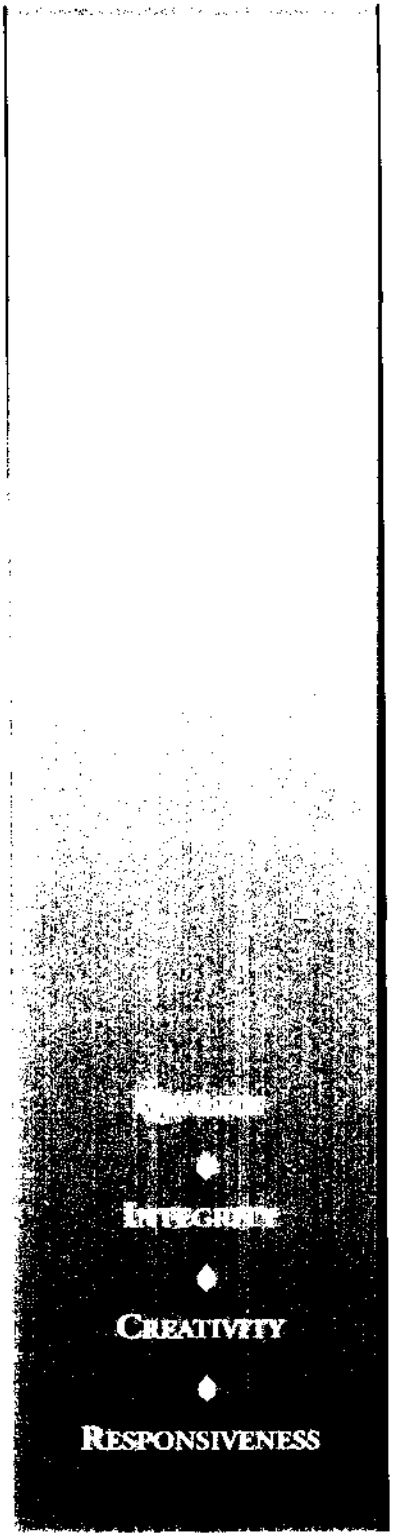
~~Draft~~ Final Feasibility Study

# Remedial Alternative Feasibility Study Operable Unit 1 Former NOP Site Mead, Nebraska

## Contract DACW 41-90-D-0009




Prepared for:

Department of the Army
U.S. Army Engineer District
Kansas City Corps of Engineers
Kansas City, Missouri

March 7, 1994

RUST ENVIRONMENT & INFRASTRUCTURE

200-1e

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# DRAFT FINAL FEASIBILITY STUDY REPORT

## REMEDIAL ALTERNATIVE FEASIBILITY STUDY
## OPERABLE UNIT 1
## FORMER NEBRASKA ORDNANCE PLANT
## MEAD, NEBRASKA
## CONTRACT DACW 41-90-D-0009

**March 7, 1994**

**Prepared For:**

**U.S. Army Corps of Engineers**
**Kansas City District**
**Kansas City, Missouri**

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## TABLE OF CONTENTS


| Section | | Page |
|---|---|---|
| 1.0 | INTRODUCTION | 1-1 |
| 1.1 | Purpose and Organization of Report | 1-1 |
| 1.1.1 | Purpose | 1-1 |
| 1.1.2 | FS Report Overview | 1-2 |
| 1.2 | Site Background | 1-2 |
| 1.2.1 | Site Description | 1-3 |
| 1.2.2 | Site History | 1-3 |
| 1.2.2.1 | U.S. Army Operations | 1-3 |
| 1.2.2.2 | Deactivation and Decontamination | 1-5 |
| 1.2.2.3 | Post-Operations Site Use | 1-6 |
| 1.2.3 | Previous Site Investigations | 1-7 |
| 1.2.4 | Nature and Extent of Contamination | 1-8 |
| 1.2.5 | Environmental Fate and Transport | 1-10 |
| 1.2.5.1 | Transformation Processes | 1-10 |
| 1.2.5.2 | Transfer Processes | 1-10 |
| 1.2.5.3 | Transport Processes | 1-11 |
| 1.2.5.4 | Fate and Transport of Explosive Compounds | 1-12 |
| 1.2.6 | Baseline Risk Assessment | 1-17 |
| 1.2.6.1 | Human Health Risk Evaluation | 1-17 |
| 1.2.6.2 | Environmental Evaluation | 1-22 |
| 1.2.7 | Treatability Studies | 1-23 |
| 1.2.7.1 | Treatability Study Sample Overview | 1-23 |
| 1.2.7.2 | Rotary Kiln Incineration Treatability Study | 1-24 |
| 1.2.7.3 | Vitrification Treatability Study | 1-24 |
| 1.2.7.4 | Biological Treatability Study | 1-25 |
| 1.3 | Site Remediation Issues and Approach | 1-26 |
| 2.0 | IDENTIFICATION AND SCREENING OF TECHNOLOGIES | 2-1 |
| 2.1 | Introduction | 2-1 |
| 2.2 | Remedial Action Objectives | 2-1 |
| 2.2.1 | Applicable or Relevant and Appropriate Requirements (ARARs) | 2-1 |
| 2.2.1.1 | RCRA | 2-2 |
| 2.2.2 | Risk-Based Remedial Action Objectives | 2-6 |
| 2.2.2.1 | Soil RAOs | 2-6 |
| 2.2.2.2 | Groundwater RAOs | 2-7 |
| 2.2.3 | PRGs | 2-6 |
| 2.2.3.1 | Excavation PRGs | 2-7 |
| 2.2.3.2 | Leach-Based PRGs | 2-7 |
| 2.2.3.3 | Treatment Goals | 2-7 |




B07NE003701-04625

**TABLE OF CONTENTS**
**(continued)**


| Section | | | | Page |
|---|---|---|---|---|
| | | 2.2.4 | Remedial Action Objectives Summary | 2-7 |
| | 2.3 | | Areas and Volumes of Contamination | 2-8 |
| | 2.4 | | Development of General Response Actions and Identification of Potential Remedial Technologies | 2-9 |
| | 2.5 | | Screening of Remedial Technologies and Process Options | 2-10 |
| | | 2.5.1 | Introduction | 2-10 |
| | | 2.5.2 | Evaluation Procedures | 2-10 |
| | | 2.5.3 | Results of Initial Screening Evaluation | 2-11 |
| | | 2.5.4 | Results of Secondary Screening Evaluation | 2-11 |
| | | | 2.5.4.1 No Action | 2-12 |
| | | | 2.5.4.2 Institutional Actions | 2-12 |
| | | | 2.5.4.3 Containment Actions - Capping | 2-13 |
| | | | 2.5.4.4 Removal Actions | 2-13 |
| | | | 2.5.4.5 Treatment Actions - Thermal Treatment | 2-14 |
| | | | 2.5.4.6 Treatment Actions - Physical/Chemical Treatment | 2-17 |
| | | | 2.5.4.7 Treatment Actions - Biological Treatment | 2-19 |
| | | | 2.5.4.8 Disposal Actions | 2-21 |
| | | | 2.5.4.9 Residuals Management Actions | 2-22 |
| | | | 2.5.4.10 Debris Management | 2-23 |
| | | 2.5.5 | Groundwater Treatment at Point-of-Use | 2-24 |
| | | 2.5.6 | Summary | 2-24 |
| 3.0 | | | **DEVELOPMENT AND SCREENING OF ALTERNATIVES** | **3-1** |
| | 3.1 | | Introduction | 3-1 |
| | 3.2 | | Alternatives Development | 3-2 |
| | 3.3 | | Alternatives Screening | 3-4 |
| | | 3.3.1 | Effectiveness | 3-4 |
| | | 3.3.2 | Implementability | 3-5 |
| | | 3.3.3 | Cost | 3-5 |
| | | 3.3.4 | Summary | 3-6 |
| 4.0 | | | **DETAILED ANALYSIS OF ALTERNATIVES** | **4-1** |
| | 4.1 | | Introduction | 4-1 |
| | | 4.1.1 | Overall Protection of Human Health and the Environment | 4-2 |
| | | 4.1.2 | Compliance with ARARs | 4-2 |
| | | 4.1.3 | Long-Term Effectiveness and Permanence | 4-2 |
| | | 4.1.4 | Reduction of Toxicity, Mobility, and Volume Through Treatment | 4-2 |
| | | 4.1.5 | Short-Term Effectiveness | 4-3 |
| | | 4.1.6 | Implementability | 4-3 |




B07NE003701-04626

**TABLE OF CONTENTS**
**(continued)**


| Section | | | | Page |
|---|---|---|---|---|
| | 4.1.7 | Cost | | 4-3 |
| | 4.1.8 | Agency Acceptance | | 4-3 |
| | 4.1.9 | Community Acceptance | | 4-4 |
| 4.2 | General Site Elements | | | 4-4 |
| | 4.2.1 | Site Preparation | | 4-4 |
| | 4.2.2 | Support Facilities | | 4-5 |
| | 4.2.3 | Source Area Excavation | | 4-5 |
| | 4.2.4 | Consolidation of Excavated Material | | 4-6 |
| | 4.2.5 | Debris Management | | 4-6 |
| | 4.2.6 | Residuals Management | | 4-6 |
| | 4.2.7 | Demolition Materials Management | | 4-7 |
| | 4.2.8 | Liquids Management | | 4-7 |
| | 4.2.9 | Groundwater Monitoring | | 4-7 |
| | 4.2.10 | Groundwater Treatment at Point-of-Use | | 4-7 |
| | 4.2.11 | Site Layout | | 4-8 |
| 4.3 | Alternative Analysis | | | 4-8 |
| | 4.3.1 | Alternative 1 - No Action | | 4-9 |
| | 4.3.2 | Alternative 2 - Excavation, Consolidation, Debris Management, Biological Treatment, Residuals Management, and Groundwater Treatment at the Point-of-Use | | 4-9 |
| | | 4.3.2.1 | Description | 4-9 |
| | | 4.3.2.2 | Overall Protection of Human Health and the Environment | 4-11 |
| | | 4.3.2.3 | Compliance with ARARs | 4-12 |
| | | 4.3.2.4 | Long-term Effectiveness and Permanence | 4-13 |
| | | 4.3.2.5 | Reduction of Toxicity, Mobility, or Volume Through Treatment | 4-14 |
| | | 4.3.2.6 | Short-Term Effectiveness | 4-14 |
| | | 4.3.2.7 | Implementability | 4-15 |
| | | 4.3.2.8 | Cost | 4-16 |
| | 4.3.3 | Alternative 3 - Excavation, Consolidation, Debris Management, Thermal Treatment, Residuals Management, and Groundwater Treatment at Point-of-Use | | 4-17 |
| | | 4.3.3.1 | Description | 4-17 |
| | | 4.3.3.2 | Overall Protection of Human Health and the Environment | 4-18 |
| | | 4.3.3.3 | Compliance with ARARs | 4-19 |
| | | 4.3.3.4 | Long-term Effectiveness and Permanence | 4-20 |




B07NE003701-04627

**TABLE OF CONTENTS**
**(continued)**


| Section | | | | Page |
|---|---|---|---|---|
| | | 4.3.3.5 | Reduction of Toxicity, Mobility, or Volume Through Treatment | 4-20 |
| | | 4.3.3.6 | Short-Term Effectiveness | 4-20 |
| | | 4.3.3.7 | Implementability | 4-21 |
| | | 4.3.3.8 | Cost | 4-22 |
| | 4.3.4 | Alternative 4 - Excavation, Consolidation, Debris Management, On-Site Landfill, Deed Restrictions, Groundwater Monitoring, and Groundwater Treatment at Point-of-Use | | 4-22 |
| | | 4.3.4.1 | Description | 4-22 |
| | | 4.3.4.2 | Overall Protection of Human Health and the Environment | 4-23 |
| | | 4.3.4.3 | Compliance with ARARs | 4-24 |
| | | 4.3.4.4 | Long-term Effectiveness and Permanence | 4-25 |
| | | 4.3.4.5 | Reduction of Toxicity, Mobility, or Volume Through Treatment | 4-26 |
| | | 4.3.4.6 | Short-Term Effectiveness | 4-26 |
| | | 4.3.4.7 | Implementability | 4-26 |
| | | 4.3.4.8 | Cost | 4-27 |
| | 4.3.5 | Alternative 5 - Excavation, Consolidation, Debris Management, Off-Site Landfill, and Groundwater Treatment at Point-of-Use | | 4-27 |
| | | 4.3.5.1 | Description | 4-27 |
| | | 4.3.5.2 | Overall Protection of Human Health and the Environment | 4-28 |
| | | 4.3.5.3 | Compliance with ARARs | 4-28 |
| | | 4.3.5.4 | Long-term Effectiveness and Permanence | 4-29 |
| | | 4.3.5.5 | Reduction of Toxicity, Mobility, or Volume Through Treatment | 4-30 |
| | | 4.3.5.6 | Short-Term Effectiveness | 4-30 |
| | | 4.3.5.7 | Implementability | 4-30 |
| | | 4.3.5.8 | Cost | 4-30 |
| | 4.3.6 | Summary | | 4-31 |
| | 4.3.7 | Agency Acceptance | | 4-31 |
| 4.4 | Comparison of Alternatives | | | 4-31 |
| | 4.4.1 | Overall Protection of Human Health and the Environment | | 4-31 |
| | 4.4.2 | Compliance with ARARs | | 4-32 |
| | 4.4.3 | Long-Term Effectiveness and Permanence | | 4-32 |
| | 4.4.4 | Reduction of Toxicity, Mobility, or Volume Through Treatment | | 4-32 |




B07NE003701-04628

## TABLE OF CONTENTS
(continued)


| Section | | Page |
|---|---|---|
| | 4.4.5 Short-Term Effectiveness | 4-33 |
| | 4.4.6 Implementability | 4-34 |
| | 4.4.7 Costs | 4-34 |
| | 4.4.7.1 Cost Summary | 4-34 |
| | 4.4.7.2 Cost Sensitivity Analysis | 4-34 |
| 4.5 | Uncertainty Analysis | 4-36 |
| | 4.5.1 Human Health Risk Evaluation Uncertainty Analysis | 4-36 |
| | 4.5.2 Effect of RAO and PRG Decisions on Costs | 4-39 |
| | 4.5.3 Uncertainties in Estimating Volume of Material Requiring Containment or Remediation | 4-40 |
| | 4.5.4 Ultimate Remediation Cost and Schedule | 4-41 |
| | 4.5.5 Technology Effectiveness | 4-41 |
| 4.6 | Additional Data Needs | 4-41 |
| **5.0** | **REFERENCES** | **5-1** |


## LIST OF TABLES


| Table | | Follows Page |
|---|---|---|
| 1-1 | Typical Soil Properties | 1-3 |
| 1-2 | Summary of Transformation Processes for Explosive Compounds | 1-10 |
| 1-3 | Selected Physical/Chemical Properties of Explosive Compounds | 1-11 |
| 1-4 | Potential Exposure Areas | 1-19 |
| 1-5 | Detailed Analysis of Lifetime Excess Cancer Risk From Explosives Compounds (Fractional Intake Factor Applied) Hypothetical Future Farm Family | 1-21 |
| 1-6 | Detailed Analysis of Lifetime Excess Cancer Risk from Explosives Compounds (Fractional Intake Factor Applied) Hypothetical Future Worker | 1-21 |
| 1-7 | Detailed Analysis of Noncancer Risks from Explosives Compounds (Fractional Intake Factor Applied) Hypothetical Future Farm Family | 1-21 |
| 1-8 | Detailed Analysis of Noncancer Risks from Explosives Compounds (Fractional Intake Factor Applied) Hypothetical Future Worker | 1-21 |
| 1-9 | Detailed Analysis of Noncancer Risk from Explosives Compounds (No Fractional Intake Factor Applied) Hypothetical Future Populations | 1-21 |
| 1-10 | Incineration Treatability Study Explosives Results | 1-24 |




B07NE003701-04629

## LIST OF TABLES
## (Continued)


| Table | | Follows Page |
|---|---|---|
| 1-11 | Incineration Treatability Study Post-Treatment RCRA Results | 1-24 |
| 1-12 | Vitrification Treatability Study Explosives Results | 1-25 |
| 1-13 | Vitrification Treatability Study Post-Treatment RCRA Characterization Analysis | 1-25 |
| 1-14 | Biological Treatability Study Explosives Results | 1-25 |
| 1-15 | Biological Treatability Study Post-Treatment RCRA Characterization Analyses | 1-25 |
| 2-1 | Identification of Potential ARARs | 2-2 |
| 2-2 | Action-Specific ARARs | 2-2 |
| 2-3 | Summary of EP Toxicity Metals Results | 2-4 |
| 2-4 | Summary of Pretreatment Metals and TCLP Metals Results | 2-4 |
| 2-5 | Summary of Pretreatment 2,4-DNT Results | 2-4 |
| 2-6 | Preliminary Remediation Goal Development | 2-6 |
| 2-7 | Excavation Preliminary Remediation Goals | 2-7 |
| 2-8 | Estimated Area and Volume of Contaminated Soil | 2-9 |
| 2-9 | Summary of General Response Actions | 2-9 |
| 2-10 | Remedial Technologies and Process Options | 2-9 |
| 2-11 | Performance Data for Thermal Treatment Process Options | 2-17 |
| 2-12 | Performance Data for Biological Treatment | 2-21 |
| 2-13 | Response Actions and Retained Remedial Technologies and Process Options | 2-24 |
| 3-1 | Summary of Alternatives Screening | 3-4 |
| 3-2 | Final Alternatives Array | 3-6 |
| 4-1 | Conceptual Costs for Alternative 2 | 4-16 |
| 4-2 | Conceptual Costs for Alternative 3 | 4-22 |
| 4-3 | Conceptual Costs for Alternative 4 | 4-27 |
| 4-4 | Conceptual Costs for Alternative 5 | 4-30 |
| 4-5 | Summary of Alternatives Analysis | 4-31 |
| 4-6 | Documentation of ARARs With Which Alternative May Be Required to Comply | 4-32 |
| 4-7 | Conceptual Cost Summary | 4-34 |
| 4-8 | Summary of Cost Sensitivity Analysis | 4-34 |
| 4-9 | Summation of RAO Assumptions and Effects on Estimated Costs and Volumes | 4-40 |




B07NE003701-04630

## LIST OF FIGURES


| Figure | | Follows Page |
|---|---|---|
| 1-1 | FS Report Flow Diagram | 1-2 |
| 1-2 | Site Location Map | 1-3 |
| 1-3 | Current Property Owners | 1-3 |
| 1-4 | Site Map | 1-3 |
| 1-5 | Typical Load Line Layout | 1-3 |
| 1-6 | RI Investigation Areas | 1-4 |
| 1-7 | Source Area and Exposure Area Boundaries | 1-19 |
| 2-1 | Contaminated Soil and Exposure Areas - Load Line 1 | 2-8 |
| 2-2 | Contaminated Soil and Exposure Areas - Load Line 2 | 2-8 |
| 2-3 | Contaminated Soil and Exposure Areas - Load Line 3 | 2-8 |
| 2-4 | Contaminated Soil and Exposure Areas - Load Line 4 | 2-8 |
| 2-5 | Contaminated Soil and Exposure Areas - Burning/Proving Grounds | 2-8 |
| 2-6 | Contaminated Soil and Exposures Areas - Bomb Booster Assembly Area | 2-8 |
| 2-7 | Initial Screening of Technologies and Process Options | 2-11 |
| 2-8 | Evaluation of Technologies and Process Options | 2-11 |
| 4-1 | Criteria for Detailed Analysis of Alternatives | 4-2 |
| 4-2 | Components of Alternative 2 | 4-9 |
| 4-3 | Site Layout for Alternative 2 | 4-9 |
| 4-4 | Components of Alternative 3 | 4-17 |
| 4-5 | Site Layout for Alternative 3 | 4-17 |
| 4-6 | Components of Alternative 4 | 4-22 |
| 4-7 | Site Layout for Alternative 4 | 4-22 |
| 4-8 | Components of Alternative 5 | 4-27 |
| 4-9 | Remediation Cost Variations with Different Soil Volume | 4-40 |
| 4-10 | Conceptual Cost Impact of Using Conservative Risk Factors | 4-40 |




B07NE003701-04631

## LIST OF APPENDICES

**Appendix**

A PRELIMINARY REMEDIATION GOALS
- A1 Development of Preliminary Remediation Goals
- A2 Qualitative Risk Evaluation of Proposed Remedial Alternatives

B APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

C ENGINEERING CALCULATIONS/EVALUATIONS
- C1 Treatability Study Sampling Summary
- C2 Areas and Volumes of Contamination
- C3 Borrow Evaluation

D VENDOR INFORMATION

E REMEDIAL TECHNOLOGY ELIMINATION - TECHNICAL FEASIBILITY SCREENING

F COST SUMMARIES
- F1 Alternative 2 Cost Summaries
- F2 Alternative 3 Cost Summaries
- F3 Alternative 4 Cost Summaries
- F4 Alternative 5 Cost Summaries



B07NE003701-04632

## LIST OF ACRONYMS

| | |
|---|---|
| ADNT | Amino-dinitrotoluene |
| AEHA | U.S. Army Environmental Hygiene Agency |
| ARAR | Applicable or Relevant and Appropriate Requirement |
| BPWC | Baseline Present Worth Cost |
| CBC | Circulating Bed Combustor |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations, latest revision |
| CWA | Clean Water Act |
| DNB | Dinitrobenzene |
| DNT | Dinitrotoluene |
| DOD | Department of Defense |
| DRE | Destruction and Removal Efficiency |
| 1E-04 | $1x10^{-4}$ |
| EPTox | Extraction Procedure Toxicity |
| FML | Flexible Membrane Liner |
| FS | Feasibility Study |
| GRAs | General Response Actions |
| HASP | Health and Safety Plan |
| HDPE | High Density Polyethylene |
| HI | Hazard Index |
| HMTA | Hazardous Materials Transportation Act |
| HMX | High Melt Explosive or Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine |
| ISAD | Initial Screening of Alternatives Document |
| IT | International Technology Corporation |
| K | Soil-Water Partition Coefficient |
| Kow | Octanol-Water Partition Coefficient |
| LEL | Lower Explosive Limit |
| LTTD | Low-Temperature Thermal Desorption |
| MCLGs | Maximum Containment Level Goals |
| MCLs | Maximum Contaminant Levels |
| MRD | Missouri River Division |
| NAAQS | National Ambient Air Quality Standards |
| NB | Nitrobenzene |
| NCP | National Contingency Plan |
| ND | Not Detected |
| NDC | Nebraska Defense Corporation |
| NDEQ | Nebraska Department of Environmental Quality |
| NOP | Nebraska Ordnance Plant |
| NPDES | National Pollutant Discharge Elimination System |
| NRD | Natural Resources District |
| NT | Nitrotoluene |
| O&M | Operation and Maintenance |



B07NE003701-04633

## LIST OF ACRONYMS
## (Continued)

| | |
|---|---|
| OEW | Ordnance and Explosive Waste |
| OU | Operable Unit |
| PCBs | Polychlorinated Biphenyls |
| PNL | Pacific Northwest Laboratory |
| POTW | Publicly Owned Treatment Works |
| PRGs | Preliminary Remediation Goals |
| PVC | Polyvinyl Chloride |
| RAO | Remedial Action Objective |
| RCRA | Resource Conservation and Recovery Act |
| RDX | Royal Demolition Explosive or Hexahydro-1,3,5-trinitro-1,3,5-triazine |
| RI | Remedial Investigation |
| RI/FS | Remedial Investigation/Feasibility Study |
| RME | Reasonable Maximum Exposure |
| SARA | Superfund Amendments and Reauthorization Act |
| SASV | Source Area Selection Value |
| SMCLs | Secondary Maximum Containment Levels |
| SVOC | Semi-volatile Organic Compound |
| SWDA | Solid Waste Disposal Act |
| TCLP | Toxicity Characteristic Leaching Procedure |
| TCT | Twin Cities Testing |
| tetryl | 2,4,6-tetranitro-n-methylaniline |
| TNB | Trinitrobenzene |
| TNT | Trinitrotoluene |
| TRL | Target Risk Level |
| TSD | Treatment, Storage, or Disposal |
| USACE | U.S. Army Corps of Engineers |
| USATHAMA | U.S. Army Toxic and Hazardous Materials Agency |
| USCS | Unified Soil Classification System |
| USEPA | U.S. Environmental Protection Agency |
| VOCs | Volatile Organic Compounds |
| WES | U.S. Army Engineer Waterways Experiment |
| WSI | Weston Services, Inc. |

RP/MEADFS/AA2



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# 1.0 INTRODUCTION

## 1.1 PURPOSE AND ORGANIZATION OF REPORT

### 1.1.1 Purpose

This Feasibility Study (FS) Report for Operable Unit (OU) 1 of the former Nebraska Ordnance Plant (NOP) site near Mead, Nebraska, has been prepared by RUST Environment & Infrastructure (RUST) (formerly SEC Donohue) under Contract No. DACW-41-90-D-0009 for the U.S. Army Corps of Engineers (USACE), Kansas City District. The report was prepared in conformance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), amended by the Superfund Amendments and Reauthorization Act (SARA), and its governing regulations, the National Contingency Plan (NCP), 40 CFR Part 300.

Under CERCLA, uncontrolled hazardous waste sites which may pose risks to public health or the environment due to contamination of environmental media (such as groundwater or soil) are studied through the Remedial Investigation/Feasibility Study (RI/FS) process. The purpose of the RI is to characterize the nature and extent of contamination. The purpose of the FS is to develop and evaluate remedial action alternatives that address potential risks and comply with regulatory requirements. The FS process is based on technical, environmental, public health, and economic considerations so an informed risk management decision can be made concerning selection of the most appropriate remedial action for a site.

The scope of work for this FS is described in the Draft Final Project Management Work Plan (SEC Donohue, 1992a) prepared by SEC Donohue and approved by USACE, U.S. Environmental Protection Agency (USEPA), and the Nebraska Department of Environmental Quality (NDEQ). The Work Plan describes the tasks performed during the FS.

According to an Interagency Agreement (USEPA et al., 1991f) between the USEPA, NDEQ, and USACE, the NOP site is divided into three operable units (OUs). Operable units are defined such that remedial activities can be streamlined for specific contaminated media. Remedial response actions at the site will be based upon the assignment of contaminated media to these operable units. OU 1, which is addressed in this FS, includes explosives-contaminated soil. OU 2 includes contaminated groundwater and trichloroethylene contaminated soil. OU 3 includes the former landfill located near the Wastewater Treatment Plant, and other disposal areas not identified at the signing of the Interagency Agreement.



B07NE003701-04636

### 1.1.2 FS Report Overview

The goal of an FS is to develop alternatives that provide a remedial action which is implementable, performance-oriented, cost-effective, and results in adequate protection of public health and the environment.

There are three phases to an FS: the identification and screening of technologies, the development and screening of alternatives, and the detailed analysis of alternatives. Figure 1-1 presents the FS Report flow diagram specific to the NOP site. Chapter 1.0 summarizes the purpose and organization of the report and presents brief summaries of the site history, site background, nature and extent of contamination, fate and transport mechanisms, the Baseline Risk Assessment, Treatability Studies, and the site remediation approach for OU 1 at the former NOP site. Further detail on these topics can be found in the RI Report (SEC Donohue, 1992b), the Final Baseline Risk Assessment (Life Systems, Inc., 1993), and the Treatability Study Report (RUST, 1993). Chapter 2.0 presents remedial action objectives (RAOs) applicable or relevant and appropriate requirements (ARARs), preliminary remediation goals (PRGs), general response actions (GRAs), identification of applicable technologies and process options, areas and volumes of contaminated material, and two screenings of applicable technologies. Chapter 3.0 presents the assembly and screening of alternatives to reduce the number of alternatives carried forward for detailed analysis. Chapter 4.0 presents the detailed analysis and comparison of the remaining alternatives.

The evaluation criteria established in the guidance for conducting CERCLA RI/FS (USEPA, 1988) are the basis for the detailed evaluation. These evaluation criteria consist of the following:

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

## 1.2 SITE BACKGROUND

The following sections present descriptions of the physical characteristics of the site, site history, previous site investigations, the nature and extent of contamination, environmental fate and transport of the explosive contaminants detected at the former NOP site, risks posed by explosives contamination at the site, and Treatability Studies conducted during the FS.



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**FIGURE 1–1**
**FS REPORT FLOW DIAGRAM**
**Former Nebraska Ordnance Plant**
**Operable Unit I FS**
**Mead, Nebraska**
**March 1994**

CHAPTER 1

INTRODUCTION

- Review Site Characteristics, History and Previous Investigations
- Review Nature and Extent, and Fate and Transport of Contamination
- Summarize Baseline Risk Assessment
- Summarize Treatability Studies
- Summarize Site Remediation Approach

↓

CHAPTER 2

REMEDIAL TECHNOLOGY DEVELOPMENT AND SCREENING

- Identify Remedial Action Objectives Consistent with NCP
- Identify Applicable or Relevant and Appropriate Requirements
- Identify General Response Actions
- Identify Applicable Remedial Technologies
- Screen Technologies on Technical Feasibility
- Screen Process Options on Effectiveness, Implementability, and Relative Cost

↓

CHAPTER 3

DEVELOPMENT AND DESCRIPTION OF REMEDIAL ACTION ALTERNATIVES

- Assemble Remedial Action Alternatives
- Screen Remedial Action Alternatives on Effectiveness, Implementability, and Costs

↓

CHAPTER 4

DETAILED ANALYSIS AND EVALUATION OF ALTERNATIVES

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### 1.2.1 Site Description

The former NOP site occupies approximately 17,253 acres, one-half mile south of the Town of Mead, Saunders County, Nebraska (Figure 1-2). Much of this land is now owned by the University of Nebraska and is used as an agricultural experiment station. Other portions of the site, owned by various individuals and corporations, are used for agricultural and industrial purposes. Figure 1-3 is a map showing current site ownership.

The site included: four load lines, where bombs, shells, and rockets were assembled; the Burning/Proving Grounds, where fuses were tested and off-spec materials were destroyed by burning; and a Bomb Booster Assembly Area. An Administrative Area, which included offices, residences, and a laundry, was also active during NOP operations. Figure 1-4 is a site map showing general locations of these areas. Figure 1-5 shows the general layout of a typical load line. Some buildings remain on-site in various states of disrepair. A wastewater treatment plant, still in limited operation, is located near the Burning/Proving Grounds.

Although the land is mostly flat, surface drainage is generally south and east, toward Johnson and Silver Creeks. During NOP operations, wash water flowed through a series of sumps and ditches. These ditches remain on-site and surface runoff flows through them. Concrete structures and debris, trees, overhead jump chutes, and steam lines are associated with the drainage ditches and sumps. In many cases, the sumps are located immediately adjacent to buildings.

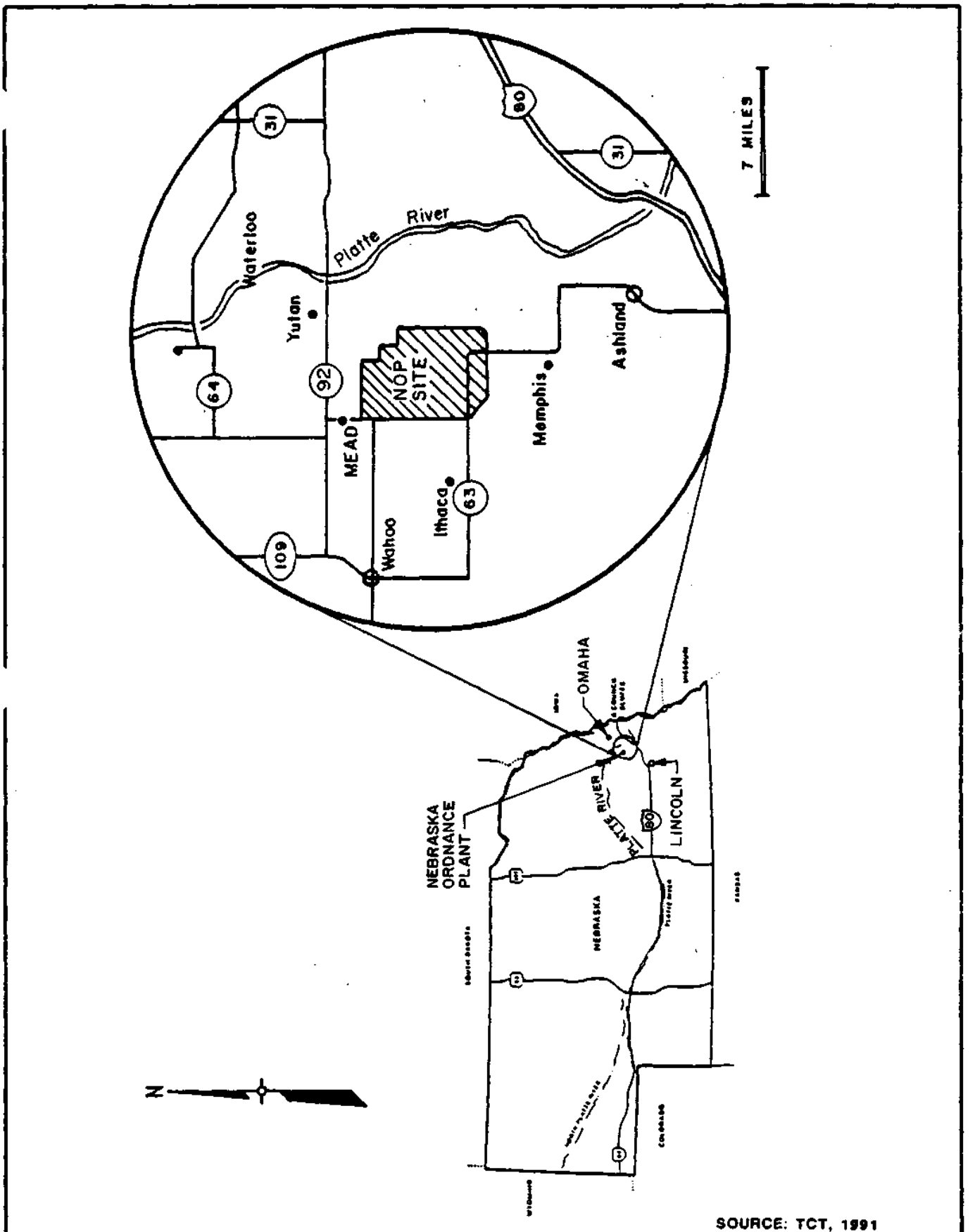
Some site-specific soil properties determined through field investigations are summarized in Table 1-1. As shown in the table, the predominant Unified Soil Classification System (USCS) soil type is silty clay soil with varying high and low plasticity (CH-CL).

### 1.2.2 Site History

#### 1.2.2.1 U.S. Army Operations

The NOP was a load, assemble, and pack facility which produced bombs, boosters, and shells. Finished munitions, bulk explosives, and related ordnance materials and components were stored and demilitarized at the site.

The Nebraska Defense Corporation (NDC), a subsidiary of Firestone Tire and Rubber Company, was contracted to provide consultant services during design and construction, and to operate the facility.




SOURCE: TCT, 1991

MARCH 1994

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RUST ENVIRONMENT & INFRASTRUCTURE

**FIGURE 1-2**
**SITE LOCATION MAP**
FINAL FEASIBILITY STUDY REPORT
OPERABLE UNIT 1
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

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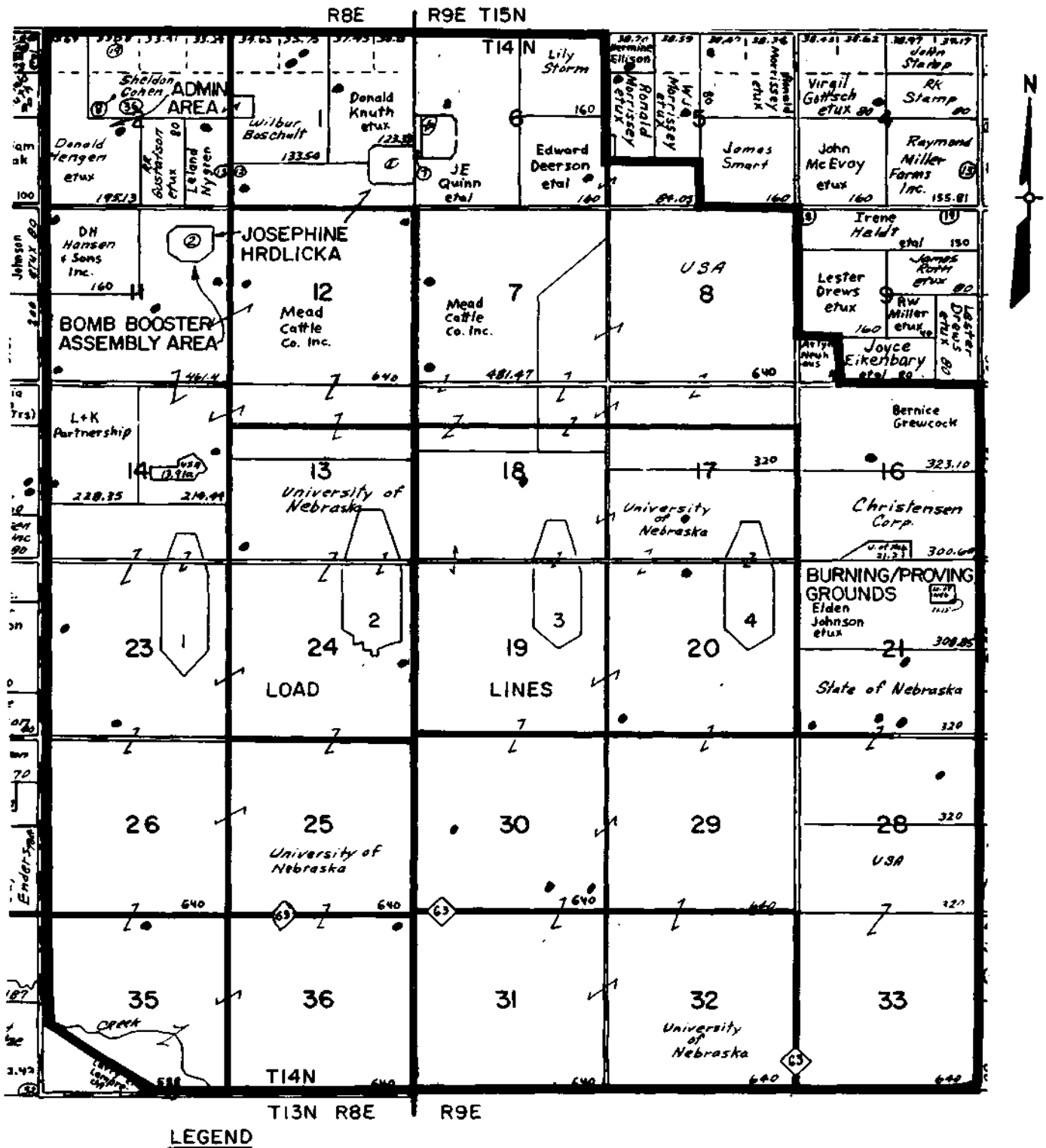


LEGEND

PROPERTY BOUNDARY OF FORMER NEBRASKA ORDNANCE PLANT

SOURCE: PLAT MAPS OF SAUNDERS COUNTY, NEBRASKA, 1990

0' 2000' 4000' 8000'

SCALE

RUST ENVIRONMENT & INFRASTRUCTURE

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**FIGURE 1-3**

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**CURRENT PROPERTY OWNERS**

FINAL FEASIBILITY STUDY REPORT
OPERABLE UNIT I
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

329965

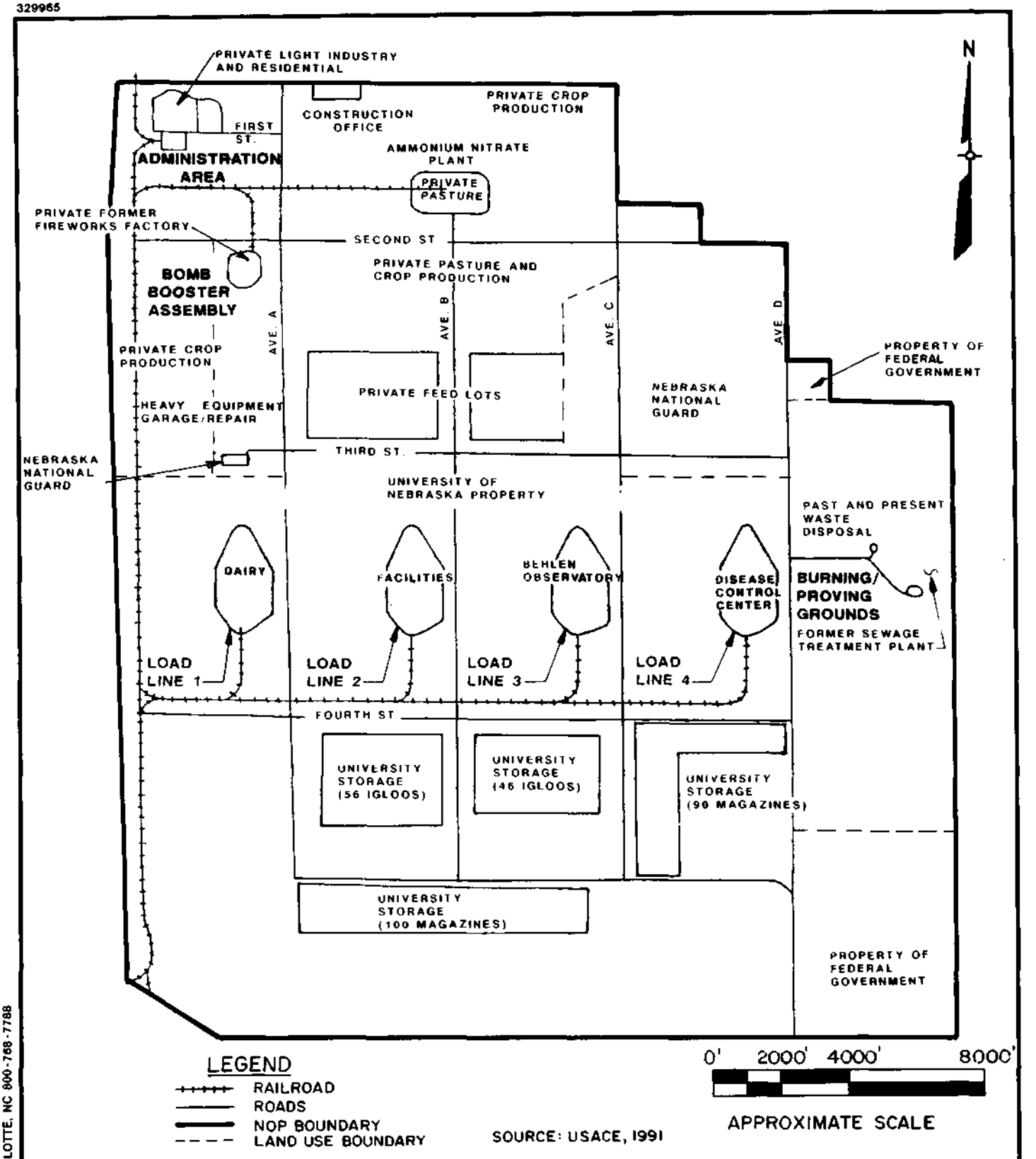


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**FIGURE 1-4**

**SITE MAP**

FINAL FEASIBILITY STUDY REPORT
OPERABLE UNIT I
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

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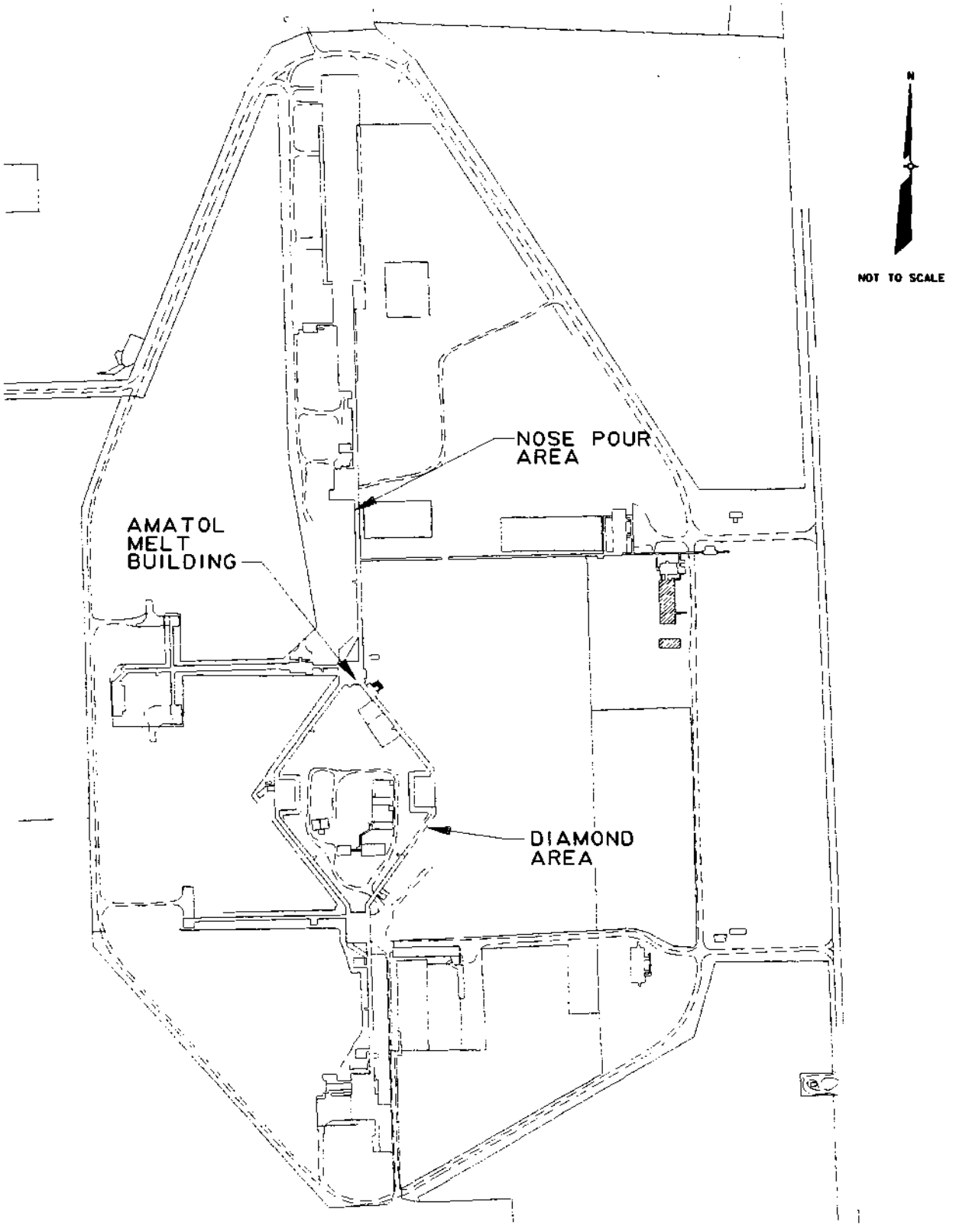
DUNCAN-PARNELL, INC. CHARLOTTE, NC 800-768-7788

B07NE003701-04642




RUST ENVIRONMENT & INFRASTRUCTURE

MARCH 1994

19536

**FIGURE 1-5**
**TYPICAL LOAD LINE LAYOUT**

FINAL FEASIBILITY STUDY - OPERABLE UNIT 1
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

**TABLE 1-1**

**TYPICAL SOIL PROPERTIES**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

USCS Soil Type: CL and CH

Soil Description: Silty Clay (low to high plasticity)

Soil pH: 6.2 to 6.5

Soil Gradation: 88 to 100% silt and clay, 0 to 12% sand

Soil Moisture Content (% of dry unit weight): 20 to 30%

Soil Unit Density (dry): 87 to 94 lb./cu. ft.

Sources: USACE (1991a), SEC Donohue (1992b), RUST (1993).

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The production facilities were active during both World War II and the Korean Conflict. Munitions and boosters were loaded with 2,4,6-trinitrotoluene (TNT), amatol (TNT and ammonium nitrate), tritonal (TNT and aluminum), Composition B (a mixture of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and TNT), and tetryl (n-2,4,6,-tetranitro-n-methylaniline). Octahydro-1,3,5,7-tetranitrio-1,3,5,7-tetrazocine, or high melt explosive (HMX), is not identified in available sources as being loaded into munitions and boosters (McMaster, 1983). The source of HMX detected on-site is believed to be impurities within RDX in Composition B.

During an interim period (1945 through 1949), the NOP was decontaminated and used primarily for storage, reworking, and disposal of bulk explosives and munitions. Decontamination procedures included cleaning, flushing, and sweeping of floors, rafters, pipes, and ventilation systems, and removal and burning of contaminated soil. Three hundred forty thousand pieces of ordnance were reportedly destroyed at three unspecified detonation pits in 1946 (USEPA, et al., 1991f).

In 1950, the plant was temporarily reactivated and produced an assortment of weapons for use in the Korean Conflict (USEPA, et al., 1991f). In 1956, NOP was placed on standby status, and in 1959 declared excess to Army needs (McMaster, 1983).

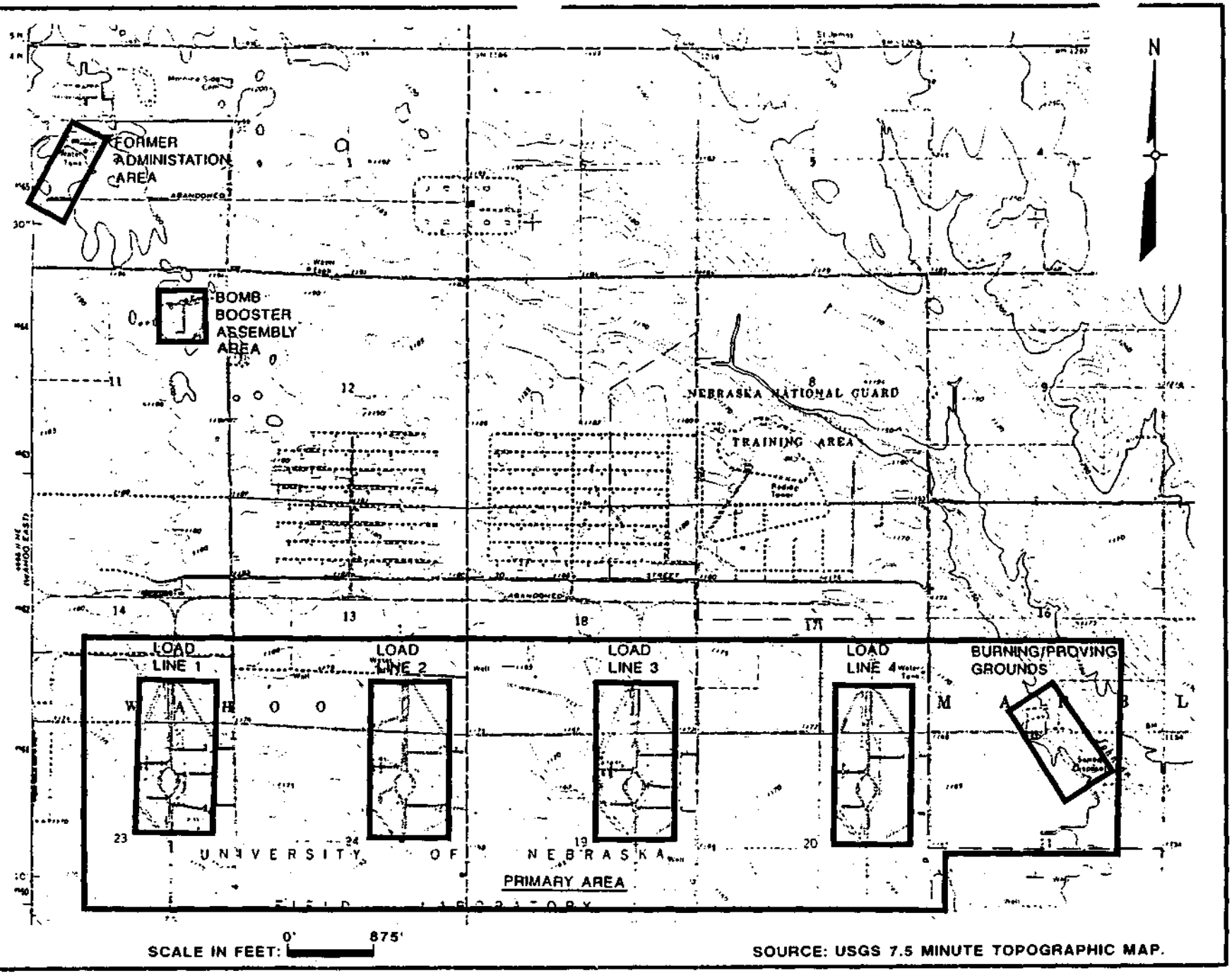
Operations for the areas investigated during this RI/FS (designated as major areas and shown in Figure 1-6) are described in further detail below.

**Load Lines**

The first bomb loading line became operational in October 1942; construction of the last line was completed by mid-December 1942. The four load lines were equipped to produce bombs weighing as much as 42,000 pounds. Bomb loading was an assembly line process. Bomb casings were delivered to the north end of each load line. The raw explosive compounds were delivered to the west side of each load line. The explosives were screened, melted, and poured into bomb casings in the central portions of the load lines. After final assembly, the bombs were washed, painted, and packaged for shipment from the south end of each load line (USACE, 1991a).

**Bomb Booster Assembly Plant**

The Bomb Booster Assembly Plant was a separate load line used to load tetryl into boosters, which aid in propulsion. Tetryl was screened and pelleted prior to booster assembly.




RUST ENVIRONMENT & INFRASTRUCTURE

MARCH 1994

**FIGURE 1-6**

**RI INVESTIGATION AREAS**

FINAL FEASIBILITY STUDY REPORT
OPERABLE UNIT I
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

19536

**Administration Area**

The Administration Area contained offices, a hospital, base housing, an analytical laboratory, vehicle maintenance, locomotive maintenance, machine shops, and a laundry. Potential toxic and hazardous materials handled or disposed of may have included medicines, chemicals, and other wastes from the hospital and analytical laboratory; petroleum, oils, lubricant products, solvents, and cleaners from the vehicle maintenance, locomotive maintenance, and machine shops; and cleaning solvents and explosive residue wastewater from the laundry. Wash waters from the laundry were discharged to a drainage ditch. The buildings in the Administration Area were not listed as contaminated in the declaration of excess (McMaster, 1983).

**Burning/Proving Grounds**

Two explosives burning areas (north and south) were used to burn waste explosives. Also, an 8.4-acre proving range, located between the wastewater treatment plant and the north burning area, was used for proof-testing boosters (McMaster, 1983). During 1944, this range was used to test caps, boosters, and fuses. Records did not indicate the number of years the range was in use (McMaster, 1983).

Records indicate that approximately 340,000 rounds of ammunition, boosters, fuses, and detonators were destroyed on-site. Information indicates that items were destroyed in pits at three locations, but exact areas are not recorded (McMaster, 1983).

**Primary Area**

The Primary Area surrounds the load lines and Burning/Proving Grounds. No DOD activities were carried out in this area. The Primary Area was investigated to determine if contamination was present outside the load line perimeter roads, and in the area surrounding the Burning/Proving Grounds.

#### 1.2.2.2 Deactivation and Decontamination

World War II operations were terminated at the NOP in 1945. The facilities and operations were placed on inactive status after decontamination and preparation for extended storage. Decontamination consisted of flushing and sweeping buildings that were not being used for storage. Explosive processing surfaces were scraped and brushed by hand. Internal roofs and trusses were flushed with high pressure water, and equipment was cleaned with steam. After flushing and steaming operations were completed, explosive residues in the sumps and settling basins, in the lead-off pipelines discharging to the drainage ditches, and an unspecified quantity of contaminated soil and sludge from the drainage ditches were removed and reportedly taken to the burning area (NDC, 1945). In some instances, portions of the tile pipe composing the drainage system from the sumps to



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the open ditches were removed and disposed. Wooden sidewalks and settling basin covers were also removed and burned in the burning area. The outside roofs of the explosives screening, melt, pour, and cooling buildings on the load lines, and the Bomb Booster Assembly Area tetryl screening and blending, pelleting, rest house, and magazine buildings were flushed (NDC, 1945).

Septic tanks were cleaned, and NDC recommended that the wastewater treatment plant be inactivated while the NOP was on standby. The decontamination report recommended that sewage be discharged directly to open drainage (NDC, 1945).

Neither the reactivation procedures for the Korean Conflict effort nor the decontamination records after final plant shutdown could be located. Recommended final decontamination procedures were reviewed (McMaster, 1983). Presumably, buildings were decontaminated with hot water and steam; buildings were mostly constructed of wood and, therefore, were not flame-flashed to eliminate residual explosive compounds (USACE, 1991a). Although these procedures were recommended in 1959, with the intent of being accomplished prior to actual excessing, later records indicate that at least some of the contaminated buildings and land in the load lines and Bomb Booster Assembly Area were not decontaminated before they were excessed (McMaster, 1983).

#### 1.2.2.3 Post-Operations Site Use

In 1956, after the Korean Conflict, the NOP was placed on standby; the NOP was declared excess in 1959. The property was transferred to the General Services Administration (GSA) for disposition (USACE, 1991a). Approximately 1,000 acres were transferred to the U.S. Army for National Guard and Army Reserve training; 12 acres were retained by the Army for use as a Nike missile maintenance area; 2,000 acres were transferred to the U.S. Air Force to build the Offutt Air Force Base Atlas Missile Site; and 40 acres were transferred to the Department of Commerce. In 1962, approximately 9,600 acres of the former NOP were purchased by the University of Nebraska for use as an agricultural research farm, and an additional 600 acres were obtained by the University in 1964. The remaining 5,250 acres were eventually purchased by private individuals and corporations.

Since NOP decommissioning, the property has been used primarily for agricultural and livestock production and research. In addition, several commercial operations were conducted on former NOP property. Apollo Fireworks operated for a period of approximately 20 years in the Bomb Booster Assembly Area. Production at Apollo was terminated in 1989. At the former administration buildings, insulation board manufacturing and styrofoam packing material processing were in operation at various times. Property was purchased for these purposes by private individuals.



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### 1.2.3 Previous Site Investigations

In 1983, an Archives Search Report was prepared for the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) (McMaster, 1983). This search was conducted to assess the potential for contamination at the former NOP site from Department of Defense (DOD) operations. Conclusions were based on the U.S. Army Ordnance Ammunition Command's 1959 Survey of Explosives Contamination. Areas recognized as having the greatest potential for contamination were the four load lines, the Bomb Booster Assembly Area, and the Burning/Proving Grounds.

In 1989, USACE conducted a confirmation study (USACE, 1989) to determine if past DOD activities at the NOP resulted in environmental contamination. Specific objectives included the identification of hazardous and toxic wastes, unexploded ordnance, and unsafe debris. A geophysical survey was conducted to screen boring locations and locate buried materials. The study concluded that explosive residues are present in soil around Load Lines 1, 2 and 3. Explosive compounds were also detected in a composite groundwater sample collected downgradient of Load Line 2. Volatile organic compounds (VOCs) were detected in groundwater, soil and sediment samples. Previous studies summarized in the Confirmation Study Report show that polychlorinated biphenyls (PCBs) were detected in surface soil samples from Load Lines 1, 2 and 4.

In 1991, Twin Cities Testing identified and assessed potential sources of explosives contamination and unexploded ordnance resulting from DOD activities on-site (TCT, 1991b). TCT reviewed records and inspected the site, excavated two test pits, and collected 18 soil samples. Locations potentially requiring remedial action were identified as those where solid pieces of TNT were visibly present or where TNT was found in soil at greater than 2 percent by weight. The following areas were identified based on these criteria: washout areas of Load Lines 1, 2 and 3; the proving range, and the south burning ground. The proving range and south burning ground are parts of the Burning/Proving Grounds. Remedial alternatives for these contaminated areas were suggested.

USACE conducted a Remedial Investigation (USACE, 1991a), in which soil borings from Load Lines 1 through 4, the Bomb Booster Assembly Area, and the Administration Area were analyzed for explosives and metals. Foundations of former boiler buildings and soils adjacent to transformer pads were sampled for PCBs. Explosives contamination was confirmed in Load Lines 1, 2, and 3. PCBs were detected in Load Lines 1, 3, and 4. Isolated locations of elevated metals concentrations were also detected.

To more completely characterize the horizontal and vertical extent of contamination at the former NOP site, SEC Donohue conducted a Supplementary RI (SEC Donohue, 1992b). RI activities included four major categories: grid sampling, confirmation/discretionary



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point sampling, transect/hot spot borings, and sediment sampling. These activities were undertaken in eight major areas: the four load lines, the Bomb Booster Assembly Area, Administration Area, Burning/Proving Grounds, and the Primary Area.

Surface soil grid sampling was conducted to characterize the lateral extent of explosives contamination in the soil. For the grid sampling, a pattern of rectangular grids was established in each of the investigation areas. The grids were divided into four quadrants, and a surface soil sample was collected at the center of each quadrant. These samples were analytically screened in the field for explosives. Based on the results of that screening, samples were selected for laboratory analysis.

Surface soil confirmatory/discretionary samples were collected to further investigate areas of soil contamination identified by field screening and laboratory analysis of grid samples, areas identified by previous investigations, areas identified by historical aerial photographs, and areas of suspected explosives contamination based on NOP operations.

Transect and hot spot borings were completed to investigate the horizontal and vertical extent of explosives contamination in areas where contamination had been found through grid or confirmatory/discretionary point sampling. Transect borings were located adjacent to drainage ditches to evaluate lateral migration of contaminants in the subsurface. Soil from borings was typically sampled approximately every 2 to 3 feet for the first 15 feet, and at 3 feet above the historical high groundwater elevation.

Two sediment samples were collected from Johnson Creek and four sediment samples were collected from the National Resources District (NRD) Impoundment located on-site. These samples were collected at a depth of 0 to 1 foot and submitted for laboratory analysis for explosives, metals, PCB/pesticides, VOCs, and semi-volatile organic compounds (SVOCs). The VOC samples were inadvertently collected from homogenized sediment and, therefore, may have resulted in low values due to volatilization (SEC Donohue, 1992b).

### 1.2.4 Nature and Extent of Contamination

Results of investigations conducted by TCT (TCT 1991b), USACE (1989, 1991a), and SEC Donohue (1992b) indicate that explosives contamination in soil is mostly limited to drainage ditches and sumps in the load lines. Explosives contamination in areas outside the ditches and sumps occurs in isolated "hot spots". In the load lines, the contamination is believed to have originated from discharge of wash water from the ordnance manufacturing process. In the Bomb Booster Assembly Area, activities involved in the manufacture of boosters probably caused contamination. In the Burning/Proving Grounds, testing and burning activities probably contributed to soil contamination. No significant explosives contamination was identified in the Primary Area or the Administration Area.



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Most of the contaminated soil is found within 5 feet of the soil surface, but the maximum depth of contamination measured and detected in these studies is approximately 30 feet. Explosive compounds detected include:

- 2,4,6-Trinitrotoluene (TNT)
- Hexahydro-1,3,5-trinitro-1,3,5-triazine (royal demolition explosive or RDX)
- 1,3-Dinitrobenzene (DNB)
- 2,4- and 2,6-Dinitrotoluenes (DNT)
- 1,3,5-Trinitrobenzene (TNB)
- Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (high melt explosive or HMX)
- n-2,4,6-Tetranitro-n-methylaniline (tetryl)
- o-Nitrotoluene (o-NT)
- m-Nitrotoluene (m-NT)
- p-Nitrotoluene (p-NT)

TNT, TNB, and RDX were the contaminants most often detected.

The Supplemental RI Report (SEC Donohue, 1992b) includes an evaluation of metals analyzed on-site. The nature and extent of metals contamination was assessed by identifying measured soil concentrations exceeding five times the mean measured background concentrations (or in some cases the reported average concentrations for U.S. soil). The majority of detected metals were not significantly above background. Two areas of elevated concentrations of chromium and silver/mercury were identified. These "hot spots" do not appear to be co-located with explosives and will, therefore, be evaluated in OU 3 as previously unidentified potential disposal areas. Twenty-three locations were identified where lead exceeded five times the background concentration. Lead contamination was identified as isolated "hot spots" in the Burning/Proving Grounds, in the drainage ditch associated with the laundry facility in the Administration Area, in the vicinity of painting operations on the load lines, and in the drainage ditch systems associated with the load lines. The USEPA uptake-biokinetic model, used to evaluate the risks due to lead contamination in the soil showed that two isolated areas may be of potential concern. However, the actual risk depends on the extent of the lead contamination (small "hot spots" vs. broad areas), which will be investigated as part of OU 3.

VOC analyses performed during the supplemental RI indicate that VOCs (included in OU 2) are also not generally co-located with explosives. Of five samples collected in the Burning/Proving Grounds for PCB/pesticide analysis, endrin aldehyde was detected in one sample. Bis(2-ethylhexyl)phthalate (BEHP) was detected in three of the five samples collected for SVOC analysis in the Burning/Proving Grounds. BEHP and other phthalates are plasticizers and degradation products which are now ubiquitous in the environment. Acetone, toluene, 1,2-dichloroethylene, and trichloroethylene (VOCs) were detected in samples from the 2- to 3-foot depth in the Burning/Proving Grounds. Acetone is believed to be present as a result of contamination from the field laboratory.



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Explosive analytes were not detected in the sediment or surface water samples collected from Johnson Creek and the NRD Impoundment. Phthalate SVOCs were measured in four of ten sediment samples, and in four surface water samples. Three VOCs (acetone, chloromethane, and 2-butanone) were detected in one or more sediment or surface water samples. As discussed above, phthalate are ubiquitous and acetone is a common laboratory contaminant.

For an RI at any site, there is residual uncertainty inherent to sampling and analysis procedures used, evaluations performed, and assumptions made. Section 1.2.3 discusses the assumptions used to determine supplemental RI sample locations.

### 1.2.5 Environmental Fate and Transport

The behavior of a chemical substance in the environment can be described in terms of three classes of processes: transformation, transfer, and transport. Transformation processes alter the substance through physical, chemical or biological processes. The combination of these processes is referred to as the fate of the substance, and determines how long the substance will persist in the environment. Transfer processes distribute a chemical substance among different phases of the environment. For these purposes, the environment is usually divided into five phases: air, soil, groundwater, surface water, and biota (plants and animals). Transport processes govern the distribution of a chemical substance within a single medium. Transport and transfer processes combine to constitute migration, which defines the distribution of a chemical substance through space and time.

#### 1.2.5.1 Transformation Processes

Transformation processes alter contaminants from their original physical/chemical form. Transformation processes that degrade explosive compounds include photolysis, oxidation/reduction, hydrolysis, and biodegradation. Photolysis involves the absorption of light energy by a molecule. This energy causes chemical bonds to break, creating a new molecule. Oxidation/reduction involves the transfer of electrons, creating new molecules from reactants. Hydrolysis refers to a reaction with water that degrades a compound. In biodegradation reactions, biological agents such as bacteria or fungi use chemical substances as energy sources, changing the composition of the chemicals in the process. A summary of the susceptibility of explosive compounds found at the NOP site to these transformation processes is included in Table 1-2.

#### 1.2.5.2 Transfer Processes

Transfer of contaminants can potentially occur between any two phases of the environment. Examples include adsorption (transfer from water to soil), desorption (transfer from soil to water), solution (transfer from solid to aqueous phases), volatilization (transfer from soil to air), and plant uptake and bioaccumulation (transfer from soil or water to biota). Transfer of contaminants from soil to human and ecological receptors is considered in the Baseline Risk Assessment (Life Systems, 1992a and 1992b) for this site.



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## TABLE 1-2

## SUMMARY OF TRANSFORMATION PROCESSES FOR EXPLOSIVE COMPOUNDS

**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Compound | CAS Registry Number | Oxidation/ Reduction | Photolysis (In Water) | Hydrolysis | Biodegradation |
|---|---|---|---|---|---|
| 2,4,6-TNT | 118-96-7 | Minimal susceptibility. (2) | Oxidation of methyl group followed by decarboxylation. Results in photosensitive products that act as catalysts for further TNT photolysis. Enhanced by humic matter. (1) | At high pH only. (1) | Aerobic and anaerobic transformation to amino compound or aromatic ring. Mineralization may be aided by nutrient addition. (1) |
| RDX | 121-82-4 | Minimal susceptibility. (2) | Fastest transformation; no acceleration due to photo-sensitive products or humic matter. (1) | At high pH only. (1) | Anaerobic transformation with nutrient addition. Products include methanol, formaldehyde, hydrazine and dimethylhydrazine isomers. (1) |
| HMX | 2691-41-0 | Minimal susceptibility. (2) | Mechanism and products similar to RDX but slower. Multiple pathways. (1,2) | No information available. | Anaerobic mechanisms and products similar to RDX, but slower. (1,2) |
| 1,3,5-TNB | 99-35-4 | Minimal susceptibility. (2) | Very little or none. (1,2,3) | None. (1,2,3) | Slow reduction of nitro groups, no mineralization. Rate enhanced by activated sludge organisms and nutrients. (1,2) |
| 2,4-DNT | 121-14-2 | Minimal susceptibility. (2) | Like TNT, products are catalysts for further DNT photolysis. Also enhanced by humic matter. Anaerobic photolysis faster than aerobic. (1,2) | None. (7) | Transformation analogous to TNT but about four times slower. (1) |
| 2,6-DNT | 606-20-2 | Minimal susceptibility. (2) | Similar to 2,4 isomer but faster rate because less stable. (1) | No information available. | Transformation only in the presence of yeast. (1) |

**TABLE 1-2**

**SUMMARY OF TRANSFORMATION PROCESSES FOR EXPLOSIVE COMPOUNDS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Compound | CAS Registry Number | Oxidation/ Reduction | Photolysis (In Water) | Hydrolysis | Biodegradation |
|---|---|---|---|---|---|
| 1,3-DNB | 99-65-0 | Minimal susceptibility. (2) | Slower rates than DNT isomers (sterically stable without methyl group.) Not significant for removal. (1,3) | No information available. | Transformation only found in adapted lab organism. (1,2) |
| Tetryl | 479-45-8 | Minimal susceptibility. (2) | Major mechanism. (1,2) | Slow. (2) | Similar to TNT. (1) |

Sources:

1) Layton et al., 1987.
2) Burrows et al., 1989.
3) Spanggord et al., 1980.
4) Greene et al., 1985.

RP/MEADFS/AB2

The transfer processes of primary significance at the NOP site include soil - water and soil - plant.

The transfer of contaminants between soil and water is governed by the soil-water partition coefficient, K. This parameter represents the distribution of a chemical substance between the two phases in saturated soil under equilibrium conditions. A higher value of K represents a greater affinity for the soil phase. Values of K are system-specific; they are only valid for a particular contaminant and a particular soil. K is related to the solubility of a chemical substance in water and its octanol-water partition coefficient, K, which is a measure of the relative distribution of a chemical substance between organic and aqueous phases.

The tendency of a contaminant to transfer from water to air is governed by its vapor pressure and its Henry's Law constant. Both of these parameters measure the amount of a substance in the vapor phase in equilibrium with a liquid. Higher values of each correspond to more volatile compounds which tend to vaporize more readily.

A summary of the physical/chemical characteristics of explosive compounds detected at the NOP relating to adsorption and volatilization is included in Table 1-3. K values given in Table 1-3 indicate that these compounds should be sorbed relatively strongly to soil solids. Henry's Law constants and vapor pressures are relatively low, indicating that these compounds do not tend to volatilize readily. As Table 1-3 shows, explosive compounds are not highly water soluble. The combination, of high K values, low volatility, and low solubility suggests these compounds tend to be relatively immobile in a soil environment.

Investigations of the plant uptake and bioaccumulation of TNT and RDX conducted by Pacific Northwest Laboratory (1989) and Folsom et al. (1988) indicate that both compounds are transferred from soil to plant tissues. This capacity for bioaccumulation appears to increase with increasing explosives concentrations. Although factors such as sorption rate and final concentrations varied significantly with different types of soils, RDX exhibited greater plant uptake. Uptake of explosives by plant tissue at the former NOP site has not been specifically studied.

#### 1.2.5.3 Transport Processes

Transport processes are those by which a substance is redistributed within a single environmental medium. The transport of compounds through the unsaturated zone to groundwater is potentially the most significant of these processes at the site. The rate at which contaminant transport occurs in the unsaturated zone is described by the degree of saturation, movement of water through the unsaturated zone, and a retardation factor, R, which is related to K and soil porosity. This retardation relates the movement of the solvent (water) to movement of the solute (contaminant). Because the soil is classified as

**TABLE 1-3**

**SELECTED PHYSICAL/CHEMICAL PROPERTIES OF EXPLOSIVE COMPOUNDS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Compound | Solubility in Water (mg/l) | Soil/Water Partition Coefficient, K (l/kg) | Octonal/Water Partition Coefficient, Log Kow | Henry's Law Constant (atm/m$^3$ mole) | Vapor Pressure |
|---|---|---|---|---|---|
| 2,4,6-TNT | 117 @ 20 C to 150 @ 25 C (1,4,5,11) | 3.8 (soil) 26.2 (bentonite) (higher in reducing environments than oxidizing) (1,5,18) | 1.65 - 2.83 (1,8,14) | $1.10 \times 10^{-8}$ @ 25 C (14) | $10^{-6}$ Torr @ 20 C (5,12,14) |
| RDX | 7.6 @ 25 C to 60 @ 23.5 C (1,4,10,11,13) | 6.16 (bentonite) (1) | 0.81 - 1.41 (1,3,8,11,14) | $1.96 \times 10^{-15}$ @ 25 C (14) | $10^{-9}$ Torr @ 25 C (4,14) |
| HMX | 5 @ 20 C to 11.6 @ 30 C (6,9,14) | 10.96 (bentonite) (1) | 0.06 - 1.13 (1,8,14) | $2.6 \times 10^{-15}$ @ 25 C (14) | $3.33 \times 10^{-14}$ Torr @ 25 C (14) |
| 1,3,5-TNB | 278 to 385 @ 25 C (4,14) | No information available. | 1.18 (14) | $2.21 \times 10^{-9}$ @ 25 C (14) | $2.2 \times 10^{-4}$ Torr @ 25 C (4) |
| 2,4-DNT | 185 @ 23 C to 300 @ 20 C* (1,4,12,14) | 25.12 to 92* (bentonite)* (1,7) | 1.88*-2.77* (1,7,14) | $1.86 \times 10^{-7}$* @ 25 C (14) | $2.17 \times 10^{-4}$ Torr @ 25 C to 0.018 Torr @ 20 C (4,12,14) |
| 2,6-DNT | 206 @ 25 C (14) | see 2,4-DNT | 1.89-2.02 (14) | $4.86 \times 10^{-7}$ @ 25 C (14) | $5.67 \times 10^{-4}$ Torr @ 25 C (14) |

*not differentiated by isomer (2,4-DNT or 2,6-DNT).

**TABLE 1-3**

**SELECTED PHYSICAL/CHEMICAL PROPERTIES OF EXPLOSIVE COMPOUNDS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Compound | Solubility in Water (mg/l) | Soil/Water Partition Coefficient, K (l/kg) | Octonal/Water Partition Coefficient, Log Kow | Henry's Law Constant (atm/m$^3$ mole) | Vapor Pressure |
|---|---|---|---|---|---|
| 1,3-DNB | 200 @ 20 C to 533 @ 25 C (4,14,21) | No information available. | 1.56 (14) | $5.44 \times 10^{-8}$ @ 25 C (14) | $1.31 \times 10^{-4}$ Torr @ 25 C to $4 \times 10^{-3}$ Torr @ 25 C (4, 14) |
| Tetryl | 50 @ 0 C to 80 @ 25 C (13,14) | High. (18) | 1.65 (14) | $2.69 \times 10^{-11}$ @ 25 C (14) | $5.69 \times 10^{-9}$ Torr @ 25 C (14) |

Sources:

1) Leggett (1985).
2) Hansch and Leo (1979) as cited in (1).
3) Sikka (1980) as cited in (1).
4) Spanggord et al. (1980).
5) Pennington (1988).
6) Glover and Hoffsommer (1973) as cited in (1).
7) Mabey et al., (1982) as cited in ATSDR (1989).
8) Banerjee, et al., (1980) as cited in (1).
9) USEPA (1988a).
10) USEPA (1988b).
11) Rosenblatt (1984).
12) OSHA (1978).
13) Military Explosives (1984).
14) Burrows et al., (1).
15) Sax (1987).
16) Layton et al., (1986).
17) Layton et al., (1987).
18) Garg et al., (1991).
19) Greene et al., (1985).
20) USATHAMA (1987).
21) Merck (1989)

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silty clay, as discussed previously, permeability is expected to be low. This and relatively high K values suggest that migration of explosive compounds through the unsaturated zone will be inhibited.

#### 1.2.5.4 Fate and Transport of Explosive Compounds

In general, two processes significantly affect the fate and distribution of explosive compounds in the environment: microbial transformation and photodecomposition. Transfer of these compounds from aqueous systems to air is not believed to be significant because volatility is relatively low. Except for the slow hydrolysis of tetryl, chemical transformations are not expected to occur under environmental conditions (Burrows et al., 1989). Available fate and transport information for some of the explosive compounds at the NOP site are summarized in the following sections. TNT has been studied more extensively than the other compounds and is, therefore, discussed in greater detail. Information on NT was not available and therefore is not included.

**TNT**

Although TNT is subject to biological degradation and photodecomposition, it still persists in environmental media for many years (Layton et al., 1987). Microorganisms capable of metabolizing TNT have been reported in soil, mud, and fresh waters and their sediment. Such transformations have been associated with species from numerous common aerobic and anaerobic bacterial genera as well as with many fungal species (Burrows et al., 1989). Only one case of a microorganism growing on TNT as a sole carbon source has been reported. Generally, supplementary nutrients are required for the metabolism of TNT. Biological systems with added domestic sewage and river sediments have resulted in significant TNT decreases, and laboratory cultures with added bacterial media have resulted in rapid TNT decreases (Burrows et al., 1989). Nutrients increase the rates of reaction and, in some cases, enable mineralization to proceed. Under environmental conditions, however, mineralization of TNT is not expected to occur. Biotransformation rates and products have also been shown to be affected by pH level and oxygen concentration (Layton et al., 1987).

Transformation proceeds through progressive reduction of the nitro groups to amino groups. The final reduced product is 2,4,6-triaminotoluene. Hydroxylamine intermediates can also couple to form tetranitroazoxytoluenes. Which product predominates depends on the nature of the microbial preparation, microbial species, and conditions under which nitro group reduction takes place (Burrows et al., 1989).

During a degradation study of pink water compounds in soil, 4-amino-2,6-DNT (4-ADNT) and 2-amino-4,6-DNT (2-ADNT) were the primary microbial intermediates formed after soil column experiments were run continuously for 110 days (Greene et al., 1985). 2-ADNT and 4-ADNT will undergo photolysis in surface water and are also susceptible to biotransformation under both aerobic and anaerobic conditions. These microbial transformation products of TNT (4-ADNT, and 2-ADNT) are not mineralized in natural



B07NE003701-04658

waters; however, they do appear to degrade. It has been been suggested that microbial reduction produces highly substituted anilines or their precursors, which subsequently react with carboxyl groups of humic acids, lipids, or proteins to form insoluble precipitates. The binding reactions appear to be enhanced by low pH (Layton et al., 1987).

In environmental waters, the rate of photochemical transformation of TNT is significantly higher than for microbial transformation. The laboratory photolysis of dilute aqueous solutions gives rise to complex mixtures because primary photoproducts undergo further reaction. The major primary photoproduct is 2,4,6-trinitrobenzaldehyde which converts to the azoxydicarboxylic acid after further oxidation and coupling (Burrows et al., 1989).

TNB (a minor product in the laboratory studies) was the major photoproduct observed in similar study of the effect of sunlight on TNT in natural river water. This compound was photostable, but underwent slow biotransformation via nitro group reduction to 3,5-dinitroaniline (Burrows et al., 1989).

The rate of photochemical disappearance appears to be inversely proportional to pH (Burrows et al., 1989). It has also been shown that the composition of photoproducts varies with pH (Layton et al., 1987). Rate enhancement in natural waters of 10 to 100-fold for TNT photolysis has been observed. Research has also shown that the rate of TNT photolysis depends in part on the concentration of photoproducts. The rate is accelerated by the presence of particular decomposition products and humic matter. Oxygen has been shown to retard aqueous TNT photolysis (Layton et al., 1987).

Overall, adsorption to soil will not effectively prevent TNT mobility through surface soil. Adsorption of TNT onto soil is most closely correlated with extractable iron, cation exchange capacity, and percent clay. Adsorption and desorption appear to occur to the same extent. This suggests that, over time, continued leaching may remove TNT from soil. Oxidized conditions decrease adsorption compared to reduced conditions. Reduction of TNT to 2-ADNT and 4-ADNT was observed during adsorption and desorption experiments. These products are more polar than TNT and have greater affinity for soil (Pennington and Patrick, 1990).

Studies have been conducted to measure the uptake of TNT by plants. Low levels of TNT, 4-ADNT, and 2-ADNT were detected in plant materials according to Folsom et al., 1988. More recent studies (1989 and 1990) by Cataldo et al., indicate that plant uptake of TNT may be significant. Soil characteristics such as clay content in NOP soil may limit uptake. Site-specific uptake information on plant uptake is not available.



B07NE003701-04659

### RDX

Aerobic biotransformation has little, if any, effect on the presence of RDX in the environment. On the other hand, certain anaerobic sludge treatment systems with high supplemental nutrient levels were found to affect the reductive transformation of RDX. Methanol, formaldehyde, hydrazine, 1,1-dimethylhydrazine, and 1,2-dimethylhydrazine were the major products (Burrows et al., 1989). In other experiments, mineralization of RDX to carbon dioxide was observed after a period of microbial adaptation (Layton et al., 1987). During a soil column degradation study of pink water, RDX exhibited low sorption and biodegradation potential (Greene et al., 1985). Thus, aerobic biotransformation of RDX in environmental surface waters appears to be insignificant, and the significance of anaerobes in removing it from soils and standing water zones or bottom sediments is not clear (Burrows et al., 1989). It appears, however, that added nutrients are required and that microbial degradation will occur only where sediment microbial populations have adapted to mineralize RDX (Layton et al., 1987).

RDX is readily degraded photochemically. Several different pathways may be operative. Photolysis in water leads to the formation of nitrate, formaldehyde, and methylenedinitramine. Methylenedinitramine decomposes in water to form formaldehyde and nitrous oxide (Burrows et al., 1989). Formaldehyde is biodegradable both aerobically and anaerobically (Verschueren, 1983). A different photolytic pathway, possibly via a transient nitrodihydrotriazine, has also been observed (Burrows et al., 1989).

Photolysis of RDX appears to increase with increasing sunlight and ambient temperatures. Unlike TNT, the presence of decomposition products or humic substances does not accelerate the rate of photolysis. Dissolved oxygen does not appear to influence RDX photolysis rates either. Photolysis of solid RDX produces polymeric products, as well as the small molecular weight products of aqueous photolysis (Layton et al., 1987).

### 2,4-DNT

2,4-DNT has been shown to be biodegradable. DNT is biotransformed more slowly and by fewer organisms than is TNT (Layton et al., 1987). A mixed culture has been developed that can grow on and extensively degrade DNT to carbon dioxide. Biotransformation involving nitro group reduction has also been observed (Burrows et al., 1989).

DNT reduction products bind to humic materials as do the reduction products of TNT. The aromatic amine reduction products may undergo condensation reactions with carboxylate groups to form polyamides. Furthermore, polyamide polymers formed from biodegradation will be long-lived because amide linkages are resistant to microbial attack. As the amino by-products are formed, they will probably adhere strongly to humic materials (Layton et al., 1987).



B07NE003701-04660

Photolysis of 2,4-DNT follows a similar course as TNT. The methyl group may accelerate photolytic decomposition of 2,4-DNT due to the steric interaction with the adjacent nitro groups on the ring (Layton et al., 1987). The major isolated products were 2-amino-4-nitrobenzoic acid, 2-amino-4-nitrobenzaldehyde, and azoxydicarboxylic acid. Photooxidation of 2,4-DNT in the presence of excess hydrogen peroxide resulted in oxidation to the corresponding acid, decarboxylation, and hydroxylation of the resulting DNB. Subsequent ring cleavage to mixtures of low molecular weight acids and aldehydes was observed (Burrows et al., 1989).

Like TNT, rate enhancements for 2,4-DNT photolysis in natural waters has been observed and may be attributed to the action of humic acids as triplet sensitizers which transfer energy to the compound, making it more reactive (Burrows et al., 1989). The presence of decomposition products also enhance the photolysis rate of 2,4-DNT. Photolysis occurs more rapidly under anaerobic conditions than aerobic (Layton et al., 1987).

2,4-DNT adsorption coefficients are comparable to those for TNT. Since sorption is not expected to prevent TNT mobility through surface soils (Pennington, 1990), it is not likely that DNT will be effectively immobilized via adsorption to soils or sediments.

**2,6-DNT**

Biodegradation of 2,6-DNT has been observed during laboratory experiments. Supplemental nutrients appear to be necessary. The relative biodegradation rate of 2,6-DNT is approximately 3.7 times slower than that of TNT (Layton et al., 1987).

The photolysis rate of 2,6-DNT is faster than that of 2,4-DNT. This enhanced rate may be due to steric crowding of the methyl group and the adjacent nitro groups on the ring. The proposed photolysis mechanism is analogous to that of 2,4-DNT and TNT (Layton et al., 1987).

**Tetryl**

The environmental fate of tetryl parallels that of TNT because of the structural similarity of the two compounds. Tetryl, however, has a functional group (the methylnitroamino group) that is subject to hydrolysis. Also, because of this functional group, tetryl may bind to naturally occurring macromolecules, lipids, and proteins (Layton et al., 1987).

Tetryl in aqueous solution is completely photolyzed by sunlight in approximately 20 days. The major photolytic products are n-methylpicramide, nitrate, and nitrite (Burrows et al., 1989).

Tetryl also undergoes slow hydrolysis under environmental conditions (Burrows et al., 1989). The hydrolysis reaction increases with increasing pH (Layton et al., 1987). Specific information regarding other fate processes, such as biodegradation, was not found. It is reasonable to assume, however, that microbial action will reduce the nitro groups to



B07NE003701-04661

amines (Layton et al., 1987). Tetryl's moderate sorption coefficients suggest that it may slowly leach to groundwater when released to soil. Volatilization from soil or water is not expected to be significant.

**HMX**

Aerobic biotransformation has little, if any, effect on HMX in the environment. Certain anaerobic sludge treatment systems with high supplemental nutrient levels were found to affect reductive transformation. The rate of HMX transformation is slower than that for RDX. Major reductive products of HMX include methanol, formaldehyde, hydrazine, 1,1-dimethylhydrazine, and 1,2-dimethylhydrazine (Burrows et al., 1989). In a soil column degradation study of pink water compounds, HMX broke through rapidly and no intermediates were detected in the leachate during the 110-day duration of the experiment (Greene et al., 1985). Thus, removal of HMX from surface water and shallow soils by aerobic microorganisms appears to be insignificant. The significance of anaerobes in removing it from deeper soils, standing water zones, or bottom sediments is not known (Burrows et al., 1989).

HMX is readily degraded photochemically. The products of aqueous photolysis of this explosive compound are nitrate, formaldehyde, and methylenedintramine. The latter then decomposes to form formaldehyde and nitrous oxide. Other products have also been isolated, indicating that more than one pathway exists (Burrows et al., 1989).

The compilation of physical and chemical properties suggests that volatilization and sediment sorption will not be significant environmental fate processes for HMX. No information concerning HMX hydrolysis was found.

**TNB**

TNB is an impurity present in TNT. It is also a stable product of TNT photolysis that occurs whenever TNT has been a surface soil or water contaminant over a period of time (Burrows et al., 1989). TNB is photostable and undergoes slow biotransformation via nitro group reduction to 3,5-dinitroaniline (3,5-DNA). This compound, however, has not been found to be biodegradable (Burrows et al., 1989). It is expected that 3,5-DNA will subsequently react with humic substances (Layton, et al., 1987).

Based on the most recent information (Burrows et al., 1989) on its physical and chemical properties, TNB should not appreciably volatilize or sorb to soils. Hydrolysis and photolysis are also not expected to occur under environmental conditions (Spanggord et al., 1980).

**DNB**

DNB has been shown to be biodegradable in some studies. A mixed culture was developed that could grow on and degrade DNB to carbon dioxide (Burrows et al., 1989). Other reported degradation products include arylamines and 3-nitroaniline. Biotransformation is



B07NE003701-04662

expected to be a significant degradation pathway for DNB only in environmental media with organisms that have adapted to transform it (Layton et al., 1987).

Based on its vapor pressure, volatilization may be an important environmental fate process. Hydrolysis is not expected to be an important removal mechanism for DNB (Spanggord et al., 1980).

DNB photolysis is not expected to be an important removal mechanism (Spanggord et al., 1980). One explanation is that DNB lacks a methyl group which accelerates the photolytic decomposition of DNT molecules. This acceleration is due to steric interaction with the adjacent nitro groups on the ring (Layton et al., 1987). Adsorption to soil and sediments should not be significant according to its sorption coefficients.

**Summary**

The fate and transport of the explosive compounds present at the former NOP site are determined primarily by adsorption, biodegradation, and photodegradation. Some biotransformation of TNT, RDX, DNT, and tetryl may occur. Biodegradation will probably not be significant, however, unless supplemental nutrients and adapted microbial populations are available. Photolysis will be potentially significant only in surface waters. The compounds at the NOP site, therefore, will likely persist in surface soil and slowly leach into the groundwater. Soil sample results under OU 1 and recent groundwater data from OU 2 are consistent with this conclusion.

### 1.2.6 Baseline Risk Assessment

The Baseline Risk Assessment (Life Systems, 1992a and 1992b) was prepared for the former NOP site to assess potential adverse health effects, including cancer and noncancer effects for current and future populations, and to assess environmental impacts resulting from explosives compound contamination. By definition, the Baseline Risk Assessment was limited to conditions under the No-Action alternative, that is, in the absence of remedial actions to control or mitigate releases. Although OU 1 addresses explosives-contaminated soil only, PCB and inorganic soil contamination and groundwater contamination were also addressed in the Baseline Risk Assessment but are evaluated in more detail in OU2 and OU3. This section summarizes the Baseline Risk Assessment only as it pertains to OU 1. Further detail can be found in the Final Baseline Risk Assessment.

#### 1.2.6.1 Human Health Risk Evaluation

The risk of cancer from exposure to a chemical is described in terms of the probability that an individual exposed over his or her lifetime will develop cancer. Cancer risk attributable to chemical exposure beyond a normal exposure for a person living in the area is referred to as excess cancer risk. Excess cancer risks are summed across chemicals of potential concern and exposure pathways that contribute to the exposure of an individual in a given



B07NE003701-04663

population. Typically, the USEPA requires remedial action at a site when total excess cancer risks to a current or hypothetical future population exceed 1E-04, or one in ten thousand (USEPA, 1991g).

The potential noncancer effect from exposure to a chemical is evaluated by comparing the estimated dose or intake of the chemical over a specific time period with the reference dose for that chemical derived for a similar time period. The reference dose used is the chemical-specific toxicity value preferred by USEPA for evaluating noncancer effects from chemical exposure. This comparison results in a hazard quotient for each chemical.

Since exposure to more than one chemical at a time occurs, hazard quotient values are summed for the chemicals and pathways that contribute to the exposure of an individual in a given population. This summed total is the Hazard Index (HI). If the total HI is equal to or less than one (1E+00), it is assumed that there is no appreciable risk that noncancer health effects will occur. If an HI exceeds 1E+00, there is some possibility that noncancer effects may occur. An HI above 1E+00 does not indicate an effect definitely will occur (USEPA, 1989c).

The quantification of risk at the former NOP site is complicated by the large area of the site, the large number of possible isolated exposure locations, the variability of chemicals detected by location, and the cancer/noncancer contribution of different chemicals. In order to identify locations of potential sources of risk, the human health risk characterization for this site consisted of two stages: a screening level analysis and a detailed analysis.

**Screening Level Analysis**

A preliminary exposure and risk calculation was made on a grid-by-grid basis (using the Supplemental RI grids, discussed in Section 1.2.3) utilizing conservative assumptions to identify grids or areas which are of greatest potential health concern and to focus the detailed risk analysis on the most heavily contaminated areas. This screening level analysis assumed that contaminant levels were uniform across each grid even though the analytical data indicated that explosives were mainly restricted to ditches and sumps. For more information on the screening level assumptions used, see the Baseline Risk Assessment Report (Life Systems, 1992a). The screening level results yielded the following general conclusions:

- Potential risks were not identified in the Primary Area or Administration Area.
- In Load Lines 1 through 4, about 20 percent of the grids contain levels of explosives compounds (RDX, HMX, TNT, TNB, and DNT) that warrant further evaluation.
- In the Burning/Proving Ground, 16 of the 71 grids contain levels of explosives compounds (RDX, HMX, TNT, and TNB) that warrant further evaluation.

**Detailed Evaluation of Risks**

A detailed exposure and risk evaluation was made for each of the grids that warranted further evaluation after the initial screening. The detailed analysis included an assessment of the risks due to explosives-contaminated soil and potential groundwater contamination beneath explosives-contaminated soil. The populations and exposure pathways analyzed during the detailed evaluation were:

- Future farm family (adults and children): Ingestion of surface soil, home-grown vegetables, and home-grown beef, and ingestion, inhalation, and direct absorption of groundwater.

- Future farmer (adult): Ingestion and inhalation of surface soil while tilling.

- Future worker (adult): Ingestion of surface soil, and ingestion, inhalation, and direct absorption of groundwater.

One of the chief components of the detailed analysis was an adjustment to account for the localized non-uniform (i.e. hot spot) pattern of soil contamination. The detailed analysis considered potentially exposed populations under both average and reasonable maximum exposure (RME) conditions. RME conditions are calculated using a combination of average and upper-bound input terms, such that the exposure estimate is approximately equal to the 95th percentile of the population distribution of doses.

Individual sample locations of potential concern were initially identified by estimating contaminant concentrations that correspond either to an excess cancer risk level of 1E-04 and 1E-06 or to a hazard index value exceeding 1E+00. These concentrations are termed the Source Area Selection Values (SASVs). Individual sample points exceeding SASVs were grouped into source areas which represent locations of high explosives compound concentrations. Source areas are primarily located in the drainage ditches. Source areas were then grouped into exposure areas. Potential exposure areas were identified for explosives compounds based on both the 1E-04 and 1E-06 SASVs and on HI exceeding 1E+00. Potential exposure areas are listed in Table 1-4. Exposure areas are designated by the major area in which they are located (e.g. LL1 for Load Line 1) and a letter to differentiate different exposure areas within a major area (e.g. LL1A vs. LL1B). The logic for identifying exposure areas is as follows.

It is generally assumed that most of the soil which humans ingest originates in their yards. Therefore, the exposure area most appropriate for residential scenarios is an area the size of a yard. A minimum size of one acre was assumed for each exposure area, and exposure was assumed to occur randomly outward in any direction from an assumed residence. Therefore, the shape of an exposure area was always considered to be a circle encompassing each group of contaminated source areas. Figure 1-7 shows an example of



B07NE003701-04665

## TABLE 1-4

## POTENTIAL EXPOSURE AREAS
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Load Line 1 | Load Line 2 | Load Line 3 | Load Line 4 | Burning/ Proving Ground | Primary Area | Administration Area | Bomb Booster Assembly Area |
|---|---|---|---|---|---|---|---|
| LL1A | LL2A | LL3A | LL4A | BPGA | No | No | BBA |
| LL1B | LL2B | LL3B | LL4B(1) | BPGB | exposure | exposure | |
| LL1C | LL2C | LL3C | | BPGC | areas | areas | |
| LL1D | LL2D | LL3D | | | present | present | |
| LL1E | | | | | | | |
| LL1F | | | | | | | |
| LL1G(1) | | | | | | | |

Note: (1) Potential exposure area present only with 1E-06 criterion.

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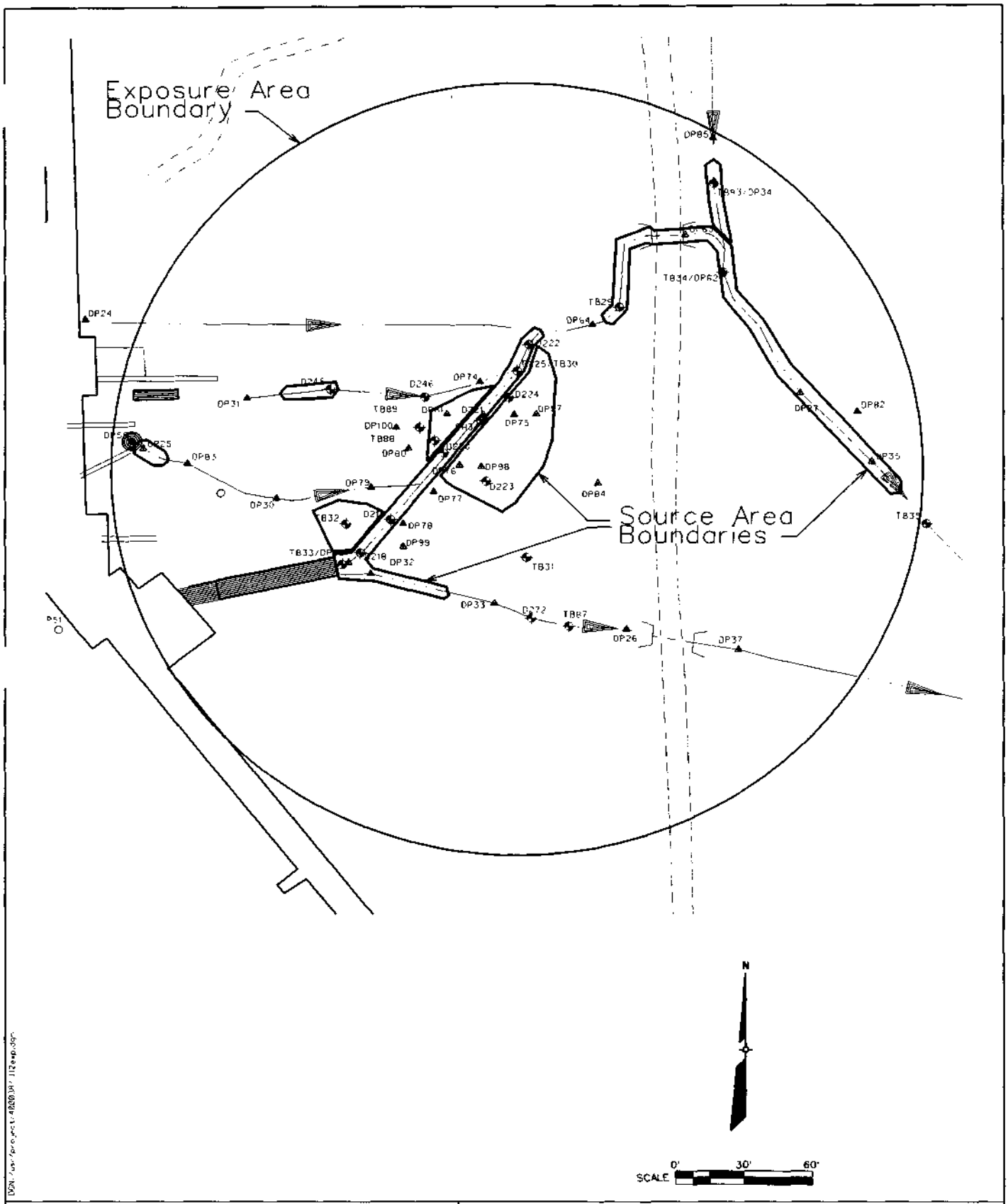


RUST ENVIRONMENT & INFRASTRUCTURE

MARCH 1994

FIGURE 1-7

SOURCE AREA AND EXPOSURE AREA BOUNDARIES

FINAL FEASIBILITY STUDY - OPERABLE UNIT 1
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

19536

the source area-exposure area relationship. Since very little is known about how much area to which a worker might be exposed, a similar circular one acre minimum exposure area was also assumed. The assumed one-acre minimum exposure area was based on visual observations of lot sizes on-site.

These exposure areas represent an area in which a receptor could carry out the activities identified by the exposure assumptions (i.e., ingest soil, plant a garden, pasture a cow, till a field or install a domestic water supply well). Since all these exposure activities could not usually occur within a source area, most exposure areas contain more than one source area. Some exposure areas containing several source areas are larger than one acre.

In order to calculate intake rates (exposure to a given amount of soil at known concentration) that fit the activities of the exposed populations, exposure point concentrations for the source area were multiplied by the ratio of the dimensions of the source area(s) to the dimensions of the exposure area to provide a fractional intake factor. This factor is mathematically analogous to assuming that the compounds in the source area(s) are uniformly distributed over the exposure area. Alternatively, this area ratio may be viewed as being equal to the fraction of total exposure that occurs at the contaminated source area(s). The factor is applied to account for the time that the assumed populations carry out their activities in areas where contamination does not exist.

Exposure concentrations were also calculated assuming no fractional intake factor. This estimate assumes that a person will be in contact with soil only within a source area and will not carry out any activities in any other portion of the exposure area.

Risks due to groundwater related to OU 1 were calculated based on the highest detected groundwater concentration for each chemical from any well on-site. Detailed calculations are presented in the Final Baseline Risk Assessment. The groundwater pathway will be further addressed for the site during OU 2.

Risks were also calculated assuming both 30-year and 70-year exposure durations and using source area delineation criteria based on $1E^{-04}$ and $1E^{-06}$ risk.

There are no exposed populations currently living in the OU 1 exposure areas. Workers may be potentially exposed to explosives-contaminated soil during tilling in the Burning/Proving Grounds. In the future, however, current occupational exposures on-site could be extended into other exposure areas, and some of the exposure areas could hypothetically become part of a farm family residence area. Therefore, the hypothetical future resident adult scenarios included inhalation exposure due to soil tilling.

**Results of Detailed Risk Evaluation**

The preliminary groundwater risk calculations indicate risks may exceed target risks. As noted previously, the groundwater pathway will be evaluated in OU 2. For the soil pathways, as noted previously, risks were calculated in the Baseline Risk Assessment both with and without the fractional intake term. Tables 1-5 and 1-6 summarize the results of the detailed evaluations of explosives-contaminated soil cancer risks with the fractional intake term. As Tables 1-5 and 1-6 show, average and RME cancer risks to hypothetical future residents and workers vary considerably from exposure area to exposure area.

The majority of potential soil risk is due to the presence of TNT in soil, with exposure via ingestion of garden vegetables contributing the most risk. Risks from direct ingestion of soil are substantially lower, and risks from consumption of beef are negligible.

Tables 1-7 and 1-8 summarize soil noncancer risks from explosives compounds at each of the exposure areas with the fractional intake factor. Eleven exposure areas (LL1A, LL1B, LL1C, LL1D, LL1E, LL2A, LL2B, LL2C, LL3B, LL3D, BPGA) yield HI values above 1E+00 for one or more of the exposed populations, under both average and RME conditions for the soil pathways. As is true for cancer risks, the large majority of noncancer soil risk is due to intake of TNT via the garden vegetable pathway. However, soil ingestion alone is also of potential concern (HI in the range of 3E+00 to 1E+01). Beef ingestion noncancer risks are not of concern under either average or RME exposure assumptions.

Table 1-9 summarizes the results of the evaluation of explosive contaminated soil cancer risk with no fractional intake term. This evaluation assumes that the source area and exposure area are equal. Because the largest source area is less than half an acre, risks from beef ingestion and tilling ar not included. The risks presented in table 1-9, are based on ingestion of soil and ingestion of garden vegetables. As Table 1-9 shows, under these assumptions fifteen source areas exceed a risk level of 1E-04 under RME conditions. Most of the excess cancer risk is due to the garden vegetable pathway, although the direct soil ingestion risk ranges as high as 7E-04 (AVG) to 2E-03 (RME).

The noncancer risk evaluation results with no fractional intake term are also summarized in Table 1-9. Under these assumptions the noncancer HI values exceed 1E+00 in most areas. Most of this risk is due to the garden vegetable pathway, but the direct soil ingestion pathway also contributes HI values greater than 1E+00 in all of the source areas except LL2D, LL3C, LL4B, BPGB, BPGC, and BBA.

# DETAILED ANALYSIS OF LIFETIME EXCESS CANCER RISK FROM EXPLOSIVES COMPOUNDS
## (FRACTIONAL INTAKE FACTOR APPLIED)
## HYPOTHETICAL FUTURE FARM FAMILY, ADULT
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Exposure Area | 1E-04 Source Selection Criteria AVG Soil | AVG Veg | AVG Total | RME Soil | RME Veg | RME Total | 1E-06 Source Selection Criteria AVG Soil | AVG Veg | AVG Total | RME Soil | RME Veg | RME Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LL1A | 6E-07 | 8E-06 | 9E-06 | 9E-01 | 3E-05 | 3E-05 | 1E-06 | 2E-05 | 2E-05 | 3E-06 | 6E-05 | 6E-05 |
| LL1B | 1E-05 | 2E-04 | 2E-04 | 4E-05 | 8E-04 | 9E-04 | 1E-05 | 2E-04 | 2E-04 | 4E-05 | 8E-04 | 8E-04 |
| LL1C | 1E-05 | 2E-04 | 2E-04 | 3E-05 | 7E-04 | 7E-04 | 1E-05 | 2E-04 | 2E-04 | 4E-05 | 8E-04 | 8E-04 |
| LL1D | 7E-07 | 1E-05 | 1E-05 | 2E-06 | 4E-05 | 4E-05 | 2E-06 | 3E-05 | 3E-05 | 5E-06 | 1E-04 | 1E-04 |
| LL1E | 6E-07 | 1E-05 | 1E-05 | 2E-06 | 4E-05 | 4E-05 | 6E-07 | 1E-05 | 1E-05 | 2E-06 | 4E-05 | 4E-05 |
| LL1F | 6E-08 | 1E-06 | 1E-06 | 2E-07 | 4E-06 | 4E-06 | 4E-08 | 7E-07 | 7E-07 | 1E-07 | 3E-06 | 3E-06 |
| LL1G | --- | --- | --- | --- | --- | --- | 3E-07 | 6E-06 | 6E-06 | 1E-06 | 2E-05 | 2E-05 |
| LL2A | 3E-05 | 1E-03 | 1E-03 | 1E-04 | 5E-03 | 5E-03 | 6E-05 | 2E-03 | 2E-03 | 2E-04 | 8E-03 | 8E-03 |
| LL2B | 2E-05 | 5E-04 | 5E-04 | 6E-05 | 2E-03 | 2E-03 | 3E-05 | 7E-04 | 7E-04 | 1E-04 | 3E-03 | 3E-03 |
| LL2C | 6E-06 | 2E-04 | 2E-04 | 2E-05 | 8E-04 | 8E-04 | 9E-06 | 3E-04 | 3E-04 | 3E-05 | 1E-03 | 1E-03 |
| LL2D | 2E-07 | 7E-06 | 7E-06 | 5E-07 | 3E-05 | 3E-05 | 3E-07 | 1E-05 | 1E-05 | 8E-07 | 4E-05 | 4E-05 |
| LL3A | 5E-08 | 8E-07 | 9E-07 | 2E-07 | 3E-06 | 3E-06 | 5E-08 | 8E-07 | 9E-07 | 2E-07 | 3E-06 | 3E-06 |
| LL3B | 3E-06 | 4E-05 | 4E-05 | 7E-06 | 2E-04 | 2E-04 | 5E-06 | 9E-05 | 1E-04 | 2E-05 | 3E-04 | 3E-04 |
| LL3C | 2E-08 | 4E-07 | 4E-07 | 7E-08 | 1E-06 | 2E-06 | 3E-08 | 4E-07 | 4E-07 | 8E-08 | 2E-06 | 2E-06 |
| LL3D | 2E-07 | 3E-06 | 3E-06 | 5E-07 | 1E-05 | 1E-05 | 2E-07 | 4E-06 | 4E-06 | 7E-07 | 1E-05 | 1E-05 |
| LL4A | 1E-07 | 2E-06 | 2E-06 | 3E-07 | 6E-06 | 6E-06 | 2E-07 | 3E-06 | 3E-06 | 7E-07 | 1E-05 | 1E-05 |
| LL4B | --- | --- | --- | --- | --- | --- | 6E-10 | 1E-08 | 1E-08 | 2E-09 | 4E-08 | 4E-08 |
| BPGA | 6E-06 | 2E-04 | 2E-04 | 2E-05 | 9E-04 | 9E-04 | 1E-05 | 4E-04 | 4E-04 | 3E-05 | 1E-03 | 1E-03 |
| BPGB | 8E-09 | 1E-07 | 1E-07 | 2E-08 | 5E-07 | 5E-07 | 2E-07 | 3E-06 | 3E-06 | 7E-07 | 1E-05 | 1E-05 |
| BPGC | — | --- | --- | --- | --- | --- | 6E-08 | 2E-06 | 2E-06 | 2E-07 | 6D-06 | 6E-06 |
| BBA | 8E-10 | 1E-08 | 1E-08 | 2E-09 | 5E-08 | 5E-08 | 8E-10 | 1E-08 | 1E-08 | 2E-09 | 5E-08 | 5E-08 |

Source: Life Systems (1992a)
"---" area not considered an exposure area when 1E-04 criteria are applied.

