molecular weight. In addition, this model also requires a chemical- and plant-specific metabolic half-life. Since values for this parameter are not readily available for all the COPCs, a default half-life of 1.8 days was used. This is the half-life presented for bromacil by Trapp et al. (1994). The surrogate value for bromacil was selected because it is a herbicide that is believed to persist in plants longer than the majority of COPCs.

The model does not provide a BTF. Instead, it estimates the concentration in each plant part and the concentration in remaining in soil after equilibrium has been reached. The BTFs used in the risk assessment are the ratio of the plant concentration (i.e., in roots, leaves, and fruits) to the residual soil concentration for all soil COPCs and are presented in Table C-4. The exposure point concentrations for produce are presented in the risk characterization tables that evaluate the produce ingestion pathway.

C.5. TOXICITY ASSESSMENT

EPA recommends two different approaches for evaluating noncancer and cancer health effects for chemicals. The two approaches for chemicals reflect a fundamental difference in the proposed mechanism of toxic action.

In assessing the potential for noncancer health effects, EPA assumes that there is a toxicologic threshold below which no adverse health effects occur. These toxicologic thresholds are represented by reference doses (RfDs) for oral exposures and reference concentrations (RfCs) for inhalation exposures. The RfDs and RfCs are levels (with uncertainty spanning an order of magnitude or greater) of daily human exposures below which adverse health effects are not anticipated, even for the most sensitive members of a population (EPA, 1989a). EPA derives

RfDs and RfCs based on estimates of the no-observable-adverse-effect level (NOAEL) or lowest-observable-adverse-effect level (LOAEL) in humans or test animals. Table C-5 presents the toxicity values for evaluating noncarcinogenic effects.

For carcinogens, however, EPA believes that the assumption of a threshold is inappropriate (EPA, 1989a). An extremely low level of exposure to a carcinogen may result in chromosomal or enzyme changes leading to cancer. Therefore, EPA does not estimate a threshold for carcinogens. Instead, EPA uses a two-part evaluation in which: (1) a chemical is assigned a weight-of-evidence classification, and (2) a cancer slope factor (CSF) is calculated for the chemical. In risk assessment, the CSF is used to estimate the probability of a cancer effect occurring in an exposed receptor over a lifetime. Cancer slope factors for evaluating chemical exposures are presented on Table C-6.

The weight-of-evidence classification evaluates the evidence that a given chemical is a carcinogen to humans and animals. These ratings are as follows:

- A: Human carcinogen
- B1: Probable human carcinogen-limited human data are available
- B2: Probable human carcinogen-sufficient data in animals, and inadequate or no evidence in humans
- C: Possible human carcinogen
- D: Not classifiable as to human carcinogenicity.

EPA develops CSFs for carcinogens that have been classified as A, B1, and B2 and for many that have been classified as C. The CSFs for chemicals are in units of inverse dose: $(mg/kg/day)^{-1}$.

C.5.1. Toxicity Equivalency Factors for PAHs

Toxicity equivalence factors (TEFs) are used to convert each carcinogenic PAH slope factor to an equivalent slope factor of benzo(a)pyrene. The adjusted slope factors are used to calculate risk to human health. TEFs have been provided for seven PAHs (Table C-7). These values are related to the toxicity of benzo(a)pyrene and are based on reliable studies in which PAHs caused cancer after repeated exposures to mouse skin.

In accordance with EPA Region IV guidance (EPA 1995c), dermal contact and inhalation of carcinogenic PAHs have been evaluated using the oral slope factor listed in IRIS and an inhalation slope factor of 3.1 mg/kg-day, respectively. The inhalation slope factor is a provisional toxicity value, which is based on a hamster inhalation study.

For PAHs exhibiting noncancer effects without EPA-approved RfDs, the RfD for pyrene was used as a surrogate. Naphthalene was not used for this purpose because a risk assessment for this substance is currently under review by an EPA work group and no toxicity value is available on either IRIS or HEAST.

C.5.2. Toxicity for Evaluation of the Dermal Pathway

Table C-8 presents the toxicity measures needed to evaluate the dermal exposure pathways.

C.6. EPA METHODS FOR RISK CHARACTERIZATION

As described in the previous section, USEPA recommends two approaches for evaluating chemical exposures which are based on the toxicological endpoints (i.e., noncarcinogenicity and carcinogenicity).

EPA methods for risk characterization distinguish cancer from noncancer effects because organisms typically respond differently following exposure to noncarcinogenic or carcinogenic agents. The cancer risk is the probability of excess (incremental) lifetime cancer risk (ELCR)

for an individual that can be attributed to long-term exposure to chemicals. The terms excess and incremental imply risk that may be attributable to the site. This means that health effects resulting from exposure to chemicals at other sites unrelated to the study areas under investigation have been excluded.

The procedure for calculating risk associated with exposure to carcinogenic compounds has been established by EPA (1989). A nonthreshold, dose-response model is used to calculate a cancer slope (potency) factor (which mathematically is the slope of the dose-response curve) for each chemical. To derive an estimate of risk for low levels (i.e., below estimated risks of 0.01), the CSF is multiplied by the estimated chronic daily dose (intake) experienced by the exposed individual:

$$\text{Risk} = \text{CDI} \times \text{CSF}$$

where:

Risk	=	Estimate of the excess lifetime cancer risk to an individual (unitless probability)
CDI	=	Chronic daily intake averaged over a 70-year period (mg/kg body weight/day)
CSF	=	Cancer slope factor, which is the 95 percent upper confidence limit of the slope of the dose-response curve $(\text{mg/kg body weight/day})^{-1}$.

In evaluating risk of exposure to more than one carcinogen, the risk measure for each compound may be summed to provide an overall estimate of total risk of cancer effects (EPA, 1989a). This assumes that the chemicals have independent actions (no chemical interactions that may increase or decrease an individual chemical's toxicity) and that all of the chemicals produce the same effect (i.e., cancer). The summation of risks is conducted for each source of environmental release, each associated exposure pathway, and each receptor group at risk of exposure.

The traditionally accepted practice of evaluating exposure to noncarcinogenic compounds has been to experimentally determine a NOAEL and to divide it by a safety factor to establish an acceptable human dose (e.g., acceptable daily intake or RfD). The RfD is then compared to the average daily dose experienced by the exposed population to obtain a measure of concern for adverse noncancer effects:

$$HQ = \frac{Dose}{RfD}$$

where:

HQ = Hazard quotient, which is a measure of the potential for adverse noncancer effects

Dose = Average daily dose for subchronic or chronic exposure (mg/kg body weight/day)

RfD = Reference dose, which is an acceptable intake for subchronic or chronic exposure (mg/kg body weight/day).

Dose and the RfD are expressed in the same units and are based upon common exposure periods (i.e., chronic [long-term], subchronic, or shorter-term). Guidelines for evaluating exposure to mixtures of noncarcinogens are presented by EPA (1989). Essentially, the EPA-recommended approach involves summing the HQs (ratio of daily dose/RfD) for all chemicals under evaluation to obtain the hazard index (HI).

After individual pathway risks are calculated, risks or HIs are combined for a receptor. The risk assessor must exercise judgment in identifying "reasonable exposure pathway combinations" and in determining "whether it is likely that the same individuals would consistently face the RME by more than one pathway" (EPA, 1989a).

C.7. REMEDIAL GOAL OPTIONS

The following sections present the equations that were used to calculate remedial goal options (RGOs) for COCs (i.e., HQ > 1) and for COPCs that are significant contributors (i.e., HQ > 0.1) to a total pathway HI > 1. Human health RGOs (HHRGOs) are presented in Section 7 of the report.

The calculations of HHRGOs use EPA-approved toxicity values and exposure assumptions from the risk assessment. HHRGOs are determined using multiple noncancer target hazard indexes (i.e., 0.1, 1, and 3). HHRGOs have been calculated using the exposure assumptions described in Section 6.

HHRGOs for soil were calculated assuming combined exposure via ingestion, dermal contact, and inhalation of fugitive dust. The following equation was used to calculate HHRGOs for soil:

$$RGO_{soil} = \frac{THQ}{((Intake_{Ing}/RfD_{oral})+(Intake_{Dem}/RfD_{Derm})+(Intake_{Inh}/RfD_{Inh}))}$$

where:

RGO_{soil}	=	remedial goal option (mg/kg soil)
THQ	=	target hazard quotient for deriving noncancer-based RGO (unitless)
$Intake_{Ing}$	=	soil intake for the ingestion pathway, excluding the concentration term (kg soil/day/kg BW) (Section C.3.1.1)
$Intake_{Der}$	=	soil intake for the dermal contact pathway, excluding the concentration term (kg soil/day/kg BW) (Section C.3.1.2)
$Intake_{Inh}$	=	soil intake for the inhalation pathway, excluding the concentration term (kg soil/day/kg BW) (Section C.3.1.3)
RfD_{oral}	=	oral reference dose (mg/kg BW/day)
RfD_{inhal}	=	inhalation reference dose (mg/kg BW/day)
RfD_{derm}	=	dermal reference dose (mg/kg BW/day)

REFERENCES

Abbott, M.L. and A.S. Rood. 1994. "COMIDA: A Radionuclide Food Chain Model for Acute Fallout Deposition." *Health Physics* 66(1):17-28.

Baes, C.F. III, R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. *A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture.*

Belcher, G.D. and C.C. Travis. 1989. *Modeling Support for the Rural and Municipal Waste Combustion Projects: Final Report on Sensitivity and Uncertainty Analysis for the Terrestrial Food Chain Model.* Interagency Agreement No. 1824-A020-A1, Contract No. DE-AC05-840R21400, Office of Risk Analysis, Health and Safety Research Division, Oak Ridge National Laboratory, Oak Ridge, TN.

Briggs, G.G., R.H. Bromilow, and A.A. Evans. 1982. "Relationships Between Lipophilicity and Root Uptake and Translocation of Non-ionised Chemicals by Barley." *Pesticide Science* 13(5), ISSN 0031-613X.

EPA. 1985. *Environmental Profiles and Hazard Indices for Constituents of Municipal Sludge.* Office of Water Regulations and Standards.

EPA. 1989a. *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part A).* OSWER Directive 9285.701A, Office of Solid Waste and Emergency and Remedial Response.

EPA. 1991. *Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part B), Development of Risk-Based Preliminary Remediation Goals.* Office of Emergency Response.

EPA. 1992. *Technical Support Document for Land Application of Sewage Sludge: Volumes I and II.* EPA 822/R-93-001a and EPA 822/R-93-001b. Office of Water.

EPA. 1992b. *Supplemental Guidance to RAGS: Calculating the Concentration Term.* Office of Emergency and Remedial Response, Hazardous Site Evaluation Division, Washington, D.C., Interim Bulletin, Vol. 1, No. 1, OSWER 9285.7-081.

REFERENCES: (Continued)

EPA. 1995. *Supplemental Guidance to RAGS: Region 4 Bulletins (Data Collection and Evaluation, Toxicity Assessment, Exposure Assessment, Risk Characterization, Development of Risk-Based Remedial Options).* Interim Draft, Office of Technical Services, Atlanta, GA. September.

EPA. 1996. *EPA Region III Risk-Based Concentration Table, January - June 1996.* Technical Support Section, Philadelphia, PA.

Gilbert, R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring.* Van Nostram Reinhold Company, New York, New York.

Hoffman, F.O. and C.F. Baes. 1979. *A Statistical Analysis of Selected Parameters for Predicting Food Chain Transport and Internal Dose of Radionuclides.* ORNL/NUREG/TM-882.

INEL. 1993. *COMIDA: A Radionuclide Food Chain Model for Acute Fallout Deposition.* EGG-GEO-10367 (Rev. 0), ITER/US/93/TE/SA-2, Idaho National Engineering Laboratory, prepared by Michael S. Abbott and Arthur S. Rood for the U.S. Department of Energy, Office of Energy Research.

NCRP (National Council on Radiation Protection and Measurements). 1989. *Screening Techniques for Determining Compliance with Environmental Standards. Releases of Radionuclides to the Atmosphere.* NCRP Report No. 3. January 1989.

NCRP. 1991. *Screening Models for Releases of Radionuclides to Air, Surface Water, and Groundwater. Description of Models.* NCRP Report No. XX, Volume 1. January 1991.

Ng, Y.C. 1982. "A Review of Transfer Factors for Assessing the Dose from Radionuclides in Agricultural Products." *Nuclear Safety* 23:57-71.

NUREG. 1994. *Residual Radioactive Contamination from Decommissioning - Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalent: Final Report.* NUREG/CR-5512, PNL-7994, Vol. 1, Prepared by Pacific Northwest Laboratory. Prepared for U.S. Nuclear Regulatory Commission. October 1994.

REFERENCES: (Continued)

Trapp, S., C. McFarlane and M. Matthies. 1994. "Model for Uptake of Xenobiotics into Plants: Validation with Bromacil Experiments." *Environmental Toxicology and Chemistry* 13(3):413-422.

Trapp, S. and M. Matthies. 1995. "Generic One-Compartment Model for Uptake of Organic Chemicals by Foliar Vegetation." *Environmental Science and Technology* 29(9):2333-2338.

Travis, C.C. and A.D. Arms. 1988. "Bioconcentration of Organics in Beef, Milk, and Vegetation." *Environmental Science and Technology* 22(3):271-274.

(This page intentionally left blank)

Table C-1. Health Based Screening Levels:

EPA Region III Risk Based Concentrations, Essential Nutrient Screening Levels

	Residential Soil (mg/kg)		Residential Soil (mg/kg)
INORGANICS		***ORGANICS***	
Aluminum	7800	Benzo(a)anthracene	880
Antimony	3.1	Benzo(a)pyrene	88
Arsenic	0.43	Benzo(b)fluoranthene	880
Barium	550	Benzo(g,h,i)perylene	NA
Beryllium	0.15	Benzo(k)fluoranthene	8800
Cadmium	3.9	Benzoic acid	31000000
Calcium	1000000	di-N-Butyl phthalate	780000
Chromium, hexavalent	39	Chrysene	88000
Cobalt	470	bis(2-Ethylhexyl)phthalate	46000
Copper	310	Fluoranthene	310000
Cyanide	160	Indeno(1,2,3-cd)pyrene	880
Iron	2300	Methylene Chloride	85000
Lead	40	di-N-Octyl phthalate	160000
Magnesium	1000000	Pyrene	230000
Manganese	39	Toluene	1600000
Mercury	0.78		
Nickel	160		
Potassium	393273		
Selenium	39		
Silver	39		
Sodium	NA		
Vanadium	55		
Zinc	2300		

Table C-2. RDAs Used to Derive Screening Levels Soil and Groundwater for Essential Nutrients

Nutrient	RDA (mg/kg BW/day)
Calcium	14
Chloride	0.51
Iodine	0.0021
Iron	0.26
Magnesium	5.7
Phosphorous	14
Potassium	0.57
Sodium	No data

U.S. recommended daily allowance (RDA) of essential minerals or Food and Drug Administration (FDA) supplemental mineral levels for a 70 kg adult

Table C-3. Exposure Assumptions

Pathway	Assumption	Units	Known On-unit Worker		Industrial Worker		Resident				
							Child (Noncancer)		Integrated Child/Adult (Cancer)		
General											
	Body Weight	kg	70	b	70	b	15	b	15 / 70	b / b	
	Exposure Duration	years	5	g	25	a	6	a	6 / 24	a / a	
	Averaging Time - Noncancer	days	1825	g	9125	a	2190	a			
	Averaging Time - Cancer	days	25550	a	25550	a			25550	a	
Soil Ingestion											
	Ingestion Rate	mg soil/day	50	a	50	b	200	a	200 / 100	a / a	
	Exposure Frequency	days/year	6	g	250	a	350	a	350	a	
	Conversion Factor - Chemicals	kg soil/mg soil	1E-06	-	1E-06	-	1E-06	-	1E-06	-	
Soil Dermal Contact											
	Skin Surface Area Available	cm^2/day	5800	d	5800	d	2010	d	2010 / 5800	d / d	
	Soil-to-skin Adherence Factor	mg soil/cm^2	1	a	1	a	1	a	1	a	
	Dermal Absorption Factor	unitless	chemical specific		hemical specifi		chemical specific		chemical specific		
	Exposure Frequency	days/year	6	g	250	a	350	a	350	a	
	Conversion Factor	kg soil/mg soil	1E-06	-	1E-06	-	1E-06	-	1E-06	-	
Fugitive Dust Inhalation											
	Inhalation Rate	m^3 air/day	20	a	20	a	15	a	15 / 20	a	
	Particulate Emission Factor	m^3 air/kg soil	4.63E+09	f	4.63E+09	f	4.63E+09	f	4.63E+09	f	
	Exposure Frequency	days/year	6	g	250	a	350	a	350	a	
Leafy Vegetables Ingestion											
	Ingestion Rate	kg produce/day					0.042	e	0.042 / 0.113	e / e	
	Exposure Frequency	days					350	a	350	a	
	Fraction Ingested	unitless					0.042	e	0.042	e	
Tuberous Vegetables Ingestion											
	Ingestion Rate	kg produce/day					0.075	e	0.075 / 0.202	e / e	
	Exposure Frequency	days					350	a	350	a	
	Fraction Ingested	unitless					0.119	e	0.119	e	
Fruit Ingestion											
	Ingestion Rate	kg produce/day					0.045	e	0.045 / 0.123	e / e	
	Exposure Frequency	days					350	a	350	a	
	Fraction Ingested	unitless					0.487	e	0.487	e	

Table C-3. Exposure Assumptions (continued)

[a] EPA 1995c, *Supplemental Guidance to RAGs: Region 4 Bulletins Human Health Risk Assessment*

[b] EPA 1991a, *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure*

[c] EPA 1993a, *Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure*

[d] EPA 1992a, *Dermal Exposure Assessment*; for skin surface area available during dermal contact with soil, assumes 25 percent of total body surface area is exposed (pp. 8-10 and 8-12)

[e] - EPA 1989b, *Exposure Factors Handbook*

[f] EPA 1991b, default values from *Human Health Evaluation Manual, Part B*

[g] - In accordance with EPA 1995c, the exposure assumptions for the current visitor land use scenarios has been developed with consideration of site-specific factors

[h] If guidance was not available for CTE but does exist for RME, the RME value was adopted for CTE

[i] A default value of 1 percent for organic compounds and 0.1 percent for inorganic chemicals was used

Table C-4. Soil-to-Plant Biotransfer Factors

	Soil-to-plant Biotransfer Factors [a]		
	Root	Leaf	Fruit
INORGANICS			
Aluminum	0.004	0.004	0.004
Arsenic	0.006	0.04	0.006
Beryllium	0.0015	0.01	0.0015
Chromium, hexavalent	0.0045	0.0075	0.0045
Iron	0.001	0.004	0.001
Manganese (food)	0.15	0.56	0.05
Sodium	0.055	0.075	0.055
Vanadium	0.002	0.002	0.002
ORGANICS			
Benzo(a)pyrene	7.07E-02	8.72E-08	1.32E-09
Benzo(g,h,i)perylene	3.61E-02	3.64E-09	5.43E-11

The units for soil-to-plant biotransfer are expressed in mg/kg plant per mg/kg soil

Table C-5. Toxicity Values for Evaluation of Noncarcinogenic Effects: Ingestion and Inhalation Pathways

	Oral Route Chronic Effects			Inhalation Route Chronic Effects				
	RfD[a] (mg/kg/day)	Uncertainty Factor	Source	RfC[a] (mg/m^3)	RfD[b] (mg/kg/day)	Uncertainty Factor	Source	Noncarcinogenic Target Organ and Critical Effect
INORGANICS								
Aluminum	--	--	--	--	--	--	--	--
Arsenic	3E-04	3	c	--	--	--	--	skin; keratosis, hyperpigmentation
Beryllium	5E-03	100	c	--	--	--	--	no observed effects
Chromium, hexavalent	5E-03	500	c	--	--	--	--	no observed effects
Iron	--	--	--	--	--	--	--	--
Manganese	2E-02	1	c,r	5E-05	1E-05	1000	c	oral-CNS effects. inhal.-impairment of neurobehavioral function
Sodium	--	--	--	--	--	--	--	--
Vanadium	7E-03	100	d	--	--	--	--	no observed effects
ORGANICS								
Benzo(a)pyrene	3E-02	--	h	--	--	--	--	--
Benzo(g,h,i)perylene	3E-02	--	h	--	--	--	--	--

a. RfD: Reference dose. RfC: Reference concentration.
b. Inhalation RfCs have been converted to inhalation RfDs by multiplying by 20m3/day and dividing by 70 kg.
c. EPA IRIS Data Base (March 1996).
d. USEPA ORD Health Effects Assessment Summary Tables (HEAST) FY 1995 Annual (May 1995) and FY-1995 Supplement (Nov. 1995).
h. In the absence of toxicity data, the RfDs for pyrene have been adopted for this compound.
r. The toxicity value is for manganese in the diet; for non-dietary exposures (e.g., soil, groundwater), the dietary toxicity value has been adjusted using a modifying factor of 3.