RP/MEADFS/AS1

**TABLE 1-6**

**DETAILED ANALYSIS OF LIFETIME EXCESS CANCER RISK FROM EXPLOSIVES COMPOUNDS (FRACTIONAL INTAKE FACTOR APPLIED) HYPOTHETICAL FUTURE WORKER**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Exposure Area | 1E-04 Source Selection Criteria AVG | 1E-04 Source Selection Criteria RME | 1E-06 Source Selection Criteria AVG | 1E-06 Source Selection Criteria RME |
|---|---|---|---|---|
| LL1A | 1E-07 | 5E-07 | 2E-07 | 1E-06 |
| LL1B | 2E-06 | 1E-05 | 2E-06 | 1E-05 |
| LL1C | 2E-06 | 1E-05 | 2E-06 | 1E-05 |
| LL1D | 1E-07 | 7E-07 | 3E-07 | 1E-06 |
| LL1E | 1E-07 | 6E-07 | 1E-07 | 6E-07 |
| LL1F | 1E-08 | 6E-08 | 7E-09 | 4E-08 |
| LL1G | -- | -- | 6E-08 | 3E-07 |
| LL2A | 6E-06 | 3E-05 | 1E-05 | 6E-05 |
| LL2B | 4E-06 | 2E-05 | 6E-06 | 3E-05 |
| LL2C | 1E-06 | 5E-06 | 2E-06 | 8E-06 |
| LL2D | 3E-08 | 2E-07 | 5E-08 | 2E-07 |
| LL3A | 9E-09 | 5E-08 | 9E-09 | 5E-08 |
| LL3B | 5E-07 | 2E-06 | 1E-06 | 5E-06 |
| LL3C | 4E-09 | 2E-08 | 5E-09 | 3E-08 |
| LL3D | 3E-08 | 2E-07 | 4E-08 | 2E-07 |
| LL4A | 2E-08 | 1E-07 | 4E-08 | 2E-07 |
| LL4B | -- | -- | 1E-10 | 6E-10 |
| BPGA | 1E-06 | 6E-06 | 2E-06 | 9E-06 |
| BPGB | 1E-09 | 7E-09 | 4E-08 | 2E-07 |
| BPGC | -- | -- | 1E-08 | 5E-08 |
| BBA | 1E-10 | 7E-10 | 1E-10 | 7E-10 |

Source: Life Systems, 1992a.
Future workers are assumed not to ingest garden vegetables.
"--", area not considered an exposure area when 1E-04 criteria are supplied.

RP/MEADFS/AV8

## TABLE 1-7

## DETAILED ANALYSIS OF NONCANCER RISKS FROM EXPLOSIVES COMPOUNDS
## (FRACTIONAL INTAKE FACTOR APPLIED)
## HYPOTHETICAL FUTURE FARM FAMILY
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| | 1E-04 Source | | | | | | | | | | | | 1E-06 Source | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Selection Criteria | | | | | | | | | | | | Selection Criteria | | | | | | | | | | | |
| | Adult | | | | | | Child | | | | | | Adult | | | | | | Child | | | | | |
| Exposure | AVG | | | RME | | | AVG | | | RME | | | AVG | | | RME | | | AVG | | | RME | | |
| Area | Soil | Veg | Total | Soil | Veg | Total | Soil | Veg | Total | Soil | Veg | Total | Soil | Veg | Total | Soil | Veg | Total | Soil | Veg | Total | Soil | Veg | Total |
| LL1A | 5E-02 | 8E-01 | 9E-01 | 6E-02 | 1E+00 | 1E+00 | 2E-01 | 2E+00 | 2E+00 | 4E-01 | 3E+00 | 3E+00 | 2E-01 | 2E+00 | 2E+00 | 3E-01 | 3E+00 | 3E+00 | 4E-01 | 4E+00 | 4E+00 | 8E-01 | 6E+00 | 7E+00 |
| LL1B | 2E+00 | 3E+01 | 3E+01 | 3E+00 | 5E+01 | 5E+01 | 7E+00 | 8E+01 | 9E+01 | 1E+01 | 1E+02 | 1E+02 | 2E+00 | 3E+01 | 3E+01 | 3E+00 | 5E+01 | 5E+01 | 7E+00 | 8E+01 | 8E+01 | 1E+01 | 1E+02 | 1E+02 |
| LL1C | 2E+00 | 3E+01 | 3E+01 | 2E+00 | 5E+01 | 5E+01 | 6E+00 | 7E+01 | 8E+01 | 1E+01 | 1E+02 | 1E+02 | 2E+00 | 3E+01 | 3E+01 | 3E+00 | 5E+01 | 5E+01 | 7E+00 | 8E+01 | 8E+01 | 1E+01 | 1E+02 | 1E+02 |
| LL1D | 1E-01 | 2E+00 | 2E+00 | 1E-01 | 3E+00 | 3E+00 | 4E-01 | 4E+00 | 4E+00 | 8E-01 | 7E+00 | 8E+00 | 3E-01 | 4E+00 | 4E+00 | 3E-01 | 7E+00 | 7E+00 | 9E-01 | 1E+01 | 1E+01 | 2E+00 | 2E+01 | 2E+01 |
| LL1E | 1E-01 | 2E+00 | 2E+00 | 1E-01 | 3E+00 | 3E+00 | 3E-01 | 4E+00 | 4E+00 | 7E-01 | 6E+00 | 7E+00 | 1E-01 | 2E+00 | 2E+00 | 1E-01 | 3E+00 | 3E+00 | 3E-01 | 4E+00 | 4E+00 | 7E-01 | 6E+00 | 7E+00 |
| LL1F | 1E-02 | 2E-01 | 2E-01 | 1E-02 | 3E-01 | 3E-01 | 3E-02 | 4E-01 | 4E-01 | 7E-02 | 6E-01 | 7E-01 | 6E-03 | 1E-01 | 1E-01 | 8E-03 | 2E-01 | 2E-01 | 2E-02 | 2E-01 | 2E-01 | 5E-02 | 4E-01 | 4E-01 |
| LL1G | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 5E-02 | 8E-01 | 9E-01 | 7E-02 | 1E+00 | 1E+00 | 2E-01 | 2E+00 | 2E+00 | 4E-01 | 3E+00 | 3E+00 |
| LL2A | 2E+00 | 3E+01 | 3E+01 | 2E+00 | 4E+01 | 4E+01 | 5E+00 | 6E+01 | 7E+01 | 1E+01 | 1E+02 | 1E+02 | 3E+00 | 5E+01 | 5E+01 | 4E+00 | 8E+01 | 8E+01 | 8E+00 | 1E+02 | 1E+02 | 2E+01 | 2E+02 | 2E+02 |
| LL2B | 3E+00 | 4E+01 | 4E+01 | 3E+00 | 7E+01 | 7E+01 | 9E+00 | 1E+02 | 1E+02 | 2E+01 | 2E+02 | 2E+02 | 4E+00 | 7E+01 | 7E+01 | 5E+00 | 1E+02 | 1E+02 | 1E+01 | 2E+02 | 2E+02 | 3E+01 | 2E+02 | 2E+02 |
| LL2C | 2E-01 | 3E+00 | 3E+00 | 2E-01 | 4E+00 | 4E+00 | 4E-01 | 6E+00 | 6E+00 | 8E-01 | 9E+00 | 1E+01 | 2E-01 | 4E+00 | 4E+00 | 3E-01 | 6E+00 | 6E+00 | 6E-01 | 9E+00 | 9E+00 | 1E+00 | 1E+01 | 1E+01 |
| LL2D | 2E-03 | 6E-02 | 6E-02 | 2E-03 | 9E-02 | 9E-02 | 5E-03 | 1E-01 | 1E-01 | 9E-03 | 2E-01 | 2E-01 | 3E-03 | 93-02 | 9E-02 | 3E-03 | 1E-01 | 1E-01 | 7E-03 | 2E-01 | 2E-01 | 2E-02 | 3E-01 | 3E-01 |
| LL3A | 1E-02 | 1E-01 | 1E-01 | 2E-02 | 2E-01 | 2E-01 | 3E-02 | 3E-01 | 3E-01 | 6E-02 | 5E-01 | 6E-01 | 1E-02 | 1E-01 | 1E-01 | 2E-02 | 2E-01 | 2E-01 | 3E-02 | 3E-01 | 3E-01 | 6E-02 | 5E-01 | 6E-01 |
| LL3B | 4E-01 | 6E+00 | 6E+00 | 5E-01 | 1E+01 | 1E+01 | 1E+00 | 1E+01 | 1E+01 | 3E+00 | 2E+01 | 2E+01 | 9E-01 | 1E+01 | 1E+01 | 1E+00 | 2E+01 | 2E+01 | 3E+00 | 3E+01 | 3E+01 | 6E+00 | 5E+00 | 6E+01 |
| LL3C | 5E-03 | 6E-02 | 7E-02 | 7E-03 | 1E-01 | 1E-01 | 1E-02 | 1E-01 | 1E-01 | 3E-02 | 2E-01 | 2E-01 | 6E-03 | 7E-02 | 8E-02 | 8E-03 | 1E-01 | 1E-01 | 2E-02 | 2E-01 | 2E-01 | 3E-02 | 3E-01 | 3E-01 |
| LL3D | 3E-02 | 4E-01 | 4E-01 | 4E-02 | 7E-01 | 7E-01 | 1E-01 | 1E+00 | 1E+00 | 2E-01 | 2E+00 | 2E+00 | 4E-02 | 5E-01 | 5E-01 | 5E-02 | 9E-01 | 1E+00 | 1E-01 | 1E+00 | 1E+00 | 2E-01 | 2E+00 | 2E+00 |
| LL4A | 9E-03 | 1E-01 | 1E-01 | 1E-02 | 2E+01 | 2E-01 | 3E-02 | 3E-01 | 3E-01 | 6E-02 | 5E-01 | 6E-01 | 2E-02 | 3E-01 | 3E-01 | 2E-02 | 4E-01 | 4E-01 | 6E-02 | 6E-01 | 6E-01 | 1E-01 | 1E+00 | 1E+00 |
| LL4B | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 1E-04 | 2E-03 | 2E-03 | 1E-04 | 3E-03 | 3E-03 | 4E-04 | 4E-03 | 4E-03 | 7E-04 | 6E-03 | 7E-03 |
| BFPA | 6E-01 | 3E+00 | 4E+00 | 7E-01 | 5E+00 | 6E+00 | 6E-01 | 7E+00 | 8E+00 | 1E+00 | 1E+01 | 1E+01 | 9E-01 | 5E+00 | 6E+00 | 1E+00 | 8E+00 | 9E+00 | 9E-01 | 1E+01 | 1E+01 | 2E+00 | 2E+01 | 2E+01 |
| BPGB | 1E-03 | 2E-02 | 2E-02 | 2E-03 | 3E-02 | 3E-02 | 4E-03 | 5E-02 | 5E-02 | 9E-03 | 7E-02 | 8E-02 | 1E-02 | 2E-01 | 2E-01 | 2E-02 | 3E-01 | 3E-01 | 5E-02 | 5E-01 | 5E-01 | 1E-02 | 8E-01 | 8E-01 |
| BPGC | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 1E-03 | 2E-02 | 2E-02 | 1E-03 | 3E-02 | 3E-02 | 3E-03 | 4E-02 | 4E-02 | 5E-03 | 6E-02 | 7E-02 |
| BBA | 8E-03 | 2E-03 | 1E-02 | 1E-03 | 3E-03 | 1E-02 | 3E-03 | 5E-03 | 8E-03 | 7E-03 | 8E-03 | 1E-02 | 8E-03 | 2E-03 | 1E-02 | 1E-02 | 3E-03 | 1E-02 | 3E-03 | 5E-03 | 5E-03 | 7E-03 | 8E-03 | 1E-02 |

Source: Life Systems, 1992a.
"---" area not considered an exposure area when 1e-04 criteria are applied.

RP/MEADFS/AW0

**TABLE 1-8**

**DETAILED ANALYSIS OF NONCANCER RISKS FROM EXPLOSIVES COMPOUNDS (FRACTIONAL INTAKE FACTOR APPLIED) HYPOTHETICAL FUTURE WORKER**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Exposure Area | 1E-04 Source Selection Criteria AVG | 1E-04 Source Selection Criteria RME | 1E-06 Source Selection Criteria AVG | 1E-06 Source Selection Criteria RME |
|---|---|---|---|---|
| LL1A | 5E-02 | 1E-01 | 1E-01 | 2E-01 |
| LL1B | 1E+00 | 3E+00 | 1E+00 | 2E+00 |
| LL1C | 9E-01 | 2E+00 | 1E+00 | 2E+00 |
| LL1D | 6E-02 | 1E-01 | 1E-01 | 3E-01 |
| LL1E | 6E-02 | 1E-01 | 6E-02 | 1E-01 |
| LL1F | 5E-03 | 1E-02 | 3E-03 | 7E-03 |
| LL1G | -- | -- | 3E-02 | 6E-03 |
| LL2A | 8E-01 | 2E+00 | 2E+00 | 3E+00 |
| LL2B | 1E+00 | 3E+00 | 2E+00 | 4E+00 |
| LL2C | 9E-02 | 2E-01 | 1E-01 | 3E-01 |
| LL2D | 9E-04 | 2E-03 | 1E-03 | 3E-03 |
| LL3A | 6E-03 | 1E-02 | 6E-03 | 1E-02 |
| LL3B | 2E-01 | 5E-01 | 5E-01 | 1E+00 |
| LL3C | 3E-03 | 6E-03 | 3E-03 | 7E-03 |
| LL3D | 2E-02 | 3E-02 | 2E-02 | 4E-02 |
| LL4A | 5E-03 | 1E-02 | 1E-02 | 2E-02 |
| LL4B | -- | -- | 5E-05 | 1E-04 |
| BPGA | 3E-01 | 6E-01 | 5E-01 | 1E+00 |
| BPGB | 7E-04 | 1E-03 | 7E-03 | 1E-02 |
| BPGC | -- | -- | 5E-04 | 1E-03 |
| BBA | 5E-03 | 9E-03 | 5E-03 | 9E-03 |

Source: Life Systems, 1992a.
Future workers are assumed not to ingest garden vegetables.
"--", area not considered an exposure area when 1E-04 criteria are supplied.

RP/MEADFS/AV9

**DETAILED ANALYSIS OF RISK FROM EXPLOSIVES COMPOUNDS**
**(NO FRACTIONAL INTAKE FACTOR APPLIED)**
**HYPOTHETICAL FUTURE POPULATIONS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Source | Size, | Average Risk Level | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $HI_S$ | | | $HI_C$ | | | Cancer Risk | | |
| Area | Acres | Soil | Veg. | Total | Soil | Veg. | Total | Soil | Veg. | Total |
| LI.1A | 0.16 | 2E+00 | 2E+01 | 3E+01 | 1E+00 | 1E+01 | 1E+01 | 7E-06 | 1E-04 | 1E-04 |
| LI.1B | 0.10 | 2E+02 | 2E+03 | 2E+03 | 5E+01 | 8E+02 | 9E+02 | 3E-04 | 5E-03 | 5E-03 |
| LI.1C | 0.046 | 2E+02 | 2E+03 | 2E+03 | 5E+01 | 8E+02 | 9E+02 | 3E-04 | 5E-03 | 6E-03 |
| LI.1D | 0.082 | 1E+01 | 1E+02 | 1E+02 | 3E+00 | 5E+01 | 5E+01 | 2E-05 | 3E-04 | 4E-04 |
| LI.1E | 0.012 | 3E+01 | 4E+02 | 4E+02 | 1E+01 | 2E+02 | 2E+02 | 6E-05 | 1E-03 | 1E-03 |
| LI.1F | 0.016 | 1E+00 | 1E+01 | 1E+01 | 3E-01 | 5E+00 | 6E+00 | 2E-06 | 3E-05 | 4E-05 |
| LI.1G | 0.023 | 9E+00 | 1E+02 | 1E+02 | 3E+00 | 4E+01 | 4E+01 | 2E-05 | 3E-04 | 3E-04 |
| LI.2A | 0.22 | 5E+01 | 6E+02 | 7E+02 | 2E+01 | 3E+02 | 3E+02 | 3E-04 | 1E-02 | 1E-02 |
| LI.2B | 0.046 | 3E+02 | 3E+00 | 3E+03 | 8E+01 | 1E+03 | 1E+03 | 7E-04 | 1E-02 | 1E-02 |
| LI.2C | 0.087 | 7E+00 | 1E+02 | 1E+02 | 3E+00 | 5E+01 | 5E+01 | 1E-04 | 4E-03 | 4E-03 |
| LI.2D | 0.057 | 1E-01 | 3E+00 | 3E+00 | 4E-02 | 1E+00 | 2E+00 | 5E-06 | 2E-04 | 2E-04 |
| LI.3A | 0.023 | 2E+00 | 2E+01 | 2E+01 | 6E-01 | 7E+00 | 7E+00 | 3E-06 | 4E-05 | 4E-05 |
| LI.3B | 0.079 | 6E+01 | 6E+02 | 7E+02 | 2E+01 | 3E+02 | 3E+02 | 1E-04 | 2E-03 | 2E-03 |
| LI.3C | 0.073 | 2E-01 | 2E+00 | 3E+00 | 9E-02 | 1E+00 | 1E+00 | 4E-07 | 6E-06 | 7E-06 |
| LI.3D | 0.028 | 4E+00 | 4E+01 | 5E+01 | 1E+00 | 2E+01 | 2E+01 | 8E-06 | 1E-04 | 1E-04 |
| LI.4A | 0.037 | 1E+00 | 2E+01 | 2E+01 | 4E-01 | 7E+00 | 7E+00 | 6E-06 | 8E-05 | 8E-05 |
| LI.4B | 0.00046 | 4E-02 | 4E-02 | 4E-01 | 1E-02 | 2E-01 | 2E-01 | 6E-08 | 1E-06 | 1E-06 |
| BPGA | 0.30 | 3E+00 | 4E+01 | 4E+01 | 3E+00 | 2E+01 | 2E+01 | 3E-05 | 1E-03 | 1E-03 |
| BPGB | 0.26 | 2E-01 | 2E+00 | 2E+00 | 5E-02 | 8E-01 | 9E-01 | 9E-07 | 1E-05 | 1E-05 |
| BPGC | 0.25 | 1E-02 | 2E-01 | 2E-01 | 4E-03 | 7E-02 | 8E-02 | 2E-07 | 7E-06 | 7E-06 |
| BBA | 0.0064 | 3E-01 | 5E-01 | 8E-01 | 8E-01 | 2E-01 | 1E+00 | 8E-08 | 1E-06 | 1E-06 |

**DETAILED ANALYSIS OF RISK FROM EXPLOSIVES COMPOUNDS**
**(NO FRACTIONAL INTAKE FACTOR APPLIED)**
**HYPOTHETICAL FUTURE POPULATIONS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| | | Reasonable Maximum Exposure (RME) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $HI_S$ | | | $HI_C$ | | | Cancer Risk | | |
| Source Area | Size, Acres | Soil | Veg. | Total | Soil | Veg. | Total | Soil | Veg. | Total |
| LL1A | 0.16 | 5E+00 | 4E+01 | 4E+01 | 2E+00 | 2E+01 | 2E+01 | 2E-05 | 4E-04 | 4E-04 |
| LL1B | 0.10 | 4E+02 | 3E+03 | 3E+03 | 7E+01 | 1E+03 | 1E+03 | 1E-03 | 2E-02 | 2E-02 |
| LL1C | 0.046 | 4E+02 | 3E+03 | 3E+03 | 6E+01 | 1E+03 | 1E+03 | 1E-03 | 2E-02 | 2E-02 |
| LL1D | 0.082 | 2E+01 | 2E+02 | 2E+02 | 4E+00 | 8E+01 | 9E+01 | 6E-05 | 1E-03 | 1E-03 |
| LL1E | 0.012 | 7E+01 | 6E+02 | 7E+02 | 1E+01 | 3E+02 | 3E+02 | 2E-04 | 4E-03 | 4E-03 |
| LL1F | 0.016 | 2E+00 | 2E+01 | 2E+01 | 4E-01 | 8E+00 | 9E+00 | 6E-06 | 1E-04 | 1E-04 |
| LL1G | 0.023 | 2E+01 | 2E+02 | 2E+02 | 3E+00 | 7E+01 | 7E+01 | 5E-05 | 1E-03 | 1E-03 |
| LL2A | 0.22 | 1E+02 | 1E+03 | 1E+03 | 2E+01 | 4E+02 | 4E+02 | 1E-03 | 5E-02 | 5E-02 |
| LL2B | 0.046 | 6E+02 | 5E+03 | 5E+03 | 1E+02 | 2E+03 | 2E+03 | 2E-03 | 5E-02 | 6E-02 |
| LL2C | 0.087 | 1E+01 | 2E+02 | 2E+02 | 4E+00 | 8E+01 | 8E+01 | 3E-04 | 2E-02 | 2E-02 |
| LL2D | 0.057 | 3E-01 | 5E+00 | 5E+00 | 6E-02 | 2E+00 | 2E+00 | 1E-05 | 7E-04 | 7E-04 |
| LL3A | 0.023 | 3E+00 | 2E+01 | 3E+01 | 8E-01 | 1E+01 | 1E+01 | 8E-06 | 2E-04 | 2E-04 |
| LL3B | 0.079 | 1E+02 | 1E+03 | 1E+03 | 2E+01 | 4E+02 | 5E+02 | 3E-04 | 7E-03 | 7E-03 |
| LL3C | 0.073 | 5E-01 | 4E+00 | 4E+00 | 1E-01 | 2E+00 | 2E+00 | 1E-06 | 2E-05 | 3E-05 |
| LL3D | 0.028 | 8E+00 | 7E+01 | 7E+01 | 2E+00 | 3E+01 | 3E+01 | 2E-05 | 5E-04 | 5E-04 |
| LL4A | 0.037 | 3E+00 | 2E+01 | 3E+01 | 6E-01 | 1E+01 | 1E+01 | 2E-05 | 3E-04 | 3E-04 |
| LL4B | 0.00046 | 7E-02 | 6E-01 | 7E-01 | 1E-02 | 3E-01 | 3E-01 | 2E-07 | 4E-06 | 4E-06 |
| BPGA | 0.30 | 6E+00 | 6E+01 | 7E+01 | 4E+00 | 3E+01 | 3E+01 | 1E-04 | 5E-03 | 5E-03 |
| BPGB | 0.26 | 4E-01 | 3E+00 | 3E+00 | 7E-02 | 1E+00 | 1E+00 | 3E-06 | 5E-05 | 5E-05 |
| BPGC | 0.25 | 2E-02 | 3E-01 | 3E-01 | 5E-03 | 1E-01 | 1E-01 | 7E-07 | 3E-05 | 3E-05 |
| BBA | 0.0064 | 7E-01 | 8E-01 | 1E+00 | 1E+00 | 3E-01 | 1E+00 | 2E-07 | 5E-06 | 5E-06 |

Note: Bold text indicates potential risks to be addressed.
Source: Life Systems, 1992a.

$HI_S$ = Subchronic Hazard Index
$HI_C$ = Chronic Hazard Index

RP/MEADFS/AV7

**Risk Management Strategy**

USACE, USEPA, and NDEQ have agreed that it is not appropriate to address potential risks from the garden vegetable pathway in this OU. This pathway will be considered in OU3. Thus, the risk management strategy for OU 1 remediation is to address the potential risk presented in Table 1-9 from the soil pathway only. The additional information concerning the vegetable pathway is provided as qualitative information only. Additionally, only the calculations using no intake factor are forwarded for use in devising the remedial action objectives.

### 1.2.6.2 Environmental Evaluation

The objective of the environmental evaluation (Life Systems, 1992b) was to determine whether ecological risk is present at the site. For the purposes of this report, a retrospective ecological assessment is defined as the determination of whether there is a potential for adverse ecological effects resulting from past operations at the site.

**Aquatic Environments**

Aquatic ecological resources are very limited at this site. The small size of Johnson Creek and the NRD Impoundment limits its carrying capacity for fish and other aquatic species.

The brook stickleback and plains topminnow are the only two aquatic species of special concern that are present in the vicinity of the site. No data are available to indicate that they are present in Johnson Creek. Further study during the Remedial Design will evaluate if potential habitats for these two species exist in Johnson Creek and if there are potential impacts to habitats as a result of the remediation.

The NRD Impoundment is likely to attract waterfowl during migration, but individuals are likely to spend little time in the area and may not visit the site on subsequent migration flights. The NRD impoundment and Johnson Creek are likely to attract wildlife and could represent an exposure route for local wildlife populations. Chemical measurements are not available to evaluate risks to wildlife and migratory waterfowl that may drink water from the NRD Impoundment.

Chemical concentrations of organic compounds in Johnson Creek (Appendix D, Supplemental RI Report, SEC Donohue, 1992b) appear to be well below health effects levels recorded in laboratory bioassays for warmwater fish species similar to those which could potentially inhabit this stream. Therefore, it is unlikely that aquatic organisms are at risk from exposure to levels of organic chemicals detected in Johnson Creek.

Risks from exposure to chemicals in sediment are difficult to determine due to the lack of standardized evaluation methods and effects data. Benchmark levels developed for other sites with varying levels of sediment contamination suggest that detected explosive concentrations in the sediment do not have the potential to contribute to adverse risks in exposed organisms at the former NOP.

**Terrestrial Environment**

Plant populations exposed to elevated levels of TNT in soil could accumulate high levels in tissues and could exhibit tissue damage and reduced growth. Accumulation of TNT is unlikely to pose a threat to any local plant species population. However, select areas of the site where the highest soil contaminant concentrations occur may not be able to support plant life. Some areas of stressed vegetation have been observed on-site (TCT, 1991b).

Some herbivorous mammals and seed-eating birds may be exposed to TNT and RDX via plants growing in areas of explosive-contaminated soil. Data on feeding behavior and distribution are not available to quantify risks to these organisms.

### 1.2.7 Treatability Studies

Treatability studies were conducted on NOP site soil for rotary kiln incineration, vitrification, and slurry-phase biological treatment. An overview of the samples collected and the objectives and preliminary results of each study are discussed below. The Treatability Study Report (RUST, 1993) presents more detailed information on each study.

#### 1.2.7.1 Treatability Study Sample Overview

Soil samples were collected from the site to provide treatability study vendors with soil that would simulate soil treated under full-scale remediation and to provide the vendors with samples containing measurable explosives concentrations to allow for evaluation of treatment performance (SEC Donohue, 1992d). Two treatability study samples were collected: a full-scale sample and a selective high sample. The full-scale simulation sample (full-scale sample) consisted of consolidated soil collected from several locations which were characterized by high RI sample density. The full-scale sample was designed to estimate full-scale consolidated pile concentrations. The selective high concentration sample (selective high sample) was a composite of a small amount of soil from four locations identified during the RI as having the highest concentrations of explosives. The selective high sample was designed to have elevated concentrations of explosives and would have been used in the event that the full-scale sample did not have sufficient explosives compound concentrations to evaluate the performance of the study. However, the full-scale sample did approximate the estimated full-scale concentrations, and therefore, was used for the treatability studies.

#### 1.2.7.2 Rotary Kiln Incineration Treatability Study

The objectives of the bench-scale rotary kiln treatability study were to evaluate:

- Whether Preliminary Remediation Goals (PRGs) developed at the time the treatability studies were performed can be achieved.
- Full-scale operating parameters.
- An estimate of full-scale costs.
- Whether treatment residues would potentially be classified as a RCRA hazardous waste by characteristic.
- Quantities and characteristics of residual waste streams
- Process-specific material handling requirements.

Validated results from the study indicate that contaminated soil from the site can be treated to nondetectable levels for explosive compounds and that treated soil would not be classified as RCRA hazardous waste by characteristic. Pre- and post-treatment results for explosives compounds and results of RCRA testing are presented in Tables 1-10 and 1-11, respectively.

#### 1.2.7.3 Vitrification Treatability Study

The objectives of the bench-scale vitrification treatability study were to evaluate:

- Whether PRGs developed at the time the treatability studies were performed can be achieved.
- If explosives-contaminated soil at the former NOP site can be remediated safely and efficiently via vitrification to produce a stable and non-toxic treated mass that is not RCRA hazardous by characteristic.
- Whether contaminant concentrations in the soil adjacent to and below the melt increase, decrease, or remain unchanged.
- Whether certain technical factors may cause the cost per ton of soil treated to vary from "typical" cost estimates.
- Which, if any, additives are necessary for the soil to be treated and the methods and costs for using any required additives.

**TABLE 1-10**

**INCINERATION TREATABILITY STUDY EXPLOSIVES RESULTS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Analyte | Pretreatment Sample | | Post-Treatment Samples: 1500/22(1) | | 1600/22 | | 1700/22 | | 1800/22 | | 1500/10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2,4-DNT | 1.43 | | 0.215 | U | 0.215 | U | 0.215 | U | 0.215 | U | 0.2 | U |
| o-NT | 0.452 | U | 0.507 | U | 0.507 | U | 0.507 | U | 0.507 | U | 0.609 | U |
| TNB | 59.6 | | 0.158 | U | 0.158 | U | 0.158 | U | 0.158 | U | 0.116 | U |
| DNB | 1.52 | | 0.137 | U | 0.137 | U | 0.137 | U | 0.137 | U | 0.12 | U |
| Tetryl | 59.8 | | 0.273 | U | 0.273 | U | 0.273 | U | 0.273 | U | 0.273 | U |
| NB | 1.27 | U | 0.176 | U | 0.176 | U | 0.176 | U | 0.176 | U | 0.211 | U |
| TNT | 1170 | | 0.2 | U | 0.2 | U | 0.2 | U | 0.2 | U | 0.188 | U |
| 4-ADNT | 5.41 | | 0.441 | U | 0.441 | U | 0.441 | U | 0.441 | U | 0.386 | U |
| 2-ADNT | 0.202 | U | 0.27 | U | 0.27 | U | 0.27 | U | 0.27 | U | 0.297 | U |
| HMX | 134 | J | 0.23 | U | 0.23 | U | 0.23 | U | 0.23 | U | 0.136 | U |
| 2,6-DNT | 0.331 | U | 0.429 | U | 0.429 | U | 0.429 | U | 0.429 | U | 0.375 | U |
| p-NT | 0.433 | U | 0.507 | U | 0.507 | U | 0.507 | U | 0.507 | U | 0.761 | U |
| m-NT | 0.409 | U | 0.441 | U | 0.441 | U | 0.441 | U | 0.441 | U | 0.619 | U |
| RDX | 300 | | 0.6 | U | 0.6 | U | 0.6 | U | 0.6 | U | 0.333 | U |

All units in mg/kg.

(1) Post-treatment sample identification numbers represent the temperature in degrees F/retention time in minutes.
U = Not detected above the quantification limit shown to the left of U.
J = Estimated value because the associated Laboratory Control Sample was low.

RP/MEADFS/AT8

**TABLE 1-11**

**INCINERATION TREATABILITY STUDY**
**POST-TREATMENT RCRA CHARACTERIZATION ANALYSES**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**

| Analyte | Regulatory Limit | Sample[1] 1500/22 | 1800/22 |
|---|---|---|---|
| TCLP[2] | | | |
| Arsenic | 5.0 | 0.110 U | 0.110 U |
| Barium | 100.0 | 1.300 J | 1.080 J |
| Benzene | 0.5 | 0.025 U | 0.025 U |
| Cadmium | 1.0 | 0.005 U | 0.005 U |
| Carbon tetrachloride | 0.5 | 0.025 U | 0.025 U |
| Chlordane | 0.03 | 0.0001 U | 0.0001 U |
| Chlorobenzene | 100.0 | 0.025 U | 0.025 U |
| Chloroform | 6.0 | 0.025 U | 0.025 U |
| Chromium | 5.0 | 0.010 U | 0.011 B |
| o-Cresol | 200.0 | 0.020 U | 0.020 U |
| m-Cresol | 200.0 | 0.020 U | 0.020 U |
| p-Cresol | 200.0 | 0.020 U | 0.020 U |
| Cresol | 200.0 | 0.020 U | 0.020 U |
| 2,4-D | 10.0 | 0.0005U J | 0.0005 UJ |
| 1,4-Dichlorobenzene | 7.5 | 0.020 U | 0.020 U |
| 1,2-Dichloroethane | 0.5 | 0.025 U | 0.025 U |
| 1,1-Dichloroethylene | 0.7 | 0.025 U | 0.025 U |
| 2,4-Dinitrotoluene | 0.13 | 0.020 U | 0.020 U |
| Endrin | 0.02 | 0.0001 U | 0.0001 U |
| Heptachlor (and its epoxide) | 0.008 | 0.0005 U | 0.0005 U |
| Hexachlorobenzene | 0.13 | 0.020 U | 0.020 U |
| Hexachlorobutadiene | 0.5 | 0.020 U | 0.020 U |
| Hexachloroethane | 3.0 | 0.020 U | 0.020 U |
| Lead | 5.0 | 0.036 B | 0.036 B |
| Lindane | 0.4 | 0.00005 U | 0.00005 U |
| Mercury | 0.2 | 0.00015 BJ | 0.0001 J |
| Methoxychlor | 10.0 | 0.0005 U | 0.0005 U |
| Methyl ethyl ketone | 200.0 | 0.050 UR | 0.050 UR |
| Nitrobenzene | 2.0 | 0.020 U | 0.020 U |
| Pentachlorophenol | 100.0 | 0.020 U | 0.020 U |
| Pyridine | 5.0 | 0.020 U | 0.020 U |
| Selenium | 1.0 | 0.176 U | 0.176 U |
| Silver | 5.0 | 0.033 U | 0.033 U |

**TABLE 1-11**

**INCINERATION TREATABILITY STUDY**
**POST-TREATMENT RCRA CHARACTERIZATION ANALYSES**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Analyte | Regulatory Limit | Sample[1] 1500/22 | Sample[1] 1800/22 |
|---|---|---|---|
| Tetrachloroethylene | 0.7 | 0.006 J | 0.006 J |
| Toxaphene | 0.5 | 0.001 U | 0.001 U |
| Trichloroethylene | 0.5 | 0.025 U | 0.025 U |
| 2,4,5-Trichlorophenol | 400.0 | 0.020 U | 0.020 U |
| 2,4,6-Trichlorophenol | 2.0 | 0.020 U | 0.020 U |
| 2,4,5-TP (Silvex) | 1.0 | 0.0005 UR | 0.0005 UR |
| Vinyl chloride | 0.2 | 0.050 U | 0.050 U |
| Ignitability[3] | see note | no flash | no flash |
| Corrosivity[4] | 6.35mm/yr | <2.1E-05 mm/yr | <2.1E-05 mm/yr |
| Reactivity[5] | | | |
| Cyanide | 250 mg/(l or kg) | 0.03 ug/g U | 0.03 ug/g U |
| Sulfide | 500 mg/(l or kg) | 105 ug/g U | 105 ug/g U |

J = Estimated value.
R = Unusable data.
U = Not detected above quantitation limit.
D = Diluted.
B = Reported value is greater than detection limit, but less than Contract Required Detection Limit.
NA = Compound or parameter not analyzed for.
[1]Samples shown are the lowest (1,500/22) and highest (1,800/22) temperatures used in the treatability study.
[2]TCLP = Toxicity Characteristic Leaching Procedure (mg/l) from 40 CFR 261.24.
[3]40 CFR 261.21; no flash below 60°C.
[4]40 CFR 261.22.
[5]40 CFR 261.23; limits from Claussen, 1985.

RP/MEADFS/AU4

- The off-gas products resulting from the vitrification of the site soil.

Validated results of the study indicate that contaminated soil from the site can be treated to nondetectable levels for explosive compounds and that the vitrified mass would not be classified as RCRA hazardous waste by characteristic. Pre- and post-treatment results for explosives compounds are shown in Table 1-12. Results of RCRA testing are presented in Table 1-13.

#### 1.2.7.4 Biological Treatability Study

Slurry-phase biological studies were conducted at both laboratory-scale and bench-scale. The objectives of the laboratory-scale biological treatability studies were to evaluate:

- Whether PRGs developed at the time the treatability studies were performed can be achieved.

- Whether conversion of contaminants to carbon dioxide (mineralization) can be achieved and to what degree.

The objectives of the bench-scale biological treatability study were to evaluate:

- The quantities and characteristics of residual waste streams.

- Whether residuals from the treatment were RCRA hazardous by characteristic.

- Scale-up information.

- Process-specific material handling requirements.

- Full-scale treatment costs on a unit cost basis.

Validated results of the biological treatability study indicate that under the conditions evaluated for this study, some treatment is achieved; however, not all PRGs were met during this study. Based on this study, biological treatment may not achieve low PRGs without further optimization. Time constraints may not have allowed for the inherently slower treatment rate of biological treatments as compared to conventional treatment technologies. However, in the time available for the study, the treatment achieved suggested that additional time and optimization would result in more effective treatment. Section 2 includes a discussion of additional treatability studies not associated with this site that suggested more effective results could be obtained. The results of this study did indicate that the treated soil would not be classified as RCRA hazardous waste by characteristic. Pre- and post-treatment results for explosives compounds measured for the NOP treatability study are shown in Table 1-14. Results of RCRA testing are presented in Table 1-15.

**TABLE 1-12**

**VITRIFICATION TREATABILITY STUDY EXPLOSIVES RESULTS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Analyte | Pretreatment Sample | Post-Treatment Glass Samples 1 | Post-Treatment Glass Samples 2 |
|---|---|---|---|
| 2,4-DNT | 0.987 | 0.200 U | 0.200 U |
| o-NT | 0.452 U | 0.609 U | 0.608 U |
| TNB | 59.3 | 0.116 U | 0.116 U |
| DNB | 0.986 | 0.120 U | 0.120 U |
| Tetryl | 106 | 0.273 U | 0.273 U |
| NB | 1.29 U | 0.211 U | 0.211 U |
| TNT | 1250 | 0.188 U | 0.188 U |
| 4-ADNT | 3.67 | 0.386 U | 0.386 U |
| 2-ADNT | 0.202 U | 0.297 U | 0.297 U |
| HMX | 49.1 J | 0.136 U | 0.136 U |
| 2,6-DNT | 0.331 U | 0.375 U | 0.375 U |
| p-NT | 0.433 U | 0.761 U | 0.761 U |
| m-NT | 0.409 U | 0.619 U | 0.618 U |
| RDX | 377 | 0.333 U | 0.333 U |

All units in mg/kg.

U = Not detected above the quantification limit shown.
J = Estimated value because the associated Laboratory Control Sample was low.

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**TABLE 1-13**

**VITRIFICATION TREATABILITY STUDY**
**POST-TREATMENT RCRA CHARACTERIZATION ANALYSIS**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**

| Analyte | Regulatory Limit | Sample Result |
|---|---|---|
| TCLP[1] | | |
| Arsenic | 5.0 | 0.110 U |
| Barium | 100.0 | 0.276 B |
| Benzene | 0.5 | 0.025 U |
| Cadmium | 1.0 | 0.005 U |
| Carbon tetrachloride | 0.5 | 0.025 U |
| Chlordane | 0.03 | 0.0001 U |
| Chlorobenzene | 100.0 | 0.025 U |
| Chloroform | 6.0 | 0.025 U |
| Chromium | 5.0 | 0.107 |
| o-Cresol | 200.0 | NA |
| m-Cresol | 200.0 | NA |
| p-Cresol | 200.0 | NA |
| Cresol | 200.0 | NA |
| 2,4-D | 10.0 | 0.0005 U |
| 1,4-Dichlorobenzene | 7.5 | 0.040 U |
| 1,2-Dichloroethane | 0.5 | 0.025 U |
| 1,1-Dichloroethylene | 0.7 | 0.025 U |
| 2,4-Dinitrotoluene | 0.13 | 0.040 U |
| Endrin | 0.02 | 0.0001 U |
| Heptachlor (and its epoxide) | 0.008 | 0.0005 U |
| Hexachlorobenzene | 0.13 | 0.040 U |
| Hexachlorobutadiene | 0.5 | 0.040 U |
| Hexachloroethane | 3.0 | 0.040 U |
| Lead | 5.0 | 0.036 U |
| Lindane | 0.4 | 0.0005 U |
| Mercury | 0.2 | 0.0001 U |
| Methoxychlor | 10.0 | 0.0005 U |
| Methyl ethyl ketone | 200.0 | 0.050 J |
| Nitrobenzene | 2.0 | 0.040 U |
| Pentachlorophenol | 100.0 | 0.100 U |
| Pyridine | 5.0 | 0.040 U |
| Selenium | 1.0 | 0.176 U |
| Silver | 5.0 | 0.033 U |

TABLE 1-13

**VITRIFICATION TREATABILITY STUDY**
**POST-TREATMENT RCRA CHARACTERIZATION ANALYSIS**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Analyte | Regulatory Limit | Sample Result |
|---|---|---|
| Tetrachloroethylene | 0.7 | 0.025 U |
| Toxaphene | 0.5 | 0.001 U |
| Trichloroethylene | 0.5 | 0.025 U |
| 2,4,5-Trichlorophenol | 400.0 | 0.040 U |
| 2,4,6-Trichlorophenol | 2.0 | 0.100 U |
| 2,4,5-TP (Silvex) | 1.0 | 0.0005 U |
| Vinyl chloride | 0.2 | 0.050 U |
| Ignitability[2] | see note | no flash |
| Corrosivity[3] | 6.35 mm/yr | 1.1E-04 mm/yr U |
| Reactivity[4] | | |
| Cyanide | 250 mg/(l or kg) | 0.025 mg/kg U |
| Sulfide | 500 mg/(l or kg) | 5.0 mg/kg U |

J = Estimated value.
U = Not detected above quantitation limit shown to the left of U.
B = Reported value is greater than detection limit, but less than Contract Required Detection Limit.
NA = Compound not analyzed.

1 TCLP = Toxicity Characteristic Leaching Procedure (mg/l) from 40 CFR 261.24.
2 40 CFR 261.21; no flash below 60°C.
3 40 CFR 261.22.
4 40 CFR 261.23; limits from Claussen, 1985.

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**TABLE 1-14**

**BIOLOGICAL TREATABILITY STUDY EXPLOSIVES RESULTS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**February 1994**

| Analyte | Pretreatment Sample | Post-Treatment Samples BSTS[1] | C-12[2] |
|---|---|---|---|
| 2,4-DNT | 1.59 | 1.14 | 1.57 |
| o-NT | 0.452 U | 0.608 U | 0.608 U |
| TNB | 53.1 | 13.7 | 6.46 |
| DNB | 1.51 | 6.95 | 1.38 |
| Tetryl | 72.4* | 3.25 | 0.273U |
| NB | 1.29 U | 8.44 UD | 2.11 U* |
| TNT | 1730** | 901 D | 116* |
| 4-ADNT | 4.44 | 50.8 D | 23.7 |
| 2-ADNT | 0.202 U | 39.7 D | 25. |
| HMX | 80.3 J* | 79. D | 85.7 |
| 2,6-DNT | 0.331 U | 1.370 | 6.48 |
| p-NT | 0.433 U | 0.618 U | 0.618 U |
| m-NT | 0.409 U | 0.760 U | 0.760 U |
| RDX | 539* | 433 D | 451* |

All units in mg/kg.
U = Not detected above the quantification limit shown to the left of U.
J = Estimated value because the associated Laboratory Control Sample was low.
D = Diluted.
* = 1:10 Dilution
** = 1:100 Dilution

[1]Conditions for the bench-scale (BSTS) sample were:

- Two-stage continuous flow aerobic treatment.
- 16-day residence time.
- 20% solids.
- 1,000 mg/l glucose
- Temperature approximately 20 to 25°C

[2]Conditions for the best laboratory scale (C-12) sample were:

- Two-stage continuous flow aerobic treatment.
- 32-day residence time.
- 20% solids.
- 1% glucose
- Temperature approximately 20 to 25°C.

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**TABLE 1-15**

**BIOLOGICAL TREATABILITY STUDY**
**POST-TREATMENT RCRA CHARACTERIZATION ANALYSES**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**

| Analyte | Regulatory Limit | Sample Result |
|---|---|---|
| TCLP[1] | | |
| Arsenic | 5.0 | 0.086 U |
| Barium | 100.0 | 2.37 |
| Benzene | 0.5 | 0.025 U |
| Cadmium | 1.0 | 0.006 B |
| Carbon tetrachloride | 0.5 | 0.025 U |
| Chlordane | 0.03 | 0.010 UD |
| Chlorobenzene | 100.0 | 0.025 U |
| Chloroform | 6.0 | 0.025 U |
| Chromium | 5.0 | 0.006 U |
| o-Cresol | 200.0 | 0.020 U |
| m-Cresol | 200.0 | 0.020 U |
| p-Cresol | 200.0 | 0.020 U |
| Cresol | 200.0 | 0.020 U |
| 2,4-D | 10.0 | 0.005 UD |
| 1,4-Dichlorobenzene | 7.5 | 0.020 U |
| 1,2-Dichloroethane | 0.5 | 0.025 U |
| 1,1-Dichloroethylene | 0.7 | 0.025 U |
| 2,4-Dinitrotoluene | 0.13 | 0.023 |
| Endrin | 0.02 | 0.010 UD |
| Heptachlor (and its epoxide) | 0.008 | 0.005 UD |
| Hexachlorobenzene | 0.13 | 0.025 U |
| Hexachlorobutadiene | 0.5 | 0.020 U |
| Hexachloroethane | 3.0 | 0.020 U |
| Lead | 5.0 | 0.062 U |
| Lindane | 0.4 | 0.005 UD |
| Mercury | 0.2 | 0.0001 U |
| Methoxychlor | 10.0 | 0.005 UD |
| Methyl ethyl ketone | 200.0 | 0.130 |
| Nitrobenzene | 2.0 | 0.020 U |
| Pentachlorophenol | 100.0 | 0.020 U |
| Pyridine | 5.0 | 0.020 U |
| Selenium | 1.0 | 0.108 U |

**TABLE 1-15**

**BIOLOGICAL TREATABILITY STUDY**
**POST-TREATMENT RCRA CHARACTERIZATION ANALYSES**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Analyte | Regulatory Limit | Sample Result |
|---|---|---|
| Silver | 5.0 | 0.013 U |
| Tetrachloroethylene | 0.7 | 0.25 U |
| Toxaphene | 0.5 | 0.100 UD |
| Trichloroethylene | 0.5 | 0.025 U |
| 2,4,5-Trichlorophenol | 400.0 | 0.020 U |
| 2,4,6-Trichlorophenol | 2.0 | 0.020 U |
| 2,4,5-TP (Silvex) | 1.0 | 0.00768 D |
| Vinyl chloride | 0.2 | 0.050 U |
| Ignitability[2,3] | see note | no flash; no flash |
| Corrosivity[4] | 6.35mm/yr | 0.00034mm/yr; NA |
| Reactivity[5] | | |
| Cyanide | 250 mg/(l or kg) | 7.9 ug/l; 0.04 mg/kg |
| Sulfide | 500 mg/(l or kg) | 20 mg/l U; 119 mg/kg U |

U = Not detected above quantitation limit shown to the left of U.
D = Diluted.
B = Reported value is greater than detection limit, but less than Contract Required Detection Limit.
NA = Compound or parameter not analyzed for.
[1]TCLP = Toxicity Characteristic Leaching Procedure (mg/l) from 40 CFR 261.24.
[2]40 CFR 261.21; no flash below 60°C.
[3]Values shown are for liquid and solid phases, respectively.
[4]40 CFR 261.22.
[5]40 CFR 261.23; limits from Claussen, 1985.

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## 1.3 SITE REMEDIATION ISSUES AND APPROACH

The remediation approach adopted through the Interagency Agreement for remedial actions at the NOP site encompasses three separate operable units: the explosives-contaminated soils (OU 1); the contaminated groundwater and VOC contaminated soil (OU 2); and other waste disposal areas (OU 3).

Some of the pertinent issues and the general approach regarding the OU 1 remedial action are as follows.

- Soil contamination with explosive compounds occurs in drainage ditches and isolated hot spots, which are unevenly distributed over the site.

- Most explosives-contaminated soil is within 5 feet of the soil surface, but some soil contamination has been measured and detected at approximately 30 feet.

- Potentially contaminated concrete and debris associated with the source areas may require remediation.

- The Baseline Risk Assessment (Life Systems, 1992a) indicated that potential cancer risks above 1E-04 and noncancer risks with HI greater than 1E+00 exist at the site for the soil and the garden vegetable pathways. Potential risks from the soil pathway only will be addressed in the OU 1 remediation. Soil having unacceptable risk for OU1 is primarily located in the upper 5 feet; in a limited number of areas, deeper soil also has unacceptable risk. The majority of soil having unacceptable risk is located around Load Lines 1 and 2; Load Lines 3 and 4 and the Burning Proving Grounds have a limited number of additional areas with unacceptable risk.

- The explosive contaminants are expected to exhibit relatively low mobility in site soil.

- The fine-grained texture of the soil (silty clay) may inhibit certain types of remedial processes.

- Remediation activities should be developed to minimize interference with current agricultural and commercial activities at the site.

- It is assumed, based on results of previous investigations, that the explosives contamination present in different source areas is sufficiently similar in nature and origin that each type of appropriate remedial technology can be applied to all the source areas.



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- Although elevated levels of some inorganic compounds and PCBs were detected in some areas, these compounds are either not co-located with explosives-contaminated soil, do not pose significant risk to exposed populations or do not pose a potential interference for any remedial action elevated for the site. The scope of this FS is limited to explosives-contaminated soils. Elevated detected inorganic compounds will be addressed under OU 3.

Therefore, the scope of contamination requiring remedial response based on risk and compliance is primarily shallow soil (less than 5 feet) located in Load Lines 1 and 2. A limited number of additional areas in Load Lines 3 and 4 and the Burning Proving Grounds also have soil with unacceptable risk. A limited number of areas have soil with unacceptable risk at depths of greater than 5 feet.

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2



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# 2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

## 2.1 INTRODUCTION

In this chapter, remedial technologies and process options are identified and screened based on site-specific information. This process involves the following four steps:

- Develop remedial action objectives (RAOs) that address site-specific contaminants, contaminated media, and exposure pathways. These RAOs are developed to meet applicable or relevant and appropriate requirements (ARARs), when available, or acceptable residual risk levels (Section 2.2).

- Identify areas and volumes of contamination (Section 2.3).

- Develop general response actions (GRAs) to satisfy the site-specific RAOs (Section 2.4).

- Identify and screen technologies and process options satisfying each GRA. The initial criterion for this screening is technical feasibility. Further screen the technically feasible technologies and process options based on effectiveness, implementability, and cost to select a representative process option for a given remedial technology type, where appropriate. Technologies retained after the second screening process (Section 2.5) are carried into Section 3 where they are assembled into alternatives.

## 2.2 REMEDIAL ACTION OBJECTIVES

RAOs are site- and medium-specific remediation goals for protecting human health and the environment. Because protection may be achieved by both reducing exposure (i.e., by containment) and reducing contaminant levels (i.e., by treatment), RAOs are developed in terms of exposure routes and acceptable contaminant levels. The RAOs may be based on Federal and State ARARs or on risk. For risk-based RAOs, contaminant concentrations (PRGs) which are protective of human health and the environment are estimated. The Federal and State ARARs, risk-based RAOs, and the PRGs for the former NOP site are described in Sections 2.2.1, 2.2.2, and 2.2.3 respectively.

### 2.2.1 Applicable or Relevant and Appropriate Requirements (ARARs)

ARARs include Federal, State, or local promulgated standards, rules, or regulations that pertain to the site contaminants, location, or remedial actions. Pertinent ARARs are classified as either "applicable" or "relevant and appropriate." Standards and requirements



B07NE003701-04692

are "applicable" if they specifically address a hazardous contaminant, remedial action, location, or other circumstances at a site, and "relevant and appropriate" if they address problems or situations sufficiently similar to those encountered at the site and it is appropriate to apply the specified regulatory requirement. ARARs are classified as:

- Chemical-specific.
- Location-specific.
- Action-specific.

Chemical-specific ARARs establish health- or risk-based concentrations that are acceptable to remain on-site or to be discharged to the environment. Location-specific ARARs place restrictions on activities due to characteristics inherent to the particular location where that activity is taking place. Action-specific ARARs pertain to activities associated with a technology chosen for containment or treatment.

ARARs are used to determine the appropriate extent of site cleanup, to scope and formulate remedial action alternatives, and to govern implementation and operation of the selected action. As specified in CERCLA Section 121(e), on-site remedial actions taken at Superfund sites need only comply with the substantive aspects of permits. Substantive requirements are those that apply directly to actions or conditions on-site. Permit applications and other administrative procedures are not considered ARARs for actions conducted entirely on-site. However, off-site actions such as treatment at an off-site treatment, storage, or disposal (TSD) facility must comply with substantive and administrative requirements.

A list of potential ARARs is shown in Table 2-1. ARARs and non-ARAR guidance pertinent to this report have been identified and are discussed below. Non-ARAR guidance refers to standards that are not promulgated but are pertinent to site conditions. The potential ARARs to be discussed include the Resource Conservation and Recovery Act (RCRA), the Nebraska Water Quality Standards, and other non-ARAR to-be-considered guidance. Remaining potential ARARs are discussed as they apply to specific alternatives in Chapter 4. Appendix B presents the rationale used to evaluate whether each potential ARAR listed in Table 2-1 is pertinent to this OU and evaluates each potential ARAR with respect to each of the Chapter 4 alternatives. Table 2-2 shows action-specific ARARs which may be pertinent to the site.

#### 2.2.1.1 RCRA

Remedial actions at Superfund sites require conformance with RCRA when RCRA is an ARAR. RCRA regulates the management of solid and hazardous waste. One way that RCRA defines a hazardous waste is as a characteristic waste based on reactivity, ignitability, corrosivity, or toxicity. Another way that RCRA classifies waste as hazardous is by listing. Based on the definitions used in 40 CFR Part 261, the explosives-contaminated soil on-site is unlikely to require management as a hazardous waste under RCRA, as



B07NE003701-04693

## TABLE 2-1

## IDENTIFICATION OF POTENTIAL ARARs
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Laws | Regulation |
|---|---|
| FEDERAL | |
| **Clean Air Act (CAA) of 1963, as amended [42 U.S.C. 7401]** | 40CFR50 - National Primary and Secondary Ambient Air Quality Standards |
| | 40CFR60 - Standards of Performance for New Stationary Sources |
| | 40CFR61 - National Emission Standards for Hazardous Air Pollutants |
| **Clean Water Act (CWA) of 1977, as amended [33 U.S.C. 1251]** | 40CFR122 - EPA Administered Permit Programs: The National Pollutant Discharge Elimination System (NPDES) |
| | 40CFR125 - Criteria and Standards for the National Pollutant Discharge Elimination System |
| | 40 CFR136 - Guidelines Establishing Test Procedures for the Analysis of Pollutants |
| | 40 CFR403 - General Pretreatment Regulations for Existing and New Sources of Pollution |
| **Endangered Species Act [16 U.S.C. 1531 Sect. 7]** | 50CFR81 - Conservation of Endangered Species of Fish, Wildlife, and Plants - Cooperation With the States |
| **Hazardous Materials Transportation Act (HMTA)** | 49CFR107 - Hazardous Materials Program Procedures |
| | 49CFR171 - General Information, Regulations, and Definitions |

## TABLE 2-1

## IDENTIFICATION OF POTENTIAL ARARs
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**
**(continued)**

| Laws | Regulation |
|---|---|
| **Hazardous Materials Transportation Act (HMTA) (cont'd)** | 49CFR172 - Hazardous Materials Tables and Hazardous Material Communications Regulations |
| | 49CFR173 - Shippers - General Requirements for Shipments and Packaging |
| | 49CFR177 - Carriage by Public Highway |
| **Public Health Service Act: Title XIV, as amended by the SAFE DRINKING WATER ACT OF 1988 [42 U.S.C. 300(f)]** | 40CFR141 - National Primary Drinking Water Regulations |
| | 40CFR143 - National Secondary Drinking Water Regulations |
| **Section 10 of the River and Harbor Act of 1899, as amended [33 U.S.C. 403]** | 33CFR320 - General Regulatory Policies |
| (NOTE: The regulations under Section 10 are also affiliated with the CWA) | 33CFR330 - Nationwide Permits |
| **Solid Waste Disposal Act (SWDA) as amended by the RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) of 1976 [42 U.S.C. 6901]** | 40CFR241 - Guidelines for the Land Disposal of Solid Wastes |
| | 40CFR257 - Criteria for Classification of Solid Waste Disposal Facilities and Practices |
| | 40CFR258 - Criteria for Municipal Solid Waste Landfills |

**TABLE 2-1**

**IDENTIFICATION OF POTENTIAL ARARs**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**
**(continued)**

| Laws | Regulation |
|---|---|
| **RCRA (cont'd)** | 40CFR261 - Identification and Listing of Hazardous Waste |
| | 40CFR262 - Standards Applicable to Generators of Hazardous Waste |
| | 40CFR263 - Standards Applicable to Transporters of Hazardous Wastes |
| | 40CFR264 - Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal (TSD) Facilities |
| | 40CFR266 - Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities |
| | 40 CFR268 - Land Disposal Restrictions |
| STATE | |
| Nebraska Department of Environmental Quality (NDEQ), Nebraska Environmental Protection Act | Title 117 - Water Quality Standards for Surface Water of the State |
| | Title 118 - Groundwater Quality Standards and Use Classification |
| | Title 119 - Rules and Regulations Pertaining to the Issuance of Permits Under the National Pollutant Discharge Elimination System |

## TABLE 2-1

## IDENTIFICATION OF POTENTIAL ARARs
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**
**(continued)**

| Laws | Regulation |
|---|---|
| NDEQ, Nebraska Environmental Protection Act | Title 121- Effluent Guidelines and Standards |
| | Title 126 - Rules and Regulations Pertaining to the Management of Wastes |
| | Title 127 - Rules and Regulations Governing the Nebraska Pretreatment Program |
| | Title 128 - Rules and Regulations Governing Hazardous Waste Management in Nebraska |
| | Title 129 - Nebraska Air Pollution Control Regulations |
| | Title 132 - Rules and Regulations Pertaining to Solid Waste Management |
| | Title 178 - Regulations Governing Licensure of Water Well and Pump Installation Contractors and Certification of Water Well Drilling and Pump Installation Supervisors |

RP/MEADFS/AB4

**TABLE 2-2**
**ACTION-SPECIFIC ARARs**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Regulation | Applicable Action | Substantive Requirement |
|---|---|---|
| 40 CFR 50 - Clean Air Act: | | |
| National primary and secondary standards for particulate matter less than or equal to 10 um diameter. | Excavation, stockpile, material handling. | Limits the maximum 24-hour-average ambient concentration of particulate matter (PM) to 150 ug/m$^3$, not to be exceeded more than once per year, and the annual arithmetic mean to 50 ug/m$^3$ as measured by the test method specified in 40 CFR 50 Appendix J. Site is not a major source of particulates, but may be relevant and appropriate. |
| National primary air quality standards for particulate matter. | Excavation, stockpile, material handling. | Limits the ambient concentration of particulate matter to 75 ug/m$^3$ based on an equal geometric mean and 260 ug/m$^3$ maximum 24-hour concentration not to be exceeded more than once per year as measured by the test method specified in 40 CFR 50 Appendix B. Site is not a major source of particulates, but may be relevant and appropriate. |
| National secondary air quality standards for particulate matter. | Excavation, stockpile, material handling. | Limits the ambient concentration of particulate matter to 60 ug/m$^3$ based on an annual geometric mean and 150 ug/m$^3$ maximum 24-hour concentration not to be exceeded more than once per year as measured by the test method specified in 40 CFR 50 Appendix B. Site is not a major source of particulates, but may be relevant and appropriate. |

**TABLE 2-2**
**ACTION-SPECIFIC ARARs**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Regulation | Applicable Action | Substantive Requirement |
|---|---|---|
| Resource Conservation and Recovery Act: | Incinerator ash. | Exceedance of the following TCLP standards requires stabilization of the ash prior to disposal on-site: Cr: 5.0 mg/l; Pb: 5.0 mg/l; Hg: 0.2 mg/l; Ag: 5.0 mg/l. |
| Title 129 - Nebraska Air Pollution Control Rules and Regulations. | Incinerator emissions. | Limits emissions of particulate matter ($PM_{10}$) to less than 10 tons/yr; particulate matter to less than 10 lbs/hr; and $NO_2$ to less than 50 lbs/consecutive 24 hrs. |

RP/MEADFS/AQ5

discussed below. However, RCRA is applicable to the site in that residuals from treatment of the soil must be managed as hazardous waste if they are hazardous by characteristic as defined by RCRA. Additional relevant and appropriate RCRA requirements may be identified as more detailed components of the remedial action are evaluated during the predesign and design phases of OU 1.

**Characteristic Wastes**

**Reactivity Characteristic**

According to 40 CFR 261.23, a solid waste is hazardous under RCRA due to the characteristic of reactivity if it is capable of an explosive reaction when subjected to a strong initiating source or heated under confinement. A study by the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA, 1987) correlated percent total explosives concentrations with tests for reactivity. The study concluded that if the total explosives concentration exceeds 12 percent, the sample will be reactive and will, therefore, be considered hazardous under RCRA. USEPA has not yet identified a test method that it considers acceptable in determining what concentrations of explosives in soils should be considered hazardous under RCRA based on the characteristic of reactivity.

As discussed previously, two sample points out of more than 1,400 taken at the former NOP site have been identified with a total explosives concentration exceeding 12 percent. These two points are located in drainage ditches less than 1 foot below the ground surface. In exposure area LL1C, sample D260, collected at an interval from 0 to 0.5 feet below ground surface, contained approximately 13 percent total explosives. In exposure area LL2B, sample D249, at a depth of 0.5 to 1 foot, contained approximately 18 percent total explosives. Based on the USACE's definition of explosives reactivity, only these two samples have been identified which exceed that definition. No other samples collected and analyzed from the same ditch segments and across the site displayed potentially reactive concentrations of explosive contaminants. According to 40 CFR 260.10 and 40 CFR 261.23(a), a representative sample used to characterize a waste as hazardous due to reactivity must "exhibit the average properties of the universe or whole (e.g. waste pile, lagoon, groundwater)." Because these two samples are not representative of either the ditch in which they were found or the site as a whole, soil managed under the remedial action is unlikely to be considered hazardous under the RCRA characteristic of reactivity.

**Metals Toxicity Characteristic**

The Supplementary RI (SEC Donohue, 1992a) indicated that some NOP soil contains elevated levels of lead, mercury, chromium, and silver which are also compounds regulated by RCRA. The Toxicity Characteristic Leaching Procedure (TCLP), which replaced the Extraction Procedure Toxicity (EPTox) test, measures the potential for contaminants to leach out of soil, and is used to define wastes as hazardous due to these inorganic elements.

Evaluation of the EPTox data (TCT, 1991) shown in Table 2-3 (which are considered to be comparable to TCLP results) indicates that the NOP soil does not exceed allowable TCLP concentrations. The corresponding total metals results for the samples shown are not included because they were not analyzed. More recent pretreatment TCLP metals data were collected for Treatability Studies conducted using NOP soil (Treatability Study Work Plan, Treatability Study Report, 1993) and are presented in Table 2-4.

Samples 1 through 4 in Table 2-4 were collected from the pile consolidated to simulate the soil treated under the full-scale remediation. Soil from the following locations was consolidated for the full-scale simulation stockpile:

- Load Line 1 ditch segment from D265 to D267
- Load Line 1 ditch segment from D261 to D263
- Load Line 2 ditch segment from D264 to D255
- Load Line 3 ditch segment from D201 to D200
- Bomb Booster Assembly Area from just west of TB82 to just east of BBA-12-13A.

Appendix C1 presents a summary of treatability study sample locations and compositing procedures used.

Based on the data to date, it is assumed that the NOP soil to be managed under OU 1 does not exceed allowable TCLP concentrations and is unlikely to be considered hazardous under the RCRA characteristic of metals toxicity. Metals contaminated soil will be further addressed in OU 3.

**2,4-DNT Toxicity Characteristic**

Data generated on pretreatment treatability study samples also included TCLP tests for organic compounds. 2,4-DNT is one of the compounds which is extracted during this analysis. The data are listed in Table 2-5. Since the total concentration of leachable 2,4-DNT is less than the allowable TCLP concentration for 2,4-DNT, the NOP soil is unlikely to be considered hazardous under the RCRA characteristic of 2,4-DNT toxicity.

**Listed Waste**

In 40 CFR 261, RCRA also classifies waste as hazardous by listing. Site soil is not considered a listed hazardous waste, based on determinations summarized in the following sections.

The potential for site soil to be classified as a RCRA "U" or "K" listed waste was evaluated based on regulatory review, Federal Register review, RCRA Hotline inquiries and precedents at other facilities. The listing codes that were assessed are:

U105 - 2,4-DNT
U106 - 2,6-DNT

**TABLE 2-3**

**SUMMARY OF EP TOXICITY METALS RESULTS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Sample Number | Units | Silver | Arsenic | Barium | Cadmium | Chromium | Mercury | Lead | Selenium |
|---|---|---|---|---|---|---|---|---|---|
| NS-1 | mg/l | <0.05 | <0.20 | <0.50 | <0.02 | <0.05 | <0.0002 | <0.10 | <0.41 |
| NS-2 | mg/l | <0.05 | <0.20 | 0.53 | <0.02 | <0.05 | <0.0002 | <0.10 | <0.41 |
| NS-4 | mg/l | <0.05 | <0.20 | <0.50 | <0.02 | <0.05 | <0.0002 | <0.10 | <0.41 |
| NS-5 | mg/l | <0.05 | <0.20 | 1.11 | <0.02 | <0.05 | <0.0002 | 0.13 | <0.41 |
| NS-6 | mg/l | <0.05 | <0.20 | 1.19 | <0.02 | <0.05 | <0.0002 | 0.12 | <0.41 |
| NS-7 | mg/l | <0.05 | <0.20 | 0.91 | <0.02 | <0.05 | <0.0002 | <0.10 | <0.41 |
| NS-8 | mg/l | <0.05 | <0.20 | 1.39 | <0.02 | <0.05 | <0.0002 | 0.16 | <0.41 |
| NS-9 | mg/l | <0.05 | <0.20 | 0.59 | <0.02 | <0.05 | <0.0002 | <0.10 | <0.41 |
| NS-10 | mg/l | <0.05 | <0.20 | 0.98 | <0.02 | <0.05 | <0.0002 | <0.10 | <0.41 |
| NS-11 | mg/l | <0.05 | <0.20 | 1.03 | <0.02 | <0.05 | <0.0002 | <0.10 | <0.41 |
| NS-12 | mg/l | <0.05 | <0.20 | <0.50 | <0.02 | <0.05 | <0.0002 | <0.10 | <0.41 |
| NS-13 | mg/l | <0.05 | <0.20 | <0.05 | <0.02 | <0.05 | <0.0002 | <0.10 | <0.41 |
| NS-15 | mg/l | <0.05 | <0.20 | 0.64 | <0.02 | <0.05 | <0.0002 | <0.10 | <0.41 |
| NS-16 | mg/l | <0.05 | <0.20 | 0.9 | <0.02 | <0.05 | <0.0002 | <0.10 | 0.45 |
| NS-17 | mg/l | <0.05 | <0.20 | 0.92 | <0.02 | <0.05 | <0.0002 | <0.10 | <0.41 |
| NS-18 | mg/l | <0.05 | <0.20 | <0.05 | <0.02 | <0.05 | <0.0002 | <0.10 | <0.41 |
| TCLP Standard | mg/l | 5.0 | 5.0 | 100.0 | 1.0 | 5.0 | 0.2 | 5.0 | 1.0 |

Sources: TCT,1991; 40 CFR 261.24.

RP/MEADFS/AN1

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**SUMMARY OF PRETREATMENT METALS AND TCLP METALS RESULTS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Analyte | TCLP Standard (ug/l) | Sample 1 Total (mg/kg) | Sample 1 TCLP (ug/l) | Sample 2 Total (mg/kg) | Sample 2 TCLP (ug/l) | Sample 3 Total (mg/kg) | Sample 3 TCLP (ug/l) | Sample 4 Total (mg/kg) | Sample 4 TCLP (ug/l) |
|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 5,000 | 7.31 | <71 | 7.14 | <71 | 7.04 | <71 | 9.25 | <71 |
| Barium | 100,000 | 236 | 2,300 | 236 | 1,840 | 239 | 2,050 | 280 | 2,100 |
| Cadmium | 1,000 | 2.02 | <5 | <1.24 | <5 | <1.26 | <5 | <1.27 | <5 |
| Chromium | 5,000 | 14.6 | <6 | 12.9 | <6 | 12.3 | <6 | 16.5 | <6 |
| Lead | 5,000 | 20.1 | <22 | 19.7 | <22 | 21.9 | <22 | 16.6 | <22 |
| Mercury | 200 | 0.139(1) | 0.13(1) | <0.100 | <0.15(1) | 0.144 | 0.15(1) | 0.152(1) | 0.10(1) |
| Selenium | 1,000 | <1.26 | <56 | <1.24 | 62 | <1.26 | <56 | <1.27 | <56 |
| Silver | 5,000 | <1.26 | <4 | <1.24 | <4 | <1.26 | <4 | <1.27 | <4 |

" < " indicates that result was below detection limit where the detection limit is the number that follows
1) Mercury detected in the laboratory blank.

RP/MEADFS/AS6

**TABLE 2-5**

**SUMMARY OF PRETREATMENT 2,4-DNT RESULTS**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**

| Sample | Soil Concentrations (mg/kg) | TCLP Concentrations (mg/l) |
|---|---|---|
| 1 | 1.08 | 0.039 |
| 2 | 0.987 | 0.032 |
| 3 | 1.59 | 0.030 |
| 4 | 0.136 U | 0.020 U |

2,4-DNT TCLP Standard = 0.130 mg/l

"U" indicates that the result was below the detection limit where the detection limit is the number shown to the left of U.

RP/MEADFS/AS5

U234 - 1,3,5-TNB

K044 - Wastewater treatment sludges from the manufacturing and processing of explosives

K045 - Spent carbon from the treatment of wastewater containing explosives

K046 - Wastewater treatment sludges from the manufacturing, formulation, and loading of lead-based initiating compounds

K047 - Pink/red water from TNT operations

The characterization of the 2,4-DNT, 2,6-DNT, and the 1,3,5-TNB in site soils as U-listed wastes is inappropriate. The 1,3,5-TNB is now present at the NOP as a result of the photo-degradation of TNT while the 2,4-DNT and the 2,6-DNT are considered impurities in the military grade chemical TNT. The U listed wastes are grouped as chemicals which are discarded commercial chemical products, off-specification species, container residues, and spill residues thereof. The definition and comment set forth in 40 CFR 261.33 does not include impurities or substances which result from the degradation process in the category of U-listed wastes. As such, these substances should not be classified under the U list of 40 CFR 261.33(f).

K044, K045, and K047 pertain to explosives wastewater and wastewater treatment operations, and are not applicable for site soil. K046 pertains to lead-based initiating compounds, which were not produced at the site; therefore, the K046 listing is not applicable or relevant and appropriate for site soil.

**Pertinent RCRA Requirements**

Because USEPA has determined that RCRA is a relevant and appropriate rather than applicable requirement for untreated site soils, certain requirements have been identified for use at the NOP site. These are discussed below.

Subtitle C of RCRA (40 CFR 264.301) specifies engineering controls related to cap and liner configuration for RCRA hazardous waste landfills. These engineering controls provide a greater degree of protection than cap and liner configurations associated with nonhazardous landfills. Although Subtitle C is not applicable to the NOP site since the explosives contaminated soil is not a RCRA hazardous waste, USEPA considers the engineering controls related to cap and liner construction as described in Subtitle C to be relevant and appropriate. The cap and liner components of any landfill evaluated in this document will comply with these engineering controls.

The requirements related to incineration that have been identified for use at this site are that a trial burn will be performed and technical performance requirements will be met.

Additional relevant and appropriate RCRA requirements may be identified as more detailed components of the remedial action are evaluated during the predesign and design phases of OU 1.

### 2.2.2 Risk-Based Remedial Action Objectives

As noted in Chapter 1, risks to hypothetical future farm family, farmer, and farm worker populations from ingestion of soil, and groundwater indicated an unacceptable risk for the four load lines, the Burning/Proving Grounds, and the Bomb Booster Area. The following sections discuss risk-based RAOs for soil and groundwater to reduce these risks to acceptable levels.

#### 2.2.2.1 Soil RAOs

For the purposes of this document, the response action and, therefore, the RAOs used to address potential risks associated with the soil pathway used the following assumptions:

- Soil ingestion only (no vegetable pathway).
- Hypothetical future farm family.
- RME assumptions.
- A 30-year exposure duration.
- No fractional intake factor applied.
- Target noncancer risk of HI = 1E+00.
- Target cancer risk equal to 3E-06.
- PRGs applied on a site-wide basis.

#### 2.2.2.2 Groundwater RAOs

The risk-based RAOs for groundwater under OU1 are based on the assumption that there is no exposure to populations in the exposure areas due to current groundwater concentrations because no current drinking water wells exist in the soil exposure areas. To prevent future exposure, drinking water wells installed and used in the OU 1 exposure areas prior to completion of OU 2 activities would be equipped with a wellhead treatment unit that would remove contamination from the water prior to use if concentrations above regulatory or health advisory limits are detected.

### 2.2.3 PRGs

Risk-based PRGs are environmental concentration levels that incorporate the exposure assumptions discussed in Section 2.2.2 and are calculated to meet target cancer and noncancer risks to human health. The target risk for noncancer effects is typically defined as a population total HI value of 1E+00 for the maximally exposed population. The target risk for cancer effects may be defined to be anywhere in the range between 1E-04 and 1E-06 excess cancer risks, depending in part on the practicality and cost of achieving each of these goals.

Several successive iterations of risk-based PRGs have been calculated throughout the NOP RI/FS. Table 2-6 presents the assumptions used in these calculations and the documents where additional detail can be found. Appendix A-1 includes a more detailed discussion of PRG development and use.

## TABLE 2-6

## PRELIMINARY REMEDIATION GOAL DEVELOPMENT
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Iteration 1 | Iteration 2 | Iteration 3 | Iteration 4 | Iteration 5 |
|---|---|---|---|---|
| o Excavation PRGs only<br>o One chemical<br>o One pathway<br>o Ingestion of contaminated surface soil<br>o Screening-level exposure assumptions<br>o Three risk levels<br>o One set for entire site<br>o Presented in the RI | o Excavation PRGs only<br>o One chemical<br>o Multiple pathway<br>o Screening level exposure assumptions<br>o Groundwater risk assumed negligible<br>o Three risk levels<br>o One set for entire site<br>o Presented in the ISAD | o Excavation and treatment PRGs<br>o Multiple chemical<br>o Multiple pathway<br>o Detailed analysis exposure assumptions<br>o Groundwater risk based on model concentrations<br>o Three risk levels<br>o Separate sets of PRGs for different areas<br>o One set for all soil so soil can be placed back on-site.<br>o Presented in the Draft FS | o Excavation and treatment PRGs<br>o Leaching PRGs developed to prevent soil source to groundwater<br>o Multiple chemical<br>o Multiple pathway<br>o Detailed analysis exposure assumptions<br>o Groundwater risk controlled at point of use<br>o Accounts for treatability, detection limits, and estimated soil pile concentrations.<br>o Three risk levels<br>o One set of excavation PRGs for each major area<br>o One set of treatment PRGs for all soil so soil can be placed back on-site.<br>o Draft Final FS | o Excavation and treatment PRGs that will be adjusted based on leaching PRGs developed under OU 2<br>o Multiple chemical (non-cancer), single chemical (cancer)<br>o Multiple pathway<br>o USEPA exposure assumptions<br>o Groundwater risk controlled at point of use<br>o One risk level<br>o One set of PRGs for whole site<br>o USEPA, June 2, 1993 |

RP/MEADFS/AS4

#### 2.2.3.1 Excavation PRGs

Excavation PRGs are values which provide the basis to define the boundaries of an area to be excavated. Table 2-7 shows the risk-based excavation PRGs (Iteration 5 PRGs developed by USEPA). These risk-based PRGs correspond to a cancer risk level of 3E-06 and noncancer HI of 1E+00 based on soil exposure only. It is assumed that populations living in the exposure area will not be exposed to groundwater. Volume calculations described in Section 2.3 and costs estimated for remedial alternatives in Section 4 are based on these excavation PRGs.

#### 2.2.3.2 Leach-Based PRGs

Leach-based PRGs are residual soil concentration levels that prevent unacceptable contaminant leaching to groundwater. Groundwater sampling and evaluation conducted during the OU 2 RI identified TNT, TNB, 2,4-DNT, RDX and HMX as compounds of concern in groundwater (Woodward-Clyde Consultants, 1993). Leach-based PRGs will be calculated based on available data, the Summers model (USEPA, 1989a), and the HYDRUS model (Kool and Van Genuchten, 1991) under OU 2. The target groundwater concentrations for the model are based on a target risk of 1E-06 for each carcinogen (TNT, 2,4-DNT, and RDX), HI=1.0 (TNB and HMX), and the EPA Region IX tap water generic PRG 1993 (WCC, 1993b).

#### 2.2.3.3 Treatment Goals

Following any treatment component of the developed alternatives, soil will be placed back in the excavations. Treatment PRGs will be selected based on results of treatability studies and other factors during the Remedial Design and will meet the total site goals between 1E-04 and 1E-06.

### 2.2.4 Remedial Action Objectives Summary

Therefore, the RAOs identified by USACE for OU 1 of the former NOP site are:

- Minimize risk to human health and the environment from ingestion of soil contaminated with DNB, TNB, 2,4-DNT, 2,6-DNT, TNT, RDX, HMX, Tetryl, and NT.

- Minimize risk to human health from ingestion of contaminated groundwater extracted from a residential well located within an exposure area, if a domestic well is installed prior to completion of OU 2 activities, by providing point-of-use treatment if water from that well exceeds health advisory or regulatory limits.

- Minimize potential additional groundwater contamination from leaching of soil contaminants.

**TABLE 2-7**

**EXCAVATION PRELIMINARY REMEDIATION GOALS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Chemical | Concentration (mg/kg) |
|---|---|
| HMX | 1715.2 |
| RDX | 5.8 |
| TNB | 1.7 |
| DNB | 3.4 |
| TNT | 17.2 |
| DNT (2,4 or 2,6) | 0.9 |
| NT | 343.0 |
| Tetryl | 343.0 |

RP/MEADFS/AU8

## 2.3 AREAS AND VOLUMES OF CONTAMINATION

Figures 2-1 through 2-6 show the approximate locations of contaminated soil (exceeding the excavation PRGs described in Section 2.2.3.1) to be excavated and managed. The estimated remediation volumes do not include the leaching soil volumes which are currently being re-evaluated in OU 2. Assumptions used to estimate contaminated areas and volumes were as follows:

- Contaminated washwater is assumed to have remained within the ditches. This assumption is made because soil samples collected directly outside the ditches are typically below the PRGs.

- Based on information provided by the RI field manager, contaminated areas in the ditches are assumed to be approximately 8 feet wide, unless data indicate otherwise.

- Contamination is assumed to extend horizontally within the ditches half-way from any sample contaminated above PRG levels to the nearest ditch sample which was not contaminated above PRG levels.

- The areal extent of contamination for isolated contaminated samples outside the ditches is approximated by geometric figures whose dimensions extend half-way to the nearest sample below the PRGs. In some cases, the area of contamination was defined by existing structures or based on historical information (e.g.,trench areas in the Burning/Proving Grounds).

- When samples were screened in the field and sent to the laboratory, the laboratory results were used. Sample locations with field-screen data only were evaluated in conjunction with surrounding samples, historical information, geography, and surrounding structures.

- Sample locations exceeding the PRGs will be excavated to a depth of 4 feet. Four feet is the estimated depth of soil at which a person is unlikely to come into direct contact with contaminated soil based on site uses and characteristics (USEPA, 1993). Even if contamination has been shown in the past to extend only to 2 feet, soil will be excavated to 4 feet in that area to eliminate the need for confirmation sampling in the bottom of the excavation and to simplify design and construction. If incorporation of leach-based PRGs requires excavation deeper than 4 feet, confirmation sampling in the bottom of the excavation will be performed.



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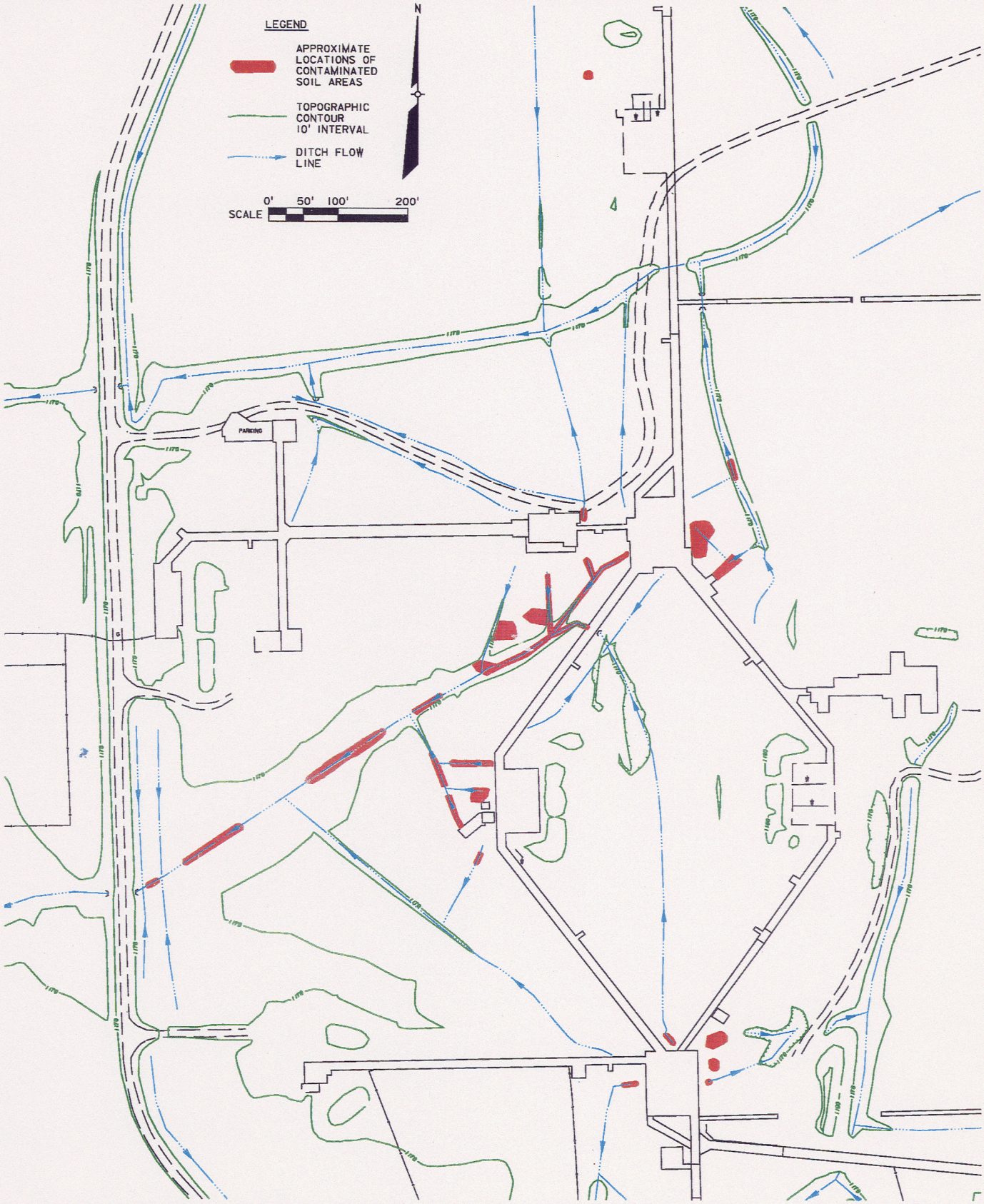
/usr/project 38/111cs.dgn Sep. 6, 1993 09:47:59

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RUST ENVIRONMENT & INFRASTRUCTURE

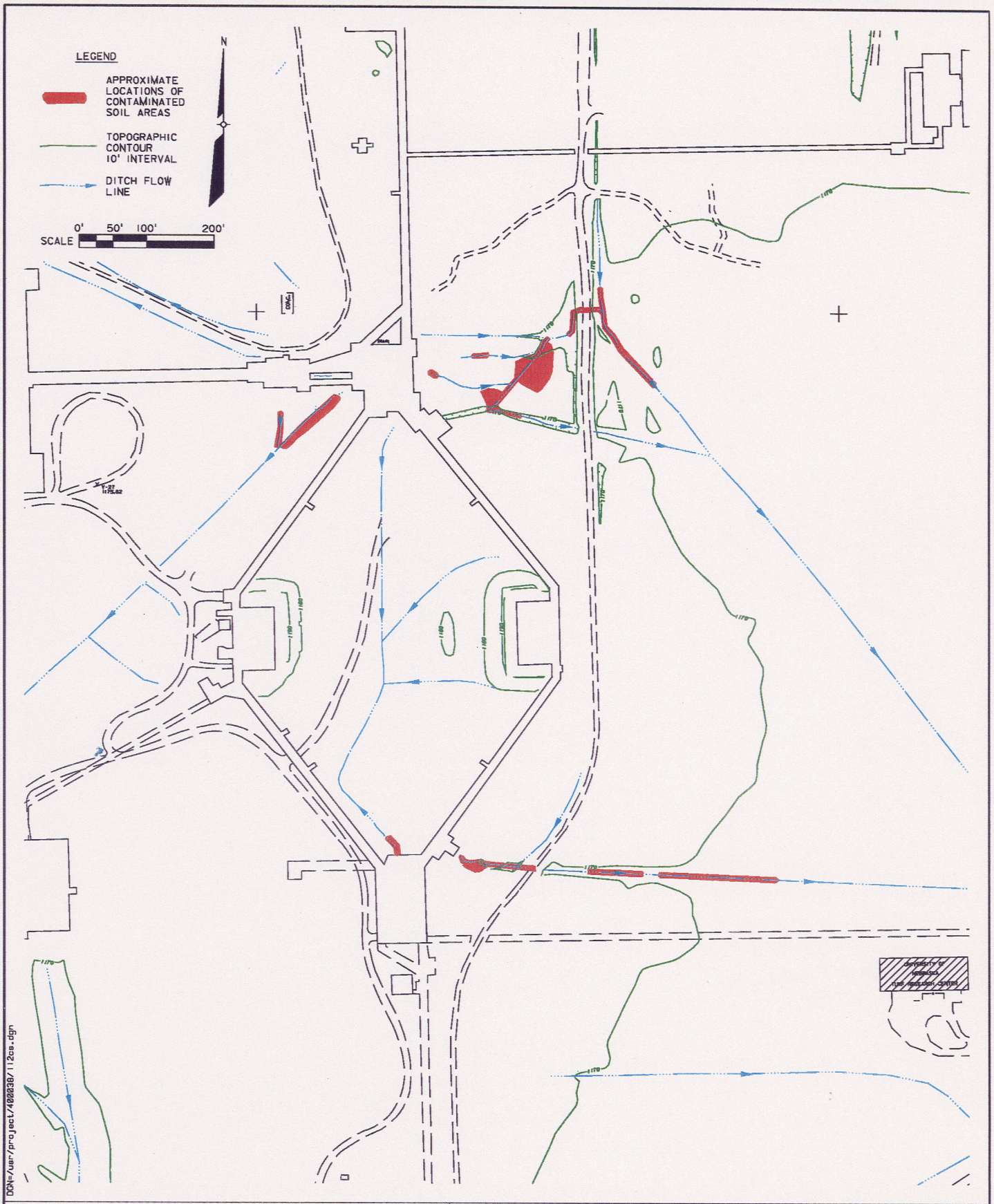
MARCH 1994

19536

FIGURE 2-1
LOAD LINE 1 - CONTAMINATED SOIL

FINAL FEASIBILITY STUDY - OPERABLE UNIT 1
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

/usr/projec 38/112cs.dgn Sep. 6, 1993 10:39:04




DGN=/usr/project/400838/112cs.dgn

RUST ENVIRONMENT & INFRASTRUCTURE

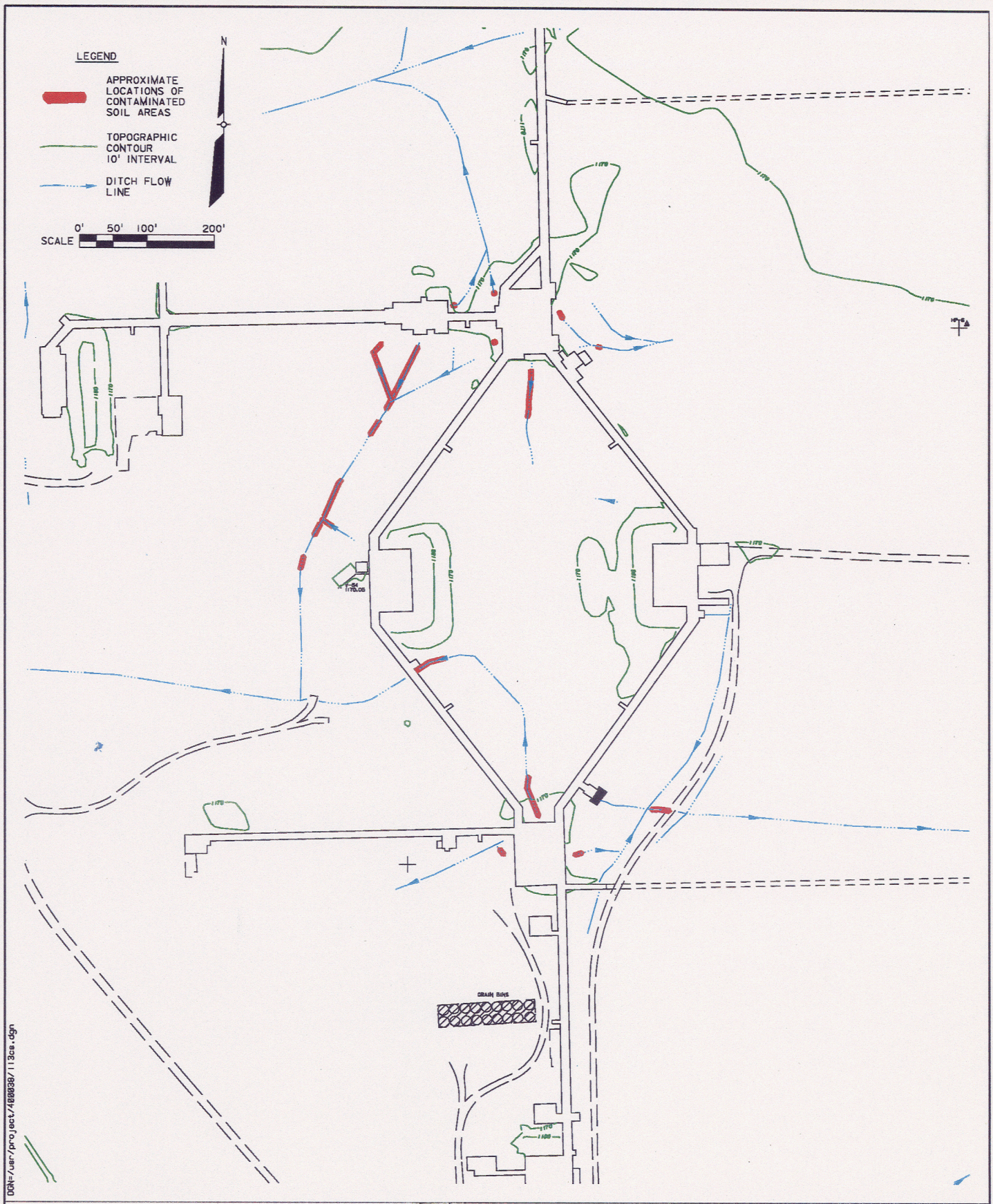
MARCH 1994

19536

FIGURE 2-2
LOAD LINE 2 - CONTAMINATED SOIL

FINAL FEASIBILITY STUDY - OPERABLE UNIT I
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

/usr/projec 038/113cs.dgn Sep. 6, 1993 10:39:37




RUST ENVIRONMENT & INFRASTRUCTURE

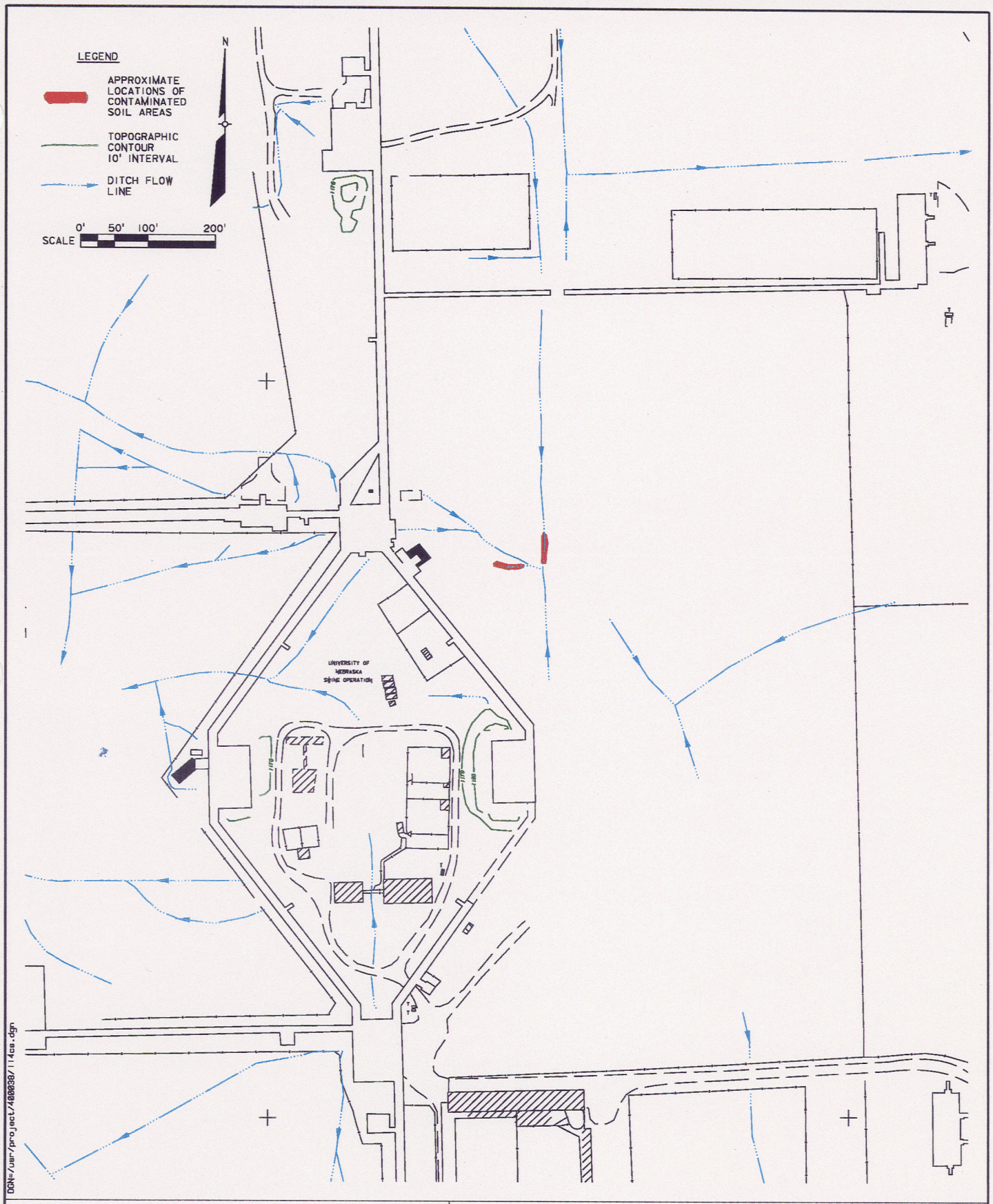
MARCH 1994

19536

FIGURE 2-3
LOAD LINE 3 - CONTAMINATED SOIL

FINAL FEASIBILITY STUDY - OPERABLE UNIT I
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

/usr/project 38/114cs.dgn Sep. 6, 1993 10:41:17




DGN=/usr/project/400038/114cs.dgn

RUST ENVIRONMENT & INFRASTRUCTURE

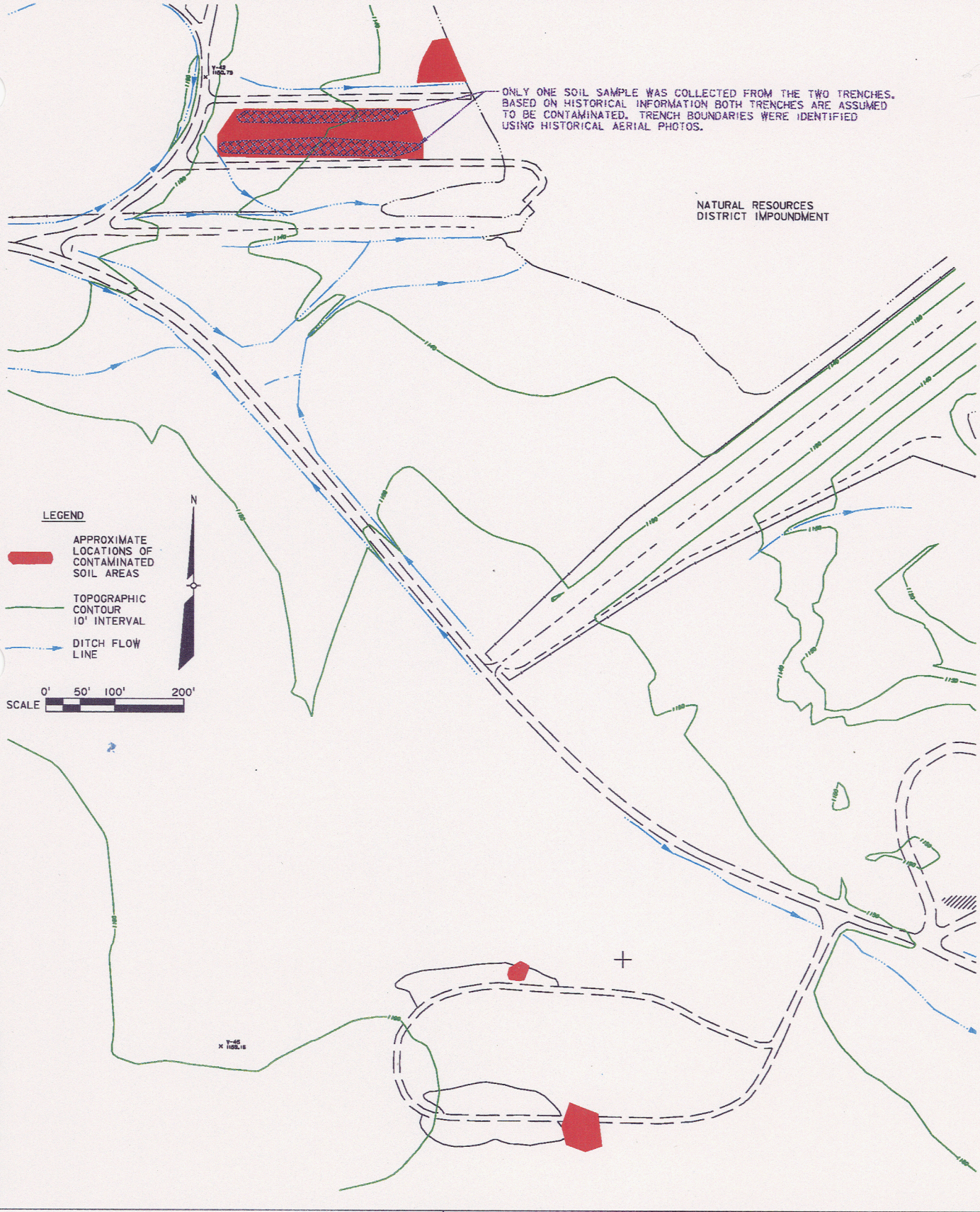
MARCH 1994

19536

FIGURE 2-4
LOAD LINE 4 - CONTAMINATED SOIL

FINAL FEASIBILITY STUDY - OPERABLE UNIT I
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

/usr/project/r00038/bpgcs.dgn Sep. 9, 1993 10:43:39




DGN=/usr/project/400038/bpgcs.dgn

RUST ENVIRONMENT & INFRASTRUCTURE

MARCH 1994

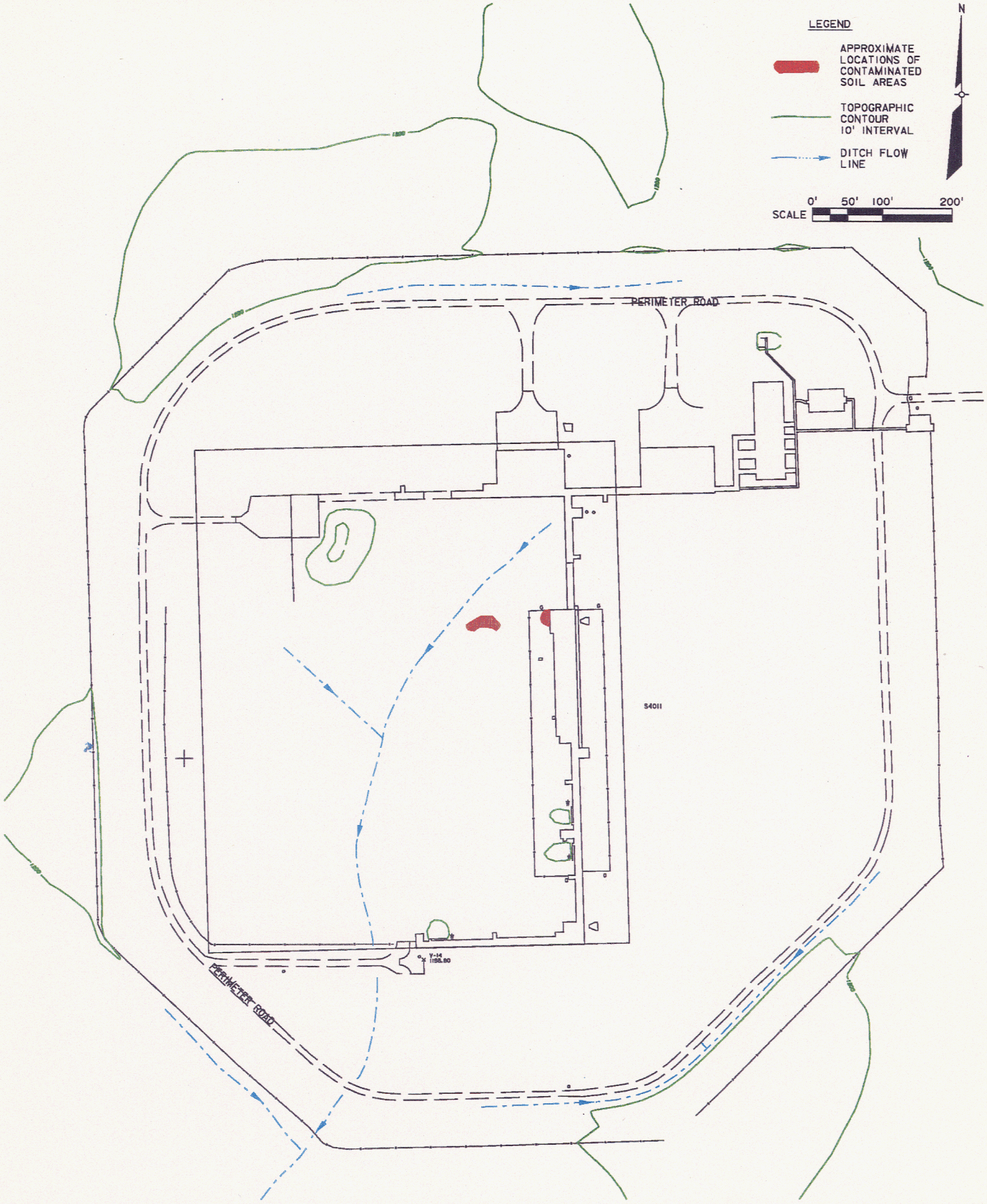
FIGURE 2-5

19536

BURNING / PROVING GROUNDS CONTAMINATED SOIL

FINAL FEASIBILITY STUDY - OPERABLE UNIT I
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

/usr/projec
J38/bbacs.dgn Sep. 6, 1993 10:59:18




DGN=/usr/project/400038/bbacs.dgn

MARCH 1994

RUST ENVIRONMENT & INFRASTRUCTURE

FIGURE 2-6

19536

BOMB BOOSTER ASSEMBLY AREA
CONTAMINATED SOIL

FINAL FEASIBILITY STUDY - OPERABLE UNIT I
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

- Trenches in the Burning/Proving Grounds are delineated based on historical information (TCT, 1991). The trench area is assumed to be excavated whether or not the one sample collected in this area is above the PRGs.

Table 2-8 shows the estimated contaminated areas and volume by major area. Appendix C-2 describes the procedures used to calculate contaminated areas and volumes in detail.

For the purpose of this document, volume calculations rely heavily upon samples having laboratory data and less strongly upon samples having field-screen data only. One-hundred-two sample points exist which have positive field-screen data but no laboratory data. The purpose of the field-screen test is to indicate whether TNT and RDX are present or absent; however, the field-screen data may not be of sufficient quality on which to base remediation decisions. In particular, the field-screen procedure demonstrated false positive results probably due to nitrates in the soil from manure or other fertilizers. In addition, the field-screen does not include all explosive contaminants analyzed by the laboratory method. Before remediation, additional samples may be collected for laboratory analysis at locations where field-screen testing detected explosives to further define the volume of soil requiring remedial action. Additional sampling and analysis requirements will be evaluated during the pre-design phase of the Remedial Design for OU 1.