Table C-6. Toxicity Values for Evaluation of Carcinogenic Effects: Ingestion and Inhalation Pathways

	Oral Route				Inhalation Route				EPA Weight-of-Evidence
	Slope Factor $(mg/kg/day)^{-1}$	Source	Unit Risk $(\mu g/L)^{-1}$	Source	Slope Factor $(mg/kg/day)^{-1}$	Source	Unit Risk $(ug/m^3)^{-1}$	Source	Classification
INORGANICS									
Aluminum	--	--	--	--	--	--	--	--	--
Arsenic	1.5	c	5.00E-05	c	50	d	4.30E-03	c	[A]
Beryllium	4.3	c	1.20E-04	c	8.4	d	2.40E-03	c	[B2]
Chromium, hexavalent	--	--	--	--	41	d	1.20E-02	c	[A]
Iron	--	--	--	--	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--	[D]
Sodium	--	--	--	--	--	--	--	--	--
Vanadium	--	--	--	--	--	--	--	--	--
ORGANICS									
Benzo(a)pyrene	7.3	c	2.10E-04	c	3.1	u	8.80E-01	u	[B2]
Benzo(g,h,i)perylene	--	--	--	--	--	--	--	--	[D]

c. EPA IRIS Data Base (March 1996).
d. USEPA ORD Health Effects Assessment Summary Tables (HEAST) FY 1995 Annual (May 1995) and FY-1995 Supplement (Nov. 1995).
u. EPA 1995. Supplemental Guidance to RAGS: Region IV Bulletins. Toxicity Assessment, Bulletin No. 2, Version No. 1, September 1995.

Table C-7. TEFs for Polycyclic Aromatic Hydrocarbons

Compound	TEF
Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenzo(a,h)anthracene	1.0
Indeno(1,2,3-cd)pyrene	0.1
Source: EPA Region IV guidance (EPA 1995c)	

Table C-8. Toxicity Values for Evaluation of Noncancer and Carcinogenic Effects: Dermal Pathway

	Dermal Route Chronic RfD [a] (mg/kg/day)	Dermal Route Slope Factor [b] $(mg/kg/day)^{-1}$	Gastrointestinal Absorption Factor (unitless)	Source	Dermal Absorption Factor (unitless)	Source
INORGANICS						
Aluminum	--	--	0.1	c	0.001	h
Arsenic	1.23E-04	3.66E+00	0.41	c	0.001	h
Beryllium	5.00E-05	4.30E+02	0.01	c	0.001	h
Chromium, hexavalent	1.00E-04	--	0.02	c	0.001	h
Iron	--	--	0.15	c	0.001	h
Manganese	2.00E-03	--	0.04	c	0.001	h
Sodium	--	--	1	c	0.001	h
Vanadium	7.00E-05	--	0.01	c	0.001	h
ORGANICS						
Benzo(a)pyrene	9.30E-03	2.35E+01	0.31	c	0.01	h
Benzo(g,h,i)perylene	9.30E-03	--	0.31	c	0.01	h

a. RfD: Reference dose. RfC: Reference concentration.
b. Inhalation RfCs have been converted to inhalation RfDs by multiplying by 20m3/day and dividing by 70 kg.
c. EPA IRIS Data Base (March 1996).
h. In the absence of toxicity data, the RfDs for pyrene have been adopted for this compound.

Table C-9. Risk characterization for soil (0 to 1 foot): FDTF on-unit workers - ingestion exposure (current land use)

		Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)									
Manganese	5.22E+01	6.13E-07	0.024	2.55E-05	99.6%	4.38E-08	--	--	--
ORGANICS (mg/kg)									
Benzo(a)pyrene	1.44E-01	1.69E-09	0.03	5.64E-08	0.2%	1.21E-10	7.3	8.82E-10	100.0%
Benzo(g,h,i)perylene	1.21E-01	1.42E-09	0.03	4.74E-08	0.2%	1.01E-10	--	--	--
Chemical hazards combined exposure:									
Hazard index (HI):				2.56E-05	100%				
Excess lifetime cancer risk:								8.82E-10	100%

[a] $$CDI = \frac{(EPC \times CF \times IR \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor - Chemicals (0.000001 kg soil/mg soil)
IR	=	Ingestion Rate (50 mg soil/day)
EF	=	Exposure Frequency (6 days/year)
ED	=	Exposure Duration (5 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (1825 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 10. Risk characterization for soil (0 to 1 foot): FDTF on-unit workers - dermal exposure (current land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Dermal Absorption Factor	Chronic Daily Intake [a]	Dermal RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Dermal CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Manganese	5.22E+01	0.001	7.11E-08	0.002	3.55E-05	98.9%	5.08E-09	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	0.010	1.96E-09	0.009	2.11E-07	0.6%	1.40E-10	23.548	3.30E-09	100.0%
Benzo(g,h,i)perylene	1.21E-01	0.010	1.65E-09	0.009	1.77E-07	0.5%	1.18E-10	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					3.59E-05	100%				
Excess lifetime cancer risk:									3.30E-09	100%

[a] $$CDI = \frac{(EPC \times CF \times SA \times AF \times ABS \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor (0.000001 kg soil/mg soil)
SA	=	Skin Surface Area Available (5800 cm2/day)
AF	=	Soil-to-skin Adherence Factor (1 mg soil/cm2)
ABS	=	Dermal Absorption Factor (chemical specific - unitless)
EF	=	Exposure Frequency (6 days/year)
ED	=	Exposure Duration (5 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (1825 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 11. Risk characterization for soil (0 to 1 foot): FDTF on-unit workers - inhalation exposure (current land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Particulate Emission Factor (PEF)	Chronic Daily Intake [a]	Inhalation RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Inhalation CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Manganese	5.22E+01	4.630E+09	5.30E-11	1.4E-05	3.71E-06	100.0%	3.78E-12	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	4.630E+09	1.46E-13	--	--	--	1.04E-14	3.1	3.23E-14	100.0%
Benzo(g,h,i)perylene	1.21E-01	4.630E+09	1.23E-13	--	--	--	8.77E-15	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					3.71E-06	100%				
Excess lifetime cancer risk:									3.23E-14	100%

[a] $$CDI = \frac{(EPC \times IR \times EF \times ED)}{(PEF \times BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
IR	=	Inhalation Rate (20 m3 air/day)
EF	=	Exposure Frequency (6 days/year)
ED	=	Exposure Duration (5 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (1825 days)
AT	=	Averaging Time - Cancer (25550 days)
PEF	=	Particulate Emission Factor (4.63E+09 m3 air/kg soil)

Table C - 12. Risk characterization for soil (0 to 1 foot): FDTF industrial workers - ingestion exposure (future land use)

		Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)									
Manganese	5.22E+01	2.55E-05	0.024	1.06E-03	99.6%	9.12E-06	--	--	--
ORGANICS (mg/kg)									
Benzo(a)pyrene	1.44E-01	7.05E-08	0.03	2.35E-06	0.2%	2.52E-08	7.3	1.84E-07	100.0%
Benzo(g,h,i)perylene	1.21E-01	5.92E-08	0.03	1.97E-06	0.2%	2.11E-08	--	--	--
Chemical hazards combined exposure:									
Hazard index (HI):				1.07E-03	100%				
Excess lifetime cancer risk:								1.84E-07	100%

[a] $$CDI = \frac{(EPC \times CF \times IR \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor - Chemicals (0.000001 kg soil/mg soil)
IR	=	Ingestion Rate (50 mg soil/day)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 13. Risk characterization for soil (0 to 1 foot): FDTF industrial workers - dermal exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Dermal Absorption Factor	Chronic Daily Intake [a]	Dermal RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Dermal CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Manganese	5.22E+01	0.001	2.96E-06	0.002	1.48E-03	98.9%	1.06E-06	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	0.010	8.17E-08	0.009	8.79E-06	0.6%	2.92E-08	23.548	6.87E-07	100.0%
Benzo(g,h,i)perylene	1.21E-01	0.010	6.87E-08	0.009	7.38E-06	0.5%	2.45E-08	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					1.50E-03	100%				
Excess lifetime cancer risk:									6.87E-07	100%

[a] $$CDI = \frac{(EPC \times CF \times SA \times AF \times ABS \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor (0.000001 kg soil/mg soil)
SA	=	Skin Surface Area Available (5800 cm2/day)
AF	=	Soil-to-skin Adherence Factor (1 mg soil/cm2)
ABS	=	Dermal Absorption Factor (chemical specific - unitless)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 14. Risk characterization for soil (0 to 1 foot): FDTF industrial workers - inhalation exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Particulate Emission Factor (PEF)	Chronic Daily Intake [a]	Inhalation RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Inhalation CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Manganese	5.22E+01	4.630E+09	2.21E-09	1.4E-05	1.54E-04	100.0%	7.88E-10	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	4.630E+09	6.09E-12	--	--	--	2.17E-12	3.1	6.74E-12	100.0%
Benzo(g,h,i)perylene	1.21E-01	4.630E+09	5.11E-12	--	--	--	1.83E-12	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					1.54E-04	100%				
Excess lifetime cancer risk:									6.74E-12	100%

[a] $$CDI = \frac{(EPC \times IR \times EF \times ED)}{(PEF \times BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
IR	=	Inhalation Rate (20 m3 air/day)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)
PEF	=	Particulate Emission Factor (4.63E+09 m3 air/kg soil)

Table C - 15. Risk characterization for soil (0 to 4 feet): FDTF industrial workers - ingestion exposure (future land use)

		Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)									
Aluminum	1.04E+04	5.09E-03	--	--	--	1.82E-03	--	--	--
Arsenic	6.00E+00	2.94E-06	3E-04	9.78E-03	10.6%	1.05E-06	1.5	1.57E-06	84.1%
Beryllium	1.50E-01	7.34E-08	0.005	1.47E-05	0.0%	2.62E-08	4.3	1.13E-07	6.0%
Chromium, hexavalent	3.85E+01	1.88E-05	0.005	3.77E-03	4.1%	6.73E-06	--	--	--
Iron	4.40E+04	2.15E-02	0.3	7.18E-02	77.7%	7.69E-03	--	--	--
Manganese	5.40E+01	2.64E-05	0.024	1.10E-03	1.2%	9.44E-06	--	--	--
Sodium	7.05E+01	3.45E-05	--	--	--	1.23E-05	--	--	--
Vanadium	8.46E+01	4.14E-05	0.007	5.91E-03	6.4%	1.48E-05	--	--	--
ORGANICS (mg/kg)									
Benzo(a)pyrene	1.44E-01	7.05E-08	0.03	2.35E-06	0.0%	2.52E-08	7.3	1.84E-07	9.8%
Benzo(g,h,i)perylene	1.21E-01	5.92E-08	0.03	1.97E-06	0.0%	2.11E-08	--	--	--
Chemical hazards combined exposure:									
Hazard index (HI):				9.23E-02	100%				
Excess lifetime cancer risk:								1.87E-06	100%

[a] $$CDI = \frac{(EPC \times CF \times IR \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor - Chemicals (0.000001 kg soil/mg soil)
IR	=	Ingestion Rate (50 mg soil/day)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 16. Risk characterization for soil (0 to 4 feet): FDTF industrial workers - dermal exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Dermal Absorption Factor	Chronic Daily Intake [a]	Dermal RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Dermal CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	1.04E+04	0.001	5.90E-04	--	--	--	2.11E-04	--	--	--
Arsenic	6.00E+00	0.001	3.41E-07	1E-04	2.77E-03	2.9%	1.22E-07	3.6585	4.45E-07	18.2%
Beryllium	1.50E-01	0.001	8.51E-09	5E-05	1.70E-04	0.2%	3.04E-09	430	1.31E-06	53.6%
Chromium, hexavalent	3.85E+01	0.001	2.18E-06	1E-04	2.18E-02	23.0%	7.80E-07	--	--	--
Iron	4.40E+04	0.001	2.50E-03	--	--	--	8.92E-04	--	--	--
Manganese	5.40E+01	0.001	3.06E-06	0.002	1.53E-03	1.6%	1.09E-06	--	--	--
Sodium	7.05E+01	0.001	4.00E-06	--	--	--	1.43E-06	--	--	--
Vanadium	8.46E+01	0.001	4.80E-06	7E-05	6.86E-02	72.3%	1.71E-06	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	0.010	8.17E-08	0.009	8.79E-06	0.0%	2.92E-08	23.548	6.87E-07	28.2%
Benzo(g,h,i)perylene	1.21E-01	0.010	6.87E-08	0.009	7.38E-06	0.0%	2.45E-08	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	9.49E-02	100%
Excess lifetime cancer risk:		2.44E-06 100%

[a] $$CDI = \frac{(EPC \times CF \times SA \times AF \times ABS \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor (0.000001 kg soil/mg soil)
SA	=	Skin Surface Area Available (5800 cm2/day)
AF	=	Soil-to-skin Adherence Factor (1 mg soil/cm2)
ABS	=	Dermal Absorption Factor (chemical specific - unitless)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 17. Risk characterization for soil (0 to 4 feet): FDTF industrial workers - inhalation exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Particulate Emission Factor (PEF)	Chronic Daily Intake [a]	Inhalation RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Inhalation CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	1.04E+04	4.630E+09	4.40E-07	--	--	--	1.57E-07	--	--	--
Arsenic	6.00E+00	4.630E+09	2.54E-10	--	--	--	9.06E-11	50	4.53E-09	16.0%
Beryllium	1.50E-01	4.630E+09	6.34E-12	--	--	--	2.26E-12	8.4	1.90E-11	0.1%
Chromium, hexavalent	3.85E+01	4.630E+09	1.63E-09	--	--	--	5.81E-10	41	2.38E-08	84.0%
Iron	4.40E+04	4.630E+09	1.86E-06	--	--	--	6.64E-07	--	--	--
Manganese	5.40E+01	4.630E+09	2.28E-09	1.4E-05	1.60E-04	100.0%	8.15E-10	--	--	--
Sodium	7.05E+01	4.630E+09	2.98E-09	--	--	--	1.06E-09	--	--	--
Vanadium	8.46E+01	4.630E+09	3.58E-09	--	--	--	1.28E-09	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	4.630E+09	6.09E-12	--	--	--	2.17E-12	3.1	6.74E-12	0.0%
Benzo(g,h,i)perylene	1.21E-01	4.630E+09	5.11E-12	--	--	--	1.83E-12	--	--	--

Chemical hazards combined exposure:

Hazard index (HI): 1.60E-04 | 100%

Excess lifetime cancer risk: 2.84E-08 | 100%

[a] $$CDI = \frac{(EPC \times IR \times EF \times ED)}{(PEF \times BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
IR	=	Inhalation Rate (20 m3 air/day)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)
PEF	=	Particulate Emission Factor (4.63E+09 m3 air/kg soil)

Table C - 18. Risk characterization for soil (0 to 1 foot): FDTF residents - ingestion exposure (future land use)

		Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)									
Manganese	5.22E+01	6.67E-04	0.024	2.78E-02	99.6%	8.17E-05	--	--	--
ORGANICS (mg/kg)									
Benzo(a)pyrene	1.44E-01	1.84E-06	0.03	6.14E-05	0.2%	2.25E-07	7.3	1.65E-06	100.0%
Benzo(g,h,i)perylene	1.21E-01	1.55E-06	0.03	5.16E-05	0.2%	1.89E-07	--	--	--
Chemical hazards combined exposure:									
Hazard index (HI):				2.79E-02	100%				
Excess lifetime cancer risk:								1.65E-06	100%

[a] $$CDI = \frac{(EPC \times CF \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor - Chemicals (0.000001 kg soil/mg soil)
IR	=	Ingestion Rate - Child (200 mg soil/day)
IR	=	Ingestion Rate - Adult (100 mg soil/day)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 19. Risk characterization for soil (0 to 1 foot): FDTF residents - dermal exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Dermal Absorption Factor	Chronic Daily Intake [a]	Dermal RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Dermal CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Manganese	5.22E+01	0.001	6.71E-06	0.002	3.35E-03	98.9%	2.00E-06	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	0.010	1.85E-07	0.009	1.99E-05	0.6%	5.51E-08	23.548	1.30E-06	100.0%
Benzo(g,h,i)perylene	1.21E-01	0.010	1.55E-07	0.009	1.67E-05	0.5%	4.63E-08	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					3.39E-03	100%				
Excess lifetime cancer risk:									1.30E-06	100%

[a] $$CDI = \frac{(EPC \times CF \times SA_c \times AF \times ABS \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times CF \times \left[\frac{(SA_c \times AF \times ABS \times EF \times ED_c)}{(BW_c)} + \frac{(SA_a \times AF \times ABS \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor (0.000001 kg soil/mg soil)
SA	=	Skin Surface Area Available - Child (2010 cm2/day)
SA	=	Skin Surface Area Available - Adult (5800 cm2/day)
AF	=	Soil-to-skin Adherence Factor (1 mg soil/cm2)
ABS	=	Dermal Absorption Factor (chemical specific - unitless)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (days)

Table C - 20. Risk characterization for soil (0 to 1 foot): FDTF residents - inhalation exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Particulate Emission Factor (PEF)	Chronic Daily Intake [a]	Inhalation RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Inhalation CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Manganese	5.22E+01	4.630E+09	1.08E-08	1.4E-05	7.57E-04	100.0%	1.99E-09	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	4.630E+09	2.98E-11	--	--	--	5.48E-12	3.1	1.70E-11	100.0%
Benzo(g,h,i)perylene	1.21E-01	4.630E+09	2.51E-11	--	--	--	4.60E-12	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					7.57E-04	100%				
Excess lifetime cancer risk:									1.70E-11	100%