## 2.4 DEVELOPMENT OF GENERAL RESPONSE ACTIONS AND IDENTIFICATION OF POTENTIAL REMEDIAL TECHNOLOGIES

GRAs are defined as actions which may satisfy RAOs and which characterize the range of remedial responses appropriate to each medium of concern at a site (USEPA, 1988). GRAs for OU 1 of the former NOP site were developed based on RAOs established in the previous section, and other site-specific characteristics.

GRAs for OU 1 include no action, institutional action, containment, removal, treatment, disposal, residuals management, and debris removal. These actions are presented and described in Table 2-9. A no action response must be carried through the FS process for comparative purposes as required by the NCP.

Several potentially applicable remedial technologies and specific technology- based process options were identified based on the GRAs. These technologies and process options were identified based on past experience and comprehensive literature and database reviews. Table 2-10 presents these remedial technologies and process options.

**TABLE 2-8**

**ESTIMATED AREA AND VOLUME OF CONTAMINATED SOIL**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Subsite | Area (sf) | Volume (cy) |
|---|---|---|
| Load Line 1 | 13,000 | 1,900 |
| Load Line 2 | 11,000 | 1,600 |
| Load Line 3 | 4,500 | 670 |
| Load Line 4 | 600 | 91 |
| Burning/Proving Ground | 27,000 | 4,000 |
| Bomb Booster Area | 900 | 130 |
| TOTAL | 57,000 | 8,400 |

RP/MEADFS/AB1

**TABLE 2-9**

**SUMMARY OF GENERAL RESPONSE ACTIONS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| General Response Action | Description |
|---|---|
| No Action | No site work other than monitoring would be performed. This GRA is required to be addressed in the FS by the National Contingency Plan (NCP). |
| Institutional Actions | Institutional actions could include legal restrictions to control future land use, physical access restrictions to contaminated areas, and long-term monitoring (including installation and/or abandonment of monitoring wells). |
| Containment Actions | Containment could consist of surface capping and/or subsurface vertical barriers around hot spots. |
| Removal Actions | Removal actions could include excavation/consolidation used in connection with containment, treatment, or disposal actions. |
| Treatment Actions | Treatment actions could consist of in-situ, on-site, or off-site treatment of soils. This would include thermal, physical/chemical, biological, solidification/stabilization, or off-site treatment. |
| Disposal Actions | Soils could be disposed of in an off-site or on-site secure landfill. |
| Residuals Treatment Actions | Residuals treatment could consist of treatment of any sidestreams, end products, and spent contaminated materials resulting from in-situ and on-site remediation. This could include on-site or off-site containment/treatment/disposal. |
| Debris Removal Actions | Debris removal could consist of removing surface and sub-surface debris followed by decontamination, separation from soil and decontamination, or management with soil. Debris not managed with soil could be disposed of on-site or off-site. |

RP/MEADFS/AB1

**TABLE 2-10**

**REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| General Response Action | Remedial Technology | Process Option |
|---|---|---|
| No Action | None | Not Applicable |
| Institutional Actions | Monitoring | Groundwater Monitoring |
| | Access Restrictions | Deed Restrictions<br>Fencing |
| Containment Actions | Vertical Barriers | Slurry Trench Wall<br>Deep Soil Mixing<br>Vibrated Beam Technique |
| | Capping | RCRA Cap<br>Soil Cap |
| Removal Actions | Excavation | Excavation<br>Consolidation |
| Treatment Actions | Thermal Treatment | Rotary Kiln Incineration<br>Infrared Thermal Treatment<br>Circulating Fluidized Bed Combustion<br>In-Situ Heating<br>Plasma Reactor<br>Above-Ground Vitrification<br>In-Situ Vitrification<br>Low-Temperature Thermal Desorption<br>Off-Site Thermal Treatment |
| | Physical/Chemical Treatment | In-Situ Vacuum Extraction<br>In-Situ Steam Extraction<br>Solvent Extraction<br>Supercritical Extraction<br>Oxidation/Hydrolysis/Photolysis<br>Soil Washing<br>In-Situ Soil Flushing |

**TABLE 2-10**

**REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| General Response Action | Remedial Technology | Process Option |
|---|---|---|
| Treatment Actions (continued) | Biological Treatment | Composting<br>Slurry-Based Biological Treatment<br>In-Situ Biological Treatment |
| | Solidification/ Stabilization | Above-Ground Stabilization<br>In-Situ Stabilization |
| Disposal Actions | Land Disposal | Off-Site Secure Landfill<br>On-Site Secure Landfill |
| Residuals Management Actions | Water Treatment | Publicly-Owned Treatment Works<br>On-Site Treatment and Discharge |
| | Solids Treatment | Treatment and Disposal |
| Debris Removal Actions | Removal | Removal/Separation/ Disposal/Management with Soil |
| Groundwater Treatment | Treatment | Groundwater Treatment at Point-of-Domestic Use |

RP/MEADFS/AB1

## 2.5 SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

### 2.5.1 Introduction

This section presents the two-step evaluation of remedial technologies and process options identified in Section 2.4. This screening identifies technologies and process options that may be appropriate to use at the former NOP site and eliminates remedial technologies and process options that are not appropriate. Specific contaminant concentrations and distribution, soil type, site layout, site use, topography, and other site conditions can affect the ability of remedial technologies and process options to achieve RAOs. Site and waste characteristics, therefore, are taken into consideration during this evaluation.

### 2.5.2 Evaluation Procedures

The two steps in the USEPA evaluation process are:

1. Technical feasibility screening.
2. Effectiveness, implementability, and cost screening.

The technical feasibility evaluation focuses on whether or not the waste characteristics and site conditions preclude the use of a process option (or an entire remedial technology). This evaluation addresses the ability to construct, reliably operate, and meet technology-specific regulatory requirements for process options until RAOs are achieved. After this screening, the remaining remedial technologies and process options should be potentially applicable to OU 1.

The purpose of the second screening evaluation is to reduce the number of process options which will be used to formulate remedial alternatives in Chapter 3. To achieve the goal of minimizing the number of process options, a single process option (or more, if appropriate) may be selected to represent a remedial technology (USEPA, 1988). The elimination of other process options in this screening is not necessarily an indication of the lack of performance or suitability of eliminated process options.

The second screening evaluation focuses on the effectiveness, implementability, and cost of remedial technologies and process options. The primary criterion is effectiveness (USEPA 1988), which consists of the following elements:

- Ability of process options to manage the estimated area or volume.
- Ability of process options to achieve RAOs.
- Short-term impacts to human health and the environment during construction and implementation.

- How proven and reliable the process option is with respect to waste and site characteristics.

A secondary criterion in this evaluation is the implementability of remedial technologies and process options. Implementability includes:

- Ability to obtain agency approval and permits.
- Availability (including capacity) of treatment, storage, and disposal services.
- Availability of necessary equipment and skilled workers.

The third criterion in this evaluation is cost. The NCP states "Alternatives providing effectiveness and implementability similar to that of another alternative by employing a similar method of treatment or engineering control, but at a greater cost, may be eliminated" (40 CFR 300.430(e)(iii)). At this stage, costs are preliminary and relative and may be based on Treatability Studies, similar sites, engineering judgment, general costing guides or technical papers. These costs are not complete and are used only for screening purposes only. These relative costs are used only to screen out process options within a remedial technology. An order-of-magnitude only difference in cost among process options within a technology is assumed to be sufficient for elimination.

Because few explosives sites have been remediated to date, and literature is limited, vendors with and without explosives-contaminated soil remediation experience were contacted for technical information on process options to determine potential applications of process options. Appendix D presents Vendor Information Summaries.

### 2.5.3 Results of Initial Screening Evaluation

Figure 2-7 summarizes the initial screening evaluation and indicates which remedial technologies and process options are retained for further evaluation. Appendix E presents further discussion of the rationale for eliminating remedial technologies and process options.

### 2.5.4 Results of Secondary Screening Evaluation

Figure 2-8 summarizes the evaluation of technologies and process options and indicates which are retained for development into alternatives in Chapter 3. Technologies and process options were screened on the basis of effectiveness, implementability, and cost. A description of the remedial technologies and related process options and the rationale for eliminating or retaining each are provided below.

Fi  E 2-7

# INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
## Former NOP Site
## Mead, Nebraska
## March 1994

| General Response Actions | Remedial Technologies | Process Options | Descriptions | Technical Feasibility Screening Comments |
|---|---|---|---|---|
| No Action | None | Not Applicable | No Action. | Required by the National Contingency Plan. |
| Institutional Actions | Monitoring | Groundwater Monitoring | Institute groundwater monitoring program. | Potentially applicable. |
| | Access Restrictions | Deed Restrictions | Institute deed restrictions on land use for contaminated properties. | Potentially applicable. |
| | | Fencing | Fence contaminated areas. | Potentially applicable. |
| Containment Actions | Vertical Barriers | Slurry Trench Wall | Vertical subsurface barriers constructed with a slurry, sometimes in combination with extraction wells. | Not suitable for shallow isolated hot spots. Requires a bottom surface (hydraulic barrier) to key into. No hydraulic barrier is present at the NOP. |
| | | Deep Soil Mixing | Vertical subsurface barrier constructed in-situ using stabilizing agents and intensive mixing. | Not suitable for shallow isolated hot spots. Requires a bottom surface (hydraulic barrier) to key into. No hydraulic barrier is present at the NOP. |
| | | Vibrated Beam Technique | Vertical subsurface barrier constructed by injecting slurry into a narrow space created by a steel beam driven into the ground by vibrating force. | Not suitable for shallow isolated hot spots. Requires a bottom surface (hydraulic barrier) to key into. No hydraulic barrier is present at the NOP. |
| | Capping | RCRA Cap | Cap that conforms to RCRA design criteria to minimize infiltration of precipitation and reduce potential for receptor-waste contact. | Potentially applicable. |
| | | Soil Cap | Cap covering waste materials to minimize infiltration of precipitation and reduce potential for receptor-waste contact. | Potentially applicable. |
| Removal Actions | Excavation | Excavation | Soil removal using standard earthwork equipment, shoring, and common construction practices. | Potentially applicable. |
| | | Consolidation | Stockpiling and sampling contaminated soil near excavated areas or in a single centralized area prior to containment or treatment actions. | Potentially applicable. |

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Potentially applicable technology.

Eliminated from further consideration.

## FIGURE 2-7
## INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
**Former NOP Site**
**Mead, Nebraska**
**March 1994**

| General Response Actions | Remedial Technologies | Process Options | Descriptions | Technical Feasibility Screening Comments |
|---|---|---|---|---|
| Treatment Actions | Thermal Treatment | Rotary Kiln Incineration | A cylindrical, refractory-lined shell with a slightly inclined axis that rotates to provide mixing of wastes and combustion air while heating wastes to combustion temperatures. Combustibles are incinerated in an afterburner. | Potentially applicable. |
| | | Infrared Thermal Treatment | Electrically powered silicon carbide rods heat the organic waste to combustion temperatures. Combustibles are incinerated in an afterburner. | Little demonstrated success in destruction of organic compounds. |
| | | Circulating Fluidized Bed Combustion | A fluidized bed incinerator with a higher airflow velocity and higher combustion efficiencies than a conventional fluidized bed. Combustibles are incinerated in an afterburner. | Potentially applicable. |
| | | In-Situ Heating | Contaminants are decomposed, vaporized, and distilled by heating soil in-situ with radio frequency waves or electrical energy. | Not appropriate due to high boiling points and low vapor pressures of contaminants at the site. Not appropriate due to widespread shallow waste distribution. |
| | | Plasma Reactor | A plasma torch heats waste, creating a molten bath, vaporizing organic contaminants, and retaining metals in the molten phase. This is not an in-situ process. | Potentially applicable. |
| | | Vitrification | Hazardous waste is consolidated above-ground or left in place and heated with electrodes to reduce organic compounds to elemental gas and carbon under anoxic conditions. Inorganic contaminants remain entrained in the glass and siliceous melts. | Potentially applicable. |
| | | Low-Temperature Thermal Desorption | A transfer process that uses air, heat, and/or mechanical agitation to volatilize contaminants into a gas stream, where the contaminants are treated further. | Potentially applicable. |
| | | Off-Site Thermal Treatment | Transportation of contaminated soils to a permitted, off-site thermal treatment facility | Potentially applicable. |
| | Physical/Chemical Treatment | In-Situ Vacuum Extraction | Volatile organic compound (VOCs) are extracted in-place by air stripping the soils using production wells, monitoring wells, and high-vacuum pumps. May be used in conjunction with surface cover and air injection systems. May use injection of heated air and/or more closely spaced wells to remove some low-volatility organic compounds. | Not appropriate at the site due to contaminants with low vapor pressures and soil with high clay content. |
| | | In-Situ Steam Extraction | Injects steam via augers into in-place soil to remove VOCs and possibly some semi-volatile organic compounds. | Not appropriate at the site due to contaminants with low vapor pressures and soil with high clay content. |
| | | Solvent Extraction | Uses solvents to extract organic compounds from the waste matrix, causing a volume reduction in hazardous materials. | Potentially applicable. |

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Potentially applicable technology.

Eliminated from further consideration.

F 2-7

# INITIAL SCREENING OF TEC. OGIES AND PROCESS OPTIONS

**Former NOP Site**
**Mead, Nebraska**
**March 1994**

| General Response Actions | Remedial Technologies | Process Options | Descriptions | Technical Feasibility Screening Comments |
|---|---|---|---|---|
| Treatment Actions (Continued) | Physical/Chemical Treatment (cont'd) | Supercritical Extraction | Liquified gases near their critical conditions used as solvents to remove organic compounds from waste matrices. | Potentially applicable. |
| | | Oxidation/Hydrolysis/ Photolysis | One or more mutually enhancing types of processes that use an oxidizing agent (usually hydrogen peroxide or ozone), water, and/or UV light to decompose organic compounds. | Potentially applicable. |
| | | Soil Washing | Contaminants are removed from soil using a washing fluid with appropriate surfactants. Highly contaminated fine materials are removed from coarse sands. | Not appropriate for the high clay content soil at NOP nor for the contaminants due to low mass transfer rates to water. |
| | | In-Situ Soil Flushing | Contaminants are washed from in-place sludges or soil using a groundwater extraction/reinjection system. | Not suitable for the low-permeability soil at NOP. |
| | Biological Treatment | Composting | Degradation of organic compounds in soil using micro-organisms and compost amendments. | Potentially applicable. |
| | | Slurry-Based Biological Treatment | Aerobic or anaerobic biological treatment of soil in a water-based slurry. Treatment may be accomplished in tanks or lined pits, with addition of amendments. | Potentially applicable. |
| | | In-Situ Biological Treatment | Degradation of organic compounds using micro-organisms in the subsurface. | Not appropriate for high-clay-content soil with very low permeability. |

14.I.MEAD.ISAD.(FROH)5.92

Potentially applicable technology.

Eliminated from further consideration.

## FIGURE 2-7
## INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
**Former NOP Site**
**Mead, Nebraska**
**March 1994**

| General Response Actions | Remedial Technologies | Process Options | Descriptions | Technical Feasibility Screening Comments |
|---|---|---|---|---|
| Treatment Actions (continued) | Solidification/ Stabilization | Above-Ground Stabilization | Excavated contaminated soil is mixed with stabilizing agents and other additives above ground to immobilize contaminants within soil matrix. | Not demonstrated effective in immobilizing organic compounds. |
| | | In-Situ Stabilization | Stabilizing agents are injected into contaminated soil using a series of hollow vertical augers or modified wheel-mounted scrapers to immobilize contaminants within soil matrix. | Not demonstrated effective in immobilizing organic compounds. |
| Disposal Actions | Land Disposal | Off-Site Secure Landfill | Excavated contaminated soil disposed of in an off-site secure landfill. | Potentially applicable. |
| | | On-Site Secure Landfill | Excavated contaminated soil disposed of in an on-site secure landfill. | Potentially applicable. |
| Residuals Management Actions | Water Treatment | Publicly-Owned Treatment Works (POTW) | Physical/biological treatment of wastewater. | Potentially applicable. |
| | | On-Site Treatment and Discharge | Secondary aqueous waste streams from soil treatment are treated separately, treated effluent discharged to Johnson Creek or uncontaminated drainage ditches. | Potentially applicable. |
| | | Off-Site Treatment and Discharge | Secondary aqueous waste streams are hauled to an off-site facility for treatment and discharge | Potentially applicable. |
| | Solids Treatment | Treatment and Disposal | Solid residuals from on-site treatment (none associated with on-site capping and landfilling) are treated (if necessary), either on-site or off-site, using one or more subsequent processes (e.g., centrifugation, neutralization, solidification/stabilization) and backfilled with treated soil on-site. | Potentially applicable. |
| Debris Removal Actions | Removal | Removal/Separation/ Decontamination/Disposal | Surface and subsurface debris such as concrete, brick, boulders, wood, metal, plastic, and glass are removed from the surface or separated from excavated soil, and decontaminated, if necessary, and disposed of. | Potentially applicable. |
| Groundwater Treatment | Treatment | Treatment at Point of Use | Treatment of groundwater used for household (drinking, washing) purposes. | Potentially applicable. |

Potentially applicable technology.

Eliminated from further consideration.

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## Fi. ..E 2–8
## EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS
**Former NOP Site**
**Mead, Nebraska**
**March 1994**

| General Response Actions | Remedial Technologies | Process Options | Effectiveness | Implementability | Cost (a) |
|---|---|---|---|---|---|
| No Action | None | Not Applicable | Not Applicable. | Not Applicable. | None |
| Institutional Actions | Monitoring | Groundwater Monitoring | Does not achieve RAOs, but is an effective indicator of migration if contaminants remain. On-site landfill and cap options require groundwater monitoring. | Implementable. | Low |
| | Access Restrictions | Deed Restrictions | May achieve RAOs by preventing certain types of site use, but effectiveness is questionable due to implementation concerns. Deed restrictions are historically not reliable in preventing access because they are not always enforced. On-site landfill and cap options require deed restrictions. | Difficult to assure long-term compliance because local government typically must enforce deed restrictions. | Low |
| | | Fencing | Individual areas are not amenable to effective fencing. Does not prevent contaminant migration or attain PRGs. Access is limited, but not prevented. Retained only in conjunction with soil consolidation. | Agency approval of several small fenced areas is unlikely, due to future site use by University of Nebraska. Approval in conjunction with consolidation is likely. | Low |
| Containment Actions | Capping | RCRA Cap | Effective in preventing exposure to contaminated soils; however, long-term integrity of cap is of concern. Not required because NOP soil is not RCRA hazardous waste. | Implementable. Requires perpetual monitoring and deed restrictions on future use. | Low |
| | | Soil Cap | Effective in preventing dermal contact, inhalation and ingestion of contaminated soil; however, long-term integrity of cap is of concern. | Implementable. Requires perpetual monitoring and restricted future use. | Low |
| Removal Actions | Excavation | Excavation | Effective for removal of contaminant source. Migration potential is eliminated after source is removed. | Implementable with standard construction equipment. | Low |
| | | Consolidation | Facilitates implementation of containment and treatment actions. | Implementable with standard construction equipment. | Low |

14.I.MEAD.ISAD.(FROH)5.92

Potentially applicable technology.

Eliminated from further consideration.

(a) Low Cost = $20 – $70 / cubic yard
Moderate Cost = $70 – $200 / cubic yard
High Cost = > $200 / cubic yard

Note: These cost ranges include only direct costs and were estimated based on vendor information.

F, ε 2–8
**EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS**
**Former NOP Site**
**Mead, Nebraska**
**March 1994**

| General Response Actions | Remedial Technologies | Process Options | Effectiveness | Implementability | Cost (a) |
|---|---|---|---|---|---|
| Treatment Actions | Thermal Treatment | Rotary Kiln Incineration | Extensive full-scale demonstrated success, including explosives treatment. | Full-scale units commercially available from many vendors. Residuals may require further treatment/disposal. | High |
| | | Circulating Fluidized Bed Combustion | May achieve complete destruction of organic compounds. No demonstrated success with explosives. | No known commercial service provider available. Residuals may require further treatment/disposal. | High |
| | | Plasma Reactor | May achieve complete destruction of organic compounds. No demonstrated success with explosives. | Not available through a service-provider in the United States. Requires long lead-time to ensure service provider availability. Residuals may require further treatment/disposal. | High |
| | | Vitrification | Immobilizes both organic and inorganic contaminants in a stable vitreous solid. Achieves mineralization of organic compounds. No demonstrated success with explosives. | Available from a limited number of vendors. Energy intensive. Would require a treatability study. | High |
| | | Low-Temperature Thermal Desorption | Some vendors claim explosives may be removed. Effectiveness uncertain due to waste and soil type. | Would require treatability studies. Easily implemented. Residuals may require further treatment/disposal. | Moderate to High |
| | | Off-Site Thermal Treatment | Proven effective in destruction of organic contaminants. | Implementability depends on available capacity. Residuals may require further treatment/disposal. | High |

14.I.MEAD.ISAD.(FROH)5.92

Potentially applicable technology.

Eliminated from further consideration.

(a) Low Cost = $20 - $70 / cubic yard
Moderate Cost = $70 - $200 / cubic yard
High Cost = > $200 / cubic yard

Note: These cost ranges include only direct costs and were estimated based on vendor information.

F. E 2-8

# EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS

**Former NOP Site**
**Mead, Nebraska**
**March 1994**

| General Response Actions | Remedial Technologies | Process Options | Effectiveness | Implementability | Cost (a) |
|---|---|---|---|---|---|
| Treatment Actions (continued) | Physical/Chemical Treatment | Solvent Extraction | No demonstrated effectiveness with contaminants of concern. High clay content of soil increases cycle time and makeup solvent loading. | Commercially available from several vendors. Would require treatability studies and further treatment of concentrated contaminants. No advantage over thermal desorption. | High |
| | | Supercritical Extraction | No demonstrated effectiveness with contaminants of concern. High clay content of soil poses problems. | Would require treatability studies and further treatment of concentrated contaminants. No advantage over thermal desorption. | High |
| | | Oxidation/Hydrolysis/ Photoysis | No demonstrated effectiveness with contaminants of concern. High clay content of soils may pose problems of oxidant/contaminant contact. | Would require treatability studies. Requires water addition to form slurry and subsequent dewatering. Difficulty in handling chemical oxidants. | High |
| | Biological Treatment | Composting | There is evidence of detoxification and polymerization, but incomplete mineralization. | Commercially available from several vendors. Treatability study and process scale-up required before implementation. | Moderate |
| | | Slurry-Based Biological Treatment | Laboratory studies have shown high level of detoxification at fairly rapid rates (30 days). | Commercially available from several vendors. Treatability study and process scale-up required prior to implementation. | Moderate to High |

14.I.MEAD.ISAD.(FROH)5.92

Potentially applicable technology.

Eliminated from further consideration.

(a) Low Cost = $20 - $70 / cubic yard
Moderate Cost = $70 - $200 / cubic yard
High Cost = > $200 / cubic yard

Note: These cost ranges include only direct costs and were estimated based on vendor information.

## Fi. .E 2-8
## EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS
**Former NOP Site**
**Mead, Nebraska**
**March 1994**

| General Response Actions | Remedial Technologies | Process Options | Effectiveness | Implementability | Cost (a) |
|---|---|---|---|---|---|
| Disposal | Land Disposal | Off-Site Secure Landfill | Provides effective site remediation, but moves wastes to another location. The effectiveness of long-term containment depends on the management of the disposal facility. | Because wastes are non-hazardous, easily implemented in Subtitle D facility. | Low to High |
| | | On-Site Secure Landfill | Effectiveness of long-term containment would depend on long-term facility management. | Materials and services for landfill construction are readily available. Future site use is restricted in the area of the landfill; University of Nebraska agreement would be considered. | Low |
| Residuals Management Actions | Water Treatment | Publicly-Owned Treatment Works (POTW) | May provide effective treatment of residual process water from soil treatment technology. | Existing POTWs will not accept effluent from remedial activities at the NOP site. | Low |
| | | On-Site Treatment and Discharge | Effectiveness varies with processes. Generally, reliable processes are utilized for secondary waste streams. | Technically implementable. Agency review is required for discharge of treated effluent. | Low |
| | | Off-Site Treatment and Discharge | Effectiveness varies with processes. Generally, reliable processes are utilized for secondary waste streams. | Technically implementable. | Low |
| | Solids Treatment | Treatment and Disposal | Effectiveness varies with processes. Generally, reliable processes are utilized for secondary waste streams. | Technically implementable. Agency approval for backfilling with treated soil on-site is required. | |
| Debris Removal Actions | Removal | Removal/Separation/ Disposal | Removal, separation, and disposal actions would be very effective in managing site debris; because contaminated soil is non-hazardous, debris decontamination may not be necessary. Very large debris (concrete troughs, escape chutes, etc.) may require size reduction prior to disposal. | Technically implementable by standard construction techniques. | Low |
| Groundwater Treatment | Treatment | Treatment at Point of Use | Effective in reducing risk from household use of contaminated groundwater. | Technically implementable. | Low |

14.I.MEAD.ISAD.(FROH)5.92

Potentially applicable technology.

Eliminated from further consideration.

(a) Low Cost = $20 - $70 / cubic yard
Moderate Cost = $70 - $200 / cubic yard
High Cost = > $200 / cubic yard

Note: These cost ranges include only direct costs and were estimated based on vendor information.

#### 2.5.4.1 No Action

The no action response is not a technology, but is required under the NCP as a baseline against which other remedial alternatives may be compared. Under no action, contaminated soil would be left undisturbed. The long-term human health and environmental risks would be the same baseline risk that exists if no remedial activity takes place. The no action response does not achieve RAOs at the NOP site, but is retained as required by the NCP.

#### 2.5.4.2 Institutional Actions

Institutional actions are monitoring or restrictions imposed on access to property or uses of property. The restrictions are imposed by legal instrument (e.g., laws, regulations, owner-imposed restrictive covenants in deeds, etc.). Institutional actions are proposed to monitor or reduce risk related to exposure to contaminated soil.

**Groundwater Monitoring**

This option does not achieve RAOs. Groundwater monitoring is retained for technologies that leave explosives-contaminated soil on-site at concentrations above the PRGs to monitor for failure. Further evaluation of groundwater contamination will be performed in the RI/FS for OU 2 of the former NOP site. Groundwater monitoring can be used to evaluate the effectiveness of a cap or landfill, and it is easily implemented. This process option is retained for use in conjunction with on-site containment technologies.

**Deed Restrictions**

Deed restrictions may be used to restrict such activities as drinking water well placement, property sale, and changes of property use. As with groundwater monitoring, deed restrictions would only be considered in conjunction with technologies that leave explosives-contaminated soil on-site at concentrations above PRGs (e.g., containment technologies). Deed restrictions may be a reliable means of preventing some types of exposure, but effectiveness is dependent on enforcement. Restrictions are therefore not generally considered reliable by themselves. USACE may be required to purchase land in order to implement and enforce deed restrictions. Costs are low, but require considerable effort to quantify (USEPA 1991i). This process option is retained for use in conjunction with on-site containment technologies.

**Fencing**

Access to contaminated soil at the former NOP site could be limited by installing fences around contaminated areas. The contaminated area is broken up into a number of isolated hot spots. Many of these hot spots are former drainage ditches which have large perimeters compared to their areas. The erection of a large number of fences, each enclosing a relatively small area, is not compatible with the present agricultural use of the

site. There are also multiple owners of on-site land, and this may make fencing of hot spots impractical. Therefore, this process option is retained only as part of an alternative in which explosives-contaminated soil is consolidated on-site at concentrations above PRGs (e.g. containment).

#### 2.5.4.3 Containment Actions - Capping

The distribution of contamination at the NOP site is in a number of isolated areas, as discussed previously, and contaminated soil is proposed to be consolidated before the cap is constructed. Consolidation is discussed in more detail in Section 2.5.4.4. If contaminated soil is not consolidated, the construction of several small caps would not be practical due to inefficiency in construction and difficulty in implementing cap maintenance and deed restrictions.

**RCRA Cap**

A RCRA cap would cover contaminated material to prevent ingestion, direct contact, and agricultural use of explosives-contaminated soil, and would reduce potential infiltration and migration of contaminants from the contaminated media into the groundwater. A RCRA minimum technology cap would include (from top to bottom) a 24-inch soil cap, 12-inch sand drainage layer, flexible membrane liner, 24-inch clay layer, and 12-inch cover soil.

The primary difference in effectiveness between a RCRA cap and a non-RCRA cap (described below) pertains to the added level of containment afforded by the RCRA cap. As discussed previously, contaminated soil from the NOP site is unlikely to be a RCRA hazardous waste. For this reason, a RCRA cap is not necessary. The RCRA cap option is not retained for further evaluation.

**Soil Cap**

A soil cap would also be used to cover contaminated material to prevent ingestion, direct contact, and agricultural use of contaminated soil, and to reduce infiltration and migration of contaminants from the contaminated soil into the groundwater. One feasible cap option consists of a 6-inch vegetated soil layer underlain by a 12-inch soil layer, and a 2-foot low-permeability compacted clay layer. The soil cap process option is retained in combination with excavation and consolidation of the contaminated soil, deed restrictions, and groundwater monitoring.

#### 2.5.4.4 Removal Actions

**Excavation**

Contaminated soil from contaminant hot spots would be primarily removed using standard excavation equipment. Contamination at depth may require the use of shoring or sideslopes to effectively implement the excavation. This contaminated soil could then be

consolidated, and contained, disposed of or treated. Excavation is required as part of alternatives which include containment, treatment, and/or disposal options and is, therefore, retained for further evaluation.

**Consolidation**

Consolidation of excavated material will be necessary in optimizing containment or treatment processes. Consolidating contaminated material in one location would allow for more efficiency in cap construction and maintenance and minimize treatment process mobilization/demobilization. Furthermore, blending to obtain consistent contaminant concentrations and physical characteristics may be beneficial for some treatment processes. For containment options, consolidation areas would allow for one containment structure, as opposed to a separate containment structure for each source area or group of nearby source areas. For these reasons, consolidation is retained for further consideration.

### 2.5.4.5 Treatment Actions - Thermal Treatment

**Rotary Kiln Incineration**

The rotary kiln incinerator is a cylindrical refractory-lined shell mounted on a slight incline and in a manner such that it can be slowly rotated. Wastes and fuels are introduced into the high end of the kiln. The kiln's rotation constantly agitates the material to expose the solids to oxygen and to improve heat transfer. Because the solids are agitated, particulates entrained in the gas stream require post-combustion control. Ash residues from the combustion process are discharged and collected at the low end of the kiln. Exhaust gases typically pass to a secondary combustion chamber or afterburner for further oxidation. These gases usually require acid gas or particulate removal. The ash and the aqueous pollution control process residues from the incinerator may require further treatment (e.g. solidification) prior to disposal.

Rotary kilns have successfully destroyed refractory compounds at destruction and removal efficiencies (DRE) in excess of 99.9999 percent. DRE is a measure of the effectiveness of removal of a particular contaminant. It is calculated using the following formula (40 CFR Part 264):

$$DRE = \frac{Win - Wout}{Win} \times 100\%$$

Where Win = mass feed rate of the contaminant in the input stream

Wout = mass emission rate of the contaminant in the exhaust

Rotary kilns can process solid particle sizes of up to 2 to 4 inches. Rotary kiln incineration has demonstrated performance in destroying explosives in soil (IT 1987a, 1989). Due to the destruction of contaminants, no long-term management is associated with rotary kiln

treatment. The availability of many commercial vendors who use rotary kilns makes this process option readily implementable. Large quantities (10 percent of treated volume) of fly ash are expected due to the high clay content of the soil (Chemical Waste Management, 1992c). However, service providers contacted consider this to be an operational factor which can be addressed through proper system design and operational control. This process option is retained for further consideration.

**Circulating Fluidized Bed Combustion**

The circulating fluidized bed combustor (CBC) is a thermal treatment process which uses a highly turbulent combustion loop consisting of a combustion chamber, a hot cyclone, and a solids return. This combustion loop improves the heat transfer to the waste stream. The combustion chamber contains a bed of inert granular materials made turbulent with high velocity air. For treatment of contaminated soils, the CBC uses the soil matrix as the bed material. Solids greater than 1 inch in diameter must be reduced in size by shredding, crushing, or grinding prior to treatment.

Similar to the rotary kiln process discussed above, CBC is a potentially effective technology for treating the contaminated soil source areas. Full-scale testing has demonstrated DREs greater than 99.99 percent for some organic compounds (USEPA, 1991b). Due to the destruction of contaminants, no long-term management is associated with CBC treatment. However, CBC has not been used for explosive compounds; therefore, a treatability study would be necessary. There are currently no known CBC commercial service providers (Ogden, 1992). Therefore, the process option is not retained for further consideration.

**Plasma Reactor**

Plasma reactor technology (also called plasma centrifugal furnace and pyrolysis) is an ex-situ process which uses the heat generated from a plasma torch to stabilize or decontaminate metal- and organic-contaminated wastes by melting metal-bearing solids and thermally destroying organic contaminants. The process forms a hard, glass-like non-leachable mass on cooling. Major components of the process are the plasma torch, rotating reactor well, afterburner, secondary combustion chamber, and off-gas treatment system. The process operates at temperatures on the order of 3,000 degrees Fahrenheit. At this temperature, organic contamination is volatilized from the soil and oxidized or mineralized under anoxic conditions. The plasma reactor technology is an energy-intensive and costly method of thermally destroying organic compounds compared to other thermal processes. Additionally, no plasma reactor service providers are established in the United States, making implementability difficult due to long lead-times associated with securing a service provider (Retech, 1992). The plasma reactor is not retained for further evaluation.

### Vitrification

Vitrification of wastes involves electrical melting of contaminated solids to destroy, remove, and/or immobilize contaminants. Soils are either consolidated into piles (above-ground) or left in-place (in-situ), and electrodes are placed in an array in the soil. The electrodes heat the soil to temperatures of 1,600 degrees to 2,000 degrees Celsius to destroy or remove organic contaminants and entrain the inorganic contaminants. The organic constituents are reduced to elemental gas and carbon either within the soil or after removal. Due to the destruction of contaminants, no long-term management is associated with vitrification. Inorganic contaminants remain entrained in a siliceous melt which forms a stable vitreous solid when cooled.

Above-ground vitrification is a modified in-situ technology that relies on the adequate characterization of contaminant concentrations for its ensured success. This process has an organic concentration loading limit of 5 to 10 percent (Geosafe, 1992). Also, vitrification adds heat to soil within the melt area and thus could present a hazard when applied to high concentrations of explosive compounds. The possible presence of detonation hazards and the organic concentration loading limit would make necessary the excavation, consolidation, and blending of site soil. The vitrification process has been implemented at full scale on only a few sites; however, it has been demonstrated for explosives-contaminated soil at the bench scale (Section 1.2.7.3). This process option is retained for further consideration.

### Low-Temperature Thermal Desorption

Two types of low-temperature thermal desorption (LTTD) systems are currently in use. One is directly fired, where heated air is forced countercurrent to soil flow, and the other is indirectly fired, where soil is heated in an oxygen-free atmosphere. Both use rotary shells to ensure uniform heat transfer and to remove volatile and semi-volatile organic compounds at temperatures less than about 1,000 degrees Fahrenheit. Organic compounds are vaporized, then removed from the vapor phase by condensation, carbon adsorption, or combustion. If vapors are condensed, they are separated into organic and aqueous phases by an oil-water separation unit. The gas stream is then discharged through a stack. Process residuals may include processed soil, a condensed organic liquid phase, an aqueous liquid stream, ash from an afterburner, spent carbon, and air emissions.

LTTD systems are generally used to remove volatile and semi-volatile organic compounds from soil. Clayey soil may require longer residence times than looser, larger-grained soils. This reduction of process rate will cause increases in cost (Chemical Waste Management, 1992b). Although this technology was deemed not effective for explosives-contaminated soil at one site in a study conducted for the U.S. Army Toxic and Hazardous Materials Agency (IT, 1987b), several technology vendors interviewed (Chemical Waste Management, 1992a; Canonie, 1992) believed that their process units could treat explosive compounds. These firms recommended the use of an afterburner to treat desorbed organic compounds. This process option is retained for further evaluation.



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**Off-Site Thermal Treatment**

This option would involve excavation of explosives-contaminated soil and transport to a permitted off-site facility for thermal treatment. Estimated costs for this process option are approximately $47,000,000 (Chemical Waste Management, Inc., 1992d) which is significantly greater than for other thermal technology costs. Due to the high cost of this process option, it is not retained for further consideration.

**Thermal Treatment Summary**

Based on the preceding evaluation, thermal treatment technology processes may be effective and implementable for OU 1. Due to the destruction of contaminants, no long-term management is associated with thermal treatment. Moisture, high clay content, and other factors, however, may complicate thermal treatment. The rotary kiln incineration process is the only thermal process option with demonstrated full-scale success in treating explosives-contaminated soil on a commercial scale. However, several of the other evaluated thermal process options have been demonstrated to be as effective as rotary kilns in treating organic (e.g., PCBs) contaminated soil. The other process options, therefore, may be equally effective in treating explosives-contaminated soil. A representative thermal process would be difficult to select because the evaluated process options may differ significantly in operation and/or cost. For these reasons, a particular or representative thermal treatment process option will not be selected for alternatives development. Rotary kiln, vitrification, and LTTD thermal treatment process options will be carried forward to represent a range of potentially effective and implementable thermal process options and will be represented as "thermal treatment". As noted previously, treatability studies or rotary kiln incineration and vitrification have been performed. The cost estimates developed in later sections of this report are based on rotary kiln incineration because information was readily available. Table 2-11 presents a summary of performance data for the retained thermal treatment process options.

### 2.5.4.6 Treatment Actions - Physical/Chemical Treatment

**Solvent Extraction**

Solvent extraction removes organic contaminants from soil by flushing the soil with non-chlorinated solvents. After the contaminants have been transferred to the solvent phase, clean soil is separated from the contaminated solvent. This contaminated solvent is then further treated to remove or destroy contaminants, and the solvent is often recycled. Although the process does not result in destruction of the contaminants, removal of contaminants with significant volume reduction of contaminated media is achieved. Possible solvents include acetone, acetone/water mix, triethylamine, and liquified gases

TABLE 2-11

**PERFORMANCE DATA FOR THERMAL TREATMENT PROCESS OPTIONS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| | Rotary Kiln Incineration | Vitrification | Low-Temperature Thermal Desorption |
|---|---|---|---|
| Volume Change | 0 to 5 percent | 0 to 30 percent | 0 to 3 percent |
| Residuals | Ash, scrubber particulates, water | Vitreous solid | Processed soil, water, afterburner ash |
| Demonstrated for Explosives | Full-scale | Treatability Level | Treatability Level |
| Operating Temperature | 1000 - 1500°F (IT)<br>2200°F (IT - afterburner) | 1600 - 2000°C | <1000°F<br>~2000°F (afterburner) |
| Maximum Particle Size | 2 inches | None | 2 inches |
| Unit Process Cost | 300 $/ton (Thermodynamics Corp)<br>200-300 $/ton (WSI) | 350-400 $/ton (Geosafe) | 140-150 $/ton (CWM)<br>125 $/ton (Canonie) |

Sources: Canonie, 1992.
CWM, 1992.
Geosafe, 1992.
IT, 1987, 1989, 1992.
Thermodynamics Corp., 1992.
Vesta, 1992a.
Weston Services, Inc. (WSI), 1992.

RP/MEADFS/AF6

such as propane or a propane/butane mix. Solvent extraction has been used to treat polychlorinated biphenyls, polynuclear aromatic hydrocarbons, and other volatile and semi-volatile organic compounds.

The advantages of the solvent extraction process are that it is effective at high concentrations, it is applicable to a wide range of organic contaminants, it has been constructed as a portable or transportable unit, and test units have shown potential versatility of either batch or continuous processes.

There are several disadvantages to the process. In particular, Sanivan, Inc. (1992), reports that a clay content of 40 percent or more would limit the treatment effectiveness (USEPA, 1990i). The NOP soils have a silt and clay content of 88 to 100 percent. There is also no documentation of treatment of explosives using this technology. Due to the high clay content of former NOP site soil, this process is eliminated from further evaluation.

**Supercritical Extraction**

The supercritical extraction process is similar to solvent extraction in that contaminants are removed from the soil matrix by a solvent medium. In this case, the solvent medium is a semi-liquified gas under extreme temperature and pressure. The process does not destroy contaminants but transfers them to the solvent matrix, which is then treated in a liquid form. The technology has not been demonstrated for explosive contaminants, and the high clay content of the former NOP soils are expected to hinder the process in the same manner as with solvent extraction. For the same reason as solvent extraction, supercritical extraction is eliminated from further consideration.

**Chemical Oxidation/Hydrolysis/Photolysis**

Heavy metals and organic compounds can be oxidized using chemicals such as ozone, chlorine dioxide, hydrogen peroxide, and Fenton's reagent. For oxidation of contaminants in water, the reaction is often catalyzed with ultraviolet light or ultrasound (USEPA, 1991b). For chemical oxidation of contaminants in soils, a slurry must be formed through the addition of water. A slurry of about 25 percent solids would be required for oxidation of contaminated soil (Exxon, 1992). The efficiency of the process could be impeded by the presence of humic materials in the soil. These naturally-occurring compounds interfere with the complete oxidation of contaminants. Residuals may contain acids or sodium chloride from oxidant formation, residual oxidant, and oxidation by-products. These usually require disposal or further treatment.

Photolysis (destruction of compounds by light energy) has been observed in liquid-phase explosives (Spanggord et al., 1980). However, no information on solid-phase photolysis of explosives was found. As indicated in Table 1-2, very little information is available on the hydrolysis of explosive compounds. Therefore, photolysis and hydrolysis are eliminated from further consideration.

Oxidants are usually formed on-site through electrical and chemical reactions of precursor chemicals. This can be a very expensive process (Exxon, 1992), and handling of these oxidants can be difficult. Oxidants are, by nature, extremely reactive and hazardous materials. Chemical oxidation is eliminated from further consideration due to the expense and difficulty in handling chemical oxidants.

### 2.5.4.7 Treatment Actions - Biological Treatment

**Composting**

Composting is an aerobic biological treatment process in which contaminated soil is mixed with organic amendments such as sewage sludge, vegetable wastes, or animal manure, and bulking agents, such as sawdust, bark, straw, or wood chips, to produce an environment in which thermophilic (active at relatively high temperatures) microorganisms flourish. Bulking agents create void volume in the compost, allowing for sufficient aeration. The enhanced biological activity tends to speed the degradation process. Organic contaminants are transformed along with the organic amendments, which serve as the main carbon source for the microorganisms.

Success with composting explosives has been demonstrated at a number of test sites using aerated static pile methods, windrowing, and a mechanically agitated vessel method (Roy F. Weston, Inc., 1988, 1989a, 1989b; U.S. Army Environmental Center, 1993). TNT has been degraded from 3,800 mg/kg to 40 mg/kg, RDX from 600 mg/kg to 46 mg/kg, and HMX from 300 mg/kg to 60 mg/kg in an aerated static pile system (Roy F. Weston, 1991). Agitated vessel experiments have resulted in reduction of TNT concentrations from 3,000 mg/kg to 6 mg/kg, RDX from 575 mg/kg to 4 mg/kg, and HMX from 120 mg/kg to 6 mg/kg (Roy F. Weston, 1991). However, experiments using radio-labeled TNT indicated mineralization (conversion to carbon dioxide, water, and inorganic nitrogen compounds) of less than 1 percent (Isbister et al., 1982). In windrow composting demonstrations, concentrations of TNT, RDX, and HMX were reduced by over 99 percent, over 99 percent, and over 96 percent, respectively. Leachate toxicity and extractable mutagenicity tests showed significant reductions of toxicity (U.S. Army Environment Center, 1993).

Development of this technology is still in progress. Explosives compounds do not appear to be mineralized, but are transformed to unknown compounds and immobilized in the compost matrix. Detailed composting treatability information is not available to date for all explosives at the former NOP. Excavation, composting, and on-site disposal has been recommended as the preferred remedial alternative for explosives-contaminated soil at the Umatilla Army Depot in Hermiston, Oregon (USEPA, 1992a). Composting is retained for further evaluation. However, a pilot-scale treatability study will be conducted to obtain site-specific composting treatment information.

**Slurry-Based Biological Treatment**

Slurry-based biological treatment can be accomplished either in mechanically agitated vessels or in a lined pit or "biopad." Nutrients (e.g., phosphorus and nitrogen) and water are added to soil to create a slurry of 20 to 50 percent solids (Treatek, 1992). In some cases, organic substrates and/or a population of microorganisms specifically acclimated to site contaminants (an inoculum) may be added. Proper conditions of pH, temperature, and redox potential are necessary for transformation of organic contaminants into less hazardous compounds. Conditions may be manipulated such that either aerobic or anaerobic biodegradation takes place at a given time during treatment.

Recent bench-scale experiments conducted at the U.S. Army Engineer Waterways Experiment Station (WES) (1992) on mixed-tank, aerobic slurry biodegradation indicate that TNT can be reduced from 10,000 mg/kg to below 5 mg/kg. In separate studies with radioactive-labeled TNT, approximately 15 percent of the TNT was completely mineralized. As the experimental apparatus used in the radioactive-labeled experiment limited nutrient addition, field-scale treatment may result in higher degrees of mineralization. Although the biological treatability studies conducted to date indicate that slurry-based biological treatment may not achieve PRGs related to this site, it is retained for further evaluation because these and other Treatability Studies indicate that greater removal may be achieved with optimization of treatment conditions.

An anaerobic slurry-based biotreatment system has been accepted into USEPA's Superfund Innovative Technology Evaluation (SITE) Program and is undergoing pilot-scale testing at the former Weldon Springs Ordnance Works near St. Louis, Missouri. This is the largest scale test which has been conducted for anaerobic bioslurry treatment of explosives-contaminated soil. Slurry-reactor bioremediation has several advantages over composting:

- Superior mixing and nutrient transfer for the contaminant-microbe interface.
- Better control of environmental parameters which effect biotreatment including temperature, dissolved oxygen (where appropriate), pH, and nutrient concentration.
- More uniform conditions throughout the reactor resulting in more uniform treatment.
- Residual volume of treated soil is not increased through the addition of bulking agents. In spike of the above advantages, composting would appear to be a more economical process.

Anaerobic slurry-based treatment has been found to transform RDX to a greater degree than aerobic treatment. The proposed treatability studies should include a bench- or pilot-scale anaerobic bioslurry study.

**Biological Treatment Summary**

Composting operations are conducted in a solid matrix with only enough water present to provide a moist environment that will enhance microbial growth. In contrast, biological slurry-phase operations are conducted in mixtures with higher water content (over 50 percent). Research on the slurry-phase systems indicates that the mass transfer of explosive contaminants from the soil into the aqueous phase is rate-determining in most cases where there is sufficient microbial activity. Good contact between microbes, contaminants, nutrients, water, carbon source, and electron acceptors is essential for optimum microbial activity. The use of surfactants has shown improved mass transfer rates with resulting increased degradation of explosive contaminants. A more dilute, well-mixed slurry system should allow for more thorough and more rapid treatment than can be expected from a nonslurried system. However, the cost of adding (and later removing) more water and the cost of adding chemicals must be taken into consideration. A summary of performance data for three types of biological treatment of TNT is shown in Table 2-12. This table also includes mention of development of intermediate compounds during biodegradation. Composting treatment of explosives-contaminated soil is somewhat more developed than slurry-based biodegradation, with success demonstrated at pilot scale.

Biological treatment techniques are commonly used in remediating a variety of contaminated media. However, further treatability testing is necessary to determine applicability for the particular explosives contaminants and soil at the former NOP site. In this case, it is not appropriate at this time to select a representative process option for biological treatment because the processes are sufficiently different and information on their relative performance used to make the decision on a particular process option will be determined based on treatability studies.

### 2.5.4.8 Disposal Actions

Because it is likely that only RCRA non-hazardous waste will be disposed, Subtitle C disposal is not required. However, the engineering controls typical of a Subtitle C landfill are being required by USEPA. Options for on-site and off-site disposal are evaluated below. Placement of contaminated soil in a secure landfill would significantly reduce potential ingestion of contaminated soil. It would also reduce the risk of infiltration of contaminants to groundwater.

**Off-Site Secure Landfill**

Contaminated soil and wastes would be transported to a landfill meeting the engineering controls described in RCRA Subtitle C for disposal. The Chemical Waste Management CID Landfill (Calumet City, IL) was contacted, and they indicated that they may accept 30,000 cubic yards of explosives-contaminated soil as long as the wastes are not listed wastes under RCRA. USPCI-Lone Mountain was also contacted and indicated they may



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**TABLE 2-12**

**PERFORMANCE DATA FOR BIOLOGICAL TREATMENT**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Criteria | Composting(1) | Anaerobic Slurry(2) | Aerobic Slurry(3) |
|---|---|---|---|
| Volume Increase | Approximately two-fold | None expected | None expected |
| Water Content | Approximately 20% | 50-95% | Approximately 60% |
| TNT Initial and Final Concentrations (mg/kg) | 1600 to 4 | 2000 to ND | 10,000 to 5 |
| Demonstrated Scale (for explosives) | Pilot Scale (1,500 cy) | Pilot Scale (11-12 cy) | Bench Scale (5 liters) |
| Intermediates | Not identified | Levels of all amino- and nitro-aromatic compounds decreased during treatment period | Gradual buildup of amino-DNTs during treatment |
| Estimated Soil Retention Time | 40 days | 1-2 months | 1 month |
| Observed Mineralization | Less than 1% | Approximately 80% | Approximately 15% |

References: (1)Roy F. Weston, Inc. (1991)
(2)Crawford and Crawford (1992), and Crawford et. al. (1993)
(3)WES (1992)

ND = Nondetectable levels.

RP/MEADFS/AB1

accept 8,200 cubic yards of non-reactive explosives-contaminated soil. As discussed previously, site wastes are not likely to be hazardous under RCRA either by listing or characteristic.

Local hauling companies (Omahaul, 1992; Aggregate Carriers, 1992; Spencer Dorothy, Inc., 1992) have been contacted, and are willing to accept and haul the waste. Off-site disposal is the least-preferred option under the NCP; however, this process option achieves RAOs at the site, but transfers contamination to another (off-site) location. The implementability of this process option depends on approval by regulatory agencies. This process option is retained.

**On-Site Secure Landfill**

An on-site landfill would be constructed to contain non-hazardous soil and/or treatment residuals at the former NOP site. Although RCRA is not applicable, the landfill design would use engineering controls as described under Subtitle C or provide equivalent controls. Applicable regulations governing the landfill location, design, operation, closure, and monitoring are addressed both by Federal and State agencies. Federal regulations (specifying materials, methods, and criteria) are found in 40 CFR 257 and 258. State solid waste management rules are found in Nebraska Department of Environmental Quality (NDEQ), Title 132.

This landfill would attain RAOs and human health and the environment would be protected. However, the landfill will require considerable long-term management and maintenance. Site use in the area of the landfill must be restricted. The administrative implementability is presently unknown. The availability of the land for siting the landfill is not finalized at this time and may be an issue. This process option is retained for further consideration.

### 2.5.4.9 Residuals Management Actions

**Publicly-Owned Treatment Works**

Many of the treatment technologies discussed previously produce residual wastewater. Decontamination wastewater will also be produced. The existing wastewater treatment plant on the former NOP site will not accept wastewater discharge from on-site treatment processes (University of Nebraska, 1992). In addition, it is not likely that the publicly-owned treatment works (POTW) in the town of Mead will accept wastewater discharge. The option of treatment of aqueous residuals at a POTW is not retained; however, it should be noted that this option will be re-evaluated if additional information indicates the Mead POTW may be available.



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**On-Site Treatment and/or Discharge of Liquids**

Because treatment of aqueous residuals at a POTW is not feasible, these wastewaters may be treated on-site. Liquid residuals may not require treatment if contaminant levels are acceptable as defined by the ARARs, including the Clean Water Act (CWA) and associated state requirements. Various physical, chemical, and biological treatment processes are appropriate for different types of wastewater streams which would be produced by different soil treatment technologies. Discharge of treated (or untreated) wastewater could be to Johnson Creek or possibly to uncontaminated drainage ditches on-site. This process option is retained for further consideration in conjunction with soil treatment technologies which produce wastewater.

**Off-Site Treatment and Disposal of Liquids**

Aqueous treatment residuals may also be treated and disposed at an off-site commercial facility. Similar processes as those discussed under on-site treatment and discharge of liquids could be used. This process option is retained for further consideration in conjunction with soil-treatment technologies which produce wastewater.

**Solids Treatment and Disposal**

If an on-site treatment process generates a solid residual sidestream (such as incinerator ash or baghouse dust or biological treatment residuals), further treatment may be required prior to on-site backfill. The type of solids treatment will depend on the treatment process generating the residual. After the residual has been treated it may be sufficiently similar to site soil that it could be blended into soil and graded onto the site as backfill. Any treated, backfilled soil or solid residual would be covered with vegetation so that site use would not be restricted. The former NOP site has sufficient space to accommodate treated backfill and the potential added volume of solid residual (anticipated to be a relatively small volume).

This process option would require solid residual sampling and analysis to determine requirements for treatment and suitability as backfill. This process option is retained for further analysis.

**2.5.4.10 <u>Debris Management</u>**

Surface and subsurface debris removal will be required at many contaminant source areas before containment or removal actions for soil may be implemented. Debris removal may include:

- Removal and treatment/disposal of surface debris such as wood, metal scrap, and concrete structures.

- Removal, separation from soil, and treatment/disposal of bucket trap sumps, associated concrete aprons, and inlet and outlet piping/structures.

- Removal and disposal of tree and brush cover.
- Removal and relocation (on-site) of large structures such as escape chutes.

Surface debris containment or disposal procedures may include the following options:

- Haul to an off-site authorized landfill.
- Place in on-site capped area (if implemented for explosives-contaminated soil).
- Place in on-site landfill (if implemented for explosives-contaminated soil).

Subsurface debris may be removed/disposed depending on size. Large subsurface debris may be separated from soil during excavation/consolidation and disposed with surface debris. Small subsurface debris may be managed with excavated soil; however, it may be removed by subsequent pre-process screening. In the latter case, the contaminated debris will be taken to an off-site disposal facility. Sampling of subsurface debris from areas of explosives contamination will occur prior to treatment or disposal. For purposes of this document, subsurface debris is assumed to be non-hazardous under RCRA because the former NOP site soil is unlikely to be hazardous under RCRA.

Debris removal may pose potential physical hazards to workers; however, these risks can be controlled by safe work practices. Dust generated during debris removal would be managed by standard practices. This action uses standard construction techniques and equipment, and is therefore considered reliable and implementable. Debris removal is retained for use in conjunction with on-site treatment or containment actions at the former NOP site.

### 2.5.5 Groundwater Treatment at Point-of-Use

While groundwater contamination is within the scope of OU 2, treatment of drinking water drawn from wells located in exposure areas is included as a temporary measure. This process option includes installation of a groundwater treatment system if domestic drinking water wells were installed in a contaminated area prior to completion of OU 2 activities. Currently, activated carbon systems at three on-site wells (not located in exposure areas) are being used to remove contaminants from groundwater to below health-based risk levels (USACE, 1993). This process option is retained for use in conjunction with other remedial actions at the former NOP site.

### 2.5.6 Summary

Table 2-13 presents remedial technologies and process options retained for the NOP site. These will be used in Chapter 3 to develop alternatives for OU 1.

**TABLE 2-13**

**RESPONSE ACTIONS AND RETAINED REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| General Response Actions | Remedial Technologies | Process Options |
|---|---|---|
| No Action | None | Not Applicable |
| Institutional Actions | Monitoring | Groundwater Monitoring |
| | Access Restrictions | Deed Restrictions |
| | | Fencing |
| Containment Actions | Capping | Soil Cap |
| Removal Actions | Excavation | Excavation |
| | | Consolidation |
| Treatment Actions | Thermal | Rotary Kiln Incineration |
| | | Above-Ground Vitrification |
| | | Low-Temperature Thermal Desorption |
| | Biological | Composting |
| | | Slurry-Based Biological Treatment |
| Disposal Actions | Land Disposal | Off-Site Secure Landfill |
| | | On-Site Secure Landfill |
| Residuals Management Actions | Water Treatment | On-Site Treatment and Discharge |
| | | Off-Site Treatment and Discharge |
| | Solids Treatment | On-Site Treatment and Disposal |
| Debris Removal Actions | Removal | Removal/Separation/ Disposal/Management with Soil |
| Groundwater Treatment | Treatment | Treatment at Point-of-Domestic Use |

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3



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# 3.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

## 3.1 INTRODUCTION

In this chapter, the retained technologies and related process options (Table 2-13) are developed into preliminary remedial alternatives to address explosives-contaminated soil at the former NOP site. These preliminary alternatives are then screened based on the three criteria (effectiveness, implementability, and cost) specified in the RI/FS guidance (USEPA, 1988) to reduce the number of alternatives which will undergo detailed analysis. These criteria are the same used in the second screening evaluation presented in Chapter 2, but they are applied to alternatives as a whole rather than to process options or technologies. Furthermore, this evaluation focuses more on implementability and cost than the previous evaluation did. Components of each criterion are listed below.

Effectiveness

- Protection of human health and the environment.
- Reductions in contaminant toxicity, mobility, and volume through treatment.
- Short-term impacts during implementation.
- Long-term impacts after implementation.

Implementability

- Technical feasibility:
  - Ability to construct, reliably operate, and meet technology-specific regulations for process options until remedial action is complete.
  - Operation, maintenance, replacement, and monitoring the components of an alternative.
- Administrative feasibility:
  - Ability to obtain agencies' approvals, permits, etc.
  - Availability of treatment, storage, and disposal services/capacity.
  - Availability of equipment and specialists.

Cost

- Relative capital costs.

As described previously, explosives-contaminated soil is present in discrete source areas throughout the site, and the type of contamination in the source areas is similar. The explosive compounds at the former NOP site appear to be sufficiently alike in nature and origin that each technology can be applied for all source areas.



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## 3.2 ALTERNATIVES DEVELOPMENT

Combining technologies into alternatives is an iterative process which systematically pairs retained process options to create remedial alternatives that can attain the RAOs for OU 1. Alternatives are developed to present an array representing both conventional and innovative treatment technologies. In general, the alternatives formulated and evaluated in the following pages are developed for remediating the former NOP OU 1 to target RAOs. The RAOs were presented in Chapter 2. Combining technologies into alternatives is primarily based on the following:

- The No Action alternative is included to provide a baseline against which other alternatives may be compared.

- Institutional controls may be included with remedial alternatives that include capping or on-site landfilling.

- Excavation, consolidation, and containment by means of a soil cap may be utilized as an alternative because capping would significantly reduce potential ingestion of contaminated soil. Consolidation and containment under a single cap rather than construction of several discrete caps would be more easily implemented and better managed in the long term. Potential institutional control difficulties and limited future land use at the site also make a single cap more practical.

- Excavation, consolidation, and thermal treatment may be suitable process options to develop a thermal treatment alternative for the explosives-contaminated soil at the former NOP site.

- Excavation, consolidation, and biological treatment may be suitable process options to develop a biological treatment alternative for the explosives-contaminated soil at the former NOP site.

- Excavation, consolidation, and on-site or off-site landfilling may be feasible disposal options for explosives-contaminated soil at the former NOP site.

- Treatment of groundwater at the point of domestic use is a suitable process for reducing risk from contaminated groundwater under the exposure areas in OU 1 if it were used for household (drinking, washing) purposes prior to completion of OU 2 activities.

- Some of the technologies and process options in Table 2-10 were retained only for specific wastes or for use in combination with other technologies. Wastewater treatment and/or discharge were retained for treatment technologies that typically



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require liquid waste stream management, such as scrubber water from a thermal treatment unit's air pollution control system. Similarly, solid residuals treatment and disposal was retained only for treatment technologies that require solid waste stream management, such as baghouse particulates from a thermal treatment unit's air pollution control system. Debris management options were retained for all alternatives which require excavation. Groundwater monitoring and deed restrictions were retained only where contaminants remain on-site above PRGs.

Seven preliminary alternatives for OU 1, including no action, resulted from this formulation of alternatives. The preliminary alternatives are listed below:

- Alternative 1: No action.
- Alternative 2: Deed restrictions and groundwater monitoring.
- Alternative 3: Excavation, consolidation, debris management, soil cap, deed restrictions, groundwater monitoring, and point-of-use groundwater treatment, if wells are installed in OU 1 exposure areas prior to completion of OU 2 activities and explosives concentrations, in the water from those wells, exceed health advisories or regulatory limits.
- Alternative 4: Excavation, consolidation, debris management, biological treatment, residuals management, and point-of-use groundwater treatment, if wells are installed in OU 1 exposure areas prior to completion of OU 2 activities and explosives concentrations, in the water from those wells, exceed health advisories or regulatory limits.
- Alternative 5: Excavation, consolidation, debris management, thermal treatment, residuals management, and point-of-use groundwater treatment, if wells are installed in OU 1 exposure areas prior to completion of OU 2 activities and explosives concentrations, in the water from those wells, exceed health advisories or regulatory limits.
- Alternative 6: Excavation, consolidation, debris management, on-site landfilling, fencing, deed restrictions, groundwater monitoring, and point-of-use groundwater treatment, if wells are installed in OU 1 exposure areas prior to completion of OU 2 activities and explosives concentrations, in the water from those wells, exceed health advisories or regulatory limits.
- Alternative 7: Excavation, consolidation, debris management, fencing, off-site landfilling, and point-of-use groundwater treatment, if wells are installed in OU 1 exposure areas prior to completion of OU 2 activities and explosives concentrations, in the water from those wells, exceed health advisories or regulatory limits.



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## 3.3 ALTERNATIVES SCREENING

The alternatives formulated in the previous section are now screened to reduce the number of alternatives which will undergo a more extensive and thorough evaluation in the detailed analysis phase of the FS. As discussed previously, alternatives are screened based on effectiveness, implementability, and relative cost. The results of the initial screening are summarized in Table 3-1 and discussed below for each criterion.

### 3.3.1 Effectiveness

The seven alternatives have various degrees of effectiveness in controlling and mitigating risks for the explosives-contaminated soil. Alternative 1 does not reduce risk. Alternative 2 reduces risk by controlling future land use and therefore minimizing the potential for exposure to contaminants. Deed restrictions however, are not legally enforceable and are often unreliable as a sole means of interrupting exposure pathways. The effectiveness of deed restrictions, therefore, depends on how well they are maintained. Alternative 3 minimizes the potential for exposure to explosives-contaminated soil by capping. Alternative 3 also relies on deed restrictions, but the engineered cap provides additional protection to human health and the environment if deed restrictions are violated.

Biological treatment methods (Alternative 4) may be effective in treating explosives-contaminated soil, but have not been demonstrated on a full-scale basis for explosives. In addition, biological treatment may not result in complete mineralization of explosive contaminants (Crawford, 1992, Isbister, 1981). The soil volume may increase during biological treatment due to the addition of amendments.

Thermal treatment (Alternative 5) is expected to effectively destroy explosive contaminants. Rotary kiln incineration and on-site vitrification have proven destruction effectiveness for explosives-contaminated soil. LTTD although not demonstrated on explosives, has proven successful in treating soil contaminated with other organic compounds. Vendors of these other processes indicated that their process units could treat explosives-contaminated soil (Appendix D).

Alternatives 6 and 7 provide landfill disposal of explosives-contaminated soil. Alternative 6 retains the soil in an on-site landfill and is expected to achieve RAOs. Alternative 7 is also expected to achieve RAOs, but transfers contamination to another location (the off-site landfill). Alternatives 3 and 6 both minimize the potential for soil ingestion, but Alternative 6 provides a greater degree of groundwater protection by leachate collection.

BLE 3-1

# SUMMARY OF ALTERNATIVES SCREENING
## Former NOP Site
## Operable Unit 1 FS
## Mead, Nebraska
## March 1994

| Alternative | Effectiveness | Implementability | Estimated Relative Cost ($M) | Screening Results |
|---|---|---|---|---|
| 1. No action. | o Risk not reduced. | NA | ---- | Retained for detailed analysis per NCP. |
| 2. Deed restrictions, groundwater monitoring. | o Effectiveness for controlling risk with future land use depends on deed restriction enforcement. | o Long-term deed restrictions often unreliable. | ---- | Eliminated from further consideration because deed restrictions are often unreliable in reducing risk. |
| 3. Excavation, consolidation, debris management, soil cap, fence, deed restriction, groundwater monitoring, groundwater treatment at point-of-use. | o Potential for exposure to contaminated soil minimized<br>o Expected to achieve RAOs.<br>o Potential for leaching of soil contaminants is somewhat minimized.<br>o Effective in reducing risk from household use of groundwater. | o Capping widely used.<br>o Long-term deed restrictions often unreliable.<br>o Future site use affected in capped area.<br>o Uses common construction methods and should be easily implemented.<br>o Operation and maintenance for 30 years is required.<br>o Agency approval unknown. | 2.0 | Eliminated from further consideration because the cap may not effectively minimize leaching of contaminants from soil to groundwater compared to the landfilling alternative. |
| 4. Excavation, consolidation, debris management, biological treatment, residuals management, groundwater treatment at point-of-use. | o Process reliability unknown, due to development status. Similar full-scale process is reliable, but not demonstrated for explosives.<br>o Treatment may not result in complete mineralization.<br>o Process (if effective) achieves RAOs.<br>o Waste volume may increase, depending on type of biological process used (composting increases volume most significantly).<br>o Effective in reducing risk from household use of groundwater.<br>o Potential for exposure to contaminated soil is eliminated (if effective). | o Uses common construction methods and should be easily implemented.<br>o Equipment and personnel are readily available.<br>o Needs treatability studies and process scale-up for full-scale application.<br>o Few specialists with explosives treatment experience exist.<br>o May require extensive staging and blending prior to treatment. | 15.4 | Retained for detailed analysis because biological treatment is a potentially viable treatment option for explosives-contaminated soil. |

BLE 3-1

**SUMMARY OF ALTERNATIVES SCREENING**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Alternative | Effectiveness | Implementability | Estimated Relative Cost ($M) | Screening Results |
|---|---|---|---|---|
| 5. Excavation, consolidation, debris management, thermal treatment, residuals management, groundwater treatment at point-of-use. | o Some process units (rotarycc kilns) have proven effectiveness for treating explosives.<br>o Process (if effective) achieves RAOs.<br>o Explosives are destroyed in soil.<br>o Effective in reducing risk from household use of groundwater.<br>o Potential for exposure to contaminated soil is eliminated (if effective). | o Mobile units commercially available.<br>o Feed requirements must be clearly defined and addressed to ensure reliable operation.<br>o Extensive substantive permit requirements may be required.<br>o May require extensive staging and blending prior to treatment.<br>o Will not require long-term management at the site. | 13.3 | Retained for detailed analysis, because some thermal processes have proven effectiveness in treating explosives-contaminated soil. |
| 6. Excavation, consolidation, debris management, on-site landfilling, fence, deed restrictions, groundwater monitoring, groundwater treatment at point-of-use. | o Expected to achieve RAOs.<br>o Long-term monitoring, maintenance, and deed restrictions aid in exposure control.<br>o Effective in reducing risk from household use of groundwater.<br>o Potential for exposure to contaminated soil is minimized. | o Long-term deed restrictions often unreliable.<br>o Uses standard construction equipment and methods.<br>o Impacts future site use in landfill area.<br>o Agency approval unknown.<br>o Will require perpetual USACE involvement at the site.<br>o Land availability uncertain. | 2.3 | Retained because on-site landfill expected to achieve RAOs through on-site containment. Landfill minimizes completion of exposure pathways if properly maintained. |
| 7. Excavation, consolidation, debris management, off-site landfilling, groundwater treatment at point-of-use. | o Expected to achieve RAOs at the site.<br>o Transfers contaminants in soil to another location.<br>o Effective in reducing risk from household use of groundwater. | o Ability to obtain agency approval unknown.<br>o Uses standard construction equipment and methods.<br>o Least preferred option under NCP. | 3.9 | Retained for detailed analysis because future site use would be unrestricted, and long-term monitoring would not be required. |

BLE 3-1

**SUMMARY OF ALTERNATIVES SCREENING**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Alternative | Effectiveness | Implementability | Estimated Relative Cost ($M) | Screening Results |
|---|---|---|---|---|
| | o Potential for on-site exposure to contaminated soil is expected to be eliminated.<br>o Potential for leaching of soil contaminants to groundwater is expected to be eliminated. | | | |

NOTES: NA - Not Applicable.
-- No capital costs incurred.

Estimated costs in this table do not include operation and maintenance (for groundwater monitoring, containment unit maintenance, leachate treatment, etc.).

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Alternatives 2, 3, and 6 rely on deed restrictions, which may be difficult to enforce. However, the containment provided by the on-site cap or secure landfill (Alternatives 3 and 6) provides additional protection to human health and the environment if deed restrictions are violated. Alternatives 3, 4, 5, 6, and 7 provide additional protection by providing treatment of groundwater at the point of domestic use.

### 3.3.2 Implementability

Alternatives 1 and 2 are the most easily implemented alternatives. Deed restrictions (Alternative 2), however, are historically unreliable in preventing access because they are not legally enforceable. Alternatives 3, 6, and 7 are also easily implemented because standard construction techniques can be used. Caps and landfills are widely used process options. The future use of capped or landfilled areas would be restricted. Off-site disposal facilities have been contacted and are capable of accepting the volume assumed for the site. However, administrative feasibility based on the approval of reviewing agencies is not known.

Implementation of Alternative 4 would require process scale-up because biological treatment processes have not been performed at full-scale for explosive compounds. However, it is assumed for purposes of this document that typical biological treatment methods can be used and adapted for NOP explosives compounds. This assumption is based on vendor information (Crawford, 1992). Alternative 4 would require treatability studies for full-scale operation; however, common construction methods and equipment are assumed. There are few biological treatment specialists with explosives treatment experience.

Substantive requirements (e.g., trial burn) may be required for Alternative 5. The permits themselves, however, will not be required for on-site treatment. Mobile incineration, vitrification, and LTTD units are anticipated to be available for this site (Chemical Waste Management, 1992a; Thermodynamics Corp., 1992; Canonie, 1992). Alternative 5 may require extensive feed requirement analysis and preprocessing due to the high clay content of NOP soils. Process parameters such as residence time and air pollution control needs may be affected by the soil type.

### 3.3.3 Cost

Preliminary relative costs were developed (SEC Donohue, 1992c) based on vendor quotes and generic unit costs. These costs are not the same as the more detailed costs presented in Chapter 4 and were developed for screening purposes only. The biological treatment component of Alternative 4 is based on composting and the thermal treatment component of Alternative 5 is based on rotary kiln incineration. Costs for the groundwater component of Alternatives 3, 4, 5, 6, and 7, are based on carbon-adsorption systems, such as the one presently in use on-site. These cost estimates are strictly for comparative purposes because they are incomplete. Table 3-1 includes the estimated relative costs for the alternatives.



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### 3.3.4 Summary

Table 3-2 presents the final alternatives array; these alternatives will be evaluated in the detailed analysis of the FS. Alternatives 2 and 3 were eliminated based on the effectiveness criteria evaluation.

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**TABLE 3-2**

**FINAL ALTERNATIVES ARRAY**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

Alternatives

1. (1) No Action.

2. (4) Excavation, consolidation, debris management, biological treatment, residuals management, and point-of-use groundwater treatment, if wells installed in OU 1 exposure areas prior to completion of OU 2 activities have explosives concentrations exceeding health advisories or regulatory limits.

3. (5) Excavation, consolidation, debris management, thermal treatment, residuals management, and point-of-use groundwater treatment, if wells installed in OU 1 exposure areas prior to completion of OU 2 activities have explosives concentrations exceeding health advisories or regulatory limits.

4. (6) Excavation, consolidation, debris management, on-site landfilling, fencing, deed restrictions, groundwater monitoring, and point-of-use groundwater treatment, if wells installed in OU 1 exposure areas prior to completion of OU 2 activities have explosives concentrations exceeding health advisories or regulatory limits.

5. (7) Excavation, consolidation, debris management, off-site landfilling, and point-of-use groundwater treatment, if wells installed in OU 1 exposure areas prior to completion of OU 2 activities have explosives concentrations exceeding health advisories or regulatory limits.

Note: Number in parentheses is the Section 3.2 alternative number during the development of alternatives.

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4



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# 4.0 DETAILED ANALYSIS OF ALTERNATIVES

## 4.1 INTRODUCTION

In this chapter, the alternatives carried forward from the screening process in Chapter 3 are evaluated and compared in detail. The alternatives are further defined by quantifying the sizes, capacities, and configurations of their components; the time frame in which removal, contains or treatment will be achieved; the spatial requirements for constructing containment or treatment technologies; the transportation distances for disposal technologies; and the long-term operation and maintenance requirements. The alternatives are then evaluated and compared using the nine criteria specified in the USEPA RI/FS guidance (USEPA, 1988). These evaluation criteria are subdivided into three categories: threshold criteria, balancing criteria, and modifying criteria. An alternative must meet the threshold criteria to be eligible for selection. The balancing criteria are the primary technical criteria upon which the detailed analysis is based. They are used to assess the positive and negative aspects of performance, implementability, and cost of each alternative. The modifying criteria will be addressed in this document for agency acceptance and in the Responsiveness Summary included in the Record of Decision for agency and community acceptance.

The evaluation criteria are:

Threshold Criteria

- Overall protection of human health and the environment.
- Compliance with ARARs.

Balancing Criteria

- Long-term effectiveness and permanence.
- Reduction of toxicity, mobility, and volume through treatment.
- Short-term effectiveness.
- Implementability.
- Cost.

Modifying Criteria

- Agency acceptance.
- Community acceptance.

The comparison of alternatives includes a cost sensitivity analysis. This section also contains an uncertainty analysis and a discussion of additional data needs.



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Elements of the nine criteria are presented in Figure 4-1 and summarized briefly below.

### 4.1.1 Overall Protection of Human Health and the Environment

This criterion assesses the protection afforded by each alternative considering long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. Protection of human health is assessed by evaluating how site risks from each exposure pathway are eliminated, reduced, or controlled through the implementation of each alternative. This evaluation takes into account short-term or cross-media impacts that result from the remedial activity.

### 4.1.2 Compliance with ARARs

Each alternative must achieve compliance with the ARARs pertinent to the site; or if compliance is not achieved, a justifiable ARAR waiver must be obtained. Section 2.2.1 contains a description of ARARs and their classification. Compliance or noncompliance with ARARs is evaluated for each alternative.

### 4.1.3 Long-Term Effectiveness and Permanence

The focus of this evaluation is to determine the effectiveness of each alternative in terms of the risk posed by treatment residuals and/or untreated wastes after the RAOs are reached. Components of this criterion include:

- Magnitude of residual risk from the alternative.
- Likelihood that the alternative will meet process efficiencies and performance specifications.
- Adequacy and reliability of long-term management controls providing continued protection from residuals.

### 4.1.4 Reduction of Toxicity, Mobility, and Volume Through Treatment

Reduction of contaminant toxicity, mobility, and volume through treatment is a key statutory preference of CERCLA. This evaluation addresses the quantity of contaminants treated or destroyed, the degree of reduction in contaminant toxicity, mobility, or volume, the degree to which the treatment is irreversible, and the type and quantity of residuals remaining.

Reduction of toxicity, mobility, and volume through containment will also be addressed under this criterion.



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FIGURE 4–1
CRITERIA FOR DETAILED ANALYSIS OF ALTERNATIVES
Former NOP Site
Operable Unit 1
Mead, Nebraska
March 1994

THRESHOLD CRITERIA:

**OVERALL PROTECTION OF HUMAN HEALTH AND THE EINVIRONMENT**

- How alternative provides human health and environmental protection

**COMPLIANCE WITH ARARs**

- Compliance with chemical-specific ARARs
- Compliance with action-specific ARARs
- Compliance with location-specific ARARs
- Compliance with other criteria, advisories, and guidances

BALANCING CRITERIA:

**LONG-TERM EFFECTIVENESS AND PERMANENCE**

- Magnitude of residual risk
- Adequacy and reliability of controls

**REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT**

- Treatment process used and materials treated
- Amount of hazardous materials destroyed or treated
- Degree of expected reductions in toxicity, mobility, and volume
- Degree to which treatment is irreversible
- Type and quantity of residuals remaining after treatment

**SHORT-TERM EFFECTIVENESS**

- Protection of community during remedial actions
- Protection of workers during remedial actions
- Environmental impacts
- Time until remedial action objectives are achieved

**IMPLEMENTABILITY**

- Ability to construct and operate the technology
- Reliability of the technology
- Ease of undertaking additional remedial actions, if necessary
- Ability to monitor effectiveness of remedy
- Ability to obtain approvals from other agencies
- Coordination with other agencies
- Availability and capacity of off-site treatment, storage, and disposal services
- Availability of necessary equipment and specialists
- Availability of prospective technologies

**COST**

- Capital costs
- Operation and maintenance costs
- Present worth cost

MODIFYING CRITERIA:

**AGENCY ACCEPTANCE**

**COMMUNITY ACCEPTANCE**

Notes:
ARARs: Applicable or relevant and appropriate requirements.

(EPA, 1988)

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### 4.1.5 Short-Term Effectiveness

The short-term effectiveness of each alternative assesses the risk to the community, workers, and environment during implementation of the remedial action. The time required to achieve RAOs is also considered. Mitigation measures to provide protection are a key issue in this determination.

### 4.1.6 Implementability

This criterion analyzes technical feasibility, administrative feasibility, and availability of services and materials. Technical feasibility assesses the difficulty of construction or operation of a particular alternative and the uncertainties associated with a technology. The reliability of the technology, based on the likelihood of technical problems that would lead to project delays, is key in this determination. The ability to monitor the effectiveness of the alternative and the ease of undertaking additional remedial action are also considered. Finally, the risk of exposure should the monitoring plan not detect a system failure is evaluated to assess a worst-case scenario.

Administrative feasibility assesses the ease or difficulty of obtaining permits or rights-of-way for construction.

Availability of services, materials, off-site treatment, storage, or disposal facilities, equipment, specialists, and additional resources are evaluated. The potential for obtaining competitive bids is also evaluated for each technology or service.

### 4.1.7 Cost

The total conceptual cost of each alternative is based on the sum of the direct capital costs (materials, equipment, labor), indirect capital costs (engineering, contingencies, licenses or permits), and operation and maintenance costs (O&M). Present worth costs (future cost discounted to a common base year) are also developed for each alternative to provide a common basis for comparing substantially different alternatives. Costs are evaluated using a sensitivity analysis after the present worth analyses are completed. The sensitivity analysis reflects the variability of costs due to uncertainties related to site or technology characteristics. Costs for the current estimated remediation volume (8,400 cubic yards) and for different volumes and variables used in the sensitivity analysis are presented in Appendix F.

### 4.1.8 Agency Acceptance

The final two criteria are modifying criteria. The agency acceptance criterion evaluates the technical and administrative issues raised by USEPA and NDEQ. Agency acceptance will be addressed in the Proposed Plan and the Record of Decision.



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### 4.1.9 Community Acceptance

This criterion evaluates comments and concerns related to the alternatives from members of the community. Public concerns and comments will be addressed in the Responsiveness Summary included in the Record of Decision.

## 4.2 GENERAL SITE ELEMENTS

Before evaluating each remedial alternative, assumptions made for the purposes of this document for general elements common to the alternatives will be addressed. It should be noted that these elements will be finalized during the Remedial Design and may change from what is noted in the document. Common elements for the remediation of explosives-contaminated soil at the former NOP site include:

- Site preparation.
- Support facilities.
- Source area excavation.
- Consolidation of excavated material.
- Debris management.
- Residuals management.
- Demolition materials management.
- Liquids management.
- Groundwater monitoring.
- Groundwater treatment at point-of-use.
- Site layout.

Cost and technical information from vendors is presented in Appendix D. Appendix F presents additional detail on general site elements as they apply to specific alternatives.

### 4.2.1 Site Preparation

Site preparation is required for all action alternatives prior to soil removal. Common elements of site preparation assumed for this document for action alternatives are:

- Decontamination Facility
- Access Roads
- Tree Clearing and Grubbing
- Topsoil Stripping and Storage

A decontamination facility estimated to be 25 feet by 50 feet with a sump and curbed concrete pad will be provided for equipment and machinery decontamination. Decontamination fluids collected in the sump are discussed in Section 4.2.8.



B07NE003701-04764

Access roads will be improved (assumed to be with a geotextile and additional (8 inches) gravel) or (where none exist) constructed for vehicle access. Roads are assumed 20 feet wide.

Tree clearing and grubbing and topsoil stripping and storage will be performed wherever necessary to construct support areas, staging (debris and/or soil) areas, process areas, capping/landfilling/residuals management areas, decontamination facility areas, and access roads. For the purposes of this document, trees are assumed to be cut into pieces and hauled to an off-site landfill under Alternatives 2, 3, and 5, and shredded when disposed of on-site (Alternative 4). Topsoil will be stockpiled next to each stripped area and covered with plastic sheeting for reuse.

Contaminated areas will be cleared, grubbed, and stripped as described in Section 4.2.3.

### 4.2.2 Support Facilities

All action alternatives require support facilities, which are assumed for this document to be identical for costing purposes. These facilities are assumed to include office and personnel decontamination trailers, parking areas, solid waste containers, and lavatories and electrical power for use by the contractor and agency staff. Visitors to the site during remediation would check in at the support facilities. Meetings, pre-field briefings, sample packaging, and shipping are some typical activities which take place in the support facilities.

### 4.2.3 Source Area Excavation

Excavation of the source areas is assumed for this document to include clearing and grubbing, soil and debris excavation, confirmation sampling, stormwater control, backfill, and revegetation. The contaminated areas to be excavated are shown in Chapter 2. Topsoil is assumed to be managed the same as contaminated material. For Alternatives 4 and 5, excavations will be backfilled with clean soil. As these areas are excavated, clean borrow clay (from an off-site source) will be hauled in to fill the excavations. Excavations will be filled after confirmation sample analyses show no further excavation is required in each area. A sampling plan will be developed prior to the Remedial Action to show how the lateral extent of excavation will be confirmed. For the purpose of this document, one confirmation sample is assumed per 1,000 square feet of excavation surface area. Each sample is assumed to be consolidated from four sides of the excavation. After the excavations are filled, clean topsoil will be added and a vegetated. For Alternatives 2 and 3, excavations will be backfilled with treated material.

Excavation of explosives-contaminated material is assumed to be performed using standard excavation equipment because after the removal action has been completed, there will be no potentially reactive soil. Stormwater run-on and runoff control will include temporary



B07NE003701-04765

berms and ditches. Dust and erosion control are included for all excavation and materials handling operations.

### 4.2.4 Consolidation of Excavated Material

Consolidation includes transporting the contaminated material from source areas to a common site and preparing it for treatment or containment. Depending on the feed requirements of the treatment system and the location and character of the containment units, each alternative includes different components under consolidation. For the purpose of costing in this document, some of the consolidation components are included under excavation costs (e.g., hauling) and others under material containment or treatment preparation costs (e.g., blending and material separation).

In alternatives involving treatment (Alternatives 2 and 3), consolidation is assumed to include a soil preprocessing structure. The structure will house activities such as blending, screening, and other preprocessing steps. The structure is assumed to be 120 feet wide by 200 feet long by 58 feet high at the apex and have a concrete floor. Excavated soil is assumed to be stockpiled adjacent to the preprocessing building for characterization and staging. Stockpiles will be lined and covered with plastic sheeting.

### 4.2.5 Debris Management

Surface debris located in source areas may require removal prior to excavation of explosives-contaminated soil. Surface debris may include wood, metal, concrete, trees, shrubs, and escape chutes. Trees and shrubs are assumed to be transported to the debris staging area where they will be shredded. Large subsurface debris separated during excavation, such as pipes and bucket trap concrete and metal, is assumed to be either shredded or reduced to a suitable hauling size. This material is assumed to be disposed off-site or recombined with the excavated soil for containment, depending on the alternative. If the material is disposed off-site, it will be sampled first to characterize the material for proper disposal. The debris staging area is assumed to consist of a 50-foot by 100-foot concrete pad (identical to the decontamination facility pad). Debris will be covered with plastic sheeting while in the staging area.

### 4.2.6 Residuals Management

Residuals management is included for Alternatives 2 and 3. Depending upon the treatment technologies used, different types of residuals will require treatment and/or disposal. Residuals management for Alternatives 2 and 3 assumes treated soil will be returned to the areas from which it was excavated, and vegetated.

### 4.2.7 Demolition Materials Management

Some demolition materials may have to be disposed of at a local landfill for each action alternative. These materials may include (depending on the alternative) concrete floors in the decontamination facility, soil staging/debris processing facility, and preprocessing facility. For Alternatives 2 and 3, these materials would not be suitable for treatment because they are over-sized. For Alternative 4, the demolition is assumed after landfill closure.

### 4.2.8 Liquids Management

Potential liquid waste streams have been identified for the alternatives. Every action alternative will generate decontamination liquids (collected from the decontamination facility sump) during implementation. Alternative 4 will generate leachate which will be collected during the groundwater monitoring period, assumed to be infinite (see Appendix F3 for quantities assumed for this document). Water from slurry-phase biological treatment is assumed to be managed at the conclusion of biological treatment. However, for the purposes of this document, the composting biological treatment is not expected to produce water that will require management. This assumption is based on composting studies at Umatilla, Oregon in which no run-off was produced (USAEC, 1993). The need for run-off collection and treatment will be evaluated in a treatability study. Thermal treatment process water (scrubber water) may be produced throughout thermal treatment. However, based on vendor conversations, it is assumed for costing purposes that scrubber water will be completely recycled (Chemical Waste Management, 1992). Specific information concerning the control of potential liquid residuals will be addressed during the Remedial Design.

### 4.2.9 Groundwater Monitoring

A groundwater monitoring program is included in Alternative 4 to determine whether the groundwater is further impacted by the on-site landfill. For the purpose of cost estimation in this document, groundwater monitoring assumes that samples will be collected and analyzed for explosives quarterly for the first 5 years and annually thereafter. Well inspection and maintenance will also be carried out concurrent with sample collection. Five monitoring wells are assumed for costing purposes.

### 4.2.10 Groundwater Treatment at Point-of-Use

Groundwater treatment at the point of domestic use is included in Alternatives 2 through 5. Point-of-use groundwater treatment units will be included on wells installed in OU 1 exposure areas prior to completion of OU 2 activities if explosives concentrations above regulatory or health advisory limits are detected. These treatment systems will remove contaminants from water used for household purposes (such as drinking, cooking, and washing) to below regulatory or health advisory limits. Two such systems, which use activated carbon adsorption, are currently in use. For costing purposes, it is assumed that



B07NE003701-04767

one carbon-adsorption system will be installed at each exposure area. Treatment is assumed to continue for a period of 30 years. The period of treatment is assumed to be less than the landfill maintenance period because it is assumed that groundwater management will transfer to OU 2. However, the actual duration of this treatment has not yet been determined and may be different than the assumed duration.

### 4.2.11 Site Layout

Potential site layouts for each alternative are included in the alternative analyses. However, as noted previously, land availability has not been finalized and may be an issue. Where possible, treatment/containment areas are proposed to be located within the diamond areas of load lines to minimize impact on University of Nebraska activities. For the treatment alternatives (Alternatives 2 and 3), the layouts are primarily inside the diamond area of Load Line 2 for access to existing utilities and support facilities which have been used during previous site investigation activities. For the on-site containment alternative (Alternative 4), the layout presented in this document is assumed primarily inside the diamond area of Load Line 3. Load Line 3 is estimated to be the least frequently used load line currently; therefore, location of a permanent containment structure in this load line would satisfy layout and remediation requirements most effectively. Support areas and decontamination facilities are shown outside the diamond areas. These assumptions are contingent upon the University of Nebraska being proactive in their support of acquiring all necessary access or real estate for remediation. Contingencies will be evaluated and negotiated during the Predesign and Design phase of OU 1.

## 4.3 ALTERNATIVE ANALYSIS

This section describes the five alternatives retained from the screening process in Chapter 3 and evaluates each in terms of seven of the nine criteria discussed in Section 4.1. Agency and community acceptance criteria will be addressed in the Responsiveness Summary included in the Record of Decision. Each alternative is first compared with respect to the two threshold criteria: overall protection of health and the environment and compliance with ARARs. Each alternative meeting the threshold criteria is then evaluated in terms of the balancing criteria: long-term effectiveness and permanence; reduction of toxicity, mobility, and volume; short-term effectiveness; implementability; and cost.

The primary components of these alternatives are assumed for the purposes of this document to include the items listed in the description for each alternative. It should be noted that these items may be modified in the Remedial Design.

### 4.3.1 Alternative 1 - No Action

This alternative is included as a NCP requirement to provide a baseline against which other alternatives are compared. The No Action alternative, by definition, involves no remediation of contaminated soil. Therefore, the potential for ingestion of contaminated soil persists. On-site contaminated soil will continue to contribute a cancer risk greater than 1E-06, non-cancer risk greater than HI=1E+00, and contribute to groundwater contamination. This alternative does not pass the threshold criteria and therefore is not evaluated further except to compare against other alternatives. There are no costs associated with Alternative 1.

### 4.3.2 Alternative 2 - Excavation, Consolidation, Debris Management, Biological Treatment, Residuals Management, and Groundwater Treatment at the Point-Of-Use

#### 4.3.2.1 Description

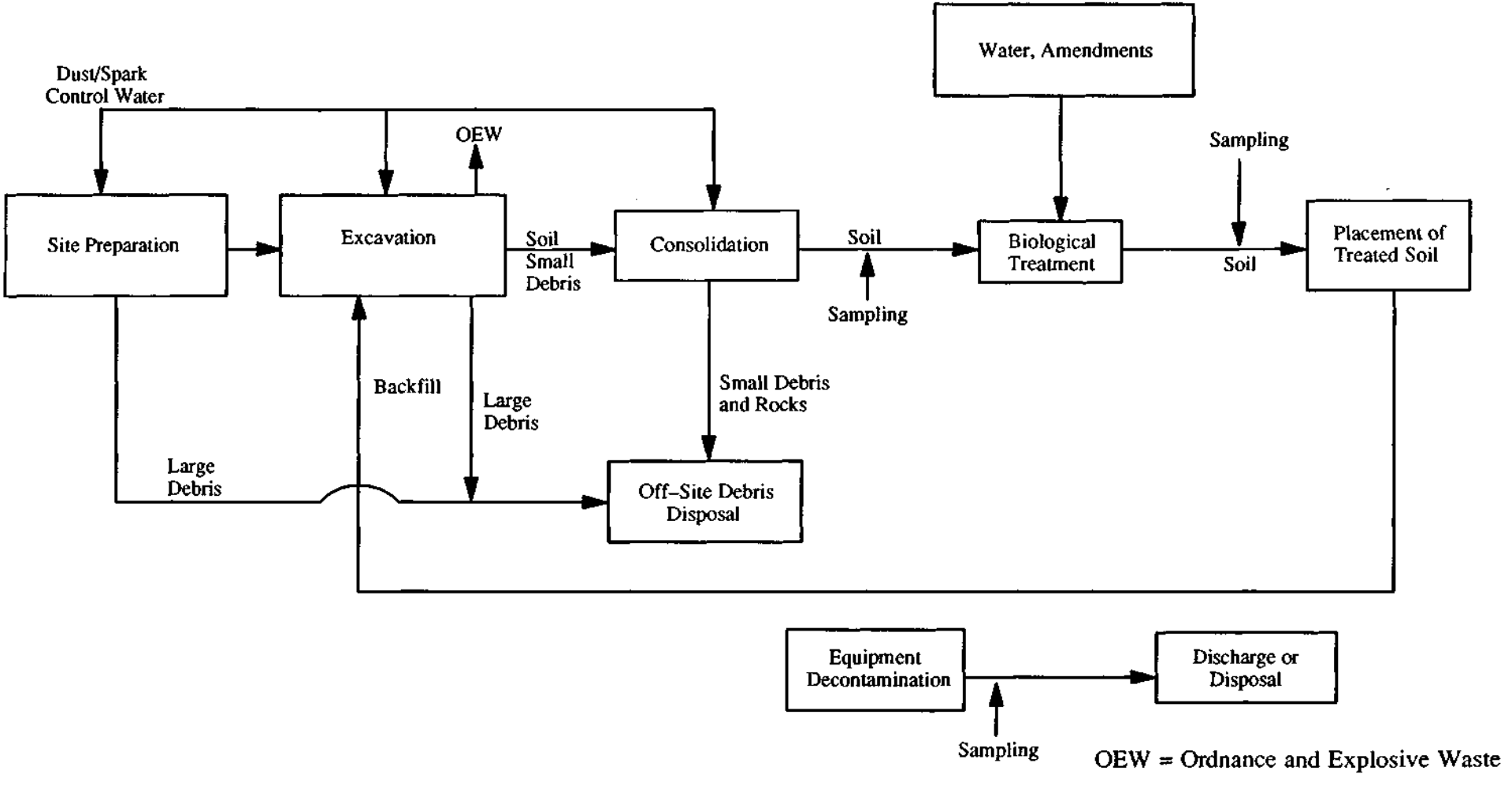
Alternative 2 provides treatment of the contaminated soil using biological treatment. For the purpose of this document, composting is used to evaluate this alternative. However, aerobic and/or anaerobic slurry-based treatment could be used. The preliminary component diagram is shown in Figure 4-2. Figure 4-3 shows the potential site layout for this alternative. The following activities are assumed for the purposes of this document for implementation of this alternative:

- Excavate contaminated soil and debris from source areas.
- Manually separate debris, shred if necessary.
- Haul excavated soil to the material staging area and stockpile.
- Screen, grind, and blend soil in an enclosed structure (preprocessing facility) to remove rocks and small debris, and break down clumps of clay which may hinder the treatment system and to reduce surges in explosives concentration which may be detrimental to treatment. The enclosed structure is intended to minimize the generation of dust during soil preprocessing.
- Treat contaminated soil using biological treatment to treatment PRGs and verify through testing.
- Return treated compost to source areas and vegetate. The volume of treated material is expected to be approximately twice as large as the original volume of contaminated soil (USACE, 1993). The volume increase, therefore, would raise the overall grade of the areas to be backfilled.



B07NE003701-04769

# Figure 4–2
# PRELIMINARY COMPONENTS OF ALTERNATIVE 2
## Former NOP Site
## Operable Unit 1 FS
## Mead, Nebraska
## March 1994

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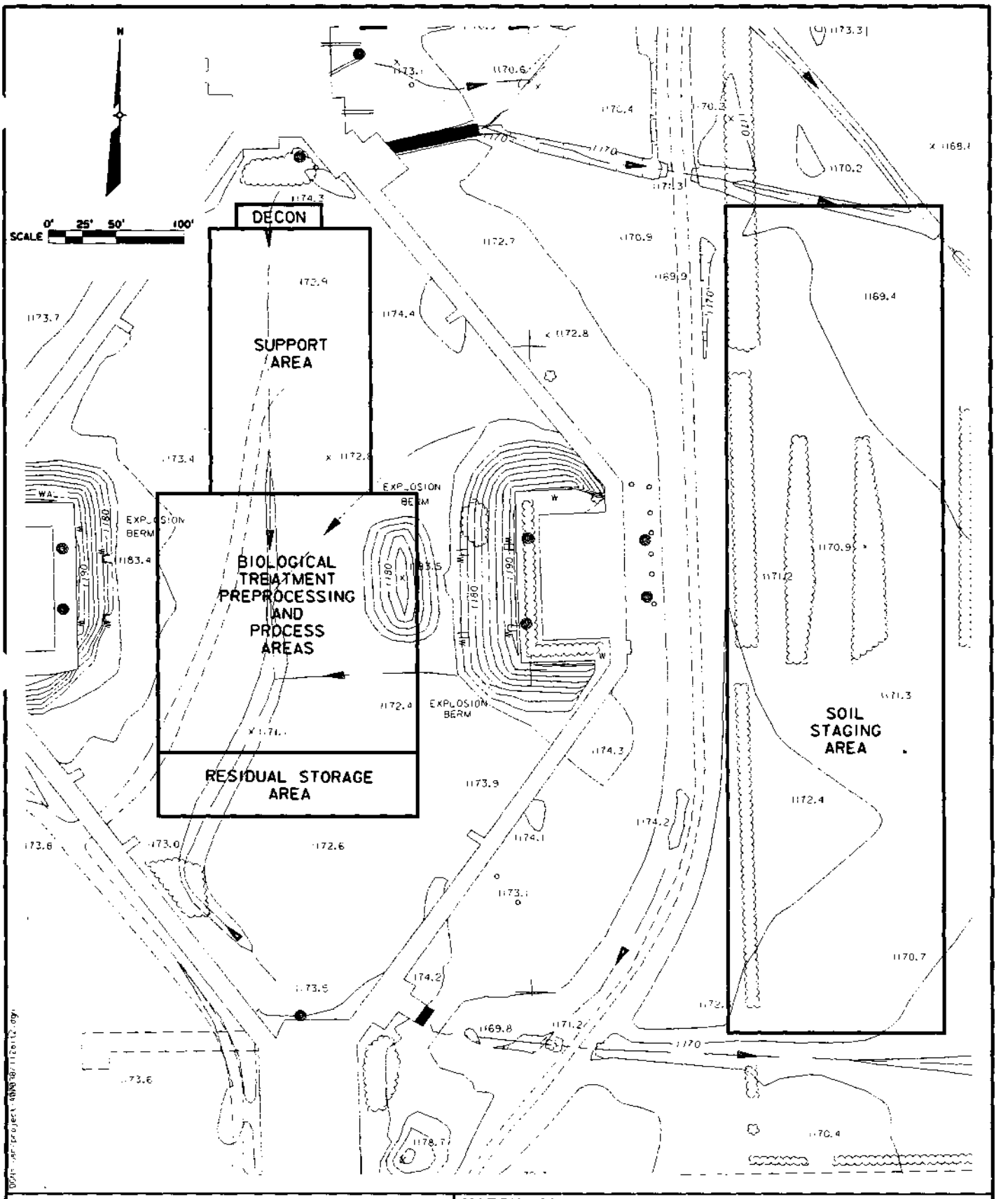


RUST ENVIRONMENT & INFRASTRUCTURE

MARCH 1994

**FIGURE 4-3**

19536

**LOAD LINE 2 - ALTERNATIVE 2**
**POTENTIAL SITE LAYOUT**

FINAL FEASIBILITY STUDY - OPERABLE UNIT 1
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

- Dispose oversize material, debris, and demolition material off-site.

- Install carbon-adsorption system if domestic wells are installed and used in the OU 1 exposure areas prior to completion of OU 2 activities and water from those wells has explosives concentrations above health advisory or regulatory limits.

The actual elements of the alternative will be finalized during the Remedial Design and could differ from the elements listed above.

If slurry treatment is employed, the treated slurry will require dewatering and the water will be discharged on-site, in accordance with the substantive requirements of a NPDES permit, or treated at an off-site facility.

**Institutional Controls**

Long-term institutional controls will not likely be required. Data from site-specific treatability studies that will be performed prior to the Remedial Design will be analyzed to determine the need for long-term controls.

**Treatment Component**

The treatment component for soil under Alternative 2 is biological treatment, for which there are two primary process options: composting and slurry-phase treatment. Composting involves mixing contaminated soil with organic amendments and bulking agents in windrows, piles, or agitated vessels. The organic amendments are a primary carbon source that the organisms use for growth and energy. The bulking agents create an open matrix in the pile for promoting oxygen transfer within the pile. Indigenous thermophilic microorganisms cometabolically transform the contaminants to less toxic compounds or immobilize them in the compost matrix.

Slurry treatment could be conducted in an agitated vessel or lined pit. The slurry matrix facilitates contact among contaminants, microbes, nutrients, carbon sources, water, and electron acceptors. The slurry is assumed to consist of approximately 40 percent soil solids (EIMCO, 1992); however, following post-treatment dewatering of the treated sludge, the volume increase is not expected to be significant. In an aerobic system, oxygen is added by mechanical mixing, air injection, or hydrogen peroxide addition. However, the treatment could also be conducted under anaerobic conditions or alternating aerobic and anaerobic conditions. Indigenous organisms or a seed of acclimated organisms are added to the slurry to degrade the contaminants.

For the purposes of the detailed analysis of this alternative, a windrow compost treatment system is evaluated because USACE has composting experience at similar sites. Composting technology has been more extensively studied, to date, for explosives than has slurry-phase biological treatment. Pilot-scale composting data is available to estimate treatment effectiveness and costs. For the purposes of this FS, it is assumed that soil will be mixed with organic amendments, placed in windrows, and mechanically agitated

periodically using a windrow turner. Water will be added as needed to maintain optimal moisture condition. Costs for this alternative include a composting treatability study to determine site-specific effectiveness and design requirements. Results from the treatability study which will be performed prior to the Remedial Design will assist in the selection of monitoring equipment and to evaluate the need for run-on/run-off control. Additional slurry studies (anaerobic or aerobic) may also be conducted to obtain additional information on the effectiveness of slurry treatment.

The groundwater treatment component of this alternative consists of carbon adsorption of contaminants in groundwater used for domestic purposes in OU 1 exposure areas prior to completion of OU 2 activities if explosives concentrations above regulatory or health advisory limits are detected.

**Containment Component**

There is no containment associated with Alternative 2.

**Disposal Component**

Disposal may be required for debris and demolition materials. Debris and untreated material removed during pretreatment processing will be disposed in an off-site landfill. Potential treatment residuals include decontaminated soil mixed with additives (carbon sources, bulking agents, bacteria, or nutrients), and water. Composting will result in a larger volume of residuals than slurry-phase treatment, but will not require extensive dewatering needed in the slurry processes. Following sampling to verify the soil has been effectively treated, solid residuals will be placed back into excavations and vegetated. The increased volume of composting residuals would raise the overall grade of the backfill areas. Additional excess treated compost mixture is assumed to be used for general site grading, with the permission and guidance of the University of Nebraska. Water removed from the slurry dewatering could be recycled, treated off-site, or discharged on-site under a NPDES permit.

#### 4.3.2.2 Overall Protection of Human Health and the Environment

Implementation of this alternative reduces the risk to human health and the environment. Biological treatment may degrade or transform the contaminants to less toxic or less mobile products. Some degree of mineralization to carbon dioxide and water is expected. However, complete mineralization may not occur. By decreasing the source of contamination, migration of explosive contaminants to other media is controlled, and ingestion of explosives-contaminated soil is minimized. As noted previously, site-specific information on the effectiveness of slurry-based biological treatment for the NOP site (from lab- and bench-scale treatability studies) indicates that biological treatment may not achieve PRGs. However, these and other studies indicate that additional removal could be



B07NE003701-04773

achieved with further optimization of treatment conditions. A composting treatability study is required to obtain site-specific information on the effectiveness of composting. These studies will also help to optimize treatment conditions.

Treatment of groundwater used for domestic purposes in OU 1 exposure areas prior to completion of OU 2 activities provides additional protection to human health by reducing exposure to contaminants in water used for drinking, cooking, and washing.

#### 4.3.2.3 Compliance with ARARs

ARARs pertinent to Alternative 2 include:

Federal

- CAA.
- CWA.
- Public Health Service Act: Title XIV as amended by SDWA.
- SWDA as amended by RCRA.

State

- Water Quality Standards for Surface Water of the State.
- Rules and Regulations Pertaining to the Issuance of Permits Under the NPDES.
- Nebraska General NPDES Rules for New and Existing Sources: Effluent Guidelines and Standards.
- Rules and Regulations Governing the Nebraska Pretreatment Program.
- Rules and Regulations Pertaining to the Management of Wastes.
- Nebraska Air Pollution Control Regulations.

The Federal CWA and SDWA and the State regulations concerning surface water quality, NPDES, and pretreatment are pertinent to Alternative 2 because decontamination water used for excavation, consolidation, and processing equipment could be discharged to the surface, surface water, treated on-site, or disposed off-site. Surface or surface water discharge is acceptable for liquid residuals that meet the substantive requirements of the NPDES and the maximum contaminant levels (MCLs) of the SWDA. If decontamination water does not meet these requirements, then on-site or off-site treatment will be required prior to discharge. In any case, the action taken to dispose of the decontamination water will meet pertinent ARARs. SDWA regulations pertaining to household drinking water are relevant and appropriate to the point-of-use treatment system to be applied to domestic wells.

These regulations are also pertinent to the discharge of residual water from slurry-phase biological treatment, possibly containing additives or biomass. Residual water is not expected from composting. As discussed for decontamination water, water may either be discharged to the surface, surface water, or treated off-site.

RCRA is pertinent to Alternative 2 due to the small potential for treatment residuals to be classified as RCRA hazardous by characteristic. Post-treatment sampling will be performed to determine if residuals are hazardous. If they are, additional treatment will be required prior to placement in site excavations. As noted previously, biological treatability study data for the site soil indicate residuals will not be hazardous. Additional testing for RCRA will be performed on site-derived biological treatment residuals generated during treatability studies that will be conducted prior to Remedial Design.

Excavation, materials handling, treatment system construction, and operation may cause particulate emission concerns. Therefore, these activities must be controlled to meet the Nebraska air regulations and CAA requirements, as appropriate. Control measures, including water or other dust suppressant, truck tarpaulins, covers for soil stockpiles, and temporary structures for the treatment process train will be used to mitigate atmospheric releases.

State regulations concerning the management of wastes are included under this alternative because they include a section on composting facility construction and operation permits. The chapter on composting in the regulations is designated as "Reserved", and there are no current requirements listed.

#### 4.3.2.4 Long-term Effectiveness and Permanence

Alternative 2 reduces the long-term risk posed by the excavated soil by transforming the contaminants to other less toxic compounds. No soil sources of unacceptable risk or potential groundwater contamination are assumed to remain on-site following treatment and subsequent disposal of the residuals. Therefore, long-term management is not anticipated for the soil treatment system, however a 5-year review may be required. Data from treatability studies that will be conducted on site soil before the Remedial Design will be evaluated to determine the need for long-term controls. If the treatability study results, or post-treatment data if biological treatment is chosen as the OU 1 remedy, indicate that RAOs cannot be met, long-term controls may be required.

The long-term effectiveness of groundwater treatment systems will rely on adequate maintenance. Periodic testing will be required, as well as replacement and regeneration of carbon adsorbent materials.

Significant uncertainties are associated with this alternative because biological treatment has not been demonstrated on a full-scale basis for explosives and because sufficient removal to achieve PRGs has not been demonstrated for some compounds. Degradation products are often bound in the biomass or immobilized in polymers and are included in

the solid residuals. Relatively little is known about the degree of mineralization, products of degradation, and time of treatment. However, composting experiments have shown that TNT was irreversibly biodegraded. Uncertainties associated with land disposal of residuals include unknown toxicity and mobility of degradation products, the reversibility of biological transformation of some of the explosive compounds, and the degree and duration of immobilization of compounds. It should be noted, however, reversibility of chemically altered contaminants is not expected. Monitoring of intermediates will be performed during future site-specific treatability testing in order to make sound decisions concerning the effectiveness of biological treatment.

#### 4.3.2.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative satisfies the statutory preference for treatment. Pilot-scale studies have revealed over 99 percent reduction of TNT concentrations, and over 96 percent reduction in HMX concentrations (U.S. Army Environmental Center, 1993). This represents a potentially significant reduction of toxicity due to explosive compounds; however, further study may be necessary to determine the composition and toxicity of transformation products. The mobility and reversibility of these products is unknown. The volume of treated material is not reduced and may increase due to additives and amendments. Treated composting material may have the following breakdown: 30 percent soil, 35 percent manure (at least 50 percent biodegradable) and/or vegetable waste (biodegradable), and 35 percent alfalfa (partially biodegradable). Therefore, the final volume of treated, unbiodegradable material is estimated to be slightly more than twice the original starting volume. Biological treatment residuals consist of treated solids and extracted water if slurry treatment is used. Carbon-adsorption water treatment of domestic well water reduces the toxicity, mobility, and volume of contaminants in groundwater if drinking water wells are installed and used in OU 1 exposure areas prior to completion of OU 2 activities.