[a] $$CDI = \frac{(EPC \times IR_c \times EF \times ED_c)}{(PEF \times BW_c \times AT_{nc})}$$

[a] $$CDI = \frac{EPC}{PEF} \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
IR	=	Inhalation Rate - Child (15 m3 air/day)
IR	=	Inhalation Rate - Adult (20 m3 air/day)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (days)
PEF	=	Particulate Emission Factor (4.63E+09 m3 air/kg soil)

Table C - 21. Risk characterization for soil (0 to 4 feet): FDTF residents - ingestion exposure (future land use)

		Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)									
Aluminum	1.04E+04	1.33E-01	--	--	--	1.63E-02	--	--	--
Arsenic	6.00E+00	7.67E-05	3E-04	2.56E-01	10.6%	9.39E-06	1.5	1.41E-05	84.1%
Beryllium	1.50E-01	1.92E-06	0.005	3.84E-04	0.0%	2.35E-07	4.3	1.01E-06	6.0%
Chromium, hexavalent	3.85E+01	4.92E-04	0.005	9.84E-02	4.1%	6.03E-05	--	--	--
Iron	4.40E+04	5.63E-01	0.3	1.88E+00	77.7%	6.89E-02	--	--	--
Manganese	5.40E+01	6.90E-04	0.024	2.88E-02	1.2%	8.45E-05	--	--	--
Sodium	7.05E+01	9.01E-04	--	--	--	1.10E-04	--	--	--
Vanadium	8.46E+01	1.08E-03	0.007	1.55E-01	6.4%	1.32E-04	--	--	--
ORGANICS (mg/kg)									
Benzo(a)pyrene	1.44E-01	1.84E-06	0.03	6.14E-05	0.0%	2.25E-07	7.3	1.65E-06	9.8%
Benzo(g,h,i)perylene	1.21E-01	1.55E-06	0.03	5.16E-05	0.0%	1.89E-07	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	2.41E+00	100%
Excess lifetime cancer risk:	1.67E-05	100%

[a] $$CDI = \frac{(EPC \times CF \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor - Chemicals (0.000001 kg soil/mg soil)
IR	=	Ingestion Rate - Child (200 mg soil/day)
IR	=	Ingestion Rate - Adult (100 mg soil/day)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 22. Risk characterization for soil (0 to 4 feet): FDTF residents - dermal exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Dermal Absorption Factor	Chronic Daily Intake [a]	Dermal RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Dermal CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	1.04E+04	0.001	1.34E-03	--	--	--	3.98E-04	--	--	--
Arsenic	6.00E+00	0.001	7.71E-07	1E-04	6.27E-03	2.9%	2.30E-07	3.6585	8.40E-07	18.2%
Beryllium	1.50E-01	0.001	1.93E-08	5E-05	3.85E-04	0.2%	5.74E-09	430	2.47E-06	53.6%
Chromium, hexavalent	3.85E+01	0.001	4.95E-06	1E-04	4.95E-02	23.0%	1.47E-06	--	--	--
Iron	4.40E+04	0.001	5.65E-03	--	--	--	1.68E-03	--	--	--
Manganese	5.40E+01	0.001	6.94E-06	0.002	3.47E-03	1.6%	2.07E-06	--	--	--
Sodium	7.05E+01	0.001	9.06E-06	--	--	--	2.70E-06	--	--	--
Vanadium	8.46E+01	0.001	1.09E-05	7E-05	1.55E-01	72.3%	3.24E-06	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	0.010	1.85E-07	0.009	1.99E-05	0.0%	5.51E-08	23.548	1.30E-06	28.2%
Benzo(g,h,i)perylene	1.21E-01	0.010	1.55E-07	0.009	1.67E-05	0.0%	4.63E-08	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	2.15E-01	100%
Excess lifetime cancer risk:	4.60E-06	100%

[a] $$CDI = \frac{(EPC \times CF \times SA_c \times AF \times ABS \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times CF \times \left[\frac{(SA_c \times AF \times ABS \times EF \times ED_c)}{(BW_c)} + \frac{(SA_a \times AF \times ABS \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor (0.000001 kg soil/mg soil)
SA	=	Skin Surface Area Available - Child (2010 cm2/day)
SA	=	Skin Surface Area Available - Adult (5800 cm2/day)
AF	=	Soil-to-skin Adherence Factor (1 mg soil/cm2)
ABS	=	Dermal Absorption Factor (chemical specific - unitless)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (days)

Table C - 23. Risk characterization for soil (0 to 4 feet): FDTF residents - inhalation exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Particulate Emission Factor (PEF)	Chronic Daily Intake [a]	Inhalation RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Inhalation CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	1.04E+04	4.630E+09	2.15E-06	--	--	--	3.96E-07	--	--	--
Arsenic	6.00E+00	4.630E+09	1.24E-09	--	--	--	2.28E-10	50	1.14E-08	16.0%
Beryllium	1.50E-01	4.630E+09	3.11E-11	--	--	--	5.71E-12	8.4	4.79E-11	0.1%
Chromium, hexavalent	3.85E+01	4.630E+09	7.97E-09	--	--	--	1.46E-09	41	6.00E-08	84.0%
Iron	4.40E+04	4.630E+09	9.11E-06	--	--	--	1.67E-06	--	--	--
Manganese	5.40E+01	4.630E+09	1.12E-08	1.4E-05	7.83E-04	100.0%	2.05E-09	--	--	--
Sodium	7.05E+01	4.630E+09	1.46E-08	--	--	--	2.68E-09	--	--	--
Vanadium	8.46E+01	4.630E+09	1.75E-08	--	--	--	3.22E-09	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	4.630E+09	2.98E-11	--	--	--	5.48E-12	3.1	1.70E-11	0.0%
Benzo(g,h,i)perylene	1.21E-01	4.630E+09	2.51E-11	--	--	--	4.60E-12	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	7.83E-04	100%
Excess lifetime cancer risk:	7.15E-08	100%

[a] $$CDI = \frac{(EPC \times IR_c \times EF \times ED_c)}{(PEF \times BW_c \times AT_{nc})}$$

[a] $$CDI = \frac{EPC}{PEF} \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
IR	=	Inhalation Rate - Child (15 m3 air/day)
IR	=	Inhalation Rate - Adult (20 m3 air/day)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (days)
PEF	=	Particulate Emission Factor (4.63E+09 m3 air/kg soil)

Table C - 24. Risk characterization for leafy vegetables (0 to 1 foot soil): FDTF residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Leafy Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Manganese	5.22E+01	5.60E-01	3.30E-03	0.024	1.37E-01	100.0%	9.34E-04	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	8.72E-08	1.42E-12	0.03	4.72E-11	0.0%	4.01E-13	7.3	2.93E-12	100.0%
Benzo(g,h,i)perylene	1.21E-01	3.64E-09	4.96E-14	0.03	1.65E-12	0.0%	1.41E-14	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					1.37E-01	100%				
Excess lifetime cancer risk:									2.93E-12	100%

[a] $$CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)}\right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.042 unitless)
IR	=	Ingestion Rate - Child (0.042 kg produce/day)
IR	=	Ingestion Rate - Adult (0.113 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 25. Risk characterization for tuberous vegetables (0 to 1 foot soil): FDTF residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Tuber Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Manganese	5.22E+01	1.50E-01	4.47E-03	0.024	1.86E-01	99.9%	1.27E-03	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	7.07E-02	5.81E-06	0.03	1.94E-04	0.1%	1.65E-06	7.3	1.20E-05	100.0%
Benzo(g,h,i)perylene	1.21E-01	3.61E-02	2.49E-06	0.03	8.31E-05	0.0%	7.07E-07	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					1.86E-01	100%				
Excess lifetime cancer risk:									1.20E-05	100%

[a] $$CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)}\right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.119 unitless)
IR	=	Ingestion Rate - Child (0.075 kg produce/day)
IR	=	Ingestion Rate - Adult (0.202 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 26. Risk characterization for fruits (0 to 1 foot soil): FDTF residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Tuber Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Manganese	5.22E+01	5.00E-02	3.66E-03	0.024	1.52E-01	100.0%	1.05E-03	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	1.32E-09	2.67E-13	0.03	8.90E-12	0.0%	7.65E-14	7.3	5.58E-13	100.0%
Benzo(g,h,i)perylene	1.21E-01	5.43E-11	9.20E-15	0.03	3.07E-13	0.0%	2.64E-15	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					1.52E-01	100%				
Excess lifetime cancer risk:									5.58E-13	100%

[a] $$CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EFxED_c)}{(BW_c)} + \frac{(IR_a \times EFxED_a)}{(BW_a)}\right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.487 unitless)
IR	=	Ingestion Rate - Child (0.045 kg produce/day)
IR	=	Ingestion Rate - Adult (0.123 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 27. Risk characterization for leafy vegetables (0 to 4 feet soil): FDTF residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Leafy Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	1.04E+04	4.00E-03	4.69E-03	--	--	--	1.33E-03	--	--	--
Arsenic	6.00E+00	4.00E-02	2.71E-05	3E-04	9.02E-02	29.3%	7.67E-06	1.5	1.15E-05	98.2%
Beryllium	1.50E-01	1.00E-02	1.69E-07	0.005	3.38E-05	0.0%	4.79E-08	4.3	2.06E-07	1.8%
Chromium, hexavalent	3.85E+01	7.50E-03	3.26E-05	0.005	6.51E-03	2.1%	9.23E-06	--	--	--
Iron	4.40E+04	4.00E-03	1.98E-02	0.3	6.62E-02	21.5%	5.62E-03	--	--	--
Manganese	5.40E+01	5.60E-01	3.41E-03	0.024	1.42E-01	46.2%	9.66E-04	--	--	--
Sodium	7.05E+01	7.50E-02	5.96E-04	--	--	--	1.69E-04	--	--	--
Vanadium	8.46E+01	2.00E-03	1.91E-05	0.007	2.73E-03	0.9%	5.41E-06	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	8.72E-08	1.42E-12	0.03	4.72E-11	0.0%	4.01E-13	7.3	2.93E-12	0.0%
Benzo(g,h,i)perylene	1.21E-01	3.64E-09	4.96E-14	0.03	1.65E-12	0.0%	1.41E-14	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	3.08E-01	100%
Excess lifetime cancer risk:	1.17E-05	100%

[a] $$CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)}\right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.042 unitless)
IR	=	Ingestion Rate - Child (0.042 kg produce/day)
IR	=	Ingestion Rate - Adult (0.113 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 28. Risk characterization for tuberous vegetables (0 to 4 feet soil): FDTF residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Tuber Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	1.04E+04	4.00E-03	2.37E-02	--	--	--	6.73E-03	--	--	--
Arsenic	6.00E+00	6.00E-03	2.05E-05	3E-04	6.85E-02	18.1%	5.82E-06	1.5	8.74E-06	41.8%
Beryllium	1.50E-01	1.50E-03	1.28E-07	0.005	2.57E-05	0.0%	3.64E-08	4.3	1.57E-07	0.7%
Chromium, hexavalent	3.85E+01	4.50E-03	9.88E-05	0.005	1.98E-02	5.2%	2.80E-05	--	--	--
Iron	4.40E+04	1.00E-03	2.51E-02	0.3	8.37E-02	22.1%	7.12E-03	--	--	--
Manganese	5.40E+01	1.50E-01	4.62E-03	0.024	1.93E-01	50.9%	1.31E-03	--	--	--
Sodium	7.05E+01	5.50E-02	2.21E-03	--	--	--	6.27E-04	--	--	--
Vanadium	8.46E+01	2.00E-03	9.65E-05	0.007	1.38E-02	3.6%	2.74E-05	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	7.07E-02	5.81E-06	0.03	1.94E-04	0.1%	1.65E-06	7.3	1.20E-05	57.5%
Benzo(g,h,i)perylene	1.21E-01	3.61E-02	2.49E-06	0.03	8.31E-05	0.0%	7.07E-07	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	3.79E-01	100%
Excess lifetime cancer risk:	2.09E-05	100%

[a] $$CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)}\right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.119 unitless)
IR	=	Ingestion Rate - Child (0.075 kg produce/day)
IR	=	Ingestion Rate - Adult (0.202 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 29. Risk characterization for fruits (0 to 4 feet soil): FDTF residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Tuber Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	1.04E+04	4.00E-03	5.83E-02	--	--	--	1.67E-02	--	--	--
Arsenic	6.00E+00	6.00E-03	5.04E-05	3E-04	1.68E-01	27.4%	1.45E-05	1.5	2.17E-05	98.2%
Beryllium	1.50E-01	1.50E-03	3.15E-07	0.005	6.30E-05	0.0%	9.03E-08	4.3	3.88E-07	1.8%
Chromium, hexavalent	3.85E+01	4.50E-03	2.43E-04	0.005	4.85E-02	7.9%	6.95E-05	--	--	--
Iron	4.40E+04	1.00E-03	6.16E-02	0.3	2.05E-01	33.5%	1.77E-02	--	--	--
Manganese	5.40E+01	5.00E-02	3.78E-03	0.024	1.58E-01	25.7%	1.08E-03	--	--	--
Sodium	7.05E+01	5.50E-02	5.43E-03	--	--	--	1.56E-03	--	--	--
Vanadium	8.46E+01	2.00E-03	2.37E-04	0.007	3.39E-02	5.5%	6.79E-05	--	--	--
ORGANICS (mg/kg)										
Benzo(a)pyrene	1.44E-01	1.32E-09	2.67E-13	0.03	8.90E-12	0.0%	7.65E-14	7.3	5.58E-13	0.0%
Benzo(g,h,i)perylene	1.21E-01	5.43E-11	9.20E-15	0.03	3.07E-13	0.0%	2.64E-15	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	6.14E-01	100%
Excess lifetime cancer risk:	2.21E-05	100%

[a] $$CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EFxED_c)}{(BW_c)} + \frac{(IR_a \times EFxED_a)}{(BW_a)}\right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.487 unitless)
IR	=	Ingestion Rate - Child (0.045 kg produce/day)
IR	=	Ingestion Rate - Adult (0.123 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 30. Risk characterization for soil (0 to 1 foot): Background on-unit workers - ingestion exposure (current land use)

		Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)									
Aluminum	9.52E+03	1.12E-04	--	--	--	7.98E-06	--	--	--
Arsenic	6.90E+00	8.10E-08	3E-04	2.70E-04	23.4%	5.79E-09	1.5	8.68E-09	92.2%
Beryllium	2.04E-01	2.40E-09	0.005	4.79E-07	0.0%	1.71E-10	4.3	7.36E-10	7.8%
Iron	1.94E+04	2.28E-04	0.3	7.59E-04	65.9%	1.63E-05	--	--	--
Manganese	4.79E+01	5.62E-07	0.024	2.34E-05	2.0%	4.02E-08	--	--	--
Sodium	7.90E+01	9.28E-07	--	--	--	6.63E-08	--	--	--
Vanadium	5.93E+01	6.96E-07	0.007	9.95E-05	8.6%	4.97E-08	--	--	--
Chemical hazards combined exposure:									
Hazard index (HI):				1.15E-03	100%				
Excess lifetime cancer risk:								9.42E-09	100%

[a] $$CDI = \frac{(EPC \times CF \times IR \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor - Chemicals (0.000001 kg soil/mg soil)
IR	=	Ingestion Rate (50 mg soil/day)
EF	=	Exposure Frequency (6 days/year)
ED	=	Exposure Duration (5 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (1825 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 31. Risk characterization for soil (0 to 1 foot): Background on-unit workers - dermal exposure (current land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Dermal Absorption Factor	Chronic Daily Intake [a]	Dermal RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Dermal CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	9.52E+03	0.001	1.30E-05	--	--	--	9.26E-07	--	--	--
Arsenic	6.90E+00	0.001	9.40E-09	1E-04	7.64E-05	6.0%	6.71E-10	3.6585	2.46E-09	22.3%
Beryllium	2.04E-01	0.001	2.78E-10	5E-05	5.56E-06	0.4%	1.98E-11	430	8.53E-09	77.7%
Iron	1.94E+04	0.001	2.64E-05	--	--	--	1.89E-06	--	--	--
Manganese	4.79E+01	0.001	6.52E-08	0.002	3.26E-05	2.6%	4.66E-09	--	--	--
Sodium	7.90E+01	0.001	1.08E-07	--	--	--	7.69E-09	--	--	--
Vanadium	5.93E+01	0.001	8.08E-08	7E-05	1.15E-03	91.0%	5.77E-09	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					1.27E-03	100%				
Excess lifetime cancer risk:									1.10E-08	100%

[a] $$CDI = \frac{(EPC \times CF \times SA \times AF \times ABS \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor (0.000001 kg soil/mg soil)
SA	=	Skin Surface Area Available (5800 cm2/day)
AF	=	Soil-to-skin Adherence Factor (1 mg soil/cm2)
ABS	=	Dermal Absorption Factor (chemical specific - unitless)
EF	=	Exposure Frequency (6 days/year)
ED	=	Exposure Duration (5 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (1825 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 32. Risk characterization for soil (0 to 1 foot): Background on-unit workers - inhalation exposure (current land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Particulate Emission Factor (PEF)	Chronic Daily Intake [a]	Inhalation RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Inhalation CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	9.52E+03	4.630E+09	9.66E-09	--	--	--	6.90E-10	--	--	--
Arsenic	6.90E+00	4.630E+09	7.00E-12	--	--	--	5.00E-13	50	2.50E-11	99.5%
Beryllium	2.04E-01	4.630E+09	2.07E-13	--	--	--	1.48E-14	8.4	1.24E-13	0.5%
Iron	1.94E+04	4.630E+09	1.97E-08	--	--	--	1.41E-09	--	--	--
Manganese	4.79E+01	4.630E+09	4.86E-11	1.4E-05	3.40E-06	100.0%	3.47E-12	--	--	--
Sodium	7.90E+01	4.630E+09	8.01E-11	--	--	--	5.72E-12	--	--	--
Vanadium	5.93E+01	4.630E+09	6.02E-11	--	--	--	4.30E-12	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	3.40E-06	100%
Excess lifetime cancer risk:		2.51E-11 | 100%

[a] $$CDI = \frac{(EPC \times IR \times EF \times ED)}{(PEF \times BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
IR	=	Inhalation Rate (20 m3 air/day)
EF	=	Exposure Frequency (6 days/year)
ED	=	Exposure Duration (5 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (1825 days)
AT	=	Averaging Time - Cancer (25550 days)
PEF	=	Particulate Emission Factor (4.63E+09 m3 air/kg soil)

Table C - 33. Risk characterization for soil (0 to 1 foot): Background industrial workers - ingestion exposure (future land use)

		Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)									
Aluminum	9.52E+03	4.66E-03	--	--	--	1.66E-03	--	--	--
Arsenic	6.90E+00	3.38E-06	3E-04	1.13E-02	23.4%	1.21E-06	1.5	1.81E-06	92.2%
Beryllium	2.04E-01	9.98E-08	0.005	2.00E-05	0.0%	3.56E-08	4.3	1.53E-07	7.8%
Iron	1.94E+04	9.49E-03	0.3	3.16E-02	65.9%	3.39E-03	--	--	--
Manganese	4.79E+01	2.34E-05	0.024	9.76E-04	2.0%	8.37E-06	--	--	--
Sodium	7.90E+01	3.86E-05	--	--	--	1.38E-05	--	--	--
Vanadium	5.93E+01	2.90E-05	0.007	4.14E-03	8.6%	1.04E-05	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	4.80E-02	100%
Excess lifetime cancer risk:		1.96E-06 | 100%

[a] $$CDI = \frac{(EPC \times CF \times IR \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor - Chemicals (0.000001 kg soil/mg soil)
IR	=	Ingestion Rate (50 mg soil/day)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 34. Risk characterization for soil (0 to 1 foot): Background industrial workers - dermal exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Dermal Absorption Factor	Chronic Daily Intake [a]	Dermal RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Dermal CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	9.52E+03	0.001	5.40E-04	--	--	--	1.93E-04	--	--	--
Arsenic	6.90E+00	0.001	3.92E-07	1E-04	3.18E-03	6.0%	1.40E-07	3.6585	5.12E-07	22.3%
Beryllium	2.04E-01	0.001	1.16E-08	5E-05	2.32E-04	0.4%	4.13E-09	430	1.78E-06	77.7%
Iron	1.94E+04	0.001	1.10E-03	--	--	--	3.93E-04	--	--	--
Manganese	4.79E+01	0.001	2.72E-06	0.002	1.36E-03	2.6%	9.71E-07	--	--	--
Sodium	7.90E+01	0.001	4.48E-06	--	--	--	1.60E-06	--	--	--
Vanadium	5.93E+01	0.001	3.37E-06	7E-05	4.81E-02	91.0%	1.20E-06	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					5.29E-02	100%				
Excess lifetime cancer risk:									2.29E-06	100%

[a] $CDI = \frac{(EPC \times CF \times SA \times AF \times ABS \times EF \times ED)}{(BW \times AT)}$

[b] $HQ = \frac{CDI}{RfD}$

[c] $ELCR = CDI \times CSF$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor (0.000001 kg soil/mg soil)
SA	=	Skin Surface Area Available (5800 cm2/day)
AF	=	Soil-to-skin Adherence Factor (1 mg soil/cm2)
ABS	=	Dermal Absorption Factor (chemical specific - unitless)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 35. Risk characterization for soil (0 to 1 foot): Background industrial workers - inhalation exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Particulate Emission Factor (PEF)	Chronic Daily Intake [a]	Inhalation RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Inhalation CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	9.52E+03	4.630E+09	4.02E-07	--	--	--	1.44E-07	--	--	--
Arsenic	6.90E+00	4.630E+09	2.92E-10	--	--	--	1.04E-10	50	5.21E-09	99.5%
Beryllium	2.04E-01	4.630E+09	8.62E-12	--	--	--	3.08E-12	8.4	2.59E-11	0.5%
Iron	1.94E+04	4.630E+09	8.20E-07	--	--	--	2.93E-07	--	--	--
Manganese	4.79E+01	4.630E+09	2.02E-09	1.4E-05	1.42E-04	100.0%	7.23E-10	--	--	--
Sodium	7.90E+01	4.630E+09	3.34E-09	--	--	--	1.19E-09	--	--	--
Vanadium	5.93E+01	4.630E+09	2.51E-09	--	--	--	8.95E-10	--	--	--

Chemical hazards combined exposure:

Hazard index (HI): 1.42E-04 | 100%

Excess lifetime cancer risk: 5.23E-09 | 100%

[a] $$CDI = \frac{(EPC \times IR \times EF \times ED)}{(PEF \times BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
IR	=	Inhalation Rate (20 m3 air/day)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)
PEF	=	Particulate Emission Factor (4.63E+09 m3 air/kg soil)

Table C - 36. Risk characterization for soil (0 to 4 feet): Background industrial workers - ingestion exposure (future land use)

		Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)									
Aluminum	7.63E+03	3.73E-03	--	--	--	1.33E-03	--	--	--
Arsenic	5.32E+00	2.60E-06	3E-04	8.68E-03	17.1%	9.30E-07	1.5	1.39E-06	93.3%
Beryllium	1.33E-01	6.51E-08	0.005	1.30E-05	0.0%	2.32E-08	4.3	9.99E-08	6.7%
Iron	2.27E+04	1.11E-02	0.3	3.70E-02	72.8%	3.97E-03	--	--	--
Manganese	4.79E+01	2.34E-05	0.024	9.76E-04	1.9%	8.37E-06	--	--	--
Sodium	5.93E+01	2.90E-05	--	--	--	1.04E-05	--	--	--
Vanadium	5.93E+01	2.90E-05	0.007	4.14E-03	8.2%	1.04E-05	--	--	--
Chemical hazards combined exposure:									
Hazard index (HI):				5.08E-02	100%				
Excess lifetime cancer risk:								1.49E-06	100%

[a] $$CDI = \frac{(EPC \times CF \times IR \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor - Chemicals (0.000001 kg soil/mg soil)
IR	=	Ingestion Rate (50 mg soil/day)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 37. Risk characterization for soil (0 to 4 feet): Background industrial workers - dermal exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Dermal Absorption Factor	Chronic Daily Intake [a]	Dermal RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Dermal CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	7.63E+03	0.001	4.33E-04	--	--	--	1.55E-04	--	--	--
Arsenic	5.32E+00	0.001	3.02E-07	1E-04	2.45E-03	4.7%	1.08E-07	3.6585	3.94E-07	25.4%
Beryllium	1.33E-01	0.001	7.55E-09	5E-05	1.51E-04	0.3%	2.70E-09	430	1.16E-06	74.6%
Iron	2.27E+04	0.001	1.29E-03	--	--	--	4.60E-04	--	--	--
Manganese	4.79E+01	0.001	2.72E-06	0.002	1.36E-03	2.6%	9.71E-07	--	--	--
Sodium	5.93E+01	0.001	3.37E-06	--	--	--	1.20E-06	--	--	--
Vanadium	5.93E+01	0.001	3.37E-06	7E-05	4.81E-02	92.4%	1.20E-06	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					5.20E-02	100%				
Excess lifetime cancer risk:									1.55E-06	100%

[a] $$CDI = \frac{(EPC \times CF \times SA \times AF \times ABS \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor (0.000001 kg soil/mg soil)
SA	=	Skin Surface Area Available (5800 cm2/day)
AF	=	Soil-to-skin Adherence Factor (1 mg soil/cm2)
ABS	=	Dermal Absorption Factor (chemical specific - unitless)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 38. Risk characterization for soil (0 to 4 feet): Background industrial workers - inhalation exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Particulate Emission Factor (PEF)	Chronic Daily Intake [a]	Inhalation RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Inhalation CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	7.63E+03	4.630E+09	3.22E-07	--	--	--	1.15E-07	--	--	--
Arsenic	5.32E+00	4.630E+09	2.25E-10	--	--	--	8.03E-11	50	4.02E-09	99.6%
Beryllium	1.33E-01	4.630E+09	5.62E-12	--	--	--	2.01E-12	8.4	1.69E-11	0.4%
Iron	2.27E+04	4.630E+09	9.59E-07	--	--	--	3.43E-07	--	--	--
Manganese	4.79E+01	4.630E+09	2.02E-09	1.4E-05	1.42E-04	100.0%	7.23E-10	--	--	--
Sodium	5.93E+01	4.630E+09	2.51E-09	--	--	--	8.95E-10	--	--	--
Vanadium	5.93E+01	4.630E+09	2.51E-09	--	--	--	8.95E-10	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					1.42E-04	100%				
Excess lifetime cancer risk:									4.03E-09	100%

[a] $$CDI = \frac{(EPC \times IR \times EF \times ED)}{(PEF \times BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
IR	=	Inhalation Rate (20 m3 air/day)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)
PEF	=	Particulate Emission Factor (4.63E+09 m3 air/kg soil)

Table C - 39. Risk characterization for soil (0 to 1 foot): Background residents - ingestion exposure (future land use)

		Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)									
Aluminum	9.52E+03	1.22E-01	--	--	--	1.49E-02	--	--	--
Arsenic	6.90E+00	8.82E-05	3E-04	2.94E-01	23.4%	1.08E-05	1.5	1.62E-05	92.2%
Beryllium	2.04E-01	2.61E-06	0.005	5.22E-04	0.0%	3.19E-07	4.3	1.37E-06	7.8%
Iron	1.94E+04	2.48E-01	0.3	8.27E-01	65.9%	3.04E-02	--	--	--
Manganese	4.79E+01	6.12E-04	0.024	2.55E-02	2.0%	7.50E-05	--	--	--
Sodium	7.90E+01	1.01E-03	--	--	--	1.24E-04	--	--	--
Vanadium	5.93E+01	7.58E-04	0.007	1.08E-01	8.6%	9.28E-05	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	1.26E+00	100%
Excess lifetime cancer risk:	1.76E-05	100%

[a] $$CDI = \frac{(EPC \times CF \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{R.fD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor - Chemicals (0.000001 kg soil/mg soil)
IR	=	Ingestion Rate - Child (200 mg soil/day)
IR	=	Ingestion Rate - Adult (100 mg soil/day)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 40. Risk characterization for soil (0 to 1 foot): Background residents - dermal exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Dermal Absorption Factor	Chronic Daily Intake [a]	Dermal RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Dermal CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	9.52E+03	0.001	1.22E-03	--	--	--	3.64E-04	--	--	--
Arsenic	6.90E+00	0.001	8.87E-07	1E-04	7.21E-03	6.0%	2.64E-07	3.6585	9.66E-07	22.3%
Beryllium	2.04E-01	0.001	2.62E-08	5E-05	5.24E-04	0.4%	7.80E-09	430	3.36E-06	77.7%
Iron	1.94E+04	0.001	2.49E-03	--	--	--	7.42E-04	--	--	--
Manganese	4.79E+01	0.001	6.15E-06	0.002	3.08E-03	2.6%	1.83E-06	--	--	--
Sodium	7.90E+01	0.001	1.02E-05	--	--	--	3.02E-06	--	--	--
Vanadium	5.93E+01	0.001	7.62E-06	7E-05	1.09E-01	91.0%	2.27E-06	--	--	--

Chemical hazards combined exposure:

Hazard index (HI): 1.20E-01 | 100%

Excess lifetime cancer risk: 4.32E-06 | 100%

[a] $$CDI = \frac{(EPC \times CF \times SA_c \times AF \times ABS \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times CF \times \left[\frac{(SA_c \times AF \times ABS \times EF \times ED_c)}{(BW_c)} + \frac{(SA_a \times AF \times ABS \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor (0.000001 kg soil/mg soil)
SA	=	Skin Surface Area Available - Child (2010 cm2/day)
SA	=	Skin Surface Area Available - Adult (5800 cm2/day)
AF	=	Soil-to-skin Adherence Factor (1 mg soil/cm2)
ABS	=	Dermal Absorption Factor (chemical specific - unitless)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (days)

Table C - 41. Risk characterization for soil (0 to 1 foot): Background residents - inhalation exposure (future land use)

Parameter	Soil Exposure Point Concentration	Particulate Emission Factor (PEF)	Noncarcinogenic Effects: Chronic Daily Intake [a]	Inhalation RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Carcinogenic Effects: Chronic Daily Intake [a]	Inhalation CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	9.52E+03	4.630E+09	1.97E-06	--	--	--	3.62E-07	--	--	--
Arsenic	6.90E+00	4.630E+09	1.43E-09	--	--	--	2.62E-10	50	1.31E-08	99.5%
Beryllium	2.04E-01	4.630E+09	4.22E-11	--	--	--	7.76E-12	8.4	6.52E-11	0.5%
Iron	1.94E+04	4.630E+09	4.02E-06	--	--	--	7.38E-07	--	--	--
Manganese	4.79E+01	4.630E+09	9.92E-09	1.4E-05	6.94E-04	100.0%	1.82E-09	--	--	--
Sodium	7.90E+01	4.630E+09	1.64E-08	--	--	--	3.01E-09	--	--	--
Vanadium	5.93E+01	4.630E+09	1.23E-08	--	--	--	2.26E-09	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	6.94E-04	100%
Excess lifetime cancer risk:		1.32E-08 100%

[a] $$CDI = \frac{(EPC \times IR_c \times EF \times ED_c)}{(PEF \times BW_c \times AT_{nc})}$$

[a] $$CDI = \frac{EPC}{PEF} \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
IR	=	Inhalation Rate - Child (15 m3 air/day)
IR	=	Inhalation Rate - Adult (20 m3 air/day)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (days)
PEF	=	Particulate Emission Factor (4.63E+09 m3 air/kg soil)

Table C - 42. Risk characterization for soil (0 to 4 feet): Background residents - ingestion exposure (future land use)

		Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)									
Aluminum	7.63E+03	9.76E-02	--	--	--	1.19E-02	--	--	--
Arsenic	5.32E+00	6.80E-05	3E-04	2.27E-01	17.1%	8.33E-06	1.5	1.25E-05	93.3%
Beryllium	1.33E-01	1.70E-06	0.005	3.40E-04	0.0%	2.08E-07	4.3	8.95E-07	6.7%
Iron	2.27E+04	2.90E-01	0.3	9.67E-01	72.8%	3.55E-02	--	--	--
Manganese	4.79E+01	6.12E-04	0.024	2.55E-02	1.9%	7.50E-05	--	--	--
Sodium	5.93E+01	7.58E-04	--	--	--	9.28E-05	--	--	--
Vanadium	5.93E+01	7.58E-04	0.007	1.08E-01	8.2%	9.28E-05	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	1.33E+00	100%
Excess lifetime cancer risk:	1.34E-05	100%

[a] $$CDI = \frac{(EPC \times CF \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor - Chemicals (0.000001 kg soil/mg soil)
IR	=	Ingestion Rate - Child (200 mg soil/day)
IR	=	Ingestion Rate - Adult (100 mg soil/day)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 43. Risk characterization for soil (0 to 4 feet): Background residents - dermal exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Dermal Absorption Factor	Chronic Daily Intake [a]	Dermal RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Dermal CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	7.63E+03	0.001	9.80E-04	--	--	--	2.92E-04	--	--	--
Arsenic	5.32E+00	0.001	6.84E-07	1E-04	5.56E-03	4.7%	2.04E-07	3.6585	7.45E-07	25.4%
Beryllium	1.33E-01	0.001	1.71E-08	5E-05	3.42E-04	0.3%	5.09E-09	430	2.19E-06	74.6%
Iron	2.27E+04	0.001	2.92E-03	--	--	--	8.68E-04	--	--	--
Manganese	4.79E+01	0.001	6.15E-06	0.002	3.08E-03	2.6%	1.83E-06	--	--	--
Sodium	5.93E+01	0.001	7.62E-06	--	--	--	2.27E-06	--	--	--
Vanadium	5.93E+01	0.001	7.62E-06	7E-05	1.09E-01	92.4%	2.27E-06	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					1.18E-01	100%				
Excess lifetime cancer risk:									2.93E-06	100%

[a] $$CDI = \frac{(EPC \times CF \times SA_c \times AF \times ABS \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times CF \times \left[\frac{(SA_c \times AF \times ABS \times EF \times ED_c)}{(BW_c)} + \frac{(SA_a \times AF \times ABS \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor (0.000001 kg soil/mg soil)
SA	=	Skin Surface Area Available - Child (2010 cm2/day)
SA	=	Skin Surface Area Available - Adult (5800 cm2/day)
AF	=	Soil-to-skin Adherence Factor (1 mg soil/cm2)
ABS	=	Dermal Absorption Factor (chemical specific - unitless)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (days)

Table C - 44. Risk characterization for soil (0 to 4 feet): Background residents - inhalation exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Particulate Emission Factor (PEF)	Chronic Daily Intake [a]	Inhalation RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Inhalation CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	7.63E+03	4.630E+09	1.58E-06	--	--	--	2.90E-07	--	--	--
Arsenic	5.32E+00	4.630E+09	1.10E-09	--	--	--	2.02E-10	50	1.01E-08	99.6%
Beryllium	1.33E-01	4.630E+09	2.75E-11	--	--	--	5.06E-12	8.4	4.25E-11	0.4%
Iron	2.27E+04	4.630E+09	4.70E-06	--	--	--	8.64E-07	--	--	--
Manganese	4.79E+01	4.630E+09	9.92E-09	1.4E-05	6.94E-04	100.0%	1.82E-09	--	--	--
Sodium	5.93E+01	4.630E+09	1.23E-08	--	--	--	2.26E-09	--	--	--
Vanadium	5.93E+01	4.630E+09	1.23E-08	--	--	--	2.26E-09	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					6.94E-04	100%				
Excess lifetime cancer risk:									1.02E-08	100%

[a] $$CDI = \frac{(EPC \times IR_c \times EF \times ED_c)}{(PEF \times BW_c \times AT_{nc})}$$

[a] $$CDI = \frac{EPC}{PEF} \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
IR	=	Inhalation Rate - Child (15 m3 air/day)
IR	=	Inhalation Rate - Adult (20 m3 air/day)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (days)
PEF	=	Particulate Emission Factor (4.63E+09 m3 air/kg soil)

Table C - 45. Risk characterization for leafy vegetables (0 to 1 foot soil): Background residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Leafy Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	9.52E+03	4.00E-03	4.29E-03	--	--	--	1.22E-03	--	--	--
Arsenic	6.90E+00	4.00E-02	3.11E-05	3E-04	1.04E-01	39.8%	8.82E-06	1.5	1.32E-05	97.9%
Beryllium	2.04E-01	1.00E-02	2.30E-07	0.005	4.60E-05	0.0%	6.52E-08	4.3	2.80E-07	2.1%
Iron	1.94E+04	4.00E-03	8.75E-03	0.3	2.92E-02	11.2%	2.48E-03	--	--	--
Manganese	4.79E+01	5.60E-01	3.02E-03	0.024	1.26E-01	48.3%	8.57E-04	--	--	--
Sodium	7.90E+01	7.50E-02	6.68E-04	--	--	--	1.89E-04	--	--	--
Vanadium	5.93E+01	2.00E-03	1.34E-05	0.007	1.91E-03	0.7%	3.79E-06	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	2.61E-01	100%
Excess lifetime cancer risk:		1.35E-05 / 100%

[a] $$CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)}\right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.042 unitless)
IR	=	Ingestion Rate - Child (0.042 kg produce/day)
IR	=	Ingestion Rate - Adult (0.113 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 46. Risk characterization for tuberous vegetables (0 to 1 foot soil): Background residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Tuber Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	9.52E+03	4.00E-03	2.17E-02	--	--	--	6.16E-03	--	--	--
Arsenic	6.90E+00	6.00E-03	2.36E-05	3E-04	7.87E-02	26.6%	6.70E-06	1.5	1.00E-05	97.9%
Beryllium	2.04E-01	1.50E-03	1.75E-07	0.005	3.49E-05	0.0%	4.95E-08	4.3	2.13E-07	2.1%
Iron	1.94E+04	1.00E-03	1.11E-02	0.3	3.69E-02	12.5%	3.14E-03	--	--	--
Manganese	4.79E+01	1.50E-01	4.10E-03	0.024	1.71E-01	57.7%	1.16E-03	--	--	--
Sodium	7.90E+01	5.50E-02	2.48E-03	--	--	--	7.03E-04	--	--	--
Vanadium	5.93E+01	2.00E-03	6.77E-05	0.007	9.67E-03	3.3%	1.92E-05	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					2.96E-01	100%				
Excess lifetime cancer risk:									1.03E-05	100%