#### 4.3.2.6 Short-Term Effectiveness

Potential risks to the community and workers during remedial actions are primarily the result of emissions resulting from excavation, materials handling, construction, and transportation activities. These emissions will be controlled as needed by spraying a dust suppressant over excavation and transportation areas, staging the soil under plastic sheeting, and enclosing the soil in buildings during preparation and treatment. Truck beds will be covered during hauling of contaminated soil for the preprocessing facility. These control measures will minimize the quantity of contaminated soil that may become airborne and will minimize the potential inhalation, ingestion, and direct contact short-term risks from particulates to workers and nearby residents. Excavated soil will be screened, prepared, and stored in a staging structure to reduce emissions.



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Odors from some types of biological treatments pose a potential nuisance to site workers and often attract insects, birds and other animals. However, processing will take place in temporary structures to control any emissions that result. Workers may also be directly exposed to contaminated soil during excavation and handling activities. Proper protective equipment will be used to reduce the potential for direct exposure. Buried, unexploded ordnance and explosive wastes (OEW) may also pose a potential risk to the site workers. Specialized construction techniques (including blast shields, misting, sparkless tools, etc.) will be used to mitigate this risk if needed. Prior to initiating work on the site, the contractor must prepare and receive approval on a Health and Safety Plan (HASP). This plan includes a discussion of personnel protective equipment and safe work practices necessary for working on this site, as well as the following:

- Applicable regulatory requirements.
- Personnel responsibilities.
- Procedures and protocols.
- Decontamination.
- Training.
- Contingencies in case of emergency.
- Medical surveillance.

The plan will identify problems and hazards that may be encountered and their solutions. Procedures for protecting third parties, such as visitors or the surrounding community, will also be provided.

Construction activities will cause an increase in noise and traffic. Due to the isolated location of the site, these are not anticipated to present a significant problem for the surrounding community (including the University of Nebraska). However, limiting the work hours to daytime and controlling access in the areas of excavation and construction will help alleviate any impacts.

No significant environmental impacts are anticipated during implementation of this alternative.

Because the biological degradation rate (presently unknown) greatly affects implementation time, implementation time of this alternative, from site preparation to site restoration, is unknown and must be evaluated further. Based on assumptions made for biological treatment processing rate, the implementation time is estimated to be 32 months (see Appendix F1).

#### 4.3.2.7 Implementability

A number of site characteristics could complicate excavation of material. These include the possibility of unexploded ordnance and unidentified explosive hot spots, which could require specialized excavation equipment and techniques. The potential presence of large buried debris and distances between contaminated areas will affect implementation time.

Uncertainties associated with construction and operation of the treatment system exist because biological treatment has not been used on a full-scale basis for explosives.

Treatment effectiveness will be monitored using a treatment performance monitoring program. Monitoring of intermediates will be performed during treatability studies on site soil prior to the Remedial Design. The available services for biological treatment may be limited because very few specialists have experience with explosives treatment. It is assumed that standard construction materials and techniques, which are readily available, can be adapted for biological treatment.

Schedule delays are possible due to the use of live organisms, which are sensitive to changes in environmental or feed conditions. These delays are assumed to be minor.

Additional remediation (prior to final on-site disposal) could be easily implemented because the contaminated soil will already be consolidated. However, the material may be more difficult to handle if the volume has increased due to amendments.

On-site disposal of solid residuals will require the cooperation of the State, USEPA, and the University of Nebraska. Residuals will be amended with site soil to support vegetation, if necessary, and provide structural stability. Based on current information on immobilization of compounds by composting, no long-term controls are assumed.

Services and materials required for installation of carbon-adsorption water treatment systems are readily available from a number of vendors.

Permits for off-site disposal of debris and demolition material and for discharge of residual water (off-site) should be easily obtained. Substantive permit requirements for any on-site discharge of residual water should be easily attained.

#### 4.3.2.8 Cost

Conceptual costs for Alternative 2, based on composting biological treatment, are summarized in Table 4-1. The estimated capital cost is $6,517,000 for 8,400 cubic yards. This includes site preparation, soil removal, treatment system construction, treatment, and site restoration. Annual costs include groundwater treatment system O & M. The total estimated present worth cost for Alternative 2 is $8,517,000. Detailed cost calculations and assumptions are presented in Appendix F1.

**TABLE 4-1**

**CONCEPTUAL COSTS FOR ALTERNATIVE 2**
**(BIOLOGICAL TREATMENT)**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| | |
|---|---|
| Capital Costs: | |
| Soil Removal | $245,000 |
| Biological Treatment | $3,555,000 |
| Treated Soil Placement | $84,000 |
| Residuals Management | $75,000 |
| Groundwater Treatment | $57,000 |
| Equipment Salvage | $-124,000 |
| Subtotal Capital Costs | $3,892,000 |
| Site Preparation/Restoration (5%) | $195,000 |
| Mobilization/Demobilization (5%) | $195,000 |
| Health & Safety (8%) | $311,000 |
| Prime Fixed Fee (5%) | $195,000 |
| Subtotal | $4,787,000 |
| Bonds and Insurance (1%) | $48,000 |
| Subtotal | $4,835,000 |
| Scope Contingency (20%) | $967,000 |
| Permitting and Legal (5%) | $242,000 |
| Design Engineering (8%) | $387,000 |
| Construction-Related Services (8%) | $387,000 |
| Total Capital Cost | $6,817,000 |
| O&M Annual Costs | $124,000 |
| O&M Present Worth Cost (6% discount rate) | $1,700,000 |
| Total Present Worth Cost | $8,517,000 |

Note: Costs based on 8,400 cubic yards.
Costs are rounded to the nearest one thousand dollars.

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### 4.3.3 Alternative 3 - Excavation, Consolidation, Debris Management, Thermal Treatment, Residuals Management, and Groundwater Treatment at Point-of-Use

#### 4.3.3.1 Description

Alternative 3 treats contaminated soil using on-site thermal treatment. The preliminary component diagram is shown in Figure 4-4. Figure 4-5 shows the potential site layout for this alternative.

The following activities are assumed for the purposes of this document for implementation of this alternative:

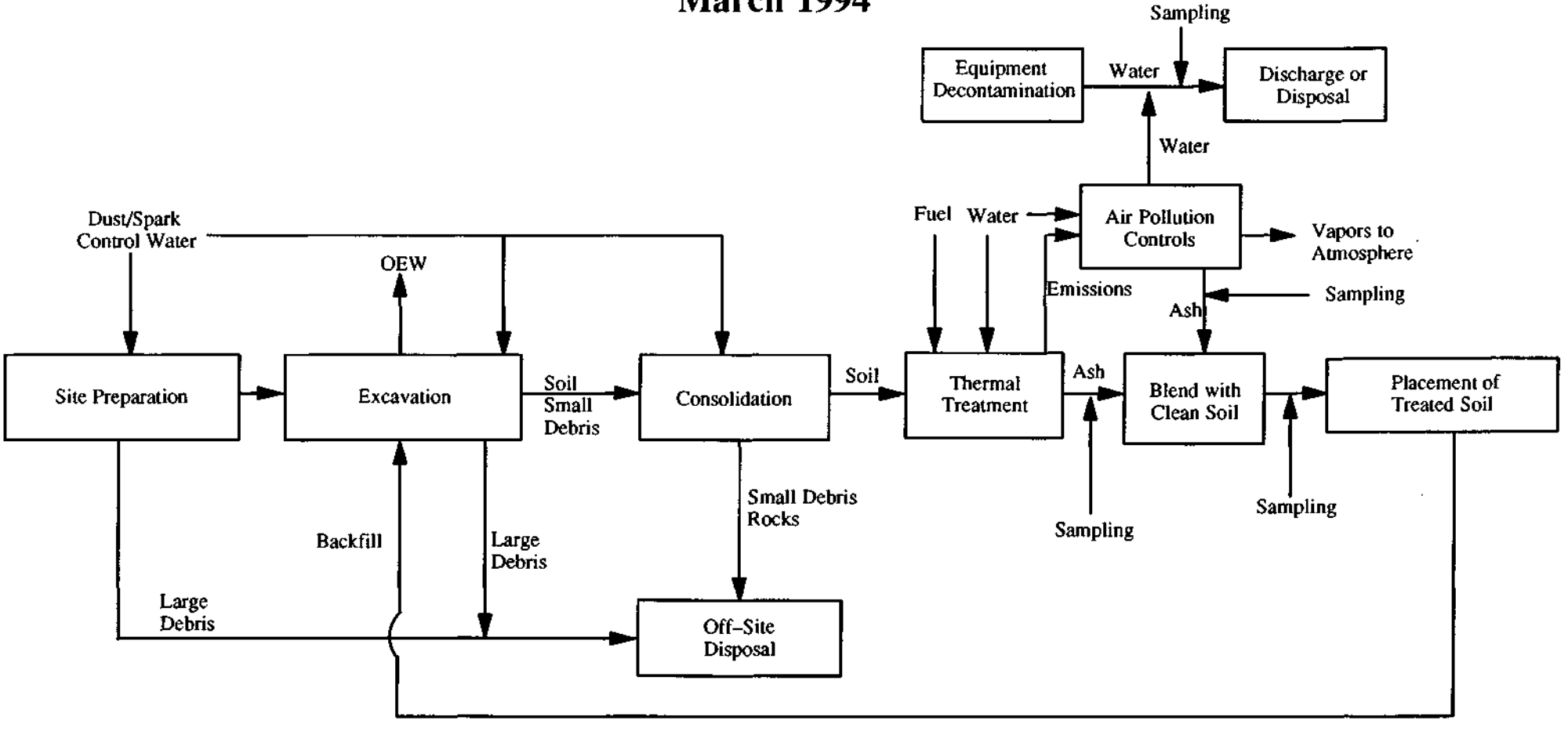
- Excavate contaminated soil and debris from source areas.
- Haul excavated soil to material staging area and stockpile.
- Screen the soil in an enclosed structure (preprocessing facility) to remove or reduce large particles and blend it prior to treatment. Blending is intended to reduce any surges in explosives concentration which may be detrimental to treatment.
- Treat contaminated soil using thermal treatment to treatment PRGs and verify through testing.
- Test soil treatment residual to verify ash is not TCLP characteristic.
- Blend solid treatment residuals with clean soil, as necessary or appropriate, to sustain vegetation; return to source areas and vegetate.
- Dispose debris and demolition material in an off-site landfill.
- Install carbon-adsorption system if domestic wells are installed and used in the OU 1 exposure areas prior to completion of OU 2 activities and water from those wells has explosives concentrations exceeding health advisories or regulatory limits.

The actual elements of the alternative will be finalized during the Remedial Design and could differ from the elements listed above.

**Institutional Controls**

Long-term institutional controls will not be required.

# Figure 4–4
# PRELIMINARY COMPONENTS OF ALTERNATIVE 3
## Former NOP Site
## Operable Unit 1 FS
## Mead, Nebraska
## March 1994




OEW = Ordnance and Explosive Waste

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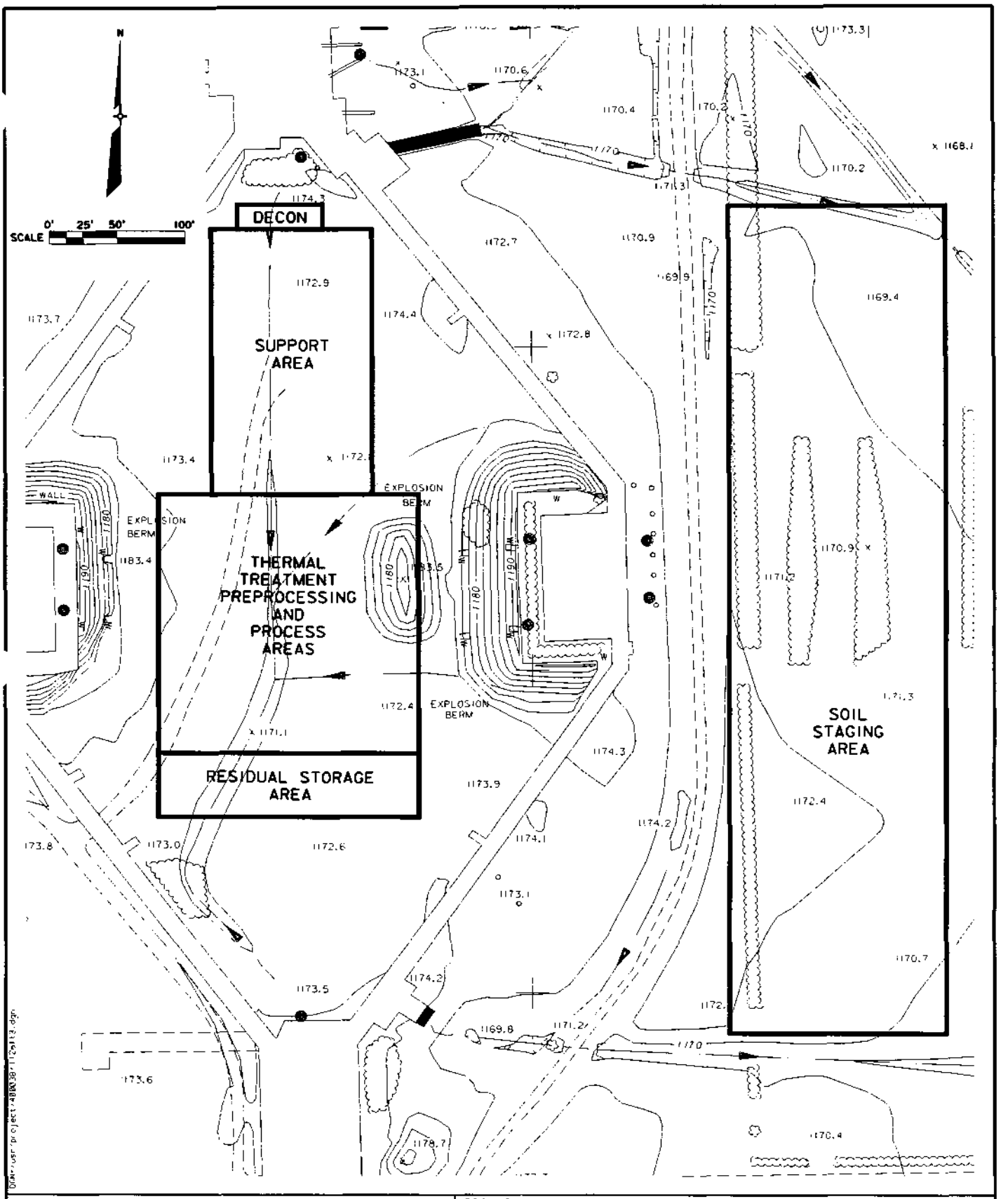


RUST ENVIRONMENT & INFRASTRUCTURE

MARCH 1994

# FIGURE 4-5

19536

## LOAD LINE 2 - ALTERNATIVE 3 POTENTIAL SITE LAYOUT

FINAL FEASIBILITY STUDY - OPERABLE UNIT I
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

**Treatment Component**

Thermal treatment under Alternative 3 could be accomplished by one of several process options. The rotary kiln destroys contaminants by passing them through a high temperature rotating drum and a high-temperature secondary combustion chamber. LTTD uses rotary shells at somewhat lower temperatures to vaporize organic compounds which can then be incinerated at high temperature with an afterburner. Secondary treatment of the vaporized gas stream can also be accomplished by carbon adsorption or condensation, but these methods are less desirable because they utilize contaminant phase transfer rather than destruction. Phase transfer could also result in concentration of explosives in the liquid or adsorbed phase. Vitrification uses temperatures of 1600 to 2000 degrees Celsius to electrically melt contaminated soil, thereby thermally destroying or removing organic contaminants and immobilizing inorganic compounds. Trial burns may be required depending on the technology applied.

The groundwater treatment component of this alternative consists of carbon adsorption of contaminants in groundwater used for domestic purposes, should drinking water wells be installed and used in the OU 1 exposure areas prior to completion of OU 2 activities and water from those wells contains explosives concentrations greater than health advisories or regulatory limits.

**Containment Component**

No containment is associated with Alternative 3.

**Disposal Component**

Disposal will be required for thermal treatment residuals. Residuals for rotary kiln incineration could consist of kiln ash, fly ash, and scrubber water. Solid residuals should not require solidification/ stabilization, prior to replacement into excavated areas and vegetation because the rotary kiln Treatability Study data indicate that the ash is not RCRA characteristic. Clean soil may be mixed with ash after testing and prior to replacement to improve its physical properties and ability to support vegetation. Scrubber water can be used as quench water or for dust control. LTTD using secondary combustion will produce residuals similar to that of a rotary kiln, which can be managed in the same manner. Vitrification residuals consist of large, solid, glass-like masses that will be left in place. Debris and demolition material will be disposed in an off-site landfill.

#### 4.3.3.2 Overall Protection of Human Health and the Environment

This alternative will protect both human health and the environment. Thermal treatment of excavated soil is expected to destroy the explosive compounds, therefore, the risk posed by the source area soil will be eliminated. Treatment of groundwater used for domestic purposes provides additional protection to human health by reducing exposure to contaminants in water used for drinking, cooking, and washing, should drinking water wells be installed in OU 1 exposure areas prior to the completion of OU 2 activities.

#### 4.3.3.3 Compliance with ARARs

ARARs pertinent to Alternative 3 include:

Federal

- CAA.
- CWA.
- Public Health Service Act: Title XIV as amended by SDWA.
- SWDA as amended by RCRA.

State

- Water Quality Standards for Surface Water of the State.
- Rules and Regulations Pertaining to the Issuance of Permits Under NPDES.
- Nebraska General NPDES Rules for New and Existing Sources: Effluent Guidelines and Standards.
- Rules and Regulations Governing the Nebraska Pretreatment Program.
- Nebraska Air Pollution Control Regulations.

As discussed under Alternative 2, the Federal CWA and SWDA and the State regulations on surface water quality, NPDES, and pretreatment must be met for decontamination water under Alternative 3. These regulations are also pertinent to the discharge of process water . Process water may either be recycled to quench the ash, sprayed back on-site for dust control, discharged to the surface or surface water, or treated off-site.

RCRA is pertinent to Alternative 3 due to the potential for residuals from thermal treatment to fail TCLP for metals, making the residuals hazardous as determined by RCRA. Post-treatment sampling will be performed to determine if residuals are hazardous. If they are, stabilization/solidification will be required prior to placement into site excavations in order to meet RCRA. As noted previously, the results from the incineration Treatability Study on site soil indicate that process residuals will not fail TCLP.

Excavation and materials handling may cause particulate emission concerns. As in Alternative 2, measures will be employed to address these concerns and meet ARARs. Thermal treatment emissions of particulate matter and nitrogen dioxide are of particular concern due to the soil type and contaminants. The air pollution control systems for the various thermal treatment systems will be designed to meet the emission standards included in the State air pollution control regulations and CAA requirements, as appropriate. SDWA regulations are relevant and appropriate to domestic well groundwater treatment systems.

#### 4.3.3.4 Long-term Effectiveness and Permanence

The risks remaining after implementation of this alternative are estimated to be less than target levels due to contaminant destruction. Rotary kiln incineration is capable of greater than 99 percent destruction of explosive contaminants. The treatability study conducted using vitrification indicates that vitrification will achieve the same level of reduction. LTTD may also achieve RAOs. Neither long-term management of the site nor a 5-year review will be required under this alternative because no explosives in concentrations above PRGs will remain on-site above a depth of 4 feet from the ground surface following excavation and treatment.

The long-term effectiveness of the potential groundwater treatment system will rely on adequate maintenance. Periodic testing will be required, as will replacement and regeneration of carbon absorbent materials.

#### 4.3.3.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative satisfies the statutory preference for treatment as a principal element. Thermal treatment using rotary kiln or vitrification (based on the treatability study) will irreversibly reduce the toxicity and mobility of the explosive contaminants. Greater than 99 percent destruction of the explosive contaminants is expected, virtually eliminating toxicity and mobility. The volume will decrease due to removal of moisture and organic content during treatment. A net soil volume decrease of approximately 35 percent was observed in the Treatability Study. However, the volume of contaminated soil is reduced by more than 99 percent since explosives contaminants are destroyed. Similar reductions of toxicity, mobility, and volume are expected for LTTD.

Vitrification is expected to achieve a high destruction efficiency, as indicated by the Treatability Study. Toxicity is expected to be reduced because the high temperatures utilized will destroy organic contaminants. Metals should be effectively immobilized in the remaining vitrified mass. A volume reduction of approximately 40 percent was observed in the Treatability Study. Each thermal treatment process option is expected to be irreversible.

Carbon-adsorption water treatment of domestic well water reduces the toxicity, mobility, and volume of contaminants in groundwater if drinking water wells are installed and used in OU 1 exposure areas prior to completion of OU 2 activities.

#### 4.3.3.6 Short-Term Effectiveness

The potential risks to workers and the community from dust emissions and the measures implemented to address these risks are the same as in Alternative 2. Thermal treatment emissions will be minimized by using appropriate air pollution control equipment. Such

equipment typically includes scrubbers to remove particulates and neutralize acid gases, and afterburners to destroy remaining contaminants or combustion products.

If thermal treatment is selected, a health and safety plan should be implemented to avoid incidents related to high-temperature activities. Other concerns regarding worker safety and construction activities will be similar to those discussed in previous alternatives.

Unless air pollution control equipment fails, no significant environmental impacts would be anticipated during implementation of this alternative. The air pollution control system has redundant equipment to avoid failure.

No significant environmental impacts are expected to occur during installation of groundwater treatment systems.

The implementation time for this alternative, from site preparation to site restoration, is estimated to be 15 months.

#### 4.3.3.7 Implementability

Implementability issues related to excavation are similar to those noted under general site elements. Rotary kiln is the only thermal treatment process option with proven effectiveness for explosives-contaminated soils and, therefore, should be implementable. The other thermal process options may be more difficult to implement because they have not been demonstrated on a full-scale basis for explosives. Services and equipment for rotary kiln incineration are readily available from several vendors. Availability of other thermal treatment options for explosives may be more limited. The availability of fuel, water, and electrical power (for vitrification) will also affect implementability. Materials handling could pose technical problems and schedule delays for all types of thermal treatment due to the high clay content of the soil, but standard procedures exist to minimize material handling difficulties.

Before final on-site disposal of residuals, expansion or additional remedial action would be easily implemented because the contaminated material will already be consolidated.

On-site disposal of solid treatment residuals will require the cooperation of the State, USEPA, and the University of Nebraska. Residuals will be blended with clean soil, as necessary, covered with topsoil and vegetated. Once disposed, no long-term controls will be required.

Services and materials for carbon-adsorption water treatment systems are readily available from a number of vendors.

Trial burns will require coordination and approval by the State and USEPA. Permits for off-site disposal of debris and demolition material, and for off-site discharge of residual water (if used) should be easily obtained. Substantive requirements for permits for on-site discharge of residual water and equipment washwater should also be easily achieved.

#### 4.3.3.8 Cost

Conceptual costs for Alternative 3 for a remediation volume of 8,400 cubic yards are summarized in Table 4-2. The estimated capital cost is $12,543,000. This cost includes site preparation, soil removal, treatment, and site restoration. Annual costs include groundwater treatment system O&M. The total estimated present worth cost is $14,243,000. Detailed cost calculations and assumptions are presented in Appendix F2.

### 4.3.4 Alternative 4 - Excavation, Consolidation, Debris Management, On-Site Landfill, Deed Restrictions, Groundwater Monitoring, and Groundwater Treatment at Point-of-Use

#### 4.3.4.1 Description

Alternative 4 minimizes the potential for exposure pathway completion through on-site containment of contaminated soil in an on-site landfill. The landfill will be designed to meet engineering controls described in RCRA Subtitle C landfill regulations or provide equivalent performance. The preliminary component diagram is shown in Figure 4-6, and the potential site layout is shown in Figure 4-7.

The following activities are assumed for the purposes of this document for implementation of this alternative:

- Clear, grub, and excavate soil from the landfill site, and construct the liner and leachate collection system. The liner will meet Subtitle C design requirements or be designed to provide equivalent performance.

- Excavate contaminated soil and debris from source areas. Manually separate oversized debris to be shredded in the staging area. Backfill excavations using clean fill, compact backfill, and revegetate the surface.

- Haul excavated soil and separated debris to the landfill area, shred debris in the debris processing area, and consolidate shredded debris with the soil in the landfill.

- Construct a cover over the consolidated soil and debris. The cover will meet performance requirements for a Subtitle C landfill.

- Erect a fence around the landfill area and implement deed restrictions.

**TABLE 4-2**

**CONCEPTUAL COSTS FOR ALTERNATIVE 3**
**(THERMAL TREATMENT)**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| | |
|---|---|
| Capital Costs: | |
| Soil Removal | $245,000 |
| Thermal Treatment | $7,091,000 |
| Treated Soil Placement | $42,000 |
| Residuals Management | $98,000 |
| Groundwater Treatment | $57,000 |
| Equipment Salvage | -$27,000 |
| Subtotal Capital Cost | $7,464,000 |
| Site Preparation/Restoration (5%) | $373,000 |
| Health & Safety (8%) | $597,000 |
| Prime Fixed Fee (5%) | $373,000 |
| Subtotal | $8,808,000 |
| Bonds and Insurance (1%) | $88,000 |
| Subtotal | $8,896,000 |
| Permitting and Legal (5%) | $445,000 |
| Design Engineering (8%) | $712,000 |
| Construction Services (8%) | $712,000 |
| Scope Contingency (20%) | $1,779,000 |
| Total Capital Cost | $12,543,000 |
| Annual O&M Costs | $124,000 |
| O&M Present Worth Cost (6% discount rate) | $1,700,000 |
| Total Present Worth Cost | $14,243,000 |

Note: Costs based on 8,200 cubic yards.
Costs rounded to the nearest one thousand dollars.

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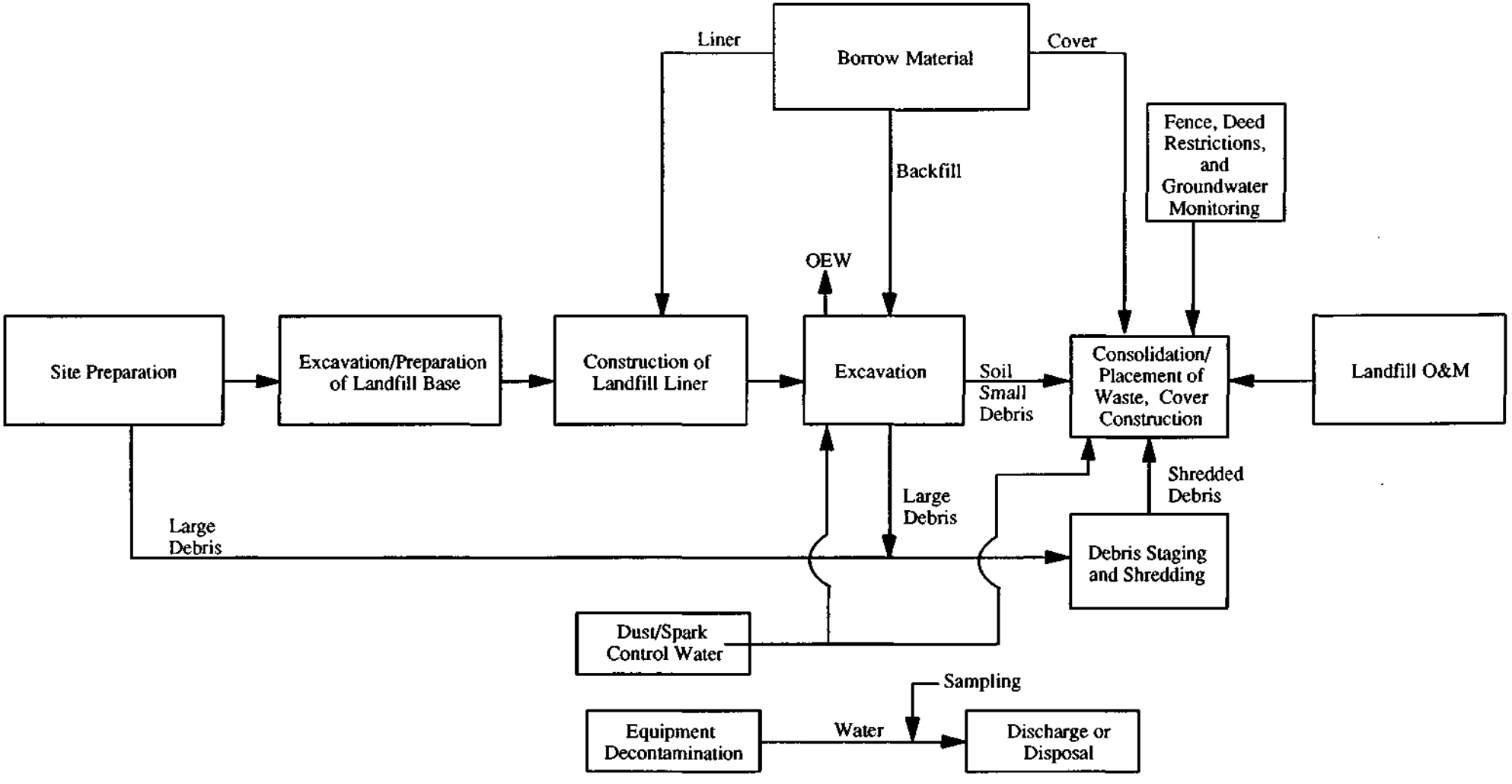
# Fig' ' 4–6
# PRELIMINARY COMPONENTS OF ALTERNATIVE 4
## Former NOP Site
## Operable Unit 1 FS
## Mead, Nebraska
## March 1994




OEW = Ordnance and Explosive Waste

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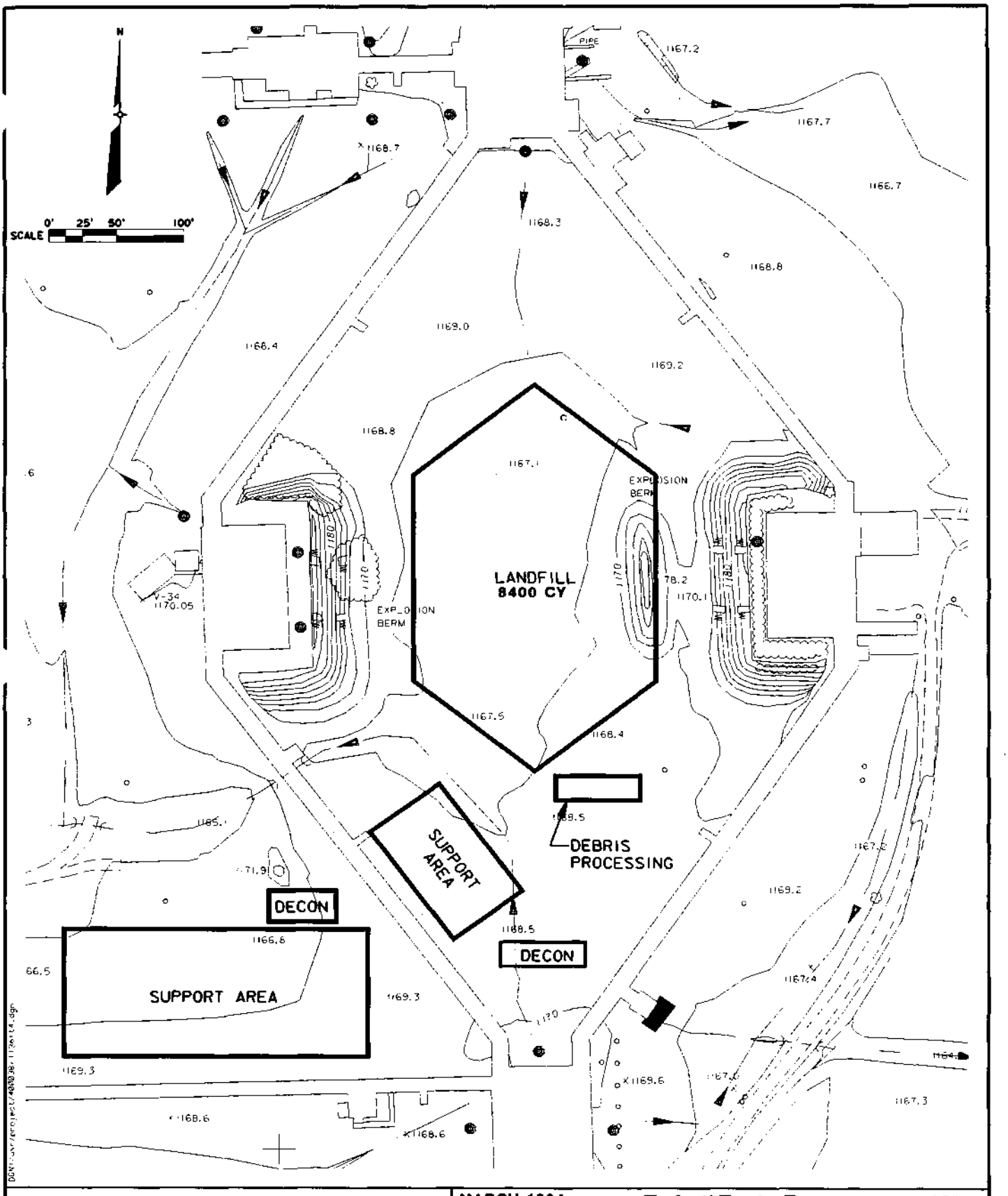


MARCH 1994

# FIGURE 4-7

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## LOAD LINE 3 - ALTERNATIVE 4 POTENTIAL SITE LAYOUT

FINAL FEASIBILITY STUDY - OPERABLE UNIT I
FORMER NEBRASKA ORDNANCE PLANT
MEAD, NEBRASKA

RUST ENVIRONMENT & INFRASTRUCTURE

- Conduct groundwater monitoring.

- Conduct quarterly leachate collection. Leachate will be discharged under an NPDES permit or treated and disposed off-site. For costing purposes, it is assumed that pretreatment of leachate before discharge will not be necessary.

- Dispose demolition material in an off-site landfill.

- Install carbon-adsorption system at each domestic well installed and used in OU 1 exposure areas prior to completion of OU 2 activities if water from that well contains explosives concentrations exceeding health advisory or regulatory limits.

The actual elements of the alternative will be finalized during the Remedial Design and could differ from the elements listed above.

**Institutional Controls**

Institutional controls include a fence and deed restrictions which limit access, use, and water well installation, and groundwater monitoring.

**Treatment Component**

No soil treatment is associated with Alternative 4. The groundwater treatment component of this alternative consists of carbon adsorption of contaminants in groundwater used for domestic purposes if domestic wells are installed and used in OU 1 exposure areas prior to completion of OU 2 activities and water from those wells contains explosives concentrations exceeding health advisory or regulatory limits.

**Containment/Disposal Component**

An on-site disposal facility (landfill) contains the contaminated soil and debris, minimizing ingestion of contaminated soil. It also limits infiltration through the material and minimizes erosion.

Decontamination liquids and demolition materials will be disposed of as indicated in Section 4.2.7 and 4.2.8.

#### 4.3.4.2 Overall Protection of Human Health and the Environment

Implementation of this alternative reduces the risk to human health and the environment by minimizing exposure to contaminated soil. In excavation areas, removal will reduce residual soil pathway risk. By containing the excavated soil in the landfill and restricting use and access, ingestion of explosives-contaminated soil is minimized. Maintenance of the landfill components and deed restrictions are essential to maintaining the protectiveness of the alternative since there is no destruction of explosives contaminants.

Treatment of groundwater used for domestic purposes provides additional protection to human health by reducing exposure to contaminants in water used for drinking, cooking, and washing if domestic wells are installed and used in OU 1 exposure areas prior to completion of OU 2 activities.

#### 4.3.4.3 Compliance with ARARs

ARARs pertinent to Alternative 4 include:

Federal

- CAA.
- CWA.
- Public Health Service Act: Title XIV as amended by the SDWA.
- SWDA as amended by RCRA.

State

- Water Quality Standards for Surface Water of the State.
- Rules and Regulations Pertaining to the Issuance of Permits Under the NPDES.
- Nebraska General NPDES Rules for New and Existing Sources: Effluent Guidelines and Standards.
- Rules and Regulations Governing the Nebraska Pretreatment Program.
- Nebraska Air Pollution Control Regulations.
- Rules and Regulations Pertaining to Solid Waste Management (Title 132).
- Regulations Governing Licensure of Water Well and Pump Installation Contractors and Certification of Water Well Drilling and Pump Installation Supervisors.

As discussed under previous alternatives, the Federal CWA and SDWA and the State regulations (or their substantive requirements for on-site activities) on surface water quality, NPDES, and pretreatment must be met for decontamination water under Alternative 4. Discharge will meet these ARARs, which are also applicable to leachate. SDWA regulations are relevant and appropriate to domestic well groundwater treatment systems.

The State water well regulations are pertinent because monitoring wells will be installed after landfill construction to monitor the landfill's long-term effectiveness. Accurate monitoring data depends upon the correct well installation. Therefore, the State has specific qualification requirements for the contractors. This ARAR will be met by employing qualified contractors and personnel during well installation.

The engineering controls of RCRA related to the cap and liner system may be relevant and appropriate to Alternative 4 because engineering controls will either be as described in Subtitle C or provide equivalent performance. Additional State requirements regarding siting and prevention of contaminant migration will also be satisfied by the landfill design. The cover configuration will either satisfy the NDEQ requirement of 2 feet of earthen cover or provide equivalent performance.

#### 4.3.4.4 Long-term Effectiveness and Permanence

The soil exposure risks at the former NOP site after implementation of this alternative will be reduced because the soil exposure pathway will no longer be complete. Access and use restrictions may further reduce the potential for ingestion of soil. Soil sources of excessive risk from explosives will be minimized as long as the landfill is properly maintained and the deed restrictions are sufficiently controlled. Furthermore, proper collection and disposal of the leachate generated by the landfill will minimize potential future groundwater contamination. Therefore, perpetual management of the site is essential for the successful implementation of this alternative.

A 5-year review is required for this alternative, since CERCLA 121(c) states that any remedial action resulting in pollutants or contaminants remaining on-site must be reviewed at least once every five years. This review will be conducted to determine whether human health and the environment continue to be protected by the remedy. Additional action may be required if this review reveals that this protection is not sustained.

Based on successful use of the landfill to control erosion and minimize infiltration, it is likely this alternative will provide effective long-term containment at the former NOP site. However, long-term effectiveness relies on inspection and maintenance. Long-term management includes landfill inspection and maintenance, fence maintenance, quarterly leachate collection, leachate collection system maintenance, groundwater monitoring, and deed enforcement. Because freeze-thaw cycles, rodents, erosion, and vandalism may cause damage to the landfill, damaged areas could pose risk until repaired. Semi-annual mowing of cover vegetation will help prevent large plants from establishing roots that could penetrate the cover surface, damaging its integrity. Site fencing may require repair due to vandalism, weather, or age. Inspection and maintenance of the landfill and fence will follow the groundwater monitoring schedule. Groundwater monitoring is assumed to be conducted as discussed in Section 4.2.9. Deed restrictions are not legally enforceable and have been historically difficult to control. Fence upkeep, sufficient posting of signs, and cooperation on the part of the University of Nebraska or the State will assist in enforcing the deed restrictions.

Landfilling is relatively simple to maintain. The greatest long-term concern lies with implementation of long-term deed and access restrictions and adherence to maintenance schedule. Therefore, perpetual management is required for the success of this alternative.

The long-term effectiveness of groundwater treatment systems will also rely on adequate maintenance. Periodic testing will be required, as will replacement and regeneration of carbon adsorbent materials.

#### 4.3.4.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative does not meet the statutory preference for treatment of contaminated media (soil). Containment and control of infiltration minimize the mobility of the contaminants. However, containment through landfilling is reversible. Contaminants remain on-site and it is possible the landfill could be breached to expose potential receptors. Therefore, perpetual management is required to maintain landfill integrity. Domestic well groundwater treatment reduces toxicity, mobility, and volume of contaminated groundwater.

#### 4.3.4.6 Short-Term Effectiveness

Short-term effectiveness, environmental impacts, and risks are similar to those for Alternative 2.

Implementation time for this alternative, from site preparation to closure, is estimated to be 8 months (see Appendix F3).

#### 4.3.4.7 Implementability

Implementability issues related to excavation are similar to those noted under General Site Elements. Implementation of the primary containment component is not difficult since landfills have been constructed at a wide variety of sites. The materials and services required for landfill construction are readily available. However, as noted previously, land availability has not been finalized and may be an issue.

If a failure of the cover does occur, repair or even replacement is easily accomplished. The effort associated with liner or leachate collection system repair or replacement would be greater than initial construction of the landfill. Repair of the liner or leachate collection system would be complicated because it would require excavation of the cover and waste. The landfill would have to be expanded since the cover material would probably be considered contaminated. Replacement of the entire landfill would require a larger capacity landfill since the cover, liner, and leachate system material would probably be considered contaminated.

The maintenance and groundwater monitoring programs included under this alternative should be adequate to detect failure of the landfill.

Implementation of long-term controls, including landfill maintenance, groundwater monitoring, and deed control, will be accomplished through cooperation between the USACE, NDEQ, and University of Nebraska.

Substantive permits requirements for on-site discharge of equipment washwater during construction and leachate following closure should be easily met. If liquids are discharged off-site, permits should be easily obtained.

Service and materials for carbon-adsorption water treatment systems are readily available from a number of vendors.

#### 4.3.4.8 Cost

Alternative 4 conceptual costs for 8,400 cubic yards are summarized in Table 4-3. The estimated capital cost is $1,498,000. This cost includes site preparation, soil removal, landfill construction, and site restoration. The annual costs include groundwater treatment O&M. The total estimated present worth costs is $3,698,000. Detailed cost calculations and assumptions are presented in Appendix F3.

### 4.3.5 Alternative 5 - Excavation, Consolidation, Debris Management, Off-Site Landfill, and Groundwater Treatment at Point-of-Use

#### 4.3.5.1 Description

Alternative 5 removes source material (contaminated soil) from the site for disposal in an off-site landfill with engineering controls meeting the technical requirements described in RCRA Subtitle C. The preliminary component diagram is shown in Figure 4-8.

The following activities are assumed for the purposes of this document for implementation of this alternative:

- Excavate contaminated soil and debris from source areas. Reduce size of debris, as necessary, to fit into transport trucks. Backfill excavations using clean fill, compact backfill, and revegetate the surface.

- Haul excavated soil, separated debris, and demolition material to an off-site landfill with engineering controls meeting the requirements described in RCRA Subtitle C.

- Install carbon-adsorption system at each domestic well installed and used in OU 1 exposure areas prior to completion of OU 2 activities if water from that well contains explosives concentrations above health advisory or regulatory limits.

The actual elements of the alternative will be finalized during the Remedial Design and could differ from the elements listed above.

Institutional Controls

No institutional controls are required under this alternative.

## TABLE 4-3

## CONCEPTUAL COSTS FOR ALTERNATIVE 4
## (ON-SITE LANDFILL)
## Former NOP Site
## Operable Unit 1 FS
## Mead, Nebraska
## March 1994

| | |
|---|---|
| Capital Costs: | |
| Soil Removal | $304,000 |
| Landfill Construction | $404,000 |
| Groundwater Treatment | $57,000 |
| Monitoring Wells | $50,000 |
| Subtotal Capital Cost | $815,000 |
| Site Preparation/Restoration (5%) | $41,000 |
| Mobilization/Demobilization (5%) | $41,000 |
| Health and Safety (8%) | $65,000 |
| Prime Fixed Fee (5%) | $41,000 |
| Subtotal | $1,002,000 |
| Bonds and Insurance (1%) | $10,000 |
| Subtotal | $1,012,000 |
| Scope Contingency (20%) | $202,000 |
| Permitting and Legal (5%) | $51,000 |
| Design Engineering (8%) | $152,000 |
| Construction Services (8%) | $81,000 |
| Total Capital Cost | $1,498,000 |
| Annual O&M Cost (years 1-5) | $166,000 |
| Annual O&M Cost (years 6-30) | $148,000 |
| Annual O&M Cost (after year 30) | $26,000 |
| O&M Present Worth Cost (6%)* | $2,200,000 |
| Total Present Worth Cost (6%)* | $3,698,000 |

* Assumes quarterly monitoring for years 1 through 5 and annual monitoring thereafter.

Note: Costs based on 8,200 cubic yards.
Costs rounded to the nearest one thousand dollars.

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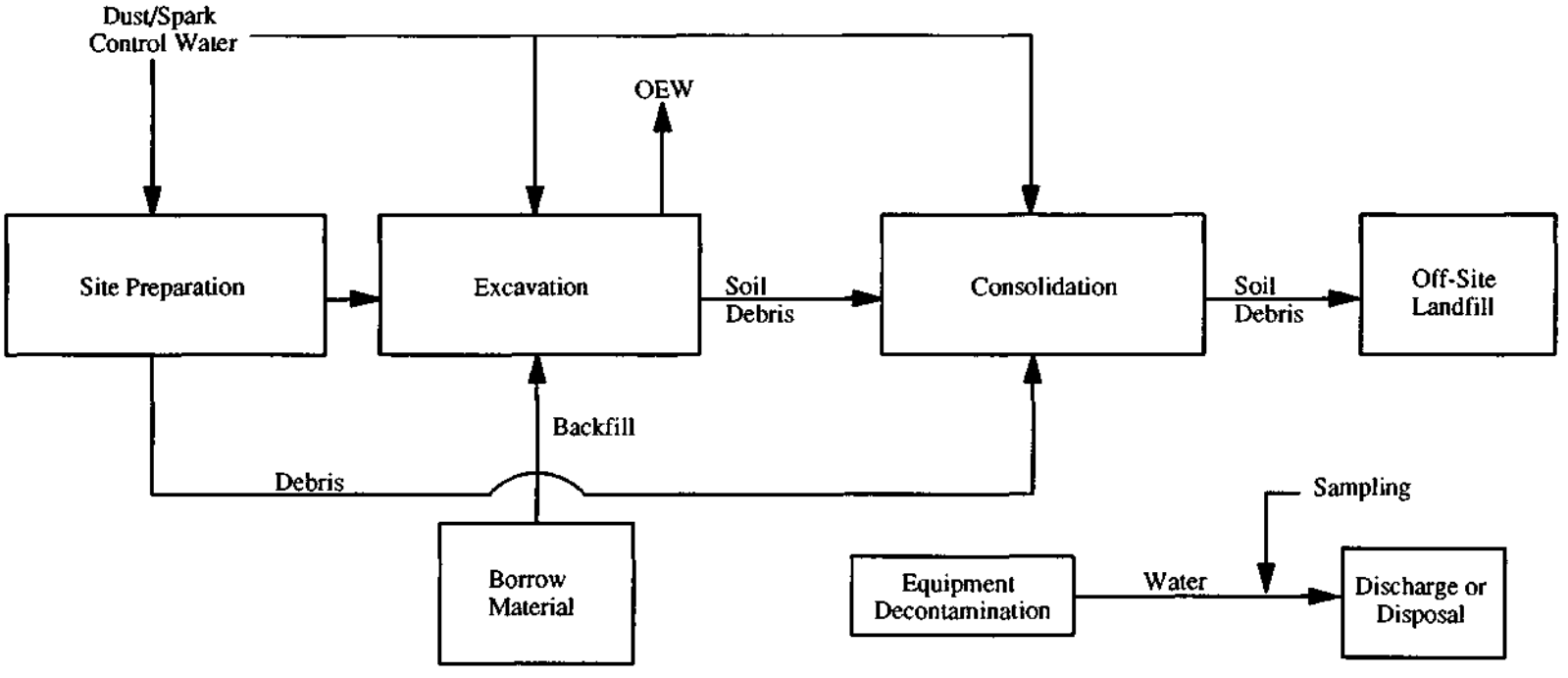
# Figure 4–8
# PRELIMINARY COMPONENTS OF ALTERNATIVE 5
## Former NOP Site
## Operable Unit 1 FS
## Mead, Nebraska
## March 1994




OEW = Ordnance and Explosive Waste

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**Treatment Component**

No soil treatment is associated with Alternative 5. The groundwater treatment component of this alternative consists of carbon adsorption of contaminants in groundwater used for domestic purposes if explosives concentrations in the water exceed health advisory or regulatory limits.

**Containment Component**

No containment component is associated with Alternative 5.

**Disposal Component**

All excavated material will be disposed in an off-site landfill with engineering controls meeting the requirements described in RCRA Subtitle C.

Demolition material and decontamination water are assumed to be disposed as discussed under General Site Elements.

#### 4.3.5.2 Overall Protection of Human Health and the Environment

Implementation of this alternative reduces the risk to human health and the environment by removing the contaminated soil. By placing the soil in an engineered landfill off-site, migration of contaminants to other media is minimized. The soil ingestion pathway, which causes potential risk on-site, and leaching of explosive contaminants to groundwater will be minimized by off-site disposal. However, off-site landfilling without treatment is the least preferred alternative under the NCP (USEPA, 1988).

Treatment of groundwater used for domestic purposes provides additional protection to human health by reducing exposure to contaminants in water used for drinking, cooking, and washing.

#### 4.3.5.3 Compliance with ARARs

ARARs pertinent to Alternative 5 include:

Federal

- CAA.
- Public Health Service Act: Title XIV as amended by the SDWA.
- Hazardous Materials Transportation Act (HMTA).
- SWDA as amended by RCRA.

State

- Water Quality Standards for Surface Water of the State.
- Rules and Regulations Pertaining to the Issuance of Permits Under the NPDES.
- Nebraska General NPDES Rules for New and Existing Sources: Effluent Guidelines and Standards.
- Rules and Regulations Governing the Nebraska Pretreatment Program.
- Nebraska Air Pollution Control Regulations.

As discussed under previous alternatives, the Federal CWA and SDWA and the State regulations on surface water quality, NPDES and pretreatment must be met for Alternative 5 for decontamination water. The washwater discharge will meet all ARARs as discussed under previous alternatives. SDWA regulations are relevant and appropriate to domestic well groundwater treatment systems.

The HMTA was implemented to control the transportation of RCRA hazardous materials on public systems. It includes regulations on the type of material transported, the containers and vehicles in which the material is transported, and the safety control and documentation associated with the transport of the material. Although this regulation is not strictly applicable because the contaminants on-site are not RCRA hazardous, it is relevant and appropriate because CERCLA materials are being transported off-site. All requirements of this regulation will be met under this alternative.

Excavation, materials handling, and landfill construction may cause particulate emission concerns. Control measures discussed under previous alternatives will be implemented to meet the State air pollution regulations and CAA requirements, as appropriate. Although off-site requirements are not pertinent to this alternative, it is important to note that the off-site landfill used for disposal must conform to Federal and State requirements, including Subtitle C requirements.

#### 4.3.5.4 Long-term Effectiveness and Permanence

The risks due to soil pathways remaining at the former NOP site after implementation of this alternative will be minimized. The off-site landfill is assumed to meet standards of construction and operation and thus control potential risks off-site due to the contaminants.
The long-term effectiveness of groundwater treatment systems will rely on adequate maintenance. Periodic testing will be required, as will replacement and regeneration of carbon-adsorbent materials.

As Alternative 5 provides removal of contaminated soil to a depth of 4 feet, future operation and maintenance, long-term management, and long-term monitoring on-site are not needed.

#### 4.3.5.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative does not satisfy the statutory preference for treatment. However, contaminant toxicity, mobility, and volume are reduced at the site. Also, containment and control of infiltration minimize the mobility of the contaminants off-site. Containment through landfilling, however, is reversible. Point-of-use treatment of groundwater used for domestic purposes reduces the toxicity, mobility, and volume of contaminated groundwater.

#### 4.3.5.6 Short-Term Effectiveness

The short-term effectiveness of the excavation and consolidation portions of this alternative are identical to those discussed under the other alternatives. Since the material would be disposed off-site, no other short-term risks could occur except during transportation. Truck beds will be covered to control fugitive dust emissions during transportation.

No significant environmental impact is expected to occur during installation of groundwater treatment systems.

Implementation times for this alternative from site preparation to site restoration are estimated to be approximately 8 months (see Appendix F4).

#### 4.3.5.7 Implementability

Implementability issues related to excavation are similar to those noted previously. Implementing this alternative is not expected to be complicated. The services and materials necessary for excavation, transportation, and disposal should be readily available. These are also reliable and proven technologies. Services and materials for carbon-adsorption water treatment systems are readily available from a number of vendors.

Permits for off-site discharge of equipment washwater during excavation should be easily obtained. If washwater is discharged on-site, substantive requirements should be easily met. Once the material is disposed off-site, additional remedial action at the landfill would be difficult because the explosives-contaminated soil would be mixed with other wastes. However, further remedial action at the former NOP site would not be difficult. Monitoring the effectiveness of the landfill is the responsibility of the receiving facility.

#### 4.3.5.8 Cost

Conceptual costs for Alternative 5 are summarized in Table 4-4 for a remediation volume of 8,400 cubic yards. The estimated capital cost is $3,215,000. This cost includes soil removal, hauling, and disposal. Annual costs include water treatment system O&M. The total present worth cost is $4,915,000. Detailed cost assumptions are presented in Appendix F4.

**TABLE 4-4**

**CONCEPTUAL COSTS FOR ALTERNATIVE 5**
**(OFF-SITE LANDFILL)**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| | |
|---|---|
| Capital Costs: | |
| Soil Removal and Backfill | $304,000 |
| Soil Disposal | $1,680,000 |
| Groundwater Treatment | $57,000 |
| Subtotal Capital Cost | $2,041,000 |
| Site Preparation/Restoration (5%) | $102,000 |
| Mobilization/Demobilization (2%) | $41,000 |
| Health & Safety (8%) | $163,000 |
| Prime Fixed Fee (5%) | $102,000 |
| Subtotal | $2,449,000 |
| Bonds and Insurance (1%) | $24,000 |
| Subtotal | $2,473,000 |
| Scope Contingency (20%) | $495,000 |
| Permitting and Legal (5%) | $124,000 |
| Design Engineering (8%) | $49,000 |
| Construction Services (3%) | $74,000 |
| Total Capital Cost | $3,215,000 |
| Annual O&M Costs | $124,000 |
| O&M Present Worth Cost (6% discount rate) | $1,700,000 |
| Total Present Worth Cost | $4,915,000 |

Note: Costs based on 8,200 cubic yards.
Costs rounded to nearest one thousand dollars.

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### 4.3.6 Summary

Table 4-5 summarizes the detailed analysis for each alternative.

### 4.3.7 Agency Acceptance

Formal comments made by the USEPA and NDEQ regarding previous phases of the RI/FS were analyzed and evaluated to determine the apparent preferences or concerns that the USEPA and/or NDEQ may have about remedial alternatives for OU 1 of the former NOP site. Comments and information were derived from the following sources:

- Quarterly project meetings between USACE, USEPA, and NDEQ.
- Formal USEPA and NDEQ review of the project work plans, supplemental RI, Baseline Risk Assessment, ISAD, and Draft FS.
- USACE comment responses to USEPA and NDEQ review comments.
- Other transmittals between the USACE, USEPA, and NDEQ.

The results of this assessment have been addressed in this phase of the RI/FS. However, agency acceptance concerning this phase cannot be completely addressed until comments on this report and the Proposed Plan have been received.

## 4.4 COMPARISON OF ALTERNATIVES

This section presents a comparative analysis of the performance of the alternatives against the nine evaluation criteria previously defined.

### 4.4.1 Overall Protection of Human Health and the Environment

Alternative 1 (No Action) does not satisfy the requirement for an overall protection of human health and the environment. The risks from implementing no action exceed 1E-06 total excess cancer risk and HI=1E+00 for non-cancer risks. This risk is primarily related to ingestion of contaminated soil and groundwater. Alternatives 2 and 3 are the most protective of human health and the environment because they include treatment. Thermal destruction (Alternative 3) of the contaminants is expected to permanently eliminate the potential for exposure by any soil exposure route. Alternative 4 is protective because it includes on-site containment of contaminated soil, thereby interrupting the potential soil exposure pathway. Alternative 5 also provides protection through containment but at an off-site location; however, this is the least preferred alternative in the NCP. All alternatives except Alternative 1 provide protection against exposure to contaminants through OU 1 domestic water use should wells be installed in OU 1 exposure areas prior to completion of OU 2 activities.

**TABLE 4-5**

**SUMMARY OF ALTERNATIVES ANALYSIS**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**

| Criteria | Alternative 1 | Alternative 2 |
|---|---|---|
| OVERALL PROTECTIVENESS | | |
| Human Health Protection | | |
| Soil ingestion | No reduction in risks. Cancer and noncancer risks remain. | Reduction of soil exposure risk. |
| Direct Exposure to Groundwater | No protection. | Protective because contaminants are treated. |
| Environmental Protection | | |
| Overall Protection | No protection. | Protective because contaminants above PRGs are treated. |
| COMPLIANCE WITH ARARs | | |
| Chemical-Specific ARARs | Does not meet ARARs. | Meets ARARs. |
| Location-Specific ARARs | Does not meet ARARs. | Meets ARARs. |
| Action-Specific ARARs | Does not meet ARARs. | Meets ARARs. |
| LONG-TERM EFFECTIVENESS AND PERFORMANCE | | |
| Magnitude of Residual Risk | Existing risk remains. | Residual soil exposure risk is minimized. However, there is uncertainty associated with the ability of biological treatment to achieve PRGs and with the toxicity and mobility of degredation products. |

TABLE 4-5

**SUMMARY OF ALTERNATIVES ANALYSIS**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Criteria | Alternative 1 | Alternative 2 |
|---|---|---|
| LONG-TERM EFFECTIVENESS AND PERFORMANCE (CONTINUED) | | |
| Adequacy and Reliability of Controls at the Site | Not applicable. | Long-term controls are assumed to be not required for soil treatment. Long-term controls may be required if data collected during site specific treatability studies or during remedy implementation indicate that RAOs cannot be met. Maintenance required to ensure reliability of groundwater treatment. |
| REDUCTION OF TOXICITY, MOBILITY, AND VOLUME | | |
| Statutory Preference for Treatment | Does not satisfy. | Biological treatment satisfies preference for treatment and use of innovative technologies. |
| Treatment/Containment Process Used | None. | Excavation and biological treatment of contaminated soil. Treatment of groundwater at point-of-use using carbon adsorption. |
| Amount Destroyed or Treated | None. | 8,400 cubic yards of soil are treated. |
| Reduction of Toxicity, Mobility, or Volume Through Treatment | None. | Toxicity and mobility are reduced by biological treatment of soil. Toxicity and mobility of groundwater is reduced by carbon adsorption. Explosive contaminant volume after treatment is expected to be zero. Treated unbiodegradable material is expected to be slightly greater than twice the original starting soil volume. |
| Irreversibility of the Treatment | None. | Information regarding the irreversibility and products of full scale biological treatment of explosives-contaminated soil is limited. Carbon adsorption is reversible. |

**TABLE 4-5**

**SUMMARY OF ALTERNATIVES ANALYSIS**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Criteria | Alternative 1 | Alternative 2 |
|---|---|---|
| REDUCTION OF TOXICITY, MOBILITY, AND VOLUME (CONTINUED) | | |
| Type and Quantity of Residuals After Treatment | None. | Approximately 24,000 cubic yards unconsolidated treated solids. Spent adsorbent materials can be regenerated. |
| SHORT-TERM EFFECTIVENESS | | |
| Community Protection | Not applicable. | Potential for exposure due to airborne emissions during excavation of the contaminated areas. However, risks can be controlled. |
| Worker Protection | Not applicable. | Potential for worker exposure from ingestion or inhalation of airborne emissions during excavation of the contaminated areas. Risks can be controlled. |
| Time Until RAOs are Attained | Not applicable. | Duration of remedy will depend on the type of treatment used and will be determined by treatability studies. An implementation time of 32 months is assumed for this report. |
| IMPLEMENTABILITY | | |
| Ability to Construct and Operate | Not applicable. | Only pilot-scale studies have been conducted. Full-scale uncertainties should be minimized by treatability studies and design. Groundwater treatment component is readily implementable. |

**TABLE 4-5**

**SUMMARY OF ALTERNATIVES ANALYSIS**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Criteria | Alternative 1 | Alternative 2 |
|---|---|---|
| IMPLEMENTABILITY (CONTINUED) | | |
| Technology Reliability | Not applicable. | Reliability of technology will be further defined by Treatability Studies. Groundwater treatment technology reliable if properly maintained. |
| Ease of Expansion or Additional Action | Not applicable. | Expansion or additional action would not be difficult although the material may be more difficult to handle if the volume has been increased by amendments. Material is consolidated. Groundwater treatment system easily expanded. |
| Ability to Monitor Effectiveness | Not applicable. | Monitoring the biologically treated systems will be done by a performance monitoring program. Monitoring requirements and equipment will be evaluated during site-specific treatability studies which will be conducted prior to Remedial Design. Groundwater treatment system easily monitored. |
| Ability to Obtain Approvals and Coordination with Other Agencies | Not applicable. | Permits or substantive permit requirements for residual discharge and disposal should be readily obtained or attained. |
| Availability of Equipment and Technologies | Not applicable. | Materials for construction and operation of soil treatment system are available from a limited number of vendors. Available services for biological treatment may be limited because very few specialists have experience with explosives. Groundwater treatment system readily available. |

TABLE 4-5

**SUMMARY OF ALTERNATIVES ANALYSIS**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Criteria | Alternative 1 | Alternative 2 |
|---|---|---|
| COSTS | | |
| Capital Costs | $0 | $6,817,000 |
| O&M Costs (Present Worth) | $0 | $1,700,000 |
| Present Worth | $0 | $8,517,000 |

Note: Costs based 8400 cubic yards.
Costs rounded to the nearest one thousand dollars.

**TABLE 4-5**

**SUMMARY OF ALTERNATIVES ANALYSIS**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| | Alternative 3 | Alternative 4 | Alternative 5 |
|---|---|---|---|
| OVERALL PROTECTIVENESS | | | |
| Human Health Protection | | | |
| Soil Ingestion | Reduction of soil exposure risk. | Reduction of soil exposure risk. | Reduction of soil exposure risk. |
| Direct Exposure to Groundwater | Protective because contaminants are treated. | Protective because contaminants are treated. | Protective because contaminants are treated. |
| Environmental Protection | | | |
| Overall Protection | Protective because contaminants above PRGs are treated. | Protective because contaminants above PRGs are contained and soil exposure pathways are interrupted. | Protective because contaminants above PRGs are removed from the site and contained in an off-site landfill. |
| COMPLIANCE WITH ARARs | | | |
| Chemical-Specific ARARs | Meets ARARs. | Meets ARARs. | Meets ARARs. |
| Location-Specific ARARs | Meets ARARs. | Meets ARARs. | Meets ARARs. |
| Action-Specific ARARs | Meets ARARs. | Meets ARARs. | Meets ARARs. |

**TABLE 4-5**

**SUMMARY OF ALTERNATIVES ANALYSIS**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Criteria | Alternative 3 | Alternative 4 | Alternative 5 |
|---|---|---|---|
| LONG-TERM EFFECTIVENESS AND PERFORMANCE | | | |
| Magnitude of Residual Risk | Treatment reduces soil and groundwater risks to below target risks. | Landfill interrupts the soil ingestion pathways. Therefore, soil residual risk is less than target risk. Groundwater risk reduced through treatment. | Excavation and off-site disposal reduces soil risks to below target risks. Groundwater risk reduced through treatment. |
| Adequacy and Reliability of Controls at the Site | Long-term controls are not required for contaminated soil. Groundwater treatment system requires maintenance to ensure effectiveness. | Landfill interrupts soil exposure pathways, but inspection and maintenance of components and controls are required. Groundwater treatment system requires maintenance to ensure effectiveness. | Off-site landfill is assumed to meet standards of construction and operation, and thus eliminates risks off-site. Groundwater treatment system requires maintenance to ensure effectiveness. |
| REDUCTION OF TOXICITY, MOBILITY, AND VOLUME | | | |
| Statutory Preference for Treatment | Satisfies preference. | Does not satisfy for soil. | Does not satisfy for soil |
| Treatment/Containment Process Used | Thermal treatment of contaminated soil. Carbon adsorption for groundwater. | On-site landfilling of contaminated soil. Carbon adsorption for groundwater. | Excavation and off-site disposal of contaminated soil. Carbon adsorption for groundwater. |

TABLE 4-5

**SUMMARY OF ALTERNATIVES ANALYSIS**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Criteria | Alternative 3 | Alternative 4 | Alternative 5 |
|---|---|---|---|
| Amount Destroyed or Treated | Total volume of 8,400 cubic yards contaminated soil are treated and contaminants of concern are expected to be destroyed. | No soil treated. | No soil treated. |
| Reduction of Toxicity, Mobility, or Volume Through Treatment | Toxicity, mobility, and volume are reduced by thermal treatment. Toxicity and mobility of contaminated groundwater reduced by treatment. Explosive contaminant volume after treatment is expected to be zero. | No reduction in soil volume or toxicity through treatment; however, mobility is reduced by on-site landfill. Toxicity and mobility of contaminated groundwater by treatment | No reduction in soil volume or toxicity through treatment; however, mobility is reduced by on-site landfill. Toxicity and mobility of contaminated groundwater reduced by treatment. |
| Irreversibility of the Treatment | Thermal treatment is irreversible. Carbon adsorption is reversible. | Not applicable to soil. Carbon adsorption is reversible. | Not applicable to soil. Carbon adsorption is reversible. |
| Type and Quantity of Residuals After Treatment | Scrubber water and kiln and fly ash (rotary kiln, CBC, LTTD). Approximately the same volume of glasslike mass (above-ground vitrification). Spent absorbant materials can be regenerated. | Not applicable for soil. Spent adsorbent materials can be regenerated. | Not applicable for soil. Spent adsorbent materials can be regenerated. |

**TABLE 4-5**

**SUMMARY OF ALTERNATIVES ANALYSIS**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Criteria | Alternative 3 | Alternative 4 | Alternative 5 |
|---|---|---|---|
| SHORT-TERM EFFECTIVENESS | | | |
| Community Protection | Potential for exposure due to airborne emissions during excavation of the contaminated areas and to incinerator emissions during treatment. However, risks can be controlled. | Potential for exposure due to airborne emissions during excavation of the contaminated areas. However, risks can be controlled. | Potential for exposure due to airborne emissions during excavation of the contaminated areas. However, risks can be controlled. |
| Worker Protection | Potential for worker exposure from ingestion or inhalation of airborne emissions during excavation of the contaminated areas. Risks can be controlled. | Potential for worker exposure from ingestion or inhalation of airborne emissions during excavation of the contaminated areas. Risks can be controlled. | Potential for worker exposure from ingestion or inhalation of airborne emissions during excavation of the contaminated areas. Risks can be controlled. |
| Time Until RAOs are Attained | Approximately 15 months. | Approximately 8 months for liner construction, excavation, and closure. | Approximately 4 months for excavation and off-site disposal. |

**TABLE 4-5**

**SUMMARY OF ALTERNATIVES ANALYSIS**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Criteria | Alternative 3 | Alternative 4 | Alternative 5 |
|---|---|---|---|
| IMPLEMENTABILITY | | | |
| Ability to Construct and Operate | Thermal treatments can involve highly technical process units, but they have been used frequently. Groundwater treatment component is readily implementible. | Components of alternative should be readily implementable. | Common construction techniques are easily implemented. |
| Technology Reliability | Rotary kiln is highly reliable. Other thermal processes may require treatability studies. Groundwater treatment technology reliable if properly maintained. | Reliable if landfill components and groundwater treatment system are maintained. | Reliable if off-site landfill meets standards of construction and operation. Groundwater treatment technology reliable if properly maintained. |
| Ease of Expansion or Additional Action | Expansion or additional action would be easily implemented. | Expansion or additional action would be easily implemented. | Once the material is disposed, additional action or expansion off-site will be difficult. Additional on-site action would be easily implemented. |
| Ability to Monitor Effectiveness | Emissions and performance monitoring will assist in monitoring effectiveness. Groundwater treatment system easily monitored. | Effectiveness will be sufficiently monitored by inspection, maintenance, and groundwater monitoring. Groundwater treatment system easily monitored. | Monitoring of off-site landfill is the responsibility of that facility. Groundwater treatment system easily monitored. |

**TABLE 4-5**

**SUMMARY OF ALTERNATIVES ANALYSIS**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Criteria | Alternative 3 | Alternative 4 | Alternative 5 |
|---|---|---|---|
| Ability to Obtain Approvals and Coordination with Other Agencies | Trial burn will require coordination and approval by the state and USEPA. Substantive permit requirements for on-site residual discharge should be easily met. | Requires coordination with state agency to ensure inspection, maintenance, and deed restriction enforcement. Substantive permit requirements for on-site residual discharge should be easily met. | Disposal in the off-site landfill will require approval of the facility by regulatory agencies.<br><br>Substantive permit requirements for on-site residual discharge should be easily met. |
| Availability of Equipment and Technologies | Readily available. | Materials and services for construction of the landfill are readily available. | Off-site disposal facilities are readily available. |
| COSTS | | | |
| Capital Costs | $12,543,000 | $1,498,000 | $3,215,000 |
| O&M Costs (Present Worth) | $1,700,000 | $2,200,000 | $1,700,000 |
| Total Present Worth | $14,243,000 | $3,698,000 | $4,915,000 |

Note: Costs based on 8400 cubic yards.
Costs rounded to the nearest one thousand dollars.

RP/MEADFS/AE6

### 4.4.2 Compliance with ARARs

A summary of ARARs for each soil remediation alternative is provided in Table 4-6. All alternatives meet the ARARs which have been identified as pertinent.

### 4.4.3 Long-Term Effectiveness and Permanence

Alternative 1 provides no long-term effectiveness and would result in the continuation of estimated baseline risk levels. Alternatives 2 and 3 reduce risks by treating the potential exposure source (contaminated soil). Thermal treatment (Alternative 3) appears to be more protective than biological treatment (Alternative 2) because it has been proven on a full scale for explosives and has achieved greater removal of explosives compounds in treatability studies. Alternatives 4 and 5 provide long-term effectiveness by interrupting the exposure pathways. However, Alternative 4 requires perpetual site management. Alternative 5 provides containment, but at an off-site location.

Each alternative except Alternative 1 relies on adequate maintenance of a domestic well water treatment system. Other long-term controls for on-site containment (Alternative 4) consist primarily of maintenance, groundwater monitoring, and deed restrictions. Maintenance and monitoring are reliable and should be adequate to detect failure, as long as they are maintained perpetually. Deed restrictions are only reliable if they are effectively enforced. No other long-term controls are required for the treatment Alternatives (2 and 3), other than the domestic well system. Long-term controls at the off-site landfill (Alternative 5) are the responsibility of the receiving facility.

### 4.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that significantly reduce toxicity, mobility, or volume of the untreated waste. Alternatives 2 and 3 are the only alternatives which satisfy this preference for the contaminated soil. These alternatives use treatment to transform or destroy the explosive compounds in the former NOP soils, thereby significantly reducing the toxicity and mobility of these compounds. Alternative 3 is expected to provide a greater reduction of toxicity and mobility because greater contaminant destruction is expected and because biological treatment (Alternative 2) may produce unknown breakdown products. In addition, there is some uncertainty in whether biological treatment can achieve the PRGs at this site. Some biological polymeric products may also be products of reversible reactions. Thermal treatment is not expected to significantly reduce the volume of soil. Biological treatment may increase the volume of soil. However, the volume of contaminated soil should be eliminated or significantly reduced by both Alternatives 2 and 3.

**TABLE 4-6**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| FEDERAL | | | | | | | | | |
| **Clean Water Act (CWA) of 1977, as amended [33 U.C.S. 1251]** | | | | | | | | | |
| 40CFR122 - EPA Administered Permit Programs: The National Pollutant Discharge Elimination System (NPDES) | 40CFR122.1-7 | Defines terminology and provides general program requirements for the NPDES. | Action | A | - | x | x | x | x |
| | 40CFR122.21,22,28,29 | Specifies the scope and details of the NPDES permit applications. | Action | A | - | x | x | x | x |
| | 40CFR122.41-48 | Specifies and establishes limitations, standards, and other permit conditions which are applicable to all permits including specified categories of NPDES permits. Specifies schedules of compliance and requirements for recording and reporting monitoring results. | Action | A | - | x | x | x | x |
| | 40CFR122.49 | Lists other Federal laws which may apply to the issuance of NPDES permits. | Action | A | - | x | x | x | x |
| | 40CFR122.61-64 | Establishes rules for transferring, revocating, reissuing, and terminating NPDES permits. | Action | A | - | x | x | x | x |

**TABLE 4-6**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| **(CWA cont'd)** | | | | | | | | | |
| 40CFR125 - Criteria and Standards for the National Pollutant Discharge Elimination System | 40CFR125.1-3 | Establishes criteria and standards for technology-based requirements in permits under Sections 301(b) and 402 of the CWA. | Chemical | A | - | x | x | x | x |
| | 40CFR125.30-32 | Establishes criteria and standards for determining whether effluent limitations alternative to those required by promulgated EPA effluent limitations guidelines under 301 and 304 of the CWA (national limits) should be imposed on a discharger. Alternative effluent limitations may be appropriate if factors relating to the discharger's facilities, equipment, or processes, or other factors related to the discharger are fundamentally different from the factors considered by EPA in development of the national limits. | Chemical | A | - | x | x | x | x |
| | 40CFR125.70-73 | Establishes criteria for determining alternative effluent limitations under Section 316(a) of the CWA for controlling the thermal component of any discharge. | Action | A | - | - | x | - | - |

**TABLE 4-6**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| (CWA cont'd) | 40CFR125.100-104 | Describes how best management practices (BMPs) for ancillary industrial activities (i.e., materials storage areas, material handling areas) under Section 304(e) of the CWA shall be reflected in permits. This rule is applicable to dischargers who use, manufacture, store, handle, or discharge any pollutants reaching waters of the United States. | Action | A | - | x | x | x | x |
| 40CFR136 - Guidelines Establishing Test Procedures for the Analysis of Pollutants | 40CFR136.1-5 and Appendices A-C | Specifies analytical procedures for NPDES applications and reports. | Action | A | - | x | x | x | x |
| 40CFR403 - General Pretreatment Regulations for Existing and New Sources of Pollution | 40CFR403.5-7,13,15 | Specifies standards for pretreatment and identifies exclusions. | Chemical | A | - | x | x | x | x |
| **Hazardous Materials Transportation Act (HMTA)** | | | | | | | | | |
| 49CFR107 - Hazardous Materials Program Procedures | 49CFR107 Subpart B, Appendix C | Regulates transportation of hazardous materials. Truck carriers of hazardous materials must obtain a permit from: Chief, Hazardous Materials Division, Office of Motor Carrier Field Operations, Federal Highway Administration, Department of Transportation, Washington, DC 20590-0001. | Action | R&A | - | - | - | - | x* |

**TABLE 4-6**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| **(HMTA cont'd)** | | | | | | | | | |
| 49CFR171 - General Information, Regulations, and Definitions | 49CFR171.1-21 | Prescribes the requirements of the Department of Transportation governing the transportation of hazardous materials and the manufacture, fabrication, marking, maintenance, reconditioning, repairing, or testing of packaging or a container which represented, marked, certified, or sold for use in transporting hazardous waste. | Action | R&A | - | - | - | - | x* |
| 49CFR172 - Hazardous Materials Tables and Hazardous Material Communications Regulations | 49CFR172.101-604 Appendix A-C | Provides tables of hazardous materials along with their descriptions, proper shipping names, classes, labels, packaging, and other requirements. Specifies shipping papers which must be completed by persons offering a hazardous material for transportation, and provides marking, labeling, and placarding requirements for the transportation of hazardous materials. | Action | R&A | - | - | - | - | x* |
| 49CFR173 - Shippers - General Requirements for Shipments and Packaging | 49CFR173.1-130 Appendix A,B | Defines regulated material and their preparation for transportation. | Action | R&A | - | - | - | - | x* |
| 49CFR177 - Carriage by Public Highway | 49CFR177.800-870 | Prescribes general regulations for the transportation of hazardous materials by public highway. Also, provides loading and unloading requirements. Specifies requirements for vehicles carrying hazardous materials in the event of any accident. | Action | R&A | - | - | - | - | x* |

**TABLE 4-6**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| **Public Health Service Act: Title XIV, as amended by the SAFE DRINKING WATER ACT OF 1988 [42 U.S.C. 300(f)** | | | | | | | | | |
| 40CFR141 - National Primary Drinking Water Regulations | 40CFR141.11-12 | Specifies maximum contaminant levels (MCLs) of public water systems for inorganic and organic chemicals. | Chemical | R&A | - | x | x | x | x |
| | 40CFR141.50 | Specifies maximum contaminant level goals (MCLGs) of public water systems for organic chemicals. | Chemical | R&A | - | x | x | x | x |
| | 40CFR141.60-63 | Establishes national revised primary drinking water regulations of MCLs for organic chemicals, inorganic chemicals, and microbiological contaminants. | Chemical | R&A | - | x | x | x | x |
| 40CFR143 - National Secondary Drinking Water Regulations | 40CFR143.03 | Establishes secondary maximum contaminant levels (SMCLs) for public water systems. These are Federally non-enforceable standards which regulate contaminants in drinking water that primarily affect aesthetic qualities. | Chemical | R&A | - | x | x | x | x |

**TABLE 4-6**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| **Solid Waste Disposal Act (SWDA) as amended by RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) of 1976 [42 U.S.C. 6901]** | | | | | | | | | |
| 40CFR241 - Guidelines for the Land Disposal of Solid Wastes | 40CFR241.100-213 | Delineates minimum levels of performance required of any solid waste land disposal site operation. | Action | A | - | - | - | x | - |
| 40CFR257 - Criteria for Classification of Solid Waste Disposal Facilities and Practices | 40CFR257.1-4 | Specifies criteria for evaluating the potential for adverse effects on human health and the environment from solid waste disposal facilities. | Action | A | - | - | - | x | - |
| 40CFR258 - Criteria for Municipal Solid Waste Landfills | 40CFR258.1-61 | Establishes minimum national criteria for municipal solid waste landfills, including location, design, operation, monitoring, and closure. | Action | A | - | - | - | x | - |
| 40CFR261 - Identification and Listing of Hazardous Waste | 40CFR261.1-7,10,11, 20-24,30-33 | Defines solid and hazardous wastes. Applies to solid and hazardous wastes as defined. | Chemical | A/R&A | - | x* | x* | x* | x* |
| 40CFR263 - Standards Applicable to Transporters | 40CFR263.30,31 | Establishes responsibilities which transporters of hazardous waste assume if discharges of hazardous wastes occur while in the custody of the transporter. Mandates immediate action and discharge cleanup. | Action | R&A | - | - | - | - | x* |

**TABLE 4-6**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| **(SWDA cont'd)** | | | | | | | | | |
| 40CFR264 - Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities | 40CFR264.301 | Describes engineering controls for a Subtitle C landfill liner configuration. | Action | R&A | - | - | - | x | - |
| | 40CFR264.340-351 | Specifies incineration trial burn requirements. | Action | R&A | - | - | x | - | - |
| 40CFR268 - Land Disposal Restrictions | 40CFR268.30,40 | Lists EPA hazardous wastes that are prohibited from land disposal. | Action | A/R&A | - | x* | x* | x* | x* |
| STATE | | | | | | | | | |
| Water Quality Standards for Surface Water of the State - Title 117 | Ch. 2-4 | Establishes surface water quality standards based on use and location. | Chemical | A | - | x | x | x | x |

**TABLE 4-6**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| Groundwater Quality Standards and Use Classification - Title 118 | Ch. 2-5 | Nebraska Department of Environmental Quality (NDEQ) shall apply standards on a site-specific basis determined by location and classification, and existing groundwater quality shall be preserved. | Chemical | A | x | x | x | x | x |
| | Ch. 6-8 | Establishes classification system for groundwater and procedures for changing classification. | Location | A | x | x | x | x | x |
| Rules and Regulations Pertaining to the Issuance of Permits Under the National Pollutant Discharge Elimination System - Title 119 | Ch. 2-66 | Defines a new source and identifies limits during a permit term and minimum monitoring requirements. | Chemical | A | - | x | x | x | x |
| Nebraska General NPDES Rules for New and Existing Sources: Effluent Guidelines and Standards - Title 121 | Ch. 2.016<br>Ch. 8 | Establishes effluent standards for point sources in general; for explosives loading, assembling and packing (as per 40CFR457); and lists analytical procedures for determining those effluent levels. | Chemical | A | - | x | x | x | x |

**TABLE 4-6**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| Rules and Regulations Pertaining to the Management of Wastes - Title 126 | Ch. 2 | Specifies the information required in a compost construction and/or operation permit for NDEQ. | Action | R&A | - | x | - | - | - |
| Rules and Regulations Governing the Nebraska Pretreatment Program - Title 127 | Ch. 2-5 | Specifies permit-specific limits based on design flow, lists prohibited discharges, prohibits dilutions used to meet limits, and exempts users from having to clean pollutants in their intake. | Chemical | A | - | x | x | x | x |
| | Ch. 6-38 | Includes details on compliance report contents effluent limits during permit term, minimum monitoring record contents, and disposal of sludge. | Action | A | - | x | x | x | x |
| Rules and Regulations Governing Hazardous Waste Management in Nebraska - Title 128 | Ch. 2, 4, and 9-15 | Defines solid and hazardous waste specifically by use/disposal, criteria, characteristics and listing. | Chemical | A | - | x | x | - | - |

**TABLE 4-6**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| Nebraska Air Pollution Control Regulations - Title 129 | Ch. 2 | Establishes air quality control regions. | Location | A | x | x | x | x | x |
| | Ch. 3 | Establishes State primary and secondary ambient air quality standards for particulate matter (<=10 um and =>10um/<=100 um), sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, and lead. | Chemical | A | - | x | x | x | x |
| | Ch. 4<br>Ch. 6.002 | Establishes emission limits for new incinerators and lists emission report contents. | Action | A | - | - | x | - | - |
| | Ch. 5 | Requires good engineering practice in the design of the stack height. | Action | A | - | - | x | - | - |
| | Ch. 6.007 | If Chapter 4 emission limits for pollutant are exceeded, may still obtain permit if BACT is applied for all pollutants and 40CFR60 and 61 standards are not exceeded. | Chemical | A | - | - | x | - | - |

**TABLE 4-6**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| | Ch. 7 | Adopts 40CFR52 regarding Prevention of Significant Deterioration of Air Quality. | Chemical | A | - | x | x | x | x |
| | Ch. 17 | Prohibits visible dust beyond the limits of the property line where handling, transportation, or construction is taking place. | Action | A | - | x | x | x | x |
| | Ch. 24 | Limits visible emissions from diesel-powered construction or transportation equipment. | Action | A | - | x | x | x | x |
| Rules and Regulations Pertaining to Solid Waste Management - Title 132 | Ch. 7 | Brief requirements for solid waste control in second class cities and villages including general prevention of contamination and location restrictions due to potential for flooding or surface drainage. | Action | A | - | - | - | x | - |
| Regulations Governing Licensure of Water Well and Pump Installation Contractors and Certification of Water Well Drilling and Pump Installation Supervisors - Title 178 | Ch. 2 | Rules regarding the qualifications of contractors installing water wells. | Action | A | - | - | - | x | - |

A = Applicable.
R&A = Relevant and Appropriate.
*Applicable only in determining if RCRA characteristic; site soil is not listed waste. Relevant and appropriate requirements may be identified as more detailed components of the remedial action are evaluated during the predesign and design phases of OU1.

RP/MEADFS/AT1

Alternatives 4 and 5 do not include treatment of contaminated soil. They do not reduce the toxicity or volume of contaminated soil. Both alternatives, however, reduce the mobility of contaminants through the environment by limiting infiltration through the contained soil. Leachate will be collected and treated under Alternative 4, reducing potential migration to groundwater. However, containment is potentially reversible (i.e., if containment structures were breached, exposure pathways would have potential to be completed again).

It should be noted that Alternatives 4 and 5 do not satisfy the statutory preference for treatment of contaminated soil expressed in the NCP. In addition, off-site disposal (Alternative 5) is the least preferred remediation option, as noted in the NCP.

Each of the alternatives, except Alternative 1, provides reduction of toxicity, mobility, and volume of contaminated groundwater through point-of-use treatment.

### 4.4.5 Short-Term Effectiveness

This criterion addresses the effects of the alternatives on human health and the environment during construction and implementation of the remedial action. All four action alternatives will have dust, noise, and increased traffic associated with excavation activities. Alternative 4 provides the most short-term effectiveness because only excavation, on-site hauling, and relatively simple construction activities are involved. Short-term risks to workers, the community (including University of Nebraska personnel), and the local environment from these activities are easily controlled. Short-term risks for Alternatives 2 and 3 are expected to be similar to those for Alternative 4. Alternative 5, off-site landfilling, poses additional potential short-term risks to both workers and the community because material must be transported off-site. Traffic accidents or spills could potentially expose additional receptors to contaminated soil.

Implementation times are, in order of increasing duration:

- Alternative 5 - 4 months
- Alternative 4 - 8 months
- Alternative 3 - 15 months
- Alternative 2 - 32 months

These durations are an estimate of the time until RAOs are achieved. In Alternatives 2, 3, and 5, excavated soil will be stored on-site prior to treatment or disposal. For Alternative 4, contaminated soil removal will occur concurrently with on-site placement.

### 4.4.6 Implementability

Alternative 5 is the most implementable because construction or process activities involved (landfills and hauling firms) are available. Construction, maintenance, and monitoring included in Alternative 4 would be easy to implement and specialists are available. Thermal treatment (Alternative 3) specialists and equipment are also readily available. Alternative 2, biological treatment, is the least implementable alternative because it has not been used full-scale on explosives, it is available from only a limited number of vendors, there is some uncertainty associated with performance, and it may be difficult to monitor due to unknown intermediate compounds.

### 4.4.7 Costs

#### 4.4.7.1 Cost Summary

Alternatives are evaluated in terms of capital cost, annual O&M cost, and present worth cost. Table 4-7 summarizes the costs for each alternative based on a remediation volume of 8,400 cubic yards. Detailed cost assumptions and cost sheets are presented in Appendix F.

#### 4.4.7.2 Cost Sensitivity Analysis

Some of the cost assumptions (see Appendix F) for each alternative may have a significant level of uncertainty. To address these uncertainties, a cost sensitivity analysis was performed. The sensitivity analyses were performed on costs for Alternatives 2 through 5. As no costs are associated with Alternative 1, no cost sensitivity analysis is performed. The sensitivity analysis consisted of the following:

1. Identifying major cost components for each alternative that have a significant degree of uncertainty.

2. Varying the values assumed for these components.

3. Evaluating the sensitivity of the baseline present worth cost (BPWC) to these variations. If the selected variations in a component of the BPWC result in a significant change in the BPWC, then the BPWC is considered sensitive to that component. For purposes of this discussion, a 20 percent change in the BPWC is considered significant.

The results of the sensitivity analysis are summarized in Table 4-8. These results are discussed below for each alternative.

**TABLE 4-7**

**CONCEPTUAL COST SUMMARY**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| | Alternative | Capital Cost | Present Worth O&M Cost | Total Present Worth Cost |
|---|---|---|---|---|
| 1. | No action. | NA | NA | NA |
| 2. | Excavation, consolidation, debris management, biological treatment, residuals management, and groundwater treatment. | $6,817,000 | $1,700,000 | $8,517,000 |
| 3. | Excavation, consolidation, debris management, thermal treatment, residuals management, and groundwater treatment. | $12,543,000 | $1,700,000 | $14,243,000 |
| 4. | Excavation consolidation, debris management, on-site landfill, deed restrictions, ground-water monitoring, and groundwater treatment. | $1,498,000 | $2,200,000 | $3,698,000 |
| 5. | Excavation, consolidation, debris management, off-site landfill, and groundwater treatment. | $3,215,000 | $1,700,000 | $4,915,000 |

Notes:
NA = Not Applicable.
All costs based on a remediation volume of 8,400 cubic yards.
Costs rounded to the nearest one thousand dollars.

RP/MEADFS/AG2

**TABLE 4-8**

**SUMMARY OF COST SENSITIVITY ANALYSIS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| | Base Cost | 50% Volume Increase | | 50% Residence Time Increase | | 50% Hauling & Disposal Costs Increase | |
|---|---|---|---|---|---|---|---|
| Alternative | ($M) | Cost ($M) | % Diff. | Cost ($M) | % Diff. | Cost ($M) | % Diff. |
| 1 | - | --- | --- | --- | --- | --- | --- |
| 2 | 8.5 | 10.6 | +25 | 9.8 | +15 | --- | --- |
| 3 | 14.2 | 20.1 | +42 | --- | --- | --- | --- |
| 4 | 3.8 | 4.2 | +11 | --- | --- | --- | --- |
| 5 | 5.0 | 6.5 | +32 | --- | --- | 6.3 | +26 |

Note: Dashed lines indicate "not applicable to alternative."

RP/MEADFS/AF7

**Alternative 2 Cost Sensitivity Analysis**

Two cost components (soil remediation volume and biological treatment residence time) were identified for Alternative 2 as having a significant degree of uncertainty. To determine how sensitive the BPWC is to these components, the following variations were evaluated:

- Modify soil remediation volume to reflect a 50 percent increase.
- Increase biological treatment residence time by 50 percent.

Table 4-8 illustrates that the BPWC for Alternative 2 is more sensitive to the selected increase in the soil remediation volume than to the treatment residence time increase.

**Alternative 3 Cost Sensitivity Analysis**

One cost component (soil remediation volume) was identified for Alternative 3 as having a significant degree of uncertainty. To determine how sensitive the BPWC is to this component, the following variation was evaluated:

- Increase soil remediation volume by 50 percent.

Table 4-8 illustrates that the BPWC for Alternative 3 is relatively sensitive to the selected increase in the soil remediation volume (+42 percent difference).

**Alternative 4 Cost Sensitivity Analysis**

One cost component (soil remediation volume) was identified for Alternative 4 as having a significant degree of uncertainty. To determine how sensitive the BPWC is to this component, the following variation was evaluated:

- Increase soil remediation volume by 50 percent.

Table 4-8 illustrates that the BPWC for Alternative 4 is somewhat sensitive to the selected increase in soil remediation volume (+11 percent difference).

**Alternative 5 Cost Sensitivity Analysis**

Two cost components (soil remediation volume and off-site hauling and disposal) were identified for Alternative 5 as having a significant degree of uncertainty. To determine how sensitive the BPWC is to these components, the following variations were evaluated:

- Increase soil remediation volume by 50 percent.
- Increase off-site hauling and disposal costs by 50 percent.

Table 4-8 illustrates that the BPWC for Alternative 5 is relatively sensitive to the selected increase in soil remediation volume (+32 percent difference from BPWC) and hauling and disposal unit cost (+26 percent).

**Cost Sensitivity Analysis Summary**

The principal results from the cost sensitivity analysis presented in Table 4-8 are as follows:

- BPWCs for all alternatives are sensitive to the selected increase in soil remediation volume.
- The BPWC for Alternative 2 is less sensitive to the selected variation in the biological treatment residence.
- The BPWC for Alternative 5 is relatively sensitive to the selected increase in off-site hauling and disposal costs.

## 4.5 UNCERTAINTY ANALYSIS

A significant challenge in conducting an RI/FS is to effectively account for the inherent uncertainties associated with the characterization and remediation of uncontrolled waste sites. These uncertainties can be numerous, ranging from potential unknowns regarding site characteristics and the extent of contamination to the performance of treatment and engineering controls. The objective of the RI/FS process is not the removal of all uncertainty, but rather gathering information sufficient to support an informed risk management decision regarding which remedy appears to be most appropriate for a given site.

The alternatives presented in the preceding sections consist of remedial actions to treat or control the explosives-contaminated soil at the NOP site. Throughout the RI/FS process, a number of assumptions and risk management considerations have been made that impact the calculated extent of contamination, environmental and health risks, volume of contamination requiring containment, disposal or treatment, and schedule and cost for remediating the site. The discussion that follows identifies a number of uncertainties specific to the NOP site and briefly reviews the implications of the assumptions and decisions.

### 4.5.1 Human Health Risk Evaluation Uncertainty Analysis

Uncertainties are associated with several aspects of the risk assessment. Uncertainties involve conservative estimates of exposure and extent of contamination, so that health risks are unlikely to be underestimated. These uncertainties must be understood, however, in developing the most effective objectives for the remedial action so that the remedial action can most appropriately determine extent of area requiring remediation and the degree of remedial action required.

Exposure concentrations with no fractional intake factor are included for risk management objectives in accordance with USEPA preferences. The uncertainties associated with this approach result in a conservative estimate that assumes a person will only be in contact with the contaminated soil within a source area and will not carry out any activities in any other portion of the exposure area. Since explosives contamination is mainly limited to drainage ditches and sumps, this assumption is conservative because, in most cases, there is insufficient space within contaminated areas for exposure activities (e.g., plant a garden, pasture a cow, and till a field) to occur. Therefore, USACE believes this assumption (no fractional intake factor) is not consistent with RME conditions. Risks calculated using the fractional intake term indicate that risks for the soil pathway generally do not exceed 1E-04 risks. This risk level falls within the acceptable risk range identified by USEPA, as discussed in Section 4.5.2.

As noted previously, potential risks from the garden vegetable pathway will not be addressed in this OU. Dose estimates for the garden vegetable pathway are relatively uncertain. This uncertainty is due primarily to:

- The amount of explosives uptake by vegetables, represented by the bioaccumulation factor. These factors are modeled and extrapolated across chemicals, are plant-type specific (garden-fruit, root vegetables, etc.) and plant-part specific, and soil-parameter specific in the absence of site-specific data or analyses.

- The estimated fraction of total vegetable intake that comes from home-grown sources.

- The assumptions that a garden covers is the entire source area and that the concentration is uniform across the garden.

- No account is made in the risk calculations for metabolism of contaminants by plants.

The vegetable pathway will be evaluated further under OU 3.

Overall, potential human health risks from the soil pathway to be addressed under OU 1 are unlikely to be underestimated.

Specifically, some uncertainty is associated with the risk assessment due to the factors used to evaluate risk and establish risk management objectives. The major sources of uncertainties in the calculations of risks for the NOP site include the following:

- Determination of the appropriate exposure factors to be used in calculating human intakes are highly uncertain. Attempts were made to use standardized exposure factors when possible, and to derive conservative values where standard factors were not available. Therefore, exposure estimates contribute to a possible overestimate of risk.



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- The accuracy of risk estimates for a given dose level directly depend on the accuracy of the toxicity value for the chemical. In many cases, these values are derived from limited databases. This can result in substantial uncertainties. In order to account for these uncertainties, the USEPA calculates toxicity values utilizing an intentionally conservative methodology. Therefore, risk estimates for the former NOP site are more likely to be conservative and overestimated.

- In some cases, it is not possible to calculate a risk estimate since toxicity values have not been derived. For example, oral toxicity data are lacking for two explosives degradation products (2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene), and inhalation toxicity values does not exist for all explosive compounds. This may result in an underestimate of risks since no risk estimates were derived for these chemicals.

- PRGs are set such that all chemicals must equal or exceed the concentrations in order to meet or exceed the target risk. However, a sample location could require remediation because a single chemical exceeds its PRG while all other chemicals at that location are low or undetected. It is possible in that situation for the sample not to exceed the target risks. Therefore, more soil could be removed than necessary.

- Total risk to an exposed individual from contaminants at a site is the sum of all complete exposure pathways. The NOP risk assessment did not quantify every conceivable complete pathway (i.e., dermal exposures to soil, exposures to surface water and sediment). Those pathways have not been quantified either because data necessary to do so are unavailable or because it is believed that they represent very minor sources of exposures. This may result in an underestimation of site risks.

- In the screening level analysis of risk, exposure point concentrations within a grid were calculated as if the contamination were uniform across the grid. This is likely to result in an overestimate of risk since soil contamination from explosives appears to follow, in most cases, a defined pattern along drainage ways or near structures.

- In the screening level analysis of risk, a very conservative approach was taken, in that any chemical detected in a large area (i.e., a load line) was assumed to be present in all grids in that area, even when the chemical was either not detected or never measured in some of the grids. This leads to an overestimate of exposure to infrequently detected chemicals. In the detailed analysis, a somewhat less conservative approach was followed, where chemicals never detected within a source area were assumed to be absent.

- The evaluation of human health risks assumed that the concentration of explosives in the soils will remain constant over time. While dramatic decreases are not expected, fate and transport processes will tend to decrease these concentrations over time. This is likely to result in an overestimate of risk.

- The evaluation of risks related to groundwater ingestion were based on the highest detected concentration for each chemical from any well on-site. This is likely to result in an overestimation of risk because a person cannot be exposed to groundwater concentrations in multiple wells simultaneously, nor will concentrations remain the same over time. Groundwater risk will be evaluated more thoroughly under OU 2.

### 4.5.2 Effect of RAO and PRG Decisions on Costs

The volumes presented in Section 2.3 are based on specific PRGs, which, in turn, are based on specific RAOs. These specific PRGs and RAOs were provided by USEPA and accepted by USACE. USACE has agreed to incorporate the numerical PRG values provided by USEPA in order to expedite OU 1 remediation. However, USACE does not concur with all the assumptions used to develop these PRGs.

USACE believes that setting the target risk equal to 1E-04 is reasonable because USEPA guidance (USEPA, 1991g) states that achieving risk reduction anywhere within the 1E-04 to 1E-06 risk range may be deemed acceptable. In addition, the assumption of future residential land use may not be justifiable if the probability that the site will support residential use in the future is small. The current agricultural use and physical layout of existing structures and drainage features reduces the potential for future residential development of the NOP site. However, it is more reasonable to use the hypothetical future farm family assumption in conjunction with a target risk equal to 1E-04.

USACE believes that applying separate PRGs by load lines or other major areas is reasonable because PRGs can differ in separate areas of the site based on identity and relative levels of explosives compounds present within a particular area. Major-area PRGs, therefore, are developed only for compounds present within a particular area, not for all of the explosive compounds detected on-site. On the other hand, by applying PRGs across the entire site, explosives compounds present in only some of the major areas must be accounted for across the entire NOP site. Because chemical risks are additive, developing PRGs for chemicals not present within a major area may result in lower numerical PRG values. Remediation volumes based on site-wide PRGs, therefore, may clean up material beyond the target risk level in some major areas.

To evaluate the effect of USEPA's PRG assumptions, additional remediation volumes corresponding to PRGs based on different RAO assumptions were calculated. The following were evaluated:

- Changing from a future farm family to future worker population.
- Adding the fractional intake factor.
- Applying PRGs by major area (loadlines, etc.) rather than site-wide.
- Adding the vegetable pathway.
- Increasing exposure duration to 70 years.
- Evaluating the difference between using 1E-04 and 1E-06 as the target cumulative target cancer risk.

The results are given in Table 4-9 and show volume changes from -34 percent to +98 percent of the base volume (8,400 cy). The volume changes indicate that changing the RAO assumptions has a significant impact on remediation volume.

Corresponding cost curves for Alternatives 2 through 5 were generated based on the volumes generated under these different risk assessment exposure assumptions. Costs were extrapolated from the curves to show the cost variability. Table 4-9 includes estimated costs for each volume. Figure 4-9 shows the curves used to estimate the costs shown in Table 4-9. The table indicates that there is a significant cost increase (particularly at the 1E-06 target cancer risk) due to the assumption that all exposure activities are carried out only in the source areas (omitting fractional intake term) and due to adding the vegetable uptake pathway. In contrast, relatively small cost increases result under the major area versus site-wide PRGs and 30-year versus 70-year assumption changes.

In general, as the conservatism and uncertainty in factors used in the exposure assumptions increases, the cost to implement an alternative increases, as shown in Figure 4-10. The lack of scale on the figure indicates that risk conservatism is not quantifiable.

### 4.5.3 Uncertainties in Estimating Volume of Material Requiring Containment or Remediation

Some uncertainties associated with the estimated volume of contaminated soil are the product of the uncertainties from the site characterization and risk calculations (SEC Donohue 1992b and Life Systems 1992a). Throughout the FS, the assumptions incorporated for volume considerations reflect conservative observations and may overestimate the volume.

## TABLE 4-9

## SUMMATION OF RAO ASSUMPTIONS AND EFFECTS ON ESTIMATED COSTS AND VOLUMES
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Summary of RAOs | Volume 1E-04 | Volume 1E-06 | % Change in Volume from EPA RAOs 1E-04 | % Change in Volume from EPA RAOs 1E-06 | Alternative | Estimated Cost ($M) Excess Cancer Risk: 1E-04 | Estimated Cost ($M) Excess Cancer Risk: 1E-06 |
|---|---|---|---|---|---|---|---|
| Major area PRGs, soil only, future farm family, 30-year exposure duration, fractional intake factor applied | 5900 | 7200 | -29 | -15 | 2 | 7.5 | 8 |
| | | | | | 3 | 11 | 13 |
| | | | | | 4 | 3 | 3.5 |
| | | | | | 5 | 4 | 4.5 |
| Major area PRGs, soil only, future farm family, `0-year, exposure uration | 7400 | 12,100 | -12 | +44 | 2 | 8 | 10.5 |
| | | | | | 3 | 3 | 20 |
| | | | | | 4 | 3.5 | 4 |
| | | | | | 5 | 4.5 | 6.5 |
| Site-wide PRGs, soil only, future farm family, 30-year exposure duration, fractional intake factor applied | 6400* | 7400 | -24 | -12 | 2 | 7.5 | 8 |
| | | | | | 3 | 12.5 | 13 |
| | | | | | 4 | 3.5 | 3.5 |
| | | | | | 5 | 4 | 4.5 |
| Major area PRGs, soil only, farm worker, 30-year exposure duration, fractional intake factor applied | 5600* | 6400 | -34 | -24 | 2 | 7.5 | 7 |
| | | | | | 3 | 11 | 12.5 |
| | | | | | 4 | 3 | 3.5 |
| | | | | | 5 | 4 | 4 |
| Major area PRGs, soil and vegetables, future farm family, 30-year exposure duration, fractional intake factor applied | 7400 | 15,000 | -12 | +78 | 2 | 8 | 12.5 |
| | | | | | 3 | 13 | 20.5 |
| | | | | | 4 | 3.5 | 5 |
| | | | | | 5 | 4.5 | 7.5 |
| Major area PRGs, soil only, future farm family, 70-year exposure duration, fractional ntake factor applied | 6500 | 7400 | -23 | -12 | 2 | 7.5 | 8 |
| | | | | | 3 | 12.5 | 13 |
| | | | | | 4 | 3.5 | 3.5 |
| | | | | | 5 | 4 | 4.5 |

## TABLE 4-9

## SUMMATION OF RAO ASSUMPTIONS AND EFFECTS ON ESTIMATED COSTS AND VOLUMES
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**
**(Continued)**

| Summary of RAOs | Volume 1E-04 | Volume 1E-06 | % Change in Volume from EPA RAOs 1E-04 | % Change in Volume from EPA RAOs 1E-06 | Alternative | Estimated Cost ($M) Excess Cancer Risk: 1E-04 | Estimated Cost ($M) Excess Cancer Risk: 1E-06 |
|---|---|---|---|---|---|---|---|
| Site-wide PRGs, soil only, future farm family, 30-year exposure duration | 7900 | 13,100 | -11 | +56 | 2 | 8.5 | 12 |
| | | | | | 3 | 14 | 20.5 |
| | | | | | 4 | 4 | 4 |
| | | | | | 5 | 5 | 6.5 |
| Site-wide PRGs, soil only, future farm family, 70-year exposure uration | 7700 | 16,600 | -8 | +98 | 2 | 8.5 | 13 |
| | | | | | 3 | 14 | 20.5 |
| | | | | | 4 | 4 | 5 |
| | | | | | 5 | 5 | 8 |

Note: A detailed discussion of exposure assumptions is included under Section 1.2.6.1.

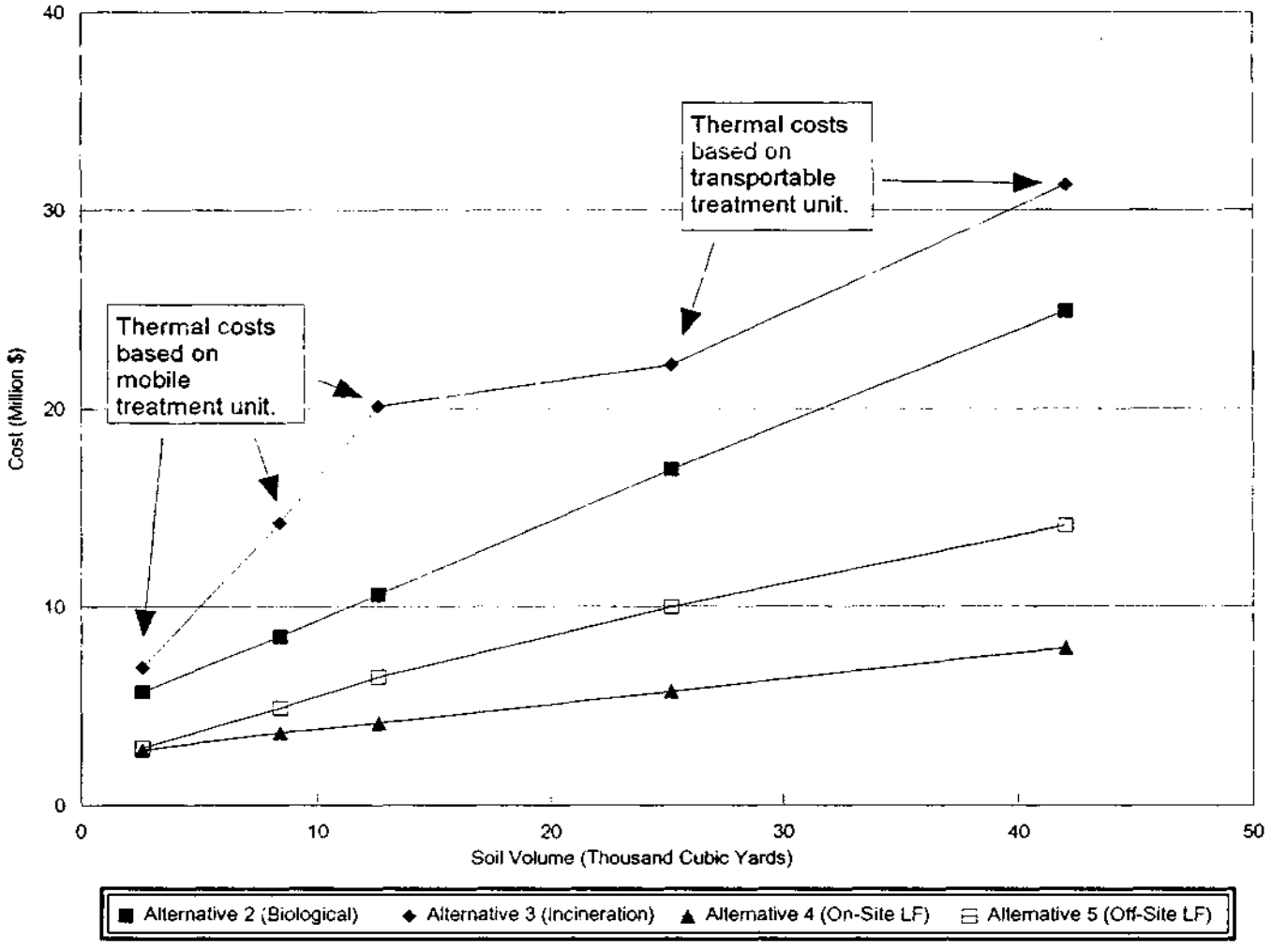
EPA RAOs
- 3E-06 Target Cancer Risk
- 1E+00 Target Noncancer HI
- Soil Ingestion Only
- Hypothetical Future Farm Family
- RME Assumptions
- 30-year Exposure Duration
- No Fractional Intake Factor Applied
- Estimated Volume = 8,400 cy

*Sample used to characterize trenches in Burning/Proving Grounds does not exceed PRGs; however, based on historical information, material within the trenches may exceed PRGs. Therefore, the approximately 3,000 cubic yards associated with the trenches is included in this volume.