[a] $$CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)}\right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.119 unitless)
IR	=	Ingestion Rate - Child (0.075 kg produce/day)
IR	=	Ingestion Rate - Adult (0.202 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 47. Risk characterization for fruits (0 to 1 foot soil): Background residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Tuber Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	9.52E+03	4.00E-03	5.33E-02	--	--	--	1.53E-02	--	--	--
Arsenic	6.90E+00	6.00E-03	5.80E-05	3E-04	1.93E-01	43.2%	1.66E-05	1.5	2.49E-05	97.9%
Beryllium	2.04E-01	1.50E-03	4.29E-07	0.005	8.57E-05	0.0%	1.23E-07	4.3	5.28E-07	2.1%
Iron	1.94E+04	1.00E-03	2.72E-02	0.3	9.06E-02	20.2%	7.79E-03	--	--	--
Manganese	4.79E+01	5.00E-02	3.36E-03	0.024	1.40E-01	31.2%	9.61E-04	--	--	--
Sodium	7.90E+01	5.50E-02	6.09E-03	--	--	--	1.74E-03	--	--	--
Vanadium	5.93E+01	2.00E-03	1.66E-04	0.007	2.37E-02	5.3%	4.76E-05	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					4.48E-01	100%				
Excess lifetime cancer risk:									2.55E-05	100%

[a] $CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$

[a] $CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)}\right] / AT_c$

[b] $HQ = \frac{CDI}{RfD}$ [c] $ELCR = CDI \times CSF$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.487 unitless)
IR	=	Ingestion Rate - Child (0.045 kg produce/day)
IR	=	Ingestion Rate - Adult (0.123 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 48. Risk characterization for leafy vegetables (0 to 4 feet soil): Background residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Leafy Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	7.63E+03	4.00E-03	3.44E-03	--	--	--	9.75E-04	--	--	--
Arsenic	5.32E+00	4.00E-02	2.40E-05	3E-04	8.00E-02	33.0%	6.80E-06	1.5	1.02E-05	98.2%
Beryllium	1.33E-01	1.00E-02	1.50E-07	0.005	3.00E-05	0.0%	4.25E-08	4.3	1.83E-07	1.8%
Iron	2.27E+04	4.00E-03	1.02E-02	0.3	3.41E-02	14.1%	2.90E-03	--	--	--
Manganese	4.79E+01	5.60E-01	3.02E-03	0.024	1.26E-01	52.1%	8.57E-04	--	--	--
Sodium	5.93E+01	7.50E-02	5.02E-04	--	--	--	1.42E-04	--	--	--
Vanadium	5.93E+01	2.00E-03	1.34E-05	0.007	1.91E-03	0.8%	3.79E-06	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	2.42E-01	100%
Excess lifetime cancer risk:	1.04E-05	100%

[a] $$CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)}\right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.042 unitless)
IR	=	Ingestion Rate - Child (0.042 kg produce/day)
IR	=	Ingestion Rate - Adult (0.113 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 49. Risk characterization for tuberous vegetables (0 to 4 feet soil): Background residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Tuber Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	7.63E+03	4.00E-03	1.74E-02	--	--	--	4.94E-03	--	--	--
Arsenic	5.32E+00	6.00E-03	1.82E-05	3E-04	6.07E-02	21.3%	5.16E-06	1.5	7.75E-06	98.2%
Beryllium	1.33E-01	1.50E-03	1.14E-07	0.005	2.28E-05	0.0%	3.23E-08	4.3	1.39E-07	1.8%
Iron	2.27E+04	1.00E-03	1.30E-02	0.3	4.32E-02	15.2%	3.67E-03	--	--	--
Manganese	4.79E+01	1.50E-01	4.10E-03	0.024	1.71E-01	60.1%	1.16E-03	--	--	--
Sodium	5.93E+01	5.50E-02	1.86E-03	--	--	--	5.28E-04	--	--	--
Vanadium	5.93E+01	2.00E-03	6.77E-05	0.007	9.67E-03	3.4%	1.92E-05	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	2.84E-01	100%
Excess lifetime cancer risk:		7.89E-06 100%

[a] $$CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)}\right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.119 unitless)
IR	=	Ingestion Rate - Child (0.075 kg produce/day)
IR	=	Ingestion Rate - Adult (0.202 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 50. Risk characterization for fruits (0 to 4 feet soil): Background residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Tuber Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Aluminum	7.63E+03	4.00E-03	4.28E-02	--	--	--	1.23E-02	--	--	--
Arsenic	5.32E+00	6.00E-03	4.47E-05	3E-04	1.49E-01	35.6%	1.28E-05	1.5	1.92E-05	98.2%
Beryllium	1.33E-01	1.50E-03	2.79E-07	0.005	5.59E-05	0.0%	8.01E-08	4.3	3.44E-07	1.8%
Iron	2.27E+04	1.00E-03	3.18E-02	0.3	1.06E-01	25.3%	9.11E-03	--	--	--
Manganese	4.79E+01	5.00E-02	3.36E-03	0.024	1.40E-01	33.4%	9.61E-04	--	--	--
Sodium	5.93E+01	5.50E-02	4.57E-03	--	--	--	1.31E-03	--	--	--
Vanadium	5.93E+01	2.00E-03	1.66E-04	0.007	2.37E-02	5.7%	4.76E-05	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					4.19E-01	100%				
Excess lifetime cancer risk:									1.96E-05	100%

[a] $$CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EFxED_c)}{(BW_c)} + \frac{(IR_a \times EFxED_a)}{(BW_a)}\right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.487 unitless)
IR	=	Ingestion Rate - Child (0.045 kg produce/day)
IR	=	Ingestion Rate - Adult (0.123 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 51. RME Risk Characterization Summary: FDTF Surface Soil (0 to 1 foot)(Screened Inorganics)

Medium	Exposure Route	Current				Future							
		Noncancer HI		Cancer Risk		Noncancer HI				Cancer Risk			
		On-Unit Worker		On-Unit Worker		Resident		Industrial Worker		Resident		Industrial Worker	
Soil	Ingestion	6E-04	B	5E-09	B	6E-01	B	2E-02	B	9E-06	B	1E-06	B
	Dermal/External	4E-05	B	1E-09	B	4E-03	B	2E-03	B	5E-07	B	3E-07	B
	Inhalation	0E+00	B	1E-11	B	0E+00	B	0E+00	B	7E-09	B	3E-09	B
Leafy Vegetables	Ingestion	NA		NA		7E-02	B	NA		3E-12	B	NA	
Tuberous Vegetables	Ingestion	NA		NA		6E-02	B	NA		1E-05	B	NA	
Fruits	Ingestion	NA		NA		2E-01	B	NA		6E-13	B	NA	
Combined Hazard Index:		6E-04	B			9E-01	B	3E-02	B				
Combined Cancer Risk:				6E-09	B					2E-05	B	1E-06	B

NA - pathway not evaluated

0E+00 - pathway evaluated but no risks could be calculated due to lack of EPA-approved toxicity values

B - HI $\leq$ 1 or ELCR $\leq 10^{-4}$ for chemical risks

E - HI > 1 or ELCR > 10^{-4} for chemical risks

Table C - 52. Risk characterization for soil (0 to 1 foot): FDTF (Screened Inorganics) on-unit workers - ingestion exposure (current land use)

		Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)									
Arsenic	3.70E+00	4.34E-08	3E-04	1.45E-04	25.3%	3.10E-09	1.5	4.65E-09	100.0%
Iron	1.09E+04	1.28E-04	0.3	4.27E-04	74.7%	9.14E-06	--	--	--
Sodium	6.77E+01	7.95E-07	--	--	--	5.68E-08	--	--	--
Chemical hazards combined exposure:									
Hazard index (HI):				5.71E-04	100%				
Excess lifetime cancer risk:								4.65E-09	100%

[a] $$CDI = \frac{(EPC \times CF \times IR \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor - Chemicals (0.000001 kg soil/mg soil)
IR	=	Ingestion Rate (50 mg soil/day)
EF	=	Exposure Frequency (6 days/year)
ED	=	Exposure Duration (5 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (1825 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 53. Risk characterization for soil (0 to 1 foot): FDTF (Screened Inorganics) on-unit workers - dermal exposure (current land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Dermal Absorption Factor	Chronic Daily Intake [a]	Dermal RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Dermal CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Arsenic	3.70E+00	0.001	5.04E-09	1E-04	4.10E-05	100.0%	3.60E-10	3.6585	1.32E-09	100.0%
Iron	1.09E+04	0.001	1.48E-05	--	--	--	1.06E-06	--	--	--
Sodium	6.77E+01	0.001	9.22E-08	--	--	--	6.59E-09	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	4.10E-05	100%
Excess lifetime cancer risk:		1.32E-09 | 100%

[a] $$CDI = \frac{(EPC \times CF \times SA \times AF \times ABS \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor (0.000001 kg soil/mg soil)
SA	=	Skin Surface Area Available (5800 cm2/day)
AF	=	Soil-to-skin Adherence Factor (1 mg soil/cm2)
ABS	=	Dermal Absorption Factor (chemical specific - unitless)
EF	=	Exposure Frequency (6 days/year)
ED	=	Exposure Duration (5 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (1825 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 54. Risk characterization for soil (0 to 1 foot): FDTF (Screened Inorganics) on-unit workers - inhalation exposure (current land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Particulate Emission Factor (PEF)	Chronic Daily Intake [a]	Inhalation RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Inhalation CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Arsenic	3.70E+00	4.630E+09	3.75E-12	--	--	--	2.68E-13	50	1.34E-11	100.0%
Iron	1.09E+04	4.630E+09	1.11E-08	--	--	--	7.90E-10	--	--	--
Sodium	6.77E+01	4.630E+09	6.87E-11	--	--	--	4.91E-12	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					0.00E+00	0%				
Excess lifetime cancer risk:									1.34E-11	100%

[a] $$CDI = \frac{(EPC \times IR \times EF \times ED)}{(PEF \times BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
IR	=	Inhalation Rate (20 m3 air/day)
EF	=	Exposure Frequency (6 days/year)
ED	=	Exposure Duration (5 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (1825 days)
AT	=	Averaging Time - Cancer (25550 days)
PEF	=	Particulate Emission Factor (4.63E+09 m3 air/kg soil)

Table C - 55. Risk characterization for soil (0 to 1 foot): FDTF (Screened Inorganics) industrial workers - ingestion exposure (future land use)

		Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)									
Arsenic	3.70E+00	1.81E-06	3E-04	6.03E-03	25.3%	6.46E-07	1.5	9.70E-07	100.0%
Iron	1.09E+04	5.33E-03	0.3	1.78E-02	74.7%	1.90E-03	--	--	--
Sodium	6.77E+01	3.31E-05	--	--	--	1.18E-05	--	--	--
Chemical hazards combined exposure:									
Hazard index (HI):				2.38E-02	100%				
Excess lifetime cancer risk:								9.70E-07	100%

[a] $$CDI = \frac{(EPC \times CF \times IR \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor - Chemicals (0.000001 kg soil/mg soil)
IR	=	Ingestion Rate (50 mg soil/day)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 56. Risk characterization for soil (0 to 1 foot): FDTF (Screened Inorganics) industrial workers - dermal exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Dermal Absorption Factor	Chronic Daily Intake [a]	Dermal RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Dermal CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Arsenic	3.70E+00	0.001	2.10E-07	1E-04	1.71E-03	100.0%	7.50E-08	3.6585	2.74E-07	100.0%
Iron	1.09E+04	0.001	6.19E-04	--	--	--	2.21E-04	--	--	--
Sodium	6.77E+01	0.001	3.84E-06	--	--	--	1.37E-06	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					1.71E-03	100%				
Excess lifetime cancer risk:									2.74E-07	100%

[a] $$CDI = \frac{(EPC \times CF \times SA \times AF \times ABS \times EF \times ED)}{(BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor (0.000001 kg soil/mg soil)
SA	=	Skin Surface Area Available (5800 cm2/day)
AF	=	Soil-to-skin Adherence Factor (1 mg soil/cm2)
ABS	=	Dermal Absorption Factor (chemical specific - unitless)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 57. Risk characterization for soil (0 to 1 foot): FDTF (Screened Inorganics) industrial workers - inhalation exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Particulate Emission Factor (PEF)	Chronic Daily Intake [a]	Inhalation RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Inhalation CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Arsenic	3.70E+00	4.630E+09	1.56E-10	--	--	--	5.59E-11	50	2.79E-09	100.0%
Iron	1.09E+04	4.630E+09	4.61E-07	--	--	--	1.65E-07	--	--	--
Sodium	6.77E+01	4.630E+09	2.86E-09	--	--	--	1.02E-09	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	0.00E+00	0%
Excess lifetime cancer risk:		2.79E-09 | 100%

[a] $$CDI = \frac{(EPC \times IR \times EF \times ED)}{(PEF \times BW \times AT)}$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
IR	=	Inhalation Rate (20 m3 air/day)
EF	=	Exposure Frequency (250 days/year)
ED	=	Exposure Duration (25 years)
BW	=	Body Weight (70 kg)
AT	=	Averaging Time - Noncancer (9125 days)
AT	=	Averaging Time - Cancer (25550 days)
PEF	=	Particulate Emission Factor (4.63E+09 m3 air/kg soil)

Table C - 58. Risk characterization for soil (0 to 1 foot): FDTF (Screened Inorganics) residents - ingestion exposure (future land use)

		Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)									
Arsenic	3.70E+00	4.73E-05	3E-04	1.58E-01	25.3%	5.79E-06	1.5	8.69E-06	100.0%
Iron	1.09E+04	1.39E-01	0.3	4.65E-01	74.7%	1.71E-02	--	--	--
Sodium	6.77E+01	8.66E-04	--	--	--	1.06E-04	--	--	--
Chemical hazards combined exposure:									
Hazard index (HI):				6.22E-01	100%				
Excess lifetime cancer risk:								8.69E-06	100%

[a] $$CDI = \frac{(EPC \times CF \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor - Chemicals (0.000001 kg soil/mg soil)
IR	=	Ingestion Rate - Child (200 mg soil/day)
IR	=	Ingestion Rate - Adult (100 mg soil/day)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 59. Risk characterization for soil (0 to 1 foot): FDTF (Screened Inorganics) residents - dermal exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Dermal Absorption Factor	Chronic Daily Intake [a]	Dermal RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Dermal CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Arsenic	3.70E+00	0.001	4.75E-07	1E-04	3.87E-03	100.0%	1.42E-07	3.6585	5.18E-07	100.0%
Iron	1.09E+04	0.001	1.40E-03	--	--	--	4.17E-04	--	--	--
Sodium	6.77E+01	0.001	8.70E-06	--	--	--	2.59E-06	--	--	--

Chemical hazards combined exposure:

Hazard index (HI):	3.87E-03	100%
Excess lifetime cancer risk:		5.18E-07 | 100%

[a] $$CDI = \frac{(EPC \times CF \times SA_c \times AF \times ABS \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times CF \times \left[\frac{(SA_c \times AF \times ABS \times EF \times ED_c)}{(BW_c)} + \frac{(SA_a \times AF \times ABS \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
CF	=	Conversion Factor (0.000001 kg soil/mg soil)
SA	=	Skin Surface Area Available - Child (2010 cm2/day)
SA	=	Skin Surface Area Available - Adult (5800 cm2/day)
AF	=	Soil-to-skin Adherence Factor (1 mg soil/cm2)
ABS	=	Dermal Absorption Factor (chemical specific - unitless)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (days)

Table C - 60. Risk characterization for soil (0 to 1 foot): FDTF (Screened Inorganics) residents - inhalation exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Particulate Emission Factor (PEF)	Chronic Daily Intake [a]	Inhalation RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Inhalation CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Arsenic	3.70E+00	4.630E+09	7.66E-10	--	--	--	1.41E-10	50	7.04E-09	100.0%
Iron	1.09E+04	4.630E+09	2.26E-06	--	--	--	4.15E-07	--	--	--
Sodium	6.77E+01	4.630E+09	1.40E-08	--	--	--	2.58E-09	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					0.00E+00	0%				
Excess lifetime cancer risk:									7.04E-09	100%

[a] $$CDI = \frac{(EPC \times IR_c \times EF \times ED_c)}{(PEF \times BW_c \times AT_{nc})}$$

[a] $$CDI = \frac{EPC}{PEF} \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)} \right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where		
CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
IR	=	Inhalation Rate - Child (15 m3 air/day)
IR	=	Inhalation Rate - Adult (20 m3 air/day)
EF	=	Exposure Frequency (350 days/year)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (days)
PEF	=	Particulate Emission Factor (4.63E+09 m3 air/kg soil)

Table C - 61. Risk characterization for leafy vegetables (0 to 1 foot soil): FDTF (Screened Inorganics) residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Leafy Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Arsenic	3.70E+00	4.00E-02	1.67E-05	3E-04	5.56E-02	77.2%	4.73E-06	1.5	7.09E-06	100.0%
Iron	1.09E+04	4.00E-03	4.92E-03	0.3	1.64E-02	22.8%	1.39E-03	--	--	--
Sodium	6.77E+01	7.50E-02	5.73E-04	--	--	--	1.62E-04	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					7.20E-02	100%				
Excess lifetime cancer risk:									7.09E-06	100%

[a] $$CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)}\right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$

[c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.042 unitless)
IR	=	Ingestion Rate - Child (0.042 kg produce/day)
IR	=	Ingestion Rate - Adult (0.113 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 62. Risk characterization for tuberous vegetables (0 to 1 foot soil): FDTF (Screened Inorganics) residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Tuber Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Arsenic	3.70E+00	6.00E-03	1.27E-05	3E-04	4.22E-02	67.1%	3.59E-06	1.5	5.39E-06	100.0%
Iron	1.09E+04	1.00E-03	6.22E-03	0.3	2.07E-02	32.9%	1.76E-03	--	--	--
Sodium	6.77E+01	5.50E-02	2.12E-03	--	--	--	6.02E-04	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					6.30E-02	100%				
Excess lifetime cancer risk:									5.39E-06	100%

[a] $$CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)}\right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.119 unitless)
IR	=	Ingestion Rate - Child (0.075 kg produce/day)
IR	=	Ingestion Rate - Adult (0.202 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

Table C - 63. Risk characterization for fruits (0 to 1 foot soil): FDTF (Screened Inorganics) residents - ingestion exposure (future land use)

			Noncarcinogenic Effects				Carcinogenic Effects			
Parameter	Soil Exposure Point Concentration	Soil-to-Plant (Tuber Veg.) Biotransfer Factor	Chronic Daily Intake [a]	Oral RfD	Hazard Quotient [b]	Hazard Quotient Percent of Total	Chronic Daily Intake [a]	Oral CSF	Excess Lifetime Cancer Risk [c]	ELCR Percent of Total
INORGANICS (mg/kg)										
Arsenic	3.70E+00	6.00E-03	3.11E-05	3E-04	1.04E-01	67.1%	8.91E-06	1.5	1.34E-05	100.0%
Iron	1.09E+04	1.00E-03	1.53E-02	0.3	5.09E-02	32.9%	4.38E-03	--	--	--
Sodium	6.77E+01	5.50E-02	5.22E-03	--	--	--	1.49E-03	--	--	--
Chemical hazards combined exposure:										
Hazard index (HI):					1.55E-01	100%				
Excess lifetime cancer risk:									1.34E-05	100%

[a] $$CDI = \frac{(EPC \times BTF \times FI \times IR_c \times EF \times ED_c)}{(BW_c \times AT_{nc})}$$

[a] $$CDI = EPC \times BTF \times CF \times \left[\frac{(IR_c \times EF \times ED_c)}{(BW_c)} + \frac{(IR_a \times EF \times ED_a)}{(BW_a)}\right] / AT_c$$

[b] $$HQ = \frac{CDI}{RfD}$$ [c] $$ELCR = CDI \times CSF$$

where

CDI	=	Chronic Daily Intake (mg/kg BW/day)
EPC	=	Exposure Point Concentration in Soil (mg chem/kg soil)
BTF	=	Soil-to-plant Biotransfer Factor (chemical specific - mg chem/kg plant per mg chem/kg soil)
FI	=	Fraction Ingested (0.487 unitless)
IR	=	Ingestion Rate - Child (0.045 kg produce/day)
IR	=	Ingestion Rate - Adult (0.123 kg produce/day)
EF	=	Exposure Frequency (350 days)
ED	=	Exposure Duration - Child (6 years)
ED	=	Exposure Duration - Adult (24 years)
BW	=	Body Weight - Child (15 kg)
BW	=	Body Weight - Adult (70 kg)
AT	=	Averaging Time - Noncancer (2190 days)
AT	=	Averaging Time - Cancer (25550 days)

ALUMINUM

CAS No(s): 7429-90-5

Major Synonym(s): NA

Aluminum is the third most abundant element (American Conference of Governmental Industrial Hygienists 1986) comprising about 8.8 percent of the earth's crust by weight (Merck Index 1983). Aluminum does not occur freely in nature, but is widely distributed combined with oxygen, fluorine, silicon, and other constituents. It is a silvery-white, malleable, ductile, light-weight metal. It is soluble in alkali and in hydrochloric and sulfuric acid, and insoluble in concentrated nitric acid, hot acetic acid, and water (Weast 1979). It has a molecular weight of 26.98 g/mole, melts at 660oC, boils at 2,450°C (at 1 atmosphere), has a vapor pressure of 1 mm Hg at 1284oC, and has a specific gravity of 2.70 at 20°C/4oC.