RP/MEADFS/AU9

**FIGURE 4-9**

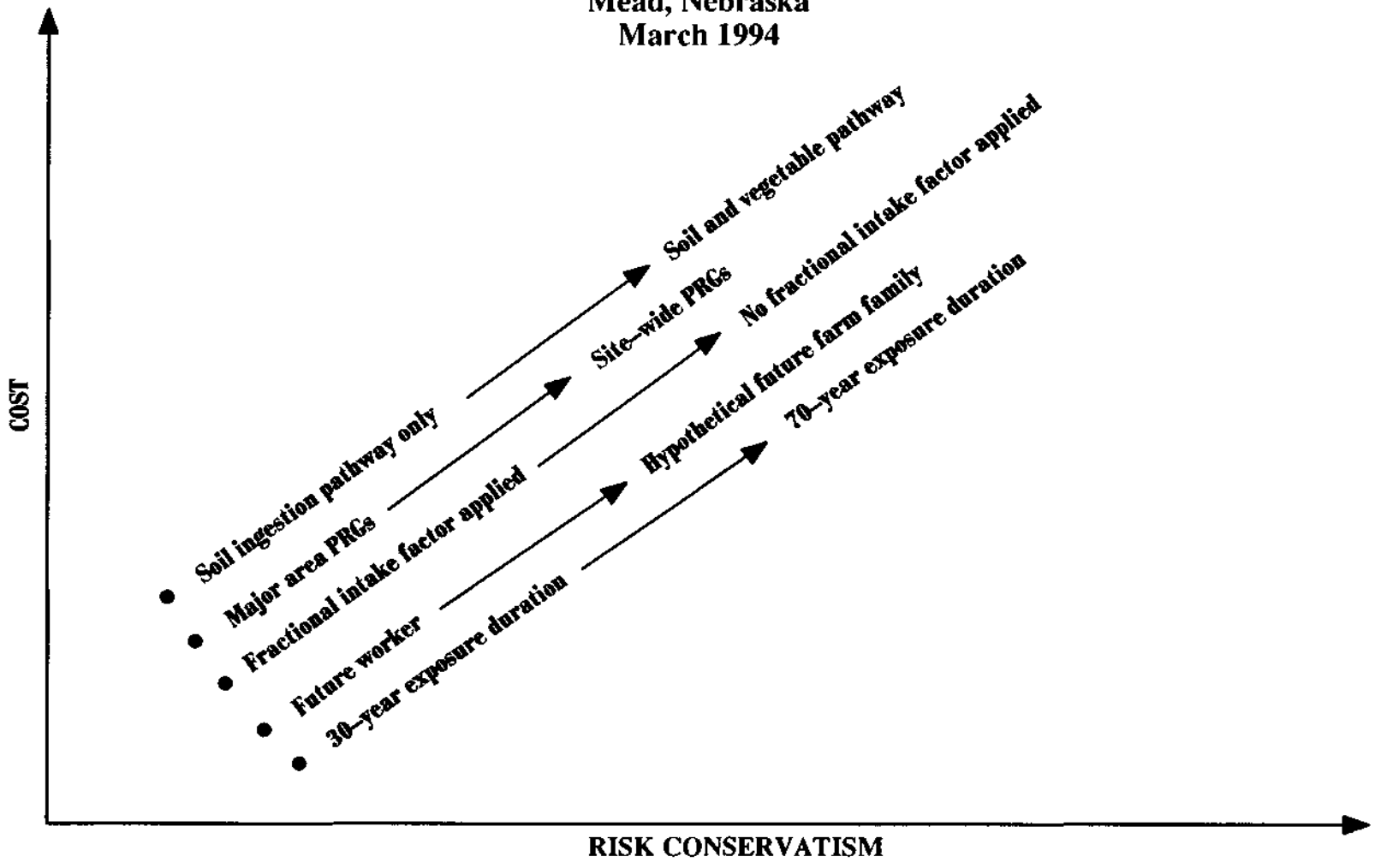
**REMEDIATION COST VARIATIONS WITH DIFFERENT SOIL VOLUME**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**




Note: The calculated volumes and corresponding estimated costs are for comparative purposes only. The relationship between volumes and costs, within and among alternatives, is based on assumptions used in this report.
A mobile treatment unit is typically mounted on one or more vehicles. Each vehicle carries a component of the system that remains on the vehicle and a relatively limited amount of connections from component to component are required for operational assembly. A transportable unit is shipped to the site in pieces by vehicle where it is off-loaded and assembled for operation.

FIGURE 4–10

CONCEPTUAL COST IMPACT OF USING CONSERVATIVE RISK FACTORS
Former NOP Site
Operable Unit 1 FS
Mead, Nebraska
March 1994




Note: Position of risk factors in figure does not suggest relative impact of factors.

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However, not all field samples were used in the volume calculations because of data validity concerns. Field screen sample validity was evaluated on a point-by-point basis (see Appendix C-1). The volumes may thus be underestimated. Prior to remediation, laboratory samples may be taken at selected positive field screen locations which indicated the presence of explosives. Laboratory samples exceeding risk-based PRGs may contribute additional volumes.

### 4.5.4 Ultimate Remediation Cost and Schedule

The estimated costs and treatment durations are from vendor information and are based upon physical/chemical sampling results, risk, RAO, and PRG assumptions and corresponding contaminated volume estimates. They are accurate only to the extent that vendor information and data are correct and representative of the site and to the extent that risk, RAO, and PRG assumptions are reasonable. As discussed previously, there are uncertainties associated with the estimated volume of soil to be remediated, and the duration necessary to complete treatment. The costs may be underestimated because they are based on low volumes (due to the exclusion of field screen data in the volume calculations).

### 4.5.5 Technology Effectiveness

As discussed previously, there are inherent uncertainties associated with the use of the innovative biological treatment technology as the principal treatment process for remediating the explosives-contaminated soil. Further treatability studies are needed to address these uncertainties.

## 4.6 ADDITIONAL DATA NEEDS

Although adequate data are available to select a remedy for this site, additional data are needed to more accurately define the requirements for the Remedial Design and reduce some of the uncertainties noted above:

- Verify delineation of the source areas.
- Evaluate optimization of biological treatment for all explosives compounds of concern in the soil matrix present at the former NOP site.
- Verify final authorization to dispose of material into an off-site landfill. This may require further testing of soil.
- Collect and analyze soil samples where field screening samples detected explosives.
- Determine specific wastewater pretreatment requirements and further characterize potential liquid process streams.

- Determine substantive requirements for NPDES discharge of potential liquid process streams.

These items will be addressed during the Remedial Design or Remedial Action.

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# APPENDIX A

## PRELIMINARY REMEDIATION GOALS

Appendix A1: Development of Preliminary Remediation Goals
Appendix A2: Qualitative Risk Evaluation of Proposed Remedial Alternatives

# APPENDIX A1

# DEVELOPMENT OF PRELIMINARY REMEDIATION GOALS

# APPENDIX A1
# DEVELOPMENT OF PRELIMINARY REMEDIATION GOALS

## 1.0 INTRODUCTION

Preliminary Remediation Goals (PRGs) are environmental concentration limits for chemicals of concern, calculated to protect humans against carcinogenic or non-carcinogenic effects under specified exposure conditions. PRGs provide targets for remedial design and are used during the analysis and selection of remedial alternatives. Risk-based PRGs are calculated using assumptions and equations similar to those used in the Baseline Risk Assessment, when appropriate. Leach-based PRGs may be calculated using OU 2 data and a model to estimate the maximum soil concentration that may exist in the unsaturated zone above the aquifer without exceeding a given concentration in the aquifer. These are not included in this document.

## 2.0 RISK-BASED PRELIMINARY REMEDIATION GOALS

The Baseline Risk Assessment report (Life Systems, 1992a) contains information regarding the media of concern, the chemicals of potential concern and the exposure factors developed in evaluating the baseline conditions at the site. The Baseline Risk Assessment evaluated a farm family (adult and child) scenario and a worker scenario. Therefore, these populations were used to calculate risk-based PRGs. Typically, PRGs are calculated in a series of iterations beginning with general default assumptions and then improving and refining the values as site-specific data become available.

In the first iteration, PRGs were calculated for each explosive, taking only one pathway (soil ingestion) into account and assuming there was no chemical additivity to the target risk. For non-carcinogens, these PRGs are the concentrations which yield a Hazard Index (HI) value of 1E+00 for a resident (adult or child) exposed under reasonable maximum exposure (RME) conditions. For carcinogens, the PRGs are equal to the concentrations which yield cancer risks of 1E-04, 1E-05, or 1E-06. For those chemicals that are carcinogens and noncarcinogens, the PRGs are the lower value of the carcinogenic and non-carcinogenic PRG for a given risk level. These PRGs are presented in the Supplemental RI (SEC Donohue, 1992b).

In the second iteration, PRGs were recalculated to take into account the multiple exposure pathways that could apply at the site under more conservative assumptions. These include ingestion of soil, ingestion of garden vegetables, ingestion of home-grown beef, and inhalation of soil particles while tilling. As before, each PRG is the concentration which yields an HI=1E+00 or a target cancer risk level (1E-04, 1E-05, or 1E-06), whichever is lower, assuming RME of a resident adult or child by each pathway simultaneously. These PRGs represent the level of each chemical that would meet health-based goals if the chemical were present alone and no additional risk was being contributed by other

chemicals. These PRGs are presented in the Initial Screening of Alternatives Document (SEC Donohue, 1992c). Detailed calculations used in development of these PRGs are included in the Draft Development of Risk-Based Preliminary Remediation Goals report (Life Systems, 1992c).

In the third iteration, PRGs were recalculated to account for the additive risks from the presence of multiple chemicals at a given source (or contaminated) area. In this case there are a wide range of possible PRGs, all of which may satisfy the health-based goals selected, but which differ in the ease and cost of attainment. During this iteration, prior to OU 2 groundwater data availability, a model was used which indicated that based on existing soil concentrations, there was limited risk from groundwater contamination due to explosives leaching from the soil.

The fourth iteration PRGs were similar to the third iteration PRGs. However, worst-case groundwater data now available from OU 2 indicated there were risks from exposure to groundwater. Risks in groundwater were assumed to be eliminated using treatment at the point-of-use. The Summers model was later used to determine the soil concentrations that must be reached in order to prevent further contamination of groundwater (leach-based PRGs). Detailed calculations used in development of the soil risk-based PRGs under a variety of exposure assumptions are included in the Development of Risk-Based Preliminary Remediation Goals Report included in Attachment A-1 of this appendix.

In the fifth iteration, the parties of the IAG agreed to transfer the investigation of the soil source-to-groundwater to OU 2. OU 2 data may be used with contaminant transport models to determine the concentrations that can be safely left in soil without causing an exceedance of target risk in groundwater. Depending on schedule constraints and the findings under OU 2, the additional volume of soil to be remediated due to leach-based PRGs may be remediated under OU 1. Also in the fifth iteration, USEPA developed PRGs for the site. Section 4.5 discusses the assumptions used by USEPA, and how they differ from the USACE assumptions. Documentation of USEPA PRGs for the site is included as Attachment A-2 of this appendix.

## 2.1 Risk-Based PRG Assumptions and Methodology

Risks to hypothetical future farm family, farmer, and farm worker populations from ingestion of soil, home-grown garden vegetables, and groundwater were evaluated for both average and RME conditions in the Baseline Risk Assessment. For the purposes of this document, PRGs are based on the following RAOs provided by USEPA and agreed upon by USACE and NDEQ:

- Soil ingestion only.
- Hypothetical future farm family.
- RME assumptions.
- A 30-year exposure duration.

- No fractional intake factor applied.
- Target noncancer risk of HI=1E+00.
- Target cancer risk equal to 3E-06.
- PRGs applied on a site-wide basis.

These factors represent conservative or reasonable maximum values. The logic for their selection is as follows. Indirect exposure to contaminated soil via consumption of home-grown garden vegetables is not included due to the high uncertainty and conservatism of this exposure pathway and will be evaluated in OU 3. While appropriate for qualitative evaluations in risk assessment, it is not appropriate for use in making risk management decisions concerning remediation. This pathway is uncertain and overly conservative primarily because the vegetable uptake is highly uncertain and over-estimated, the fraction of total vegetable intake that comes from home-grown sources is uncertain, soil concentration and garden size are over-estimated, and there is no account for breakdown of compounds by the plants. In addition, explosives concentrations in NOP plants have not been studied.

The contaminated areas are located on University land, and it is not apparent that the University would sell the land for residential farm use. However, the hypothetical future farm family was assumed to be the exposed population because it uses more conservative exposure assumptions and accounts for the possibility that the land could one day be used for family farming.

The reasonable maximum exposure (RME) assumptions use more conservative dose factors than average exposure assumptions. The 30-year exposure duration was selected because, based on available data, most residents would not occupy a single location for 70 years.

The Baseline Risk Assessment evaluated the risks to receptors assuming that they only ingest soil and vegetables from within the contaminated areas. Using an intake factor that does not assume a fractional intake is conservative, because, in most cases, there is insufficient space within contaminated areas for exposure activities (e.g., plant a garden, pasture a cow, and till a field) to occur. Thus, in order to be conservative, no fractional intake factor was applied.

## 2.2 Excavation PRGs

Excavation PRGs are values which are used to define the boundaries of an area which must be excavated. For the purposes of this document, the excavation PRGs are based on RAOs provided by USEPA and agreed upon by USACE and NDEQ. The risk-based PRGs are calculated based on the assumption that risk to the populations in the exposure areas due to current groundwater concentrations is zero. No current drinking water wells exist in the exposure areas, and if drinking water wells were installed and used in the OU 1 exposure areas prior to completion of OU 2 activities and explosives concentrations in the well water



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exceed regulatory or health advisory limits, they would be equipped with a wellhead treatment unit that would remove contamination from the water prior to use. Therefore, the risk-based excavation PRGs are calculated based on exposure via the soil pathways only. The home-grown vegetable ingestion pathway is not included due to the high uncertainty in the plant uptake and ingestion factors and will be evaluated in OU 3.

As discussed in the Baseline Risk Assessment, evaluation of exposure at source areas (and hence calculation of PRGs) depends on the relative size of the source area compared to the area over which exposure occurs. This area ratio (source area divided by exposure area) is referred to as the fractional intake factor, and can have a value ranging from 1.0 (the source completely fills the exposure area) to close to zero (the source is very small compared to the exposure area). Based on a minimum 1-acre exposure area, the fractional intake factor for exposure areas at the site ranges from approximately 0.02 to 0.50. In order to be conservative, USEPA calculated PRGs based on no fractional intake factor because USEPA believes it is more appropriate for the NOP site. USACE believes that use of the fractional intake factor is appropriate for the NOP site. The USEPA PRGs are shown in Table A-1. For the purpose of the sensitivity/uncertainty analysis, risk-based PRGs were also calculated for the exposure assumptions shown in Table A-2. If leach-based PRGs calculated under OU 2 are lower than risk-based PRGs, then excavation PRGs may be adjusted in order to be protective of groundwater.

## 2.3 Treatment PRGs

Treatment PRGs are the concentrations to which the soil needs to be treated under treatment alternatives after the soil is excavated and consolidated in order to meet target site risks.

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**TABLE A-1**

**EXCAVATION PRGs**
**(FUTURE FARM FAMILY, SOIL INGESTION ONLY)**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**September 1993**

| Chemical | Concentration (mg/kg) |
|---|---|
| RDX | 5.8 |
| DNB | 3.4 |
| DNT | 0.9 |
| HMX | 1715.2 |
| NT | 343 |
| Tetryl | 343 |
| TNB | 1.7 |
| TNT | 17.2 |

RP/MEADFS/AR0

**TABLE A-2**

**RAO ASSUMPTIONS USED IN SENSITIVITY/UNCERTAINTY ANALYSIS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**September 1993**

| Summary of RAOs | Represents |
|---|---|
| Major area PRGs, soil only, future farm family, 30-year exposure duration, fractional intake factor applied | Army base position |
| Major area PRGs, soil only, future farm family, 30-year exposure duration | Increase when omitting intake factor |
| Site wide PRGs, soil only, future farm family, 30-year exposure duration, fractional intake factor applied | Increase due to site wide PRGs |
| Major area, soil only, farm worker, 30 years exposure duration, fractional intake factor applied | Effect of farm worker |
| Major area PRGs, soil and vegetable, future farm family, 30-year exposure duration,fractional intake factor applied | Increase due to vegetable uptake |
| Major area PRGs, soil only, future farm family, 70-year exposure duration, fractional intake factor applied | Increase due to 70 year exposure duration |

**TABLE A-2**

**RAO ASSUMPTIONS USED IN SENSITIVITY/UNCERTAINTY ANALYSIS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**September 1993**
**(Continued)**

| Summary of RAOs | Represents |
|---|---|
| Site wide PRGs, soil only, future farm family, 30-year exposure duration | EPA assumptions except target risk: 1E-04 and 1E-06 target cancer risk (see Notes) |
| Site wide PRGs, soil only, future farm family, 70-year exposure duration | NDEQ position on exposure duration |

Notes:

EPA RAOs:
- 3E-06 Target Cancer Risk
- 1E+00 Target Noncancer HI
- Soil Ingestion Only
- Hypothetical Future Farm Family
- RME Assumptions
- 30-year Exposure Duration
- No Fractional Intake Factor Applied

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**ATTACHMENT A-1**

Submitted to:

RUST Environment & Infrastructure Inc.
4738 North 40th Street
Sheboygan, WI 53083

Attention: Ms. Susan Shultz, Project Manager (2 copies)

TR-1571-3A

# DEVELOPMENT OF RISK-BASED PRELIMINARY REMEDIATION GOALS

Remedial Investigation/Feasibility Study
Support for the Nebraska Ordnance Plant

Prepared Under

Program No. 1609

Under

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Delivery Order No. 0007

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June 30, 1993

TABLE OF CONTENTS

PAGE

LIST OF ACRONYMS . . . . . iii

LIST OF FIGURES . . . . . iii

LIST OF TABLES . . . . . iii

1.0 INTRODUCTION . . . . . 1

2.0 APPROACH AND CALCULATION . . . . . 1

2.1 General Approach . . . . . 1
2.2 Calculation of Site-Specific PRGs . . . . . 1

2.2.1 Site-Specific PRGs for Carcinogens . . . . . 2
2.2.2 Calculation of Site-Specific PRGs for Noncarcinogenic Chemicals . . . . . 3

2.3 Optimized PRGs . . . . . 4

3.0 RESULTS . . . . . 1

4.0 REFERENCES . . . . . 1

Appendix 1 Worksheets for Health-Based PRGs . . . . . A1-1

LIST OF ACRONYMS

| | |
|---|---|
| HI | Hazard Index |
| HIF | Human Intake Factor |
| NOP | Nebraska Ordnance Plant |
| PRG | Preliminary Remediation Goal |
| RfD | Reference Dose |
| SF | Slope Factor |
| TR | Target Risk |
| USEPA | U.S. Environmental Protection Agency |

## 1.0 INTRODUCTION

Preliminary Remediation Goals (PRGs) are initial clean up levels which are chemical specific, protective of human health and the environment and comply with chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs). The PRGs developed for a site provide targets for remedial design and are used during the analysis and selection of remedial alternatives. This report documents the development of PRGs for the Nebraska Ordnance Plant (NOP) site in Mead, Nebraska. Guidance for these calculations can be found in USEPA (1991).

Preliminary remediation goals set concentration limits using carcinogenic or noncarcinogenic toxicity values, under specified exposure conditions. The calculation of PRGs considers all chemicals of potential concern as identified in the baseline risk assessment for each pathway which is likely to result in exposure to the selected populations. The baseline risk assessment report (ICAIR 1993) should be referred to for information regarding the media of concern, the chemicals of potential concern and the exposure factors developed in evaluating the baseline (or no-action alternative) conditions at the site.

The Baseline Risk Assessment evaluated both a Farm Family (adult and child) scenario and a worker scenario. These populations were used to calculate PRGs. The PRGs were calculated for the reasonable maximum combination of exposure factors. Since the baseline risk assessment evaluated only soil, PRGs were calculated for this medium only and only for explosive compounds.

In order to account for various exposure factors assumed in the baseline risk assessment, different PRGs were calculated by varying exposure duration (30 years vs. 70 years for the farm family) and including or excluding the vegetable pathway. In addition, a term in the risk equation that accounts for the fraction of soil or vegetables ingested from the contaminated area ("f") was varied from 1 to 0.02. This range accounts for the variability across source areas in how much an explosive-contaminated source could contribute to assumed exposure area.

Finally, six separate portions of the site were evaluated in addition to an all-site calculation. The areas are the burning/proving ground, the bomb booster area and four load lines (load lines 1-4). As required by USEPA (1991), PRGs were calculated for three carcinogenic target risk levels (1E-04, 1E-05, 1E-06).

## 2.0 APPROACH AND CALCULATION

### 2.1 General Approach

For carcinogens, PRGs are calculated that correspond to incremental risks of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. Acceptable target risk levels for cancer are designated by the National Contingency Plan at levels of 1E-04 (1 in 10,000), 1E-05 (1 in 100,000) and 1E-06 (1 in 1,000,000) excess occurrences of cancer in an exposed population. Preliminary remediation goals for carcinogenic chemicals are calculated by the following general equation:

$$\text{PRG (mg/kg)} = \frac{TR}{\Sigma HIF \cdot SF} \qquad (1)$$

where:

- PRG = Preliminary Remediation Goal for carcinogenic effects in a given medium
- TR = Target Risk level (i.e., 1E-04, 1E-05, 1E-06)
- HIF = Human Intake Factor - lifetime (kg/kg-day). The term in the risk equation which accounts for exposure factors (e.g., contact rate, exposure frequency and duration, body weight, etc.)
- SF = Slope Factor $(mg/kg\text{-}day)^{-1}$. The route-specific toxicity value which estimates the upper-bound probability of an individual developing cancer as a result of a lifetime of exposure.

Preliminary remediation goals for chemicals with noncarcinogenic effects are developed by using a Hazard Index (HI) approach. The PRG is the concentration which corresponds to an HI of 1.0. Noncarcinogenic PRGs are calculated by the following general equation:

$$\text{PRG (mg/kg)} = \frac{RfD}{\Sigma HIF} \qquad (2)$$

where:

- PRG = Preliminary Remediation Goal for noncarcinogenic effects in a given medium
- HIF = Human Intake Factor (chronic or subchronic), as defined in Equation (1)
- RfD = Reference Dose (chronic or subchronic); the toxicity value which estimates acceptable exposures to noncarcinogenic chemicals

For both equations, the HIF terms, SFs and RfDs are the same as those used in the baseline risk assessment prepared for this site (ICAIR 1993).

### 2.2 Calculation of Site-Specific PRGs

Typically, PRGs are calculated in a series of iterative steps. In the first iteration, a chemical-specific PRG is calculated using the general equations

(1) and (2) and considering all pathways relevant for each exposed population. The PRGs calculated at this stage considered only those pathways associated with soil contamination. Risks from groundwater at this site were assumed to be eliminated using point-of-use treatment. In subsequent iterations additivity among chemicals and optimization considerations were included.

For the farm family scenario, exposures to the explosives were evaluated by four different pathways:

- Ingestion of yard soil
- Ingestion of beef
- Ingestion of garden vegetables
- Ingestion of field soil while tilling

All these pathways were relevant to each population (child, adult) were considered in developing the PRG.

### 2.2.1 Site-Specific PRGs for Carcinogens

In calculating a PRG for carcinogenic exposure for an adult member of the farm family, equation (1) was modified as follows:

$$PRG = \frac{TR}{SF_o(HIF_{sl} + (BCF_b \cdot HIF_{bl}) + (BCF_v \cdot HIF_{vl}) + HIF_{fsl})} \quad (3)$$

where:

- PRG = Preliminary Remediation Goal for carcinogenic effects, soil
- TR = Target Risk Level (1E-04, 1E-05, 1E-06)
- $SF_o$ = Slope Factor, oral route
- $HIF_{sl}$ = Human Intake Factor for adult farmer, ingestion of yard soil, lifetime
- $HIF_{bl}$ = Human Intake Factor for adult farmer, ingestion of beef, lifetime
- $HIF_{vl}$ = Human Intake Factor for adult farmer, ingestion of vegetables, lifetime
- $HIF_{fsl}$ = Human Intake Factor for adult farmer, ingestion of field soil, lifetime
- $BCF_b$ = Bioconcentration factor for beef
- $BCF_v$ = Bioconcentration factor for vegetables

The worker is only exposed via one pathway (ingestion of soil), therefore, the equation to calculation the PRG would be:

$$PRG = \frac{TR}{SF_o \cdot HIF_{sl}} \quad (4)$$

where:

$HIF_{sl}$ = Human Intake Factor for worker, ingestion of soil, lifetime

### 2.2.2 Calculation of Site-Specific PRGs for Noncarcinogenic Chemicals

There are two PRGs that can be calculated for noncarcinogenic chemicals, based on either subchronic or chronic exposures. The farm family child is evaluated for subchronic exposure; the adult farm family member and the adult worker are evaluated for chronic exposures.

Equation (2) was modified to account for subchronic exposures at the NOP as follows:

$$PRG = \frac{RfD_{os}}{HIF_{ss} + (BCF_b \cdot HIF_{bs}) + (BCF_v \cdot HIF_{vs})} \quad (5)$$

where:

- PRG = Preliminary Remediation Goal for subchronic exposures to noncarcinogens
- $RfD_{os}$ = Subchronic Reference Dose, oral
- $HIF_{ss}$ = Human Intake Factor for the child, soil ingestion, subchronic
- $HIF_{bs}$ = Human Intake Factor for the child, beef ingestion, subchronic
- $HIF_{vs}$ = Human Intake Factor for the child, vegetable ingestion, subchronic

For chronic exposures, Equation (5) was modified to include all exposures to the adult family member, including ingestion of field soil while tilling:

$$PRG = \frac{RfD_{oc}}{HIF_{sc} + (BCF_b \cdot HIF_{bc}) + (BCF_v \cdot HIF_{vc}) + HIF_{fsc}} \quad (6)$$

where:

- $RfD_{oc}$ = Chronic reference dose, oral
- $HIF_{sc}$ = Human Intake Factor for the adult farmer, ingestion of soil, chronic
- $HIF_{bc}$ = Human Intake Factor for the adult farmer, ingestion of beef, chronic
- $HIF_{vc}$ = Human Intake Factor for the adult farmer, ingestion of vegetables, chronic
- $HIF_{fsc}$ = Human Intake Factor for the adult farmer, ingestion of field soil while tilling, chronic

The PRG equation for the worker, who is exposed only via soil ingestion is given as:

$$PRG = \frac{RfD_{oc}}{HIF_{sc}} \quad (7)$$

where:

$RfD_{oc}$ = Chronic reference dose, oral
$HIF_{sc}$ = Human Intake Factor for the worker, ingestion of soil, chronic

## 2.3 Optimized PRGs

The PRGs were further refined to account for additivity among chemicals detected in a particular source area at NOP. A large number of solutions to the risk equations are possible when some fraction of the target risk or hazard index can be allocated to each chemical. Several approaches to this allocation include assigning equal risk (or hazard index) to each chemical, assigning equal concentrations to each chemical or reducing the existing concentrations in soil proportionately in order to achieve the target risk (or hazard index). At NOP, the proportional reduction approach was selected for developing this iteration of the PRGs. By this approach, the existing concentration of each chemical at the site or area was multiplied by a risk proportionality constant (some fraction less than 1) such that the target risk or hazard index is achieved:

$$PRG = C_i \cdot K_r \qquad (8)$$

where:

$C_i$ = Existing concentration of the chemical at the site
$K_r$ = Risk proportionality constant

A different risk proportionality constant was derived for the farm family child (subchronic), farm family adult (chronic and lifetime) and worker (chronic and lifetime). This approach was modified slightly for chemicals judged not to contribute significantly to either risk estimates or the relevant hazard index. For minor risk contributors (i.e., those chemicals which contribute less than 5% of total risk or 5% of the hazard index), the PRGs were held to some multiple of their detection limit. The remaining major chemicals were reduced proportionately to achieve the target risk or hazard index.

A further step was taken to optimize the PRGs to ensure that both noncancer and cancer targets were simultaneously achieved, whenever possible. In order to achieve the highest possible PRG, without exceeding a risk goal, worksheets were set up which contained a risk check feature. As PRGs were adjusted to incorporate achievable optimization, risks were recalculated to determine whether they remained within acceptable parameters (i.e., a specified carcinogenic target risk, or an HI = 1). Worksheets in Appendix 1 provide the final optimized PRGs for each explosive detected at NOP and assuming different receptors and exposure factors.

## 3.0 RESULTS

The baseline risk assessment for the former Nebraska Ordnance Plant, Operable Unit 1 indicated that explosives detected in soil contribute to unacceptable carcinogenic risks and adverse health effects (ICAIR 1993). Preliminary remediation goals were calculated such that target risk levels were achieved in each area and across site areas under several assumed scenarios. These PRGs will be incorporated into the Feasibility Study as means for analyzing and selecting remedial alternatives. They also provide targets for remedial design.

## 4.0 REFERENCES

ICAIR. 1993. ICAIR, Inc. Baseline risk assessment - human health evaluation for the Nebraska Ordnance Plant site. Cleveland, OH: Life Systems, Inc. TR-1571-1c.

USEPA. 1991. U.S. Environmental Protection Agency. Office of Emergency and Remedial Response. Risk assessment guidance for Superfund. Volume I. Human health evaluation manual (Part B, Development of risk-based preliminary remediation goals). Interim. Washington, DC: U.S. Environmental Protection Agency. Publication 9285.7-01B.

# APPENDIX 1

## WORKSHEETS FOR RISK-BASED PRGs


| Exposure Scenario Evaluated | Page |
|---|---|
| Worker | A1-2 |
| Farm Family - 30-year exposure duration, vegetables excluded | A1-9 |
| Farm Family - 30-year exposure duration, with vegetables | A1-16 |
| Farm Family - 70-year exposure duration, vegetables excluded | A1-23 |
| Farm Family - 70-year exposure duration, with vegetables | A1-30 |

EXPOSURE AREA: ALLSITE
EXPOSURE DURATION = 25 YRS
WORKER SOIL INGESTION

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION ( 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | -- | -- | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 3.00 | 1.00 | 17.0 | 37.4 | 93.4 | 186.8 | 373.6 | 933.9 |
| | 1,3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.6 |
| | 2,4-DNT | 305 | 669 | 1.3 | 118.5 | 3.00 | 0.25 | 193.8 | 200.7 | 503.9 | 1007.9 | 2015.8 | 5039.5 |
| | 2,6-DNT | 7 | 222 | 0.2 | 5.6 | 3.00 | 0.26 | 3.6 | 196.1 | 488.0 | 975.8 | 1951.5 | 4878.9 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 10.0 | 10.0 | 16.0 | 31.9 | 63.8 | 159.5 |
| | Nitrobenzene | | 210 | 0.0 | 0.0 | 1.00 | 0.26 | - | - | -- | -- | -- | -- |
| | m-Nitrotoluene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | - | - | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 2.0 | 4.3 | 10.8 | 21.5 | 43.1 | 107.7 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 456.5 | 1004.4 | 2511.0 | 5021.9 | 10043.9 | 25109.7 |
| | 1,3,5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 4.0 | 4.9 | 12.1 | 24.3 | 48.6 | 121.5 |
| | 2,4,6-TNT | 651 | 755 | 1221.2 | 175929.3 | 2.50 | 0.25 | 179.1 | 394.2 | 985.4 | 1970.9 | 3941.8 | 9854.4 |
| | | | | | | RISK CHECK: | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | -- | -- | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 1.00 | 1.00 | 17.0 | 37.4 | 93.4 | 186.8 | 373.6 | 933.9 |
| | 1,3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.6 |
| | 2,4-DNT | 305 | 669 | 1.3 | 118.5 | 0.25 | 0.25 | 5.2 | 12.9 | 40.8 | 87.3 | 180.2 | 240.3 |
| | 2,6-DNT | 7 | 222 | 0.2 | 5.6 | 0.25 | 0.26 | 5.1 | 5.6 | 5.6 | 5.6 | 5.6 | 224.3 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 10.0 | 10.0 | 16.0 | 31.9 | 63.8 | 159.5 |
| | Nitrobenzene | | 210 | 0.0 | 0.0 | 1.00 | 0.26 | - | - | -- | -- | -- | -- |
| | m-Nitrotoluene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | - | - | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 2.0 | 4.3 | 10.8 | 21.5 | 43.1 | 107.7 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 456.5 | 1004.4 | 2511.0 | 5021.9 | 10043.9 | 25109.7 |
| | 1,3,5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 4.0 | 4.9 | 12.1 | 24.3 | 48.6 | 121.5 |
| | 2,4,6-TNT | 651 | 755 | 1221.2 | 175929.3 | 0.25 | 0.25 | 179.1 | 394.2 | 985.4 | 1970.9 | 3941.8 | 9854.4 |
| | | | | | | RISK CHECK: | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | -- | -- | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 1.00 | 1.00 | 2.5 | 5.9 | 16.4 | 32.8 | 65.6 | 164.0 |
| | 1,3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 | 156.3 |
| | 2,4-DNT | 305 | 669 | 1.3 | 118.5 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.4 | 0.8 | 1.9 |
| | 2,6-DNT | 7 | 222 | 0.2 | 5.6 | 0.25 | 0.26 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 2431.2 | 2431.2 | 2431.2 | 2431.2 | 2431.2 | 78142.5 |
| | Nitrobenzene | | 210 | 0.0 | 0.0 | 1.00 | 0.26 | - | - | -- | -- | -- | -- |
| | m-Nitrotoluene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | - | - | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 160.0 | 160.0 | 160.0 | 160.0 | 160.0 | 15302.3 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 1488.3 | 3817.4 | 10215.1 | 20998.3 | 42564.7 | 67142.3 |
| | 1,3,5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 9.2 | 18.9 | 50.7 | 104.2 | 211.2 | 505.7 |
| | 2,4,6-TNT | 651 | 755 | 1221.2 | 175929.3 | 0.25 | 0.25 | 26.8 | 62.1 | 173.0 | 346.1 | 692.1 | 1730.3 |
| | | | | | | RISK CHECK: | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: 8BA
EXPOSURE DURATION = 25 YRS
WORKER SOIL INGESTION

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1.00 | 0.50 | 0.20 | 0.10 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 3.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1.3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.2 | 2.3 | 4.7 | 11.6 |
| | 2.4-DNT | | 3 | | | 3.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2.6-DNT | | 2 | | | 3.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 16.9 | 37.8 | 104.6 | 209.1 | 418.2 | 1045.6 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 3933.1 | 8797.6 | 24322.3 | 48644.7 | 97289.4 | 243223.4 |
| | 1.3.5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 7.8 | 19.4 |
| | 2.4.6-TNT | 1 | 3 | 2.6 | 7.0 | 2.50 | 0.25 | 2.5 | 2.5 | 3.4 | 6.8 | 13.7 | 34.2 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 5E-08 | 3E-08 | 1E-08 | 1E-08 | 1E-08 | 1E-08 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 1.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1.3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.2 | 2.3 | 4.7 | 11.6 |
| | 2.4-DNT | | 3 | | | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2.6-DNT | | 2 | | | 0.25 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 16.9 | 37.8 | 104.6 | 209.1 | 418.2 | 1045.6 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 3933.1 | 8797.6 | 24322.3 | 48644.7 | 97289.4 | 243223.4 |
| | 1.3.5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 7.8 | 19.4 |
| | 2.4.6-TNT | 1 | 3 | 2.6 | 7.0 | 0.25 | 0.25 | 0.6 | 1.2 | 3.4 | 6.8 | 13.7 | 34.2 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-08 | 1E-08 | 1E-08 | 1E-08 | 1E-08 | 1E-08 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 1.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1.3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.2 | 2.3 | 4.7 | 11.6 |
| | 2.4-DNT | | 3 | | | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2.6-DNT | | 2 | | | 0.26 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 16.9 | 37.8 | 104.6 | 209.1 | 418.2 | 1045.6 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 3933.1 | 8797.6 | 24322.3 | 48644.7 | 97289.4 | 243223.4 |
| | 1.3.5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 7.8 | 19.4 |
| | 2.4.6-TNT | 1 | 3 | 2.6 | 7.0 | 0.25 | 0.25 | 0.6 | 1.2 | 3.4 | 6.8 | 13.7 | 34.2 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-08 | 1E-08 | 1E-08 | 1E-08 | 1E-08 | 1E-08 |

EXPOSURE AREA: BPG
EXPOSURE DURATION = 25 YRS
WORKER SOIL INGESTION

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1.00 | 0.50 | 0.20 | 0.10 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 3.00 | 1.00 | 29.1 | 54.6 | 161.6 | 323.2 | 646.4 | 1615.9 |
| | 1.3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 1.0 | 1.0 | 1.8 | 3.6 | 7.3 | 18.2 |
| | 2.4-DNT | 1 | 15 | 0.01 | 0.271 | 3.00 | 0.25 | 196.7 | 390.3 | 975.8 | 1951.6 | 3903.2 | 9758.0 |
| | 2.6-DNT | | 15 | 0.00 | 0 | 3.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 10.0 | 10.0 | 16.5 | 33.1 | 66.1 | 165.3 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 105.3 | 234.0 | 585.1 | 1170.1 | 2340.2 | 5850.6 |
| | 1.3.5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 4.0 | 4.0 | 8.6 | 17.1 | 34.3 | 85.6 |
| | 2.4.6-TNT | 22 | 28 | 81.01 | 350 | 2.50 | 0.25 | 197.8 | 439.6 | 1098.9 | 2197.9 | 4395.7 | 10989.3 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 1.00 | 1.00 | 29.1 | 54.6 | 161.6 | 323.2 | 646.4 | 1615.9 |
| | 1.3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 1.0 | 1.0 | 1.8 | 3.6 | 7.3 | 18.2 |
| | 2.4-DNT | 1 | 15 | 0.01 | 0.271 | 0.25 | 0.25 | 7.6 | 12.2 | 30.4 | 60.8 | 121.7 | 304.2 |
| | 2.6-DNT | | 15 | 0.00 | 0 | 0.26 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 10.0 | 10.0 | 16.5 | 33.1 | 66.1 | 165.3 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 105.3 | 234.0 | 585.1 | 1170.1 | 2340.2 | 5850.6 |
| | 1.3.5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 4.0 | 4.0 | 8.6 | 17.1 | 34.3 | 85.6 |
| | 2.4.6-TNT | 22 | 28 | 81.01 | 350 | 0.25 | 0.25 | 197.8 | 439.6 | 1098.9 | 2197.9 | 4395.7 | 10989.3 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 1.00 | 1.00 | 3.9 | 8.5 | 22.7 | 45.4 | 90.9 | 227.2 |
| | 1.3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 1.0 | 4.5 | 37.0 | 91.6 | 205.5 | 528.3 |
| | 2.4-DNT | 1 | 15 | 0.01 | 0.271 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2.6-DNT | | 15 | 0.00 | 0 | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 207.0 | 1947.4 | 18219.4 | 45512.4 | 99314.5 | 263855.9 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 223.0 | 571.1 | 3825.5 | 9284.1 | 20044.5 | 52952.8 |
| | 1.3.5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 20.4 | 37.0 | 53.3 | 80.6 | 134.4 | 298.9 |
| | 2.4.6-TNT | 22 | 28 | 81.01 | 350 | 0.25 | 0.25 | 26.8 | 57.7 | 154.5 | 309.0 | 618.0 | 1545.0 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL1
EXPOSURE DURATION = 25 YRS
WORKER SOIL INGESTION PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f)

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | DL | 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | -- | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 5.5 |
| | 1.3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 135 | 246 | 1.97 | 25.05 | 3.00 | 0.25 | 100.3 | 201.4 | 506.2 | 1014.1 | 2029.4 | 5073.7 |
| | 2.6-DNT | 3 | 92 | 0.13 | 2.93 | 3.00 | 0.25 | 100.3 | 198.4 | 494.1 | 987.0 | 1973.3 | 4933.4 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | -- | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | -- | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | -- | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1.3.5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 4.0 | 5.0 | 12.5 | 25.0 | 49.9 | 124.8 |
| | 2.4.6-TNT | 248 | 276 | 3069.31 | 132800 | 2.50 | 0.25 | 204.4 | 449.9 | 1124.8 | 2249.6 | 4499.3 | 11248.2 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | -- | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.1 | 2.2 | 5.5 |
| | 1.3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 135 | 246 | 1.97 | 25.05 | 0.25 | 0.25 | 9.4 | 19.1 | 28.2 | 56.7 | 113.5 | 283.7 |
| | 2.6-DNT | 3 | 92 | 0.13 | 2.93 | 0.25 | 0.26 | 2.9 | 2.9 | 27.0 | 54.0 | 107.9 | 269.6 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | -- | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | -- | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | -- | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1.3.5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 4.0 | 5.0 | 12.5 | 25.0 | 49.9 | 124.8 |
| | 2.4.6-TNT | 248 | 276 | 3069.31 | 132800 | 0.25 | 0.25 | 192.2 | 449.9 | 1124.8 | 2249.6 | 4499.3 | 11248.2 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | -- | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 |
| | 1.3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 4.9 | 4.9 | 4.9 | 4.9 | 37.7 | 342.5 |
| | 2.4-DNT | 135 | 246 | 1.97 | 25.05 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.6 | 1.5 |
| | 2.6-DNT | 3 | 92 | 0.13 | 2.93 | 0.25 | 0.26 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 15.0 | 15.0 | 15.0 | 15.0 | 16431.1 | 168822.9 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | -- | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | -- | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | -- | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 56.7 | 56.7 | 56.7 | 56.7 | 3339.9 | 33818.3 |
| | 1.3.5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 19.0 | 39.2 | 98.3 | 200.4 | 354.4 | 506.8 |
| | 2.4.6-TNT | 248 | 276 | 3069.31 | 132800 | 0.25 | 0.25 | 32.4 | 80.0 | 234.1 | 468.1 | 936.2 | 2340.5 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL2
EXPOSURE DURATION = 25 YRS
WORKER SOIL INGESTION PRGs (mg/kg) AS A FUNCTION OF AREA FRACTIO

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 3.00 | 1.00 | 53.8 | 107.7 | 269.2 | 538.5 | 1076.9 | 2692.3 |
| | 1.3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.8 |
| | 2.4-DNT | 138 | 314 | 2.41 | 118.51 | 3.00 | 0.25 | 3.0 | 4.5 | 11.3 | 22.5 | 45.1 | 112.6 |
| | 2.6-DNT | | 69 | 0.00 | 0 | 3.00 | 0.25 | - | - | - | - | - | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 10.0 | 18.6 | 46.4 | 92.8 | 185.6 | 464.0 |
| | Nitrobenzene | | 62 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1.3.5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 4.0 | 6.9 | 17.3 | 34.5 | 69.0 | 172.5 |
| | 2.4.6-TNT | 260 | 325 | 2570.34 | 175929.3 | 2.50 | 0.25 | 206.2 | 412.5 | 1031.2 | 2062.4 | 4124.9 | 10312.2 |
| | | | | | | RISK CHECK: | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 1.00 | 1.00 | 53.8 | 107.7 | 269.2 | 538.5 | 1076.9 | 2692.3 |
| | 1.3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.8 |
| | 2.4-DNT | 138 | 314 | 2.41 | 118.51 | 0.25 | 0.25 | 3.2 | 6.4 | 16.0 | 32.0 | 64.0 | 160.0 |
| | 2.6-DNT | | 69 | 0.00 | 0 | 0.26 | 0.26 | - | - | - | - | - | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 10.0 | 18.6 | 46.4 | 92.8 | 185.6 | 464.0 |
| | Nitrobenzene | | 62 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1.3.5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 4.0 | 6.9 | 17.3 | 34.5 | 69.0 | 172.5 |
| | 2.4.6-TNT | 260 | 325 | 2570.34 | 175929.3 | 0.25 | 0.25 | 206.2 | 412.5 | 1031.2 | 2062.4 | 4124.9 | 10312.2 |
| | | | | | | RISK CHECK: | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 1.00 | 1.00 | 5.3 | 12.6 | 31.4 | 62.8 | 125.7 | 314.2 |
| | 1.3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 347.7 |
| | 2.4-DNT | 138 | 314 | 2.41 | 118.51 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.5 | 1.1 |
| | 2.6-DNT | | 69 | 0.00 | 0 | 0.26 | 0.26 | - | - | - | - | - | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 2431.2 | 2431.2 | 2431.2 | 2431.2 | 2431.2 | 175142.6 |
| | Nitrobenzene | | 62 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 34548.3 |
| | 1.3.5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 19.3 | 41.4 | 108.9 | 221.3 | 430.0 | 602.7 |
| | 2.4.6-TNT | 260 | 325 | 2570.34 | 175929.3 | 0.25 | 0.25 | 20.4 | 48.1 | 120.3 | 240.7 | 481.4 | 1203.4 |
| | | | | | | RISK CHECK: | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL3
EXPOSURE DURATION = 25 YRS
WORKER SOIL INGESTION

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTIO 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 3.8 | 7.5 | 18.8 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 3.00 | 0.25 | 200.6 | 399.0 | 998.2 | 1996.8 | 3993.7 | 9984.2 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 3.00 | 0.25 | - | - | - | - | - | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | - | - | - | - | - | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | - | - | - | - | - | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 4.0 | 4.0 | 7.8 | 15.5 | 31.1 | 77.6 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 2.50 | 0.25 | 204.5 | 468.7 | 1171.8 | 2343.6 | 4687.2 | 11718.0 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 1.00 | 1.00 | 1.0 | 1.0 | 1.9 | 3.8 | 7.5 | 18.8 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 0.25 | 0.25 | 12.4 | 21.2 | 53.0 | 106.1 | 212.2 | 530.4 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 0.25 | 0.26 | - | - | - | - | - | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | - | - | - | - | - | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | - | - | - | - | - | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 4.0 | 4.0 | 7.8 | 15.5 | 31.1 | 77.6 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 0.25 | 0.25 | 192.3 | 468.7 | 1171.8 | 2343.6 | 4687.2 | 11718.0 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.5 | 3.7 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 2.5 | 2.5 | 2.5 | 109.4 | 312.9 | 923.4 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.4 | 0.7 | 1.9 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 0.26 | 0.26 | - | - | - | - | - | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | - | - | - | - | - | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | - | - | - | - | - | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 19.9 | 40.6 | 95.3 | 148.8 | 250.5 | 555.8 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 0.25 | 0.25 | 38.3 | 81.1 | 232.5 | 465.0 | 929.9 | 2324.8 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 9E-07 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL4
EXPOSURE DURATION = 25 YRS
WORKER SOIL INGESTION PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f)

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | - | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | -- | -- | -- | -- | -- |
| | RDX | 4 | 16 | 7.4 | 34.0 | 3.00 | 1.00 | 26.4 | 52.3 | 132.1 | 264.1 | 528.3 | 1320.7 |
| | 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 1.0 | 1.4 | 3.5 | 7.0 | 14.0 | 34.9 |
| | 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 3.00 | 0.25 | 117.1 | 234.2 | 585.4 | 1170.8 | 2341.6 | 5854.0 |
| | 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 3.00 | 0.26 | 79.5 | 158.9 | 397.4 | 794.7 | 1589.5 | 3973.7 |
| | HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 10.0 | 10.7 | 26.7 | 53.4 | 106.7 | 266.8 |
| | Nitrobenzene | | 12 | | | 1.00 | 0.26 | - | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 12 | | | 1.00 | 0.25 | - | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 12 | | | 1.00 | 0.25 | - | -- | -- | -- | -- | -- |
| | Tetryl | | 12 | | | 1.00 | 0.65 | - | -- | -- | -- | -- | -- |
| | 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 4.0 | 6.4 | 16.1 | 32.2 | 64.4 | 161.1 |
| | 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 2.50 | 0.25 | 209.8 | 419.7 | 1049.2 | 2098.3 | 4196.7 | 10491.7 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | - | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | -- | -- | -- | -- | -- |
| | RDX | 4 | 16 | 7.4 | 34.0 | 1.00 | 1.00 | 21.5 | 42.9 | 107.3 | 214.5 | 429.1 | 1072.7 |
| | 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 3.1 | 6.8 | 15.9 | 33.8 | 67.6 | 169.1 |
| | 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 0.25 | 0.25 | 6.9 | 13.8 | 34.4 | 68.9 | 137.8 | 344.5 |
| | 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 0.25 | 0.26 | 3.1 | 6.3 | 15.6 | 31.3 | 62.6 | 156.5 |
| | HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 1040.1 | 2693.3 | 6733.1 | 13466.3 | 26932.5 | 67331.4 |
| | Nitrobenzene | | 12 | | | 1.00 | 0.26 | - | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 12 | | | 1.00 | 0.25 | - | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 12 | | | 1.00 | 0.25 | - | -- | -- | -- | -- | -- |
| | Tetryl | | 12 | | | 1.00 | 0.65 | - | -- | -- | -- | -- | -- |
| | 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 5.0 | 9.1 | 22.8 | 45.6 | 91.3 | 228.1 |
| | 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 0.25 | 0.25 | 170.4 | 340.8 | 852.1 | 1704.2 | 3408.4 | 8521.1 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | - | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | -- | -- | -- | -- | -- |
| | RDX | 4 | 16 | 7.4 | 34.0 | 1.00 | 1.00 | 2.1 | 4.3 | 10.7 | 21.5 | 42.9 | 107.3 |
| | 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 12.2 | 27.7 | 74.2 | 151.7 | 306.8 | 772.0 |
| | 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 0.25 | 0.25 | 0.7 | 1.4 | 3.4 | 6.9 | 13.8 | 34.4 |
| | 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 0.26 | 0.26 | 0.3 | 0.6 | 1.6 | 3.1 | 6.3 | 15.6 |
| | HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 5593.3 | 13346.7 | 36606.7 | 75373.4 | 152906.9 | 385507.1 |
| | Nitrobenzene | | 12 | | | 1.00 | 0.25 | - | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 12 | | | 1.00 | 0.25 | - | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 12 | | | 1.00 | 0.25 | - | -- | -- | -- | -- | -- |
| | Tetryl | | 12 | | | 1.00 | 0.65 | - | -- | -- | -- | -- | -- |
| | 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 11.5 | 19.3 | 42.6 | 81.4 | 158.9 | 391.5 |
| | 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 0.25 | 0.25 | 17.0 | 34.1 | 85.2 | 170.4 | 340.8 | 852.1 |
| | | | | | RISK CHECK: | | HIs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: ALLSITE
EXPOSURE DURATION = 30 YRS
VEGETABLES EXCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 3.00 | 1.00 | 3.1 | 7.0 | 17.5 | 35.0 | 70.0 | 174.9 |
| | 1.3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 305 | 669 | 1.3 | 118.5 | 3.00 | 0.25 | 82.6 | 88.1 | 222.6 | 446.7 | 894.0 | 4388.7 |
| | 2.6-DNT | 7 | 222 | 0.2 | 5.6 | 3.00 | 0.25 | 5.6 | 87.9 | 217.5 | 433.5 | 866.4 | 12.3 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 12.0 | 29.9 |
| | Nitrobenzene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluen | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 1.0 | 1.0 | 2.0 | 4.0 | 8.1 | 20.2 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 83.8 | 188.1 | 470.4 | 940.7 | 1881.5 | 4703.7 |
| | 1.3.5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.6 | 9.1 | 22.8 |
| | 2.4.6-TNT | 651 | 755 | 1221.2 | 175929.3 | 2.50 | 0.25 | 32.9 | 73.8 | 184.6 | 369.2 | 738.4 | 1846.0 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.6 | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 1.00 | 1.00 | 3.1 | 7.0 | 17.5 | 35.0 | 70.0 | 174.9 |
| | 1.3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 305 | 669 | 1.3 | 118.5 | 0.25 | 0.25 | 3.5 | 8.0 | 28.5 | 62.5 | 130.9 | 172.0 |
| | 2.6-DNT | 7 | 222 | 0.2 | 5.6 | 0.25 | 0.25 | 3.5 | 5.6 | 5.6 | 5.6 | 5.5 | 169.4 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 12.0 | 29.9 |
| | Nitrobenzene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | -Nitrotoluene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | -Nitrotoluen | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 1.0 | 1.0 | 2.0 | 4.0 | 8.1 | 20.2 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 84.0 | 188.1 | 470.4 | 940.7 | 1881.5 | 4703.7 |
| | 1.3.5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.6 | 9.1 | 22.8 |
| | 2.4.6-TNT | 651 | 755 | 1221.2 | 175929.3 | 0.25 | 0.25 | 33.0 | 73.8 | 184.6 | 369.2 | 738.4 | 1846.0 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.6 | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 1.00 | 1.00 | 1.0 | 2.0 | 6.4 | 14.1 | 28.2 | 70.4 |
| | 1.3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 4.5 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 |
| | 2.4-DNT | 305 | 669 | 1.3 | 118.5 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.8 |
| | 2.6-DNT | 7 | 222 | 0.2 | 5.6 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 1765.7 | 2431.2 | 2431.2 | 2431.2 | 2431.2 | 2431.2 |
| | Nitrobenzene | 0 | 210 | 0.0 | 0.0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluen | 0 | 210 | 0.0 | 0.0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluen | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 160.0 | 160.0 | 160.0 | 160.0 | 160.0 | 160.0 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 435.3 | 1557.6 | 5199.7 | 11170.0 | 22908.2 | 52000.0 |
| | 1.3.5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 5.8 | 10.8 | 27.6 | 55.7 | 114.2 | 320.5 |
| | 2.4.6-TNT | 651 | 755 | 1221.2 | 175929.3 | 0.25 | 0.25 | 4.6 | 21.2 | 67.3 | 148.7 | 297.3 | 743.3 |
| | | | | | RISK CHECK: | | HIs | 0.5 | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: 33A
EXPOSURE DURATION = 30 YRS
VEGETABLES EXCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1.00 | 0.50 | 0.20 | 0.10 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 3.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1.3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.2 | 2.5 | 6.2 |
| | 2.4-DNT | | 3 | | | 3.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2.6-DNT | | 2 | | | 3.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 7.1 | 18.1 | 55.4 | 110.7 | 221.4 | 553.5 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 1643.8 | 4218.9 | 12875.7 | 25751.5 | 51503.0 | 128757.4 |
| | 1.3.5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.1 | 10.3 |
| | 2.4.6-TNT | 1 | 3 | 2.6 | 7.0 | 2.50 | 0.25 | 2.5 | 2.5 | 2.5 | 3.6 | 7.2 | 18.1 |
| | | | | | RISK CHECK: | | HIs | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-07 | 6E-08 | 2E-08 | 2E-08 | 2E-08 | 2E-08 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 1.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1.3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.2 | 2.5 | 6.2 |
| | 2.4-DNT | | 3 | | | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2.6-DNT | | 2 | | | 0.26 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 7.1 | 18.1 | 55.4 | 110.7 | 221.4 | 553.5 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 1643.8 | 4218.9 | 12875.7 | 25751.5 | 51503.0 | 128757.4 |
| | 1.3.5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.1 | 10.3 |
| | 2.4.6-TNT | 1 | 3 | 2.6 | 7.0 | 0.25 | 0.25 | 0.3 | 0.6 | 1.8 | 3.6 | 7.2 | 18.1 |
| | | | | | RISK CHECK: | | HIs | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-08 | 1E-08 | 2E-08 | 2E-08 | 2E-08 | 2E-08 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 1.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1.3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.2 | 2.5 | 6.2 |
| | 2.4-DNT | | 3 | | | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2.6-DNT | | 2 | | | 0.25 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 7.1 | 18.1 | 55.4 | 110.7 | 221.4 | 553.5 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 1643.8 | 4218.9 | 12875.7 | 25751.5 | 51503.0 | 128757.4 |
| | 1.3.5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.1 | 10.3 |
| | 2.4.6-TNT | 1 | 3 | 2.6 | 7.0 | 0.25 | 0.25 | 0.3 | 0.6 | 1.8 | 3.6 | 7.2 | 18.1 |
| | | | | | RISK CHECK: | | HIs | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-08 | 1E-08 | 2E-08 | 2E-08 | 2E-08 | 2E-08 |

EXPOSURE AREA: BPG
EXPOSURE DURATION = 30 YRS
VEGETABLES EXCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1.00 | 0.50 | 0.20 | 0.10 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 3.00 | 1.00 | 4.9 | 10.3 | 27.3 | 54.6 | 109.1 | 272.8 |
| | 1.3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.2 | 3.1 |
| | 2.4-DNT | 1 | 15 | 0.01 | 0.271 | 3.00 | 0.25 | 88.0 | 175.7 | 438.5 | 876.9 | 1753.9 | 4384.7 |
| | 2.6-DNT | | 15 | 0.00 | 0 | 3.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 11.2 | 27.9 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 17.6 | 37.4 | 98.8 | 197.6 | 395.1 | 987.8 |
| | 1.3.5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 5.8 | 14.5 |
| | 2.4.6-TNT | 22 | 28 | 81.01 | 350 | 2.50 | 0.25 | 33.1 | 70.2 | 185.5 | 371.1 | 742.1 | 1855.3 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.6 | 0.4 | 0.4 | 0.3 | 0.3 | 0.3 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 1.00 | 1.00 | 4.9 | 10.3 | 27.3 | 54.6 | 109.1 | 272.8 |
| | 1.3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.2 | 3.1 |
| | 2.4-DNT | 1 | 15 | 0.01 | 0.271 | 0.25 | 0.25 | 6.8 | 13.3 | 32.5 | 65.0 | 130.1 | 325.1 |
| | 2.6-DNT | | 15 | 0.00 | 0 | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 11.2 | 27.9 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 17.6 | 37.4 | 98.8 | 197.6 | 395.1 | 987.8 |
| | 1.3.5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 5.8 | 14.5 |
| | 2.4.6-TNT | 22 | 28 | 81.01 | 350 | 0.25 | 0.25 | 33.1 | 70.2 | 185.5 | 371.1 | 742.1 | 1855.3 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.6 | 0.4 | 0.4 | 0.3 | 0.3 | 0.3 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 1.00 | 1.00 | 1.4 | 3.3 | 9.2 | 19.5 | 39.0 | 97.6 |
| | 1.3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 0.6 | 0.6 | 12.0 | 41.5 | 100.9 | 279.0 |
| | 2.4-DNT | 1 | 15 | 0.01 | 0.271 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2.6-DNT | | 15 | 0.00 | 0 | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 207.0 | 207.0 | 5922.1 | 20656.4 | 50332.7 | 139361.5 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 223.0 | 223.0 | 1366.3 | 4313.8 | 10250.4 | 28060.1 |
| | 1.3.5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 10.7 | 22.5 | 41.0 | 55.8 | 85.4 | 174.5 |
| | 2.4.6-TNT | 22 | 28 | 81.01 | 350 | 0.25 | 0.25 | 9.2 | 22.5 | 62.3 | 132.7 | 265.5 | 663.7 |
| | | | | | RISK CHECK: | | HIs | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL1
EXPOSURE DURATION = 30 YRS
VEGETABLES EXCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| | 1.3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 135 | 246 | 1.97 | 26.05 | 3.00 | 0.25 | 44.1 | 88.4 | 222.8 | 447.4 | 896.5 | 2243.3 |
| | 2.6-DNT | 3 | 92 | 0.13 | 2.93 | 3.00 | 0.26 | 44.1 | 88.4 | 219.4 | 437.5 | 873.7 | 2183.0 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1.3.5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.2 | 8.4 | 21.1 |
| | 2.4.6-TNT | 248 | 276 | 3069.31 | 132800 | 2.50 | 0.25 | 33.4 | 71.9 | 190.0 | 380.1 | 760.2 | 1900.5 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.6 | 0.4 | 0.4 | 0.3 | 0.3 | 0.3 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1.3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 135 | 246 | 1.97 | 26.05 | 0.25 | 0.25 | 4.4 | 11.6 | 33.6 | 37.2 | 74.5 | 186.6 |
| | 2.6-DNT | 3 | 92 | 0.13 | 2.93 | 0.25 | 0.25 | 3.0 | 2.9 | 2.9 | 36.1 | 72.2 | 180.5 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1.3.5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.2 | 8.4 | 21.1 |
| | 2.4.6-TNT | 248 | 276 | 3069.31 | 132800 | 0.25 | 0.25 | 33.8 | 76.0 | 190.0 | 380.1 | 760.2 | 1900.5 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.6 | 0.5 | 0.4 | 0.3 | 0.3 | 0.3 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1.3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 | 115.1 |
| | 2.4-DNT | 135 | 246 | 1.97 | 26.05 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.6 |
| | 2.6-DNT | 3 | 92 | 0.13 | 2.93 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 55097.0 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 56.7 | 56.7 | 56.7 | 56.7 | 56.7 | 11075.5 |
| | 1.3.5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 9.9 | 21.1 | 54.7 | 110.6 | 221.7 | 393.0 |
| | 2.4.6-TNT | 248 | 276 | 3069.31 | 132800 | 0.25 | 0.25 | 5.2 | 25.7 | 87.0 | 189.3 | 402.1 | 1005.3 |
| | | | | | RISK CHECK: | | HIs | 0.5 | 0.5 | 0.8 | 0.3 | 0.8 | 0.8 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL2
EXPOSURE DURATION = 30 YRS
VEGETABLES EXCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 3.00 | 1.00 | 8.5 | 18.9 | 47.3 | 94.6 | 189.3 | 473.2 |
| | 1,3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 138 | 314 | 2.41 | 118.51 | 3.00 | 0.25 | 87.4 | 174.2 | 435.4 | 870.9 | 1741.7 | 4354.3 |
| | 2,6-DNT | | 69 | 0.00 | 0 | 3.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 16.3 | 32.6 | 81.5 |
| | Nitrobenzene | | 62 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3,5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 6.1 | 12.1 | 30.3 |
| | 2,4,6-TNT | 260 | 325 | 2570.34 | 175929.3 | 2.50 | 0.25 | 32.5 | 72.5 | 181.2 | 362.5 | 724.9 | 1812.4 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.6 | 0.5 | 0.4 | 0.3 | 0.3 | 0.3 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 1.00 | 1.00 | 8.5 | 18.9 | 47.3 | 94.6 | 189.3 | 473.2 |
| | 1,3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 138 | 314 | 2.41 | 118.51 | 0.25 | 0.25 | 6.2 | 11.8 | 29.5 | 58.9 | 117.9 | 294.7 |
| | 2,6-DNT | | 69 | 0.00 | 0 | 0.25 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 16.3 | 32.6 | 81.5 |
| | Nitrobenzene | | 62 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3,5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 6.1 | 12.1 | 30.3 |
| | 2,4,6-TNT | 260 | 325 | 2570.34 | 175929.3 | 0.25 | 0.25 | 32.5 | 72.5 | 181.2 | 362.5 | 724.9 | 1812.4 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.6 | 0.5 | 0.4 | 0.3 | 0.3 | 0.3 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 1.00 | 1.00 | 2.0 | 4.7 | 13.5 | 27.0 | 54.0 | 135.0 |
| | 1,3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 89.3 |
| | 2,4-DNT | 138 | 314 | 2.41 | 118.51 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.5 |
| | 2,6-DNT | | 69 | 0.00 | 0 | 0.26 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 2431.2 | 2431.2 | 2431.2 | 2431.2 | 2431.2 | 45956.9 |
| | Nitrobenzene | | 62 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 8713.1 |
| | 1,3,5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 8.9 | 21.0 | 57.2 | 118.0 | 239.5 | 473.5 |
| | 2,4,6-TNT | 260 | 325 | 2570.34 | 175929.3 | 0.25 | 0.25 | 7.6 | 18.0 | 51.7 | 103.4 | 206.8 | 517.0 |
| | | | | | RISK CHECK: | | HIs | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL3
EXPOSURE DURATION = 30 YRS
VEGETABLES EXCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.1 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 3.00 | 0.25 | 88.3 | 176.8 | 442.2 | 884.8 | 1770.1 | 4426.0 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 3.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 5.1 | 12.6 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 2.50 | 0.25 | 33.4 | 71.9 | 190.9 | 381.7 | 763.4 | 1908.5 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.6 | 0.4 | 0.4 | 0.3 | 0.3 | 0.3 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.2 | 3.1 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 0.25 | 0.25 | 7.4 | 14.7 | 36.5 | 73.2 | 146.6 | 366.4 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 0.26 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 5.1 | 12.6 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 0.25 | 0.25 | 33.8 | 72.2 | 190.9 | 381.7 | 763.4 | 1908.5 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.6 | 0.4 | 0.4 | 0.3 | 0.3 | 0.3 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.6 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 2.5 | 2.5 | 2.5 | 18.3 | 130.6 | 467.7 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.8 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 0.26 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 10.9 | 22.1 | 55.6 | 103.2 | 159.4 | 327.9 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 0.25 | 0.25 | 11.1 | 31.5 | 92.9 | 199.7 | 399.4 | 998.6 |
| | | | | | RISK CHECK: | | HIs | 0.6 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

SUMMARY OF HEALTH-BASED EXCAVATION-TYPE PRGs 06/17/93

EXPOSURE AREA: LL4
EXPOSURE DURATION = 30 YRS
VEGETABLES EXCLUDED

| CHEMICAL | HIT | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| RDX | 4 | 16 | 7.4 | 34.0 | 3.00 | 1.00 | 4.3 | 9.3 | 23.3 | 46.6 | 93.2 | 233.1 |
| 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.2 | 2.5 | 6.2 |
| 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 3.00 | 0.25 | 52.1 | 104.0 | 259.9 | 519.9 | 1039.8 | 2599.5 |
| 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 3.00 | 0.25 | 35.9 | 71.7 | 179.2 | 358.4 | 716.7 | 1791.9 |
| HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 18.8 | 47.1 |
| Nitrobenzene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| m-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| o-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| Tetryl | | 12 | | | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 5.7 | 11.4 | 28.4 |
| 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 2.50 | 0.25 | 34.1 | 74.1 | 185.1 | 370.3 | 740.5 | 1851.4 |
| | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | HIc | 0.6 | 0.5 | 0.4 | 0.3 | 0.3 | 0.3 |
| | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| RDX | 4 | 16 | 7.4 | 34.0 | 1.00 | 1.00 | 4.3 | 9.3 | 23.3 | 46.6 | 93.2 | 233.1 |
| 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.2 | 2.5 | 6.2 |
| 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 0.25 | 0.25 | 4.2 | 8.3 | 20.6 | 41.3 | 82.5 | 206.3 |
| 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 0.25 | 0.25 | 2.6 | 5.0 | 12.5 | 25.1 | 50.2 | 125.5 |
| HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 18.8 | 47.1 |
| Nitrobenzene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| m-[illegible]oluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| o-[illegible]oluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| Tet[illegible] | | 12 | | | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 5.7 | 11.4 | 28.4 |
| 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 0.25 | 0.25 | 34.1 | 74.1 | 185.1 | 370.3 | 740.5 | 1851.4 |
| | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | HIc | 0.6 | 0.5 | 0.4 | 0.3 | 0.3 | 0.3 |
| | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| RDX | 4 | 16 | 7.4 | 34.0 | 1.00 | 1.00 | 1.0 | 1.8 | 4.6 | 9.2 | 18.4 | 46.1 |
| 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 5.2 | 13.3 | 38.3 | 79.9 | 163.1 | 412.9 |
| 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 0.25 | 0.25 | 0.3 | 0.6 | 1.5 | 3.0 | 5.9 | 14.8 |
| 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 0.26 | 0.25 | 0.3 | 0.3 | 0.7 | 1.3 | 2.7 | 6.7 |
| HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 2099.9 | 6162.9 | 18646.6 | 39452.6 | 81064.8 | 205901.3 |
| Nitrobenzene | | 12 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| m-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| o-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| Tetryl | | 12 | | | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 8.1 | 12.2 | 24.6 | 45.5 | 87.1 | 211.9 |
| 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 0.25 | 0.25 | 4.4 | 14.6 | 36.6 | 73.2 | 146.4 | 366.0 |
| | | | | RISK CHECK: | | HIs | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: ALLSITE
EXPOSURE DURATION = 30 YRS
VEGETABLES INCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | - | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | - | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 3.8 | 7.5 | 18.8 |
| | 1.3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 305 | 669 | 1.3 | 118.5 | 3.00 | 0.25 | 3.4 | 9.4 | 32.5 | 77.2 | 80.2 | 201.2 |
| | 2.6-DNT | 7 | 222 | 0.2 | 5.6 | 3.00 | 0.26 | 3.4 | 5.6 | 5.6 | 5.6 | 80.2 | 199.8 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 210 | 0.0 | 0.0 | 1.00 | 0.26 | -- | -- | -- | - | -- | -- |
| | m-Nitrotoluene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | -- | -- | -- | - | -- | -- |
| | o-Nitrotoluen | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.2 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 1.0 | 15.6 | 50.6 | 101.1 | 202.3 | 505.7 |
| | 1.3.5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2.4.6-TNT | 651 | 755 | 1221.2 | 175929.3 | 2.50 | 0.25 | 2.5 | 6.5 | 19.8 | 39.7 | 79.4 | 198.4 |
| | | | | | | RISK CHECK: | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.8 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | - | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | - | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 1.00 | 1.00 | 1.0 | 1.0 | 1.9 | 3.8 | 7.5 | 18.8 |
| | 1.3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 4.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 305 | 669 | 1.3 | 118.5 | 0.25 | 0.25 | 0.3 | 0.4 | 1.1 | 2.2 | 4.4 | 16.2 |
| | 2.6-DNT | 7 | 222 | 0.2 | 5.6 | 0.26 | 0.26 | 0.3 | 0.4 | 1.1 | 2.2 | 4.4 | 5.6 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 28.3 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | -- | -- | -- | - | -- | -- |
| | m-Nitrotoluene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | -- | -- | -- | - | -- | -- |
| | o-Nitrotoluen | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 160.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.2 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 316.2 | 18.6 | 50.6 | 101.1 | 202.3 | 505.7 |
| | 1.3.5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 5.5 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2.4.6-TNT | 651 | 755 | 1221.2 | 175929.3 | 0.25 | 0.25 | 0.3 | 7.3 | 19.8 | 39.7 | 79.4 | 198.4 |
| | | | | | | RISK CHECK: | HIs | 0.5 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 1.0 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | - | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | - | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 3.4 |
| | 1.3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 4.1 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 |
| | 2.4-DNT | 305 | 669 | 1.3 | 118.5 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2.6-DNT | 7 | 222 | 0.2 | 5.6 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 28.3 | 78.8 | 235.1 | 495.7 | 960.0 | 2382.4 |
| | Nitrobenzene | 0 | 210 | 0.0 | 0.0 | 1.00 | 0.26 | -- | -- | -- | - | -- | -- |
| | m-Nitrotoluen | 0 | 210 | 0.0 | 0.0 | 1.00 | 0.25 | -- | -- | -- | - | -- | -- |
| | o-Nitrotoluen | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 160.0 | 160.0 | 160.0 | 160.0 | 160.0 | 160.0 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 316.2 | 1178.1 | 3846.3 | 8291.5 | 16220.5 | 40508.3 |
| | 1.3.5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 5.5 | 9.8 | 23.0 | 45.0 | 84.1 | 204.0 |
| | 2.4.6-TNT | 651 | 755 | 1221.2 | 175929.3 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 10.9 | 36.2 |
| | | | | | | RISK CHECK: | HIs | 0.5 | 0.4 | 0.3 | 0.3 | 0.4 | 0.5 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-05 | 6E-06 | 2E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: SBA
EXPOSURE DURATION = 30 YRS
VEGETABLES INCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1.00 | 0.50 | 0.20 | 0.10 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 3.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1,3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.2 | 2.4 | 6.0 |
| | 2,4-DNT | | 3 | | | 3.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2,6-DNT | | 2 | | | 3.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 4.6 | 15.9 | 49.5 | 107.0 | 214.0 | 535.1 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 1062.9 | 3698.5 | 11515.6 | 24893.9 | 49787.8 | 124469.5 |
| | 1,3,5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 9.9 |
| | 2,4,6-TNT | 1 | 3 | 2.6 | 7.0 | 2.50 | 0.25 | 2.5 | 2.5 | 2.5 | 3.5 | 7.0 | 17.5 |
| | | | | | RISK CHECK: | | HIs | 0.9 | 0.6 | 0.4 | 0.4 | 0.4 | 0.4 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 2E-06 | 8E-07 | 3E-07 | 2E-07 | 2E-07 | 2E-07 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 1.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1,3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.2 | 2.4 | 6.0 |
| | 2,4-DNT | | 3 | | | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2,6-DNT | | 2 | | | 0.26 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 6.7 | 17.4 | 53.5 | 107.0 | 214.0 | 535.1 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 1558.0 | 4047.4 | 12446.9 | 24893.9 | 49787.8 | 124469.5 |
| | 1,3,5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 9.9 |
| | 2,4,6-TNT | 1 | 3 | 2.6 | 7.0 | 0.25 | 0.25 | 0.3 | 0.6 | 1.8 | 3.5 | 7.0 | 17.5 |
| | | | | | RISK CHECK: | | HIs | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 2E-07 | 2E-07 | 2E-07 | 2E-07 | 2E-07 | 2E-07 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 1.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1,3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.2 | 2.4 | 6.0 |
| | 2,4-DNT | | 3 | | | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2,6-DNT | | 2 | | | 0.26 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 6.7 | 17.4 | 53.5 | 107.0 | 214.0 | 535.1 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 1558.0 | 4047.4 | 12446.9 | 24893.9 | 49787.8 | 124469.5 |
| | 1,3,5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 9.9 |
| | 2,4,6-TNT | 1 | 3 | 2.6 | 7.0 | 0.25 | 0.25 | 0.3 | 0.6 | 1.8 | 3.5 | 7.0 | 17.5 |
| | | | | | RISK CHECK: | | HIs | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 2E-07 | 2E-07 | 2E-07 | 2E-07 | 2E-07 | 2E-07 |

EXPOSURE AREA: EPG
EXPOSURE DURATION = 30 YRS
VEGETABLES INCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1.00 | 0.50 | 0.20 | 0.10 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 5.7 | 11.5 | 28.7 |
| | 1,3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 1 | 15 | 0.01 | 0.271 | 3.00 | 0.25 | 6.8 | 15.0 | 39.6 | 79.3 | 158.6 | 396.4 |
| | 2,6-DNT | | 15 | 0.00 | 0 | 3.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 1.0 | 3.5 | 10.4 | 20.7 | 41.5 | 103.7 |
| | 1,3,5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2,4,6-TNT | 22 | 28 | 81.01 | 350 | 2.50 | 0.25 | 2.5 | 6.5 | 19.5 | 39.0 | 77.9 | 194.8 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.8 | 0.5 | 0.5 | 0.5 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 1.00 | 1.00 | 1.0 | 1.1 | 2.9 | 5.7 | 11.5 | 28.7 |
| | 1,3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 1 | 15 | 0.01 | 0.271 | 0.25 | 0.25 | 0.3 | 0.8 | 1.7 | 3.4 | 6.9 | 17.2 |
| | 2,6-DNT | | 15 | 0.00 | 0 | 0.26 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 26.6 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 223.0 | 3.9 | 10.4 | 20.7 | 41.5 | 103.7 |
| | 1,3,5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 5.4 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2,4,6-TNT | 22 | 28 | 81.01 | 350 | 0.25 | 0.25 | 2.5 | 7.3 | 19.5 | 39.0 | 77.9 | 194.8 |
| | | | | | RISK CHECK: | | HIs | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 1.0 | 0.5 | 0.5 | 0.5 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.6 | 4.5 |
| | 1,3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 0.6 | 0.6 | 6.1 | 37.7 | 97.8 | 282.1 |
| | 2,4-DNT | 1 | 15 | 0.01 | 0.271 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2,6-DNT | | 15 | 0.00 | 0 | 0.26 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 46.1 | 124.6 | 240.0 | 427.1 | 783.5 | 1876.6 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 223.0 | 223.0 | 779.1 | 3933.5 | 9943.3 | 28375.2 |
| | 1,3,5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 7.0 | 13.7 | 38.1 | 53.9 | 83.9 | 176.1 |
| | 2,4,6-TNT | 22 | 28 | 81.01 | 350 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 2.5 | 11.2 | 30.9 |
| | | | | | RISK CHECK: | | HIs | 0.4 | 0.4 | 0.3 | 0.4 | 0.4 | 0.5 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 9E-06 | 4E-06 | 2E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL1
EXPOSURE DURATION = 30 YRS
VEGETABLES INCLUDED

| TARGET | CHEMICAL | HI | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTIO 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| | 1.3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 135 | 246 | 1.97 | 26.05 | 3.00 | 0.25 | 3.8 | 12.0 | 36.6 | 40.2 | 81.2 | 205.1 |
| | 2.6-DNT | 3 | 92 | 0.13 | 2.93 | 3.00 | 0.26 | 3.0 | 3.0 | 3.0 | 40.2 | 81.2 | 203.3 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1.3.5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2.4.6-TNT | 248 | 276 | 3069.31 | 132800 | 2.50 | 0.25 | 2.5 | 6.5 | 18.9 | 41.2 | 82.5 | 206.2 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.8 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1.3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 4.9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 135 | 246 | 1.97 | 26.05 | 0.25 | 0.25 | 0.3 | 0.4 | 1.3 | 2.8 | 8.9 | 27.3 |
| | 2.6-DNT | 3 | 92 | 0.13 | 2.93 | 0.26 | 0.26 | 0.3 | 0.4 | 1.3 | 2.8 | 2.9 | 2.9 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 15.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 56.7 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1.3.5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 8.3 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2.4.6-TNT | 248 | 276 | 3069.31 | 132800 | 0.25 | 0.25 | 0.3 | 7.3 | 20.6 | 41.2 | 82.5 | 206.2 |
| | | | | | RISK CHECK: | | HIs | 0.5 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 1.0 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1.3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 | 125.2 |
| | 2.4-DNT | 135 | 246 | 1.97 | 26.05 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2.6-DNT | 3 | 92 | 0.13 | 2.93 | 0.26 | 0.26 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 728.6 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 56.7 | 56.7 | 56.7 | 56.7 | 56.7 | 12088.6 |
| | 1.3.5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 8.3 | 21.5 | 61.3 | 127.5 | 243.5 | 398.1 |
| | 2.4.6-TNT | 248 | 276 | 3069.31 | 132800 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 12.3 | 57.8 |
| | | | | | RISK CHECK: | | HIs | 0.5 | 0.4 | 0.4 | 0.4 | 0.5 | 0.6 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-05 | 6E-06 | 2E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL2
EXPOSURE DURATION = 30 YRS
VEGETABLES INCLUDED

| TARGET | CHEMICAL | HI | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTIO 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 3.00 | 1.00 | 3.0 | 3.0 | 4.9 | 9.8 | 19.5 | 48.8 |
| | 1,3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 138 | 314 | 2.41 | 118.51 | 3.00 | 0.25 | 6.8 | 15.0 | 38.7 | 77.4 | 154.8 | 386.9 |
| | 2,6-DNT | | 69 | 0.00 | 0 | 3.00 | 0.26 | - | - | - | - | - | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 62 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3,5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2,4,6-TNT | 260 | 325 | 2570.34 | 175929.3 | 2.50 | 0.25 | 2.5 | 6.5 | 18.7 | 37.3 | 74.7 | 186.7 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.8 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 1.00 | 1.00 | 1.0 | 1.8 | 4.9 | 9.8 | 19.5 | 48.8 |
| | 1,3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 2.2 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 138 | 314 | 2.41 | 118.51 | 0.25 | 0.25 | 0.3 | 0.4 | 0.8 | 1.5 | 3.1 | 7.7 |
| | 2,6-DNT | | 69 | 0.00 | 0 | 0.26 | 0.26 | - | - | - | - | - | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 35.4 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 62 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 6.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3,5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 6.1 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2,4,6-TNT | 260 | 325 | 2570.34 | 175929.3 | 0.25 | 0.25 | 1.8 | 7.0 | 18.7 | 37.3 | 74.7 | 186.7 |
| | | | | | RISK CHECK: | | HIs | 0.8 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 1.0 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 | 5.6 |
| | 1,3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| | 2,4-DNT | 138 | 314 | 2.41 | 118.51 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2,6-DNT | 0 | 69 | 0.00 | 0 | 0.26 | 0.26 | - | - | - | - | - | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 47.7 | 126.2 | 361.7 | 741.8 | 1477.6 | 2431.2 |
| | Nitrobenzene | 0 | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | m-Nitrotoluene | 0 | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | 0 | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| | 1,3,5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 7.2 | 13.8 | 33.6 | 65.7 | 127.7 | 423.3 |
| | 2,4,6-TNT | 260 | 325 | 2570.34 | 175929.3 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 1.3 | 7.5 | 21.5 |
| | | | | | RISK CHECK: | | HIs | 0.4 | 0.4 | 0.3 | 0.3 | 0.4 | 0.4 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 9E-06 | 4E-06 | 2E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL3
EXPOSURE DURATION = 30 YRS
VEGETABLES INCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTIO 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 3.00 | 0.25 | 6.8 | 15.0 | 39.5 | 80.5 | 162.5 | 408.4 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 3.00 | 0.25 | - | - | - | - | - | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | - | - | - | - | - | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | - | - | - | - | - | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 2.50 | 0.25 | 2.5 | 6.6 | 19.0 | 41.2 | 82.5 | 206.2 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.7 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 2.5 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 0.25 | 0.25 | 0.3 | 0.8 | 2.6 | 5.6 | 11.8 | 30.2 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 0.26 | 0.26 | - | - | - | - | - | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | - | - | - | - | - | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | - | - | - | - | - | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 9.4 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 0.25 | 0.25 | 1.5 | 7.4 | 20.6 | 41.2 | 82.5 | 206.2 |
| | | | | | RISK CHECK: | | HIs | 0.7 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 1.0 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 2.5 | 2.5 | 2.5 | 35.6 | 147.0 | 482.1 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 0.26 | 0.26 | - | - | - | - | - | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | - | - | - | - | - | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | - | - | - | - | - | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 11.1 | 24.4 | 64.1 | 111.9 | 167.6 | 335.1 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 1.5 | 17.0 | 62.5 |
| | | | | | RISK CHECK: | | HIs | 0.5 | 0.4 | 0.4 | 0.4 | 0.5 | 0.6 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 9E-06 | 4E-06 | 2E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL4
EXPOSURE DURATION = 30 YRS
VEGETABLES INCLUDED

| TARGET | CHEMICAL | HI | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 4 | 16 | 7.4 | 34.0 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 4.9 | 9.9 | 24.7 |
| | 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 3.00 | 0.25 | 3.4 | 9.4 | 22.4 | 45.1 | 90.2 | 225.5 |
| | 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 3.00 | 0.25 | 3.4 | 5.6 | 17.1 | 34.6 | 69.1 | 172.8 |
| | HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | | 12 | | | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| | 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 2.50 | 0.25 | 2.5 | 6.5 | 19.6 | 39.3 | 78.5 | 196.3 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.8 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 4 | 16 | 7.4 | 34.0 | 1.00 | 1.00 | 1.0 | 1.0 | 2.5 | 4.9 | 9.9 | 24.7 |
| | 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 0.25 | 0.25 | 0.3 | 0.5 | 1.2 | 2.4 | 4.9 | 12.1 |
| | 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 0.26 | 0.25 | 0.3 | 0.4 | 0.7 | 1.4 | 2.8 | 6.9 |
| | HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 12 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | | 12 | | | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| | 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 11.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 0.25 | 0.25 | 0.3 | 6.9 | 19.6 | 39.3 | 78.5 | 196.3 |
| | | | | | RISK CHECK: | | HIs | 0.5 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 1.0 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 4 | 16 | 7.4 | 34.0 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 3.0 |
| | 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 4.3 | 13.2 | 39.6 | 83.7 | 164.0 | 414.5 |
| | 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 1.0 |
| | 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 0.26 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 |
| | HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 29.3 | 82.1 | 239.1 | 500.7 | 976.5 | 2462.5 |
| | Nitrobenzene | | 12 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | | 12 | | | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| | 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 7.7 | 12.1 | 25.3 | 47.4 | 87.5 | 212.8 |
| | 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 9.0 | 23.9 |
| | | | | | RISK CHECK: | | HIs | 0.5 | 0.4 | 0.3 | 0.3 | 0.4 | 0.4 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-05 | 6E-06 | 2E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: ALLSITE
EXPOSURE DURATION = 70 YRS
VEGETABLES EXCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 3.00 | 1.00 | 3.1 | 7.0 | 17.5 | 35.0 | 70.0 | 174.9 |
| | 1,3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 305 | 669 | 1.3 | 118.5 | 3.00 | 0.25 | 55.4 | 116.1 | 153.5 | 308.4 | 618.1 | 1545.3 |
| | 2,6-DNT | 7 | 222 | 0.2 | 5.6 | 3.00 | 0.26 | 5.6 | 5.6 | 150.8 | 300.0 | 598.8 | 1497.0 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 12.0 | 29.9 |
| | Nitrobenzene | | 210 | 0.0 | 0.0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 1.0 | 1.0 | 2.0 | 4.0 | 8.1 | 20.2 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 83.8 | 188.1 | 470.4 | 940.7 | 1881.5 | 4703.7 |
| | 1,3,5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.6 | 9.1 | 22.8 |
| | 2,4,6-TNT | 651 | 755 | 1221.2 | 175929.3 | 2.50 | 0.25 | 32.9 | 73.8 | 184.6 | 369.2 | 738.4 | 1846.0 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 1.00 | 1.00 | 3.1 | 7.0 | 17.5 | 35.0 | 70.0 | 174.9 |
| | 1,3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 305 | 669 | 1.3 | 118.5 | 0.25 | 0.25 | 2.2 | 4.1 | 14.9 | 35.5 | 76.6 | 199.9 |
| | 2,6-DNT | 7 | 222 | 0.2 | 5.6 | 0.25 | 0.26 | 2.2 | 4.1 | 5.6 | 5.6 | 5.6 | 5.6 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 12.0 | 29.9 |
| | Nitrobenzene | | 210 | 0.0 | 0.0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 1.0 | 1.0 | 2.0 | 4.0 | 8.1 | 20.2 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 84.0 | 188.1 | 470.4 | 940.7 | 1881.5 | 4703.7 |
| | 1,3,5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.6 | 9.1 | 22.8 |
| | 2,4,6-TNT | 651 | 755 | 1221.2 | 175929.3 | 0.25 | 0.25 | 33.0 | 73.8 | 184.6 | 369.2 | 738.4 | 1846.0 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 1.00 | 1.00 | 1.0 | 1.2 | 4.2 | 9.2 | 19.7 | 49.2 |
| | 1,3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 | 126.0 |
| | 2,4-DNT | 305 | 669 | 1.3 | 118.5 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.6 |
| | 2,6-DNT | 7 | 222 | 0.2 | 5.6 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 2431.2 | 2431.2 | 2431.2 | 2431.2 | 2431.2 | 62962.4 |
| | Nitrobenzene | | 210 | 0.0 | 0.0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 160.0 | 160.0 | 160.0 | 160.0 | 160.0 | 12270.5 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 1172.3 | 3207.1 | 9327.5 | 19480.9 | 39400.2 | 64110.5 |
| | 1,3,5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 9.4 | 19.1 | 48.3 | 97.3 | 196.7 | 490.6 |
| | 2,4,6-TNT | 651 | 755 | 1221.2 | 175929.3 | 0.25 | 0.25 | 0.3 | 12.2 | 44.5 | 97.5 | 207.8 | 519.5 |
| | | | | | RISK CHECK: | | HIs | 0.6 | 0.7 | 0.8 | 0.8 | 0.8 | 0.8 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: 3BA
EXPOSURE DURATION = 70 YRS
VEGETABLES EXCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1.00 | 0.50 | 0.20 | 0.10 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 3.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1.3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 2.0 | 3.9 | 9.8 |
| | 2.4-DNT | | 3 | | | 3.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2.6-DNT | | 2 | | | 3.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 13.6 | 31.2 | 87.9 | 175.9 | 351.8 | 879.4 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 3159.9 | 7251.1 | 20456.0 | 40912.1 | 81824.2 | 204560.4 |
| | 1.3.5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 6.5 | 16.3 |
| | 2.4.6-TNT | 1 | 3 | 2.6 | 7.0 | 2.50 | 0.25 | 2.5 | 2.5 | 2.9 | 5.8 | 11.5 | 28.8 |
| | | | | | RISK CHECK: | | HIs | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 2E-07 | 9E-08 | 4E-08 | 4E-08 | 4E-08 | 4E-08 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 1.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1.3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 2.0 | 3.9 | 9.8 |
| | 2.4-DNT | | 3 | | | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2.6-DNT | | 2 | | | 0.26 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 13.6 | 31.2 | 87.9 | 175.9 | 351.8 | 879.4 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 3159.9 | 7251.1 | 20456.0 | 40912.1 | 81824.2 | 204560.4 |
| | 1.3.5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 6.5 | 16.3 |
| | 2.4.6-TNT | 1 | 3 | 2.6 | 7.0 | 0.25 | 0.25 | 0.4 | 1.0 | 2.9 | 5.8 | 11.5 | 28.8 |
| | | | | | RISK CHECK: | | HIs | 0.5 | 0.5 | 0.6 | 0.6 | 0.5 | 0.6 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 3E-08 | 4E-08 | 4E-08 | 4E-08 | 4E-08 | 4E-08 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 1.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1.3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 2.0 | 3.9 | 9.8 |
| | 2.4-DNT | | 3 | | | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2.6-DNT | | 2 | | | 0.26 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 13.6 | 31.2 | 87.9 | 175.9 | 351.8 | 879.4 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 3159.9 | 7251.1 | 20456.0 | 40912.1 | 81824.2 | 204560.4 |
| | 1.3.5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 6.5 | 16.3 |
| | 2.4.6-TNT | 1 | 3 | 2.6 | 7.0 | 0.25 | 0.25 | 0.4 | 1.0 | 2.9 | 5.8 | 11.5 | 28.8 |
| | | | | | RISK CHECK: | | HIs | 0.5 | 0.5 | 0.6 | 0.6 | 0.5 | 0.6 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 3E-08 | 4E-08 | 4E-08 | 4E-08 | 4E-08 | 4E-08 |

EXPOSURE AREA: BPG
EXPOSURE DURATION = 70 YRS
VEGETABLES EXCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION ( 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 1.00 | 1.00 | 4.9 | 10.3 | 27.3 | 54.6 | 109.1 | 272.8 |
| | 1.3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.2 | 3.1 |
| | 2.4-DNT | 1 | 15 | 0.01 | 0.271 | 0.25 | 0.25 | 61.0 | 121.5 | 302.4 | 608.2 | 1213.4 | 3029.9 |
| | 2.6-DNT | | 15 | 0.00 | 0 | 0.26 | 0.26 | - | - | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 11.2 | 27.9 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.26 | - | - | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | - | - | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | - | - | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 17.6 | 37.4 | 98.8 | 197.6 | 395.1 | 987.8 |
| | 1.3.5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 5.8 | 14.5 |
| | 2.4.6-TNT | 22 | 28 | 81.01 | 350 | 0.25 | 0.25 | 33.1 | 70.2 | 185.5 | 371.1 | 742.1 | 1855.3 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 1.00 | 1.00 | 4.9 | 10.3 | 27.3 | 54.6 | 109.1 | 272.8 |
| | 1.3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.2 | 3.1 |
| | 2.4-DNT | 1 | 15 | 0.01 | 0.271 | 0.25 | 0.25 | 4.1 | 7.9 | 19.2 | 38.1 | 75.9 | 189.5 |
| | 2.6-DNT | | 15 | 0.00 | 0 | 0.26 | 0.26 | - | - | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 11.2 | 27.9 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.26 | - | - | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | - | - | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | - | - | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 17.6 | 37.4 | 98.8 | 197.6 | 395.1 | 987.8 |
| | 1.3.5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 5.8 | 14.5 |
| | 2.4.6-TNT | 22 | 28 | 81.01 | 350 | 0.25 | 0.25 | 33.1 | 70.2 | 185.5 | 371.1 | 742.1 | 1855.3 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 1.00 | 1.00 | 1.0 | 2.1 | 6.2 | 13.6 | 27.3 | 68.2 |
| | 1.3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 1.0 | 2.7 | 32.8 | 82.8 | 183.3 | 485.8 |
| | 2.4-DNT | 1 | 15 | 0.01 | 0.271 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2.6-DNT | | 15 | 0.00 | 0 | 0.26 | 0.26 | - | - | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 207.0 | 1067.1 | 16117.2 | 41096.9 | 91235.7 | 241507.1 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.26 | - | - | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | - | - | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | - | - | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 223.0 | 395.1 | 3406.2 | 8403.9 | 18435.2 | 48500.1 |
| | 1.3.5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 18.7 | 36.2 | 51.2 | 76.2 | 126.4 | 276.7 |
| | 2.4.6-TNT | 22 | 28 | 81.01 | 350 | 0.25 | 0.25 | 5.2 | 14.5 | 42.3 | 92.8 | 185.6 | 463.9 |
| | | | | | RISK CHECK: | | HIs | 0.7 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: [illegible]
EXPOSURE DURATION = [illegible] YRS
VEGETABLES EXCLUDED

| TARGET | CHEMICAL | HI | TOTA | AVG | MAX | LL | CL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| | 1,3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 135 | 246 | 1.97 | 26.05 | 3.00 | 0.25 | 30.5 | 61.2 | 153.9 | 309.6 | 620.9 | 1554.9 |
| | 2,6-DNT | 3 | 92 | 0.13 | 2.93 | 3.00 | 0.25 | 30.5 | 61.2 | 152.4 | 303.6 | 605.9 | 1512.8 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3,5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.2 | 8.4 | 21.1 |
| | 2,4,6-TNT | 248 | 276 | 3069.31 | 132800 | 2.50 | 0.25 | 33.4 | 71.9 | 190.0 | 380.1 | 760.2 | 1900.5 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 135 | 246 | 1.97 | 26.05 | 0.25 | 0.25 | 2.3 | 6.1 | 20.0 | 43.1 | 47.0 | 117.7 |
| | 2,6-DNT | 3 | 92 | 0.13 | 2.93 | 0.25 | 0.25 | 2.3 | 3.0 | 3.0 | 3.0 | 45.4 | 113.5 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3,5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.2 | 8.4 | 21.1 |
| | 2,4,6-TNT | 248 | 276 | 3069.31 | 132800 | 0.25 | 0.25 | 33.8 | 76.0 | 190.0 | 380.1 | 760.2 | 1900.5 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 4.9 | 4.9 | 4.9 | 4.9 | 30.7 | 325.0 |
| | 2,4-DNT | 135 | 246 | 1.97 | 26.05 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.5 |
| | 2,6-DNT | 3 | 92 | 0.13 | 2.93 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 15.0 | 15.0 | 15.0 | 15.0 | 12924.7 | 160012.2 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 56.7 | 56.7 | 56.7 | 56.7 | 2639.5 | 32067.5 |
| | 1,3,5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 18.2 | 37.9 | 96.7 | 194.7 | 350.9 | 498.0 |
| | 2,4,6-TNT | 248 | 276 | 3069.31 | 132800 | 0.25 | 0.25 | 0.3 | 13.4 | 56.2 | 127.7 | 281.0 | 702.6 |
| | | | | | RISK CHECK: | | HIs | 0.6 | 0.7 | 0.8 | 0.8 | 0.9 | 0.9 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL2
EXPOSURE DURATION = 70 YRS
VEGETABLES EXCLUDED

| TARGET | CHEMICAL | HI | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) I | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 3.00 | 1.00 | 8.5 | 18.9 | 47.3 | 94.6 | 189.3 | 473.2 |
| | 1.3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 138 | 314 | 2.41 | 118.51 | 3.00 | 0.25 | 60.2 | 119.8 | 299.6 | 599.1 | 1198.2 | 2995.6 |
| | 2.6-DNT | | 69 | 0.00 | 0 | 3.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 16.3 | 32.6 | 81.5 |
| | Nitrobenzene | | 62 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1.3.5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 6.1 | 12.1 | 30.3 |
| | 2.4.6-TNT | 260 | 325 | 2570.34 | 175929.3 | 2.50 | 0.25 | 32.5 | 72.5 | 181.2 | 362.5 | 724.9 | 1812.4 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 1.00 | 1.00 | 8.5 | 18.9 | 47.3 | 94.6 | 189.3 | 473.2 |
| | 1.3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 138 | 314 | 2.41 | 118.51 | 0.25 | 0.25 | 3.5 | 6.4 | 15.9 | 31.8 | 63.5 | 158.8 |
| | 2.6-DNT | | 69 | 0.00 | 0 | 0.26 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 16.3 | 32.6 | 81.5 |
| | Nitrobenzene | | 62 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1.3.5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 6.1 | 12.1 | 30.3 |
| | 2.4.6-TNT | 260 | 325 | 2570.34 | 175929.3 | 0.25 | 0.25 | 32.5 | 72.5 | 181.2 | 362.5 | 724.9 | 1812.4 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 1.00 | 1.00 | 1.1 | 3.1 | 8.8 | 18.9 | 37.7 | 94.4 |
| | 1.3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 292.2 |
| | 2.4-DNT | 138 | 314 | 2.41 | 118.51 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2.6-DNT | | 69 | 0.00 | 0 | 0.26 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 2431.2 | 2431.2 | 2431.2 | 2431.2 | 2431.2 | 147368.3 |
| | Nitrobenzene | | 62 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 29003.7 |
| | 1.3.5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 17.0 | 37.3 | 98.0 | 199.1 | 401.8 | 575.0 |
| | 2.4.6-TNT | 260 | 325 | 2570.34 | 175929.3 | 0.25 | 0.25 | 4.3 | 11.7 | 33.6 | 72.3 | 144.6 | 361.4 |
| | | | | | RISK CHECK: | | HIs | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL3
EXPOSURE DURATION = 70 YRS
VEGETABLES EXCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.1 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 3.00 | 0.25 | 61.1 | 122.4 | 306.3 | 613.1 | 1226.6 | 3067.3 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 3.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 5.1 | 12.6 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 2.50 | 0.25 | 33.4 | 71.9 | 190.9 | 381.7 | 763.4 | 1908.5 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.2 | 3.1 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 0.25 | 0.25 | 4.7 | 9.3 | 22.9 | 46.0 | 92.2 | 230.5 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 0.26 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 5.1 | 12.6 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 0.25 | 0.25 | 33.8 | 72.2 | 190.9 | 381.7 | 763.4 | 1908.5 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 2.5 | 2.5 | 2.5 | 102.2 | 298.5 | 887.3 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.5 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 19.3 | 38.9 | 95.3 | 145.2 | 243.3 | 537.7 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 0.25 | 0.25 | 5.0 | 18.8 | 62.1 | 139.6 | 279.2 | 697.9 |
| | | | | | RISK CHECK: | | HIs | 0.7 | 0.8 | 0.8 | 0.9 | 0.9 | 0.9 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL4
EXPOSURE DURATION = 70 YRS
VEGETABLES EXCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 4 | 16 | 7.4 | 34.0 | 3.00 | 1.00 | 4.3 | 9.3 | 23.3 | 46.6 | 93.2 | 233.1 |
| | 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.2 | 2.5 | 6.2 |
| | 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 3.00 | 0.25 | 36.1 | 71.9 | 179.9 | 359.7 | 719.4 | 1798.5 |
| | 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 3.00 | 0.25 | 24.8 | 49.4 | 123.4 | 246.8 | 493.6 | 1234.1 |
| | HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 18.8 | 47.1 |
| | Nitrobenzene | | 12 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | | 12 | | | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| | 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 5.7 | 11.4 | 28.4 |
| | 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 2.50 | 0.25 | 34.1 | 74.1 | 185.1 | 370.3 | 740.5 | 1851.4 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 4 | 16 | 7.4 | 34.0 | 1.00 | 1.00 | 4.3 | 9.3 | 23.3 | 46.6 | 93.2 | 233.1 |
| | 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.2 | 2.5 | 6.2 |
| | 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 0.25 | 0.25 | 2.6 | 5.0 | 12.6 | 25.2 | 50.5 | 126.2 |
| | 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 0.25 | 0.26 | 1.5 | 2.8 | 7.0 | 13.9 | 27.9 | 69.7 |
| | HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 18.8 | 47.1 |
| | Nitrobenzene | | 12 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | | 12 | | | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| | 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 5.7 | 11.4 | 28.4 |
| | 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 0.25 | 0.25 | 34.1 | 74.1 | 185.1 | 370.3 | 740.5 | 1851.4 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 |
| | | | | | | | Risk | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 4 | 16 | 7.4 | 34.0 | 1.00 | 1.00 | 1.0 | 1.2 | 3.2 | 6.4 | 12.9 | 32.2 |
| | 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 15.5 | 35.6 | 97.0 | 199.6 | 405.3 | 1022.2 |
| | 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 0.25 | 0.25 | 0.3 | 0.4 | 1.0 | 2.1 | 4.1 | 10.3 |
| | 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 0.26 | 0.26 | 0.3 | 0.3 | 0.5 | 0.9 | 1.9 | 4.7 |
| | HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 18.8 | 47.1 |
| | Nitrobenzene | | 12 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 12 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | | 12 | | | 1.00 | 0.65 | -- | -- | -- | -- | -- | -- |
| | 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 13.2 | 23.3 | 54.0 | 105.2 | 207.4 | 514.0 |
| | 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 0.25 | 0.25 | 0.3 | 9.5 | 25.6 | 51.2 | 102.3 | 255.8 |
| | | | | | RISK CHECK: | | HIs | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: ALLSITE
EXPOSURE DURATION = 70 YRS
VEGETABLES INCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | - | -- | - | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | -- | - | -- | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 1.00 | 1.00 | 3.0 | 3.0 | 3.0 | 3.8 | 7.5 | 18.8 |
| | 1.3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 305 | 669 | 1.3 | 118.5 | 0.25 | 0.25 | 1.5 | 3.4 | 10.4 | 27.6 | 60.8 | 160.6 |
| | 2.6-DNT | 7 | 222 | 0.2 | 5.6 | 0.25 | 0.25 | 0.5 | 2.4 | 5.6 | 5.6 | 5.6 | 5.6 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | - | -- | - | -- | -- | -- |
| | m-Nitrotoluene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | - | -- | - | -- | -- | -- |
| | o-Nitrotoluen | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.2 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 1.0 | 16.6 | 50.5 | 101.1 | 202.3 | 505.7 |
| | 1.3.5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2.4.6-TNT | 651 | 755 | 1221.2 | 175929.3 | 0.25 | 0.25 | 2.5 | 6.5 | 19.8 | 39.7 | 79.4 | 198.4 |
| | | | | | | RISK CHECK: | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.7 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | - | -- | - | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | -- | - | -- | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 1.00 | 1.00 | 1.0 | 1.0 | 1.2 | 2.9 | 6.3 | 16.8 |
| | 1.3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 |
| | 2.4-DNT | 305 | 669 | 1.3 | 118.5 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2.6-DNT | 7 | 222 | 0.2 | 5.6 | 0.26 | 0.26 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 37.3 | 89.7 | 179.3 | 293.1 | 682.8 | 1178.9 |
| | Nitrobenzene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | - | -- | - | -- | -- | -- |
| | m-Nitrotoluene | | 210 | 0.0 | 0.0 | 1.00 | 0.25 | - | -- | - | -- | -- | -- |
| | o-Nitrotoluen | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 160.0 | 160.0 | 160.0 | 160.0 | 160.0 | 160.0 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 735.3 | 2144.0 | 4567.1 | 6199.3 | 7740.6 | 13602.4 |
| | 1.3.5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 7.6 | 14.6 | 26.6 | 34.5 | 41.7 | 69.5 |
| | 2.4.6-TNT | 651 | 755 | 1221.2 | 175929.3 | 0.25 | 0.25 | 0.3 | 0.3 | 13.1 | 31.0 | 67.0 | 177.6 |
| | | | | | | RISK CHECK: | HIs | 0.6 | 0.5 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 0.8 | 0.8 | 0.7 |
| | | | | | | | Risk | 3E-05 | 2E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | - | -- | - | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | -- | - | -- | -- | -- |
| | RDX | 423 | 759 | 115.7 | 23270.1 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.2 |
| | 1.3-DNB | 93 | 658 | 0.3 | 4.9 | 1.00 | 0.25 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 |
| | 2.4-DNT | 305 | 669 | 1.3 | 118.5 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2.6-DNT | 7 | 222 | 0.2 | 5.6 | 0.26 | 0.26 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | HMX | 279 | 672 | 19.8 | 2431.2 | 10.00 | 2.20 | 37.5 | 90.0 | 247.2 | 509.4 | 1033.7 | 2431.2 |
| | Nitrobenzene | 0 | 210 | 0.0 | 0.0 | 1.00 | 0.25 | - | -- | - | -- | -- | -- |
| | m-Nitrotoluen | 0 | 210 | 0.0 | 0.0 | 1.00 | 0.25 | - | -- | - | -- | -- | -- |
| | o-Nitrotoluen | 1 | 210 | 13.3 | 160.0 | 1.00 | 0.25 | 160.0 | 160.0 | 160.0 | 160.0 | 160.0 | 160.0 |
| | Tetryl | 18 | 620 | 3111.7 | 52000.0 | 1.00 | 0.65 | 742.3 | 2151.0 | 6377.5 | 13419.9 | 27504.7 | 52000.0 |
| | 1.3.5-TNB | 503 | 659 | 15.1 | 430.0 | 4.00 | 0.25 | 7.7 | 14.7 | 35.6 | 0.0 | 140.5 | 430.0 |
| | 2.4.6-TNT | 651 | 755 | 1221.2 | 175929.3 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 13.1 |
| | | | | | | RISK CHECK: | HIs | 0.6 | 0.5 | 0.5 | 0.5 | 0.4 | 0.5 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 3E-05 | 1E-05 | 6E-06 | 3E-06 | 1E-06 | 1E-06 |