Fate and Transport

Aluminum is abundant in soils although concentrations vary with solubility, which is a function of pH (National Research Council 1981). It is amphoteric, being more soluble in acidic and basic solutions than in more neutral solutions (U.S. Environmental Protection Agency 1988). Some acid soils contain sufficient aluminum in soluble form to kill some types of plants (Farm Chemicals Handbook 1984). Soil concentrations of aluminum have been recorded up to 150 to 600 grams per kilogram (Friberg et al. 1979). Human activities tend to increase aluminum content in surface waters (Friberg et al. 1979) and acid rain can cause aluminum to leach out of soil at a higher than normal rate, thus increasing the aluminum uptake by plants and animals. Aluminum concentrations in urban air are reported as high as 10 mg per cubic meter. In non-urban areas, values as low as 0.5 mg per cubic meter have been reported (Friberg et al. 1979). Aluminum tends to bioaccumulate only slightly in aquatic organisms. Cleveland et al. (1986) reported BCFs of 50 to 230 among young brook trout.

Human Health Effects

Humans are exposed to aluminum by ingestion of foods and beverages and by inhalation from the atmosphere. Human ingestion of aluminum is typically 30 to 50 mg per day (Bjorksten 1982), with a daily absorption rate 0.1 to 2 mg (Rosas 1978). Although not essential for human health, normal total body content of aluminum in humans is around 30 milligrams. Soluble forms of aluminum chloride, aluminum fluoride, and aluminum sulfate are potentially toxic, and may play a role in several disease conditions. Insoluble forms of aluminum do not seem to have a measurable acute response (Rumack and Spoerke 1989). Chronic inhalation of fine metallic aluminum dust, such as may occur in the manufacture of aluminum abrasives, explosives, and fireworks, has been shown to cause a distinctive type of pulmonary fibrosis with emphysema, chronic interstitial pneumonia, dyspnea, cough, and pneumothorax (Clayton and Clayton 1981). In addition, the inhalation of this aluminum dust has caused progressive encephalopathy, in which the brain shows evidence of neurofibrillary degeneration (Venugopal and Luckey 1978). Gastrointestinal problems develop when aluminum hydroxide is chronically administered orally, causing severe constipation by inhibiting muscle contraction of the intestines (Hamilton and Hardy 1974). It can also cause flatulence, inflammation, and colitis. Aluminum salts may cause a dialysis encephalopathy syndrome among kidney patients, resulting in progressive fatal brain disease characterized by impaired speech, dementia, and seizures (Rumack and Spoerke 1989). Increasing evidence indicates that the brains of Alzheimer's victims contain a much higher than normal level of aluminum (Rumack and Spoerke 1989). Repeated contact of the skin with soluble aluminum salts

Stanley, R.A. 1974. Toxicity of Heavy Metals and Salts to Eurasian Watermilfoil (*Myriophyllum spicatum* L.). Arch. Environ. Contam. Toxicol. 2:331-341.

U.S. Environmental Protection Agency. 1988. Ambient Water Quality Criteria for Aluminum, Doc. No.EPA 440/5-86-008. Washington,, DC.

Venugopal, B. and T.D. Luckey. 1978. Metal Toxicity in Mammals, Vol. 2. Plenum Press, New York, NY.

Weast, R.C. (ed.). 1979. Handbook of Chemistry and Physics, 60th Ed. CRC Press Inc., Boca Raton, FL.

ARSENIC

CAS No(s): 7440-38-2

Major Synonym(s): None

Arsenic exists in low concentrations in all environmental media as a natural component of the earth's crust. Typical arsenic concentrations are less than ten parts per billion in water and less than 40 parts per million in soil (U.S. Department of Health and Human Services 1991). It is a silver-gray, brittle, crystalline substance (International Labour Office 1983) that is soluble in nitric acid but insoluble in water (Weast 1987-1988) and in caustic and non-oxidizing acids. It has a molecular weight of 74.92 g/mole, sublimes at 613°C, melts at 817°C (at 28 atmospheres), has a vapor pressure of 1 mm Hg at 372°C, and has a density of 5.73 at 14°C (U.S. Department of Health and Human Services 1991). Arsenic will vaporize when heated to 100°C, with rapid vaporization at 450°C (Merck 1983).

Fate and Transport

Arsenic is found primarily in soil or rock and is mainly transported adsorbed onto particulate material. In water, soluble forms of arsenic can be carried long distances, but may be adsorbed onto sediments or soils due to chemical or biological reactions that change arsenic speciation (U.S. Department of Health and Human Services 1991). In soil, arsenic is subject to a number of transformation processes, such as oxidation-reduction reactions, ligand exchange, biotransformation, precipitation, and adsorption. It is rarely encountered as a free element in natural waters (U.S. Environmental Protection Agency 1980), where it is also subject to processes such as oxidation-reduction reactions, ligand exchange, biotransformation, precipitation, and adsorption (U.S. Department of Health and Human Services 1991). Arsenic accumulates to varying degrees in some organisms such as algae and shellfish, but does not biomagnify in the food chain. Some arsenic is absorbed via inhalation and oral routes, but dermal absorption is considered to be minor (U. S. Department of Health and Human Services 1991).

Human Health Effects

Inorganic arsenic compounds are generally more toxic than organic forms. For inorganic arsenic, human oral exposures of approximately 1 to 3 mg per kg body weight appear to be the minimum lethal dose, based upon clinical reports (U.S. Department of Health and Human Services 1991). Populations at special risk from arsenic exposure include persons with existing diabetes, cardiovascular diseases, allergic or other skin diseases, neurologic or hepatic disease, or renal lesions. Children may be at special risk for the effects of inorganic arsenic. Exposure to high levels of arsenic results in a number of systemic effects on the respiratory system, heart and vascular system, gastrointestinal system, blood, liver, kidney, skin, eye, and nervous system. Specific effects reported include decreased production of red and white blood cells, abnormal heart and nerve function, damage to blood vessels, kidneys and liver, and possible mutagenic activity. The burden of evidence shows inorganic arsenic to be a carcinogen, resulting in an increased risk of lung and dermal cancer by inhalation and oral exposure, respectively. Organic arsenic has not been demonstrated to be carcinogenic to humans. The U.S. Environmental Protection Agency has classified arsenic as class A, a known human carcinogen.

Ecological Effects

Arsenic toxicity to microorganisms produces a decline in growth and metabolic rates. The more tolerant species can withstand arsenic levels up to 1,000 ppm, whereas the

BENZO(A)PYRENE

CAS No(s).: 50-32-8

Major Synonym(s): NA

Human Health Effects

Benzo(a)pyrene is a polycyclic aromatic hydrocarbon (PAH) formed from the incomplete combustion of organic matter (U.S. Public Health Service 1987). Benzo(a)pyrene is absorbed by inhalation, oral, and dermal routes of exposure. It may be distributed in the liver, tissues of the gastrointestinal tract, kidneys, and blood (U.S. Public Health Service 1987).

Metabolism of PAHs occurs in the liver, bronchus epithelium, esophagus, kidney, colon, placenta, and skin. Electrophilic PAH metabolites bind to DNA and other cellular macromolecules. Such adduct formation has been found for benzo(a)pyrene for almost every tissue that has been examined regardless of species or route of administration. Benzo(a)pyrene is metabolized in two phases. In the first phase, benzo(a)pyrene may be metabolized into several arene oxides. In the second phase, metabolites from the first phase are transformed into one of several bay-region diol epoxides, of which B(a)P 7,8-diol-9,10-epoxide has been established as an ultimate carcinogen (U.S. Public Health Service 1987).

Although human data specifically linking benzo(a)pyrene to a carcinogenic effect are lacking, there are multiple animal studies in rodent and non-rodent species demonstrating benzo(a)pyrene to be a potent carcinogen following administration by oral, intratracheal, inhalation, and dermal routes. In addition, the compound has produced positive results in several in vitro bacterial and mammalian genetic toxicology assays. Consequently, benzo(a)pyrene has been classified by IARC as a probable human carcinogen (2B) and by the U.S. EPA as a B2 carcinogen. Benzo(a)pyrene has an oral cancer slope factor of $[7.3\ mg/kg/day]^{-1}$ and an inhalation slope factor of $[6.1\ mg/kg/day]^{-1}$. No oral or inhalation RfDs have been established (U.S. EPA 1994).

There is an increasing body of evidence that several carcinogenic PAHs produce severe, long term immunotoxicity. Exposure to benzo(a)pyrene, among others, results in long lasting reductions in the activities of antibody-producing cells. Exposure of pregnant mice to a single dose (100-150 mg/kg) of benzo(a)pyrene produced severe suppression of antibody response in pups shortly after birth (Dean et al. 1986). Under certain conditions, benzo(a)pyrene seems to be able to cause a mitogenic response, and topical application of this PAH to mouse skin has been shown to stimulate mitosis in the epidermis.

BENZO(G,H,I)PERYLENE

CAS No(s).: 191-24-2

Major Synonym(s): NA

Human Health Effects

Benzo(g,h,i)perylene, being a PAH, is highly lipid soluble and is probably readily absorbed from the GI tract (U.S. EPA, 1984).

In general, PAH metabolism by the microsomal mixed function oxidase enzyme system yields several types of reactive and potentially carcinogenic intermediates (U.S. EPA, 1984). Chemicals known to induce or inhibit this enzyme system subsequently alter the patterns of PAH metabolism; therefore, their toxic and carcinogenic properties may also be altered.

Benzo(g,h,i)perylene has been classified in group D, not classifiable as to human carcinogenicity (U.S. EPA, 1992). No human data are available, and animal data from animal bioassays are inadequate to establish a positive classification as a human carcinogen.

No oral or inhalation RfDs have been established (U.S. EPA, 1992).

BERYLLIUM

CAS No(s).: 7440-41-7

Major Synonym(s): Beryllium-9, Glucinium, Glucinum, Beryllium metallic

Beryllium does not occur naturally, but is produced commercially from bertrandite and beryl ores (Weast 1985). Most of the beryllium produced is converted to alloys used in electrical parts, metal springs, aircraft engine parts, precision instruments, non-sparking tools, and injection molded plastics (EPA 1987). Pure beryllium metal, produced from beryllium hydroxide, is used in aircraft brakes, space technology, fuel containers, and precision instruments (EPA 1987). Beryllium oxide, also produced from beryllium hydroxide, is utilized in ceramics, electronics, microwave ovens, gyroscopes, military vehicles, rocket nozzles, and laser structural components (EPA 1987).

Beryllium is a hard, gray metal having a molecular weight of 9.012. It is a solid at ambient conditions with a melting point of 1,287-1,292°C and a boiling point of 2,970°C. It is insoluble in water, but certain of its compounds are water soluble. Beryllium metal and most of its compounds are soluble in acidic and/or alkaline solvents (HSDB 1990).

Fate and Transport

Beryllium is released to the atmosphere during processing of ores and production and use of beryllium alloys and chemicals. Combustion of fuel oils and coal account for the majority of beryllium releases to the air; however much of the beryllium contained in coal fly ash is captured by emission control devices (Holcombe et al. 1985; Fishbein 1981). Beryllium is also released atmospherically in relatively small amounts from volcanoes and as wind-blown dusts (ATSDR 1991). It is suspected that most of the beryllium released atmospherically is in the form of beryllium oxide. This compound cannot be destroyed; however ,it may be converted to other more water-soluble forms such as beryllium sulfate and beryllium nitrate. These compounds are subject to both wet and dry deposition to terrestrial and aquatic surfaces (ATSDR 1991; EPA 1987).

Beryllium deposited in soil is expected to adsorb tightly to particles and to displace other divalent cations with a lower affinity for soil particles (Fishbein 1981). The degree of adsorption is pH dependent with the affinity for soil higher at low pH's (Callahan et al. 1979). Beryllium in soils may be hydrolyzed (the soluble salts) and/or converted to other forms. There is no evidence that biotransformation of beryllium occurs in soils (ATSDR 1991).

Beryllium which reaches surface waters typically becomes concentrated in aquatic sediments, where it may be complexed with particles or simply present as insoluble forms of beryllium (Bowen 1979).

Human Health Effects

In studies of inhalation exposure, the toxicity and subsequent lethality of beryllium was dependent on the water solubility of the specific beryllium compound inhaled. The soluble forms of beryllium produced acute pneumonitis whereas the insoluble forms of beryllium have been associated with chronic beryllium disease, a disease characterized by respiratory granulomas (ATSDR 1991). Case histories indicate that chronically exposed individuals suffered from respiratory irritation, anorexia, weight loss, increased fatigue, labored breathing, cough, and hypertrophy of the right atrium and ventricle (Hardy and Tabershaw 1946). The cardiovascular changes associated with beryllium

EPA. 1987. Health assessment document for beryllium. Prepared by Environmental Criteria and Assessment Office. Office of Health and Environmental Assessment, U.S. Environmental Protection Agency, Research Triangle Park, NC for Office of Health and Environmental Assessment, Office of Research and Development, Washington, D.C.

Fishbein, L. 1981. Sources, transport and alterations of metal compounds: An overview. I. Arsenic, beryllium, cadmium, chromium, and nickel. Environ. Health Perspect. 40:43-64.

Hardy, H.L., Tabershaw, I.R. 1946. Delayed chemical pneumonitis occurring in workers exposed to beryllium compounds. J. Ind. Hyg. Toxicol. 28:197-211.

Holcombe, I.J., Eynon, B.P., Switzer, P. 1985. Variability of elemental concentrations in power plant ash. Environ. Sci. Technol. 19:615-620.

HSDB. 1990. Hazardous Substance Data Bank. National Library of Medicine, National Toxicology Information Program. Bethesda, MD.

Meehan, W.R., Smythe, L.E. 1967. Occurrence of beryllium as a trace element in environmental materials. Environ. Sci. Technol. 1:839-844.

Reeves, A.L. 1986. Beryllium. In: Friberg, L., Nordberg, G.F., Vouk, V.B, eds. Handbook on the toxicology of metals. Second edition. Volume II: Specific metals. New York. Elsevier Science Publishers, 95-116.

Rossman, M.D., Kern, J.A., Elias, J.A. et al. 1988. Proliferative response of bronchoalveolar lymphocytes to beryllium. Ann. Intern. Med. 108:687-693.

Weast, R.C. ed. 1985. CRC Handbook of chemistry and physics. 66th ed. Boca Raton, FL CRC Press.

CHROMIUM

CAS No.: 7440-47-3 (Cr VI), 18540-29-9 (Cr III)

Major Synonym(s) Chromium III, Chromium VI

Chromium is a naturally occurring element found in rocks, plants and animals, soil, and volcanic dust and gases as Chromium (III). Other forms, such as Chromium (O) and Chromium (VI) are produced commercially. Chromium compounds of sodium, potassium, and aluminum are also produced industrially, principally using the forms Chromium (III) and Chromium (VI). These products are used for chrome plating, in the manufacture of dyes, leather (as a tanning agent), wood preservatives, in toner for copying machines, and in textiles.

Chromium is a steel-gray metal that can be highly polished. It has a molecular weight of 52. It melts at 1857°C and boils at 2670°C (EHRAV 1995).

Fate and Transport

Chromium release to the atmosphere occurs primarily from industry and fuel combustion. Natural releases result form continental dust and volcanic dust and gases (Fisbein 1981; Towill et al. 1978).

The predominant form of atmospheric chromium is particulate, and transport and deposition are determined primarily by particle size and density (Cary 1982). Chromium is reduced by other elements and compounds present in air; however, removal of chromium from the atmosphere is accomplished through wet and dry deposition of the materials to soil and surface water (Schroeder et al. 1987).

Excessive chromium in surface and ground waters are generated by waste water from industry and deposition of airborne chromium. In water, oxidation and reduction reactions occur, generally at slow rates.

Disposal of commercial chromium-containing products, industrial disposal, agricultural wastes, animal wastes, and atmospheric deposition account for the presence of unnaturally high levels of chromium in soil. Most soil-bound chromium is in an insoluble form and not mobile; however, rainwater and anaerobic biodegradation of plant materials tend to increase mobility, particularly in acidic conditions (Stackhouse and Benson 1989). Mobile chromium may be transported to surface water, ground water, or the atmosphere.

Human Health Effects

The primary damage from inhalation of hexavalent Chromium (Cr VI) compounds is to the respiratory tract as a consequence of their acidic and oxidative nature. Subchronic exposure in the workplace can lead to accumulation of Cr VI compounds in the lining of the nose, with resultant perforation of the nasal septum (Royle 1975). Rhinitis and pharyngitis are frequently reported (Mancuso 1951). Kidney damage may result from absorption of soluble chromates through the lungs (Rinehart and Gad 1986).

In laboratory animals exposure to Cr VI by inhalation, either acutely or chronically, has produced bronchitis and pneumonia, chronic irritation of the bronchi and lung

References

Alderson, M.R., N.S. Rattan, and L. Bidstrup. 1981. Health of workmen in the chromate-producing industry in Britain. Br. J. Ind. Med. 38:117-124.

Anwar, R.A., R.F. Langham, C.A. Hoppert, B.V. Alfredson. and R.U. Byerrum. 1961. Chronic toxicity studies: III. Chronic toxicity of cadmium and chromium in dogs. Arch. Environ. Health 3:456-460.

Blokin, V.S. and F.S. Trop. 1977. In: Dubinin, N.P., ed. Genetic Effects of the Pollution of the Environment, pp. 173-176. (Cited in Tandon, 1982).

Cary, E.E. 1982. Chromium in air, soil and natural. In: Langard, S., ed. Topics in environmental health 5: Biological and environmental aspects of chromium. New York, NY: Elsevier Science Publishes, 49-64.

EPA. 1980. Ambient Water Quality Criteria for chromium. Washington, DC: Office of Water Regulations and Standards, Criteria and Standards Division, U.S. Environmetnal Protection Agency. EPA-440/5-80-035.

EPA. 1984a. Health assessment document for chromium. Research Triangle Park, NC: Environmental Assessment and Criteria Office, U.S. Environmental Protection Agency. EPA 600/8-83-014F.

Fishbein, L. 1981. Sources, transport and alterations of metal compounds: An overview. I. Arsenic, beryllium, cadmium, chromium and nickel. Environ Health Perspect 40-43-64.

IARC (International Agency for Research on Cancer). 1980. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans: Some metals and metallic compounds. WHO, IARC, Lyon, France. Vol. 23, p. 205-323.

MacKenzie, R.D., R.U. Byerrum, C.F. Decker, C.A. Hoppert and R.F. Langham. 1958. Chronic toxicity studies. II. Hexavalent and trivalent chromium administered in drinking water to rats. AMA Arch. Ind. Health. 18:232-234.

Mancuso, T.F. 1951. Occupational cancer and other health hazards in a chromate plant: A medical appraisal. II. Clinical and toxicologic aspects. Ind. Med. Surg. 20:393-407.

Mancuso, T.F. 1975. Consideration of chromium as an industrial carcinogen. In: Hutchinson, T.C., ed. Proceedings of the International Conference on Heavy Metals in the Environment. Toronto, Canada: Toronto Institute for Environmental Studies, pp 343-356.

NAS (National Academy of Sciences). 1974. Medical and biological effects of environmental pollutants: Chromium. Washington, D.C. 155 pp.

NIOSH (National Institute of Occupational Safety and Health). 1983. Registry of toxic effects of chemical substances (RTECS). Vol. 2: p. 72.

Pederson, N.B. 1982. The effects of chromium on the skin In: Langard, ed. Biological and Environmental Aspects of Chromium. Elsevier Biomedical Press, 249-275.

Rinehart, W.E. and S.C. Gad. 1986. Current concepts in occupational health: Metals - chromium. Am. Ind. Hyg. Assoc. J. 47(11):696-699.

Royle, H. 1975. Toxicity of chromic acid in the chromium-plating industry (1). Environ. Res. 10:39-53.

IRON

CAS No(s).: 7439-89-6

Major Synonym(s): NA

Iron is the 4th most abundant element in the earth's crust. Chemically unstable metallic iron is converted to the ferrous or ferric state. The ferric form of iron is insoluble in water and is found in rock and soils. Iron is used in the production of steel; oxides and carbonates are the primary ores from which the metal is extracted (Parmeggiani 1983).

Iron has a molecular weight of 55.85, a melting point of 1,535°C, and a boiling point of 2,750°C. It is insoluble in water but will dissolve in acids. It is a tough, malleable, silver magnetic metal.

Fate and Transport

Iron is not subject to significant environmental release by natural weathering processes. However, air pollution may occur as releases of aerosols during the processing of iron. Smaller particles suspended in the air will be washed out by rain, whereas larger particles fall to the earth by gravity (Bowen 1979).

Contamination of surface waters may result from run off due to the industrial practice of using water to quench coke and slag and from scrubbing of particulates. Iron tends to sink in water, and aquatic sediments act as an effective sink in both fresh and estuarine systems (Moore and Moore 1976; Bowen 1979).

Human Health Effects

Inhalation of silica or iron oxide dusts during mining and preparing iron ores may result in siderosis and pneumoconiosis (Parmeggiani 1983). Siderosis results when the body's iron storage capacities have been exceeded, and excess iron is deposited in vital organs. The liver and pancreas are primary target organs and damage to these systems produces cirrhosis of the liver and diabetes, respectively. A small amount of iron may be deposited in myocardium, producing abnormal rhythms of the heart. Pneumoconiosis is a lung disease, most commonly observed among coal miners. This disease progresses from diffuse fibroids in lung tissue to progressive massive fibrosis, affecting the air exchange tissues of the lungs. This disease is reversible prior to entering the progressive stage. Iron workers also have an increased incidence of lung cancer and hepatic cell carcinoma (Jorgensen 1973; Morgan 1978).

Ingested iron is toxic but rarely fatal in adults. Young children are most susceptible to iron poisoning. Acute symptoms include abdominal pain, diarrhea, and vomiting. Life-threatening effects are manifested as cyanosis, lassitude, drowsiness, acidosis, and dehydration and may culminate in cardiovascular collapse and shock (Finch 1980).

Ecological Effects

The availability of iron in nature is limited. It can be solubilized by acids or converted to organic compounds by microorganisms. Plants take up iron from soils and store it within their structures. Bacteria are also able to take up iron from soil and have adaptive mechanisms which make them efficient at this process. Iron is passed up the foodchain to higher vertebrates in the form of plant and animal food stuffs.

MANGANESE

CAS No(s).: 7439-96-5

Major Synonym(s): NA

Manganese is a widely-distributed metal constituting 0.085 percent of the earth's crust. It is found in the minerals manganosite and braunite, and in minute quantities in water, plants, and animals (Merck Index 1983). Nodules on the floors of the Pacific Ocean and Lake Michigan contain manganese (Clayton and Clayton 1981-1982; Worthing and Walker 1987). Manganese may be gray-pink, steel-gray, whitish-gray, or silvery white in color, depending upon its form or refining process (Weast 1988-1989; Merck Index 1983; Browning 1969). It has a molecular weight of 54.938 g/mole, melts at 1,244 +/- 3°C, boils at 1,962 °C, and has a density of 7.47 for the alpha form. It is readily dissolved in dilute mineral acids and in sodium or potassium bicarbonate (Worthing and Walker 1987; Sittig 1985).

Fate and Transport

Manganese enters the atmosphere primarily through anthropogenic sources. Vegetation may concentrate manganese under some conditions. Oats and barley grown in acid sulfate soils have unusually high concentrations of cobalt, nickel, and manganese (Palko and Yli-Hala 1988) due to higher concentrations of extractable cobalt, nickel, and manganese in the acidic soils. The World Health Organization (1981) reported availability of soil manganese to vegetation is influenced by the activity of soil microorganisms that can alter pH and oxidation/reduction potentials of manganese compounds. Heavy fertilization of acidic soils without liming increases manganese solubility and availability. Addition of organic material to soils can increase manganese uptake by vegetation under certain pH and aeration conditions. However, the absorption capacity of plants varies from species to species with as much as a 60-fold difference in absorption capacity between species. Honda et al. (1987), studied manganese accumulation in Japanese serows, which are long-lived and free-ranging ruminants related to cattle. The body burden of manganese in serow fetuses was low compared to mothers (less than one percent of the adult females). High manganese concentrations in the intestinal organs of two adult serows was thought to be specific to the species because serows have not developed an excretory system for manganese via bile. The serow's uptake of manganese correlated with the concentration found in plants utilized as a source of food.

Human Health Effects

Human exposure to manganese is typically via inhalation, although ingestion through diet, drinking water, and inhaled particles cleared from the respiratory tract also occurs (U.S. Environmental Protection Agency 1984). Manganese is considered essential to human health. No cases of manganese toxicity have been reported from excessive human intake in foods or beverages (National Research Council 1980). The World Health Organization (1981) reported sixteen cases of manganese poisoning, including three fatalities, in a small Japanese community where dry-cell batteries were buried near water supply wells in which manganese concentrations varied from 8 mg/L to 14 mg/L. Individuals affected exhibited psychological and neurological disorders typical of industrial manganese poisoning. Susceptibility to inhaled manganese varies widely among individuals. The very young, individuals with iron deficiency, and workers exposed to manganese at or near the recommended threshold limit value are at greatest risk for adverse effects due to manganese exposure (U.S. Environmental Protection Agency 1984). High levels of manganese may increase anemia by interfering with iron absorption (National Research Council 1980). Inhalation of manganese and its

VANADIUM

CAS No(s).: 7440-62-2

Major Synonym(s): NA

Vanadium occurs naturally in more than 65 different minerals and in oxidized form, usually as metal vanadate. Trace amounts are found in fossil fuels (National Research Council 1977). Vanadium is usually a light-grey or white lustrous powder, but can be found in fused hard lumps. It is relatively insoluble in water, hydrochloric acid, and alkali solutions (Merck Index 1983). It is soluble in aqua regia, sulfuric acid, nitric acid, and hydrogen fluoride (Weast 1979). Vanadium has a molecular weight of 50.94 g/mole, melts at 1,917°C (at one atmosphere), boils at 3,380°C (at one atmosphere), and has a specific gravity of 6.11 at 18.7°C.

Fate and Transport

Vanadium is ubiquitous, entering the environment from mining operations, refineries, and the use of petroleum products, as well as via plants that absorb vanadium from naturally occurring sources. It can form covalent bonds with organic molecules to create organometal compounds (National Research Council 1977). Vanadium has been measured in urban air in the United States as a result of the use of fossil fuels in these areas. Marine invertebrates, such as the ascidians, and plants tend to accumulate vanadium, which is deposited in sediment upon their death. Among terrestrial mammals, inhaled soluble salts of vanadium are readily absorbed, while there is little absorption of salts in the gastrointestinal tract and only minor amounts of absorption through the skin (World Health Organization 1988).

Human Health Effects

Vanadium is considered nontoxic as a metal when ingested (Hawley 1977). Humans do not store or accumulate vanadium in toxic amounts. Most ingested vanadium remains unabsorbed in the gastrointestinal tract and is excreted (National Research Council 1977 and 1980). The only reported biological effect of ingested vanadium is the possible alteration of sulfur metabolism of the liver and an increased turnover of protein sulfur (Clayton and Clayton 1981-1982). Dermatitis was reported in workers exposed to 6.5 mg vanadium pentoxide per cubic meter in air (World Health Organization 1988). Short-term exposure to vanadium symptoms include respiratory irritation, including coughing, wheezing, breathing difficulties, bronchitis, and chest pains; eye irritation; possible skin irritation; and greenish black discoloration of the tongue (National Institute for Occupational Safety and Health 1977; National Academy of Sciences 1974). Among persons who recover from acute vanadium exposure, persistent bronchitis resembling asthma, as well as labored breathing, can occur (National Institute for Occupational Safety and Health 1977). There is no evidence of carcinogenicity for vanadium and the U.S. Environmental Protection Agency has classed it as a Class D carcinogen.

Ecological Effects

Vanadium has been shown to reduce growth levels in rainbow trout (Hilton and Bettger 1988). At high levels of dietary vanadium (greater than 493 mg/kg), feed avoidance and increased mortality were apparent. The dietary vanadium appeared to bioaccumulate in the fish as opposed to waterborne vanadium, which does not bioaccumulate. Giles et al. (1979) reported a 96-hour LC_{50} of 6.43 to 21.75 mg/L for rainbow trout, while Sprague

References

Agency for Toxic Substances and Disease Registry. 1990. Toxicological Profile for Vanadium. Prepared by Clement Inernational Corp., contract no. 205-88-0608.

Cannon, H.L. 1963. The Biogeochemistry of Vanadium. Soil Sci., 96(3):196-204.

Clayton, G.D. and F.E. Clayton (eds.). 1981-1982. Patty's Industrial Hygiene and Toxicology, 3rd Ed., Vols. 2A, 2B, 2C. John Wiley and Sons, New York, NY.

Giles, M.A., J.F. Klaverkamp, and S.G. Lawrence. 1979. The Acute Toxicity of Saline Groundwater and of Vanadium to Fish and Aquatic Invertebrates. Environment Alberta, Edmonton, Alberta, Canada.

Hawley, G.G. 1977. The Condensed Chemical Dictionary, 9th Ed. Van Nostrand Reinhold Co., New York, NY.

Hilton, J.W. and W.J. Bettger. 1988. Aquat Toxicol 12:63-72.

Hopkins, L.L., H.L. Cannon, A.T. Musch, R.M. Welch, and F.H. Nielsen. 1977. Vanadium. Geochem. Environ., 2:93-107.

Hudson, T.G.F. 1964. Vanadium: Toxicology and Biological Significance. Elsevier Science Publishers, New York, NY.

Merck Index; 10th Ed. 1983. Merck and Co., Rahway, NJ.

National Academy of Sciences. 1974. Vanadium. Committee of Biologic Effects of Atmospheric Pollutants, Division of Medical Sciences, National Research Council, Washington, DC.

National Institute for Occupational Safety and Health. 1977. Criteria for a Recommended Standard--Occupational Exposure to Vanadium, NIOSH Pub. No. 77-22. National Institute for Occupational Safety and Health, Washington, DC.

National Research Council. 1977. Drinking Water and Health, Vol. I. National Academy Press, Washington, DC.

National Research Council. 1980. Drinking Water and Health, Vol. 3. National Academy Sprague, J.B., D.A. Holdway, and D.H. Stendahl. 1978. Acute and Chronic Toxicity of Vanadium to Fish. Environment Alberta, Edmonton, Alberta, Canada.

Weast, R.C. (ed.). 1979. Handbook of Chemistry and Physics, 60th Ed. CRC Press Inc., Boca Raton, FL.

World Health Organization. 1988. Vanadium. Environmental Health Criteria 81. Geneva, Switzerland.

Venugopal, B. and T.D. Luckey. 1978. Metal Toxicity in Mammals, Vol.2. Plenum Press, New York, NY.

Weast, R.C. (ed.). 1988-1989. Handbook of Chemistry and Physics, 69th Ed. CRC Press, Inc., Boca Raton, FL.

World Health Organization. 1981. Environmental Health Criteria: Manganese. World Health Organization, Geneva, Switzerland.

Worthing, C.R. and S.B. Walker (eds.). 1987. The Pesticide Manual - A World Compendium, 8th ed. The British Crop Protection Council, Thornton Heath, U.K.

SODIUM

CAS No(s).: 7440-23-5

Major Synonym(s): Natrium, Sodium metal, Sodium-23

Sodium is a naturally occurring element which is found in the earth's crust in combination with other elements such as the halides, silicates, and carbonates (Budvari 1989). Sodium is the principal cation in the hydrosphere (Budvari 1989). Sodium has excellent electrical conductivity and has a high capacity for heat absorption (Sax 1987).

Sodium is a silver-white alkali metal with a molecular weight of 22.9. It has a melting point of 97.82°C and a boiling point of 881.4°C. Pure metallic sodium burns in air to form sodium oxide, which takes up water to form sodium hydroxide. When the pure form of this metal mixes with water, it forms sodium hydroxide and releases hydrogen, which can ignite spontaneously (Budvari 1989).

Fate and Transport

No information was available on the Fate and Transport of sodium in the environment.

Human Health Effects

Sodium and sodium hydroxide are irritating to the gastrointestinal tract when ingested. Burns to the lips, tongue, oral mucosa, and esophagus may occur. Exposure of the eye to sodium causes distortion of cellular membranes, loss epithelium, and loss of the endothelium of the cornea and blood vessels. Inhalation exposure to sodium and sodium hydroxide produces stridor, dyspnea, and pulmonary edema in the respiratory tract and abdominal pain, emesis, and sysphagia with drooling in the GI tract. Dermal exposure leads to severe skin irritation and lesions (HSDB 1994).

Ecological Effects

No information was available on the ecological impacts of sodium release to the environment.

References

Budvari. 1989. The Merck Index. 11th ed. Rahway, NJ: The Merck Corporation.

Weast, R.C. 1988. CRC handbook of chemistry and physics. 69th ed. Boca Raton, FL: CRC Press.

APPENDIX D

ECOLOGICAL RISK CHARACTERIZATION

Table D-1. Dietary Intake Factors for Ecological Receptors at FDTF

Receptor	Dietary Intake Rates			BW (kg)
	I_p (kg/d)	I_a (kg/d)	I_s (kg/d)	
Short-tailed shrew	1.24E-03	7.76E-03	1.17E-03	1.50E-02
Meadow vole	5.00E-03	0.00E+00	1.20E-04	4.40E-02
American robin	4.65E-02	4.65E-02	1.90E-03	7.70E-02
Red-tailed hawk	0.00E+00	1.09E-01	0.00E+00	1.13E+00

I_p = Daily ingestion of plants
I_a = Daily ingestion of animals
I_s = Daily ingestion of soil
BW = Body weight
All values from Sample and Suter (1994)
where Ia + Ip = Food Consumption Rate (kg/ d wet weight)

Table D-2. Biouptake Factors for Ecological COPCs at FDTF

COPC	Soil-to-Plant Transfer		Soil-to-Animal Transfer		Log(K_{ow})
	SPv	SPr	BAF_{inv}	BAF_{mamm}	Value
Inorganics					
Aluminum	8.00E-04 a	1.30E-04 a	7.50E-02 b	7.50E-02 b	NA
Antimony	4.00E-02 a	6.00E-03 a	5.00E-02 b	5.00E-02 b	NA
Arsenic	8.00E-03 a	1.20E-03 a	6.60E-03 b	1.00E-01 b	NA
Cadmium	1.10E-01 a	3.00E-02 a	1.10E+01 b	2.80E-02 b	NA
Calcium	7.00E-01 a	7.00E-02 a	3.50E-02 b	3.50E-02 b	NA
Chromium	1.50E-03 a	9.00E-04 a	1.60E-01 b	2.80E-01 b	NA
Iron	8.00E-04 a	2.00E-04 a	1.00E+00 b	1.00E+00 b	NA
Lead	9.00E-03 a	1.80E-03 a	see note c	1.50E-02 b	NA
Magnesium	2.00E-01 a	1.10E-01 a	2.50E-01 b	2.50E-01 b	NA
Potassium	2.00E-01 a	1.10E-01 a	1.00E+00 b	1.00E+00 b	NA
Selenium	5.00E-03 a	5.00E-03 a	7.60E-01 b	7.50E-01 b	NA
Silver	8.00E-02 a	2.00E-02 a	1.50E-01 b	1.50E-01 b	NA
Sodium	1.50E-02 a	1.10E-02 a	2.75E+00 b	2.75E+00 b	NA
Vanadium	1.10E-03 a	6.00E-04 a	1.30E-01 b	1.30E-01 b	NA
Organics					
SVOCs					
Benzoic acid	2.00E-02 b	2.00E-02 b	5.00E-02 b	1.86E-06 d	1.87 e
Phthalates					
Di-n-octylphthalate	3.73E-05 d	3.73E-05 d	5.00E-02 b	2.40E+03 b	9.2 b

SP = Soil-to-Plant Transfer; v = vegetative parts, r = reproductive parts

BAF_{inv} = Bioaccumulation factor, soil to earthworms (kg soil/kg tissue)

BAF_{mamm} = Bioaccumulation factor, ingestion to small mammals (d/kg)

K_{ow} = Octanol-water partitioning coefficient

NA = not applicable

a. Baes, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. *A Review of Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture.* ORNL-5786, Oak Ridge National Laboratory, Oak Ridge, TN. **Note: These values are adjusted to wet-weight basis.**

b. HAZWRAP. 1994. *Loring Air Force Base Ecological Risk Methodology*. Martin Marietta Energy Systems, Inc. Draft. **Note: These values are presented on a wet-weight basis.**

c. Calcium-dependent: BAF-Pb = $C_{Worm\text{-}Pb} / C_{Soil\text{-}Pb}$, where $C_{Worm\text{-}Pb} = 14.45 \times 10^{0.916 \log(C_{Soil\text{-}Pb})} / 10^{0.326 \log(C_{Soil\text{-}Ca})}$ (HAZWRAP 1994)

d. Travis, C.C., and A.D. Arms. 1988. "Bioconcentration of Organics in Beef, Milk, and Vegetation." *Environ. Sci. Technol.* 22(3):271-274. **Note: These values are adjusted to wet-weight basis.**

e. Howard, P.H., R.S. Boethling, W.F. Jarvis, Jr., W.M. Meylan, and E.M. Michalenko. 1991. *Handbook of Environmental Degradation Rates*. Lewis Publishers, Inc. Chelsea, MI.