B07NE003701-04906

EXPOSURE AREA: SBA
EXPOSURE DURATION = 70 YRS
VEGETABLES INCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1.00 | 0.50 | 0.20 | 0.10 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 3.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1.3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.9 | 3.7 | 9.3 |
| | 2.4-DNT | | 3 | | | 1.50 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2.6-DNT | | 2 | | | 0.50 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 9.7 | 29.3 | 83.4 | 166.8 | 333.5 | 833.8 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 2245.6 | 6826.5 | 19394.6 | 38789.1 | 77578.2 | 193945.5 |
| | 1.3.5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 6.2 | 15.5 |
| | 2.4.6-TNT | 1 | 3 | 2.6 | 7.0 | 2.50 | 0.25 | 2.5 | 2.5 | 2.7 | 5.5 | 10.9 | 27.3 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 0.8 | 0.7 | 0.7 | 0.6 | 0.6 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 4E-06 | 2E-06 | 8E-07 | 8E-07 | 8E-07 | 8E-07 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 1.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1.3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.9 | 3.7 | 9.3 |
| | 2.4-DNT | | 3 | | | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2.6-DNT | | 2 | | | 0.26 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 12.7 | 29.3 | 83.4 | 166.8 | 333.5 | 833.8 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 2947.6 | 6826.5 | 19394.6 | 38789.1 | 77578.2 | 193945.5 |
| | 1.3.5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 6.2 | 15.5 |
| | 2.4.6-TNT | 1 | 3 | 2.6 | 7.0 | 0.25 | 0.25 | 0.4 | 1.0 | 2.7 | 5.5 | 10.9 | 27.3 |
| | | | | | RISK CHECK: | | HIs | 0.6 | 0.6 | 0.7 | 0.7 | 0.6 | 0.6 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 6E-07 | 7E-07 | 8E-07 | 8E-07 | 8E-07 | 8E-07 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | | 3 | | | 1.00 | 1.00 | -- | -- | -- | -- | -- | -- |
| | 1.3-DNB | 1 | 3 | 0.9 | 1.8 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.9 | 3.7 | 9.3 |
| | 2.4-DNT | | 3 | | | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | 2.6-DNT | | 2 | | | 0.26 | 0.26 | -- | -- | -- | -- | -- | -- |
| | HMX | | 3 | | | 10.00 | 2.20 | -- | -- | -- | -- | -- | -- |
| | Nitrobenzene | | 2 | | | 1.00 | 0.26 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 2 | | | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | 1 | 2 | 80.1 | 160.0 | 1.00 | 0.25 | 12.7 | 29.3 | 83.4 | 166.8 | 333.5 | 833.8 |
| | Tetryl | 3 | 3 | 18627.0 | 52000.0 | 1.00 | 0.65 | 2947.6 | 6826.5 | 19394.6 | 38789.1 | 77578.2 | 193945.5 |
| | 1.3.5-TNB | 1 | 3 | 1.5 | 3.6 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 6.2 | 15.5 |
| | 2.4.6-TNT | 1 | 3 | 2.6 | 7.0 | 0.25 | 0.25 | 0.4 | 1.0 | 2.7 | 5.5 | 10.9 | 27.3 |
| | | | | | RISK CHECK: | | HIs | 0.6 | 0.6 | 0.7 | 0.7 | 0.6 | 0.6 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 6E-07 | 7E-07 | 8E-07 | 8E-07 | 8E-07 | 8E-07 |

EXPOSURE AREA: EPG
EXPOSURE DURATION = 70 YRS
VEGETABLES INCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1.00 | 0.50 | 0.20 | 0.10 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 5.7 | 11.5 | 28.7 |
| | 1,3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 1 | 15 | 0.01 | 0.271 | 1.00 | 0.25 | 2.1 | 5.6 | 16.1 | 32.3 | 64.6 | 161.4 |
| | 2,6-DNT | | 15 | 0.00 | 0 | 0.50 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 1.0 | 3.5 | 10.4 | 20.7 | 41.5 | 103.7 |
| | 1,3,5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2,4,6-TNT | 22 | 28 | 81.01 | 350 | 2.50 | 0.25 | 2.5 | 6.5 | 19.5 | 39.0 | 77.9 | 194.8 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.7 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 1.00 | 1.00 | 1.0 | 1.0 | 1.8 | 3.9 | 8.4 | 21.0 |
| | 1,3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 73.4 | 100.8 | 254.4 |
| | 2,4-DNT | 1 | 15 | 0.01 | 0.271 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2,6-DNT | | 15 | 0.00 | 0 | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 57.6 | 136.4 | 273.5 | 281.5 | 901.0 | 2271.3 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 223.0 | 223.0 | 223.0 | 7260.9 | 10024.5 | 25440.8 |
| | 1,3,5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 10.3 | 20.9 | 39.3 | 40.2 | 53.9 | 130.7 |
| | 2,4,6-TNT | 22 | 28 | 81.01 | 350 | 0.25 | 0.25 | 0.3 | 0.3 | 12.4 | 26.7 | 57.2 | 143.1 |
| | | | | | RISK CHECK: | | HIs | 0.6 | 0.5 | 0.9 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 2E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | -- | -- | -- | -- | -- | -- |
| | RDX | 26 | 28 | 11.91 | 1700 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.8 |
| | 1,3-DNB | 4 | 15 | 0.13 | 0.587 | 1.00 | 0.25 | 1.0 | 1.0 | 20.5 | 73.2 | 178.3 | 480.6 |
| | 2,4-DNT | 1 | 15 | 0.01 | 0.271 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2,6-DNT | | 15 | 0.00 | 0 | 0.25 | 0.25 | -- | -- | -- | -- | -- | -- |
| | HMX | 10 | 15 | 1.22 | 207 | 10.00 | 2.20 | 57.6 | 136.4 | 280.5 | 477.6 | 871.8 | 2005.2 |
| | Nitrobenzene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | m-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | o-Nitrotoluene | | 15 | 0.00 | 0 | 1.00 | 0.25 | -- | -- | -- | -- | -- | -- |
| | Tetryl | 3 | 15 | 43.13 | 223 | 1.00 | 0.65 | 223.0 | 223.0 | 2184.1 | 7440.6 | 17953.6 | 48180.9 |
| | 1,3,5-TNB | 4 | 15 | 0.63 | 35.3 | 4.00 | 0.25 | 10.3 | 20.9 | 45.1 | 71.4 | 124.0 | 275.1 |
| | 2,4,6-TNT | 22 | 28 | 81.01 | 350 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 12.4 |
| | | | | | RISK CHECK: | | HIs | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 2E-05 | 1E-05 | 4E-06 | 2E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL1
EXPOSURE DURATION = 70 YRS
VEGETABLES INCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTIO 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| | 1,3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 135 | 246 | 1.97 | 26.05 | 1.50 | 0.25 | 1.5 | 3.3 | 13.2 | 30.6 | 34.8 | 87.7 |
| | 2,6-DNT | 3 | 92 | 0.13 | 2.93 | 0.50 | 0.26 | 0.5 | 2.3 | 2.9 | 2.9 | 33.8 | 86.1 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3,5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2,4,6-TNT | 248 | 276 | 3069.31 | 132800 | 2.50 | 0.25 | 2.5 | 6.5 | 18.9 | 41.2 | 82.5 | 206.2 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.7 | 0.5 | 0.5 | 0.5 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 4.9 | 4.9 | 4.9 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 135 | 246 | 1.97 | 26.05 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.5 | 1.2 | 3.7 |
| | 2,6-DNT | 3 | 92 | 0.13 | 2.93 | 0.26 | 0.26 | 0.3 | 0.3 | 0.3 | 0.5 | 1.2 | 2.9 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 15.0 | 15.0 | 15.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 56.7 | 56.7 | 56.7 | 1.0 | 1.0 | 1.0 |
| | 1,3,5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 14.9 | 35.9 | 43.2 | 4.0 | 4.0 | 4.0 |
| | 2,4,6-TNT | 248 | 276 | 3069.31 | 132800 | 0.25 | 0.25 | 0.3 | 0.3 | 15.2 | 41.2 | 82.5 | 206.2 |
| | | | | | RISK CHECK: | | HIs | 0.6 | 0.6 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 0.8 | 0.4 | 0.4 | 0.4 |
| | | | | | | | Risk | 3E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 52 | 272 | 1.50 | 39.62 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3-DNB | 23 | 241 | 0.17 | 4.9 | 1.00 | 0.25 | 4.9 | 4.9 | 4.9 | 4.9 | 43.1 | 342.8 |
| | 2,4-DNT | 135 | 246 | 1.97 | 26.05 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2,6-DNT | 3 | 92 | 0.13 | 2.93 | 0.26 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | HMX | 4 | 246 | 0.23 | 15 | 10.00 | 2.20 | 15.0 | 15.0 | 15.0 | 15.0 | 158.3 | 1281.9 |
| | Nitrobenzene | | 87 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 87 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 1 | 232 | 0.25 | 56.7 | 1.00 | 0.65 | 56.7 | 56.7 | 56.7 | 56.7 | 3879.1 | 33846.0 |
| | 1,3,5-TNB | 185 | 237 | 34.05 | 337.95 | 4.00 | 0.25 | 14.9 | 35.9 | 99.0 | 204.1 | 357.1 | 506.9 |
| | 2,4,6-TNT | 248 | 276 | 3069.31 | 132800 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 15.2 |
| | | | | | RISK CHECK: | | HIs | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 3E-05 | 1E-05 | 6E-06 | 3E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: [illegible]
EXPOSURE DURATION = 70 YRS
VEGETABLES INCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | CL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTIO 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 3.00 | 1.00 | 3.0 | 3.0 | 4.9 | 9.8 | 19.5 | 48.8 |
| | 1,3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 138 | 314 | 2.41 | 118.51 | 1.50 | 0.25 | 2.1 | 5.6 | 15.2 | 30.3 | 60.7 | 151.7 |
| | 2,6-DNT | | 69 | 0.00 | 0 | 0.50 | 0.25 | - | - | - | - | - | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 52 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3,5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2,4,6-TNT | 260 | 325 | 2570.34 | 175929.3 | 2.50 | 0.25 | 2.5 | 6.5 | 18.7 | 37.3 | 74.7 | 186.7 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.7 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 1.00 | 1.00 | 1.0 | 1.0 | 2.2 | 4.7 | 10.3 | 25.8 |
| | 1,3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| | 2,4-DNT | 138 | 314 | 2.41 | 118.51 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2,6-DNT | | 69 | 0.00 | 0 | 0.25 | 0.25 | - | - | - | - | - | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 59.3 | 138.2 | 304.9 | 618.1 | 1218.0 | 2431.2 |
| | Nitrobenzene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| | 1,3,5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 10.6 | 21.1 | 43.3 | 85.1 | 165.1 | 496.3 |
| | 2,4,6-TNT | 260 | 325 | 2570.34 | 175929.3 | 0.25 | 0.25 | 0.3 | 0.3 | 8.6 | 17.9 | 39.5 | 98.7 |
| | | | | | RISK CHECK: | | HIs | 0.5 | 0.5 | 0.8 | 0.8 | 0.8 | 0.9 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 2E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 317 | 333 | 671.05 | 23270.09 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 2.2 |
| | 1,3-DNB | 57 | 308 | 0.45 | 2.23 | 1.00 | 0.25 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 140.2 |
| | 2,4-DNT | 138 | 314 | 2.41 | 118.51 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2,6-DNT | | 69 | 0.00 | 0 | 0.25 | 0.25 | - | - | - | - | - | -- |
| | HMX | 263 | 316 | 115.65 | 2431.18 | 10.00 | 2.20 | 59.3 | 138.2 | 374.7 | 768.9 | 1557.2 | 2948.5 |
| | Nitrobenzene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 62 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | 11 | 279 | 0.07 | 6 | 1.00 | 0.65 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 13804.1 |
| | 1,3,5-TNB | 244 | 313 | 43.01 | 430 | 4.00 | 0.25 | 10.6 | 21.1 | 52.5 | 105.2 | 210.3 | 499.0 |
| | 2,4,6-TNT | 260 | 325 | 2570.34 | 175929.3 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 8.6 |
| | | | | | RISK CHECK: | | HIs | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.5 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 2E-05 | 1E-05 | 4E-06 | 2E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL3
EXPOSURE DURATION = 70 YRS
VEGETABLES INCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | DL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTION (f) 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 1.50 | 0.25 | 2.1 | 5.6 | 16.1 | 33.5 | 68.6 | 173.8 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 0.50 | 0.26 | - | - | - | - | - | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | - | - | - | - | - | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | - | - | - | - | - | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 2.50 | 0.25 | 2.5 | 6.6 | 19.0 | 41.2 | 82.5 | 206.2 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.6 | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 2.5 | 2.5 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.9 | 2.4 | 6.5 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 0.26 | 0.26 | - | - | - | - | - | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | - | - | - | - | - | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | - | - | - | - | - | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 18.4 | 39.4 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 0.25 | 0.25 | 0.3 | 0.3 | 19.9 | 41.2 | 82.5 | 206.2 |
| | | | | | RISK CHECK: | | HIs | 0.7 | 0.6 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 1.0 | 1.0 | 0.4 | 0.4 | 0.4 | 0.4 |
| | | | | | | | Risk | 2E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 24 | 107 | 2.48 | 55 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 1,3-DNB | 5 | 79 | 0.07 | 2.45 | 1.00 | 0.25 | 2.5 | 2.5 | 9.7 | 114.8 | 325.1 | 914.6 |
| | 2,4-DNT | 22 | 79 | 1.25 | 14.8 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | 2,6-DNT | | 32 | 0.00 | 0 | 0.26 | 0.26 | - | - | - | - | - | -- |
| | HMX | | 80 | 0.00 | 0 | 10.00 | 2.20 | - | - | - | - | - | -- |
| | Nitrobenzene | | 32 | 0.00 | 0 | 1.00 | 0.26 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 32 | 0.00 | 0 | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | | 79 | 0.00 | 0 | 1.00 | 0.65 | - | - | - | - | - | -- |
| | 1,3,5-TNB | 61 | 79 | 10.23 | 95.3 | 4.00 | 0.25 | 18.4 | 39.4 | 98.9 | 151.5 | 256.6 | 551.4 |
| | 2,4,6-TNT | 104 | 107 | 1544.90 | 29651.58 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 19.9 |
| | | | | | RISK CHECK: | | HIs | 0.7 | 0.6 | 0.6 | 0.5 | 0.6 | 0.6 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 2E-05 | 1E-05 | 4E-06 | 2E-06 | 1E-06 | 1E-06 |

EXPOSURE AREA: LL4
EXPOSURE DURATION = 70 YRS
VEGETABLES INCLUDED

| TARGET | CHEMICAL | HIT | TOTA | AVG | MAX | LL | OL | PRGs (mg/kg) AS A FUNCTION OF AREA FRACTIO 1 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1E-4 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 4 | 16 | 7.4 | 34.0 | 3.00 | 1.00 | 3.0 | 3.0 | 3.0 | 4.9 | 9.9 | 24.7 |
| | 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 1.50 | 0.25 | 1.5 | 3.3 | 10.4 | 18.6 | 37.3 | 93.2 |
| | 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 0.50 | 0.25 | 0.5 | 2.3 | 5.6 | 14.0 | 28.0 | 70.1 |
| | HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | Nitrobenzene | | 12 | | | 1.00 | 0.25 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 12 | | | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 12 | | | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | | 12 | | | 1.00 | 0.65 | - | - | - | - | - | -- |
| | 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 2.50 | 0.25 | 2.5 | 6.5 | 19.6 | 39.3 | 78.5 | 196.3 |
| | | | | | RISK CHECK: | | HIs | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | HIc | 0.7 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 |
| | | | | | | | Risk | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 | 1E-04 |
| 1E-5 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 4 | 16 | 7.4 | 34.0 | 1.00 | 1.00 | 1.0 | 1.0 | 1.3 | 2.6 | 5.3 | 13.2 |
| | 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 10.2 | 24.2 | 51.8 | 106.5 | 215.8 | 543.9 |
| | 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 0.25 | 0.25 | 0.3 | 0.3 | 0.4 | 0.8 | 1.7 | 4.2 |
| | 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.4 | 0.8 | 1.9 |
| | HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 44.5 | 97.1 | 200.4 | 405.4 | 815.5 | 2045.5 |
| | Nitrobenzene | | 12 | | | 1.00 | 0.25 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 12 | | | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 12 | | | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | | 12 | | | 1.00 | 0.65 | - | - | - | - | - | -- |
| | 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 8.6 | 15.6 | 29.4 | 56.7 | 111.4 | 275.4 |
| | 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 0.25 | 0.25 | 0.3 | 0.3 | 10.5 | 20.9 | 41.9 | 104.6 |
| | | | | | RISK CHECK: | | HIs | 0.6 | 0.5 | 0.9 | 0.9 | 0.9 | 0.9 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 3E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 | 1E-05 |
| 1E-6 | 4-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | 2-Amino-DNT | | | | | 0.00 | NA | - | - | - | - | - | -- |
| | RDX | 4 | 16 | 7.4 | 34.0 | 1.00 | 1.00 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.3 |
| | 1.3-DNB | 3 | 12 | 0.2 | 0.7 | 1.00 | 0.25 | 8.9 | 22.9 | 64.9 | 135.0 | 275.2 | 681.2 |
| | 2.4-DNT | 9 | 12 | 2.4 | 12.0 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 |
| | 2.6-DNT | 4 | 12 | 1.1 | 5.6 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| | HMX | 2 | 12 | 1.5 | 4.9 | 10.00 | 2.20 | 39.5 | 92.1 | 249.7 | 512.5 | 1038.1 | 2560.5 |
| | Nitrobenzene | | 12 | | | 1.00 | 0.25 | - | - | - | - | - | -- |
| | m-Nitrotoluene | | 12 | | | 1.00 | 0.25 | - | - | - | - | - | -- |
| | o-Nitrotoluene | | 12 | | | 1.00 | 0.25 | - | - | - | - | - | -- |
| | Tetryl | | 12 | | | 1.00 | 0.65 | - | - | - | - | - | -- |
| | 1.3.5-TNB | 8 | 12 | 0.9 | 6.0 | 4.00 | 0.25 | 9.9 | 16.9 | 38.0 | 73.0 | 143.1 | 346.1 |
| | 2.4.6-TNT | 16 | 16 | 59.1 | 131.0 | 0.25 | 0.25 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 10.5 |
| | | | | | RISK CHECK: | | HIs | 0.5 | 0.5 | 0.5 | 0.5 | 0.4 | 0.5 |
| | | | | | | | HIc | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| | | | | | | | Risk | 3E-05 | 1E-05 | 6E-06 | 3E-06 | 1E-06 | 1E-06 |

**ATTACHMENT A-2**

EXPLOSIVES

AGE-ADJUSTED
CALCULATION OF CONTAMINANT CONCENTRATION IN SOIL: RESIDENTIAL EXPOSURE

Exposure Pathway: Incidental Ingestion of Contaminated Soil (Age-Adjusted, Chronic)

NON-CARCINOGENIC PRG CALCULATION

Intake (mg/kg-day)= CSxIRxCFxFIxEFxED/BWxAT
Intake age/adj (mg/kg-day)= IFxCSxCFxFIxEF/AT where IF=(IRage1-6 x EDage1-6/BWage1-6) + (IRage7-31/EDage7-31/BWage7-31)
(HI = Intake/RfD)
CS(mg/kg)= HIxATxRfd/IFxCFxFIxEF

| Chemical | HMX | RDX | 1,3,5-TNB | DNB | 2,4,6-TNT | DNT | NT | Tetryl |
|---|---|---|---|---|---|---|---|---|
| Critical effect: | hepatic lesions | prostate inflammation | increased splenic wt. | increased splenic wt. | liver effects | neurotoxicity | spleen lesions | |
| RfD: reference dose (mg/kg-day | 5.00E-02 | 3.00E-03 | 5.00E-05 | 1.00E-04 | 5.00E-04 | 2.00E-03 | 1.00E-02 | 1.00E-02 |
| HI: hazard index (unitless) (1/#chemicals) | 0.125 | 0.125 | 0.125 | 0.125 | 0.125 | 0.125 | 0.125 | 0.125 |
| IF: age-adj. ingestion factor(mg-yr/kg-day) | 114 | 114 | 114 | 114 | 114 | 114 | 114 | 114 |
| CF: conversion factr.(10-6 kg/mg) | 1.0E-06 | 1.0E-06 | 1.0E-06 | 1.0E-06 | 1.0E-06 | 1.0E-06 | 1.0E-06 | 1.0E-06 |
| FI: fraction ingest. (unitless) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| EF: exposure frequency (days/year) | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 |
| AT: averaging time (days:EDx365 or 30x365) | 10950 | 10950 | 10950 | 10950 | 10950 | 10950 | 10950 | 10950 |
| CS: chemical conc. in soil (mg/kg) | 1715.2 | 102.9 | 1.7 | 3.4 | 17.2 | 68.6 | 343.0 | 343.0 |

CARCINOGENIC PRG CALCULATION

Intake (mg/kg-day)=CSxIRxCFxFIxEFxED/BWxAT
Intake age/adj (mg/kg-day)= IFxCSxCFxFIxEF/AT where IF= (IRage1-6 x EDage1-6/BWage1-6)) + IRage7-31 x EDage7-31/BWage7-31)

(RISK = Intake x SF)
CS age/adj (mg/kg-day)= RISKxAT/SFxIFxCFxFIxEF

| Cancer Group<br>Chemical | D<br>HMX | C<br>RDX | -<br>1,3,5-TNB | D<br>DNB | C<br>2,4,6-TNT | B2<br>DNT | NT | Tetryl |
|---|---|---|---|---|---|---|---|---|
| SF: slope factor (mg/kg/dy)-1 | not avail. | 1.10E-01 | not avail | not avail. | 3.00E-02 | 6.80E-01 | not avail. | not avail. |
| RISK: (unitless) | 1.0E-06 | 1.0E-06 | 1.0E-06 | 1.0E-06 | 1.0E-06 | 1.0E-06 | 1.0E-06 | 1.0E-06 |
| IF: age-adj.ingestion factoring(mg-yr/kg-day) | 114 | 114 | 114 | 114 | 114 | 114 | 114 | 114 |
| CF: conversion factr.(10-6 kg/mg) | 1.0E-6 | 1.0E-6 | 1.0E-6 | 1.0E-6 | 1.0E-6 | 1.0E-6 | 1.0E-6 | 1.0E-6 |
| FI: fraction inges. (unitless) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| EF: exposure frequency (days/year) | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 |
| AT: averaging time (days:70x365) | 25550 | 25550 | 25550 | 25550 | 25550 | 25550 | 25550 | 25550 |
| CS: chemical conc. in soil (mg/kg) | ERR | 5.8 | ERR | ERR | 21.3 | 0.9 | ERR | ERR |

NOTE: - Cleanup levels shall be based upon the carcinogenic risk for carcinogens.
- Cleanup levels shall be based upon the hazard index for non-carcinogens.
- Averaging time for carcinogenic effects is 70 years x 365 days/year.
- Averaging time for non-carcinogenic effects is ED years x 365 days/year.
- Since the sum of the Hazard Quotients should not exceed 1.0 to be protective, each was set equal to 1/#chemicals of concern.

Attachment 1

# APPENDIX A2

## QUALITATIVE RISK EVALUATION OF PROPOSED REMEDIAL ALTERNATIVES

## APPENDIX A2

## QUALITATIVE RISK EVALUATION OF PROPOSED REMEDIAL ALTERNATIVES

### INTRODUCTION

The National Contingency Plan specifies that a number of criteria be used to evaluate proposed remedial alternatives. Several of these are risk related. They include:

- Overall protection of human health and the environment.
- Long-term effectiveness.
- Short-term effectiveness.

Overall protection of human health and the environment is evaluated by determining if a particular alternative is capable of meeting remediation goals. The evaluation of whether an alternative is likely to achieve remediation goals is discussed elsewhere in the Feasibility and is based on engineering principles and judgements.

The long-term health risks associated with a given remedial alternative are those that are expected to remain once a remedy has been implemented. This concept is referred to as residual risk. Evaluation of residual risk is generally accomplished by comparing expected final chemical concentrations that a remedy is expected to achieve with the established remediation goals.

Short-term risks are those that could occur during implementation of a selected alternative. There are several potential sources of short-term risk. These are evaluated by determining whether a remedial alternative would result in new releases, which would subsequently lead to exposure and risk, or whether new chemicals are produced as a result of the implementation of a remedial action. The exposure and risk potential of new releases, new exposure pathways, and new chemicals can be determined, if relevant, in much the same way as was done in the baseline risk assessment.

Each of the seven alternatives proposed for the Nebraska Ordnance Plant is evaluated for long- and short-term effectiveness in the following sections. These sections contain general statements based on professional judgement regarding the residual risks associated with each alternative proposed for the site. It is expected that other portions of the Feasibility Study will provide additional engineering-based substantiation for these statements.

### Alternative No. 1: No Action

The baseline risk assessment is the presentation of the no-action alternative. If no remediation is undertaken, there is no reduction in risk. Therefore, the risks presented in the baseline risk assessment report are the residual risks.

**Alternative No. 2: Excavation, Consolidation, Biological Treatment, Debris Management, and Residuals Management**

**Long-Term Effectiveness**

In the source areas, contaminated soil is removed until remediation goals are met. Treated soil is then placed back into the source areas, covered with clean soil, and vegetated.

The consolidated contaminated soil is then biologically treated either via composting or within a slurry reactor (aerobic or anaerobic). This treatment results in contaminants which are assumed to be less toxic, therefore, there is little residual risk. The final residue of the treatment is eventually covered with topsoil and revegetated, thereby blocking exposures in any future use scenarios.

**Short-Term Effectiveness**

Excavation of the areas contaminated by explosives is likely to generate dust. Additionally, transporting the excavated soil across dirt roads also generates dust. These particulate emissions are a source of exposure to both the remedial workers involved in excavation and to any potential downwind populations. The highest exposure potential for particulate release would be closed to the excavation area where explosive-contaminated soil is being disturbed. Calculations provided by SEC Donohue indicate that approximately 58 pounds of particulate matter would be generated during the proposed excavation activities.

There is little information regarding the inhalation toxicity of the explosives which contaminate this material. There are no available toxicity values for the inhalation route. It is possible that dust particles could be deposited on surfaces which are touched by remedial workers. Ingestion of those particles could be a cause for some concern. It is assumed, however, that remedial workers would be furnished personal protection equipment (i.e., gloves, overalls, etc.) and would be instructed in the routine safety to prevent ingestion or dermal contact with the contaminated soils.

It is believed that the potential for downwind exposures would be minimal. The contaminated areas within the site are remove (over a mile away) from any current residential or occupational populations. Transport and dispersion of the particles over distance would result in further reduced concentrations to any downwind populations.

It is assumed that transport across the site would be across non-contaminated portions of the site, thus, generation of dust via this activity should not be of health concern. In addition, it is assumed that the truck beds during hauling would be covered to prevent release of explosive-contaminated particulates.

During the treatment of the contaminated soil, it is unknown whether any new release would occur during composting and whether these releases might pose any health concern. In the slurry reactors, releases to the atmosphere would not occur since the vessel would capture them.

**Alternative No. 3: Excavation, Consolidation, Thermal Treatment, Debris Management, and Residuals Management**

**Long-Term Effectiveness**

In the source areas, the long-term effectiveness of this alternative is identical to Alternative No. 2. Contaminated soil is removed until the remediation goals are met.

The residuals of the thermal treatment will also require disposal. Since it is proposed that they will be covered, there does not appear to be any concern for residual risks. The topsoil cover will effectively block any direct exposures.

**Short-Term Effectiveness**

The short-term effectiveness of the excavation/consolidation portions of this alternative is identical to that of Alternative No. 2. There does not appear to be any short-term risks associated with thermal treatment. Releases during the process are captured by an air pollution control system. The residuals from this treatment will also require disposal. The alternative includes provisions for stabilization or immobilization before covering, if metals are of concern based on RCRA, therefore, there should be no concern for potential exposures to the residuals.

**Alternative No. 4: Excavation, Consolidation, Debris Management, On-Site Landfill, Deed Restrictions, and Groundwater Monitoring**

**Long-Term Effectiveness**

In the source areas, the long-term effectiveness of Alternative No. 5 is identical to the Alternative No. 2. Removing contaminated soil until remediation goals are reached results in residual risks below the agreed upon target risk level.

At the landfill site, there would be no long-term risks once remediation is complete. The landfill as envisioned would be constructed so that no direct contact or releases of explosives would occur. Thus, exposure to contaminated soils would be blocked. Since wastes are left on-site, however, a five-year review would be necessary.

### Short-Term Effectiveness

The short-term effectiveness of the excavation/consolidation portions of this alternative is identical to that of Alternative No. 2. In addition, there would be similar fugitive dust emissions in preparing the portion of the site to be used as a landfill. It is assumed that the location chosen will be in an uncontaminated area, thus fugitive emissions, controlled by good engineering practices, should not be of concern.

## Alternative No. 5: Excavation, Consolidation, Debris Management, Off-Site Landfill

### Long-Term Effectiveness

This alternative does not differ from Alternatives 2 through 4 in its long-term effectiveness at the contaminated areas.

Since the contaminated soil would be removed to an off-site location, there are no other residual risks.

### Short-Term Effectiveness

The excavation/consolidation portions of this alternative are identical to those already discussed as part of Alternatives 2 through 4. Since the material would be disposed of off-site, there are no further short-term risks except that releases via fugitive dusts during transport should be prevented by covering contaminated soils in vehicles.

## Summary

All alternatives, except the no-action alternative, proposed for the former NOP site will meet proposed remediation goals for soil. This will be accomplished by excavating soil until confirmatory sampling indicates that concentrations of explosives are below the established remediation goals.

All five remedial alternatives offer a variety of treatment or disposal remedies for the excavated soil. Two alternatives meet long-term goals by landfilling the contaminated soil, thereby blocking exposures to the explosives. Two alternatives treat the soils either biologically or thermally. The long-term effectiveness of thermal treatment appears to be more certain than that of biological. There is some uncertainty regarding the formation of new chemicals which may or may not be as toxic as the original contaminants.

*B*



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# APPENDIX B

# APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

**MEMORANDUM**

**DATE:** April 19, 1993

**TO:** Mead FS Files

**FROM:** Chandler Taylor

**SUBJECT:** ARARs Evaluation

The purpose of this memorandum is to evaluate whether or not potential regulations are applicable or relevant and appropriate to the NOP OU 1 and to specific remedial alternatives. The attached table (Table B-1) provides a description of each regulatory citation in this memo.

**FEDERAL**

**Procedures For Implementing the Requirements of the Council on Environmental Quality on the National Environmental Policy Act:**

40 CFR 6.301(C)

Since this site has been used as an agricultural research station and is of no known historic or archaeological value, this regulation is not an ARAR.

**Clean Air Act of 1963, as amended:**

40 CFR 50. 1-6, 8, 9, 11, 12 and Appendices A-H, J, K

Current site conditions do not exceed ambient air quality standards. Excavation and materials handling operations associated with Alternatives 2 through 5 may cause atmospheric releases of particulate matter. Incineration in Alternative 3 may also increase releases to the atmosphere. Measures will be implemented to control emissions. However, not an ARAR because activities are not considered a major source (USEPA, 1989g).

40 CFR 60.50-54

Not an ARAR because Alternative 3 will not employ an incinerator treating solid waste containing greater than 50 percent municipal waste.

40 CFR 61.01

Not an ARAR because proposed remedial actions do not include sources specified in the National Emissions Standards for Hazardous Air Pollutants (NESHAPs).

**TABLE B-1**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**September 1993**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| FEDERAL | | | | | | | | | |
| Clean Air Act (CAA) of 1963, as amended [42 U.S.C. 7401] | | | | | | | | | |
| 40CFR50 - National Primary and Secondary Ambient Air Quality Standards | 40CFR50.1-6,8,9,11,12, and Appendices A-H,J,K | Establishes national primary and secondary ambient air quality standards. The appendices provide methods and procedures for measuring specific air pollutants. | Chemical | - | - | - | - | - | - |
| 40CFR60 - Standards of Performance for New Stationary Sources | 40CFR60.50-54 | Indicates applicability, sets particulate matter effluent standards, specifies monitoring requirements, and outlines test methods and procedures for incinerators. | Chemical | - | - | - | - | - | - |
| 40CFR61 - National Emission Standards for Hazardous Air Pollutants | 40CFR61.01 | Identifies substances that have been designated hazardous air pollutants, and for which a Federal Register notice has been published. | Chemical | - | - | - | - | - | - |
| | 40CFR61.05-06 | Specifies prohibited activities, describes procedures for determining whether construction or modification is involved, prescribes methods of applying for approval, and covers manner in which start-up notification is to be provided. | Action | - | - | - | - | - | - |
| | 40CFR61.10,11 | Specifies source reporting and waivers of compliance with a standard. | Chemical | - | - | - | - | - | - |

**TABLE B-1**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**September 1993**
**(Continued)**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| (CAA cont'd) | 40CFR61.12-14 | Specifies compliance with emission standards. Also, specifies regulations for emission tests and maintenance and monitoring requirements. | Chemical | - | - | - | - | - | - |
| | 40CFR61.15 | Defines modification to a stationary source and specifies tasks that must be performed in the event that a modification is performed. | Action | - | - | - | - | - | - |
| | 40CFR61.19 | Prohibits concealing emissions. | Chemical | - | - | - | - | - | - |
| **Clean Water Act (CWA) of 1977, as amended [33 U.C.S. 1251]** | | | | | | | | | |
| 40CFR122 - EPA Administered Permit Programs: The National Pollutant Discharge Elimination System (NPDES) | 40CFR122.1-7 | Defines terminology and provides general program requirements for the NPDES. | Action | A | - | x | x | x | x |
| | 40CFR122.21,22,28,29 | Specifies the scope and details of the NPDES permit applications. | Action | A | - | x | x | x | x |
| | 40CFR122.41-48 | Specifies and establishes limitations, standards, and other permit conditions which are applicable to all permits including specified categories of NPDES permits. Specifies schedules of compliance and requirements for recording and reporting monitoring results. | Action | A | - | x | x | x | x |

**TABLE B-1**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**September 1993**
**(Continued)**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| (CWA cont'd) | 40CFR122.49 | Lists other Federal laws which may apply to the issuance of NPDES permits. | Action | A | - | x | x | x | x |
| | 40CFR122.61-64 | Establishes rules for transferring, revocating, reissuing, and terminating NPDES permits. | Action | A | - | x | x | x | x |
| 40CFR125 - Criteria and Standards for the National Pollutant Discharge Elimination System | 40CFR125.1-3 | Establishes criteria and standards for technology-based requirements in permits under Sections 301(b) and 402 of the CWA. | Chemical | A | - | x | x | x | x |
| | 40CFR125.30-32 | Establishes criteria and standards for determining whether effluent limitations alternative to those required by promulgated EPA effluent limitations guidelines under 301 and 304 of the CWA (national limits) should be imposed on a discharger. Alternative effluent limitations may be appropriate if factors relating to the discharger's facilities, equipment, or processes, or other factors related to the discharger are fundamentally different from the factors considered by EPA in development of the national limits. | Chemical | A | - | x | x | x | x |
| | 40CFR125.70-73 | Establishes criteria for determining alternative effluent limitations under Section 316(a) of the CWA for controlling the thermal component of any discharge. | Action | A | - | - | x | - | - |

**TABLE B-1**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**September 1993**
**(Continued)**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| **(CWA cont'd)** | 40CFR125.100-104 | Describes how best management practices (BMPs) for ancillary industrial activities (i.e., materials storage areas, material handling areas) under Section 304(e) of the CWA shall be reflected in permits. This rule is applicable to dischargers who use, manufacrure, store, handle, or discharge any pollutants reaching waters of the United States. | Action | A | - | x | x | x | x |
| 40CFR136 - Guidelines Establishing Test Procedures for the Analysis of Pollutants | 40CFR136.1-5 and Appendices A-C | Specifies analytical procedures for NPDES applications and reports. | Action | A | - | x | x | x | x |
| 40CFR403 - General Pretreatment Regulations for Existing and New Sources of Pollution | 40CFR403.5-7,13,15 | Specifies standards for pretreatment and identifies exclusions. | Chemical | A | - | x | x | x | x |
| **Endangered Species Act, [16 U.S.C. 1531 Sect. 7]** | | | | | | | | | |
| 50CFR81 - Conservation of Endangered Species of Fish, Wildlife, and Plants - Cooperation With the States | 50CFR81.2,3 | Establishes authority by which the Federal government may cooperate with any State that has an established and maintained an adequate and active program for the conservation and preservation of various endangered and threatened species. | Location | - | - | - | - | - | - |

TABLE B-1

DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY
Former NOP Site
Operable Unit 1
Mead, Nebraska
September 1993
(Continued)

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| **Procedures for Implementing the Requirements of the Council on Environmental Quality on the National Environmental Policy Act** | | | | | | | | | |
| 40CFR6 - Wetlands, Floodplains, Important Farmlands Coastal Zones, Wild and Scenic Rivers, Fish and Wildlife, and Endangered Species | 40CFR6.302 | Establishes policy on the protection of sensitive ecosystems and wildlife. Protects significant/important agricultural lands from impacts that reduce environmental or food-producing quality. | Location | - | - | - | - | - | - |
| **Hazardous Materials Transportation Act (HMTA)** | | | | | | | | | |
| 49CFR107 - Hazardous Materials Program Procedures | 49CFR107 Subpart B, Appendix C | Regulates transportation of hazardous materials. Truck carriers of hazardous materials must obtain a permit from: Chief, Hazardous Materials Division, Office of Motor Carrier Field Operations, Federal Highway Administration, Department of Transportation, Washington, DC 20590-0001. | Action | R&A | - | - | - | - | x* |
| 49CFR171 - General Information, Regulations, and Definitions | 49CFR171.1-21 | Prescribes the requirements of the Department of Transportation governing the transportation of hazardous materials and the manufacture, fabrication, marking, maintenance, reconditioning, repairing, or testing of packaging or a container which represented, marked, certified, or sold for use in transporting hazardous waste. | Action | R&A | - | - | - | - | x* |

**TABLE B-1**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**September 1993**
**(Continued)**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| **(HMTA cont'd)** | | | | | | | | | |
| 49CFR172 - Hazardous Materials Tables and Hazardous Material Communications Regulations | 49CFR172.101-604 Appendix A-C | Provides tables of hazardous materials along with their descriptions, proper shipping names, classes, labels, packaging, and other requirements. Specifies shipping papers which must be completed by persons offering a hazardous material for transportation, and provides marking, labeling, and placarding requirements for the transportation of hazardous materials. | Action | R&A | - | - | - | - | x* |
| 49CFR173 - Shippers - General Requirements for Shipments and Packaging | 49CFR173.1-130 Appendix A,B | Defines regulated material and their preparation for transportation. | Action | R&A | - | - | - | - | x* |
| 49CFR177 - Carriage by Public Highway | 49CFR177.800-870 | Prescribes general regulations for the transportation of hazardous materials by public highway. Also, provides loading and unloading requirements. Specifies requirements for vehicles carrying hazardous materials in the event of any accident. | Action | R&A | - | - | - | - | x* |
| **Public Health Service Act: Title XIV, as amended by the SAFE DRINKING WATER ACT OF 1988 [42 U.S.C. 300(f)]** | | | | | | | | | |
| 40CFR141 - National Primary Drinking Water Regulations | 40CFR141.11-12 | Specifies maximum contaminant levels (MCLs) of public water systems for inorganic and organic chemicals. | Chemical | R&A | - | x | x | x | x |

**TABLE B-1**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**September 1993**
**(Continued)**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| **(Title XIV cont'd)** | | | | | | | | | |
| | 40CFR141.50 | Specifies maximum contaminant level goals (MCLGs) of public water systems for organic chemicals. | Chemical | R&A | - | x | x | x | x |
| | 40CFR141.60-63 | Establishes national revised primary drinking water regulations of MCLs for organic chemicals, inorganic chemicals, and microbiological contaminants. | Chemical | R&A | - | x | x | x | x |
| 40CFR143 - National Secondary Drinking Water Regulations | 40CFR143.03 | Establishes secondary maximum contaminant levels (SMCLs) for public water systems. These are Federally non-enforceable standards which regulate contaminants in drinking water that primarily affect aesthetic qualities. | Chemical | R&A | - | x | x | x | x |
| **Section 10 of the River and Harbor Act of 1899, as amended [33 U.S.C. 403]** | | | | | | | | | |
| (NOTE: The following regulations under Section 10 are also affiliated with the CWA with the exception of 33CFR329) | | | | | | | | | |
| 33CFR320 - General Regulatory Policies | 33CFR320.1-4 | Specifies the regulatory approach of the Corps of Engineers (C.O.E.) and the types of activities regulated. The C.O.E. has the responsibility of protecting important resources, including the wetlands. | Action | - | - | - | - | - | - |

**TABLE B-1**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**September 1993**
**(Continued)**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| 33CFR330- Nationwide Permits | 33CFR330.1,2,4-9 11,12 | Describes the Department of the Army's nationwide permits program and lists current nationwide permits. Nationwide permits include staff gauges and similar structures, survey activities including core sampling, and outfall structures where effluent has been permitted under the NPDES. | Action | - | - | - | - | - | - |
| **Solid Waste Disposal Act (SWDA) as amended by RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) of 1976 [42 U.S.C. 6901]** | | | | | | | | | |
| 40CFR241 - Guidelines for the Land Disposal of Solid Wastes | 40CFR241.100-213 | Delineates minimum levels of performance required of any solid waste land disposal site operation. | Action | A | - | - | - | x | - |
| 40CFR257 - Criteria for Classification of Solid Waste Disposal Facilities and Practices | 40CFR257.1-4 | Specifies criteria for evaluating the potential for adverse effects on human health and the environment from solid waste disposal facilities. | Action | A | - | - | - | x | - |
| 40CFR258 - Criteria for Municipal Solid Waste Landfills | 40CFR258.1-61 | Establishes minimum national criteria for municipal solid waste landfills, including location, design, operation, monitoring, and closure. | Action | A | - | - | - | x | - |

**TABLE B-1**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**September 1993**
**(Continued)**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| **(SWDA cont'd)** | | | | | | | | | |
| 40CFR261 - Identification and Listing of Hazardous Waste | 40CFR261.1-7, 10,11, 20-24,30-33 | Defines solid and hazardous wastes. Applies to solid and hazardous wastes as defined. | Chemical | A/R&A | - | * | x* | * | * |
| 40CFR263 - Standards Applicable to Transporters of Hazardous Wastes | 40CFR263.30,31 | Establishes responsibilities which transporters of hazardous wastes assume if discharges of hazardous wastes occur while in the custody of the transporter. Mandates immediate action and discharge cleanup. | Action | R&A | - | - | - | - | x* |
| 40CFR264 - Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal (TSD) Facilities | 40CFR264.90-101 | Identifies groundwater protection standards, hazardous constituent concentration limits. | Chemical | - | - | - | - | - | - |
| | 40CFR264.110-120 | Specifies standards and procedures for closure and post-closure of hazardous waste management units. | Chemical | - | - | - | - | - | - |
| | 40CFR264.220-231 | Specifies surface impoundment management. | Action | - | - | - | - | - | - |

**TABLE B-1**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**September 1993**
**(Continued)**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| **(SWDA cont'd)** | | | | | | | | | |
| | 40CFR264.250-259 | Specifies waste pile management. | Action | - | - | - | - | - | - |
| | 40CFR264.270-283 | Specifies land treatment system management. | Action | - | - | - | - | - | - |
| | 40CFR264.300-317 | Specifies Subtitle C landfill management and design. | Action | R&A | - | - | - | x | - |
| | 40CFR264.340-351 | Specifies incineration trial burn requirements. | Action | R&A | - | - | x | - | - |
| | 40CFR264.600-603 | Specifies miscellaneous hazardous waste system management. | Action | - | - | - | - | - | - |
| 40CFR266 - Standards for Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities | 40CFR266.30-35 | Regulates hazardous wastes burned for energy recovery in any boiler or industrial furnace. | Action | - | - | - | - | - | - |
| 40CFR268 - Land Disposal Restrictions | 40CFR268.30,40 | Lists EPA hazardous wastes that are prohibited from land disposal. | Action | A/R&A | - | x* | x* | x* | x* |
| STATE | | | | | | | | | |
| Water Quality Standards for Surface Water of the State - Title 117 | Ch. 2-4 | Establishes surface water quality standards based on use and location. | Chemical | A | - | x | x | x | x |

**TABLE B-1**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**September 1993**
**(Continued)**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| Groundwater Quality Standards and Use Classification - Title 118 | Ch. 2-4 | Nebraska Department of Environmental Quality (NDEQ) shall apply standards on a site-specific basis determined by location and classification, and existing groundwater quality shall be preserved. | Chemical | A | x | x | x | x | x |
| | Ch. 6-8 | Establishes classification system for groundwater and procedures for changing classification. | Location | A | x | x | x | x | x |
| Rules and Regulations Pertaining to the Issuance of Permits Under the National Pollutant Discharge Elimination System - Title 119 | Ch. 2-66 | Defines a new source and identifies limits during a permit term and minimum monitoring requirements. | Chemical | A | - | x | x | x | x |
| Nebraska General NPDES Rules for New and Existing Sources: Effluent Guidelines and Standards - Title 121 | Ch. 2.016<br>Ch. 8 | Establishes effluent standards for point sources in general; for explosives loading, assembling and packing (as per 40CFR457); and lists analytical procedures for determining those effluent levels. | Chemical | A | - | x | x | x | x |
| Rules and Regulations Pertaining to the Management of Wastes - Title 126 | Ch. 2 | Specifies the information required in a compost construction and/or operation permit for NDEQ. | Action | R&A | - | x | - | - | - |

**TABLE B-1**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**September 1993**
**(Continued)**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| Rules and Regulations Governing the Nebraska Pretreatment Program - Title 127 | Ch. 2-5 | Specifies permit-specific limits based on design flow, lists prohibited discharges, prohibits dilutions used to meet limits, and exempts users from having to clean pollutants in their intake. | Chemical | A | - | x | x | x | x |
| | Ch. 6-38 | Includes details on compliance report contents effluent limits during permit term, minimum monitoring record contents, and disposal of sludge. | Action | A | - | x | x | x | x |
| Rules and Regulations Governing Hazardous Waste Management in Nebraska - Title 128 | Ch. 2,4, and 9-15 | Defines solid and hazardous waste specifically by use/disposal, criteria, characteristics and listing. | Chemical | A | - | x | x | - | - |
| | Ch. 20 | Rules governing the transportation of hazardous waste. | Action | - | - | - | - | - | - |
| | Ch. 6,23 | Definition of and requirements for small quantity generators. | Action | - | - | - | - | - | - |
| Nebraska Air Pollution Control Regulations - Title 129 | Ch. 2 | Establishes air quality control regions. | Location | A | x | x | x | x | x |

**TABLE B-1**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**September 1993**
**(Continued)**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| (Title 129 cont'd) | Ch. 3 | Establishes State primary and secondary ambient air quality standards for particulate matter (< =10 um and = >10um/ < =100 um), sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, and lead. | Chemical | A | - | x | x | x | x |
| | Ch. 4<br>Ch. 6.002 | Establishes emission limits for new incinerators and lists emission report contents. | Action | A | - | - | x | - | - |
| | Ch. 5 | Requires good engineering practice in the design of the stack height. | Action | A | - | - | x | - | - |
| | Ch. 6.006 | Operational and/or compensatory requirements for construction of sources in areas where National Ambient Air Quality Standards have been exceeded (non-attainment). | Location | - | - | - | - | - | - |
| | Ch. 6.007 | If Chapter 4 emission limits for pollutant are exceeded, may still obtain permit if BACT is applied for all pollutants and 40CFR60 and 61 standards are not exceeded. | Chemical | A | - | - | x | - | - |
| | Ch. 7 | Adopts 40CFR52 regarding Prevention of Significant Deterioration of Air Quality. | Chemical | A | - | x | x | x | x |
| | Ch. 12 | Adopts National Emission Standards For Hazardous Air Pollutants. | Chemical | - | - | - | - | - | - |

**TABLE B-1**

**DOCUMENTATION OF ARARs WITH WHICH EACH ALTERNATIVE MAY BE REQUIRED TO COMPLY**
**Former NOP Site**
**Operable Unit 1**
**Mead, Nebraska**
**September 1993**
**(Continued)**

| Laws/Regulations | Applicable Rules | Description | Classification | Type | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|
| | Ch. 17 | Prohibits visible dust beyond the limits of the property line where handling, transportation, or construction is taking place. | Action | A | - | x | x | x | x |
| | Ch. 24 | Limits visible emissions from diesel-powered construction or transportation equipment. | Action | A | - | x | x | x | x |
| Rules and Regulations Pertaining to Solid Waste Management - Title 132 | Ch. 7 | Brief requirements for solid waste control in second class cities and villages including general prevention of contamination and location restrictions due to potential for flooding or surface drainage. | Action | A | - | - | - | x | - |
| Regulations Governing Licensure of Water Well and Pump Installation Contractors and Certification of Water Well Drilling and Pump Installation Supervisors - Title 178 | Ch. 2 | Rules regarding the qualifications of contractors installing water wells. | Action | A | - | - | - | x | - |

A = Applicable
R&A = Relevant and Appropriate
*Applicable only in determining RCRA characteristic; site soil is not a listed waste. Relevant and appropriate requirements may be identified as more detailed components of the remedial action are evaluated during the predesign and design phases of OU1.

RP/MEADFS/AV1

40 CFR 61.05-06

Not an ARAR because no pollutants of the type indicated in the regulation will be emitted.

40 CFR 61.10-11

Not an ARAR because no pollutants of the type indicated in the regulation will be emitted.

40 CFR 61.12-15

Not an ARAR because no pollutants of the type indicated in the regulation will be emitted.

40 CFR 61.19

Not an ARAR because no pollutants of the type indicated in the regulation will be emitted.

**Clean Water Act of 1977, as amended:**

40 CFR 122.1-7

Applicable to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged to the surface or to surface water. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, liquids may be treated on-site prior to on-site discharge or they may be treated at an off-site commercial facility.

40 CFR 122.21, 22, 28, 29

Applicable to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged to the surface or to surface water. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, liquids may be treated on site prior to on-site discharge or they may be treated at an off-site commercial facility.

40 CFR 122.41-48

Applicable to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged to the surface or to surface water. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, liquids may be treated on-site prior to on-site discharge or they may be treated at an off-site commercial facility.

40 CFR 122.49

Applicable to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged to the surface or to surface water. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, liquids may be treated on-site prior to on-site discharge or they may be treated at an off-site commercial facility.

40 CFR 122.61-64

Applicable to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged to the surface or to surface water. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, liquids may be treated on-site prior to on-site discharge or they may be treated at an off-site commercial facility.

40 CFR 125.1-3

Applicable to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged to the surface or to surface water. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, liquids may be treated on-site prior to on-site discharge or they may be treated at an off-site commercial facility.

40 CFR 125.30-32

Applicable to Alternatives 2 through 5 if effluent discharge factors are fundamentally different from the factors considered by EPA in the development of the national limits. Under CWA 301 and 304, EPA may require that the effluent be analyzed for explosives, which are not on the analytical list of compounds.

40 CFR 125.70-73

Applicable to Alternative 3 if the thermal treatment discharge limit to surface water is "more stringent than necessary". This regulation specifies requirements for obtaining approval of an alternate thermal effluent limit.

40 CFR 125.100-104

Applicable to Alternatives 2 through 5. Provides guidelines for preventing discharge of toxic pollutants from material handling and storage areas to waters of the United States.

40 CFR 136.1-5 and Appendices A-C

Applicable to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged to the surface or to surface water. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, liquids may be treated on-site prior to on-site discharge or they may be treated at an off-site commercial facility.

40 CFR 403.5-7, 13, 15

Applicable to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged to the surface or to surface water. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, liquids may be treated on-site prior to on-site discharge or they may be treated at an off-site commercial facility.

**Endangered Species Act:**

50 CFR 81.2,3

Not an ARAR. No endangered species are known to inhabit the site.

**Procedures for Implementing the Requirements of the Council on Environmental Quality on the National Environmental Policy Act:**

40 CFR 6.302

Not an ARAR because no activities affect wetlands, wild, scenic, or recreational rivers, or important farm lands (as defined); no activities occur in a coastal area or the Coastal Barrier Resources System; no activities involve the control or structural modification of rivers; no activities jeopardize threatened or endangered species.

**Hazardous Materials Transportation Act (HMTA):**

49 CFR 107. Subpart B, Appendix C

Regulation is not applicable because there are no known hazardous wastes on-site. However, it is relevant and appropriate for Alternative 5 because CERCLA materials are transported off-site.

49 CFR 171.1-21

Regulation is not applicable because there are no known hazardous wastes on-site. However, it is relevant and appropriate for Alternative 5 because CERCLA materials are transported off-site.

49 CFR 172.101-604, Appendix A, B, C

Regulation is not applicable because there are no known hazardous wastes on-site. However, it is relevant and appropriate for Alternative 5 because CERCLA materials are transported off-site.

49 CFR 173.1-1,300, Appendix A, B

Regulation is not applicable because there are no known hazardous wastes on-site. However, it is relevant and appropriate for Alternative 5 because CERCLA materials are transported off-site.

49 CFR 177.800-870

Regulation is not applicable because there are no known hazardous wastes on-site. However, it is relevant and appropriate for Alternative 5 because CERCLA materials are transported off-site.

**National Historic Preservation Act:**

36 CFR 800.1-15

Not an ARAR because the site is used as an agriculture research station and is of no known historic value.

**Public Health Service Act: Title XIV, as amended by the Safe Drinking Water Act of 1986, as amended:**

40 CFR 141.11-12

Relevant and appropriate to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged at the surface where it can percolate into groundwater. This regulation is not applicable to explosive compounds. However, due to the chemical structure of explosives, there is a potential for nitrate in the discharge. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, liquids may be treated on-site prior to on-site discharge or they may be treated at an off-site commercial facility. Private use of groundwater is not precluded, therefore these requirements are relevant and appropriate.

40 CFR 141.50

Relevant and appropriate to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged at the surface where it can percolate into groundwater. This regulation is not applicable to explosive compounds. However, due to the chemical structure of explosives, there is a potential for nitrate in the discharge. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, liquids may be treated on-site prior to on-site discharge or they may be treated at an off-site commercial facility. Private use of groundwater is not precluded, therefore these requirements are relevant and appropriate.

40 CFR 141.60-63

Relevant and appropriate to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged at the surface where it can percolate into groundwater. This regulation is not applicable to explosive compounds. However, due to the chemical structure of explosives, there is a potential for nitrate in the

discharge. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, liquids may be treated on-site prior to on-site discharge or they may be treated at an off-site commercial facility. Private use of groundwater is not precluded, therefore these requirements are relevant and appropriate.

40 CFR 143.03

Relevant and appropriate to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged at the surface where it can percolate into groundwater. This regulation is not applicable to explosive compounds. However, due to the chemical structure of explosives, there is a potential for nitrate in the discharge. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, liquids may be treated on-site prior to on-site discharge or they may be treated at an off-site commercial facility. Private use of groundwater is not precluded, therefore these requirements are relevant and appropriate.

40 CFR 146.01-73

Not an ARAR because injection wells will not be used.

40 CFR 147.01-3109

Not an ARAR because injection wells will not be used.

**Section 10 of the River and Harbor Act of 1899, as amended:**

33 CFR 320.1-4

Not an ARAR because navigable waters will not be affected by site activities.

33 CFR 330.1, 2, 4-9, 11, 12

Not an ARAR because navigable waters will not be affected by site activities.

**Solid Waste Disposal Act (SWDA) as amended by Resource Conservation and Recovery Act (RCRA) of 1976:**

40 CFR 241.100-213

Applicable to Alternative 4.

40 CFR 257.1-4

Applicable to Alternative 4.

40 CFR 258.1-61

Applicable to Alternative 4.

40 CFR 261.1-7, 10, 11, 20-24, 30-33

Pertinent to contaminated soil in determining its classification as non-hazardous; however, not applicable because soil is not likely to be considered hazardous as defined. Solid residuals produced under Alternatives 2 and 3 may exhibit the toxicity characteristic, and, if so, will require stabilization/solidification prior to on-site disposal. Relevant and appropriate requirements may be identified as more detailed components of the remedial action are evaluated during the predesign and design phases of OU 1.

40 CFR 263.30, 31

Not applicable because no hazardous waste is likely to exist on-site. Relevant and appropriate requirements may be identified as more detailed components of the remedial action are evaluated during the predesign and design phases of OU 1.

40 CFR 264.90-603

Not applicable because no hazardous waste exists on-site. 40 CFR 264.301 (Subtitle C engineering design) is relevant and appropriate to Alternative 4. 40 CFR 264 (Subpart O trial burns) is relevant and appropriate to Alternative 3. Additional relevant and appropriate requirements may be identified as more detailed components of the remedial action are evaluated during the predesign and design phases of OU 1.

40 CFR 266.30-35

Not applicable because no hazardous waste is likely to exist on-site. Relevant and appropriate requirements may be identified as more detailed components of the remedial action are evaluated during the predesign and design phases of OU 1.

40 CFR 268.30,40

Not applicable because no hazardous waste is likely to exist on-site. Solid residuals produced under Alternatives 2 and 3 may exhibit the toxicity characteristic, and, if so, would require stabilization/solidification prior to on-site disposal. Relevant and appropriate requirements may be identified as more detailed components of the remedial action are evaluated during the predesign and design phases of OU 1.

## STATE

**Water Quality Standards for Surface Water of the State:**

Ch. 2-4

Applicable to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged to the surface or to surface water. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, liquids may be treated on-site prior to on-site discharge or they may be treated at an off-site commercial facility.

**Groundwater Quality Standards and Use Classification:**

Ch. 6-8

Applicable to all alternatives because it establishes a classification system for groundwater which is used to develop site-specific standards on discharge to the surface or surface water. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, it may be more cost-effective to discharge to a POTW.

**Rules and Regulations Pertaining to the Issuance of Permits Under the National Pollutant Discharge Elimination System:**

Ch. 2-66

Applicable to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged under an NPDES permit.

**Nebraska General NPDES Rules for New and Existing Sources: Effluent Guidelines and Standards:**

Ch. 2, 8

Applicable to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged under an NPDES permit.

**Rules and Regulations Pertaining to the Management of Wastes:**

Ch. 2

Relevant and appropriate to Alternative 2 if composting is the type of biological treatment used.

**Rules and Regulations Governing the Nebraska Pretreatment Program:**

Ch. 2-38

Applicable to Alternatives 2 through 5. Dewatering fluids from biological treatment, residual water from thermal treatment, fluids from equipment decontamination, and leachate collected from a landfill may be discharged to the surface or to surface water. Surface or surface water discharge is acceptable for liquid residuals that meet substantive requirements; however, if treatment is required prior to surface discharge, liquids may be treated on-site prior to on-site discharge or they may be treated at an off-site commercial facility.

**Rules and Regulations Governing Hazardous Waste Management in Nebraska:**

Ch. 2, 4, 9-15

Not an ARAR because no hazardous waste exists on-site. Solid residuals produced under Alternatives 2 and 3 will require testing to show it is not hazardous.

Ch. 20

Not an ARAR because it is assumed that no hazardous waste will be transported off-site.

Ch. 6, 23

Not an ARAR because treatment systems on-site are not small quantity generators.

**Nebraska Air Pollution Control Regulations:**

Ch. 2

Applicable to all alternatives because it places the site in the Nebraska Interstate Air Quality Control Region.

Ch. 3

Applicable to Alternatives 2 through 5, due to the potential for particulate matter emissions during excavation and nitrogen dioxide during treatment.

Ch. 4, 6.002

Applicable to Alternative 3 which has a thermal treatment component which will meet emission requirements.

Ch. 5

Applicable to Alternative 3 which has a thermal treatment component with an emissions stack.

Ch. 6.006

Not an ARAR because the site is not in a non-attainment area (40 CFR 81).

Ch. 6.007

Applicable to Alternative 3 due to the potential for particulate matter and nitrogen dioxide emissions during treatment.

Ch. 7

Applicable to Alternatives 2 through 5, due to the potential for particulate matter emissions during excavation and nitrogen dioxide during treatment.

Ch. 12

Not an ARAR because no contaminants exist from the sources specified in the NESHAPs.

Ch. 17

Applicable to Alternatives 2 through 5 because they all have a potential for dust emission during excavation, handling, transportation, and construction.

Ch. 24

Applicable to Alternatives 2 through 5 because they will all incorporate the use of diesel-powered equipment for excavation, handling, transportation, and construction.

**Rules and Regulations Pertaining to Solid Waste Management:**

Ch. 7

Applicable to Alternative 4 because it involves containment of solid waste.

**Regulations Governing Licensure of Water Well and Pump Installation Contractors and Certification of Water Well Drilling and Pump Installation Supervisors:**

Ch. 2

Applicable to Alternative 4 which includes the installation of groundwater wells on-site for monitoring.

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*C*



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# APPENDIX C

## ENGINEERING CALCULATIONS/EVALUATIONS

Appendix C1: Treatability Study Sampling Summary
Appendix C2: Area and Volume Calculations
Appendix C3: Borrow Evaluation

# APPENDIX C1

# TREATABILITY STUDY SAMPLING SUMMARY

## APPENDIX C1

## TREATABILITY STUDY SAMPLING SUMMARY

### 1.0 INTRODUCTION

Samples to be used in the thermal and biological treatability studies were collected at the site and provided to the treatability study vendors. The following sections describe the assumptions used in determining the locations from which the samples were collected, the procedures used to collect and prepare the samples for the vendors, and the results of the analyses done on the pretreatment samples.

### 2.0 SAMPLE OBJECTIVES

During full-scale remediation of the site, contaminated soil will be excavated from many small, isolated "hot spots" and consolidated into a single pile prior to treatment. The treatability study samples were collected in order to simulate the full-scale process as closely as possible so that conclusions reached during the study can be applied to the full-scale process. However, the treatability studies were also conducted to determine whether or not a technology can treat contaminants in the waste. Therefore, the following goals for the treatability study sample selection were identified:

- Collect samples for the treatability study from several areas and consolidate them into a mixed pile to (simulate full-scale remediation).
- Provide the vendors with pretreatment samples that have measurable concentrations of explosives (to evaluate treatment performance).
- Provide the thermal treatment vendors with background soil which will be used to conduct an incinerated ash geotechnical study and to determine whether contaminants leach from the vitrified block into surrounding clean soil.

### 3.0 SELECTION OF TREATABILITY STUDY SAMPLE LOCATIONS

Three types of treatability study samples were collected in the field. Each type was consolidated and mixed in a separate stockpile. A check sample from each stockpile was analyzed for explosives to evaluate assumptions made on sample type. Bulk soil from the sample stockpiles that best satisfied the treatability study sample selection goals was sent to the treatability study vendors. The three treatability study samples were defined as follows:

Full-Scale Simulation (FSS): This treatability study sample consisted of soil collected from several locations which are well-characterized by a high RI sample density. The RI

samples used to select these locations were expected to approximate (when consolidated) the estimated full-scale consolidated pile concentrations and also contain measurable explosives concentrations.

Selective High Concentration Sample (SH): This treatability study sample was a composite of soil from locations identified during the RI as having the highest concentrations of explosives. This treatability study sample was more likely to contain measurable levels of explosives and would have been used in the event that the full-scale sample did not contain adequate contaminant concentrations.

Background Sample (BG): This sample was collected from an area where all explosive concentrations were nondetectable, the soil type was typical of the site soil, and the excavation did not disturb site activity.

### 3.1 Full-Scale Simulation Sampling Locations

Based on knowledge of historical operations, the concentration of explosives in samples where the preliminary remediation goals (PRG) reported in the Draft Feasibility Study were exceeded, and extrapolation between measured sample concentrations, an average concentration in the full-scale consolidated pile was estimated.

The volume-weighted average concentration of each explosive in the consolidated pile was estimated using the following equation:

$$C = \frac{(C_{eai} * V_{eai} + C_{ea2} * + \ldots C_{ean} * V_{ean})}{V}$$

where:

| | | |
|---|---|---|
| $C$ | = | the volume-weighted average concentration in the consolidated pile |
| $C_{eai}$ | = | the average concentration of a chemical in all samples within exposure area "i"where any one chemical exceeds its PRG (includes shallow samples in the same holes) |
| $V_{eai}$ | = | the exposure area "i" volume |
| $V$ | = | the sum of all exposure area volumes on site |
| $n$ | = | total number of exposure areas |

Exposure areas are made up of a group of source areas. Source areas are defined as contiguous areas defined by samples where one or more chemicals exceed its PRG. Average concentrations were calculated by exposure areas ($C_{eai}$ in the equation above). These averages incorporated not only chemical concentrations in the sample intervals where any one or more chemicals exceeded the PRGs, but also the concentrations in sample intervals above that in which the PRG was exceeded. This was done in order to account for those samples which might be excavated despite the fact that no chemicals exceeded the PRGs.

Site maps showing relative concentrations of total explosives were inspected to identify locations that are well-characterized (having a sample density of greater than or equal to two samples per 25 feet of ditch) and located in exposure areas which contribute large volumes to their respective major area volumes. Areas which contribute unique chemicals to the consolidated sample pile were also considered. Volume-weighted calculations similar to those used for the full-scale remediated pile were performed on selected RI sample locations to match the estimated consolidated pile concentrations. All samples in an excavation were assumed to contribute an equal weight to the concentration in the excavation. Table C-1 shows the estimated concentrations for the consolidated full-scale pile at the time of remediation and for the full-scale simulation treatability study sample pile. The following locations were excavated and consolidated for the full-scale simulation treatability study sample:

- Load Line 1 ditch segment from D265 to D267
- Load Line 1 ditch segment from D261 to D263
- Load Line 2 ditch segment from D254 to D255
- Load Line 2 ditch segment from D221 to D224
- Load Line 3 ditch segment from D201 to D200
- Bomb Booster Assembly Area from just west of TB82 to just east of BBA-12-13A

### 3.2 Selective High Concentration Locations

The selective high concentration treatability study sample was a composite of a small volume of soil from locations on site having the highest measured explosives concentrations. Table C-2 shows the locations selected for the selective high concentration excavations.

### 3.3 Background Sample Location

Surface soil from an area of fallow land where the sample (LL2-38C) results were nondetectable for all explosives was selected for the background sample.

## 4.0 TREATABILITY STUDY SAMPLE COLLECTION AND HANDLING

Samples for the treatability study were collected in accordance with the RI Field Sampling Plan Addendum No. 1 (SEC Donohue, 1992). Figures C-1 through C-5 show the locations for the full-scale simulation and selective high sample. Test pit excavations were conducted with a backhoe to collect explosives contaminated soil from within the former waste disposal ditches. The RI soil boring or surface soil sample location associated with each test pit were ground surveyed and the dimensions of the test pit were marked in the field with wooden lath prior to excavation. Test pit locations were established by the State Plan Coordinate System.



B07NE003701-04953

**TABLE C-1**

**ESTIMATED PILE CONCENTRATIONS**
**OU 1 Feasibility Study Report**
**Former NOP Site**
**Mead, Nebraska**
**March 1994**

| | Estimated Consolidated Pile Concentration at Time of Remediation | Estimated Full-Scale Simulation Treatability Study Sample Concentration |
|---|---|---|
| NB | ND | ND |
| 2,4 DNT | 1.1 | 0.9 |
| 2,6 DNT | 0.3 | ND |
| RDX | 220 | 660 |
| TNB | 19 | 23 |
| DNB | 0.2 | 0.1 |
| TNT | 1,600 | 1,500 |
| oNT | 0.4 | ND |
| mNT | ND | ND |
| pNT | 0.3 | ND |
| Tetryl | 88 | 32 |
| HMX | 39 | 180 |

* Concentrations in mg/kg.

ND = not detected.

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**TABLE C-2**

**SELECTIVE HIGH CONCENTRATION SAMPLE LOCATIONS**
**OU 1 Feasibility Study Report**
**Former NOP Site**
**Mead, Nebraska**
**March 1994**

| Sample I.D. | Chemical | Concentration (mg/kg) | Excavation |
|---|---|---|---|
| LL2-D249 | TNT | 17529 | 2'x 8'x 1' south of D249 |
| | 2,4-DNT | 119 | |
| LL2-D218 | RDX | 23,270 | 2'x 8'x 1' northeast of D218 |
| | HMX | 2,431 | |
| LL2-DP97 | TNB | 430 | 4'x 4'x 1' northwest of DP97 |
| BBA-TB81 | Tetryl | 52,000 | 4'x 4'x 1' east of TB81 |
| | o-NT | 160 | |

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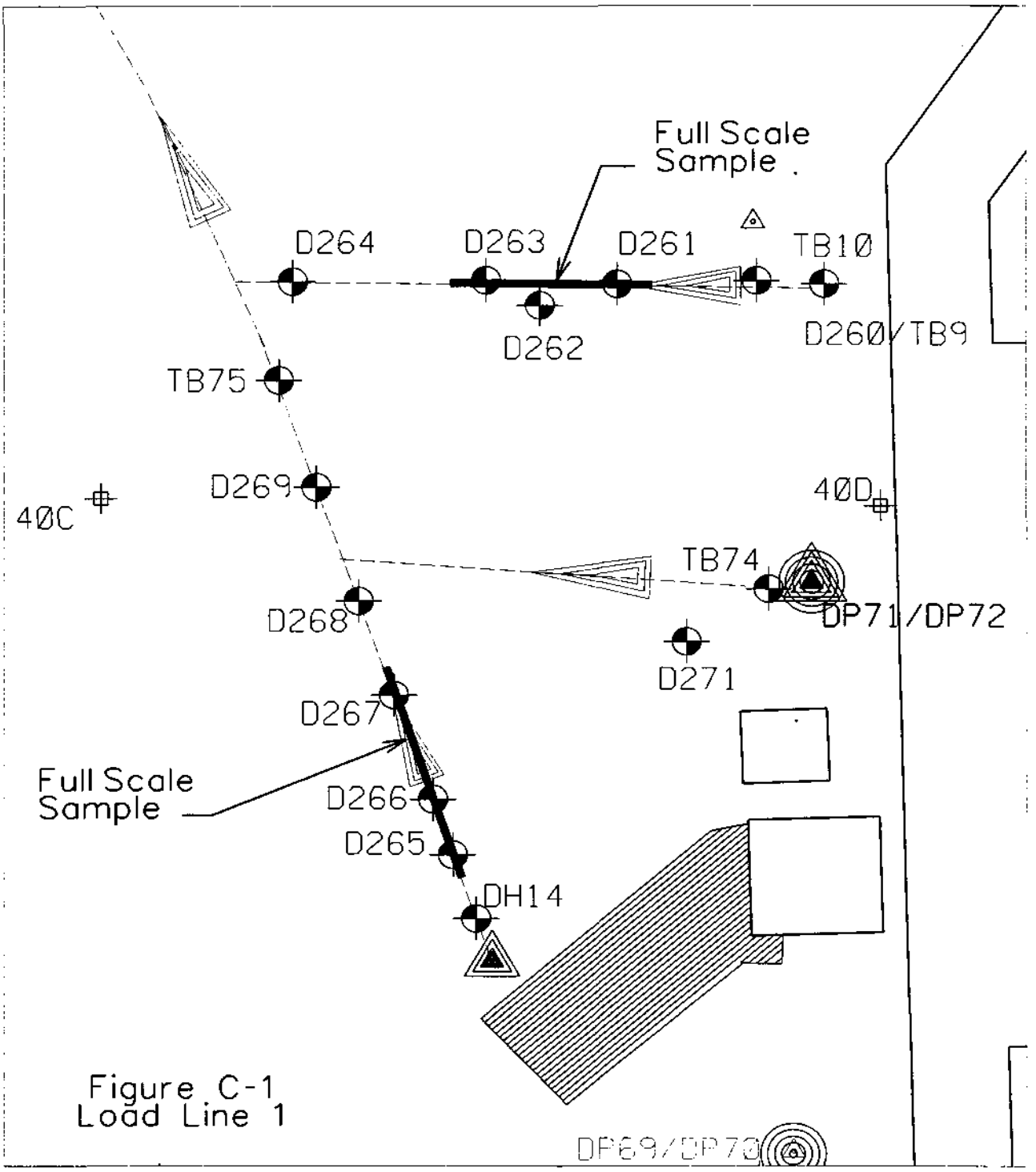


Figure C-1
Load Line 1

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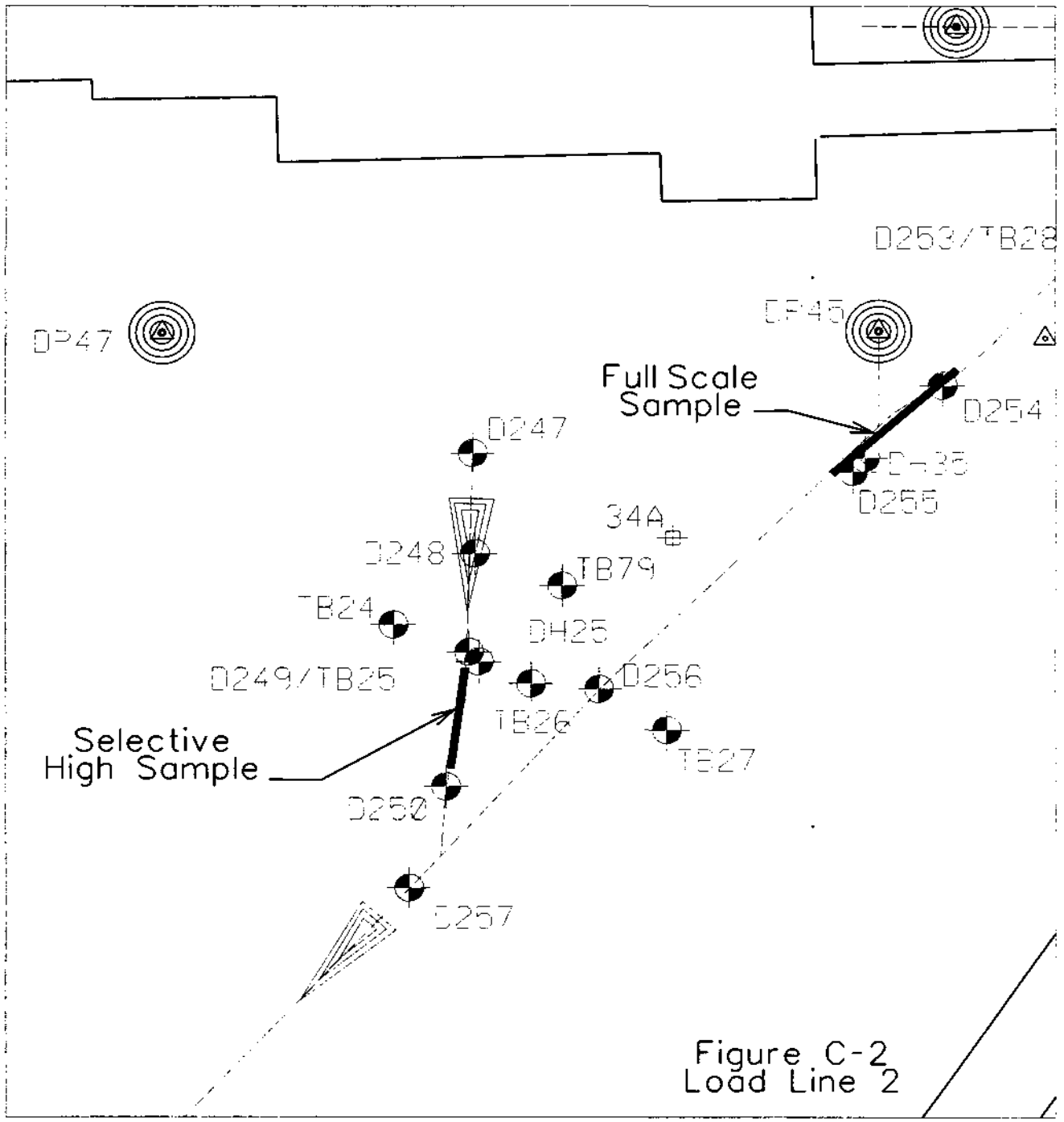


Figure C-2
Load Line 2

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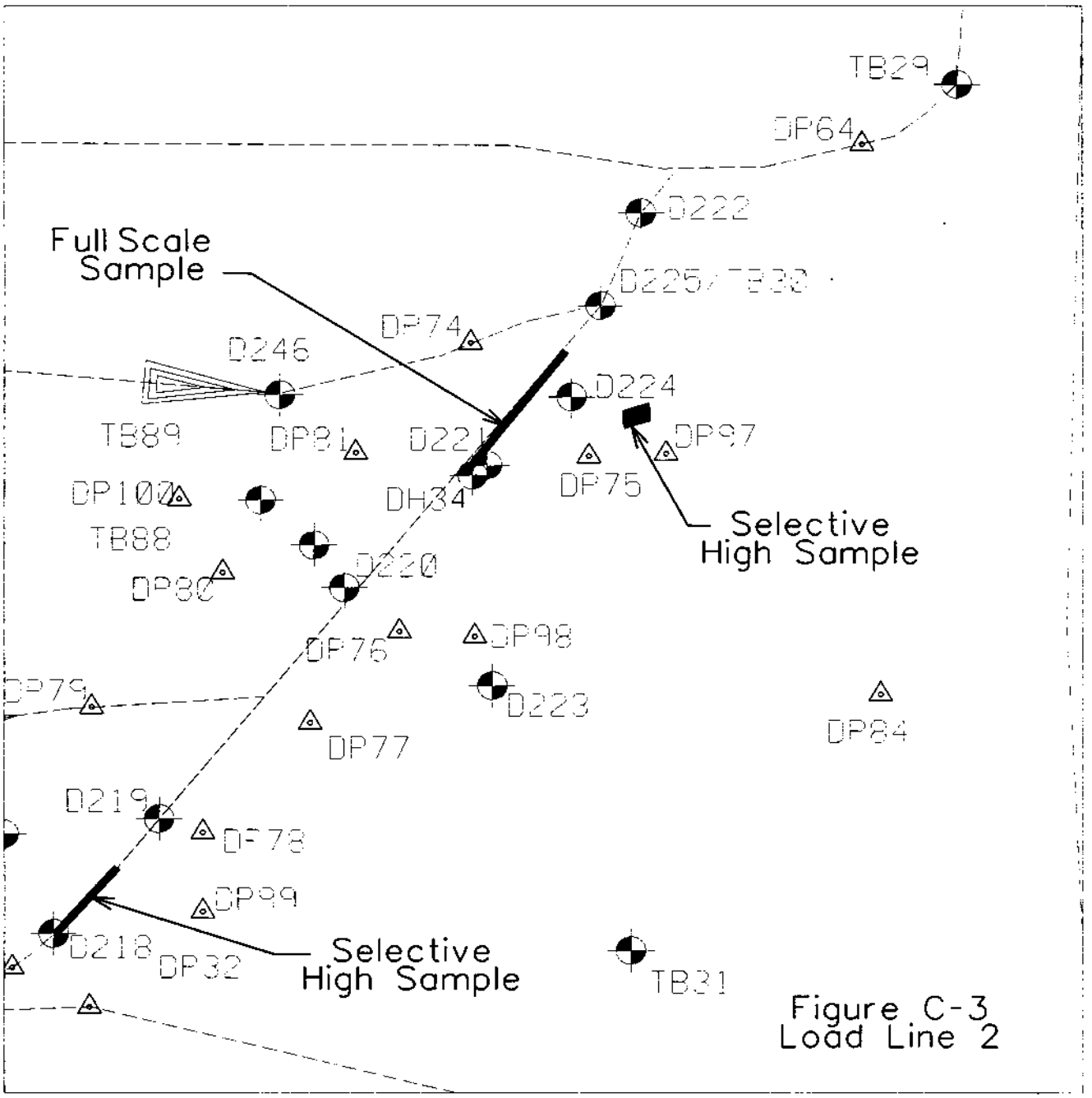


Figure C-3
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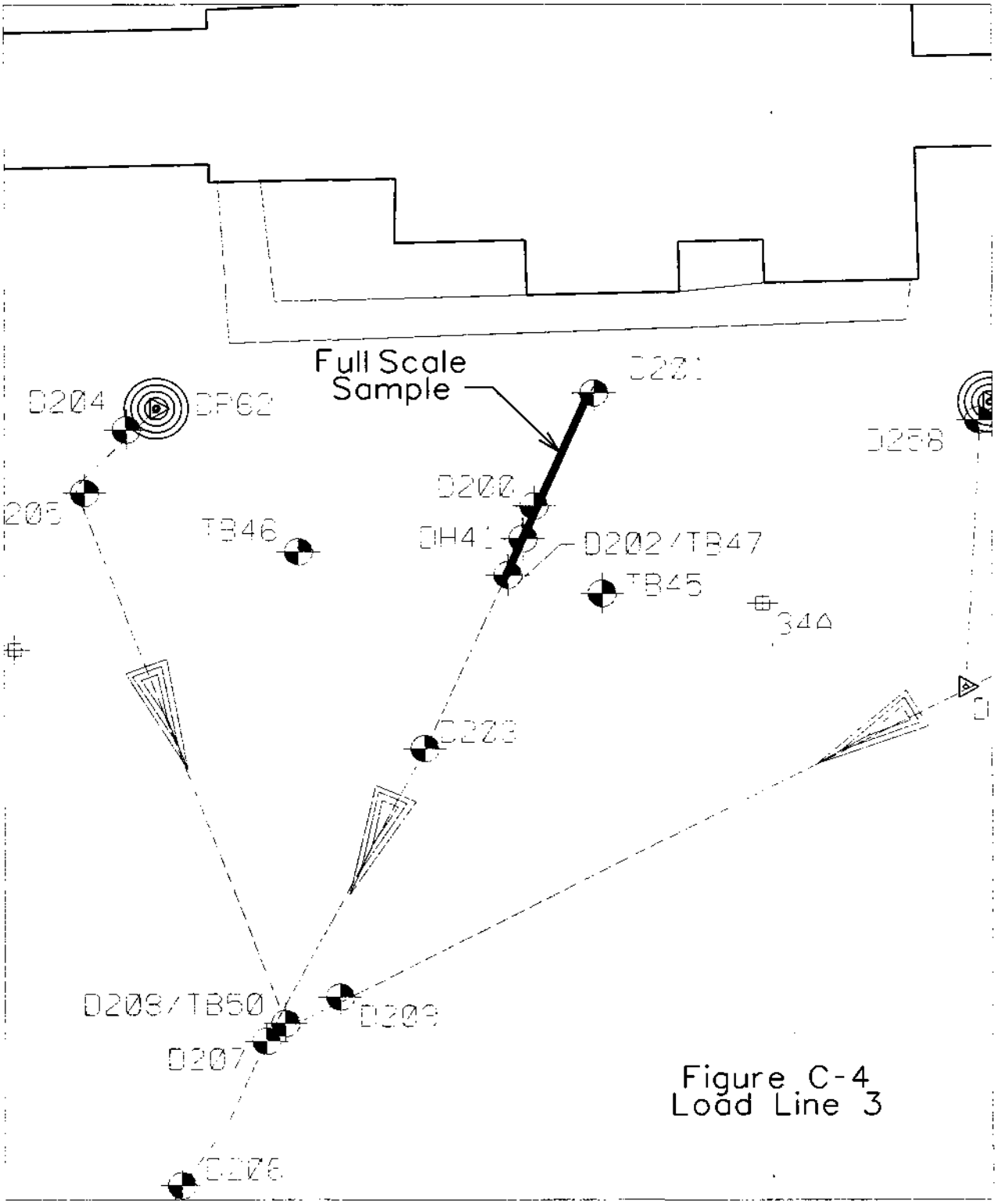


Figure C-4
Load Line 3

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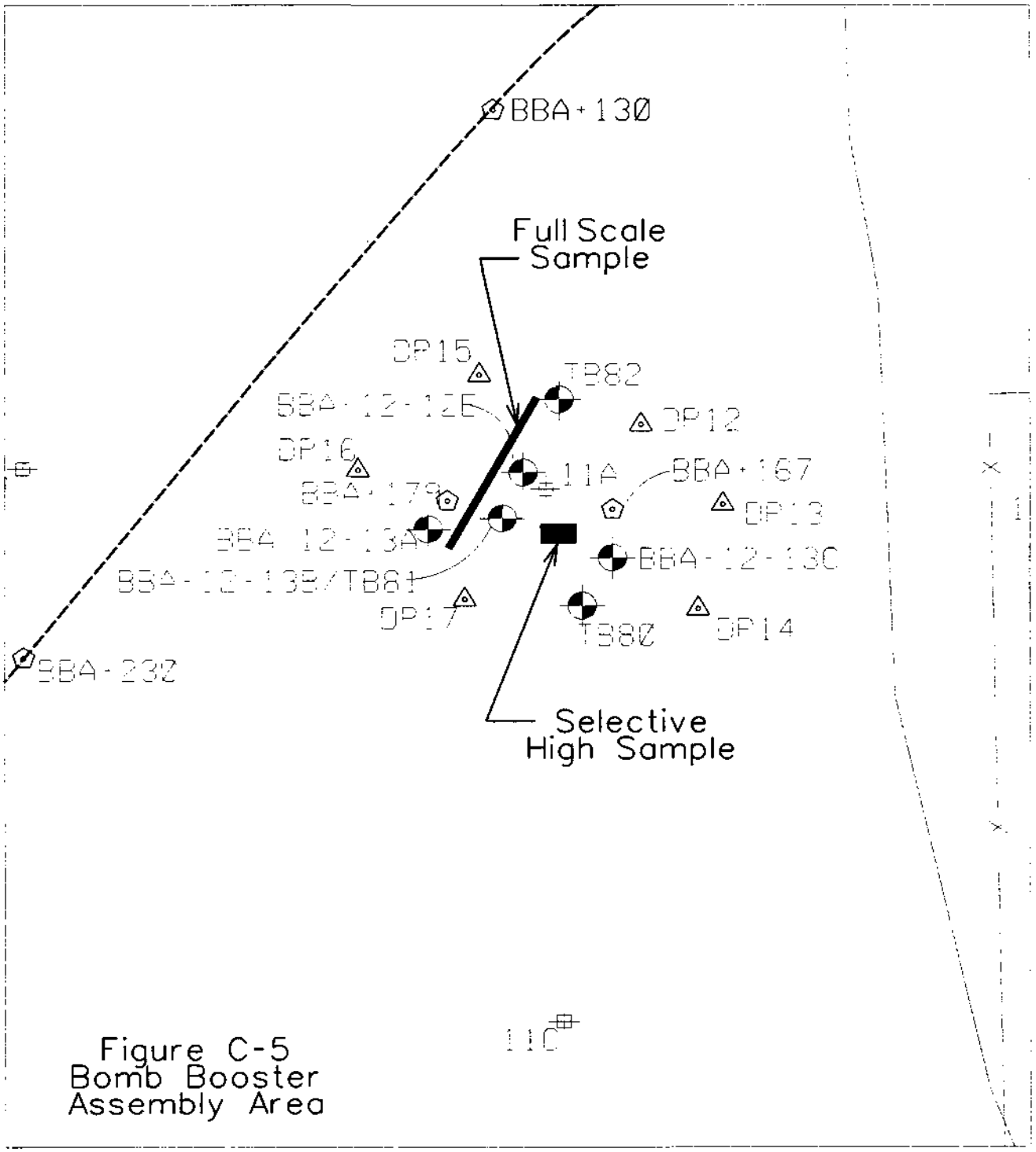


Figure C-5
Bomb Booster
Assembly Area

The excavation contractor loaded the excavated soil for compositing in dump trucks lined with plastic. One dump truck was designated to receive full-scale remediation simulation concentration soil and a second dump truck to receive selective high concentration soil. Background soil was excavated, composited in place, and packaged for shipment prior to excavating in contaminated soil areas. When the soil from each area was collected, the final compositing of each type of soil was conducted. The excavation contractor maintained each test pit in a stable condition until the soil sample crew completed their tasks.

Upon completion of the test pit excavations for the full-scale remediation simulation and the selective high concentration soil, the soils were stockpiled and composited separately. The soil compositing was conducted in an area of explosive-contaminated soil. The soil was thoroughly mixed with the backhoe bucket until visual homogeneity was obtained. The soil in each stockpile was then divided into four quadrants. A portion of soil from each quadrant was then placed into final composite stockpiles for both the full-scale and selective soil. These stockpiles were composited separately by hand using shovels, rakes, and hoes, to further breakdown the soil into small pieces required for treatability study analysis. Soil from each quadrant of each final stockpile was shoveled into 5-gallon plastic containers to meet the volume requirements of each of three treatability vendors. Eight check samples were subsequently collected for 4-day turnaround explosives analysis. Each sample was comprised of subsamples collected from each of the 5-gallon plastic containers (full-scale and selective high concentration) for each of three vendors. Two of the eight samples were comprised of subsamples collected from the final composite stockpiles (full-scale and selective high concentration). Each test pit excavation was backfilled with soil from an explosion berm borrow source as soon as possible after the required soil samples were obtained.

## 5.0 SAMPLE RESULTS

Table C-3 shows the explosives results for the full-scale simulation sample consolidated from the locations shown in Section 2.1. Table C-4 shows the explosives results for the selective high concentration sample. Results from the background sample were nondetectable for all explosive compounds analyzed. Because the full-scale simulation sample and background sample could be used to meet the objectives described in Section 2.0 of this appendix, they were sent to the vendors to be used in the study.

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**TABLE C-3**

**FULL-SCALE SIMULATION PRE-TREATMENT SAMPLE EXPLOSIVES RESULTS**
**Operable Unit 1 FS**
**Former NOP Site**
**Mead, Nebraska**
**March 1994**

| Analyte | FS-1 | | FS-2 | | FS-3 | |
|---|---|---|---|---|---|---|
| 2.4-DNT | 1.43 | | 0.987 | | 1.59 | |
| o-NT | 0.452 | U | 0.452 | U | 0.452 | U |
| TNB | 59.6 | | 59.3 | | 53.1 | |
| DNB | 1.52 | | 0.986 | | 1.51 | |
| Tetryl | 59.8 | | 106 | | 72.4 | * |
| NB | 1.27 | U | 1.29 | U | 1.29 | U |
| TNT | 1,170 | | 1,250 | | 1,730 | ** |
| 4-ADNT | 5.41 | | 3.67 | | 4.44 | |
| 6-ADNT | 0.202 | U | 0.202 | U | 0.202 | U |
| HMX | 134 | J | 49.1 | J | 80.3 | J* |
| 2,6-DNT | 0.331 | U | 0.331 | | 0.331 | U |
| p-NT | 0.433 | U | 0.433 | | 0.433 | U |
| m-NT | 0.409 | U | 0.409 | | 0.409 | U |
| RDX | 300 | | 377 | | 539* | |

Notes:

All units in mg/kg.
* 1=10 dilution.
** 1=100 dilution.
U Not detected above quantitation limit shown.
J Estimated value.

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**TABLE C-4**

**SELECTIVE HIGH CONCENTRATION**
**TREATABILITY STUDY SAMPLE EXPLOSIVES RESULTS**
**Former NOP Site**
**Operable Unit 1 FS**
**Mead, Nebraska**
**March 1994**

| Analyte | SH-1 | SH-2 | SH-3 | SH-4 |
|---|---|---|---|---|
| NB | ND | ND | ND | ND |
| 2,4-DNT | 4.0 | 10.8 | 6.8 | 6.2 |
| 2,6-DNT | ND | ND | ND | ND |
| RDX | 190 | 477 | 217 | 179 |
| TNB | 21.2 | 29 | 20.9 | 23.5 |
| DNB | 0.6 | 1.1 | 0.9 | 0.9 |
| TNT | 3590 | 7070 | 7150 | 4950 |
| o-NT | ND | ND | ND | ND |
| m-NT | ND | ND | ND | ND |
| p-NT | ND | ND | ND | ND |
| Tetryl | 121 | 108 | 71.4 | 87.7 |
| HMX | 24.4 | 37.9 | 28.4 | 16.1 |

All units = mg/kg except as indicated.
ND = Not detected.
RP/MEADFS/AW2

# APPENDIX C2

# AREA AND VOLUME CALCULATIONS

## APPENDIX C-2

## PROCEDURES USED TO CALCULATE CONTAMINATED AREAS AND VOLUMES

### 1.0 OBJECTIVES

In order to expedite the calculation of areas and volumes, a procedure was developed that used computer software. This procedure improved the consistency and efficiency of these calculations through automation. This appendix describes how that procedure was used. The objectives of this appendix are:

1. Summarize the assumptions and "rules" that were used to determine areas and calculate volumes.

2. Explain how RUSt E&I staff used the computer to calculate volumes.

3. Compare volumes calculated with the computer to volumes calculated manually.

### 2.0 DEFINITIONS

PRG: Risk-based Preliminary Remediation Goals (PRGs) are chemical concentration limits based on target health risks which are used to aid in the analysis and selection of remedial alternatives. Excavation PRGs are used to estimate the volume of soil potentially requiring remediation.

DATABASE: The database is a collection of records containing information, such as sample locations and chemical results, which is kept on the computer with the other project files. The records can be queried, sorted, and displayed in a variety of ways to meet the needs of the project. The records which contain the source area and volume values are connected to shapes in the CADD files which represent those respective areas. The database was also used to calculate the estimated remediation volume.

CADD: The maps of the site have been digitized into Computer Aided Design and Drafting (CADD) files. In essence, these are maps which are stored on a computer and can be viewed on a computer screen. The source areas potentially requiring remediation were drawn on the computer as shapes overlaying the topographic maps.

MGE: Modular GIS Environment (MGE) is a commercially available software package which can be used with the database and the CADD files. Three of its primary uses for this project were 1) to create the connections between the database records and the source area shapes and 2) to automatically calculate the square footage of the area shapes and 3) to put the area and depth values into the associated database records.



B07NE003701-04965

## 3.0 ASSUMPTIONS

The following assumptions were used to estimate contaminated areas:

- Field screen data were evaluated on a point-by-point basis because the field screen data appeared to have a problem with false positives. Field screen results, surrounding lab data, and knowledge of the site were evaluated to determine the validity of each point. For example, if a field screen point along a ditch was negative, but surficial lab points upgradient and downgradient of this point were positive, the field screen point was included in the contaminated area. On the other hand, if a positive field screen point was located in an isolated field area or if it was surrounded by negative lab points, the field screen point was not included in the area.

- If samples were located in the vicinity (for an isolated area) or along the same ditch (for ditch segments) contamination was assumed to extend halfway from the contaminated sample to the "clean" sample.

- Buildings and concrete pads were used, where appropriate, to delineate contaminated areas.

- Topography was used, in the absence of other information, to delineate contamination.

- Contamination between two adjacent ditches was assumed, in the absence of other information, to extend to the ditches.

- Ditch widths were assumed to be 8 feet unless data indicated otherwise. This width was based on a conversation with RI field manager.

- Sumps were considered as contamination sources but some sumps sampled were "clean", probably due to the reported excavation of source sumps. Area between buildings and sumps was assumed to be "clean" unless specific data indicates otherwise.

- Trenches in the Burning/Proving Grounds are delineated based on historical information (TCT, 1991). The trench area is assumed to be excavated whether or not the one sample collected in this area is above the PRGs.

- All areas are assumed to be excavated to a 4-foot depth.

The estimated remediation volumes corresponding to the EPA PRGs and to 1E-04 and 1E-06 target risk levels for a variety of exposure assumptions are shown in Table C-1.

- Four feet is the estimated depth of soil at which a person is unlikely to come into direct contact with contaminated soil, based on best professional judgement taking into account usual site conditions, activities and characteristics (USEPA, 1993).

## 4.0 PROCEDURES

After RUST E&I received the PRGs (see Table A-1), a query was run against the records in the database to find sample locations where at least one PRG was exceeded (in this case, in the top 4 ft of soil). This list of samples, with their coordinate locations, was output to a file. Proprietary programming techniques placed symbols in a CADD file at these locations. The symbols included sample identification and the depth (up to 4 ft) at which the PRG was exceeded.

Once these locations were in a CADD file, the areas requiring remediation were outlined using topography and the assumptions. The symbols which were placed were squares with either solid or dashed sides, which were various colors, and text containing the sample ID and depth. These different types of symbology visually indicated whether it was a lab or field sample result. If we needed to see more information to determine area sizes or depths, another screen was used to display sample information from the database.

The MGE software was used to link the area shapes in the CADD files to new database records. It was then used to calculate the square footage of each shape, and to insert those values into the new associated records. Because a depth of 4 ft was assumed for all areas, a depth of 4 ft was entered into all of the database records for the areas. (If a constant depth had not been assumed, available database information could be reviewed to estimate a specific depth for each area.) Once the square footage and depth of the areas were in the database, the database's functionality was used to calculate the volumes.

## 5.0 COMPARISON

The example below shows how a typical volume calculation would perform if done by hand:

Area 1 (see Figure 1) is a typical polygon-shaped area not located within a ditch. The square footage of Area 1 was measured by geometric approximation to be 770 square feet. Using a depth of 4 feet, the volume is calculated as follows:

$$770 \text{ sq ft} \times 4 \text{ ft} \times \frac{1 \text{ cu yd}}{27 \text{ cu ft}} = \mathbf{114 \text{ cu yd}}$$

Area 2 (see Figure 2) is a typical ditch area with an assumed uniform width of 8 feet. To calculate the square footage manually, the length of the ditch was measured and found to be 51.7 feet. Assuming the 8-foot uniform width and 4-foot depth, the volume is calculated as follows:

$$51.7 \text{ ft} \times 8 \text{ ft} \times 4 \text{ ft s } \frac{1 \text{ cu yd}}{27 \text{ cu ft}} = \mathbf{61.3 \text{ cu yd}}$$

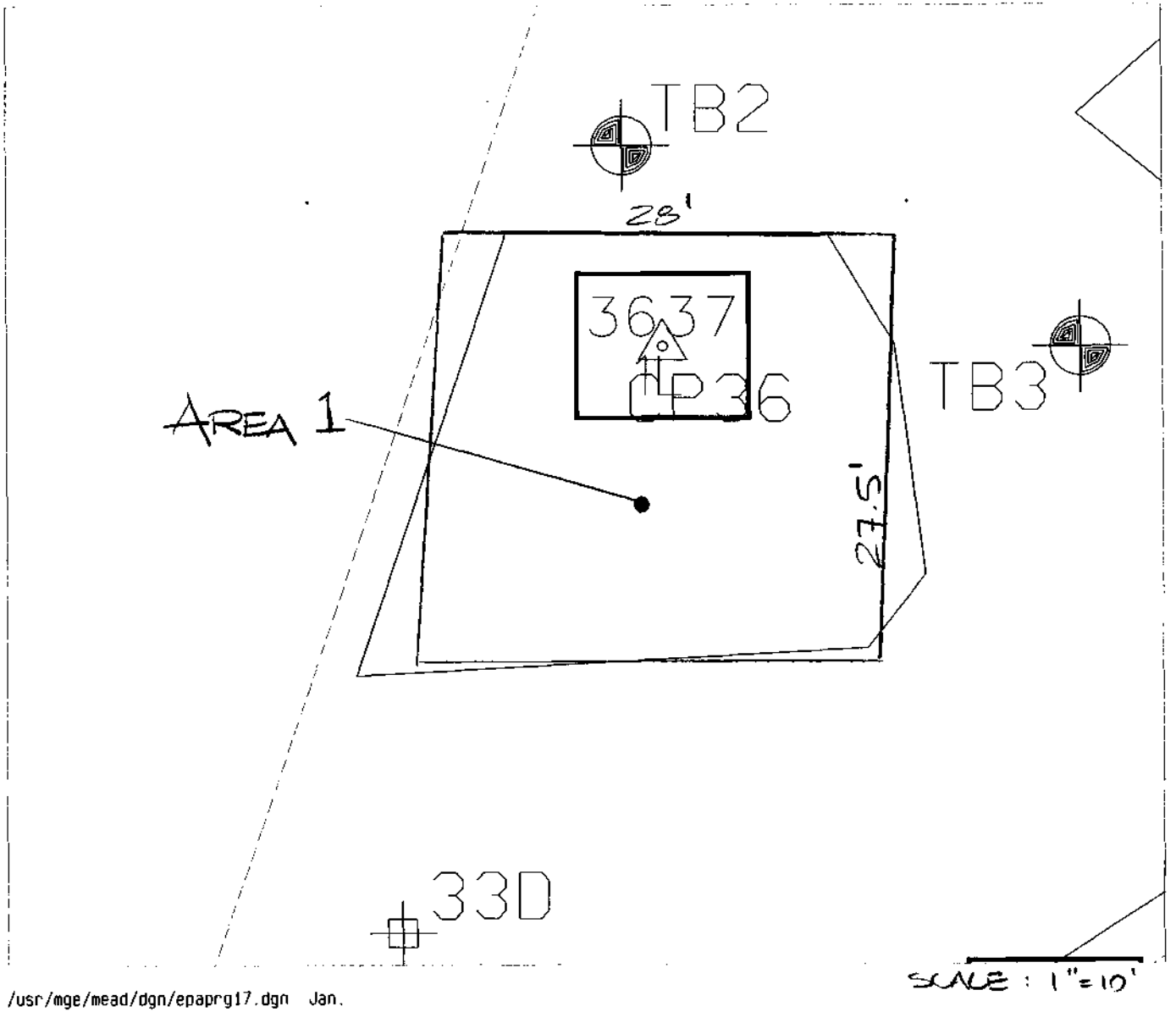
The following chart illustrates the minor percent difference between the manual and computer calculations:

| Area No. | Manual Volume (cu yd) | Computer Volume (cu yd) | Percent Difference |
|---|---|---|---|
| 1 | 114 | 116 | +1.7 |
| 2 | 61.3 | 61.2 | -0.2 |

These results show that the manual and computer calculations, though they use different methods, produce the same result. The computer calculations are estimated to be 70 to 90 percent faster than the hand calculations.

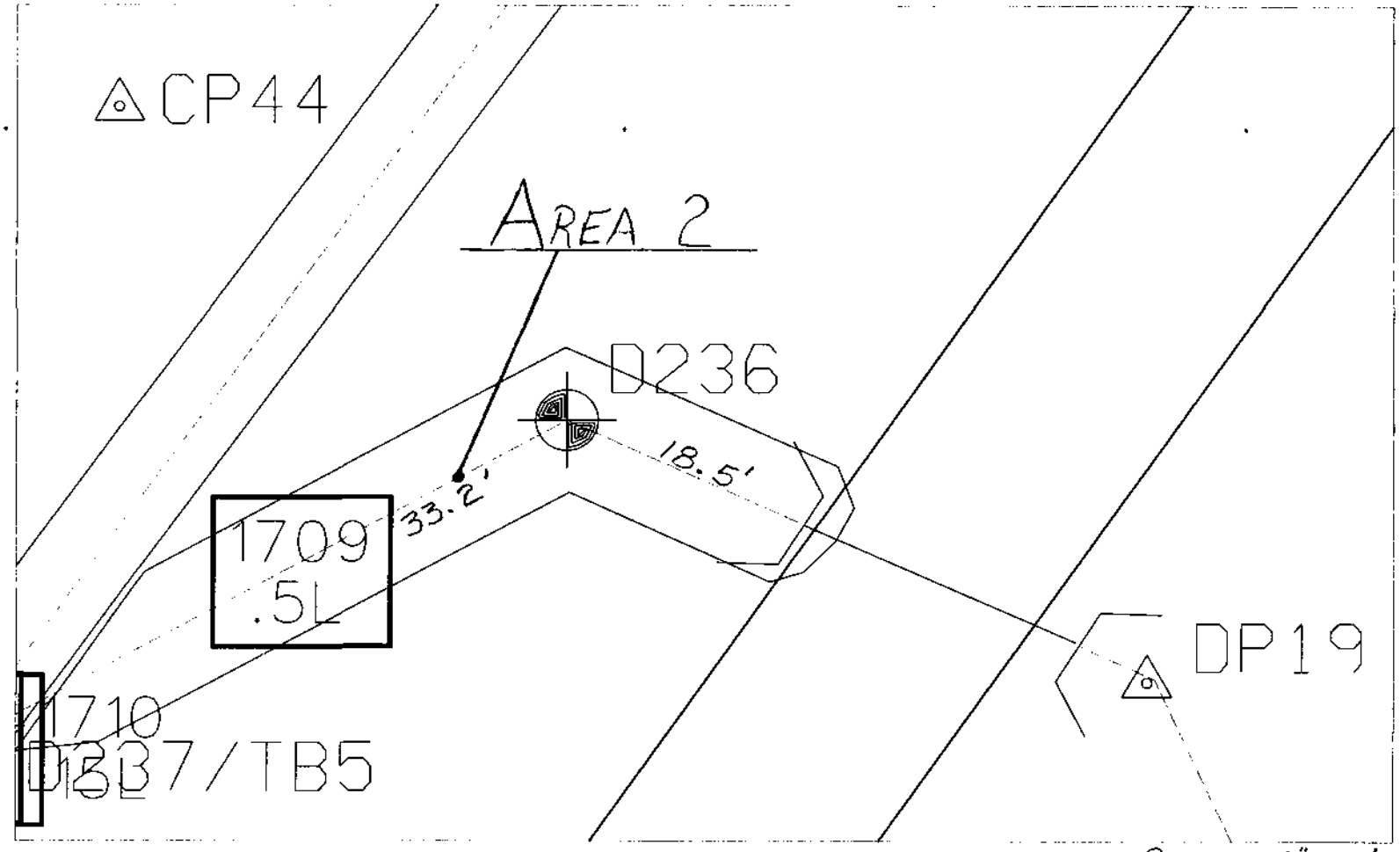
The accuracy of volume calculations depended primarily on the computer operator's decisions for area delineation, which followed the assumptions as guidelines.

RP/MEADFS/AR3




/usr/mge/mead/dgn/epaprg17.dgn Jan. 20, 1994 09:15:48

FIGURE 1




/usr/mge/mead/dgn/epaprg17.dgn Jan. 20, 1994 11:18:50

FIGURE 2

RUST ENVIRONMENT & INFRASTRUCTURE

CALCULATION SHEET

PAGE ____ OF ____

PROJECT NO. ____

CLIENT ____

PROJECT ____

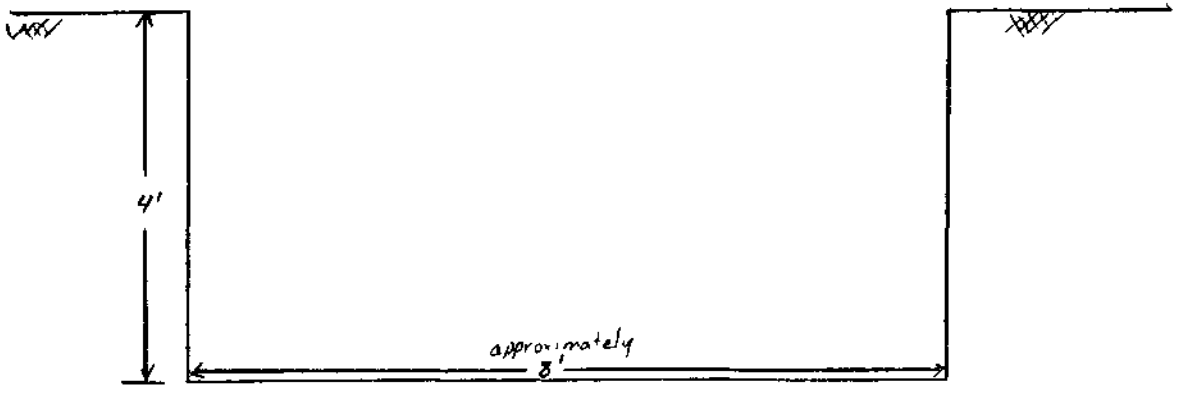
SUBJECT ____

Prepared By ____ Date ____

Reviewed By ____ Date ____

Approved By ____ Date ____

EXCAVATION CROSS-SECTION
PERPENDICULAR TO THE DITCH LINE




Scale 1" = 0.5'

# APPENDIX C3

# BORROW EVALUATION

**MEMORANDUM**

**DATE:** April 8, 1993

**TO:** Mead NOP FS File

**FROM:** David Heim

**SUBJECT:** Suitability of NOP Site Soils for Landfill Uses

As indicated by testing conducted in the USACE's Remedial Investigation (1989) (attached), the native soils at the former NOP site are primarily clayey, with a Unified Soil Classification of CL-CH. This refers to clays of low and high plasticity. These types of soils are generally suitable for use in landfill barrier layer applications such as liners, daily cover, and caps. The primary requirement for the soil barrier/liner material is that it must be capable of being compacted to produce a suitably low permeability (1E-07 cm/sec). To meet this requirement, the following conditions should be met (USEPA 1991k).