Table D-3. Exposure of Mammals to Ecological COPCs at FDTF Background Subsurface Soil (0-1 ft.)

COPC	C_s	EDsoil[a] (mg/kg bw/d) Short-Tailed Shrew	EDsoil[a] (mg/kg bw/d) Meadow Vole
Inorganics (mg/kg)			
Silver	ND		
Organics (µg/kg)			
Benzoic acid	ND		

[a] $ED_{soil} = [(C_s \times SP_v \times CF \times I_p) + (C_s \times BAF_{inv} \times I_a) + (C_s \times I_s)] \times UFF / BW$

C_s = RME soil concentration (mg/kg for inorganics, µg/kg for organics)

SP_v = Soil-to-plant uptake factor for vegetative parts (Table D-2)

CF = Plant wet to dry weight conversion factor (unitless), 0.2 for dry weight SP values

I_p = Daily plant ingestion rate (1.24E-03 kg/d for shrews, 5.00E-03 kg/d for voles)

BAF_{inv} = Soil-invertebrate uptake factor (Table D-2)

I_a = Daily animal ingestion rate (7.76E-03 kg/d for shrews, 0 for voles)

I_s = Daily soil ingestion rate (1.17E-03 kg/d for shrews, 1.20E-04 kg/d for voles)

UFF = Unit foraging factor (Table 6.3-3)

BW = Body.weight (0.015 kg for shrews, 0.044 kg for voles)

ND = Not detected

Table D-4. Exposure of Birds to Ecological COPCs at FDTF Background Surface Soil (0-1 ft.)

COPC	C_s	EDsoil (mg/kg bw/d) American Robin[a]	EDsoil (mg/kg bw/d) Red-Tailed Hawk[b]
Inorganics (mg/kg)			
Silver	ND		
Organics (µg/kg)			
Benzoic acid	ND		

[a] $ED_{soil} = [(C_s \times SP_r \times CF \times I_p) + (C_s \times BAF_{inv} \times I_a) + (C_s \times I_s)] \times UFF / BW$

C_s = RME soil concentration (mg/kg for inorganics, µg/kg for organics)

SP_r = Soil-to-plant uptake factor for reproductive parts (Table D-2)

CF = Plant wet to dry weight conversion factor (unitless), 0.2 for dry weight SP values

I_p = Daily plant ingestion rate (4.65E-02 kg/d)

BAF_{inv} = Soil-invertebrate uptake factor (Table D-2)

I_a = Daily animal ingestion rate (4.65E-02 kg/d)

I_s = Daily soil ingestion rate (1.90E-03 kg/d)

UFF = Unit foraging factor (Table 6.3-3)

BW = Body weight (7.70E-02 kg)

[b] $ED_{soil} = [(C_s \times SP_v \times CF \times I_{p(shrew)}) + (C_s \times BAF_{inv} \times I_{a(shrew)}) + (C_s \times I_{s(shrew)})] \times BAF_{mamm} \times I_{a(hawk)} \times UFF / BW$ (See Eq. 6.3-4)

C_s = RME soil concentration (mg/kg for inorganics, µg/kg for organics)

SP_v = Soil-to-plant uptake factor for vegetative parts (Table D-2)

CF = Plant wet to dry weight conversion factor (unitless), 0.2 for dry weight SP values

$I_{p(shrew)}$ = Daily plant ingestion rate by shrews (1.24E-03 kg/d)

BAF_{inv} = Soil-invertebrate uptake factor (Table D-2)

$I_{a(shrew)}$ = Daily animal ingestion rate by shrews (7.76E-03 kg/d)

BAF_{mamm} = Mammal intake-to-tissue uptake factor (Table D-2)

$I_{s(shrew)}$ = Daily soil ingestion rate by shrews (1.17E-03 kg/d)

$I_{a(hawk)}$ = Daily animal ingestion rate by hawks (1.09E-01 kg/d)

UFF = Unit foraging factor (Table 6.3-3)

BW = Body weight (1.13 kg)

ND = Not detected

Table D-5. Exposure of Mammals to Ecological COPCs at FDTF Background Subsurface Soil (0-4 ft.)

COPC	C_s	EDsoil[a] (mg/kg bw/d) Short-Tailed Shrew	EDsoil[a] (mg/kg bw/d) Meadow Vole
Inorganics (mg/kg)			
Aluminum	5.89E+03	1.76E+01	2.00E+00
Antimony	5.79E-01	1.59E-03	5.07E-04
Arsenic	2.87E+00	6.04E-03	1.26E-03
Cadmium	3.07E-01	4.55E-02	5.63E-04
Calcium	1.52E+02	6.00E-01	1.51E+00
Chromium	1.25E+01	5.16E-02	4.36E-03
Iron	1.05E+04	1.60E+02	3.57E+00
Lead	6.04E+00	2.06E-01	2.73E-03
Magnesium	7.94E+01	4.56E-01	2.44E-01
Potassium	6.91E+01	1.08E+00	2.12E-01
Selenium	4.89E-01	5.91E-03	1.94E-04
Silver	ND		
Sodium	2.98E+01	1.15E+00	1.59E-02
Vanadium	2.72E+01	1.01E-01	9.35E-03
Organics (µg/kg)			
SVOCs			
Benzoic acid	ND		
Phthalates			
Di-n-octylphthalate	ND		

[a] $ED_{soil} = [(C_s \times SP_v \times CF \times I_p) + (C_s \times BAF_{inv} \times I_a) + (C_s \times I_s)] \times UFF / BW$

C_s = RME soil concentration (mg/kg for inorganics, µg/kg for organics)

SP_v = Soil-to-plant uptake factor for vegetative parts (Table D-2)

CF = Plant wet to dry weight conversion factor (unitless), 0.2 for dry weight SP values

I_p = Daily plant ingestion rate (1.24E-03 kg/d for shrews, 5.00E-03 kg/d for voles)

BAF_{inv} = Soil-invertebrate uptake factor (Table D-2)

I_a = Daily animal ingestion rate (7.76E-03 kg/d for shrews, 0 for voles)

I_s = Daily soil ingestion rate (1.17E-03 kg/d for shrews, 1.20E-04 kg/d for voles)

UFF = Unit foraging factor (Table 6.3-3)

BW = Body weight (0.015 kg for shrews, 0.044 kg for voles)

ND = Not detected

Table D-6. Exposure of Birds to Ecological COPCs at FDTF Background Subsurface Soil (0-4 ft.)

COPC	C_s	EDsoil (mg/kg bw/d) American Robin[a]	EDsoil (mg/kg bw/d) Red-Tailed Hawk[b]
Inorganics (mg/kg)			
Aluminum	5.89E+03	9.88E+00	3.22E-06
Antimony	5.79E-01	1.09E-03	1.93E-10
Arsenic	2.87E+00	2.29E-03	1.47E-09
Cadmium	3.07E-01	4.92E-02	3.09E-09
Calcium	1.52E+02	1.70E+00	5.11E-08
Chromium	1.25E+01	3.64E-02	3.51E-08
Iron	1.05E+04	1.57E+02	3.90E-04
Lead	6.04E+00	2.14E-01	7.50E-09
Magnesium	7.94E+01	5.60E-01	2.77E-07
Potassium	6.91E+01	1.23E+00	2.63E-06
Selenium	4.89E-01	5.67E-03	1.08E-08
Silver	ND		
Sodium	2.98E+01	1.20E+00	7.67E-06
Vanadium	2.72E+01	6.73E-02	3.20E-08
Organics (µg/kg)			
SVOCs			
Benzoic acid	ND		
Phthalates			
Di-n-octylphthalate	ND		

[a] $ED_{soil} = [(C_s \times SP_r \times CF \times I_p) + (C_s \times BAF_{inv} \times I_a) + (C_s \times I_s)] \times UFF / BW$

C_s = RME soil concentration (mg/kg for inorganics, µg/kg for organics)

SP_r = Soil-to-plant uptake factor for reproductive parts (Table D-2)

CF = Plant wet to dry weight conversion factor (unitless), 0.2 for dry weight SP values

I_p = Daily plant ingestion rate (4.65E-02 kg/d)

BAF_{inv} = Soil-invertebrate uptake factor (Table D-2)

I_a = Daily animal ingestion rate (4.65E-02 kg/d)

I_s = Daily soil ingestion rate (1.90E-03 kg/d)

UFF = Unit foraging factor (Table 6.3-3)

BW = Body weight (7.70E-02 kg)

[b] $ED_{soil} = [(C_s \times SP_v \times CF \times I_{p(shrew)}) + (C_s \times BAF_{inv} \times I_{a(shrew)}) + (C_s \times I_{s(shrew)})]$
$\times BAF_{mamm} \times I_{a(hawk)} \times UFF / BW$ (See Eq. 6.3-4)

C_s = RME soil concentration (mg/kg for inorganics, µg/kg for organics)

SP_v = Soil-to-plant uptake factor for vegetative parts (Table D-2)

CF = Plant wet to dry weight conversion factor (unitless), 0.2 for dry weight SP values

$I_{p(shrew)}$ = Daily plant ingestion rate by shrews (1.24E-03 kg/d)

BAF_{inv} = Soil-invertebrate uptake factor (Table D-2)

$I_{a(shrew)}$ = Daily animal ingestion rate by shrews (7.76E-03 kg/d)

BAF_{mamm} = Mammal intake-to-tissue uptake factor (Table D-2)

$I_{s(shrew)}$ = Daily soil ingestion rate by shrews (1.17E-03 kg/d)

$I_{a(hawk)}$ = Daily animal ingestion rate by hawks (1.09E-01 kg/d)

UFF = Unit foraging factor (Table 6.3-3)

BW = Body weight (1.13 kg)

ND = Not detected

Table D-7. Ecological HQs for Plants and Earthworms Exposed to FDTF Background Surface Soil (0-1 ft.)

COPC	C_s	Plants TRV	Plants HQ	Earthworms TRV	Earthworms HQ
Inorganics (mg/kg)					
Silver	ND	2.00E+00		None	
Organics (µg/kg)					
Benzoic acid	ND	None		None	

C_s = RME soil concentration; mg/kg for inorganics, µg/kg for organics (See Table D-3)
TRV = Toxicity Reference Value (See Table 6.3-8)
HQ = Hazard Quotient = Cs/TRV
Cells with heavy outlines = HQs >1
ND = Not detected

Table D-8. Ecological HQs for Mammals Exposed to FDTF Background Surface Soil (0-1 ft.)

COPC	Short-Tailed Shrew EDsoil (mg/kg/d)	Short-Tailed Shrew TRV (mg/kg/d)	Short-Tailed Shrew HQ	Meadow Vole EDsoil (mg/kg/d)	Meadow Vole TRV (mg/kg/d)	Meadow Vole HQ
Inorganics						
Silver	ND	None		ND	None	
Organics						
Benzoic acid	ND	None		ND	None	

EDsoil = Estimated dose from soil (See Table D-3)
TRV = Toxicity Reference Value (See Table 6.3-9)
HQ = Hazard Quotient = ED/TRV
Cells with heavy outlines = HQs >1
ND = Not detected

Table D-9. Ecological HQs for Birds Exposed to FDTF Background Surface Soil (0-1 ft.)

COPC	American Robin EDsoil (mg/kg/d)	American Robin TRV (mg/kg/d)	American Robin HQ	Red-Tailed Hawk EDsoil (mg/kg/d)	Red-Tailed Hawk TRV (mg/kg/d)	Red-Tailed Hawk HQ
Inorganics						
Silver	ND	None		ND	None	
Organics						
Benzoic acid	ND	None		ND	None	

EDsoil = Estimated dose from soil (See Table D-4)
TRV = Toxicity Reference Value (See Table 6.3-10)
HQ = Hazard Quotient = ED/TRV
Cells with heavy outlines = HQs >1
ND = Not detected

Table D-10. Ecological HQs for Plants and Earthworms Exposed to FDTF Background Subsurface Soil (0-4 ft.)

COPC	C_s	Plants TRV	Plants HQ	Earthworms TRV	Earthworms HQ
Inorganics (mg/kg)					
Aluminum	5.89E+03	5.00E+01	**1.18E+02**	None	
Antimony	5.79E-01	5.00E+00	1.16E-01	None	
Arsenic	2.87E+00	1.00E+01	2.87E-01	6.00E+01	4.78E-02
Cadmium	3.07E-01	3.00E+00	1.02E-01	2.00E+01	1.54E-02
Calcium	1.52E+02	None		None	
Chromium	1.25E+01	1.00E+00	**1.25E+01**	3.20E+01	3.91E-01
Iron	1.05E+04	None		None	
Lead	6.04E+00	5.00E+01	1.21E-01	5.00E+02	1.21E-02
Magnesium	7.94E+01	None		None	
Potassium	6.91E+01	None		None	
Selenium	4.89E-01	1.00E+00	4.89E-01	7.00E+01	6.99E-03
Silver	ND	2.00E+00		None	
Sodium	2.98E+01	None		None	
Vanadium	2.72E+01	2.00E+00	**1.36E+01**	None	
Organics (µg/kg)					
SVOCs					
Benzoic acid	ND	None		None	
Phthalates					
Di-n-octylphthalate	ND	1.00E+05		2.00E+05	

C_s = RME soil concentration; mg/kg for inorganics, ug/kg for organics (See Table D-5)
TRV = Toxicity Reference Value (See Table 6.3-8)
HQ = Hazard Quotient = Cs/TRV
Cells with heavy outlines = HQs >1
ND = Not detected

Table D-11. Ecological HQs for Mammals Exposed to FDTF Background Subsurface Soil (0-4 ft.)

COPC	Short-Tailed Shrew EDsoil (mg/kg/d)	Short-Tailed Shrew TRV (mg/kg/d)	Short-Tailed Shrew HQ	Meadow Vole EDsoil (mg/kg/d)	Meadow Vole TRV (mg/kg/d)	Meadow Vole HQ
Inorganics						
Aluminum	1.76E+01	2.43E+01	7.26E-01	2.00E+00	1.70E+01	1.18E-01
Antimony	1.59E-03	1.57E+00	1.01E-03	5.07E-04	1.10E+00	4.61E-04
Arsenic	6.04E-03	1.59E+00	3.80E-03	1.26E-03	1.11E+00	1.13E-03
Cadmium	ND	2.86E-02		ND	2.00E-02	
Calcium	6.00E-01	None		1.51E+00	None	
Chromium	5.16E-02	7.82E+04	6.59E-07	4.36E-03	5.46E+04	7.99E-08
Iron	1.60E+02	None		3.57E+00	None	
Lead	2.06E-01	2.29E+02	9.00E-04	2.73E-03	1.60E+02	1.71E-05
Magnesium	4.56E-01	None		2.44E-01	None	
Potassium	1.08E+00	None		2.12E-01	None	
Selenium	5.91E-03	9.58E-01	6.17E-03	1.94E-04	6.69E-01	2.90E-04
Silver	ND	None		ND	None	
Sodium	1.15E+00	None		1.59E-02	None	
Vanadium	1.01E-01	5.43E+00	1.86E-02	9.35E-03	3.80E+00	2.46E-03
Organics						
SVOCs						
Benzoic acid	ND	None		ND	None	
Phthalates						
Di-n-octylphthalate	ND	6.93E+02		ND	4.84E+02	

EDsoil = Estimated dose from soil (See Table D-5)
TRV = Toxicity Reference Value (See Table 6.3-9)
HQ = Hazard Quotient = ED/TRV
Cells with heavy outlines = HQs >1
ND = Not detected

Table D-12. Ecological HQs for Birds Exposed to FDTF Background Subsurface Soil (0-4 ft.)

COPC	American Robin EDsoil (mg/kg/d)	American Robin TRV (mg/kg/d)	American Robin HQ	Red-Tailed Hawk EDsoil (mg/kg/d)	Red-Tailed Hawk TRV (mg/kg/d)	Red-Tailed Hawk HQ
Inorganics						
Aluminum	9.88E+00	1.39E+03	7.13E-03	3.22E-06	5.66E+02	5.68E-09
Antimony	1.09E-03	None		1.93E-10	None	
Arsenic	2.29E-03	3.02E+01	7.58E-05	1.47E-09	1.23E+01	1.19E-10
Cadmium	4.92E-02	4.93E+01	9.99E-04	3.09E-09	2.02E+01	1.54E-10
Calcium	1.70E+00	None		5.11E-08	None	
Chromium	3.64E-02	1.27E+01	2.87E-03	3.51E-08	5.18E+00	6.78E-09
Iron	1.57E+02	None		3.90E-04	None	
Lead	2.14E-01	1.41E+01	1.51E-02	7.50E-09	5.77E+00	1.30E-09
Magnesium	5.60E-01	None		2.77E-07	None	
Potassium	1.23E+00	None		2.63E-06	None	
Selenium	5.67E-03	2.35E+00	2.41E-03	1.08E-08	9.61E-01	1.12E-08
Silver	ND	None		ND	None	
Sodium	1.20E+00	None		7.67E-06	None	
Vanadium	6.73E-02	2.82E+02	2.38E-04	3.20E-08	1.15E+02	2.77E-10
Organics						
SVOCs						
Benzoic acid	ND	None		ND	None	
Phthalates						
Di-n-octylphthalate	ND	1.39E+00		ND	5.68E-01	

EDsoil = Estimated dose from soil (See Table D-6)
TRV = Toxicity Reference Value (See Table 6.3-10)
HQ = Hazard Quotient = ED/TRV
Cells with heavy outlines = HQs >1
ND = Not detected