- Greater than 20 percent fines (pass No. 200 sieve).
- Plasticity index (PI) between 10 and 35 percent (soils with PI greater than 35 percent are difficult to work with as they form hard clods when dry and are very sticky when wet).
- Maximum of 10 percent gravel.
- No pebbles or stones larger than 1 inch.

Site soils have an average PI of about 17 to 28 percent and generally greater than 90 percent fines. However, some samples did have PIs greater than 35. Also, field observations indicate that soils may contain stones larger than 1 inch. These conditions could be addressed through mixing and screening, if necessary.

Investigations have been performed to determine site soils' compaction and permeability characteristics, however, data are not yet available. It is possible that native soils will be suitable for use in construction of an on-site landfill.

Based on contacts with local borrow sources (see Appendix D1), it is anticipated that soil from local borrow sources would have approximately the same physical properties as site soil, and would also be considered suitable. These sources have also indicated that near-surface clays are abundant throughout the area and that they would meet the parameters outlined above.

For the purposes of this Feasibility Study, it has been assumed that all soils necessary for liner and cap construction will be imported from off-site. This assumption assures a suitable borrow source and avoids the uncertainty and expense involved with testing native soils for physical characteristics (permeability and compaction) as well as sampling to ensure that soil used in landfill construction is not itself contaminated with the compounds of concern.

DH/jb

RP/MEADFS/AE9

*D*



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# APPENDIX D

## VENDOR INFORMATION

Appendix D1: Vendor Information: General Site Elements
Appendix D2: Vendor Information: Pretreatment/Post-Treatment
Appendix D3: Vendor Information: Biological Treatment
Appendix D4: Vendor Information: Thermal Treatment
Appendix D5: Vendor Information: Containment/Disposal

Appendix D contains vendor information survey memoranda. This information provides backup documentation that supports technical evaluations in the text and cost assumptions in Appendix F. Also included are questionnaires completed by Waterways Experiment Station and University of Idaho pertaining to biological treatment.

# APPENDIX D1

## VENDOR INFORMATION: GENERAL SITE ELEMENTS

**MEMORANDUM**

**DATE:** June 5, 1992

**TO:** NOP FS File

**CC:** Dave Froh

**FROM:** Greg Johnson

**SUBJECT:** Vendor Information Summary - Excavation

**Vendor:** UXB International, Inc.
**Contact:** Jerry Kitzmiller
**Phone:** 703-803-8904

UXB provided a cost estimate (attached) to excavate 7,000 cy of explosives-contaminated soil at the NOP site. This memorandum summarizes a follow-up conversation with Jerry Kitzmiller. Jerry indicated the following:

- The estimate assumes one excavator (trackhoe) moving from source area to source area.
- Costs include decontamination of equipment between source areas and misting (as needed) during excavation.
- Soil sampling costs are for on-site sampling/testing to determine limits of excavation (screening). Final lab confirmation of cleanup and stockpile characterization sampling and testing are not included.
- Cost assumes excavation of 20 cy (>10 percent concentration) by hand with a beryllium shovel and stainless steel buckets. Cost also assumes blending of soil at these hot spots.

GJ/bjz

attach: As Noted

RP/MEADFS/AP3

14600 CONFERENCE CENTER DRIVE
SUITE 100
CHANTILLY, VA
22021-3806
TELEPHONE 703/803-8904
TELEFAX 703/803-9353

UXB
INTERNATIONAL
INC.

June 3, 1992

Mr. Greg Johnson
SEC Donohue
4738 N. 40th Street
Sheboygan, WI. 53083

Re: Cost Estimate

Dear Mr. Johnson

UXB International, Inc., is pleased to assist you in your endeavor to establish a budget line for work to be performed at the Former Nebraska Ordnance Plant, Meade, Nebraska.

Our cost estimate to accomplish TNT excavation is in a range of $150,000.00 and $165,000.00 based on the following assumptions:

a. Estimated time to complete the tasks of hand and mechanical excavation for approximately 7,000 cu yds is 25 working days. Tasks will require wear of modified level C protection (Tyvex and rubber boots) for contamination control.

b. Labor cost is estimated to be $45,000.00 to $50,000.00.

c. Other direct costs to accomplish excavation include travel, perdeim, equipment rental, PPE, and purchase of expendables. Heavy equipment rental rates are based on an averaged cost prevailing throughout the United States. This cost estimate is in a range from $85,000 to $90,000.00 and may be lower for the State of Nebraska.

d. Access to the job site is possible by motor vehicle and roads will not need improvement to allow heavy equipment to move to the excavation site.

e. Movement of the excavated energetic material to the staging area is within a one mile radius of the work site.

f. Clean soil is available locally within a 10 mile area for

**MEMORANDUM**

**DATE:** July 17, 1992

**TO:** Mead NOP FS File

**CC:** Dave Froh

**FROM:** Mark J. Mobley

**SUBJECT:** Availability and Cost of Landfill Clay, Common Fill, Sand, and Topsoil

**Vendor:** Aggregate Carriers, Mead, NE
**Contact:** Jim Eckley
**Phone:** (402) 624-2975
**Treatment:** Not Treatment - Contact for Landfill Clay, etc.

## 1.0 INTRODUCTION

Mr. Eckley indicated that he carries potentially suitable topsoil, common fill, clay, and sand. He said these materials would be available at sufficient volumes, but he would have to mix the clay and sand to produce the common fill.

## 2.0 COSTS

Costs to purchase material and load into trucks for the above materials were quoted as follows:

- Clay - $2.00 to $2.25/ton
- Sand - $1.50 to $3.00/ton (depending on quality requirements)
- Topsoil and Common Fill - $1.50 to $2.00/ton

  (Mr. Eckley indicated he did not want to be held to the sand prices because he thinks once he is sure what we want he will be able to fix a price.)

Mr. Eckley indicated the cost for hauling (estimated 10 mi. for all materials) and dumping at the site would be $1.75/ton.

MM/ke

RP/MEADFS/AD8

approximately $12,000.00 - $13,000.00.

g. UXB estimates approximately 70 soil samples will be required $6,800.00.

The above estimates are based on labor and equipment availability for the 1992 fiscal year. UXB anticipates this estimate to be within a competitive range for the SOW discussed.

Upon completion of your review please do not hesitate to call with questions and comments.

GERALD C. KITEMILLER
Project Manager

**MEMORANDUM**

**DATE:** July 17, 1992

**TO:** Mead NOP FS File

**CC:** Dave Froh

**FROM:** Mark J. Mobley

**SUBJECT:** Availability and Cost of Landfill Clay, Topsoil, Common Fill, and Sand

**Vendor:** Todd Valley Farms
**Contact:** Unknown
**Phone:** (402) 624-6385
**Treatment:** Not Treatment - Contact for Landfill Sand and Common Fill

## 1.0 INTRODUCTION

The Todd Valley Farms representative said they have sold their sand and gravel pit to Aggregate Carriers, also in Mead, Nebraska. Aggregate Carriers will be contacted for pricing and material availability.

MM/ke

RP/MEADFS/AD7

**MEMORANDUM**

**DATE:** July 17, 1992

**TO:** Mead NOP FS File

**CC:** Dave Froh

**FROM:** Mark J. Mobley

**SUBJECT:** Availability and Cost of Landfill Clay and Well-Drained Soil

**Vendor:** Land Construction
**Contact:** Gary Varley
**Phone:** (402) 477-5263
**Treatment:** Not Treatment - Contact for Landfill Clay and Well-Drained Soil Availability and Cost

## 1.0 INTRODUCTION

Gary indicated that potentially suitable clay is available within the upper 4 feet of soil throughout the southeastern Nebraska region, Saunders County included.

## 2.0 COSTS

Gary quoted the following costs for soil and clay interchangeably:

- Locate borrow source, purchase material, excavate material, load into trucks, haul (assumed less than 5 mi. from site), and dump in final destination area $4.00/cy.

MM/ke

RP/MEADFS/AD9

**MEMORANDUM**

**DATE:** July 17, 1992

**TO:** Mead NOP FS File

**CC:** Dave Froh

**FROM:** Mark Mobley

**SUBJECT:** Availability of Landfill Clay

**Vendor:** Nebraska Department of Transportation
**Contact:** Irv Harr
**Phone:** (402)479-4742
**Treatment:** Not Treatment - Contact for Landfill Clay Availability

## 1.0 INTRODUCTION

Mr. Harr indicated that potentially suitable clay is available within the upper 4 ft of soil throughout the southeastern Nebraska region.

Mr. Harr gave me the number for the Association of General Contractors in Lincoln for contractor names.

MM/ke

RP/MEADFS/AE0

**MEMORANDUM**

**DATE:** August 3, 1992

**TO:** Mead NOP FS File

**CC:** Dave Froh

**FROM:** Mark J. Mobley

**SUBJECT:** Availability and Cost of Landfill Clay, Topsoil, Common Fill, and Sand

**Vendor:** Saunders County Highway Department
**Contact:** Bill Lindholm
**Phone:** (402) 443-8124
**Treatment:** Not Treatment - Contact for Landfill Clay, etc.

## 1.0 INTRODUCTION

Mr. Lindholm identified the following contacts as possible sources:

- Todd Valley Farms, Mead (624-6385) - sand and common fill.
- Western Sand and Gravel (944-3331) - sand and gravel.
- Spence Dorothy, Wahoo (443-4362) - sand, topsoil, common fill, and clay.

## 2.0 COSTS

Mr. Lindholm estimated a cost for clay based on his experience. He said landfill quality clay would be found in the Prague area about 15 miles northeast of Mead. His estimate was as follows:

- Locate borrow source, purchase clay - $0.50/ton.
- Excavate, load onto trucks - $0.50/ton.
- Haul 15 miles and dump - $1.89/ton.

MM/ke

RP/MEADFS/AE3

**MEMORANDUM**

**DATE:** August 13, 1992

**TO:** Mead NOP FS File

**CC:** Dave Froh

**FROM:** Mark Mobley

**SUBJECT:** Soil Staging Structure

**Vendor Name:** Sprung Instant Structures
**Contact Name:** John Bergin
**Phone:** (215)391-9553

---

## 1.0 INTRODUCTION

It was assumed for costing purposes that a structure would be used for staging soil during treatment alternatives (Alternatives 3 and 4). Mr. Bergin provided technical information and costs for a building sized to contain the total 7,000 cubic yards of soil assumed. Based on calculations of the soil staging area (documented in the detailed cost assumptions), a building approximately 630 feet by 120 feet would be required.

## 2.0 STRUCTURE DESCRIPTION

The structure for which costs were provided by Mr. Bergin is approximately 630 feet long, 120 feet wide, and 58 feet high at the apex. Additional information on the size and shape of the structure is attached.

## 3.0 COSTS

Based on the quote from Mr. Bergin, the cost for the structure (materials only) would be $726,300 for the first 12 months of rental and $1,085,400 for 18-months rental. The purchase price for the building would be $1,188,000. Costs for scaffolding, electric power extension, structure installation, and a crane operator are not included and will be costed in the detailed cost assumptions.

Mr. Bergin indicated a technical consultant will be supplied and that travel would be charged at cost and per diem would be $95 per day. The approximate weight of this size structure was estimated at 3.5 pounds per square foot, by Mr. Bergin.

Mr. Bergin indicated that a 30-ton crane with a 125-foot boom would be required.

## 4.0 SCHEDULE

According to this quote, Mr. Bergin said that approximately 60 days would be required for structure erection and dismantling, and where preferred, approximately 40 days could be expected for dismantling. Mr. Bergin indicated that a maximum rate of structure erection of 1500 square feet per day could be achieved using a larger size crew and two technical consultants.

Mr. Bergin indicated that the crane would only be required for 30 days during erection and 15 days during dismantling.

RP/MEADFS/AM9

1-800-528-9899
1-215-391-9553

FAX 1-215-391-0669

Sprung Instant Structures, Inc.

5100 TILGHMAN STREET, #215, ALLENTOWN, PENNSYLVANIA 18104-9102

August 13, 1992

Mr. Mark Mobley
SEC Donohue
4738 N. 40th Street
Sheboygan, WI 53083

Dear Mr. Mobley:

We are pleased to submit the following quotation on behalf of Allan Engineering for a structure to be located at your job site.

**REVISED**

**STRUCTURE SIZE:** Approximately 120 feet wide by 630 feet long.

**COLOR:** To be determined.

**LEASE PRICE:** Structure, including the following accessories for eighteen months firm:

8 - Single Personnel Doors.
2 - Side Sliding Cargo Doors.

Total Lease Price, F.O.B. Fontana, CA, sales and/or use taxes extra:

Total 12 months: $ 726,304.00
Total 18 months: $1,085,395.00

**TERMS, O.A.C.:** 12 Months:

$ 363,150.00 with order for the first month;
$ 33,014.00 payable monthly, in advance thereafter for the next 11 months.

18 Months:

$ 363,150.00 with order for the first month;
$ 42,485.00 payable monthly, in advance thereafter for the next 17 months.

Mr. Mark Mobley
SEC Donohue
August 13, 1992
REVISED

**OPTION TO PURCHASE:** In the case of a lease, an option to purchase is offered. Provided that all payments have been made on time, 50% of the lease payments, to the maximum of the first twelve months, will be applied against the purchase price of the structure. This option can only be exercised by payment of the full purchase price less the applicable lease credit prior to the expiry of the lease, or one year from date of erection, whichever comes first.

**DELIVERY:** 90 days from date of order.

**ERECTION:** We will supply one Technical Consultant, equipped with all hand tools, free of charge to supervise the erection of this structure by your work force. It will be your responsibility to supply the following:

a) Scaffolding on wheels and/or manlifts.
b) Electric power to site.
c) 15 unskilled workmen for approximately 60 8 hour working days.
d) A crane with operator.

**TECHNICAL CONSULTANT:** Although the Technical Consultant is supplied, his travel, accommodation and meals will be charged to you. Travel is charged at cost; meals and accommodation at $95.00 per day. If circumstances dictate, overtime charges may occur, with your approval.

**ANCHORAGE:** Concrete footings.

**DISMANTLING:** Leased structures will require our Technical Consultant for dismantling. The same terms as outlined above under the heading "Erection" and "Technical Consultant" will apply. Return freight will be charged to you.

Mr. Mark Mobley
SEC Donohue
August 13, 1992
REVISED

**PERMITS AND LICENSES:** It will be your responsibility to obtain all permits and licenses. Standard pre-engineered drawings are available upon request.

This quotation is valid for 120 days.

Thank you for the opportunity to submit this quotation. We look forward to being of service to you.

Sincerely,

**SPRUNG INSTANT STRUCTURES, INC.**

John Bergin
Regional Sales Manager

JB/apk

cc: Allan Engineering

**MEMORANDUM**

**DATE:** August 13, 1992

**TO:** Mead NOP FS File

**CC:** Dave Froh

**FROM:** Mark Mobley

**SUBJECT:** Disposal and Hauling Cost Revisions and Rolloff Box Rental Costs

**Vendor Name:** Waste Management of Nebraska
**Contact Name:** Bill Fletcher
**Phone:** (402)731-0138

---

## 1.0 INTRODUCTION

Mr. Fletcher provided costs for Rolloff box rental for use during treatment alternatives (Alternatives 3 and 4). In addition, Mr. Fletcher provided an update on waste disposal costs due to an increase in state taxes and also provided a transportation cost and other transportation information. This memorandum documents information obtained from Mr. Fletcher.

## 2.0 COSTS

Costs for Rolloff boxes were based on the assumption that the boxes would be used for a period of up to 18 months and would not be used for disposal at the Douglas County Landfill (which would make the rental costs cheaper). Based on a rental rate including depreciation of Rolloff boxes only, an estimated $50 delivery charge for each Rolloff box plus $35 per month, was quoted by Mr. Fletcher.

Mr. Fletcher also indicated that a recent State tax law had increased the solid waste disposal cost for special waste from $32 per ton to $33.25 per ton. Costs will be revised to reflect this increase.

Mr. Fletcher indicated that transportation from the Town of Mead to the landfill would be approximately a 44-mile, one-way trip (compared to the 30-mile trip assumed previously). Mr. Fletcher indicated that approximately $90 per load would be charged for hauling

contaminated soil to the landfill based on 44 miles haul distance and a maximum of 8 tons per vehicle. Mr. Fletcher also indicated that approximately five to six loads per day per truck could be easily expected as a hauling rate during excavation. Mr. Fletcher indicated that 15 to 18 loads per day would be a feasible load rate for the site, assuming 3 vehicles (more vehicles would be impractical due to loading considerations at the excavation site).

RP/MEADFS/AM8

**MEMORANDUM**

**DATE:** May 11, 1992

**TO:** NOP FS File

**CC:** Dave Froh

**FROM:** Greg Johnson

**SUBJECT:** Vendor Information Summary - Decontamination Trailer

**Vendor:** HAZCO
**Contact:** Rhonda
**Phone::** (800) 332-0435

Monthly decontamination trailer rental: $1,900
Mobilization/Demobilization: $1.50/loaded mile.

DH/ke

RP/MEADFS/AO9

**MEMORANDUM**

**DATE:** August 28, 1992

**TO:** NOP FS File

**CC:** Dave Froh

**FROM:** Sarah Levin

**SUBJECT:** Analytical Costs

SEC Donohue Analytical costs were used for decontamination water testing, residual sample analysis, and untreated solids analysis. The costs used are attached.

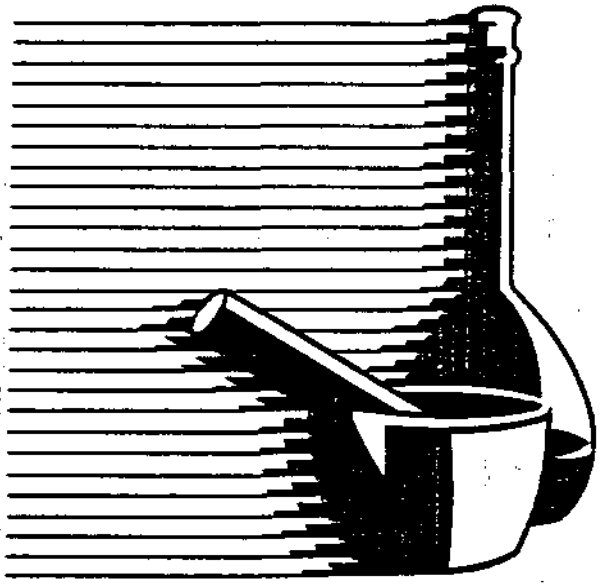
DH/ke

RP/MEADFS/AP0

# Analytical Reference Guide

for

# Environmental Professionals



## SEC Donohue

## ENVIRONMENT ANALYSES

| | Minimum Sample Size ML | Container (Plastic, Glass) | Preservation | Holding Time | Fee |
|---|---|---|---|---|---|
| **SOLIDS** | | | | | |
| Dissolved Solids, Total | 100 | P. or G. | Cool 4°C | 7d | $11.00 |
| Percent Solids, Total | 100 | P. or G. | Cool 4°C | 7–14d | $11.00 |
| Settleable Solids, Total | 1000 | P. or G. | Cool 4°C | 48h | $14.00 |
| Solids, Total | 500 | P. or G. | Cool 4°C | 7d | $11.00 |
| Suspended Solids, Total | 1000 | P. or G. | Cool 4°C | 7d | $11.00 |
| Volatile Dissolved Solids | 500 | P. or G. | Cool 4°C | 7d | $15.00 |
| Volatile Suspended Solids | 1000 | P. or G. | Cool 4°C | 7d | $15.00 |
| Volatile Solids, Total | 500 | P. or G. | Cool 4°C | 7d | $15.00 |
| Reduction, Total Volatile Solids | 2x500 | P. or G. | Cool 4°C | 7d | $30.00 |
| **OXYGEN DEMAND** | | | | | |
| $BOD_5$, Soluble | 1000 | P. or G. | Cool 4°C | 48h | $30.00 |
| $BOD_5$, Total | 1000 | P. or G. | Cool 4°C | 48h | $25.00 |
| CBOD, Soluble | 1000 | P. or G. | Cool 4°C | 48h | $35.00 |
| CBOD, Total | 1000 | P. or G. | Cool 4°C | 48h | $30.00 |
| COD, Soluble | 100 | P. or G. | Filter before-$H_2SO_4$ | 28d | $28.00 |
| COD, Total | 100 | P. or G. | $H_2SO_4$, Cool 4°C | 28d | $22.00 |
| Oxygen, Dissolved | 300 | G. + top | None | Analyze Immediately | $10.00 |
| **MICROBIOLOGY** | | | | | |
| Chlorophyll a, b, and c and Pheophytin a | 500 | P. or G. | None | 48h | $38.00 |
| Coliforms, Fecal | 125 | P. or G. Sterilized | Cool 4°C .008% $Na_2S_2O_3$ | 6h/24h | $20.00 |
| Coliforms, Total | 125 | P. or G. Sterilized | Cool 4°C .008% $Na_2S_2O_3$ | 6h/24h | $20.00 |
| Iron Bacteria | 125 | P. or G. Sterilized | Cool 4°C .008% $Na_2S_2O_3$ | 6h | $30.00 |
| Standard Plate Count | 125 | P. or G. Sterilized | Cool 4°C .008% $Na_2S_2O_3$ | 6h | $25.00 |
| Strep, Fecal | 125 | P. or G. Sterilized | Cool 4°C .008% $Na_2S_2O_3$ | 6h | $25.00 |
| Salmonella | 250 | P. or G. Sterilized | Cool 4°C | | $88.00 |



B07NE003701-04997

## ENVIRONMENTAL ANALYSES
(Continued)

| | Minimum Sample Size ML | Container (Plastic, Glass) | Preservation | Holding Time | Fee |
|---|---|---|---|---|---|
| **NUTRIENTS** | | | | | |
| Ammonia Nitrogen | 500 | P. or G. | $H_2SO_4$ Cool 4°C | 28d | $13.00 |
| Distilled | | | | | $20.00 |
| Kjeldahl Nitrogen, Total | 500 | P. or G. | $H_2SO_4$ Cool 4°C | 28d | $19.00 |
| Nitrate Nitrogen | 100 | P. or G. | Cool 4°C | 48h | $17.00 |
| Nitrite Nitrogen | 100 | P. or G. | Cool 4°C | 48h | $11.00 |
| Nitrate + Nitrite Nitrogen | 200 | P. or G. | Cool 4°C $H_2SO_4$ | 28d | $17.00 |
| Organic Nitrogen (TKN – $NH_3$) | 500 | P. or G. | $H_2SO_4$ | 28d | $39.00 |
| Orthophosphorus ($PO_4$) | 250 | P. or G. | Cool 4°C | 48h | $17.00 |
| Orthophosphorus, Soluble | 250 | P. or G. | Filter Immediately | 28d | $17.00 |
| Phosphorus, Total (P) | 250 | P. or G. | $H_2SO_4$ | 28d | $19.00 |
| Phosphorus, Soluble | 250 | P. or G. | Filter Before Preserving $H_2SO_4$ | 28d | $22.00 |
| **MINERALS** | | | | | |
| Acidity, Total | 100 | P. or G. | Cool 4°C | 14d | $10.00 |
| Alkalinity, Total | 200 | P. or G. | Cool 4°C | 14d | $10.00 |
| Alkalinity, Bicarbonate and Carbonate | 200 | P. or G. | Cool 4°C | 14d | $20.00 |
| Chloride, Total | 100 | P. or G. | None | 28d | $10.00 |
| Chlorine, Residual | 500 | P. or G. | None | Analyze Immediately | $20.00 |
| Fluoride, Clean Waters | 300 | P. or G. | None | 28d | $12.00 |
| Solids & Colored Solutions | | | | | $35.00 |
| Hardness, Total | 500 | P. or G. | $HNO_3$ | 6 months | $20.00 |
| Silica, dissolved | 250 | P | $HNO_3$ | 28d | $15.00 |
| Sulfate ($SO_4$) | 100 | P. or G. | Cool 4°C | 28d | $11.00 |
| Sulfide ($H_2S$) | 100 | P. or G. | 2N Zinc Acetate Cool 4°C NaOH | 7d | $30.00 |
| Sulfide, Reactive | 500 | P. or G. | Cool 4°C | 7d | $40.00 |
| Sulfite | 100 | P. or G. | None | Analyze Immediately | $20.00 |

## ENVIRONMENT ANALYSES
(Continued)

| | Minimum Sample Size Ml. | Container (Plastic, Glass) | Preservation | Holding Time | Fee |
|---|---|---|---|---|---|
| **OTHER** | | | | | |
| % Ash | 250 | P. or G. | None | None | $16.00 |
| Bromide | 250 | P. or G. | None | 28d | $30.00 |
| BTU | 250 | P. or G. | None | 28d | $36.00 |
| Cation/Anion Balance Calculation | | | | | $22.00 |
| Color | 500 | P. or G. | Cool 4°C | 48h | $11.00 |
| Cyanide, Amenable (Includes Total Cyanide) | 1000 | P. or G. | 100mg $Na_2S_2O_3$/l | 14d | $70.00 |
| Cyanide, Reactive | 500 | P. or G. | NaOH, Cool 4°C | 14d | $28.00 |
| Cyanide, Total | 500 | P. or G. | NaOH, Cool 4°C | 14d | $33.00 |
| Flashpoint (Pensky-Martens) | 250 | G. T-Cap | None | 28d | $35.00 |
| Formaldehyde | 250 | G. | Cool 4°C | 14d | $30.00 |
| Free Liquids (Paint filter test) | 10g | P. or G. | None | None | $11.00 |
| Oil and Grease (Total) | 1000 | G. Wide Mouth | $H_2SO_4$ Cool 4°C | 28d | $30.00 |
| Mineral Oil Grease | 1000 | G. Wide Mouth | $H_2SO_4$ Cool 4°C | 28d | $35.00 |
| Vegetable Oil Grease | 1000 | G. Wide Mouth | $H_2SO_4$ Cool 4°C | 28d | $40.00 |
| Threshold Odor Test | 500 | G. | None | Analyze Immediately | $25.00 |
| Oxidation Potential (eH) | 100 | P. or G. | None | | $10.00 |
| Phenol, Total | 1000 | G. T-Cap | $H_2SO_4$ Cool 4°C | 28d | $30.00 |
| % Water (Karl Fischer) | 100 | P. or G. | None | 14d | $30.00 |
| pH (water) | 100 | P. or G. | None | Analyze Immediately | $ 6.00 |
| pH (solids) | 100 | P. or G. | None | Analyze Immediately | $12.00 |
| pH Range | 100 | P. or G. | None | Analyze Immediately | $28.00 |
| Specific Conductance | 500 | P. or G. | Cool 4°C | 28d | $10.00 |
| Specific Gravity | 100 | P. or G. | Cool 4°C | 28d | $10.00 |
| Sulfur, % | 100 | P. or G. | Cool 4°C | 28d | $30.00 |
| Surfactants (MBAS) | 1000 | P. or G. | Cool 4°C | 48h | $43.00 |
| Temperature | 250 | P. or G. | None | Analyze Immediately | N.C. |
| Turbidity | 250 | P. or G. | Cool 4°C | 48h | $11.00 |
| Total Halogen by Bomb Calorimeter | 250 | P. or G. | None | 28d | $30.00 |
| Volatile Acids | 250 | P. or G. | None | 14d | $25.00 |
| **DIGESTION FOR METALS** | | | | | |
| Water, Wastewater | | | | | $10.00 |
| Soils, Sludges, Solids, Wastes, Leachates | | | | | $25.00 |

## SAFE DRINKING WATER ACT (SDWA)
### Primary Drinking Water Regulations

SDWA Metals and Inorganics ..... $ 242.00

| | | |
|---|---|---|
| Arsenic | Copper | Silver |
| Barium | Lead (F) | Fluoride |
| Cadmium (F) | Mercury | Nitrate |
| Chromium (F) | Selenium | Turbidity |

SDWA Microbiological ..... $ 20.0

Coliforms, Total

SDWA Pesticides/Herbicides ..... $ 315.00

| | | |
|---|---|---|
| Chlordane | Heptachlor epoxide | Toxaphene |
| Endrin | Lindane | 2,4–D |
| Heptachlor | Methoxychlor | 2,4,5–TP (Silvex) |

SDWA Volatile Organic Compounds ..... $ 275.00

Trip Blank ..... $ 100.00

| | | |
|---|---|---|
| *Benzene | Dibromomethane | *Ethylbenzene |
| Bromobenzene | *1,2–Dichlorobenzene | Ethylene dibromide [EDB] |
| *Bromodichloromethane | *1,3–Dichlorobenzene | *Styrene |
| *Bromoform | *1,4–Dichlorobenzene | 1,1,1,2–Tetrachloroethane |
| Bromomethane | 1,1–Dichloroethane | 1,1,2,2–Tetrachloroethane |
| *Carbon Tetrachloride | *1,2–Dichloroethane | *Tetrachloroethylene |
| *Chlorobenzene | *1,1–Dichloroethylene | *1,1,1–Trichloroethane |
| *Chlorodibromomethane | *cis–1,2–Dichloroethylene | 1,1,2–Trichloroethane |
| Chloroethane | *trans–1,2–Dichloroethylene | *Trichloroethylene |
| *Chloroform | Dichloromethane | 1,2,3–Trichloropropane |
| Chloromethane | 1,1–Dichloropropene | *Toluene |
| o–Chlorotoluene | *1,2–Dichloropropane | *Vinyl Chloride |
| p–Chlorotoluene | 1,3–Dichloropropane | *m & p–Xylene |
| 1,2–Dibromo–3–chloropropane [DBCP] | 1,3–Dichloropropene | *o–Xylene |
| | 2,2–Dichloropropane | |

* Regulated

SDWA Radioactivity ..... $ 219.00

Radium 226 & 228
Gross Alpha
Gross Beta

Total SDWA Analysis ..... $1,171.00

## WASTE MANAGEMENT OF NORTH AMERICA, INC.
## SUMMARY OF SITE SPECIFIC ACCEPTANCE LIMITS

| | Acceptance Limits | Protocol A | B | C | D1 | D2 | D3 | D4 |
|---|---|---|---|---|---|---|---|---|
| pH | 2.5 ≤ pH ≤ 12.5 | X | X | X | | | X | X |
| Specific Gravity | no limit | X | X | X | | | | |
| Total Solids | > 40% | X | X | | | | X | X |
| Total Solids | 20-40% | | | X | | | | |
| Free Liquids | 0% free liquids (paint filter test) | X | X | X | X | X | X | X |
| Flashpoint | > 140°F (closed cup) | X | X | X | X | X | X | X |
| % Acidity (if pH ≤ 4) | no limit | X | X | X | | | | |
| % Alkalinity (if pH ≥ 10) | no limit | X | X | X | | | | |
| Arsenic | TCLP extraction procedure < 5.0 mg/l | X | X | X | | | | |
| Barium | TCLP extraction procedure < 100.0 mg/l | X | X | X | | | | |
| Cadmium | TCLP extraction procedure < 1.0 mg/l | X | X | X | | X | | |
| Chromium | TCLP extraction procedure < 5.0 mg/l | X | X | X | | | | |
| Copper | TCLP extraction procedure < 100.0 mg/l | X | X | X | | | | |
| Lead | TCLP extraction procedure < 5.0 mg/l | X | X | X | X | X | X | X |
| Mercury | TCLP extraction procedure < 0.2 mg/l | X | X | X | | | | |
| Nickel | TCLP extraction procedure < 35.0 mg/l | X | X | X | | | | |
| Selenium | TCLP extraction procedure < 1.0 mg/l | X | X | X | | | | |
| Silver | TCLP extraction procedure < 5.0 mg/l | X | X | X | | | | |
| Zinc | TCLP extraction procedure < 200.0 mg/l | X | X | X | | | | |
| Chlorine | < 1.0% | X | X | X | | | | X |
| Reactive Sulfide | < 50 mg/l | X | X | X | | | | |
| PCBs | < detection limit | | X | | | | | X |
| Phenol | TCLP extraction procedure < 2000 mg/l | X | X | X | | | | |
| Cyanide (as free CN) | < 50 mg/l | X | X | X | | | | |
| Benzene | TCLP extraction procedure < 0.5 mg/l | X | X | X | | | X | X |
| Carbon Tetrachloride | TCLP extraction procedure < 0.5 mg/l | X | X | X | | | X | X |
| Chlorobenzene | TCLP extraction procedure < 100.0 mg/l | X | X | X | | | X | X |
| oform | TCLP extraction procedure < 6.0 mg/l | X | X | X | | | X | X |
| sol | TCLP extraction procedure < 200.0 mg/l | X | X | X | | | X | X |
| n. resol | TCLP extraction procedure < 200.0 mg/l | X | X | X | | | X | X |
| p-Cresol | TCLP extraction procedure < 200.0 mg/l | X | X | X | | | X | X |
| 1,4-Dichlorobenzene | TCLP extraction procedure < 7.5 mg/l | X | X | X | | | X | X |
| 1,2-Dichloroethane | TCLP extraction procedure < 0.5 mg/l | X | X | X | | | X | X |
| 1,1-Dichloroethylene | TCLP extraction procedure < 0.7 mg/l | X | X | X | | | X | X |
| 2,4-Dinitrotoluene | TCLP extraction procedure < 0.13 mg/l | X | X | X | | | X | X |
| Hexachlorobenzene | TCLP extraction procedure < 0.13 mg/ | X | X | X | | | X | X |
| Hexachloro-1,3-butadiene | TCLP extraction procedure < 0.5 mg/l | X | X | X | | | X | X |
| Hexachloroethane | TCLP extraction procedure < 3.0 mg/l | X | X | X | | | X | X |
| Methyl Ethyl Ketone | TCLP extraction procedure < 200.0 mg/l | X | X | X | | | X | X |
| Nitrobenzene | TCLP extraction procedure < 2.0 mg/l | X | X | X | | | X | X |
| Pentachlorophoenol | TCLP extraction procedure < 100.0 mg/l | X | X | X | | | X | X |
| Pyridine | TCLP extraction procedure < 5.0 mg/l | X | X | X | | | X | X |
| Tetrachloroethylene | TCLP extraction procedure < 0.7 mg/l | X | X | X | | | X | X |
| Trichloroethylene | TCLP extraction procedure < 0.5 mg/l | X | X | X | | | X | X |
| 2,4,5-Trichlorophenol | TCLP extraction procedure < 400.0 mg/l | X | X | X | | | X | X |
| 2,4,6-Trichlorophenol | TCLP extraction procedure < 2.0 mg/l | X | X | X | | | X | X |
| Vinyl Chloride | TCLP extraction procedure < 0.2 mg/l | X | X | X | | | X | X |
| Toluene | < 1000 ppm | | | | | | X | |
| Xylene | < 1000 ppm | | | | | | X | |
| Total Petroleum Hydrocarbons | < 3000 ppm | | | | | | X | |
| Benzene | ≤ 1000 ppm | | | | X | | | |
| GRO (for all gasolines) | < 2000 ppm | | | | X | | | |
| DRO (for diesel, jet fuel, #1, 2, or 4 fuel oil) | < 2000 ppm | | | | X | | | |
| TRPH (for crude oil, lube oil for #6 fuel oil) | < 2000 ppm | | | | X | | | |
| VOC Scan | case by case review | | | | | X | | |
| Reactive Cyanide | ≤ 50 ppm * | | | | | X | | |
| Reactive Sulfide | ≤ 50 ppm ** | | | | | X | | |
| GRO (unknown petroleum) | < 3000 | | | | | X | | |
| ) (unknown petroleum) | < 3000 | | | | | X | | |
| H (waste oil) | < 3000 ppm | | | | | X | | |
| | | $1,041 | $1,126 | $1,041 | $525 | $800 | $922 | $825 |

For all constituents which are identified as TCLP extraction, it is permissible to do a totals analysis instead of the extraction. If the totals analysis is not over the acceptance limit, no extraction is required.

* For facilities which have purchased cyanide or performed metal finishing such as heat treating, stripping, or plating.

** F[illegible] facilities which purchased metal cutting oils or performed metal finishing.

# TCT - St. Louis

Consulting Engineers, Scientists and Analytical Services

1908 Innerbelt Business Center Drive
St. Louis, Missouri 63114-5700
Phone (314) 426-0880
Fax (314) 426-4212

September 16, 1991

Ted Harztig
Donahue and Associates
4738 N. 40th Street
Sheboygan, WI 53083

Dear Mr. Harztig:

TCT-St. Louis is pleased to submit the following price quotation in response to your request for proposal of analytical services September 13, 1991.

| PARAMETER | PRICE/SAMPLE | METHOD |
|---|---|---|
| EXPLOSIVES(Soil) | $245 | SW846-8330 |

The turn around time for this type of analysis with summary report is generally three weeks. An additional 25% surcharge will be invoiced for two week turn around and a 50% surcharge will be invoiced for one week turn around.

These prices are estimated on an approximate delivery of 400 - 700 soil samples with sampling occuring over two months.

Please note that soil samples for explosive analysis must be air dried to constant weight by the laboratory before any analysis can begin. This procedure generally takes between three to four days.

Quality control samples which may be required by the methodology will be separately billable, and will generally consist of one or two additional samples per batch or group of twenty samples. Invoices will be submitted for each batch of samples when the reports are completed, and payment will be due 30 days after receipt of the invoice.

If you have any questions about this price quotation, please contact Paul Smith at (314) 426-0880.

Sincerely,

Paul J. Smith
Senior Project Manager

# TCT - St. Louis

Consulting Engineers, Scientists and Analytical Services

1908 Innerbelt Business Center Drive
St. Louis, Missouri 63114-5700
Phone (314) 426-0880
Fax (314) 426-4212

April 23, 1992
9062

Greg Ruechel
Donohue and Associates
4738 N. 40th Street
Sheboygan, WI 53083

Re: Ft. McCoy, Sparta, WI price quote for explosive analysis

Dear Mr. Ruechel:

TCT-St. Louis is pleased to submit the following price quotation in response to your request for proposal of analytical services of this date.

| PARAMETER | PRICE/SAMPLE | METHOD |
|---|---|---|
| EXPLOSIVES(Water) | $335 | SW846-8330 |

TCT-St. Louis can meet the detection limits listed in Table 5.3 of the proposal for aqueous samples.

TCT-St. Louis will deliver a data package in the format specifed in the analytical request, within 28 days of sample receipt of the last sample in the data batch.

The price quoted above is based on a total of five samples for analysis with diskette deliverable data option. Quality control analyses, required by the methodology will be invoiced at unit rate.

Just as a note, the soil method detection limits listed in Table 5-3 has the units for the detection limits incorrectly listed in ug/kg. The correct units should be ug/g or mg/kg.

If you have any questions, please call me at (314) 426-0880.

Sincerely,

Paul J. Smith
Sr. Project Manager

**MEMORANDUM**

**DATE:** September 29, 1992

**TO:** FS File

**FROM:** Mark Mobley

**SUBJECT:** Acceptance of Soil or Debris at Off-Site Landfill

**Vendor Name:** Waste Management of Nebraska
**Contact Name:** Kathy O'Keefe
**Phone:** (402) 478-5141

This call was made to Ms. O'Keefe to verify that the Douglas County Landfill could accept contaminated soil and/or debris from the NOP site. She said that as a Subtitle D landfill, they were not permitted to accept hazardous wastes, but if it was not a RCRA hazardous waste, there should not be a problem. She was not familiar with explosives, so she did not know what particular tests would be necessary to determine whether it would be a hazardous waste or it would require special handling for safety reasons. She was particularly concerned about safety issues, as the landfilling process could generate friction and heat, which may initiate explosive compounds.

Disposal rate and procedures may require some specialized design. The NDEC has to approve the disposal if constituents seem questionable and may require more stringent testing on a case-by-case basis. However, they often defer to Waste Management unless circumstances warrant increased NDEC attention.

MM/bjz

RP/MEADFS/AQ9

**MEMORANDUM**

**DATE:** July 27, 1992

**TO:** Mead NOP FS File

**CC:** Dave Froh

**FROM:** Sarah Levin

**SUBJECT:** Hauling Explosives-Contaminated Soil

**Vendors Contacted:**
Aggregate Carriers
Connie Eckley
402-624-2975

Spencer Dorothy, Inc.
Rick Dorothy
402-443-4362

## 1.0 INTRODUCTION

Two additional hauling companies were contacted to confirm the availability of local contractors willing to haul soil contaminated with low-level explosives.

## 2.0 RESULTS

Connie said they would be willing to haul the soil as long as it is not a RCRA-hazardous waste and not a direct threat to their employees. Rick said they would have no problem with hauling the soil.

DF/ke

RP/MEADFS/AC2

**MEMORANDUM**

**DATE:** August 3, 1992

**TO:** Mead NOP FS File

**CC:** Dave Froh

**FROM:** Mark J. Mobley

**SUBJECT:** Cost of Power at University of Nebraska

**Vendor:** University of Nebraska
**Contact:** Mr. MacMannaman, Facility Manager
**Phone:** (402) 624-2275

## 1.0 INTRODUCTION

Mr. MacMannaman quoted the power cost paid by the University of Nebraska to the local power company.

## 2.0 COSTS

The cost of power at the University of Nebraska was quoted as $0.065/KWhr.

MM/ke

RP/MEADFS/AE2

# APPENDIX D2

## VENDOR INFORMATION: PRETREATMENT/POST-TREATMENT

**MEMORANDUM**

**DATE:** August 5 and 10 , 1992

**TO:** NOP FS File

**CC:** Dave Froh

**FROM:** Greg Johnson

**SUBJECT:** Vendor Information Summary - Fine Screen, Slurry Tank

**Vendor:** Mills-Winfield Engineering Sales, Inc.
**Contact:** Terry Mueller
**Phone:** 414-466-7900

Mills-Winfield Engineering Sales, Inc., is a distributor of Rotex Screeners (fine screens). Mr. Mueller indicated that a screen with a 40 mesh separation would cost $11,213. He indicated that the screen could be fed by a conveyor.

Rotex brochures, including equipment specifications, are on file at SEC Donohue.

Mr. Mueller also indicated that Mills-Winfield could supply a slurry mixing tank. He indicated that a 20,000-gallon mixing tank would cost $16,588 ($7,200 for the tank and $9,388 for the 2 HP, 45 RPM agitator).

GJ/bjz

RP/MEADFS/AG6

**MEMORANDUM**

**DATE:** August 3, 1992

**TO:** NOP FS File

**CC:** Dave Froh

**FROM:** Greg Johnson

**SUBJECT:** Vendor Information Summary - Screen, Grinder

**Vendor:** Aring Equipment
**Contact:** George Mumau
**Phone:** 414-781-3770

Aring Equipment is a distributor for Powerscreen of America and Royer, Inc. Mr. Mumau indicated that Powerscreen's "Power Grid" and Royer's grinder/shredders have been implemented several times at hazardous waste sites.

The Power Grid screens out material greater than 3 inches to 4 inches in size. The power grid is diesel powered, loaded with a front-end loader, and equipped with a discharge conveyor. The Royer grinders will reduce material size to less than 1 inch to 1.5 inches. The purchase price of the Power Grid is $65,000, and the grinders range from $70,000 to $120,000. Shredder belts on the grinder require replacement every 2 to 3 months and cost between $1,600 and $2,200.

Aring does not rent these units for hazardous waste sites. Aring brochures, including equipment specifications, are on file at SEC Donohue.

GJ/bjz

RP/MEADFS/AG3

**MEMORANDUM**

**DATE:** August 3, 1992

**TO:** NOP FS File

**CC:** Dave Froh

**FROM:** Greg Johnson

**SUBJECT:** Vendor Information Summary - Conveyor

**Vendor:** Screw Conveyor Corporation
**Contact:** John Swanson
**Phone:** 219-931-1450

Screw Conveyor Corporation (SCC) sells a variety of conveying systems. Mr. Swanson indicated that screw conveyors have been implemented at several hazardous waste sites. He stated that clayey material would not be a problem to convey. He indicated the conveyors are rugged and can handle 30 ton/hr. The cost for a 15 to 20-foot conveyor would be about $4,500 ($3,000 for conveyor and $1,500 for drive).

SCC brochures, including equipment specifications, are on file at SEC Donohue.

GJ/ke

RP/MEADFS/AG4

**MEMORANDUM**

**DATE:** August 3, 1992

**TO:** NOP FS File

**CC:** Dave Froh

**FROM:** Greg Johnson

**SUBJECT:** Vendor Information Summary - Clay Grinder

**Vendor:** J.C. Steele & Sons, Inc.
**Contact:** David Steele
**Phone:** 704-872-3681

J.C. Steele & Sons, Inc., sells clay soil grinders which have been implemented at hazardous waste sites for incineration pre-processing. Mr. Steele stated that these feeder systems reduce clay clumps to less than 0.5 inches to 1.0 inch in size. The units cost approximately $40,000. Mr. Steele indicated that the process rate is about 1,000 cf/hr. The unit will not grind metal or concrete greater than 3 inches in size. The unit can be loaded with a conveyor or front-end loader (with hopper attachment) and has a bottom discharge (usually to a conveyor).

J.C. Steele brochures, including equipment specifications, are on file at SEC Donohue.

GJ/ke

RP/MEADFS/AG5

**MEMORANDUM**

**DATE:** August 3, 1992

**TO:** NOP FS File

**CC:** Dave Froh

**FROM:** Greg Johnson

**SUBJECT:** Vendor Information Summary - Filter Press

**Vendor:** Star Systems
**Contact:** J. Scott Thomas
**Phone:** 800-845-5381

Star Systems sells filter manufacturer's filter presses. Mr. Thomas indicated that a 50 cu. ft. press could handle a slurry flow rate of 10 gpm. He stated that the press was semi-automated and would be emptied once per 8-hour shift. The cost of the press is $64,000.

Star Systems brochures, including equipment specifications, are on file at SEC Donohue.

GJ/ke

RP/MEADFS/AG7

**MEMORANDUM**

**DATE:** July 24, 1992

**TO:** NOP FS File

**CC:** Dave Froh

**FROM:** Greg Johnson

**SUBJECT:** Vendor Information Summary - Shredding

**Vendor:** SSI Shredding Systems (SSI)
**Contact:** Joyce Beasley
**Phone:** 503-682-3633
**Treatment:** Shredding

SSI has mobile rotary shear shredding equipment which has been used on several hazardous waste sites for pre-processing contaminated soils and debris prior to incineration and landfilling.

SSI recommended their model 3400-E/H for shredding approximately 10,000 tons of clay soil and debris. This system was used to process clayey soil and debris prior to incineration at the Paxton Avenue site in Chicago, Illinois.

The costs for this unit include:

| | |
|---|---|
| Equipment and Operator Mobilization/Demobilization | $7,000 |
| First Month Equipment Lease | $38,729 |
| Second and Additional Month Equipment Lease | $16,329 |
| Operator | $600/day |

Costs do not include equipment decontamination.

DF/ke

RP/MEADFS/AB9

**MEMORANDUM**

**DATE:** July 24, 1992

**TO:** NOP FS File

**CC:** Dave Froh

**FROM:** Greg Johnson

**SUBJECT:** Vendor Information Summary - Shredding

**Vendor:** Waco Tire Recycling (WTR)
**Contact:** Jenny Stevens, Gene Webb
**Phone:** 606-369-5959
**Treatment:** Shredding

WTR has a mobile process unit that is capable of shredding wood, metal, and concrete debris. The unit has been used at several hazardous waste sites. Costs for the unit are as follows:

Rental $250/hour (40-hour minimum)
Includes supervisor with 40-hour hazardous waste site training and a generator with diesel fuel to power the unit.

Mobilization/Demobilization $1.25/mile
(from Waco, Kentucky)

Blade Resharpening (may be required)
WTR indicated this cost would be about $5,000.

Area requirements for the unit are approximately 50 feet by 15 feet. Costs do not include equipment decontamination.

DF/ke

RP/MEADFS/AC0

**MEMORANDUM**

**DATE:** September 28, 1992

**TO:** NOP FS File

**FROM:** David Heim

**SUBJECT:** Soil Preprocessing Equipment for Biological Treatment

**Vendor Name:** Denver Equipment Co.
**Contact:** Bill Schlittler
**Phone:** 719-471-3443

Bill said that his company, which specializes in mining equipment, is familiar with the kind of equipment used in soil washing and slurry-phase processing. I described our requirements, and he recommended an attrition scrubber. When I told him that we were expecting a throughput of about 1 ton per hour, he said that we would probably require a machine with two cells of 24 inches per side. Each cell has a propeller which breaks up clumps of soil and mixes soil with water. Power requirements for this unit are approximately 10 horsepower and the cost is about $17,000.

RP/MEADFS/AQ7

# APPENDIX D3

## VENDOR INFORMATION: BIOLOGICAL TREATMENT

**MEMORANDUM**

**DATE:** July 30, 1992

**TO:** Mead NOP FS file

**FROM:** David Heim

**SUBJECT:** Conference Call with Mark Zappi, Army Engineer Waterways Experiment Station, re: slurry biodegradation

Today Dick Johnson of the Maple Grove office and I had a conference call with Mark Zappi, Project Engineer, of the U.S. Army Engineer Waterways Experiment Station (WES), in Vicksburg, Mississippi. The topic of our discussion was a series of slurry-phase biodegradation experiments conducted at WES on explosives-contaminated soils from a site in Hastings, Nebraska. The results are still very preliminary, as data have not yet been completely analyzed and compared with controls. The studies were intended to establish whether the process would be feasible on a qualitative basis, rather than to optimize reactor conditions.

In the bench scale batch experiments, additives to the soil-water slurry were varied to determine how they effected microbial degradation of TNT. Solids concentration in the slurry for this experiment was about 25 percent. The additives varied were nutrients and surfactants. The surfactant, consisting mostly of polysorbate-80 (a medium-weight carboxylic acid commonly used in food processing), was used to aid in mass transfer of TNT from the soil particle surface to the aqueous phase. It was believed that the mass transfer might be the rate-limiting step, rather than the actual biodegradation of the TNT. The surfactant is biodegradable and is destroyed along with the TNT. Because of its biodegradability, it must be added fairly regularly and is not left as a residual from the biological process. Mr. Zappi said that it was added weekly to the reactors in an amount equal to 3 percent of the soil weight in the slurry. In addition to surfactant, ammonia and phosphate were added as nutrients. Nutrients were added as needed to keep them at given concentrations in the slurry. Sodium acetate was used as the primary substrate and was added weekly at 1.5 percent of soil weight.

Duplicate experiments were run with addition of acetate only, acetate and nutrients, acetate and surfactants, and all three added. In each case, starting concentrations of TNT were about 18,000 mg/kg in the soil. Degradation of greater than 99 percent of the TNT was observed in approximately 3 weeks in one of the reactors to which all of the additives were added. He reiterated that these were preliminary results, although the breakdown of TNT was encouraging.

Another set of experiments was conducted with radio-labeled TNT to determine the amount of mineralization of TNT by microbes in the biological slurry. Although the percentage of mineralization was relatively high (up to 20 percent), Mr. Zappi said that experimental conditions were limited by the apparatus used in the radio-label study. Surfactants, nutrients, and primary substrate could not be added after the beginning of the experiment. He said that he is working on developing an experimental apparatus which would allow more flexibility in the conduct of radio-label studies.

Additives experiments were conducted in EIMCO bench-sized Bio-Lift reactors. Mr. Zappi said that they had worked well. Although these experiments were performed at 25 percent solids, he recommended a solids loading of 40 percent for a clayey soil such as that found at the NOP site. We discussed retention times, which would control cost estimates, and agreed that about 30 days was a conservative estimate which may be lowered after results of testing with NOP soil and process optimization are available. For field-scale applications, molasses would be a suitable primary substrate.

Not a lot is known about the breakdown products or the biodegradation pathway of TNT, although some amino-dinitrotoluenes and diamino-nitrotoluenes were observed after a time in the batch reactors. These products did not remain long in the vessel, apparently having been further degraded into unknown products. Mr. Zappi did add that no 2,4- or 2,6-dinitrotoluene was observed. That is an important concern, as these chemicals are known to be toxic, and are parameters in the TCLP test. The degree of mineralization found in the radio-labeled study provide strong evidence of aromatic ring cleavage.

Mr. Zappi said that he is unaware of any slurry biodegradation studies being performed on explosive compounds other than TNT. RDX and HMX are very difficult to handle in the pure-product form commonly used in research, but he hopes to do some work on them in the near future. He added that Woodward-Clyde was doing a similar conceptual design for the Hastings site and that we might wish to speak to Chuck Coyle of the Corps of Engineers in Kansas City to get some further information.

DH/jb

RP/MEADFS/AD5



B07NE003701-05018

**MEMORANDUM**

**DATE:** August 4, 1992

**TO:** NOP FS File

**FROM:** David Heim

**SUBJECT:** Primary Substrate Costs for Biological Treatment

**Vendor:** Crompton & Knowles Corp.
**Phone:** (312) 646-2203
**Contact:** John Edwards
**Treatment:** Biological

On the recommendation of M. Zappi of the U.S. Army Engineer Waterways Experiment Station, it is assumed that molasses would be a suitable primary substrate for aerobic biological treatment of NOP site soil. In bench-scale experiments, a different primary substrate (sodium acetate) was used, but molasses would probably be more appropriate for a full-scale process. The amount to be used is assumed to be 1.5 percent of the weight of the soil treated. This means that 170 tons of molasses would be required over the life of the project.

Mr. Edwards, of Crompton & Knowles quoted a price of $0.10 per pound for bulk delivery of the lowest grade of molasses which his company supplies. Bulk delivery would occur in tanker trucks.

DH/ke

RP/MEADFS/AO8

**MEMORANDUM**

**DATE:** August 18, 1992

**TO:** NOP FS File

**FROM:** David Heim

**SUBJECT:** Surfactant Costs

**Vendor:** Aldrich Chemical Co.
**Phone:** 800-255-3756
**Treatment:** Biological

In conversations with Mark Zappi, U.S. Army Engineer Waterways Experiment Station (WES), he mentioned that the desorption of TNT from the surface of soil particles could control the rate of the biodegradation process. To accelerate this desorption, he added a surfactant agent to the bio-slurry. He recommended a biodegradable surfactant which he called "Tween 80". This is a medium-weight carboxylic acid which is often used as an emulsifier in food processing. It is also known as "polysorbate-80", and its CAS number is 9005-65-6. To obtain rough costs for this substance, a call was placed to the bulk sales toll-free telephone number of Aldrich Chemical Co., Milwaukee, Wisconsin. The sales representative there said that chemical, delivered in tankers, would cost approximately $2.50 per pound.

DH/bjz

RP/MEADFS/AM7

**MEMORANDUM**

**DATE:** July 28, 1992

**TO:** Mead NOP FS File

**FROM:** David Heim

**SUBJECT:** Discussions re: Slurry Biological Treatment

This memorandum is intended to follow up on the memo dated July 27, 1992, to Dick Johnson (Maple Grove) regarding discussions with John Manning of Argonne National Laboratories and Gunter Brox of EIMCO Process Equipment. I spoke again with Mr. Brox regarding his company's slurry biological reactor. He referred me to the SITE program Application Analysis Report for BioTrol's soil washing process. The contaminated fines from the washing process were treated in EIMCO Bio-Lift slurry biological reactors. Mr. Brox said that the process train and pricing information in that document would probably be appropriate for application to contaminated soils at the NOP site. He recommended that reactors be placed in series, cascading to at least three reactor vessels. This helps to optimize reaction kinetics. He also added that the processed sludge handling stream from the BioTrol system may not be appropriate for our soils.

I also spoke with Mr. Thomas Chresand of BioTrol regarding their SITE demonstration. He said that BioTrol has not commercially used the soil washing system since that demonstration. He mentioned that the residence time we were suggesting (20 to 60 days) was too long, and that his company would try to optimize conditions such that residence time was on the order of 5 to 10 days. I told him that the longer period was based on bench-scale batch tests performed on explosives, and probably could be optimized somewhat. He could not be very specific about what a process train might include for our soil, but said that a treatability study would probably cost in the neighborhood of $20,000.

DH/bjz

RP/MEADFS/AC4

**MEMORANDUM**

**DATE:** July 27, 1992

**TO:** Dick Johnson, Maple Grove

**FROM:** Dave Heim, Sheboygan

**SUBJECT:** Discussions Re: Slurry Biological Treatment

This memorandum is to document some of the information I have gotten in conversations with Gunter Brox, EIMCO Process Equipment (801-526-2082), and John Manning, Argonne National Laboratories (708-252-7854). Mr. Brox had sent me some information on EIMCO's bioslurry reactor, including a videotape. Mr. Manning has been performing treatability studies with biological slurry treatment in Joliet (IL) AAP soil, which is contaminated with TNT, but not RDX or HMX. I got his number through a friend of Greg Johnson's at Illinois EPA.

Some of the treatability study work being done at WES (both on explosives and on wood preservatives) is being performed on EIMCO's bench-scale reactors. The reactors are essentially tanks with a rake-impeller in the center. The impeller has rakes, like a sludge thickener, and bubble diffusers mounted on the rake arms. These help to keep fine soil particles in suspension, both through agitation and flotation. They also assist in keeping a relatively even aeration through the slurry. Sandy soils present a problem, as they settle out of the aeration zone too readily. We talked a little about the advantages of a cascade system over batch operations. Among the advantages he mentioned were acclamation of microorganisms, and that microbes would not be going through a "feast-famine" cycle for batch processes. Also, the first reactor in the series could have fairly high reaction kinetics, and do the bulk of the concentration reduction. Later stages could perhaps work on smaller increments of concentration decrease, and "polish" the slurry to PRG levels.

Mr. Manning has been doing slurry bioremediation treatability tests on soil from the Joliet AAP. That soil is more loamy than the Mead soil, with about equal parts sand, silt, and clay. They screen the soil through about a #40 mesh before going to the slurry reactor. This also serves to remove any residual TNT crystals which may be encountered, as they are likely to be toxic to microbes. Pilot scale studies have shown concentration decreases from about 4,000-5,000 mg/kg to about 100 or so, in 15 to 30 days. Tests are being performed at 15 to 20 percent solids in the slurry. The site is only in the RI phase of the process, so he does not know what his PRGs will be. He is starting to think about some more experiments to perform at the pilot scale, including the use of a series of reactors in the cascade mode, to see if that will increase levels of TNT decomposition. They are using modified versions of the EIMCO Bio-Lift slurry reactor in their pilot studies, which will use 400-gallon reactors.

We also talked about some of the possibilities regarding dewatering of the soil slurry after the biological treatment. While filtration has worked well in the lab, he said that field experience with filter presses has not been good with soil slurries. Clogging and tearing of filter fabric were problems which impeded the process. They are investigating the use of sand filters and geotextiles for dewatering, with a sort of filtrate collection system underlying the drying beds. A pilot study (approximately 100 sq. ft. drying beds) is being conducted with the Joliet soil, comparing the two filtration media. This may be a good idea for us to think about, although the high content of fines (approximately 90 percent) will complicate matters.

If you have any questions, give me a call. I am looking forward to reading more about the sludge treatment train of the BioTrol SITE demonstration we talked about on Friday.

DH/bjz

RP/MEADFS/AD2

SEC DONOHUE
Environment & Infrastructure

July 14, 1992

Douglas Gunnison, PhD.
Aquatic Processes and Effects Group
US Army Engineer-Waterway Experiment Station
5900 Wells Ferry Road
Vicksburg, MS 39180

Dear Dr. Gunnison:

SEC Donohue is conducting an investigation into alternative technologies for remediation of explosives-contaminated soils at a former U.S. munitions plant site. The investigation will be part of a feasibility study (FS) that is scheduled to be completed this October. SEC Donohue will also be preparing the Record of Decision (ROD) for the site. Both aerobic and anaerobic biological treatment have been retained in the initial screening of alternatives as technologies that merit further consideration.

We were introduced to your work on aerobic slurry bioremediation of explosives contaminated soils by Mr. Charles Coyle of the Corps District office in Kansas City. Mr. Coyle provided us with some of your preliminary results on TNT disappearance in treatability studies on explosives-contaminated soil from a site in Hastings, Nebraska.

In an effort to better document the results of your research on your aerobic slurry method of bioremediation of explosive compounds, I have prepared the enclosed questionnaire. Please provide as much information as you are able. I recognize that you are in the middle of your research on this subject and that it is difficult to disclose raw data without the necessary interpretation and cross-checking of results. However, in view of our schedule on the FS and our need to document our findings properly, please provide as many answers on your aerobic slurry process. If possible, I would like to receive your response before July 24.

I have enclosed a table of data on the site soils and a list of the contaminants, their concentrations and our preliminary remediation goals for your reference. I appreciate any help you can provide. I am sure you recognize the importance of accurately describing the results of your research and properly referencing your process in the FS.

7200 Hemlock Lane North • Maple Grove, Minnesota 55369 • (612) 425-2181 • Fax: (612) 425-1913

I look forward to your reply. Thanks for your help.

Sincerely,

Richard Johnson, P.E.

RJ/vaj

Enclosure

T/L/DC9

Questionnaire
Aerobic Bioremediation of Explosives
Waterways Experiment Station

1.0 You have advised that you are conducting a treatability study on a sample of explosives-contaminated soil from a site near Hastings, Nebraska.

1.1 What are the results of your study to date?

- Disappearance of TNT, RDX, HMX, DNT or tetryl
- Toxicity results
- Rate of transfer of contaminants to the aqueous phase.
- Hydraulic retention time
- Observed degree of mineralization
- By products
- Evidence of ring cleavage
- Absence of dimerization or polymerization (how determined)

1.2 Is the Hastings soil similar to the heavy clay soil described in table 1? Please provide any soils analysis data that you have obtained on the Hastings soil sample.

1.3 Please describe your experimental methods.

- Batch size
- Temperature control
- Any pH adjustment?
- Nutrients/substrate addition (rate, frequency, etc.)
- Agitation
- Inoculation
- Percent solids

1.4 Please describe your analytical procedures.

1.5 Are levels of contamination similar to the contaminants listed in table 1? Did the contaminants present any observed toxicity effects on the microbes?

2.0 Please provide any reports or other documentation that you have on earlier treatability studies.

3.0 Have you given thought to scaling up the process to remediate large volumes?

- Can you describe how you plan to mix substrates and soil and water?
- Are subsequent additions going to be required after the initial mixture is prepared?
- What is the preferred method of treatment? Biopad, mixing vessel, other?
- How much area (including soil mixing and staging area) will your process require for 20,000 cu.yds. of contaminated soil? 6,000 cu.yds.?
- Will slurry dewatering be required after treatment is complete? If so, how do you anticipate dewatering? Can the water be discharged to the surface waters (NPDES)?
- What percent solids would you anticipate slurrying the soil described in table 1?
- Should the treatment area be covered with a greenhouse-type structure or can it be left open to wind and rain?
- If we elect to wash the screened out debris, can the wash water be mixed into the slurry? Will surfactants affect the microbes?
- Will there be any air emissions? Odor problems? Is there any risk from emissions to workers or community?
- Do you have any drawings or sketches of your process that we can use to explain the process or treatment area?

4.0 What is your schedule of future bench scale tests or pilot scale tests? Do you expect to publish results of treatability study on Hastings soil before September? Please provide any reports on the subject matter that you can release.

5.0 Can you provide process cost estimates? What are your estimates of the cost per cu. yd. (or ton) for two volumes of the contaminated soil described in the attached table; 20,000 cu. yds. vs. 6,000 cu. yds.? (Just treatment cost--the excavation/consolidation costs will be worked out separately.)

TABLE 1

Soil type: CL and CH
Soil description:

0-16 in. silty clay loam
1 to 17 ft. silty clay (loess)

Soil pH: 5.1 to 7.3 (Sharpsburg series)
6.6 to 8.4 (Fillmore series)
Debris in soil (description): None
Soil moisture (% of dry unit weight): 17±4
Soil unit weight (wet): 100 lb./cu. ft.
Porosity: 0.5
Description of areas to be treated: Shallow soil (mostly <5') in drainage ditches and hot spots
Total Volume: 6,000 cy (order of magnitude estimate)
Distance between contaminated areas: Contaminated areas are separated by distances of 1/2 to 1 mile.

Space available: Large open area, but space available for remediation activities as yet unknown.
Utility hookups on-site: Electric service - 13,500 V; 440 (3Ph), 240 (3Ph), and 120 (1Ph). Water service - 12-inch main; 60 psi; max flow rate available is 100 gpm, summer months supply is minimal. Water may be contaminated; can haul water from nearby town. Gas service - 2-1/2 inch; 60 psi.

| Contaminants of Concern | Preliminary Remediation Goals *(mg/kg) | Maximum Concentration Detected (mg/kg) | Average Range of Concentrations Above PRGs (mg/kg) |
|---|---|---|---|
| RDX | 10 | 6,000 | 10 - 1,600 |
| 2,4-DNT | 0.98 | 119 | 5 - 33 |
| 2,6-DNT | 0.98 | 33 | 4 - 11 |
| 2,4,6-TNT | 4 | 297,000 | 3,000 - 34,000 |
| 1,3-Dinitrobenzene | 28 | 9.8 | -- |
| HMX | 160 | 2,020 | 300 - 900 |
| Nitrobenzene | 140 | 92.5 | -- |
| Tetryl | 2,800 | 52,000 | 3,600 - 28,000 |
| 1,3,5-Trinitrobenzene | 14 | 430 | 52 - 177 |
| Nitrotoluene | 2,800 | 96 | -- |
| Lead | NA | 576 | 30 - 300 |
| Chromium (1 area only) | NA | 268 | -- |
| Mercury (1 area only) | NA | 3 | -- |

* Preliminary only; will change during RI/FS.
NA Not Available

T/L/DD0

SEC DONOHUE
Environment & Infrastructure

July 14, 1992

Dr. Ronald Crawford
Center for Hazardous Waste Remediation Research
University of Idaho
Moscow, Idaho 83843

Dear Ron:

As we have discussed previously, SEC Donohue is conducting an investigation into alternative technologies for remediation of explosives-contaminated soils at a former U.S. munitions plant site. The investigation will be part of feasibility study (FS) that is scheduled to be completed this October. SEC Donohue will also be preparing the Record of Decision (ROD) for the site.

Both aerobic and anaerobic biological treatment have been retained in the initial screening of alternatives as technologies that merit further consideration. In an effort to document the results of your research on your anaerobic slurry method of bioremediation of explosive compounds, I have prepared the enclosed questionnaire. Please provide as much information as you are able. I recognize that you are in the middle of your research on this subject and that it is difficult to disclose raw data without the necessary interpretation and cross-checking of results. However, in view of our schedule on the FS and our need to document our findings properly, please provide as many answers as you can on your anaerobic process. If possible, I would like to receive your response before July 24.

I have enclosed the Table 1 data on the site soils that I sent you earlier for your reference. The table has been modified somewhat to show a lower volume of soil that needs to be treated and some of the PRG's have been revised slightly. Ron, I appreciate your response in this matter. I am sure you recognize the importance of entering as much support data for your process into the FS as possible.

I look forward to your reply. Thanks for your help.

Sincerely,

Richard E. Johnson, P.E.

REJ/vaj

T/L/DB8

7200 Hemlock Lane North • Maple Grove, Minnesota 55369 • (612) 425-2181 • Fax: (612) 425-1913

Questionnaire
Anaerobic Bioremediation of Explosives
University of Idaho Hazwaste Center

1.0 You have advised that you are conducting a treatability study on a sample of explosives-contaminated soil for the U.S. Army Corps of Engineers (USACE) from a site near Weldon Springs, Missouri.

1.1 What are the results of your study to date?

- Disappearance of TNT, RDX, HMX, DNT or tetryl
- Toxicity results
- Rate of transfer of contaminants to the aqueous phase.
- Hydraulic retention time
- Observed degree of mineralization
- By products
- Evidence of ring cleavage
- Absence of dimerization or polymerization (how determined)

1.2 Is the Weldon Springs soil similar to the heavy clay soil described in table 1? Please provide any soils analysis data that you have obtained on the Weldon Springs soil sample.

1.3 Please describe your experimental methods.

- Batch size
- Temperature control
- Any pH adjustment?
- Nutrients/substrate addition (rate, frequency, etc.)
- Agitation
- Inoculation
- Percent solids

1.4 Please describe your analytical procedures.

1.5 Are levels of contamination similar to the contaminants listed in table 1? Did the contaminants present any observed toxicity effects on the microbes?

2.0 Please document your results on earlier treatability studies. The disappearance graphs you provided earlier are helpful, but can you provide corresponding tabulated data? I need to know final concentrations of contaminants after treatment and days required to reach the end result.

3.0 Have you given more thought to scaling up the process to remediate large volumes?

- Can you describe how you plan to mix substrates and soil and water?
- Are subsequent additions going to be required after the initial mixture is prepared?
- Is a Biopad (pit) still the preferred method of treatment?
- How much area (including soil mixing and staging area) will your process require for 20,000 cu.yds.? 6,000 cu.yds.?
- Will slurry dewatering be required after treatment is complete? If so, how do you anticipate dewatering? Can the water be discharged to the surface waters (NPDES)?
- What percent solids would you anticipate slurrying the soil described in table 1?
- Should the treatment area be covered with a greenhouse-type structure or can it be left open to wind and rain?
- If we elect to wash the screened out debris, can the wash water be mixed into the slurry? Will surfactants affect the microbes?
- Will there be any air emissions? Odor problems? Is there any risk from emissions to workers or community?
- Do you have any drawings or sketches of your process that we can use to explain the process or treatment area?

4.0 What is your schedule of future bench scale tests or pilot scale tests (either explosives or Dinoseb)? Do you expect to publish results before September?

5.0 Can you provide more detailed cost estimates? What effect would a reduction of 20,000 cu. yds. down to 6,000 cu. yds. of treated soil have on cost? (Just treatment cost--the excavation/consolidation costs will be worked out separately.)

TABLE 1

Soil type: CL and CH
Soil description:

0-16 in. silty clay loam
1 to 17 ft. silty clay (loess)

Soil pH: 5.1 to 7.3 (Sharpsburg series)
6.6 to 8.4 (Fillmore series)
Debris in soil (description): None
Soil moisture (% of dry unit weight): 17±4
Soil unit weight (wet): 100 lb./cu. ft.
Porosity: 0.5
Description of areas to be treated: Shallow soil (mostly <5') in drainage ditches and hot spots
Total Volume: 6,000 cy (order of magnitude estimate)
Distance between contaminated areas: Contaminated areas are separated by distances of 1/2 to 1 mile.

Space available: Large open area, but space available for remediation activities as yet unknown.
Utility hookups on-site: Electric service - 13,500 V; 440 (3Ph), 240 (3Ph), and 120 (1Ph). Water service - 12-inch main; 60 psi; max flow rate available is 100 gpm, summer months supply is minimal. Water may be contaminated; can haul water from nearby town. Gas service - 2-1/2 inch; 60 psi.

| Contaminants of Concern | Preliminary Remediation Goals *(mg/kg) | Maximum Concentration Detected (mg/kg) | Average Range of Concentrations Above PRGs (mg/kg) |
|---|---|---|---|
| RDX | 10 | 6,000 | 10 - 1,600 |
| 2,4-DNT | 0.98 | 119 | 5 - 33 |
| 2,6-DNT | 0.98 | 33 | 4 - 11 |
| 2,4,6-TNT | 4 | 297,000 | 3,000 - 34,000 |
| 1,3-Dinitrobenzene | 28 | 9.8 | -- |
| HMX | 160 | 2,020 | 300 - 900 |
| Nitrobenzene | 140 | 92.5 | -- |
| Tetryl | 2,800 | 52,000 | 3,600 - 28,000 |
| 1,3,5-Trinitrobenzene | 14 | 430 | 52 - 177 |
| Nitrotoluene | 2,800 | 96 | -- |
| Lead | NA | 576 | 30 - 300 |
| Chromium (1 area only) | NA | 268 | -- |
| Mercury (1 area only) | NA | 3 | -- |

* Preliminary only; will change during RI/FS.
NA Not Available

T/L/DD0

*Center for Hazardous Waste Remediation Research*

University of Idaho

July 24, 1992

Richard E. Johnson, P.E.
SEC Donohue
7200 Hemlock Lane North
Maple Grove, Minnesota 55369

Dear Richard:

Enclosed are our answers to your questionnaire of July 14, 1992. Given the short turnaround time, we have done the best we can. Also enclosed are several supporting documents:

1. Copies of two presentations at the 1992 Annual Meeting of the American Society for Microbiology.
2. A recent paper about dinoseb bioremediation.
3. A copy of a "scale-up" paper (book chapter) about dinoseb bioremediation.

I hope this material is of assistance.

Sincerely,

R. L. Crawford

R. L. Crawford, Ph.D.

encls.

Dr. Ronald L. Crawford
*Co-Director*
Food Research Center 202
University of Idaho
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(208) 885-6580
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University of Idaho
Moscow, Idaho 83843
(208) 885-6429
FAX: (208) 885-6431

## Answers to Questionnaire

### *1.0 Weldon Springs Soil Results*

#### *1.1 Treatability studies*

In the initial batch experiment, with 5% solids (20 g of a soil containing 2,000 mg TNT/kg soil) in 400 ml of a phosphate buffer, TNT in the liquid phase decreased below detectable levels within one week. The soil did not contain any other recognizable explosive compounds.

The soil did not appear to be toxic to the inoculum used and itself contained a natural microflora of bacteria capable of removing TNT.

When soil containing 2,000 mg/kg TNT was mixed into 400 ml of phosphate buffer we observed immediate transfer of TNT to the aqueous phase The initial transfer rate was approximately 0.2 mg TNT/hr; however, because TNT concentrations in the liquid phase were observed to decrease in some cases within the first day, it is difficult to separate TNT transfer from soil to buffer from the degradation of TNT. We can say with confidence that the rate of TNT transfer from soil to buffer was slower than the rate of TNT degradation by the third day of this experiment.

No mineralization studies are being conducted at this time.

TNT is initially reduced to the compound 4-amino-2,6-dinitrotoluene. A second reduction is then observed to 2,4-diamino-6-nitrotoluene and 2,6-diamino-4-nitrotoluene. Both of the diamino compounds decreased below detectable levels within the first thirty days of incubation. Further by-products are being observed, but their identifications have not yet been verified.

There are no verified ring cleavage products identified for Weldon Springs soil. Readily biodegradable, late-stage intermediates (e.g., *p*-cresol) have been identified in other soils.

The dimers or polymers formed from the unstable hydroxylamine intermediates tend to aggregate and precipitate out of the liquid medium. We can determine the presence of polymer in a non-soil TNT degradation study by filtering a well-mixed sample through a Whatman #1 filter and quantifying the retentate. This method gives its best results when used in a labelled study because the amount of radioactivity trapped on the filter indicates the amount of precipitate present. A gross estimate of polymer formation can be obtained by observing the cultures; previous experience has shown that the polymers in question lead to a red-brown color in the liquid phase and can be observed as a shiny brown-red layer on top of the soil or as dense, dark-brown clumps. Although no analytical technique to detect linked TNT molecules has been performed in conjunction with the Weldon Springs soil experiment, there is no visual evidence of these linked compounds.

#### *1.2 Soil composition*

The soil appears to have a relatively high clay content. No soil analyses have been performed, but Charles G. Coyle of the U.S. Army Corps of Engineers, Kansas City, Missouri, has informed us that these analyses will be performed in the near future.

#### *1.3 Experimental methods*

The initial experiment with the Weldon Springs soil was a batch, non-agitated experiment with incubation at 30°C. Twelve flasks were prepared, each containing 20 grams of soil (≈2000 mg TNT/kg soil), 400 ml of a pH 7, 50 mM phosphate buffer containing 20 mM ammonium chloride, and approximately 4 grams of potato starch. This mixture was therefore approximately 5% solids. Half of the cultures were inoculated with a bacterial consortium known in this laboratory as DSA-1, to lower

redox potential by utilizing dissolved oxygen. After two days of incubation, we inoculated half of the cultures (three DSA-1 cultures and three non-inoculated cultures) with 40 ml of an aqueous, sludge-derived, TNT-acclimated culture. Samples were taken from the liquid phase of all flasks and analyzed by our HPLC method.

The first experiment was originally intended merely to confirm the efficacy of the DSA-1 and sludge-culture inoculations, but it was working so well that we extended the experiment. The twelve cultures were given another ≈4 grams of potato starch after approximately four weeks of incubation, and six of the twelve cultures were put into a 30°C shaker incubation chamber to make them aerobic. The other six cultures remained stationary and anaerobic. We intend to determine whether a change in incubation conditions aids the further degradation of some of the late, unidentified degradation products.

A second experiment has been started with the same quantity of soil (at 2000 mg TNT /kg soil), the same amount of starch, and the same quantity of liquid. However, the phosphate "buffer" was adjusted to a range of pH from 6.0 to 6.9. In that experiment, pH was measured and adjusted (if necessary) every other day. Potassium hydroxide and phosphoric acid were used to adjust pH.

### *1.4 Analytical procedures*

All experiments are performed in triplicate and repeated twice. The data are analyzed statistically to determine the significance of any hypotheses derived from data analyses. T-tests, ANOVA, and multiple mean comparisons are computed to allow correct interpretation of comparisons of data values. Trends are summarized graphically with the use of error bars as an indication of confidence in the results.

Representative samples of the aqueous phase of the experimental cultures are obtained daily or as required by the rate of compound removal in the experiments. When the aqueous phase shows complete removal of all of the compounds, then portions of the soil phase are extracted to determine the level of residual compounds. This sampling plan has worked well with the sandy soil from Umatilla, Oregon. The clay soil from Weldon Springs, Missouri, appears to allow a slower release of the contaminant compounds, so it will probably require more monitoring of the soil phase since the biological activity appears to exceed the desorption rate.

The routine analyses of munitions compounds in the aqueous and soil phases of the anaerobic cultures is performed using a Hewlett-Packard HPLC equipped with a UV/visible diode array detector. The column and conditions now in use are as follows: a 250 x 2 mm Phenomonex (Torrance, Calif.) Spherex 5-$\mu$m $C_{18}$ reverse phase column is used for separation in a Hewlett-Packard model 1090A instrument, equipped with a diode-array detector and a computerized data system. The column is run with 10% acetonitrile and 90% 11 mM phosphate buffer (pH 4.0) isocratically for 2 min. The acetonitrile is then increased to 85% in a linear gradient over 15 min. The acetonitrile is then brought to 100% in 1 min and sustained at this level for 2 min. The acetonitrile is then decreased back to 10% over the final 2 min. The solvent flow rate used is 0.4 ml/min, and the column temperature is set at 40°C.

This method provides a baseline separation of the munitions compounds TNT and RDX and the initial metabolic intermediates that are found to accumulate in the aqueous phase of the cultures. The use of the diode array detector, by allowing the spectra of each peak to be compared to that of standard compounds, allows compound identity to be confirmed by a means other than retention time. The quantitation of the concentrations of known compounds is carried out by comparing peak areas to those recorded for a series of known concentrations of standards. The standard curve is run at least once a week, and under the conditions used shows very little variation with time. Correlation coefficients for TNT and RDX standard curves are at least 0.99 or the standards are remade and reanalyzed.

Radiolabeled experiments are conducted by the following protocol: $^{14}$C-U-ring-labeled TNT is added to replicate batch cultures in butyl-rubber-sealed serum bottles to provide 20,000 dpm/ml for intermediary



B07NE003701-05035

metabolism studies and 10,000 dpm/culture for mineralization studies. The cultures are incubated for specific time periods and are sacrificed for final mass balance determinations. These are performed by acidifying the culture to pH 1 with $H_2SO_4$ and then flushing and trapping the volatile compounds in toluene-based flour and the $CO_2$ in Carbosorb in flour. The extent of polymerized or precipitated intermediates is determined by filtration of a mixed sample of the supernatant before acidification through a Whatman-type filter paper. This will retain precipitated material but not cells. The acidified, flushed aqueous phase is filtered through a 22-$\mu$m filter and rinsed with water, 10% TCA, 50% TCA, and methanol. The material remaining on the filter is described as macromolecular material. Intermediates and starting products remaining in the aqueous phase are analyzed by HPLC. Fractions are collected every 1 min during the separation and analyzed by liquid scintillation spectrometry.

### *1.5 Contaminants*

The two soils received from Weldon Springs contained approximately 20,000 mg TNT/kg soil and 50,000 mg TNT/kg soil, respectively. In the initial experiments, the less contaminated soil was mixed with uncontaminated soil to give a final concentration of about 2,000 mg TNT/kg soil. In later experiments, we intend to mix the soil to give a concentration of 5,000 mg TNT/kg soil.

At this time, we have not examined TNT soils for toxicity. We observed bacterial and fungal growth in the current experimental cultures, indicating lack of acute toxicity during bioremediation. We are developing a pollen germination assay as a bioassay of toxicity reduction, but have applied it thus far only to dinoseb-contaminated soils. Biotreatment of dinoseb eliminates toxicity to pollen.

## *2.0 Earlier Treatability Studies*

See poster presentations enclosed.

## *3.0 Scale-Up*

We have no current plans to scale up the remediation process with the Weldon Springs soil. Scale-up plans for TNT soils, however, will be basically similar to our approach with dinoseb-contaminated soils (the largest experiments to date used 11-12 $yd^3$). A copy of a manuscript describing this scale-up is enclosed.

*a.* Screened soil will be added to water, along with starch. The water will be buffered with phosphate, and $NH_4Cl$ may also have to be added.
*b.* We aim for a 50% soil/water mixture. It may be desirable to reach this 50% level by adding soil in several increments.
*c.* A lined pit is still the preferred method, although aboveground containers will also work well.
*d.* The area required for 20,000 $yd^3$ would be 200 yards long by 50 yards wide by 2.5 yards deep. The area required for 6,000 $yd^3$ would be 50 yards long by 50 yards wide by 2.5 yards deep.
*e.* After treatment, we allow solids to settle, pump the water phase off (for land or sewer disposal), air dry the soil, and backfill the treated soil to its original location or to a landfill. The state of Idaho has given permission for this approach with dinoseb-contaminated soils, after they undergo biotreatment.
*f.* Treatment pits should be covered by a simple plastic tarp.
*g.* Wash water from solid screening can be mixed into reactors. Small amounts of surfactants should not affect the microbes.
*h.* If soils contain sulfate, $H_2S$ may cause odors during the late stages of the treatment. This problem can be avoided by converting the system to aerobic conditions after TNT and its biotransformation intermediates are gone. Sulfate reduction occurs after this phase. TNT vapors



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are toxic, but localized. Plastic covers will minimize vapor problems, but workers will need to wear respirators and protective clothing.

*i.* The enclosed book chapter shows some conceptual drawing of a typical pit bioreactor.

### *4.0 Publication Plans*

A publication on dinoseb is already in print (in *Applied and Environmental Microbiology*; enclosed).

Our book chapter (enclosed) is in press and may be out as early as September 1992.

Papers about TNT degradation are now being prepared, and will be out early next year.

### *5.0 Cost Estimates*

We believe soils can be treated by our methods for $110-$200/yd$^3$ . The cost of treatment is discussed in our enclosed book chapter.



B07NE003701-05037

# APPENDIX D4

## VENDOR INFORMATION: THERMAL TREATMENT

**MEMORANDUM**

**DATE:** May 8, 1992

**TO:** Mead NOP FS File

**CC:** Dave Froh

**FROM:** Greg Johnson

**SUBJECT:** Vendor Information Survey - Off-Site Treatment

**Vendor:** Chemical Waste Management, Inc. (CWM)
**Contact:** Judy Sullivan
**Phone:** (708) 513-4577
**Treatment:** Incineration

---

## 1.0 INTRODUCTION

CWM reviewed the site soil and chemical data and indicated that the soils could be incinerated at their Sauget, Illinois, facility.

## 2.0 COSTS

CWM stated that processing costs would be \$0.55 to \$2.20 per pound depending on the BTU value of the soil. Illinois tax would be an additional \$6.06 per cubic yard. Transportation costs would be about \$2,560 per lined 30 cubic yard dump trailer assuming 500 miles from site to Sauget.

If an excavated soil volume of 30,000 cubic yards and a soil density of 100 lbs/ $ft^3$ is assumed, the total cost would be \$47 million to \$181 million as shown below:

Processing Costs:

$$30{,}000\ yd^3 \times 100\ \frac{lbs}{ft^3} \times 27\ \frac{ft^3}{yd^3} = 81{,}000{,}000\ lbs.\ (40{,}500\ tons)$$

\$0.55/lb x 81,000,000 lbs. = \$44,550,000
\$2.20/lb x 81,000,000 lbs. = \$178,200,000

Illinois Tax:

$$30{,}000\ yd^3 \times \$6.60/yd^3 = \$198{,}000$$

Transportation:

$$30{,}000\ yd^3 \times \frac{1\ \text{trailer}}{30\ yd^3} \times \frac{\$2{,}560}{\text{trailer}} = \$2{,}560{,}000$$

Total Cost:

| | |
|---|---|
| 44,550,000 | 178,200,000 |
| 198,000 | 198,000 |
| 2,560,000 | 2,560,000 |
| 47,308,000 | 180,958,000 |

RP/MEADISAD/AE6

MEMORANDUM

**DATE:** May 1, 1992

**TO:** Mead NOP FS File

**CC:** Dave Froh

**FROM:** Greg Johnson

**SUBJECT:** Vendor Information Summary - Thermal Treatment

**Vendor:** Weston Services, Inc. (WSI)
**Contact:** Mike Cosmos
**Phone:** 215-430-7423
**Treatment:** Rotary Kiln Incineration

---

## 1.0 INTRODUCTION

WSI owns and operates a transportable incineration system that has proven effectiveness with explosives-contaminated soils. WSI is currently treating explosives-contaminated soil at the Savanna Army Depot, Savanna, Illinois.

The WSI system employs a two-stage combustion process: a rotary kiln furnace and secondary combustion chamber or afterburner. Additional system components include a hopper/screw feed system, exhaust gas fabric filtration system, ash handling equipment, gas scrubbing system (cooling and neutralization), and induced draft fan and exhaust stack with an optional air heater for plume suppression.

## 2.0 TREATABILITY STUDIES

WSI indicated that treatability studies would not be required to implement their system for explosives treatment.

## 3.0 MOBILIZATION/DEMOBILIZATION

The WSI unit would require 9 to 15 weeks to mobilize at the site. Mobilization would include foundation construction and incinerator erection. Utility requirements would include electric (3,750 amps @ 480 volts), gas (1,700 cfm @ 15 psig) and water (220 gpm/@ 30 psig). The unit placement site must be capable of receiving overweight vehicles with 80,000 lb total load. The area requirements for the unit processes, staging, and residuals would be about 200 ft by 300 ft.



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Regulatory requirements for the WSI process have varied from site to site. The unit has operated under state land pollution and air pollution control permits and federal RCRA Part B and TSCA permits. Actual permit conditions will depend on trial burn results.

## 4.0 PROCESS OPERATIONS

A trial burn is generally required under the operating permit. The trial burn would take about one week to complete with an additional 30 to 90 days for report preparation and approvals.

The process is continuous with an anticipated process rate of 20 tons/hr. However, this rate may vary depending on trial burn results. WSI anticipates a 30 percent down time during process operation.

WSI indicated that their process could easily achieve the preliminary remediation goals. WSI also stated that the soil conditions and metals present would not inhibit the effectiveness of the process.

Based on the maximum contaminant concentrations. WSI indicated that feed material blending may be required. Also, the feed material may require pre-process screening.

WSI employs subcontractors to assemble and dissassemble the unit. The WSI unit requires about 15 to 20 personnel to operate. WSI would perform excavation.

WSI would prefer 7 days of feed storage. Dust controls would be required during material handling.

Process residuals would include scrubber blowdown wastewater, fly ash, and treated soils. The residuals would require sampling and testing to determine disposal requirements. The process would not remove metals; therefore, treated soils and fly ash may require stabilization/fixation prior to disposal.

## 5.0 COSTS

WSI estimates that mobilization/demobilization costs would be about $2,000,000 to $3,000,000 depending on site conditions and permitting requirements. This cost would include site preparation, incinerator foundation and assembly, utility hookup, and permitting.

Trial burn costs are generally $300,000 to $500,000.

WSI process treatment costs would be about $200 to $300 per ton (based on 20 percent moisture content). This cost would include material handling; system operation, monitoring and maintenance; residual sampling and testing; decontamination; and site security. Soil storage and pre-processing of soils would be additional costs.

Excavation cost would be about $50 per cubic yard. This cost would include air monitoring during excavation; however, cleanup confirmation sampling would be an additional cost.

Residual disposal costs will depend on test results.

RP/MEADISAD/AE6

**MEMORANDUM**

**DATE:** July 15, 1992

**TO:** NOP FS File

**CC:** Dave Froh

**FROM:** Greg Johnson

**SUBJECT:** Vendor Information Summary - Thermal Treatment

**Vendor:** Vesta Technology, Ltd.
**Contact:** Patrick A. Phillips, Tricia Jack
**Phone:** 305-978-1300
**Treatment:** Rotary Kiln Incineration

## 1.0 INTRODUCTION

Vesta owns and operates a mobile rotary kiln system. Vesta has worked on several CERCLA sites and has experience treating soil contaminated with PCBs, dioxins, nitrobenzene, and pentachlorophenol as the principle organic hazardous constituent. Although Vesta has no experience with explosives-contaminated soils, Mr. Phillips believed the Vesta system would be effective for this type of waste.

## 2.0 TREATABILITY STUDIES

Mr. Phillips indicated that treatability studies would not be needed. He indicated that characterization data consisting of contaminant concentrations, BTU content, moisture content, and soil type would be sufficient. A 3-day trial burn would be required. Trial burn costs would be between $175,000 and $200,000. The time required for the trial burn would depend on the regulatory review/approval process.

## 3.0 MOBILIZATION/DEMOBILIZATION

Mr. Phillips indicated that the system is modular, mobile, and easy to assemble. Setup can be less than one week after arrival on-site. Mobilization/demobilization costs would be about $100,000. Utility requirements include oxygen/liquid propane gas/fuel oil fuels, 800 amp/480 volt three-phase electrical, and 40 gpm water. No special foundations are required; however, Vesta prefers a level, stable base that is easily cleaned.

## 4.0 PROCESS OPERATIONS

The Vesta system consists of a feed conveyor rotary kiln furnace, secondary combustion chamber, low pressure drop venturi scrubber (quench), packed tower, ionized wet scrubber, exhaust fan, emission stack, and ash conveyor. Additional equipment includes a lamella plate settling tank, filter press, caustic tanks, assorted pumps, control trailer, 18-point data logger, and computer control system.

Scrubber water is recycled. The wet scrubbing system incorporates a system that removes a high proportion of suspended solids and blows the scrubber water into the ash quench. Recirculated scrubber liquids are cooled by means of a closed loop heat exchanger and cooling tower.

Mr. Phillips indicated that pre-processing would be required to declump clay and reduce size of any debris. He stated that the maximum input material size should be about 2-inch diameter. Mr. Phillips stated that pre-process blending would only be required for materials with significantly differing BTU values.

Mr. Phillips stated that the Vesta system process rate was 8,000 to 10,000 lb/hr. He also indicated that the system operates 24 hours/day with 20 percent downtime.

Mr. Phillips stated that based on his experience with clay incineration, that no significant volume change occurs.

Process costs would be approximately $400 to $500 ton. Process costs would include blending, if required, and feed and ash handling, including discharge bins and dust control. These costs also include verification sampling and testing for principal contaminants. Additional parameter testing (TCLP) would not be included. Costs also do not include site preparation, pre-process size reduction, or off-site disposal of any residuals.

DF/ke

RP/MEADFS/AA7

**MEMORANDUM**

**DATE:** July 15, 1992

**TO:** NOP FS File

**CC:** Dave Froh

**FROM:** Greg Johnson

**SUBJECT:** Thermal Treatment Residuals

**Vendor:** Chemical Waste Management Remediation Services
**Contact:** Tim Briggs
**Phone:** 708-218-1711
**Treatment:** Thermal

Solid Residuals

Mr. Briggs indicated that there would be no significant volume change from input soils to output solid residuals. He stated that there may be a 5 to 10 percent net decrease in volume due to loss of moisture and organic content. The decrease would not be as great as the initial water/organic content because the moisture content is increased by post-treatment handling processes such as quenching (cooling) and dust control wetting.

Mr. Briggs indicated that the ash from clay soil is very fine and would require routine wetting to control dust during post-treatment handling. He said we can expect a fly ash volume of about 10 percent of input soil volume. Tim suggested the ash and fly ash streams be combined prior to testing (TCLP) and backfill. He stated that, if required, stabilization/solidification would be readily accomplished and effective for this ash. Tim also stated that the ash would not be difficult to compact if properly wetted.

Liquid Residuals

Mr. Briggs stated that, based on his experience, scrubber water could be used to cool ash (quenching) and for dust control.

He indicated that discharge to surface water under NPDES would be difficult without pre-treatment to remove dissolved solids.

General

As stated in a memorandum dated May 15, 1992, CWM is not interested in this project. They are only interested in projects with soil volumes greater than 20,000 cy. Tim suggested we contact Vesta Technology, Ltd.

DF/ke

RP/MEADFS/AA6

MEMORANDUM

**DATE:** April 30, 1992

**TO:** Mead NOP FS File

**CC:** Dave Froh

**FROM:** Mark Mobley

**SUBJECT:** Vendor Information Summary - Solidification/Stabilization

**Vendor:** Enreco, Inc.
**Contact:** Steve Erlanson
**Phone:** 513-528-3525
**Treatment:** Solidification/Stabilization

---

## 1.0 INTRODUCTION

Solidification/stabilization (S/S) is a process that uses reagents such as lime, fly ash, and portland cement and calcium oxide to solidify and chemically stabilize inorganic and organic wastes. In some cases, admixtures of proprietary compounds are added to assist in immobilization of organic wastes.

Enreco uses two systems to stabilize wastes. The first is a pug mill system (on-site) and the second is a rotary mixing system (in-situ). Steve Erlanson provided information on the application of both systems to the contaminated soils at the Mead site.

Three objectives were defined so that Steve Erlanson would be able to provide specific costs and information to determine whether or not our objectives could be met. The objectives are:

- Prevent explosives migration.
- Solidify sludges for the purpose of passing the paint filter test so that disposal of waste will be a viable option.
- Chemically alter the explosives such that they are less soluble and more chemically stable.

Mr. Erlanson provided information on the process variations and cost variations expected based on those three objectives. This summary refers to the objectives, and to the two systems that Enreco utilizes, throughout.

## 2.0 TREATABILITY STUDIES

Treatability studies would be required to determine whether or not the goal stated in Section 1.0 could be achieved. Treatability studies consist of chemical analysis, a batch of mixes, and evaluation of physical tests followed by a subsequent test of two to three mixes to try and determine process rates reagent to water to soil ratios and other process parameters. Mr. Erlanson estimated costs and duration of treatability studies for the three objectives stated in Section 1.0, respectively, as follows:

- $10,000 6 to 8 weeks
- $5,000 2 to 4 weeks
- $15,000 6 to 8 weeks

Mr. Erlanson indicated that these costs and durations reflect plus or minus 20 percent variation and should be considered as such.

## 3.0 MOBILIZATION/DEMOBILIZATION

Mobilization is anticipated to take approximately 2 weeks and require approximately 1 week of site preparation in addition to that. Approximately 6 people would be required for the rotary mixing system, while 12 people would be required for the pug mill system. The duration of mobilization would not vary depending on systems.

Utility requirements are different for the pug mill system and rotary mixing system. For the pug mill, electrical requirements and water stated in Table 1 are adequate. Mr. Erlanson indicated that a generator could be used if adequate power is not available for the pug mill system. The rotary mixing system does not require electrical power as it is a self-powered unit and supplies its own operating energy. However, water would be required to add to soil if the soil does not contain enough water to hydrolize reagents that are added.

Special site access needs are limited to access road improvements to accommodate trailers for the pug mill system. Such access roads would not be needed for the rotary mixing system.

Approximately 1/2-acre would be required for the pug mill and 1/4-acre for staging equipment for the pug mill system. The rotary mixing system would require 1/4-acre for staging equipment and reagents but would not require the additional 1/2-acre as would the pug mill.

Mobilization costs were estimated at $50,000 for the pug mill and $20,000 for the rotary mixing system.



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## 4.0 PROCESS OPERATIONS

The expected duration of treatment was estimated at 40 days. Mr. Erlanson indicated that this was 40 working days, and if weekends were not included in working days the schedule should be extended accordingly.

Typically, regulatory requirements are not a problem for this process.

Mr. Erlanson was not able to say whether the preliminary cleanup levels identified in Table 1 would be achieved by the process. This will be determined during treatability studies.

Factors inhibiting the effectiveness of the process are more sensitive in the pug mill system where if 10 percent solids or below or 60 percent solids or above are indicative of the wastes, the pug mill system will operate well. However, between 10 and 60 percent solids, the pug mill system will not operate as well due to clogging and sticking in the mechanism. Mr. Erlanson indicated that there are several types of pug mill systems and that they are more costly to operate than the rotary mixing system.

Process streams and personnel required differ between the pug mill and rotary mixing system. For the pug mill, there is one processing stream in and one processing stream out. The processing stream in includes reagent and water as it does for the rotary mixing system. However, the rotary mixing system does not require process waste to be put through the system. Rather, the rotary mixing system is a piece of earthwork equipment that has been modified such that it can be driven over the contaminated wastes treating them in-situ.

Materials preparation and storage requirements also differ between the two systems. The pug mill system requires approximately one days worth of feed which equates to approximately 500 cubic yards, while the rotary mixing system does not require any materials preparation or temporary storage area. The rotary mixing system is an in-situ process and because the equipment drives over the waste to be treated, materials handling and preparation are not needed. However, if the rotary mixing system is used contaminants will have to be treated in lifts of approximately 1.5 feet. That is, treatment will occur on 2 feet and then 1.5 feet will be removed and placed in a final disposal area. The next layer will be treated in a similar manner, etc., until all layers have been treated to the desired depth. This method is limited to 5 to 10 feet at best.

The only emissions control requirements are for fugitive emissions associated with earthwork.

No process residuals are anticipated from either of these processes.

Both of Enreco's processes are considered continuous processes which process soil at a rate of approximately 500 cubic yards per day. The rate of 500 cubic yards per day includes downtime, maintenance, and seasonal variation.

Enreco does not typically subcontract excavation or other work. However, they sometimes work as a subcontractor for a full-service remediation firm and only perform solidification/stabilization work.

Technologies which may be useful in conjunction with this process include fixation or chemical conversion of waste to another form prior to stabilization and desorption. Desorption is the physical/chemical attraction of waste to medium added to the waste.

Decontamination and site security are not of special interest or concern for Enreco's processes.

Additional site information required is limited to a list of specific objectives for treatability studies. Without treatability studies no additional information would be helpful to further define costs or other parameters.

Enreco does not have experience with explosives treatment but is interested in the potential for using their processes in the treatment of explosives. However, subsequent conversations with Enreco chemists indicated that they did not expect successful application of solidification/stabilization in explosives.

## 5.0 COSTS

Costs for treatment vary for the two systems that Enreco uses. The rotary mixing system would cost approximately $25 to $35 for cubic yard. The primary factor affecting cost is type and quantity of reagent used. Mr. Erlanson estimated that costs are related as follows:

| | |
|---|---|
| Mobilization/Demobilization | 20 percent |
| Reagents | 60 percent |
| Labor | 10 percent |
| Equipment | 10 percent |

The pug mill system would cost the same but would have additional costs for materials handling while the rotary mixing system would not. Costs to be added by the FS staff include material handling, and that includes adding a dump truck under the hopper from a pug mill system. The rotary mixing system would not require materials handling cost to be added. Mr. Erlanson indicated that site monitoring including health and safety air monitoring, post treatment sampling, personal protection, and extent of contamination testing are included in the process cost.

**MEMORANDUM**

**DATE:** August 3, 1992

**TO:** Mead NOP FS File

**CC:** Dave Froh

**FROM:** Mark J. Mobley

**SUBJECT:** Laboratory Analysis Quote for BTU

**Vendor:** Twin City Testing (TCT)
**Contact:** Amy Sumariwalla, Laboratory Director
**Phone:** (314) 426-0880

## 1.0 INTRODUCTION

Ms. Sumariwalla provided a cost quote for soil BTU analysis during thermal treatment under Alternative 4.

## 2.0 COSTS

The cost was quoted as $33/sample, plus an increase by a factor of 1.5 for 48-hour turnaround (for up to 15 samples at a time), or:

$33/sample x 1.5 = $50/sample.

MM/ke

RP/MEADFS/AE1

**MEMORANDUM**

**DATE:** July 28, 1992

**TO:** NOP FS File

**CC:** Dave Froh

**FROM:** Sarah Levin

**SUBJECT:** In-Situ Vitrification

**Vendor:** Geosafe
**Contact:** James Hansen
**Phone:** 509-375-0710

## 1.0 INTRODUCTION

During a previous conversation with Geosafe (April 30, 1992), Mr. Hansen indicated that some clays contain no alkali earth metals and require soda ash addition prior to vitrification. Alkali earth metals are required to keep operating costs down and to minimize potential equipment damage. Geosafe was contacted again to determine if soda ash is commonly needed and how much soda ash costs.

## 2.0 RESULTS

Most naturally occurring soil contain enough (2 to 5 weight percent) alkali earth metals for vitrification. The clays that require soda ash addition are highly leached and consist of almost pure silica and alumina. Such soil only occurs along seaboards or in areas that were once covered by seas. It is not likely, therefore, that soda ash would be required. Geosafe has only encountered three such clays during approximately 35 projects. To determine if the clay contains adequate alkali metals, a "whole rock" analysis should be performed to determine oxide content. This analysis costs approximately $100 per sample. Mr. Hansen indicated that a sample from an uncontaminated portion of the site could be used for the whole rock analysis. If soda ash is required for NOP soil (which is not likely), it would cost approximately $160 per ton. The soda ash could be easily added during staging and blending activities.

RP/MEADFS/AC6

**MEMORANDUM**

**DATE:** September 4, 1992

**TO:** NOP FS File

**FROM:** David Heim

**SUBJECT:** Vendor Information Summary - Circulating Fluidized Bed Combustion

**Vendor:** Ogden Environmental Services
**Contact:** Mark White
**Phone:** 619-455-4351
**Treatment:** Thermal

I inquired about circulating fluidized bed combustion (CBC) services at Ogden, and Mr. White told me that they no longer perform that service. He said there were problems with the feed systems, and often costs were not competitive with other types of thermal treatment. Ogden is trying to sell or lease their CBC units to other firms who may wish to provide treatment service. At this point in time, none are active and there are no other CBC service providers that he is aware of.

DH/bjz

RP/MEADFS/AQ4

# APPENDIX D5

## VENDOR INFORMATION: CONTAINMENT/DISPOSAL

**MEMORANDUM**

**DATE:** April 22, 1992

**TO:** Mead NOP FS Files

**CC:** Dave Froh

**FROM:** Chandler Taylor

**SUBJECT:** Vendor Information Summary - Off-Site Hauling

**Vendor:** Jack Gray Trucking
**Contact:** Mike Fejes
**Phone:** 219-938-7020
**Treatment:** Off-Site Hauling for Treatment or Disposal

---

The price quoted during a previous contact was confirmed by Mr. Fejes at $2.63/loaded mile. Less than 150 miles would be $4.50/loaded mile and more than 1,000 miles would be about $2.73/loaded mile. These all apply to 22-ton trucks. Liners would be an additional $25/truckload. Other additional costs might be due to state permitting, depending where the waste is disposed.

RP/MEADISAD/AD1



B07NE003701-05056

**MEMORANDUM**

**DATE:** May 25, 1993

**TO:** Former NOP File

**FROM:** David Heim

**SUBJECT:** Availability of Subtitle C Landfill

**Vendor:** Chemical Waste Management
**Contact:** Marguerite Raminsky
**Phone:** (708) 513-4334

---

I asked Ms. Raminsky about availability of landfill space at the CID Landfill in Calumet City, Illinois. She said that there was ample landfill space for 30,000 cubic yards of material in the RCRA Subtitle C landfill. She also said that the waste would have to meet landfill permit requirements, but there were no other restrictions. There may be some concern if the waste was a listed hazardous waste, regarding RCRA land ban requirements. I told her that we had a price list for special wastes, including taxes, effective date 1/1/91. Ms. Raminsky said that those prices were still effective.

RP/MEADISAD/AE6

Chemical Waste Management, Inc.

CID Treatment Center
P.O. Box 1296
138th and Calumet Expressway
Calumet City, Illinois 60409
312/646-6060
Fax: 312/646-6809

**CWM/CID**

**SPECIAL WASTE RATES/TAXES**

**(EFFECTIVE 1/1/91)**

## Rates

Direct Disposal

Bulk Solids . . . . . $150.00/ton *

Waste transported in skaff bags or similar containers (for direct disposal only) will be charged bulk rates with an additional $30.00 handling fee per bag.

Stabilization

Bulk Solids (Subtitle C Disposal) . . . . . $230.00/ton *
Bulk Solids (Subtitle D Disposal) . . . . . $135.00/ton *

The above stabilization rates assume the use of standard reagent recipes; difficult-to-treat waste streams will be priced on a case-by-case basis.

NOTE: The above disposal and stabilization rates do not include applicable state and local fees/taxes as listed below.

## Fees/Taxes

Direct Disposal

Bulk Hazardous Solids (State) . . . . . $ 18.18/cu. yd.
Bulk Hazardous Solids (Calumet City) . . . . . $ 5.00/cu. yd.
Bulk Non-Hazardous Solids (State) . . . . . $ 0.60/cu. yd.
(Unless Excluded)

Stabilization

Bulk Hazardous Solids (State) . . . . . $ 6.06/cu. yd.

* Assumes a minimum density of 2,000 pounds per cubic yard; if less, rate will be charged on a "per yard" basis or the price per ton will be adjusted.

**MEMORANDUM**

**DATE:** September 1, 1992

**TO:** Mead NOP FS File

**CC:** Dave Froh

**FROM:** Mark Mobley

**SUBJECT:** Flexible Membrane Liner (FML) and Geosynthetics Costs

Costs for FMLs and geotextiles are from the attached agreement between Waste Management of North America and National Seal Company.

attach: As Noted

RP/MEADFS/AP4

19470.200

Waste Management of North America, Inc.
[illegible]

LETTER AGREEMENT

December 10, 1991

National Seal Company
1245 Corporate Boulevard
Suite 300
Aurora, IL 60504

ATTENTION: Mr. John Hardison, President

Dear Mr. Hardison:

This Letter Agreement, between National Seal Company (NSC) and Waste Management of North America (WMNA), establishes terms, conditions, and pricing for the supply and installation of geosynthetic materials. NSC agrees to sell to WMNA the materials and services specified herein. These services shall be performed and materials provided consistent with the following:

1. Pricing of the work performed by NSC for WMNA shall be as defined in Letter Agreement Attachment I: "Standard Pricing Terms" with changes as necessary to reflect project-specific requirements. Pricing is subject to annual updating as of the first of the calendar year.

2. All work performed by NSC will be governed by one of the following two agreements:

- **Agreement for Supply and Installation of Geosynthetic Materials (ASIGM):** The ASIGM, included herein as Letter Agreement Attachment II, is the preferred agreement for projects that consist primarily of the supply and installation of geosynthetic materials. The ASIGM is to include extensive project specific requirements including plans and specifications. The primary pricing structure of the ASIGM is unit pricing, with payments made on actual quantities supplied and installed. Non-standard items, including winter installation services and change orders, are performed on a cost reimbursable basis at the respective rates defined in Letter Agreement Attachment I.

- Limited Services Agreement (LSA): The LSA, included herein as Letter Agreement Attachment III, is the preferred agreement on geosynthetic repair projects for which the scope of work can not be accurately defined in advance. Geosynthetic materials supplied under the LSA are provided at the standard unit pricing. Services performed under the LSA are done on a cost reimbursable basis at the LSA rates defined in Letter Agreement Attachment I.

One of the above Agreements will be executed for each project performed by NSC with the WMNA entity authorizing the performance of the work. The terms and conditions of the Agreement are not subject to further negotiation between NSC and the WMNA facility authorizing the work, except to add project-specific information.

Very truly yours,
WASTE MANAGEMENT OF NORTH AMERICA

Signature: William P. Hulligan

Printed Name: William P. Hulligan

Title: President

THE ABOVE TERMS AGREED to by John L. Hardison, the Authorized Agent of National Seal Company this 17th day of December, 1991.

Signature: [illegible]

Printed Name: John L. Hardison

Title: President

LETTER AGREEMENT ATTACHMENT I BETWEEN

STANDARD PRICING TERMS

Effective January 1, 1992 through December 31, 1992

Pricing of Supply and installation of geosynthetic materials by NSC shall be based on the following provisions:

Price Adjustments Due To Changes In Raw Material Cost

If raw material prices increase, or decrease, after the date of this contract, the actual increase, or decrease, in the cost of the raw materials will be added to, or deducted from, the prices reflected herein. When adjusting the prices due to changes in raw material cost there shall be no allowance for overhead or profit. NSC will provide documentation substantiating any change in price resulting from the application of this paragraph. For purposes of this paragraph "raw materials" includes products purchased for resale from others including geotextiles and bentonite mats.

Basis For Charges

Charges for materials shall be based on quantities actually shipped. Charges for installation services other than cost reimbursable work shall be based on measured in place quantities with an allowance for anchor trenches. Cost reimbursable rates are included at the end of this Letter Agreement Attachment I. Differing rates apply for the following three categories of cost reimbursable work:

1. Level IV (winter) installation
2. Change order work under the WMNA/NSC ASIGM
3. Repair work or other miscellaneous unscoped work performed under the WMNA/NSC LSA.

Labor Wages

Installation pricing is based on a work week composed of six ten hour days using non-union, non-prevailing wage labor rates. In the event that union labor or prevailing wage labor is necessary, a surcharge equal to the total increase in labor costs plus fifteen percent (15%) will be added.

Scheduling of Work

NSC forces will work 10 hour days, Monday through Saturday. The following days are Company holidays and work will not be scheduled:

| | |
|---|---|
| Memorial Day | July 4 |
| Labor Day | Thanksgiving (2 days) |
| December 23 through January 2 | |

Work will be performed on these days at a site specific negotiated rate.

Standby Time

No Standby allowances are included in this Agreement. Standby Time as defined in Article 3.3 of the General Specifications will be reimbursed as specified herein.

Health and Safety

1) Pricing is based on NSC supplying safety equipment consisting of hardhats and safety glasses only. Additional safety equipment will be supplied by NSC and the cost will be addressed in the site specific documents.

2) If physical examinations or site specific health monitoring are required before, during or after the installation, the cost will be addressed as a separate cost item in the site specific documents.

Freight and Taxes

All prices are F.O.B. Jobsite - Freight will be prepaid and added to the Application for Payment at actual cost. Prices do not include applicable Federal, State or Local Sales, Use or Excise taxes, if any. Cost of freight and applicable taxes will be estimated as separate items in NSC's proposal and will be listed as separate line items in NSC's Application for Payment. If tax exempt status is claimed, WMNA must provide NSC with proper documentation.

Additional detailed terms and conditions upon which pricing is based are included in the General Conditions and General Specifications of the "Agreement For Supply and Installation of Geosynthetic Materials".

## 41000 GENERAL REQUIREMENTS

| | |
|---|---|
| 41002 Demobilization and Remobilization (together considered one event) | $1,400 plus<br>$ 750 per crew member per event |
| 41003 Standby Charges | $1,500 plus<br>$ 300 per crew member per day |
| 41300 Submittals | Project Specific |
| 41400 Quality Control Activities | Project Specific |
| 41500 Temporary Facilities | Project Specific |
| 41800 Health and Safety Requirements | Project Specific |
| 41850 Labor Surcharge | Project Specific |
| 70100 Taxes | Project Specific |
| 72000 Freight | Project Specific |

## 42000 SITE WORK

### NSC Material and Level II Installation Pricing

### Effective 01/01/92 through 12/31/92

SYNTHETIC LINER

MATERIAL SUPPLY - HDPE

| | | |
|---|---|---|
| A.1. | Supply 40 mil HDPE | |
| A.1.1 | Smooth | $0.163/FT² |
| A.1.2. | Textured/One Side | $0.220/FT² |
| A.1.3. | Textured/Two Sides | $0.251/FT² |
| A.2. | Supply 60 mil HDPE | |
| A.2.1. | Smooth | $0.244/FT² |
| A.2.2. | Textured/One Side | $0.314/FT² |
| A.2.3. | Textured/Two Sides | $0.345/FT² |
| A.3. | Supply 80 mil HDPE | |
| A.3.1. | Smooth | $0.326/FT² |
| A.3.2. | Textured/One Side | $0.408/FT² |
| A.3.3. | Textured/Two Sides | $0.439/FT² |
| A.4. | Supply 100 mil HDPE | |
| A.4.1. | Smooth | $0.408/FT² |
| A.5. | Raw Material Reference Price | $0.360/LB |

MATERIAL SUPPLY - VLDPE

| | | |
|---|---|---|
| B.1. | Supply 40 mil VLDPE | |
| B.1.1. | Smooth | $0.183/FT² |
| B.1.2. | Textured/One Side | $0.264/FT² |
| B.1.3. | Textured/Two Sides | $0.281/FT² |
| B.2. | Supply 60 mil VLDPE | |
| B.2.1. | Smooth | $0.273/FT² |
| B.2.2. | Textured/One Side | $0.352/FT² |
| B.2.3. | Textured/Two Sides | $0.386/FT² |
| B.3. | Supply 80 mil VLDPE | |
| B.3.1. | Smooth | $0.365/FT² |
| B.3.2. | Textured/One Side | $0.457/FT² |
| B.3.3. | Textured/Two Sides | $0.492/FT² |
| B.4. | Raw Material Reference Price | $0.430/LB |

MATERIAL SUPPLY - CO-EX SEAL

| | | |
|---|---|---|
| C.1. | Supply 40 mil | |
| C.1.1. | Smooth | $0.196/FT² |
| C.1.2. | Textured/One Side | $0.264/FT² |
| C.1.3. | Textured/Two Sides | $0.301/FT² |
| C.2. | Supply 60 mil | |
| C.2.1. | Smooth | $0.293/FT² |
| C.2.2 | Textured/One Side | $0.377/FT² |
| C.2.3 | Textured/Two Sides | $0.414/FT² |
| C.3. | Supply 80 mil | |
| C.3.1 | Smooth | $0.391/FT² |
| C.3.2 | Textured/One Side | $0.490/FT² |
| C.3.3 | Textured/Two Sides | $0.527/FT² |
| C.4. | Raw Material Reference Price | $0.430/LB |

## 42000 SITE WORK

### NSC Material and Level II Installation Pricing

**Effective 01/01/92 through 12/31/92**

**LEVEL II INSTALLATION - HDPE**

| | | 40 & 60 Mil | 80 & 100 Mil |
|---|---|---|---|
| D.1. | Less than 160,000 Square Feet (Per Layer) | | |
| D.1.1. | Single Lined Smooth | $0.210/FT² | $0.220/FT² |
| D.1.2. | Double Lined Smooth | $0.223/FT² | $0.234/FT² |
| D.1.3. | Single Lined Textured | $0.242/FT² | $0.254/FT² |
| D.1.4. | Double Lined Textured | $0.258/FT² | $0.271/FT² |
| D.2. | 160,001 to 305,000 Square Feet (Per Layer) | | |
| D.2.1. | Single Lined Smooth | $0.160/FT² | $0.170/FT² |
| D.2.2. | Double Lined Smooth | $0.173/FT² | $0.184/FT² |
| D.2.3. | Single Lined Textured | $0.192/FT² | $0.204/FT² |
| D.2.4. | Double Lined Textured | $0.208/FT² | $0.221/FT² |
| D.3. | 305,001 to 522,000 Square Feet (Per Layer) | | |
| D.3.1. | Single Lined Smooth | $0.150/FT² | $0.160/FT² |
| D.3.2. | Double Lined Smooth | $0.162/FT² | $0.173/FT² |
| D.3.3. | Single Lined Textured | $0.180/FT² | $0.192/FT² |
| D.3.4. | Double Lined Textured | $0.194/FT² | $0.208/FT² |
| D.4. | More than 522,001 Square Feet (Per Layer) | | |
| D.4.1. | Single Lined Smooth | $0.120/FT² | $0.130/FT² |
| D.4.2. | Double Lined Smooth | $0.130/FT² | $0.141/FT² |
| D.4.3. | Single Lined Textured | $0.144/FT² | $0.156/FT² |
| D.4.4. | Double Lined Textured | $0.156/FT² | $0.169/FT² |
| D.5. | Tie-In Seam to Existing Liner | | |
| D.5.1. | 0-500 LF | | $9.60/LF |
| D.5.2. | 501-2000 LF | | $7.35/LF |
| D.5.3. | 2001 LF and up | | $5.85/LF |
| D.6. | Standard Separation/Rain Flap Installation - Single Weld | | |
| D.6.1. | 0-500 LF | | $8.60/LF |
| D.6.2. | 501-2000 LF | | $6.65/LF |
| D.6.3. | 2001 LF and up | | $5.30/LF |
| D.7. | Optional Separation/Rain Flap Installation - Three Welds | | |
| D.7.1. | 0-500 LF | | $13.73/LF |
| D.7.2. | 501-2000 LF | | $12.83/LF |
| D.7.3. | 2001 LF and up | | $11.98/LF |
| D.8. | Pipe Penetration Attachment | | |
| D.8.1. | 2" Diameter to 12" Diameter | | $110.00 each |
| D.8.2. | 13" Diameter to 24" Diameter | | $165.00 each |
| D.8.3. | 25" Diameter and up | | $260.00 each |
| D.8.4. | Mechanical Attachment to any concrete | | $17.80/LF |
| D.9. | Steep Slope Surcharge | | |
| D.9.1. | Slopes between 2:1 and 3:1 Horizontal: Vertical | | $0.094/FT² |
| D.9.2. | Slopes between 1:1 and 2:1 Horizontal: Vertical | | $0.133/FT² |

**MATERIAL SUPPLY - POLY-NET**

| | | |
|---|---|---|
| E.1. | Supply PN3000 | $0.164/FT² |
| E.2. | Supply PN 3000CN (Foamed) | $0.143/FT² |
| E.3. | Supply PN3000 VRP (Regrind) | $0.159/FT² |
| E.4. | Raw Material Reference Price | $0.360/LB |

## 42000 SITE WORK

### NSC Material and Level II Installation Pricing

### Effective 01/01/92 through 12/31/92

**LEVEL II INSTALLATION - POLY-NET**

| | | |
|---|---|---|
| F.1. | Install PN3000 or PN3000 CN | $0.045/FT² |
| F.2. | Steep Slope Surcharge | |
| F.2.1. | Slopes between 2:1 and 3:1 Horizontal: Vertical | $0.012/FT² |
| F.2.2. | Slopes between 1:1 and 2:1 Horizontal: Vertical | $0.017/FT² |

**MATERIAL SUPPLY - POLYESTER GEOTEXTILE (HOECHST - TREVIRA)**

| | | |
|---|---|---|
| G.1. | 4.0 oz. | $0.40/YD² |
| G.2. | 6.0 oz. | $0.53/YD² |
| G.3. | 7.0 oz. | $0.67/YD² |
| G.4. | 8.0 oz. | $0.72/YD² |
| G.5. | 10.0 oz. | $0.93/YD² |
| G.6. | 12.0 oz. | $1.11/YD² |
| G.7. | 13.0 oz. | $1.22/YD² |
| G.8. | 16.0 oz. | $1.46/YD² |

"Note - Add one cent ($0.01) per square yard surcharge for flat bed delivery."

**MATERIAL SUPPLY - POLYPROPYLENE GEOTEXTILE (AMOCO)**

| | | EASTERN U.S. | WESTERN U.S.* |
|---|---|---|---|
| H.1. | 4.0 oz. | $ 0.34/YD² | $ 0.36/YD² |
| H.2. | 6.0 oz. | $ 0.51/YD² | $ 0.54/YD² |
| H.3. | 8.0 oz. | $ 0.67/YD² | $ 0.70/YD² |
| H.4. | 10.0 oz. | $ 0.84/YD² | $ 0.88/YD² |
| H.5. | 12.0 oz. | $ 1.00/YD² | $ 1.05/YD² |
| H.6. | 16.0 oz. | $ 1.34/YD² | $ 1.40/YD² |

* West of the Mississippi River

**LEVEL II INSTALLATION - GEOTEXTILE**

| | | |
|---|---|---|
| I.1. | Install any geotextile with overlap of seams | $ 0.045/FT² |
| I.2. | Install any geotextile with sewing of seams | $ 0.065/FT² |
| I.3. | Steep Slope Surcharge | |
| I.3.1. | Slopes between 2:1 and 3:1 Horizontal: Vertical | $ 0.014/FT² |
| I.3.2. | Slopes between 1:1 and 2:1 Horizontal: Vertical | $ 0.019/FT² |

**MATERIAL SUPPLY - TEX-NET GEOCOMPOSITE**

| | PN3000 | |
|---|---|---|
| J.1. | TN3001 1125 - 1 side | $ 0.349/FT² |
| J.2. | TN3002 1125 - 2 sides | $ 0.449/FT² |
| J.3 | TN3001 1127 - 1 side | $ 0.356/FT² |
| J.4. | TN3002 1127 - 2 sides | $ 0.463/FT² |
| J.5. | TN3001 1135 - 1 side | $ 0.383/FT² |
| J.6 | TN3002 1135 - 2 sides | $ 0.518/FT² |
| J.7 | TN3001 1142 - 1 side | $ 0.405/FT² |
| J.8. | TN3001 1142 - 2 sides | $ 0.566/FT² |
| J.9. | TN3001 1155 - 1 side | $ 0.448/FT² |
| J.10. | TN3002 1155 - 2 sides | $ 0.652/FT² |

## 42000 SITE WORK

### NSC Material and Level II Installation Pricing

**Effective 01/01/92 through 12/31/92**

PN3000CN

| | | |
|---|---|---|
| J.11. | TN3001CN 1125 - 1 side | $ 0.306/FT² |
| J.12. | TN3002CN 1125 - 2 sides | $ 0.413/FT² |
| J.13. | TN3001CN 1127 - 1 side | $ 0.313/FT² |
| J.14. | TN3002CN 1127 - 2 sides | $ 0.427/FT² |
| J.15. | TN3001CN 1135 - 1 side | $ 0.340/FT² |
| J.16. | TN3002CN 1135 - 2 sides | $ 0.482/FT² |
| J.17. | TN3001CN 1142 - 1 side | $ 0.362/FT² |
| J.18. | TN3002CN 1142 - 2 sides | $ 0.526/FT² |
| J.19. | Raw Material Reference Price | $ 0.360/LB |

LEVEL II INSTALLATION - TEX-NET GEOCOMPOSITE

| | | |
|---|---|---|
| K.1. | Install any Tex-Net with Heat Bond | $ 0.087/FT² |
| K.2. | Install any Tex-Net with Sewing | $ 0.108/FT² |
| K.3. | Steep Slope Surcharge | |
| K.3.1. | Slopes between 2:1 and 3:1 Horizontal: Vertical | $ 0.025/FT² |
| K.3.2. | Slopes between 1:1 and 2:1 Horizontal: Vertical | $ 0.035/FT² |

MATERIAL SUPPLY - BENTONITE MAT

| | | |
|---|---|---|
| L.1. | Supply Bentonite Mat | $ 0.510/FT² |

LEVEL II INSTALLATION - BENTONITE MAT

| | | |
|---|---|---|
| M.1. | Install Bentonite Mat | $ 0.155/FT² |
| M.2. | Steep Slope Surcharge | |
| M.2.1. | Slopes between 2:1 and 3:1 Horizontal: Vertical | $ 0.040/FT² |
| M.2.2. | Slopes between 1:1 and 2:1 Horizontal: Vertical | $ 0.057/FT² |

MATERIAL SUPPLY - REINFORCEMENT GRID

| | | |
|---|---|---|
| N.1. | Biaxial Grid | |
| N.1.1. | BX100060 | $0.095/FT² |
| N.1.2. | BX110060 | $0.133/FT² |
| N.1.3. | BX120060 | $0.246/FT² |
| N.2. | Uniaxial Grid | |
| N.2.1 | UX140019 | $0.425/FT² |
| N.2.2 | UX150019 | $0.661/FT² |
| N.2.3 | UX160019 | $0.898/FT² |
| N.2.4 | UX170019 | $1.208/FT² |
| N.3. | Bodkin Splice Bars | $2.470/EA |

## INSTALLATION PRICING SEASONS

The various pricing levels will apply during the following pricing seasons:

| STATE | LEVEL I | LEVEL II | LEVEL III | LEVEL IV |
|---|---|---|---|---|
| Alabama | Jan.-April | May-Aug. | Sept.-Dec. | N/A |
| Alaska | N/A | May-Aug. | N/A | Sept.-April |
| Arizona | Jan.-April | May-July | Aug.-Dec. | N/A |
| Arkansas | March-May | June-Sept. | Oct.-Nov. | Dec.-Feb. |
| California | Jan.-April | May-July | Aug.-Dec. | N/A |
| Colorado | May-June | July-Aug. | Sept.-Oct. | Nov.-April |
| Connecticut | April-May | June-Aug. | Sept.-Nov. | Dec.-March |
| Delaware | March-May | June-Aug. | Sept.-Nov. | Dec.-Feb. |
| Florida | Dec.-April | May-July | Aug.-Nov. | N/A |
| Georgia | Dec.-April | May-July | Aug.-Nov. | N/A |
| Hawaii | Jan.-March | April-Aug. | Sept.-Dec. | N/A |
| Idaho | May-June | July-Aug. | Sept.-Oct. | Nov.-April |
| Illinois | April-May | June-Aug. | Sept.-Nov. | Dec.-March |
| Indiana | April-May | June-Aug. | Sept.-Nov. | Dec.-March |
| Iowa | April-May | June-Aug. | Sept.-Nov. | Dec.-March |
| Kansas | April-May | June-Aug. | Sept.-Nov. | Dec.-March |
| Kentucky | April-May | June-Aug. | Sept.-Nov. | Dec.-March |
| Louisiana | Jan.-March | April-Aug. | Sept.-Dec. | N/A |
| Maine | N/A | April-Oct. | N/A | Nov.-March |
| Maryland | March-May | June-Aug. | Sept.-Nov. | Dec.-Feb. |
| Massachusetts | N/A | April-Oct. | N/A | Nov.-March |
| Michigan | N/A | April-Oct. | N/A | Nov.-March |
| Minnesota | N/A | April-Oct. | N/A | Nov.-March |
| Mississippi | Jan.-April | May-Aug. | Sept.-Dec. | N/A |
| Missouri | March-May | June-Aug. | Sept.-Nov. | Dec.-Feb. |
| Montana | N/A | May-Sept. | N/A | Oct.-April |

42000 SITE WORK

NSC Material and Level II Installation Pricing

Effective 01/01/92 through 12/31/92

LEVEL II INSTALLATION - REINFORCEMENT GRIDS

| | | |
|---|---|---|
| O.1. | Install Biaxial Grids | $0.07/FT$^2$ |
| O.2. | Install Uniaxial Grids | $0.07/FT$^2$ |
| O.3. | Steep Slope Surcharge | |
| | O.3.1. Slopes between 2:1 and 3:1 Horizontal: Vertical | $0.012/FT$^2$ |
| | O.3.2. Slopes between 1:1 and 2:1 Horizontal: Vertical | $0.017/FT$^2$ |

MISCELLANEOUS PRODUCTS

MATERIAL SUPPLY

| | | |
|---|---|---|
| P.1. | NSC Enviro Lock Concrete Anchor | $2.63/LF |
| P.2. | Amoco 2002 (200# Slit Film) | $0.43/YD$^2$ |
| P.3. | Amoco 2006 (300# Slit Film) | $0.57/YD$^2$ |
| P.4. | Amoco 2125 (Silt Fence) | $0.31/YD$^2$ |
| P.5. | Amoco 2044 (High Strength Woven) | $1.41/YD$^2$ |

ALTERNATE DAILY COVER-SANI-COVER™

MATERIAL SUPPLY

| | | |
|---|---|---|
| Q.1. | 100 Nonwoven Polypropylene-Standard Size (105 Ft x 100 Ft) | $0.135/FT$^2$ |
| Q.2. | 150 Nonwoven Polypropylene-Custom Size | $0.150/FT$^2$ |
| Q.3. | 200 Woven Slit Film Polypropylene-Standard Size (90 Ft x 83 Ft) | $0.135/FT$^2$ |
| Q.4. | 250 Woven Slit Film Polypropylene-Custom Size | $0.150/FT$^2$ |
| Q.5. | 300 Nonwoven Polyester-Standard Size (105 Ft x 100 Ft) | $0.135/FT$^2$ |
| Q.6. | 350 Nonwoven Polyester-Custom Size | $0.150/FT$^2$ |

(A.D.C. Material invoiced by Fluid Systems, Inc., a wholly owned subsidiary.)

| | | | | |
|---|---|---|---|---|
| Nebraska | April-May | June-Aug. | Sept.-Nov. | Dec.-March |
| Nevada | March-May | June-Aug. | Sept.-Dec. | Jan.-Feb. |
| New Hampshire | N/A | April-Oct. | N/A | Nov.-March |
| New Jersey | April-May | June-Aug. | Sept.-Nov. | Dec.-March |
| New Mexico | Jan.-March | April-July | Aug.-Dec. | N/A |
| New York | N/A | April-Oct. | N/A | Nov.-March |
| North Carolina | Dec.-April | May-Aug. | Sept.-Nov. | N/A |
| North Dakota | N/A | May-Oct. | N/A | Nov.-April |
| Ohio | April-May | June-Aug. | Sept.-Nov. | Dec.-March |
| Oklahoma | March-May | June-Aug. | Sept.-Nov. | Dec.-Feb. |
| Oregon | April-June | July-Sept. | Oct.-Nov. | Dec.-March |
| Pennsylvania | April-May | June-Aug. | Sept.-Nov. | Dec.-March |
| Rhode Island | April-May | June-Aug. | Sept.-Nov. | Dec.-March |
| South Carolina | Dec.-April | May-July | Aug.-Nov. | N/A |
| South Dakota | N/A | April-Oct. | N/A | Nov.-March |
| Tennessee | March-May | June-Aug. | Sept.-Nov. | Dec.-Feb. |
| Texas | Jan.-March | April-July | Aug.-Dec. | N/A |
| Utah | N/A | May-Oct. | N/A | Nov.-April |
| Vermont | N/A | April-Oct. | N/A | Nov.-March |
| Virginia | March-May | June-Aug. | Sept.-Nov. | Dec.-Feb. |
| Washington | April-June | July-Aug. | Sept.-Nov. | Dec.-March |
| West Virginia | March-May | June-Aug. | Sept.-Nov. | Dec.-Feb. |
| Wisconsin | N/A | April-Oct. | N/A | Nov.-March |
| Wyoming | N/A | May-Oct. | N/A | Nov.-April |

LEVEL I PRICING: Level I pricing is NSC's standard installation pricing less 12%. Level I pricing shall apply only to that quantity of material which was, in fact, installed during the Level I pricing months.

LEVEL II PRICING: Level II pricing is NSC's standard installation pricing as set forth in Attachment 1.

LEVEL III PRICING: Level III pricing is NSC's standard installation pricing plus 12%. Level III pricing shall apply to all materials installed during the Level III pricing months.

LEVEL IV PRICING: Level IV pricing is NSC's published winter daily rates for WMNA installation services. A copy of these rates is attached. (These rates are approximately 30% below NSC's customary daily rate charge.) Level IV pricing shall apply to all materials installed during the Level IV pricing months.

## WMNA/NSC LETTER AGREEMENT

**COST REIMBURSABLE RATES**
**EFFECTIVE: JANUARY 1, 1992**

| ITEM | LEVEL IV INSTALLATION WINTER PERIOD | | CHANGE ORDER WORK | LIMITED SERVICES AGREEMENT (LSA) WORK | |
|---|---|---|---|---|---|
| **PERSONNEL:** | WORK RATE | STANDBY RATE | | WORK RATE | NON-WORK AND/OR TRAVEL DAYS |
| roject Manager | | | $66.60 per hour | $552.00 per day | $461.00 |
| uperintendent | $397.00 per day | $341.00 per day | $61.00 per hour | $505.00 per day | $432.00 |
| oreman | $341.00 per day | 293.00 per day | $52.30 per hour | $432.00 per day | $372.00 |
| echnician | 265.00 per day | $245.00 per day | $43.50 per hour | $361.00 per day | $311.00 |
| abor | Base Rate + 25% Fringes + 10% Per Hour | Base Rate + 25% Fringes + 10% Per Hour | Base Rate + 25% Fringes + 15% OH + 10% Profit | Base Rate + 25% Fringes + 15% OH + 10% Profit | Base Rate + 25% Fringes + 15% OH + 10% Profit |
| **EQUIPMENT** | | | | | |
| oader | Cost + 10% per day | Cost + 10% per day | Cost + 15% OH + 10% Profit per hour | | |
| raller | Cost + 10% per day | Cost + 10% per day | Cost + 15% OH + 10% Profit per hour | | |
| ollets | Cost + 10% per day | Cost + 10% per day | Cost + 15% OH + 10% Profit per hour | | |
| Truck - Pickup | $45.00 per day | $45.00 per day | $15.00 per hour | $65.00 per day + $0.33 per mile | $65.00 per day + $0.33 per mile |
| Truck - Equipment | $63.00 per day | $63.00 per day | N/A | $90.00 per day + $0.33 per mile | $90.00 per day + $0.33 per mile |
| Generators | $ 7.00 per day | $ 7.00 per day) | | | |
| Extruders | $15.00 per day | $ 15.00 per day) | | | |
| Mice | $10.00 per day | $10.00 per day) | $45.00 per hour flat rate for liner installation equipment | $360.00 per day flat rate for liner installation equipment. | $360.00 per day flat rate for liner installation equipment. |
| ATV's | $20.00 per day | $20.00 per day) | | | |
| QA/QC Equipment | $25.00 per day | $25.00 per day) | | | |
| Miscellaneous | $35.00 per day | $35.00 per day) | | | |
| **MISC. EXPENSE** | | | | | |
| Lodging - Per Man | Cost + 10% | Cost + 10% | Cost + 15% OH + 10% Profit (See 4) | Cost + 15% OH + 10% Profit | Cost + 15% OH + 10% Profit |
| Per Diem - Per Man | $30.00 per day | $30.00 per day | $30.00 per day (See 4 Below) | $30.00 per day | $30.00 per day |
| Fuel | Cost + 10% | Cost + 10% | Cost + 15% OH + 10% Profit | Cost + 15% OH + 10% Profit | Cost + 15% OH + 10% Profit |
| Any Other Expenses | Cost + 10% | Cost + 10% | Cost + 15% OH + 10% Profit | Cost + 15% OH + 10% Profit | Cost + 15% OH + 10% Profit |

Note to Above Rates:

1. Rates are based on an eight (8) hour work day.
2. All charges are portal to portal; closest location of available personnel.
3. Receipts will be provided for expenses charged to the job.
4. Per diem and lodging charges shown apply for each NSC personnel working six (6) or more hours on change order work.

*E*



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# APPENDIX E

# TECHNOLOGY ELIMINATION - TECHNICAL FEASIBILITY SCREENING

## APPENDIX E

## REMEDIAL TECHNOLOGY ELIMINATION--TECHNICAL FEASIBILITY SCREENING

The following sections present some results of the initial screening of technologies and process options for containment and treatment of contaminated soil areas at the Former Nebraska Ordnance Plant site. The technologies and related process options described below are those which are not technically feasible for implementation at the site, due to characteristics of the soil and the contaminants of concern. Technologies and process options which were considered technically feasible were included in the second screening of technologies, described in Section 2.5.4 of this report. Summaries of the evaluations presented below are included in Figure 2-13.

### E.1 Containment

#### E.1.1 Slurry Walls

A slurry wall is a subsurface barrier constructed in a vertical trench that is excavated and backfilled in a slurry consisting of either a soil/bentonite or cement/bentonite mixture. Slurry walls are common subsurface structures used for reducing groundwater flow and containing contaminated soils. A soil-bentonite backfill mixture is most commonly used because it has the lower installation costs, wider range of chemical compatibilities, and can easily be built to a permeability of less than 1E-07 cm/s. These vertical barriers must be keyed into a deeper stratum which acts as an aquitard. The combination of the vertical barrier and the lower aquitard act to contain contamination, preventing its migration to groundwater.

At the NOP site, this stratum lies approximately 125 feet below ground surface. This is approximately the upper limit of depth to which a slurry wall can be constructed. This shale stratum, while having a low permeability, may be fractured, rendering it ineffective as an aquitard. The large perimeter of the contaminated areas of the site would make the construction so extensive as to be impractical. For these reasons, the slurry wall technique is eliminated from further consideration.

#### E.1.2 Deep Soil Mixing

Deep soil mixing (DSM) is a specialized technique for the construction of a vertical subsurface barrier without excavation. Hydraulically-driven mixing paddles and augers are driven into the ground by a crane-supported set of leads. As the ground is penetrated, stabilizing agents are fed through the centers of the shafts, while the augers and paddles break the soil and mix the stabilizing agents with the soil. The mixing process is continued as the augers are brought to the surface. Continuity of the vertical barrier is assured by

overlapping augers. However, quality assurance is difficult at large depths, which may be needed to key into an aquitard. Like the slurry wall technique, DSM requires an intact aquitard to complete the containment of contaminants inside the barriers.

At this site, the key-in layer is very deep and of questionable integrity. As in the case of slurry walls, these site characteristics cause DSM to be eliminated from further consideration.

### E.1.3 Vibrated Beam Technique

The vibrated beam technique consists of a steel beam which is driven into the soil by a vibratory pile driver-extractor. A slurry is then injected underground through a set of nozzles at the base of the beam. This slurry consists of materials such as mixtures of cement and bentonite, fly ash and bentonite, or cold asphalt emulsion with certain additives. These materials create a vertical barrier that is relatively nonerodable, chemically compatible, and has low permeability. Like the slurry wall and deep soil mixing techniques, this process is intended to key into an intact bottom layer of low permeability to completely contain an area of contaminated soil in order to prevent migration of contaminants.

The depth to the confining layer at this site may make the implementation of this technique difficult, if not impossible. Quality assurance is difficult at great depths, and the potential for chemical incompatibility exists unless testing is performed with the contaminants at this site. The difficulty encountered at the great depth required to key into a relatively low-permeability layer, and the questionable integrity of that layer, eliminate the vibrated beam technique from further consideration.

## E.2 Thermal Treatment

### E.2.1 Infrared Thermal Treatment

The infrared incineration system consists of a series of silicon-carbide rods which emit infrared radiant heat. Soil is carried past the rods on a mesh conveyor belt. Temperatures in the primary incineration chamber reach up to 1800°F. Exhaust gases are fed to a secondary combustion chamber, and a scrubber. The infrared primary incineration chamber is powered by electricity, and the secondary chamber is propane-fired.

Since soil is conveyed through the primary chamber on a belt, there is little agitation of the soil. This limits heat transfer through large clumps of soil. The soil at the NOP is rather fine-grained, and has been shown to form large clumps, which will need to be ground before processing. Infrared thermal treatment is eliminated from further consideration due to this need for excessive preprocessing.

## E.3 Physical/Chemical Treatment

### E.3.1 In-Situ Soil Flushing

In-situ soil flushing involves the extraction of contaminants from the soil with an appropriate flushing solution. The extract is collected in a series of shallow wells or subsurface drains. Flushing solutions may include water, acidic solutions, basic solutions, or surfactants.

In-situ soil flushing requires careful management and knowledge of reactions that may adversely affect soil permeability. Also, the required flushing solutions may themselves have negative environmental impacts.

In-situ soil flushing is not applicable to clay soils because of their low permeability, making it very difficult to disperse flushing solution through the soil. It is not known what type of solution would be appropriate to extract the contaminants of concern at the NOP site. For these reasons, in-situ soil flushing is eliminated from further consideration.

### E.3.2 In-Situ Vacuum/Steam Extraction

In-situ steam extraction is similar to in-situ soil flushing, discussed above, except that steam is injected into the subsurface instead of an extracting solution. The heat carried in the steam also helps to volatilize contaminants, thus increasing transport out of the soil. In-situ vacuum extraction also volatilizes contaminants by lowering vapor pressure in the subsurface, allowing volatile contaminants to vaporize and exit the subsurface.

A vendor's brochure (LaMori and Guenther) states that "silts remediate more easily than clay", referring to one of the main problems associated with mass transfer through a low-permeability soil, such as the ones present at the NOP site.

A technical article on soil venting systems (Johnson, et al., 1991) states that "soils contaminated with compounds (mixtures) having saturated vapor concentrations less than 0.3 mg/L will not be good candidates for venting...[this] corresponds to compounds...with pure vapor pressures less than 0.0001 atmospheres evaluated at the subsurface temperature".

The low permeability of the soil at the site and the low vapor pressures of the contaminants of concern make this site a poor candidate for in-situ vacuum or steam extraction.

### E.3.3 In-Situ Heating

This process involves heating soil in situ to moderate temperatures (150 to 400 degrees Celsius), thus volatilizing most organic contaminants. Gases and vapor from the soil matrix are then recovered at the surface and treated. The organic compounds in the vapor phase

may be destroyed in a combustion unit, adsorbed onto activated carbon, or condensed into a liquid for subsequent off-site treatment or disposal.

The greatest advantage of in-situ heating is that the process eliminates the need for soil excavation and the associated risk to human health through exposure. It is especially suited to cases where excavation of contaminated soils is difficult. However, in-situ heating does not treat inorganics of low-vapor-pressure organics which may be present in soil.

In-situ heating has not yet been demonstrated on a commercial scale for hazardous waste treatment. Available performance data on hazardous waste treatment are limited.

Due to the high boiling points and low vapor pressures of the contaminants of concern, and the mostly shallow waste depth (which facilitates excavation) at the NOP site, this technology is eliminated from further consideration.

### E.3.4 Soil Washing

The soil washing process extracts contaminants from soil using water or an aqueous solution composed of chelating agents, surfactants, acids, or bases. The process generally involves the use of high-intensity mixing and flotation to remove contaminants from the surfaces of soil particles. The primary function of soil washing is a physical volumetric reduction of fine silt, clay, and colloidal fractions from coarse sand and gravel which can be cleaned. Fine silts and clays typically adsorb organic contaminants more strongly than larger soil particles and are more difficult to separate from the washing solution.

This technology has been demonstrated to remove halogenated and nonhalogenated hydrocarbons and heavy metals such as lead, chromium, cadmium, copper, and nickel. This technology is most effective for soil with a large percentage of particles larger than 200 mesh or 0.074 mm (USEPA, 1988c). This treatment is most appropriate for heavy metals and some semi-volatile organics. A pilot-scale study at a Superfund site in Minnesota (USEPA 1992) indicated that slightly soluble to relatively insoluble semi-volatile organics compounds are effectively removed along with the fines. The soil at that site was primarily sandy.

The fines content of the soil at the NOP site is high. The soil types, CL and CH, present on site have high content of particles in size ranges smaller than 0.004 mm. For soil washing to be cost-effective, the sand content should be 60 percent or greater. Therefore, this process option is not recommended for further evaluation.

### E.3.5 Solidification/Stabilization

Solidification/stabilization (S/S) processes involve the mixing of contaminated materials with appropriate amounts of reagents (which combine physically or chemically with the materials) to decrease their mobility. Portland cement and pozzolanic materials such as fly ash, blast furnace slag, and cement kiln dust are commonly used reagents because of their effectiveness and availability. In addition, proprietary reagents may be used to improve physical and chemical characteristics of the soil system and decrease leaching losses from the solidified material. Depending on the amount of reagent added, the end product may be a monolithic solid or have a fiable, soil-like consistency. Solidification/stabilization is especially effective for immobilizing metals and organics of low mobility.

Vendors contacted do not have experience treating explosive compounds by S/S, but were able to hypothesize probable results. Generally, S/S will not immobilize most organic compounds, but will slow their migration. Vendors indicated that the concentrations in soil at the site were such that absorbents, such as activated carbon or organophyllic clays, would be needed to bind organic contaminants; the carbon or clay would then be immobilized in the S/S matrix. This method is costly to implement, and its effectiveness is not known for explosives. Treated soil may not be suitable for agricultural use. Due to uncertainties regarding waste characteristics with respect to S/S, this technology is eliminated from further consideration. Treatability testing (Cross/Tessitore & Associates, 1993) has shown that S/S will not be required for thermal treatment residuals.

## E.4 Biological Treatment

### E.4.1 In-Situ Biological Treatment

In-situ biological treatment of contaminated soils can be effective in soils that contain easily-degraded compounds, where the soils have a high permeability, and where contamination is restricted to a shallow layer near the soil surface. The contamination at the NOP site is mostly confined to shallow areas. However, the high clay content and low permeability of the soil make in-situ biological processing more difficult. Another complicating factor is the presence of contaminants in a large number of "hot spots", rather than a single (or few) location(s). Areas of high concentrations of TNT at the site may also make in-situ biological treatment impossible due to microbial toxicity at high concentrations. Excavation and preblending may be necessary. Any excavation needed would remove the major advantage of in-situ treatment, the lack of excavation needed. Most vendors of biological processes contacted prefer to process contaminated soil of the type found at the NOP site under controlled conditions in a lined pit or in an enclosed vessel. Therefore, the in-situ biological treatment process option is not recommended for further evaluation.

F



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# APPENDIX F

# COST SUMMARIES

# COST SUMMARIES

## INTRODUCTION

The purpose of this Appendix is to present backup documentation to support alternative cost estimates, sensitivity analyses and uncertainty analyses. Costs are calculated for five different volumes of soil: The base volume (8,400 cy), and four volumes for sensitivity/uncertainty analyses (2,600 cy, 12,600 cy, 25,200 cy and 42,000 cy). The smallest volume of contaminated soil from Table 2-10 is 2,600 cy (does not include Burning/Proving ground trenches estimated to be 3,000 cy; see note on Table 2-10). The other volumes were extrapolated by multiplying the base volume by approximately 1.5 (12,600 cy), 3 (25,200 cy), and 5 (42,000 cy).

## FORMAT OF THE APPENDIX

This appendix is divided into sections dedicated to each alternative. Each section consists of cost tables, which contain itemized line items costs, followed by the assumptions used in estimating each line item. Calculation sheets follow the assumptions. Documentation of vendor quotes are contained in Appendix D. As Alternative 1, No Action, has no associated costs, the first Alternative described is Alternative 2, Biological Treatment. For cost estimating purposes, it is assumed that windrow composting will be the method of biological treatment. The cost for Alternative 3 (Thermal Treatment) is estimated based on rotary kiln incineration. Alternatives 4 (on-site landfilling) and 5 (off-site landfilling) follow.

Abbreviations Used in Cost Tables

| | |
|---|---|
| AC | Acre |
| CY | Cubic Yard |
| EA | Each |
| EJ | Estimator Judgement |
| LS | Lump Sum |
| MO | Month |
| SY | Square Yard |
| VQ | Vendor Quote |

## ACCURACY OF COST ESTIMATES

The cost estimates presented in this appendix are intended to be to the level of accuracy specified in Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA Interim Final, USEPA, 1988. This document specifies an accuracy level of +50 percent to -30 percent. Cost totals include capital and operations and maintenance (O&M) costs. Present worth (PW) of O&M costs are calculated using an assumed discount rate of 6 percent, before taxes and after inflation.



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## GLOBAL MARKUPS

Each cost estimate includes capital cost global markups. These markups are based on percentages of the total capital cost. Global markups are used for capital cost components that are difficult to adequately define or breakdown for itemized costing because they would be specific to the Contractor or to the contracting mechanism or because of the lack of information available at the FS stage. Global markups are also used to cover costs resulting from unforeseen circumstances during implementation. The following global markups and corresponding percentages are assumed:

| Global Markup | Percentage |
|---|---|
| Site Preparation/Restoration | 5 |
| Mobilization/Demobilization | 2[1], 5[2,3] |
| Health and Safety | 8 |
| Prime Contractor Fixed Fee | 5 |
| Bonds and Insurance | 1 |
| Permitting and Legal | 5 |
| Design Engineering | 2[1], 8[2], 15[3] |
| Construction Related Services | 3[1], 8[2,3] |
| Scope Contingencies | 20 |

Notes: [1]Alternative 5
[2]Alternative 2, 3
[3]For Alternative 4, mobilization/demobilization costs are included in verda cost quotes and are thus included as line item costs.

### Site Preparation

Preparation of the site for remedial activities is assumed to include the following:

| | Alternative 2 | Alternative 3 | Alternative 4 | Alternative 5 |
|---|---|---|---|---|
| Support facilities | X | X | X | X |
| Decontamination facility | X | X | X | X |
| Debris processing area | X | X | -- | -- |
| Landfill area preparation | -- | -- | X | -- |
| Access roads | X | X | X | X |
| Clearing and grubbing | X | X | X | X |
| Topsoil stripping | X | X | X | X |
| Removal of surface debris | X | X | X | X |
| Treatment area preparation | X | X | -- | -- |



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| | Alternative 2 | Alternative 3 | Alternative 4 | Alternative 5 |
|---|---|---|---|---|
| Water supply | X | X | X | -- |
| Residuals storage area | X | X | -- | -- |
| Dust and erosion control | X | X | X | X |

**Site Restoration**

Restoration of the site after the completion of remedial activities is assumed to include the following items:

Removal/Demolition of Process/Decontamination Facilities
Revegetation of Disturbed Areas
Miscellaneous Site Cleanup



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# APPENDIX F1

# ALTERNATIVE 2 COST SUMMARY

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 2**
**(BIOLOGICAL TREATMENT)**
**BASE VOLUME = 8400 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 8,400 | $24 | VQ | $201,600 |
| Ordnance Management | | 10% | | EJ | $20,160 |
| Confirmation Sampling | EA | 63 | $368 | VQ | $23,184 |
| **Subtotal** | | | | | $244,944 |
| **BIOLOGICAL TREATMENT** | | | | | |
| Treatability Studies | LS | 1 | $700,000 | EJ | $700,000 |
| Characterization Sampling and Analysis | EA | 84 | $368 | VQ | $30,912 |
| Processing Structures | | | | | |
| Structure | LS | 1 | $341,700 | VQ | $341,700 |
| Floors | LS | 1 | $153,400 | Means | $153,400 |
| Installation | LS | 1 | $39,000 | EJ | $39,000 |
| Subtotal | | | | | $534,100 |
| Biological Processing | | | | | |
| Manure | CY | 10,100 | $3 | VQ | $30,300 |
| Alfalfa | CY | 7,600 | $13 | VQ | $98,800 |
| Sawdust | CY | 7,600 | $45 | VQ | $342,000 |
| Subtotal | | | | | $471,100 |
| Windrow Machine | LS | 1 | $130,000 | VQ | $130,000 |
| Instrumentation | LS | 1 | $2,000 | VQ | $2,000 |
| Subtotal | | | | | $132,000 |
| Ancillary/Maintenance Equip. | | 10% | | EJ | $13,200 |
| Process Sampling and Analysis | EA | 756 | $368 | VQ | $278,208 |
| Labor | MO | 32 | $41,600 | EJ | $1,331,200 |
| Process Utilities/Fuel | MO | 32 | $2,000 | EJ | $64,000 |
| Subtotal | | | | | $1,818,608 |
| **Subtotal** | | | | | $3,554,720 |
| **RESIDUALS MANAGEMENT** | | | | | |
| Residuals Characterization | EA | 34 | $1,100 | VQ | $37,400 |
| Treated Soil Placement | CY | 16,800 | $5 | EJ | $84,000 |
| Oversize Material Disposal | CY | 840 | $45 | VQ | $37,800 |
| **Subtotal** | | | | | $159,200 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 2**
**(BIOLOGICAL TREATMENT)**
**BASE VOLUME = 8400 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **EQUIPMENT SALVAGE** | | | | | |
| Dismantling | | 10% | | EJ | $34,170 |
| Processing Structures | | –20% | | EJ | –$68,340 |
| Windrow Machine Resale | | –$90,000 | | VQ | –$90,000 |
| **Subtotal** | | | | | –$124,170 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $3,892,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $194,600 |
| Mobilization/Demobilization | | 5% | | | $194,600 |
| Health & Safety | | 8% | | | $311,360 |
| Prime Contractor Fixed Fee | | 5% | | | $194,600 |
| **Subtotal** | | | | | $4,787,000 |
| Bonds and Insurance | | 1% | | | $47,870 |
| **Subtotal** | | | | | $4,835,000 |
| Permitting and Legal | | 5% | | | $241,750 |
| Design Engineering | | 8% | | | $386,800 |
| Construction–Related Services | | 8% | | | $386,800 |
| Scope Contingency | | 20% | | | $967,000 |
| **TOTAL CAPITAL COST** | | | | | $6,817,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 YRS, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | **$8,517,000** |

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**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 2**
**(BIOLOGICAL TREATMENT)**
**VOLUME = 2600 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 2,600 | $24 | VQ | $62,400 |
| Ordnance Management | | 10% | | EJ | $6,240 |
| Confirmation Sampling | EA | 20 | $368 | VQ | $7,360 |
| **Subtotal** | | | | | $76,000 |
| **BIOLOGICAL TREATMENT** | | | | | |
| Treatability Studies | LS | 1 | $700,000 | EJ | $700,000 |
| Characterization Sampling and Analysis | EA | 26 | $368 | VQ | $9,568 |
| Processing Structures | | | | | |
| Structure | LS | 1 | $341,700 | VQ | $341,700 |
| Floors | LS | 1 | $153,400 | Means | $153,400 |
| Installation | LS | 1 | $39,000 | EJ | $39,000 |
| Subtotal | | | | | $534,100 |
| Biological Processing | | | | | |
| Manure | CY | 3,100 | $3 | VQ | $9,300 |
| Alfalfa | CY | 2,300 | $13 | VQ | $29,900 |
| Sawdust | CY | 2,300 | $45 | VQ | $103,500 |
| Subtotal | | | | | $142,700 |
| Windrow Machine | LS | 1 | $130,000 | VQ | $130,000 |
| Instrumentation | LS | 1 | $2,000 | VQ | $2,000 |
| Subtotal | | | | | $132,000 |
| Ancillary/Maintenance Equip. | | 10% | | EJ | $13,200 |
| Process Sampling and Analysis | EA | 252 | $368 | VQ | $92,736 |
| Labor | MO | 14 | $41,600 | EJ | $582,400 |
| Process Utilities/Fuel | MO | 14 | $2,000 | EJ | $28,000 |
| Subtotal | | | | | $848,336 |
| **Subtotal** | | | | | $2,234,704 |
| **RESIDUALS MANAGEMENT** | | | | | |
| Residuals Characterization | EA | 11 | $1,100 | VQ | $12,100 |
| Treated Soil Placement | CY | 5,200 | $5 | EJ | $26,000 |
| Oversize Material Disposal | CY | 260 | $45 | VQ | $11,700 |
| **Subtotal** | | | | | $49,800 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 2**
**(BIOLOGICAL TREATMENT)**
**VOLUME = 2600 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **EQUIPMENT SALVAGE** | | | | | |
| Dismantling | | 10% | | EJ | $34,170 |
| Processing Structures | | –20% | | EJ | –$68,340 |
| Windrow Machine Resale | | –$90,000 | | VQ | –$90,000 |
| **Subtotal** | | | | | –$124,170 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $2,293,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $114,650 |
| Mobilization/Demobilization | | 5% | | | $114,650 |
| Health & Safety | | 8% | | | $183,440 |
| Prime Contractor Fixed Fee | | 5% | | | $114,650 |
| **Subtotal** | | | | | $2,820,000 |
| Bonds and Insurance | | 1% | | | $28,200 |
| **Subtotal** | | | | | $2,848,000 |
| Permitting and Legal | | 5% | | | $142,400 |
| Design Engineering | | 8% | | | $227,840 |
| Construction–Related Services | | 8% | | | $227,840 |
| Scope Contingency | | 20% | | | $569,600 |
| **TOTAL CAPITAL COST** | | | | | $4,016,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 YRS, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | **$5,716,000** |

ALT2BT1.WK3

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 2**
**(BIOLOGICAL TREATMENT)**
**VOLUME = 12,600 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 12,600 | $24 | VQ | $302,400 |
| Ordnance Management | | 10% | | EJ | $30,240 |
| Confirmation Sampling | EA | 93 | $368 | VQ | $34,224 |
| **Subtotal** | | | | | $366,864 |
| **BIOLOGICAL TREATMENT** | | | | | |
| Treatability Studies | LS | 1 | $700,000 | EJ | $700,000 |
| Characterization Sampling and Analysis | EA | 126 | $368 | VQ | $46,368 |
| Processing Structures | | | | | |
| Structure | LS | 1 | $341,700 | VQ | $341,700 |
| Floors | LS | 1 | $153,400 | Means | $153,400 |
| Installation | LS | 1 | $39,000 | EJ | $39,000 |
| Subtotal | | | | | $534,100 |
| Biological Processing | | | | | |
| Manure | CY | 15,100 | $3 | VQ | $45,300 |
| Alfalfa | CY | 11,300 | $13 | VQ | $146,900 |
| Sawdust | CY | 11,300 | $45 | VQ | $508,500 |
| Subtotal | | | | | $700,700 |
| Windrow Machine | LS | 1 | $130,000 | VQ | $130,000 |
| Instrumentation | LS | 1 | $2,000 | VQ | $2,000 |
| Subtotal | | | | | $132,000 |
| Ancillary/Maintenance Equip. | | 10% | | EJ | $13,200 |
| Process Sampling and Analysis | EA | 1,116 | $368 | VQ | $410,688 |
| Labor | MO | 46 | $41,600 | EJ | $1,913,600 |
| Process Utilities/Fuel | MO | 46 | $2,000 | EJ | $92,000 |
| Subtotal | | | | | $2,561,488 |
| **Subtotal** | | | | | $4,542,656 |
| **RESIDUALS MANAGEMENT** | | | | | |
| Residuals Characterization | EA | 51 | $1,100 | VQ | $56,100 |
| Treated Soil Placement | CY | 25,200 | $5 | EJ | $126,000 |
| Oversize Material | CY | 1,300 | $45 | VQ | $58,500 |
| **Subtotal** | | | | | $240,600 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 2**
**(BIOLOGICAL TREATMENT)**
**VOLUME = 12,600 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **EQUIPMENT SALVAGE** | | | | | |
| Dismantling | | 10% | | EJ | $34,170 |
| Processing Structures | | –20% | | EJ | –$68,340 |
| Windrow Machine Resale | | –$90,000 | | VQ | –$90,000 |
| **Subtotal** | | | | | –$124,170 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $5,083,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $254,150 |
| Mobilization/Demobilization | | 5% | | | $254,150 |
| Health & Safety | | 8% | | | $406,640 |
| Prime Contractor Fixed Fee | | 5% | | | $254,150 |
| **Subtotal** | | | | | $6,252,000 |
| Bonds and Insurance | | 1% | | | $62,520 |
| **Subtotal** | | | | | $6,315,000 |
| Permitting and Legal | | 5% | | | $315,750 |
| Design Engineering | | 8% | | | $505,200 |
| Construction–Related Services | | 8% | | | $505,200 |
| Scope Contingency | | 20% | | | $1,263,000 |
| **TOTAL CAPITAL COST** | | | | | $8,904,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 YRS, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | **$10,604,000** |

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**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 2**
**(BIOLOGICAL TREATMENT)**
**VOLUME = 25,200 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 25,200 | $24 | VQ | $604,800 |
| Ordnance Management | | 10% | | EJ | $60,480 |
| Confirmation Sampling | EA | 187 | $368 | VQ | $68,816 |
| **Subtotal** | | | | | $734,096 |
| **BIOLOGICAL TREATMENT** | | | | | |
| Treatability Studies | LS | 1 | $700,000 | EJ | $700,000 |
| Characterization Sampling and Analysis | EA | 252 | $368 | VQ | $92,736 |
| Processing Structures | | | | | |
| Structure | LS | 1 | $341,700 | VQ | $341,700 |
| Floors | LS | 1 | $153,400 | Means | $153,400 |
| Installation | LS | 1 | $39,000 | EJ | $39,000 |
| Subtotal | | | | | $534,100 |
| Biological Processing | | | | | |
| Manure | CY | 30,200 | $3 | VQ | $90,600 |
| Alfalfa | CY | 22,700 | $13 | VQ | $295,100 |
| Sawdust | CY | 22,700 | $45 | VQ | $1,021,500 |
| Subtotal | | | | | $1,407,200 |
| Windrow Machine | LS | 1 | $130,000 | VQ | $130,000 |
| Instrumentation | LS | 1 | $2,000 | VQ | $2,000 |
| Subtotal | | | | | $132,000 |
| Ancillary/Maintenance Equip. | | 10% | | EJ | $13,200 |
| Process Sampling and Analysis | EA | 2,268 | $368 | VQ | $834,624 |
| Labor | MO | 88 | $41,600 | EJ | $3,660,800 |
| Process Utilities/Fuel | MO | 88 | $2,000 | EJ | $176,000 |
| Subtotal | | | | | $4,816,624 |
| **Subtotal** | | | | | $7,550,660 |
| **RESIDUALS MANAGEMENT** | | | | | |
| Residuals Characterization | EA | 101 | $1,100 | VQ | $111,100 |
| Treated Soil Placement | CY | 50,400 | $5 | EJ | $252,000 |
| Oversize Material Disposal | CY | 2,520 | $45 | VQ | $113,400 |
| **Subtotal** | | | | | $476,500 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 2**
**(BIOLOGICAL TREATMENT)**
**VOLUME = 25,200 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **EQUIPMENT SALVAGE** | | | | | |
| Dismantling | | 10% | | EJ | $34,170 |
| Processing Structures | | –20% | | EJ | –$68,340 |
| Windrow Machine Resale | | –$90,000 | | VQ | –$90,000 |
| **Subtotal** | | | | | –$124,170 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $8,694,000 |
| **GLOBAL MARKUPS** | | | | | |
| Mobilization/Demobilization | | 5% | | | $434,700 |
| Site Preparation/Restoration | | 5% | | | $434,700 |
| Health & Safety | | 8% | | | $695,520 |
| Prime Contractor Fixed Fee | | 5% | | | $434,700 |
| **Subtotal** | | | | | $10,694,000 |
| Bonds and Insurance | | 1% | | | $106,940 |
| **Subtotal** | | | | | $10,801,000 |
| Permitting and Legal | | 5% | | | $540,050 |
| Design Engineering | | 8% | | | $864,080 |
| Construction–Related Services | | 8% | | | $864,080 |
| Scope Contingency | | 20% | | | $2,160,200 |
| **TOTAL CAPITAL COST** | | | | | $15,229,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 YRS, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | $16,929,000 |

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**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 2**
**(BIOLOGICAL TREATMENT)**
**VOLUME = 42,000 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 41,000 | $24 | VQ | $984,000 |
| Ordnance Management | | 10% | | EJ | $98,400 |
| Confirmation Sampling | EA | 312 | $368 | VQ | $114,816 |
| **Subtotal** | | | | | $1,197,216 |
| **BIOLOGICAL TREATMENT** | | | | | |
| Treatability Studies | LS | 1 | $700,000 | EJ | $700,000 |
| Characterization Sampling and Analysis | EA | 420 | $368 | VQ | $154,560 |
| Processing Structures | | | | | |
| Structure | LS | 1 | $341,700 | VQ | $341,700 |
| Floors | LS | 1 | $153,400 | Means | $153,400 |
| Installation | LS | 1 | $39,000 | EJ | $39,000 |
| Subtotal | | | | | $534,100 |
| Biological Processing | | | | | |
| Manure | CY | 50,400 | $3 | VQ | $151,200 |
| Alfalfa | CY | 37,800 | $13 | VQ | $491,400 |
| Sawdust | CY | 37,800 | $45 | VQ | $1,701,000 |
| Subtotal | | | | | $2,343,600 |
| Windrow Machine | LS | 1 | $130,000 | VQ | $130,000 |
| Instrumentation | LS | 1 | $2,000 | VQ | $2,000 |
| Subtotal | | | | | $132,000 |
| Ancillary/Maintenance Equip. | | 10% | | EJ | $13,200 |
| Process Sampling and Analysis | EA | 3,672 | $368 | VQ | $1,351,296 |
| Labor | MO | 140 | $41,600 | EJ | $5,824,000 |
| Process Utilities/Fuel | MO | 140 | $2,000 | EJ | $280,000 |
| Subtotal | | | | | $7,600,496 |
| **Subtotal** | | | | | $11,332,756 |
| **RESIDUALS MANAGEMENT** | | | | | |
| Residuals Characterization | EA | 168 | $1,100 | VQ | $184,800 |
| Treated Soil Placement | CY | 84,000 | $5 | EJ | $420,000 |
| Oversize Material Disposal | CY | 4,200 | $45 | VQ | $189,000 |
| **Subtotal** | | | | | $793,800 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 2**
**(BIOLOGICAL TREATMENT)**
**VOLUME = 42,000 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **EQUIPMENT SALVAGE** | | | | | |
| Dismantling | | 10% | | EJ | $34,170 |
| Processing Structures | | –20% | | EJ | –$68,340 |
| Windrow Machine Resale | | –$90,000 | | VQ | –$90,000 |
| **Subtotal** | | | | | –$124,170 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $13,257,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $662,850 |
| Mobilization/Demobilization | | 5% | | | $662,850 |
| Health & Safety | | 8% | | | $1,060,560 |
| Prime Contractor Fixed Fee | | 5% | | | $662,850 |
| **Subtotal** | | | | | $16,306,000 |
| Bonds and Insurance | | 1% | | | $163,060 |
| **Subtotal** | | | | | $16,469,000 |
| Permitting and Legal | | 5% | | | $823,450 |
| Design Engineering | | 8% | | | $1,317,520 |
| Construction–Related Services | | 8% | | | $1,317,520 |
| Scope Contingency | | 20% | | | $3,293,800 |
| **TOTAL CAPITAL COST** | | | | | $23,221,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 YRS, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | **$24,921,000** |

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**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 2**
**(BIOLOGICAL TREATMENT)**
**(SENSITIVITY ANALYSIS BASE VOLUME, RETENTION TIME x 1.5)**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 8,400 | $24 | VQ | $201,600 |
| Ordnance Management | | 10% | | EJ | $20,160 |
| Confirmation Sampling | EA | 63 | $368 | VQ | $23,184 |
| **Subtotal** | | | | | $244,944 |
| **BIOLOGICAL TREATMENT** | | | | | |
| Treatability Studies | LS | 1 | $700,000 | EJ | $700,000 |
| Characterization Sampling and Analysis | EA | 84 | $368 | VQ | $30,912 |
| Processing Structures | | | | | |
| Structure | LS | 1 | $341,700 | VQ | $341,700 |
| Floors | LS | 1 | $153,400 | Means | $153,400 |
| Installation | LS | 1 | $39,000 | EJ | $39,000 |
| Subtotal | | | | | $534,100 |
| Biological Processing | | | | | |
| Manure | CY | 10,100 | $3 | VQ | $30,300 |
| Alfalfa | CY | 7,600 | $13 | VQ | $98,800 |
| Sawdust | CY | 7,600 | $45 | VQ | $342,000 |
| Subtotal | | | | | $471,100 |
| Windrow Machine | LS | 1 | $130,000 | VQ | $130,000 |
| Instrumentation | LS | 1 | $2,000 | VQ | $2,000 |
| Subtotal | | | | | $132,000 |
| Ancillary/Maintenance Equip. | | 10% | | EJ | $13,200 |
| Process Sampling and Analysis | EA | 1,116 | $368 | VQ | $410,688 |
| Labor | MO | 46 | $41,600 | EJ | $1,913,600 |
| Process Utilities/Fuel | MO | 46 | $2,000 | EJ | $92,000 |
| Subtotal | | | | | $2,561,488 |
| **Subtotal** | | | | | $4,297,600 |
| **RESIDUALS MANAGEMENT** | | | | | |
| Residuals Characterization | EA | 34 | $1,100 | VQ | $37,400 |
| Treated Soil Placement | CY | 16,800 | $5 | EJ | $84,000 |
| Oversize Material | CY | 840 | $45 | VQ | $37,800 |
| **Subtotal** | | | | | $159,200 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 2**
**(BIOLOGICAL TREATMENT)**
**(SENSITIVITY ANALYSIS BASE VOLUME, RETENTION TIME x 1.5)**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **EQUIPMENT SALVAGE** | | | | | |
| Dismantling | | 10% | | EJ | $34,170 |
| Processing Structures | | –20% | | EJ | –$68,340 |
| Windrow Machine Resale | | –$90,000 | | VQ | –$90,000 |
| **Subtotal** | | | | | –$124,170 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $4,635,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $231,750 |
| Mobilization/Demobilization | | 5% | | | $231,750 |
| Health & Safety | | 8% | | | $370,800 |
| Prime Contractor Fixed Fee | | 5% | | | $231,750 |
| **Subtotal** | | | | | $5,701,000 |
| Bonds and Insurance | | 1% | | | $57,010 |
| **Subtotal** | | | | | $5,758,000 |
| Permitting and Legal | | 5% | | | $287,900 |
| Design Engineering | | 8% | | | $460,640 |
| Construction–Related Services | | 8% | | | $460,640 |
| Scope Contingency | | 20% | | | $1,151,600 |
| **TOTAL CAPITAL COST** | | | | | $8,119,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 YRS, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | **$9,819,000** |

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# ALTERNATIVE 2 (BIOLOGICAL TREATMENT) COST ANALYSIS ASSUMPTIONS

## SOIL REMOVAL

The following components are assumed to be included in soil removal.

### Soil/Debris Excavation

Source area soil and debris are assumed to be excavated and hauled to the biological treatment area. Large subsurface debris such as bucket trap elements and piping is assumed to be separated during excavation and transported to the debris processing area. Costs for excavation and hauling are based on a quote from UXB International, Inc. (UXB, 1992) for 7,000 cy of soil. It is assumed for this estimate, that cost is directly proportional to volume. The cost in the UXB quotation is $165,000 for 7000 cy ($165,000/7000 = $24/cy). This cost includes:

Heavy equipment rental
Labor, travel, per diem
Health and safety provisions and equipment
Excavation and hauling
Excavation screening sampling and analysis
(UXB estimated 70 samples for 7,000 cy)
Decontamination between source areas

### Ordnance Management

If ordnance is discovered during excavation, USACE center of expertise for ordnance and explosive waste (OEW) would be contacted for a determination of the standard operating procedures (SOPs) for managing the particular ordnance type discovered. Ordnance management was not included in the UXB quote. In most contaminated areas, it is not anticipated that ordnance would be encountered. However, some areas (e.g., burning/proving ground) may contain unexploded ordnance. Therefore, 10 percent (estimator judgement) is added to the excavation cost to account for ordnance management.

### Confirmation Sampling

Confirmation sampling and analytical testing would be performed to verify that source areas are excavated to the target depth in which soil meets remediation target levels. It is assumed that confirmation samples would be composite samples from each sidewall of the excavation. Samples would be analyzed for explosives. It is assumed that one confirmation sample would be collected for each 1,000 sf of excavation surface area. Also, it is assumed that a QA/QC sample would be collected for each 10 confirmation samples. Costs are based on a quote from TCT (TCT, 1991). As no surface area was calculated for the sensitivity analysis volumes, surface area increases and decreases are assumed to be proportional to volume changes.

| Soil Volume (cy) | Surface Area (sf) | Number of Samples |
|---|---|---|
| 2,600 | 17,600 | 20 |
| 8,400 | 56,700 | 63 |
| 12,600 | 85,100 | 93 |
| 25,200 | 170,100 | 187 |
| 42,000 | 283,500 | 312 |

## BIOLOGICAL TREATMENT

Although several biological treatment options were considered potentially applicable for NOP soil, costs for biological treatment were developed for a windrow composting system. The following components are included in biological treatment.

### Treatability Studies

As composting of explosives contaminated soils is an innovative treatment technology, extensive treatability studies will be required before full-scale implementation can begin. These are estimated to include studies for optimization of amendments, and determination of treatment time required to meet remediation target levels. A lump sum cost of $700,000 for treatability studies and pilot studies are based on Army experience at other sites where composting of explosives-contaminated soils has been considered (AEC, 1993) . For the purpose of this estimate, $700,000 is used because the AEC study was conducted on explosives contaminated soil. An independent quote of $400,000 was also obtained from Waste Stream Technologies (Waste Stream Technologies, 1993). These cost estimates for treatability studies and pilot studies are within the range given in USEPA guidance (USEPA, 1990j).

### Post-Excavation Characterization and Analysis

Excavated soils are assumed to undergo characterization sampling and testing for total explosives content. It is assumed that preprocessing workers would collect samples. Analytical costs are based on a quote from Twin City Testing (TCT, 1991a), assuming a 7-day turnaround time. It is assumed that 1 sample would be collected for each 100 cubic yards of soil excavated. Characterized soils would be classified and inventoried in preparation for treatment preprocessing .

### Processing Structures

Temporary structures are assumed to be constructed to house windrows. This would allow for more effective control of moisture , temperature, and potential dust and volatile emissions during biological treatment. It will also limit problems associated with wind and cold weather. It is assumed that three structures would be used for processing. The size structures is assumed to be 60 feet by 150 feet each. The structure floors would be stabilized by proof-rolling/grading and would consist of an 8-inch gravel base covered with a concrete pad. The pad would be curbed and sloped to a built-in sump. Costs are based on Means.



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The cost for the structures (identified as "structures" line item in the cost tables) is based on a quote from Sprung Instant Structures, Inc. (Sprung, 1993). After review of rental and purchase prices provided, it is assumed that the structures would be purchased. The structure quote includes a lump sum for the buildings structural material.The cost assumptions, based on the Sprung quote, are summarized as follows:

The cost table line item "Installation" includes the following items based on the spring structures quote:

- Scaffolding - Required for setup - costs from Means.
- Setup labor - Seven unskilled laborers, one crane operator (modified Means B-95 crew) for 24 days, 8 hrs/day.
- Crane - 5000 lb electric hoist, 100 feet high would be required for 24 days. Cost from Means.
- Construction Supervisor - Provided by Sprung, free of labor charge. Charge of $95/day for per diem, plus airfare at cost (assume $400).
- Electrical Extension - Temporary electrical extension would be required for installation and operation.

The cost line item "Floors" includes:

- Concrete Floor and Storage Area - 300 feet by 200 feet, 8-inch curbed pad with a lined precast concrete manhole sump. The concrete pad is assumed to have a gravel subbase stabilized by proof-rolling/grading and a geotextile. Costs are from Means.

It is assumed that the structures would be sold by USACE, for salvage value of approximately 20 percent of materials cost.

**Amendment Materials Preparation**

Soil would be moved with a front-end loader from stockpiles to the mixing area where organic amendments may be added. It is assumed that no preprocessing of soil will be necessary. This assumption is based on previous Army experience at similar sites (AEC, 1993). Although the mixture of amendments would be determined through a treatability study, for the purposes of this estimate, it is assumed that the amendments would consist of 40 percent cow manure, 30 percent alfalfa, and 30 percent sawdust (estimator judgement, based on Army experience and locally available amendments). It is also assumed that this amendment mixture would be added at a ratio of three parts amendment to one part soil. Costs for amendments are estimated based on quotes from Northwest Feed and Grain, (Northwest Feed and Grain, 1993), Ms. Sue Hilgen (Hilgen, 1993) and the Franz Company (Franz, 1993). Amendments would be staged on a concrete pad, outside the temporary structures, and covered with plastic sheeting when windrows are not being constructed. A front-end loader would transport amendments to the temporary structures, and



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deposit them at the doors of the structures, to avoid entering the potentially contaminated treatment area. A second front-end loader inside the contaminated area would move amendments to the windrow mixing areas. More than one pass with the windrow turner may be required to homogenize the compost mixture. The exact number of passes required would be determined through pilot studies. For the purpose of this estimate, it is assumed that one windrow can be placed per day (estimator judgement).

**Biological Processing**

Each day the windrow would be treated with the windrow machine. Costs for the windrow machine and resale value are estimated based on a quote from Resource Recovery System of Nebraska, Inc. (1993). The front-end loader operating inside the contaminated area would be used to help in keeping the windrows in the proper shape. Costs for front-end loaders and crew are estimated from Means.

Windrows would be monitored for temperature, moisture content, percent oxygen, and explosives concentration. Temperature would be monitored by inserting thermocouples into the windrow with an extended temperature probe and a hand-held digital controller. Temperature would be monitored at six points in the windrow before turning. Percent oxygen would be monitored daily, before turning, with a hand-held oxygen meter inserted into the windrows. Percent oxygen would also be monitored at six points in the windrow. Percent moisture would be measured twice weekly. Water would be added as necessary to maintain optimum moisture content. Instrumentation costs are from Omega (1991) and VWR Scientific (1992).

It is assumed that the water requirements for the composting process (approximately 5 to 8 gallons per minute) could be met by the existing water supply system on-site, with some modifications. Water supply costs are included in site preparation costs.

It is assumed that one sample would be collected per windrow (approximately 180 cy), every 10 days for analysis for explosive contaminants to determine when target treatment levels are achieved. Analytical costs are based on a quote from TCT (TCT, 1991).

It is assumed that the labor crew would consist of one technical manger (1 day/week), a maintenance supervisor (5 days/week), two Means B-10S crews (7 days/week), and one clerical worker (1 day/week). Costs, except for the Means crew which includes front-end loaders and operators (mentioned above), are by estimator judgement. Fuel costs are based on estimator judgement.

It is assumed that each of the three structures would house three windrows each. Windrows are assumed to be 14 feet wide, 6 feet high, and 100 feet long, with a trapezoidal profile with 45 degree sideslopes, for a volume of approximately 180 cubic yards each. For the purpose of this estimate, it is assumed, based on explosives-composting treatability studies performed at other sites (U.S. Army Environmental Center, 1993), that the composting process will require approximately 40 days to reach target treatment levels.



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## RESIDUALS MANAGEMENT

The following components are included in Residuals Management.

### Residuals Sampling

Following confirmation of target treatment levels and prior to on-site placement, treated solids would be sampled and analyzed to document their suitability for unrestricted backfill in excavations. These analytes would be different from those used to test for attainment of target treatment levels. It is assumed that one composite sample would be collected per 500 cubic yards of treated compost. For the purpose of this estimate, it is assumed that analytical costs would be approximately equal to those of Waste Management Protocol A (which includes TCLP) (SEC Donohue, 1991), although the selected parameters may be quite different.

### Treated Solids Placement

It is assumed that treated solids would be placed back in excavations and vegetated. Hauling, placement, and compaction costs are based on estimator judgement. It is expected that the treated compost would have a volume of approximately 2 times that of the contaminated soil. Original volume of soil and amendments is 4 times that of the contaminated soil, but volume reduction occurs during composting as a large portion of the amendments are biodegradable. For the purposes of this estimate, it is assumed that the excess composted soil will be used for general site grading, with the guidance and permission of the site owner, the University of Nebraska-Lincoln.

### Oversize Material Disposal

It is assumed that untreated solids (5 percent) and other source area debris (5 percent) would be disposed of in an off-site landfill. Prior to disposal, the material will be characterized to determine the required method for its disposal. For the purpose of this estimate, costs for hauling and disposal are based on a quote from Waste Management of Nebraska (Waste Management of Nebraska, 1992b) for the Douglas County Landfill. This landfill is located in the Omaha area, approximately 40 miles from the site.

Hauling costs are based on an 8-ton maximum load at $90/load. It is assumed that the density of the load is approximately 1.0 ton/cubic yards.

Hauling: $90/load x 1 load/8 ton x 1.0 ton/cy = $11.25/cy

Disposal: $33.25/ton (including tax) x 1.0 ton/cy = $33.25/cy

Untreated solids and debris may require sampling prior to off-site disposal. It is assumed that a total of two discretionary composite samples will be collected and analyzed for Waste Management Protocol A parameters (SEC Donohue, 1991). It is assumed that process workers would collect residual samples.

## POINT OF USE GROUNDWATER TREATMENT SYSTEM

Until implementation of remedial action for Operable Unit 2, it is assumed that point-of-use groundwater treatment systems would be installed on all domestic supply wells in contaminated areas. These groundwater treatment systems would consist of liquid-phase activated carbon adsorption units. It is assumed that 19 units (one in each exposure area) would be installed at $3,000 each. Costs for the carbon adsorption system and carbon regeneration are based on a quote from Culligan (Culligan, 1993).

## EQUIPMENT SALVAGE

Salvage value of process equipment was assumed through estimator judgement, as were labor costs for dismantling equipment. Resale of the windrow turning machine is based on a cost quote by Resource Recovery Systems of Nebraska, Inc. (Resource Recovery Systems of Nebraska, 1993).

## OPERATIONS AND MAINTENANCE (O&M) COSTS

The only O&M costs associated with this alternative are those needed for upkeep of the groundwater treatment systems. This involves analytical testing, energy usage, carbon regeneration, and spent carbon disposal.

# CALCULATIONS FOR COMPOST AMENDMENT QUANTITIES, LABOR COSTS, EQUIPMENT COSTS, PROCESS SAMPLING, AND IMPLEMENTATION TIME

## COMPOST AMENDMENTS

Assume 3:1 amendments/soil ratio, amendments consist of 40 percent manure, 30 percent alfalfa, and 30 percent sawdust (estimator judgement based on conversations with vendors and other composting experts).

| Soil Volume | Manure Volume | Alfalfa Volume | Sawdust Volume | Total |
|---|---|---|---|---|
| 2,600 | 3,000 | 2,300 | 2,300 | 10,300 |
| 8,400 | 10,100 | 7,600 | 7,600 | 33,700 |
| 12,600 | 15,100 | 11,300 | 11,300 | 50,300 |
| 25,200 | 30,200 | 22,700 | 22,700 | 100,800 |
| 42,000 | 50,400 | 37,800 | 37,800 | 168,000 |

(Soil Volume) x 3 x (0.4 for Manure or 0.3 for Alfalfa or Sawdust) = Amendment Volume

## LABOR

Assume crew consists of:

| | | |
|---|---|---|
| 1 Supervisor/Technical Director | @ $ 80.00/hr x 8 hr/wk = | $640/wk |
| 1 Maintenance Supervisor | @ 40.00/hr x 40 hr/wk = | 1,600/wk |
| 2 FE Loaders & Crew (Means B-105) | @ 64.36/hr x 2 crews x 56 hr/wk = | 7,208/wk |
| 1 Clerical Worker | @ 20.00/hr x 8 hr/wk = | 160/wk |
| Total | | $9,600/wk |

($9,600/wk) (52 wk/yr) (yr/12 mo) = $41,600/month



B07NE003701-05103

**IMPLEMENTATION TIME**

Assume windrows of 100 ft L x 6 ft H x 14 ft W, trapezoidal shape, 2 ft crown

$$volume/windrow = \frac{1}{2}(14 + 2)(6)(100) \times \frac{1\ cy}{27\ cf} = 180\ cy$$

Assume 9 windrows in operation simultaneously (3 buildings x 3 windrows/building).

180 cy x 9 = 1,620 cy per "cycle"

"Steady-state" remediation time:

| Volume (cy) | |
|---|---|
| 2,600 | 10,300 cy/1,620 cy/cycle = 7 cycles x 40 days/cycle = 280 days |
| 8,400 | 33,700 cy/1,620 cy/cycle = 21 cycles x 40 days/cycle = 840 days |
| 8,400 | 33,700 cy/1,620 cy/cycle = 21 cycles x 60 days/cycle = 1,260 days* |
| 12,600 | 50,300 cy/1,620 cy/cycle = 31 cycles x 40 days/cycle = 1,240 days |
| 25,200 | 100,800 cy/1,620 cy/cycle = 63 cycles x 40 days/cycle = 2,520 days |
| 42,000 | 168,000 cy/1,620 cy/cycle = 102 cycles x 40 days/cycle = 4,080 days |

* Note: For Sensitivity Analysis, a treatment time of 60 days (1.5 x base treatment time) is assumed.

Not all windrows can be initiated and terminated at the same time. Assume 60 days additional for initial placement and 60 days for final removal of compost windrows.

| Volume (cy) | |
|---|---|
| 2,600 | (280 + 60 + 60) days x 1 month/30 days = 14 months |
| 8,400 | (840 + 60 + 60) days x 1 month/30 days = 32 months |
| 8,400 | (1,260 + 60 + 60) days x 1 month/30 days = 46 months |
| 12,600 | (1,240 + 60 + 60) days x 1 month/30 days = 46 months |
| 25,200 | (2,520 + 60 + 60) days x 1 month/30 days = 88 months |
| 42,000 | (4,080 + 60 + 60) days x 1 month/30 days = 140 months |

**PROCESS SAMPLING**

Assume one sample per windrow per 10 days of processing will be collected to confirm that target treatment levels are met. Assume each windrow would be sampled a total of four times.

| Volume (cy) | | | | | | | | No. Samples |
|---|---|---|---|---|---|---|---|---|
| 2,600: | 9 windrows | x | 4 samples | x | 7 cycles | = | | 252 |
| 8,400: | 9 windrows | x | 4 samples | x | 21 cycles | = | | 756 |
| 12,600: | 9 windrows | x | 4 samples | x | 31 cycles | = | | 1,116 |
| 25,200: | 9 windrows | x | 4 samples | x | 63 cycles | = | | 2,268 |
| 42,000: | 9 windrows | x | 4 samples | x | 102 cycles | = | | 3,672 |

Extended Retention Time: Each windrow sampled six times.

9 windrows x 6 samples x 21 cycles = 1,116 samples

RUST ENVIRONMENT & INFRASTRUCTURE

CALCULATION SHEET



PROJECT NO 19536.2.91

CLIENT USACE - KC

SUBJECT FS COST ESTIMATE

PROJECT NOP FS

Prepared By GJ 4/13/93

Reviewed By M. Wells 4-13-93

Approved By _____ Date _____

POINT OF USE GROUNDWATER TREAMENT

| CAPITAL COSTS | | SOURCE |
|---|---|---|
| CARBON TREATMENT UNIT | 1,000 | CULLIGAN |
| PRETREATMENT UNIT | 1,000 | CULLIGAN |
| SUBTOTAL | 2,000 | |
| ANCILLARY EQUIPMENT | 500 | ESTIMATOR JUDGEMENT |
| SUBTOTAL | 2,500 | |
| CONTINGENCIES (20%) | 500 | ESTIMATOR JUDGEMENT |
| TOTAL CAPITAL COSTS | $3,000/UNIT | |

| ANNUAL O&M COSTS | | |
|---|---|---|
| ENERGY USAGE | 800 | CULLIGAN/ESTIMATOR JUDGE. |
| CARBON USAGE | 1,400 | CULLIGAN/ESTIMATOR JUDGE. |
| PRETREATMENT ADDITIVES | 500 | ESTIMATOR JUDGEMENT |
| DISPOSAL OF SPENT CARBON | 500 | CWM/ESTIMATOR JUDGE. |
| ANALYTICAL TESTING | 3,000 | TCT / RUST REFERENCE |
| SUBTOTAL | 6,200 | |
| MAINTENANCE (10% CAP) | 1,300 | ESTIMATOR JUDGEMENT |
| TOTAL ANNUAL O&M | 6,500 | |
| | | ESTIMATOR JUDGEMENT |

PRESENT WORTH OF O&M

$6500/yr/unit x 19 units x 13.7648 = $1,700,000 = PW

(PW factor for 30 yrs @ 6%)

ENERGY USAGE

$P = \frac{I E}{P.F.}$ Assume P.F. = 90%

$= \frac{(10)(110)}{0.90}$

= 1222 watts (1.2 kw)

$\$\frac{0.08}{kw \cdot hr} \times 1.2\ kw \times 24\ \frac{hr}{day} \times 365\ \frac{day}{yr} = \$841/yr$ SAY $800/yr

CARBON USAGE

Assume REFILL EVERY 3 MONTHS

$4\ \frac{FILLS}{YR} \times \$\frac{350}{FILL} = \$1400/yr$

SPENT CARBON DISPOSAL (INCLUDING PRETREATMENT RESIDUALS)

Assume 1 DRUM/YR AT $250/DRUM (CWM, Attached)
ADD 100% FOR TRANSPORT, SURCHARGE, TIPP, ETC.

$\frac{1\ DRUM}{YR} \times \$\frac{250}{DRUM} + \$\frac{250}{YR} = \$500/YR$

ANALYTICAL (WATER)

Assume 2 SAMPLES/YR ANALYZED FOR EXPLOSIVES AND SDWA PARAMETERS

EXPLOSIVES $335/SAMPLE (TCT, Attached)
SDWA $1,171/SAMPLE (SEC Donohue, Attached)

$2\ \frac{SAMPLES}{YR} \times \frac{\$335 + \$1,171}{SAMPLE} = \$3012/yr$ SAY $3000/yr

# CHEMICAL WASTE MANAGEMENT, INC.

Emelle, Alabama

January 1, 1992

PRICE SCHEDULE

| | 55 GALLON DRUM*** |
|---|---|
| **A. DRUMMED WASTE** | |
| 1. Solid | $104.00 |
| 2. Solid (Non-Hazardous) | $88.00 |
| 3. Solid/Sludge/Liquid (Requiring Stabilization To Meet Treatment Standards) | [redacted] |
| 4. Liquid/Sludge (Inorganic or Organic Non-Hazardous) | $160.00 |
| 5. Liquid/Sludge (Organic Requiring Solidification) | $410.00 |
| 6. Lab Packs (Direct Landfill) | $275.00 |
| 7. Lab Packs (Requiring Stabilization) | $550.00 |
| 8. Empty Drums | $45.00 |
| 9. Mineral Acids: | |
| % Concentration | |
| 0 - 40% | $300.00 |
| 41 - 60% | $480.00 |
| > 61% | $620.00 |
| % Solids | SURCHARGE |
| 0 - 10% | None |
| 11 - 25% | $25.00 |
| 26 - 50% | $50.00 |
| 51 - 75% | $75.00 |
| 76 - 100% | $100.00 |
| 10. Fuels Substitution | |
| Inches of Settled Solids | |
| 0 - 3 | $45.00 |
| 4 - 17 | $180.00 |
| 18 - 34 | $285.00 |
| 11. Off-Site Incineration Services | |
| Processing, Pre-Treatment, Repackaging, Transportation and Incineration | Priced Upon Approval |
| 12. Battery Disposal | |
| a. Spent Lead Acid Batteries * | $500.00 / Pallet |
| | $135.00 / 55 Gal. Drum |
| | $0.27 / Pound |
| b. Ni-Cad Batteries * | $905.00 / Ton |
| | $250.00 / 55 Gal. Drum |
| | $0.50 / Pound |
| * Includes disposal, transshipment, and repackaging. | |
| **B. MINIMUM DISPOSAL FEE AND SURCHARGE SCHEDULE FOR DRUMMED WASTE** | |
| 1. Drummed Waste Minimum | $225.00 / Profile / Shipment |
| 2. Waste Stream Evaluation Fee | |
| a. Direct Landfill/Deepwell/Fuels | $400.00 |
| b. Stabilization | $800.00 |
| c. Incineration | |
| 1. No Sample Required | $400.00 |
| 2. Sample Required | $800.00 |
| 3. All Three Incinerators | $1,000.00 |
| 3. Surcharge - 85 Gallon Overpack (Drummed Waste Received in Overpacks) | $35.00 / Drum |
| 4. Manifest Discrepancies | $200.00 / Manifest |
| 5. Rejected Loads (Plus Return Transportation Charges if applicable) | $225.00 / Profile |
| 6. Surcharge for Leaking Drums | $150.00 / Drum |

# APPENDIX F2

# ALTERNATIVE 3 COST SUMMARY

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 3**
**(THERMAL TREATMENT)**
**BASE VOLUME = 8400 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 8,400 | $24 | VQ | $201,600 |
| Ordnance Management | | 10% | | EJ | $20,160 |
| Confirmation Sampling | EA | 63 | $368 | VQ | $23,184 |
| **Subtotal** | | | | | $244,944 |
| **THERMAL TREATMENT** | | | | | |
| Pretreatment Processing | | | | | |
| Grinder | LS | 1 | $40,000 | VQ | $40,000 |
| Conveyor | LS | 1 | $4,500 | VQ | $4,500 |
| Installation | | 20% | | EJ | $8,900 |
| Pre–Processing Structure | | | | | |
| Structure | LS | 1 | $114,000 | VQ | $114,000 |
| Floor | LS | 1 | $40,600 | Means | $40,600 |
| Installation | LS | 1 | $52,000 | EJ | $52,000 |
| Thermal Treatment | | | | | |
| Soil Characterization | EA | 17 | $50 | VQ | $850 |
| Trial Burn | LS | 1 | $200,000 | VQ | $200,000 |
| Treatment Process | TON | 13,000 | $500 | VQ | $6,500,000 |
| Treatment Verification Sampling | EA | 82 | $368 | VQ | $30,176 |
| Mobilization/Demobilization | LS | 1 | $100,000 | VQ | $100,000 |
| **Subtotal** | | | | | $7,091,026 |
| **RESIDUALS MANAGEMENT** | | | | | |
| Residuals Characterization | EA | 17 | $1,100 | EJ | $18,700 |
| Treated Soil Placement | CY | 8,400 | $5 | EJ | $42,000 |
| Oversize Material | CY | 840 | $45 | VQ | $37,800 |
| **Subtotal** | | | | | $98,500 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **EQUIPMENT SALVAGE** | | | | | |
| Dismantling | | 10% | | EJ | $4,450 |
| Pre–Process Equipment | | –20% | | EJ | –$8,900 |
| Pre–Process Structure | | –20% | | EJ | –$22,800 |
| **Subtotal** | | | | | –$27,250 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $7,464,000 |

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 3**
**(THERMAL TREATMENT)**
**BASE VOLUME = 8400 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $373,200 |
| Health & Safety | | 8% | | | $597,120 |
| Prime Contractor Fixed Fee | | 5% | | | $373,200 |
| **Subtotal** | | | | | $8,808,000 |
| Bonds and Insurance | | 1% | | | $88,080 |
| **Subtotal** | | | | | $8,896,000 |
| Permitting and Legal | | 5% | | | $444,800 |
| Design Engineering | | 8% | | | $711,680 |
| Construction–Related Services | | 8% | | | $711,680 |
| Scope Contingency | | 20% | | | $1,779,200 |
| **TOTAL CAPITAL COST** | | | | | $12,543,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 YRS, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | **$14,243,000** |

ALT3THBV.WK3

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 3**
**(THERMAL TREATMENT)**
**VOLUME = 2600 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 2,600 | $24 | VQ | $62,400 |
| Ordnance Management | | 10% | | EJ | $6,240 |
| Confirmation Sampling | EA | 20 | $368 | VQ | $7,360 |
| **Subtotal** | | | | | $76,000 |
| **THERMAL TREATMENT** | | | | | |
| Pretreatment Processing | | | | | |
| Grinder | LS | 1 | $40,000 | VQ | $40,000 |
| Conveyor | LS | 1 | $4,500 | VQ | $4,500 |
| Installation | | 20% | | EJ | $8,900 |
| Pre–Processing Structure | | | | | |
| Structure | LS | 1 | $114,000 | VQ | $114,000 |
| Floor | LS | 1 | $40,600 | Means | $40,600 |
| Installation | LS | 1 | $52,000 | EJ | $52,000 |
| Thermal Treatment | | | | | |
| Soil Characterization | EA | 5 | $50 | VQ | $250 |
| Trial Burn | LS | 1 | $200,000 | VQ | $200,000 |
| Treatment Process | TON | 4,000 | $600 | VQ | $2,400,000 |
| Treatment Verification Sampling | EA | 26 | $368 | VQ | $9,568 |
| Mobilization/Demobilization | LS | 1 | $100,000 | VQ | $100,000 |
| **Subtotal** | | | | | $2,969,818 |
| **RESIDUALS MANAGEMENT** | | | | | |
| Residuals Characterization | EA | 5 | $1,100 | VQ | $5,500 |
| Treated Soil Placement | CY | 2,600 | $5 | EJ | $13,000 |
| Oversize Material | CY | 260 | $45 | VQ | $11,700 |
| **Subtotal** | | | | | $30,200 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **EQUIPMENT SALVAGE** | | | | | |
| Dismantling | | 10% | | EJ | $4,450 |
| Pre–Process Equipment | | –20% | | EJ | –$8,900 |
| Pre–Process Structure | | –20% | | EJ | –$22,800 |
| **Subtotal** | | | | | –$27,250 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $3,106,000 |

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 3**
**(THERMAL TREATMENT)**
**VOLUME = 2600 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $155,300 |
| Health & Safety | | 8% | | | $248,480 |
| Prime Contractor Fixed Fee | | 5% | | | $155,300 |
| **Subtotal** | | | | | $3,665,000 |
| Bonds and Insurance | | 1% | | | $36,650 |
| **Subtotal** | | | | | $3,702,000 |
| Permitting and Legal | | 5% | | | $185,100 |
| Design Engineering | | 8% | | | $296,160 |
| Construction–Related Services | | 8% | | | $296,160 |
| Scope Contingency | | 20% | | | $740,400 |
| **TOTAL CAPITAL COST** | | | | | $5,220,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 YRS, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | **$6,920,000** |

ALT3TH1.WK3

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 3**
**(THERMAL TREATMENT)**
**VOLUME = 12,600 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 12,600 | $24 | VQ | $302,400 |
| Ordnance Management | | 10% | | EJ | $30,240 |
| Confirmation Sampling | EA | 93 | $368 | VQ | $34,224 |
| **Subtotal** | | | | | $366,864 |
| **THERMAL TREATMENT** | | | | | |
| Pretreatment Processing | | | | | |
| Grinder | LS | 1 | $40,000 | VQ | $40,000 |
| Conveyor | LS | 1 | $4,500 | VQ | $4,500 |
| Installation | | 20% | | EJ | $8,900 |
| Pre–Processing Structure | | | | | |
| Structure | LS | 1 | $114,000 | VQ | $114,000 |
| Floor | LS | 1 | $40,600 | Means | $40,600 |
| Installation | LS | 1 | $52,000 | EJ | $52,000 |
| Thermal Treatment | | | | | |
| Soil Characterization | EA | 26 | $50 | VQ | $1,300 |
| Trial Burn | LS | 1 | $200,000 | VQ | $200,000 |
| Treatment Process | TON | 19,600 | $500 | VQ | $9,800,000 |
| Treatment Verification Sampling | EA | 126 | $368 | VQ | $46,368 |
| Mobilization/Demobilization | LS | 1 | $100,000 | VQ | $100,000 |
| **Subtotal** | | | | | $10,407,668 |
| **RESIDUALS MANAGEMENT** | | | | | |
| Residuals Characterization | EA | 26 | $1,100 | VQ | $28,600 |
| Treated Soil Placement | CY | 12,600 | $5 | EJ | $63,000 |
| Oversize Material | CY | 1,260 | $45 | VQ | $56,700 |
| **Subtotal** | | | | | $148,300 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **EQUIPMENT SALVAGE** | | | | | |
| Dismantling | | 10% | | EJ | $4,450 |
| Pre–Process Equipment | | –20% | | EJ | –$8,900 |
| Pre–Process Structure | | –20% | | EJ | –$22,800 |
| **Subtotal** | | | | | –$27,250 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $10,953,000 |

FS COST ESTIMATE
FORMER NOP SITE – OU1
ALTERNATIVE 3
(THERMAL TREATMENT)
VOLUME = 12,600 CY

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $547,650 |
| Health & Safety | | 8% | | | $876,240 |
| Prime Contractor Fixed Fee | | 5% | | | $547,650 |
| **Subtotal** | | | | | $12,925,000 |
| Bonds and Insurance | | 1% | | | $129,250 |
| **Subtotal** | | | | | $13,054,000 |
| Permitting and Legal | | 5% | | | $652,700 |
| Design Engineering | | 8% | | | $1,044,320 |
| Construction–Related Services | | 8% | | | $1,044,320 |
| Scope Contingency | | 20% | | | $2,610,800 |
| **TOTAL CAPITAL COST** | | | | | $18,406,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 YRS, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | $20,106,000 |

ALT3TH2.WK3

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 3**
**(THERMAL TREATMENT)**
**VOLUME = 25,200 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 25,200 | $24 | VQ | $604,800 |
| Ordnance Management | | 10% | | EJ | $60,480 |
| Confirmation Sampling | EA | 187 | $368 | VQ | $68,816 |
| **Subtotal** | | | | | $734,096 |
| **THERMAL TREATMENT** | | | | | |
| Mobilization | LS | 1 | $1,094,920 | VQ | $1,094,920 |
| Pre–Treatment Building | LS | 1 | $114,000 | VQ | $114,000 |
| Floor | LS | 1 | $40,600 | Means | $40,600 |
| Operating Documents | LS | 1 | $261,000 | VQ | $261,000 |
| Startup/Pre–Trial Burn | LS | 1 | $1,292,300 | VQ | $1,292,300 |
| Trial Burn | LS | 1 | $743,500 | VQ | $743,500 |
| Thermal Treatment | LS | 1 | $7,103,700 | VQ | $7,103,700 |
| Demobilization | LS | 1 | $521,560 | VQ | $521,560 |
| **Subtotal** | | | | | $11,171,580 |
| **RESIDUALS MANAGEMENT** | | | | | |
| reated Soil Placement | CY | 25,200 | $5 | EJ | $126,000 |
| Oversize Material | CY | 2,520 | $45 | VQ | $113,400 |
| **Subtotal** | | | | | $239,400 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $12,202,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $610,100 |
| Health & Safety | | 8% | | | $976,160 |
| Prime Contractor Fixed Fee | | 5% | | | $610,100 |
| **Subtotal** | | | | | $14,398,000 |
| Bonds and Insurance | | 1% | | | $143,980 |
| **Subtotal** | | | | | $14,542,000 |
| Permitting and Legal | | 5% | | | $727,100 |
| Design Engineering | | 8% | | | $1,163,360 |
| Construction–Related Services | | 8% | | | $1,163,360 |
| Scope Contingency | | 20% | | | $2,908,400 |
| **TOTAL CAPITAL COST** | | | | | $20,504,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 YRS, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | $22,204,000 |

ALT3TH3.WK3

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 3**
**(THERMAL TREATMENT)**
**VOLUME = 42,000 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 42,000 | $24 | VQ | $1,008,000 |
| Ordnance Management | | 10% | | EJ | $100,800 |
| Confirmation Sampling | EA | 312 | $368 | VQ | $114,816 |
| **Subtotal** | | | | | $1,223,616 |
| **THERMAL TREATMENT** | | | | | |
| Mobilization | LS | 1 | $1,094,920 | VQ | $1,094,920 |
| Pre–Treatment Building | LS | 1 | $114,000 | VQ | $114,000 |
| Floor | LS | 1 | $40,600 | Means | $40,600 |
| Operating Documents | LS | 1 | $261,000 | VQ | $261,000 |
| Startup/Pre–Trial Burn | LS | 1 | $1,292,300 | VQ | $1,292,300 |
| Trial Burn | LS | 1 | $743,500 | VQ | $743,500 |
| Thermal Treatment | LS | 1 | $11,845,600 | VQ | $11,845,600 |
| Demobilization | LS | 1 | $521,560 | VQ | $521,560 |
| **Subtotal** | | | | | $15,913,480 |
| **RESIDUALS MANAGEMENT** | | | | | |
| Treated Soil Placement | CY | 42,000 | $5 | EJ | $210,000 |
| Oversize Material | CY | 4,200 | $45 | VQ | $189,000 |
| **Subtotal** | | | | | $399,000 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $17,593,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $879,650 |
| Health & Safety | | 8% | | | $1,407,440 |
| Prime Contractor Fixed Fee | | 5% | | | $879,650 |
| **Subtotal** | | | | | $20,760,000 |
| Bonds and Insurance | | 1% | | | $207,600 |
| **Subtotal** | | | | | $20,968,000 |
| Permitting and Legal | | 5% | | | $1,048,400 |
| Design Engineering | | 8% | | | $1,677,440 |
| Construction–Related Services | | 8% | | | $1,677,440 |
| Scope Contingency | | 20% | | | $4,193,600 |
| **TOTAL CAPITAL COST** | | | | | $29,565,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 YRS, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | **$31,265,000** |

ALT3TH4.WK3

# ALTERNATIVE 3 (THERMAL TREATMENT) COST ANALYSIS ASSUMPTIONS

## SOIL REMOVAL

Assumptions for soil removal for Alternative 3 are the same as those listed in the assumptions for Alternative 2.

## THERMAL TREATMENT

The following components are included in Thermal Treatment:

### Pretreatment Processing

Prior to thermal treatment, soils are assumed to require screening/grinding to provide the required feed particle size. Soil is assumed to be loaded into a coarse screen with the front-end loader; screened soil would drop into the feeder/grinder (clay declumper); declumped soil may then be conveyed to the thermal treatment unit by a screw or drag-flight auger. Costs for the coarse screen and feeder/grinder are based on quotes from Airing Equipment (Airing Equipment, 1992) and J.C. Steele & Sons, Inc. (J.C. Steele & Sons, Inc., 1992), respectively. The cost for the conveyor was based on a quote from Screw Conveyor Corporation (Screw Conveyor Corporation, 1992). Preprocessing installation costs are by estimator judgement.

### Pre-Processing Structure

Pretreatment processing is assumed to take place inside a preprocessing structure. Costs for the structure are adapted from a quote from Sprung (1993). It is assumed that one of the structures for which Sprung quoted costs will be used. Flooring would be similar to that described in Alternative 2. Costs for flooring for the structure are from Means. Installation of the structure is similar to that described in Alternative 2.

### Thermal Treatment

Thermal treatment is estimated to include the following: soil characterization, mobilization/demobilization, trial burn, and thermal processing. Mobilization/demobilization costs are assumed to be a percent of capital costs.

As in Alternative 2, it is assumed that sufficient process water can be obtained though modification of the existing distribution system.

It is assumed that the excavated soil will be characterized by BTU content, moisture content, and soil type. It is assumed that 1 sample will be collected for each 500 cy of soil. Analytical costs are based on a quote from Twin City Testing (TCT, 1991a), assuming a 7-day turnaround time.

For the volumes 2600 cy, 8400 cy and 12,600 cy, trial burn costs and thermal treatment costs are based on a quote from Vesta (Vesta, 1992). For the two larger volumes (25,200 cy and 42,000 cy), costs are based on an estimate by Cross/Tessitore & Associates (C/TA, 1993).

The Vesta estimate provides costs for mobilization/demobilization, the trial burn, and thermal processing. It is assumed, based on discussions with Vesta that these costs will cover other activities needed before thermal processing startup. Thermal processing costs are estimated on a cost-per-ton basis. In contrast, the C/TA estimate provides itemized costs for pre-thermal processing activities. These items are independent of volume, and include preparation of operating documents, startup/pre-trial burn activities, and the trial burn. The C/TA estimate includes preprocessing equipment but not the building to house the equipment. Thermal processing costs are estimated on a cost-per-hour basis, using a process rate of 15 tons/hr with 50 percent downtime (the amount of downtime equals the amount of operating time).

### Verification Sampling

It is assumed that thermal treatment residuals (ash and fly ash) will be analyzed to verify target treatment levels and to determine their suitability for on-site placement. Treated soil that does not meet target treatment levels would be retreated at the contractor's expense. C/TA's cost estimate includes analytical costs for explosives and TCLP metals. These items are not included in Vesta's cost estimate. It is assumed that one sample for explosives analysis to verify target treatment levels will be collected per 100 cy of treated soil. Analytical costs are based on an estimate from TCT (1991).

## RESIDUALS MANAGEMENT

### Residuals Characterization

Since the Vesta cost estimate does not include testing to determine suitability for on-site placement, it is assumed that one sample will be collected for TCLP metals analysis per 500 cy of solid residuals. Analytical costs are based on SEC Donohue (1991).

### Treated Soil Placement

It is assumed that all ash would be placed back into excavations and vegetated. Ash should not be difficult to compact with proper moisture control (Chemical Waste Management Remediation Services 1992c). Treatability studies (Cross/Tessitore & Associates, 1993) have shown that stabilization of treated soil would not be necessary prior to placement. Hauling, placement, and compaction costs are based on estimator judgement.

### Oversize Material

It is assumed that untreated solids (debris and screened solids) volumes and disposal methods would be the same as Alternative 2.



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## GROUNDWATER TREATMENT

It is assumed that point-of-use groundwater treatment systems for Alternative 3 would be the same as for Alternative 2.

## OPERATIONS AND MAINTENANCE (O&M) COSTS

It is assumed that operations and maintenance costs for Alternative 3 would be the same as those for Alternative 2.



B07NE003701-05120

# CALCULATIONS FOR THERMAL TREATMENT COSTS AND IMPLEMENTATION TIME

## 1. Smaller Volumes

$$8{,}400\ cy\ x\ 27\ cf/cy\ x\ 115\ lb/cf\ x\ \frac{1\ ton}{2000\ lb} = 13{,}000\ tons\ soil$$

$$2{,}600\ cy\ x\ 27\ cf/cy\ x\ 115\ lb/cf\ x\ \frac{1\ ton}{2000\ lb} = 4{,}000\ tons\ soil$$

$$12{,}600\ cy\ x\ 27\ cf/cy\ x\ 115\ lb/cf\ x\ \frac{1\ ton}{2000\ lb} = 19{,}600\ tons\ soil$$

Process rate of 4 ton/hr (Vesta) with 30 percent downtime (downtime based on vendor information). Processing 24 hours per day, 30 days per month.

$$\frac{13{,}000\ tons}{4\ ton/hr}\ x\ \frac{1}{0.7\ uptime} = 4{,}643\ hr = 193\ days \qquad 7\ months$$

$$\frac{4{,}000\ tons}{4\ ton/hr}\ x\ \frac{1}{0.7\ uptime} = 1{,}429\ hr = 60\ days \qquad 2\ months$$

$$\frac{19{,}600\ tons}{4\ ton/hr}\ x\ \frac{1}{0.7\ uptime} = 7{,}000\ hr = 292\ days \qquad 10\ months$$



B07NE003701-05121

| | | 8,400 cy | 2,600 cy | 12,600 cy |
|---|---|---|---|---|
| Assume: | Site Preparation | 2 Months | 2 Months | 2 Months |
| | Soil Removal | 1 Month | 1 Month | 1 Month |
| | Mobilization/Setup | 1 Month | 1 Month | 1 Month |
| | Test Burn, Permitting | 6 Months | 6 Months | 6 Months |
| | Treatment | 7 Months | 2 Months | 10 Months |
| | Demobilization | 1 Month | 1 Month | 1 Month |
| | | 18 Months | 13 Months | 21 Months |

**2. Larger Volumes**

Costs are based on an estimate supplied by C/TA.

Treatment costs are broken down into the following categories:

Operating Documents

Startup-Pretrial Burn Activities
Trial Burn
Thermal Treatment

Operating documents, startup/pretrial burn, and trial burn are given as volume-independent lump sum costs.

| | |
|---|---|
| Operating Documents | $261,000 |
| Startup/Pretrial Burn | $1,292,300 |
| Trial Burn | $743,500 |

Thermal treatment costs are based on a processing rate of 15 tons/hour with less than 50 percent downtime (downtime = operating time).

Hourly costs are divided into:

| | |
|---|---|
| Labor | $337.76/hr |
| Equipment | $516.94/hr |
| Materials | $474.43/hr |
| Analytical | $1,607/day |

Analytical costs are incurred only during treatment (50% downtime).

$$\$1{,}607/2 = 803.50/day \times \frac{1\ day}{24\ hrs} = \$33.48/hr$$

Total hourly cost = $1,362.61/hr

$$25{,}200\ cy\ x\ 27\ cf/cy\ x\ 115\ lb/cf\ x\ \frac{1\ ton}{2000\ lb} = 39{,}100\ tons$$

$$42{,}000\ cy\ x\ 27\ cf/cy\ x\ 115\ lb/cf\ x\ \frac{1\ ton}{2000\ lb} = 65{,}200\ tons$$

Thermal treatment costs:

$$\frac{39{,}100\ tons}{15\ tons/hr}\ x\ \frac{1}{0.5\ uptime}\ x\ \$1{,}362.61/hr = \$7{,}103{,}700$$

$$\frac{65{,}200\ tons}{15\ tons/hr}\ x\ \frac{1}{0.5\ uptime}\ x\ \$1{,}362.61/hr = \$11{,}845{,}600$$

Implementation Times:

$$\frac{39{,}100\ tons}{15\ tons/hr}\ x\ \frac{1}{0.5\ uptime} = 5{,}213\ hr = 217\ days \qquad 8\ months$$

$$\frac{65{,}200\ tons}{15\ tons/hr}\ x\ \frac{1}{0.5\ uptime} = 8{,}693\ hr = 362\ days \qquad 12\ months$$



B07NE003701-05123

| | | 25,000 cy | 41,000 cy |
|---|---|---|---|
| Assume: | Site Preparation | 2 Months | 2 Months |
| | Soil Removal | 2 Months | 3 Months |
| | Mobilization/Setup | 2 Months | 2 Months |
| | Test Burn, Permitting | 6 Months | 6 Months |
| | Treatment | 8 Months | 12 Months |
| | Demobilization | 1 Month | 1 Month |
| | | 21 Months | 26 Months |



B07NE003701-05124

# APPENDIX F3

# ALTERNATIVE 4 COST SUMMARY

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 4**
**(ON–SITE LANDFILLING)**
**BASE VOLUME = 8400 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 8,400 | $24 | VQ | $201,600 |
| Ordnance Management | | 10% | | EJ | $20,160 |
| Confirmation Sampling | EA | 63 | $368 | VQ | $23,184 |
| Backfill | CY | 8,400 | $7 | VQ–Means | $58,800 |
| **Subtotal** | | | | | $303,744 |
| **LANDFILL CONSTRUCTION** | | | | | |
| Land Acquistion | LS | 1 | $20,000 | VQ | $20,000 |
| Site Fence | LS | 1 | $14,300 | Means | $14,300 |
| Excavation | CY | 11,600 | $1.86 | Means | $21,576 |
| Clay Liner | CY | 3,400 | $9.70 | VQ–Means | $32,980 |
| Geomembrane Construction | SY | 6,800 | $10 | EJ | $68,000 |
| Leachate Collection System | LS | 1 | $50,000 | EJ | $50,000 |
| Liner Geotextile | SY | 13,600 | $3.30 | EJ | $44,880 |
| Contaminated Soil Placement | CY | 8,400 | $5.50 | Means | $46,200 |
| ap Clay Layer | CY | 3,100 | $9.70 | VQ–Means | $30,070 |
| Cap Drainage Layer | CY | 1,500 | $10.18 | VQ–EJ | $15,270 |
| Cap Geotextile | SY | 9,200 | $3.30 | EJ | $30,360 |
| Cap Soil Layer (Rooting Zone) | CY | 2,900 | $6.95 | VQ–Means | $20,155 |
| Topsoil and Spreading | CY | 1,500 | $5.80 | VQ–Means | $8,700 |
| Seed/Fertilize/Mulch | AC | 1 | $1,600 | Means | $1,600 |
| **Subtotal** | | | | | $404,100 |
| **MONITORING WELLS** | | | | | |
| Well Installation | EA | 5 | $10,000 | EJ | $50,000 |
| **Subtotal** | | | | | $50,000 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $815,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $40,750 |
| Mobilization/Demobilization | | 5% | | | $40,750 |
| Health & Safety | | 8% | | | $65,200 |
| Prime Contractor Fixed Fee | | 5% | | | $40,750 |
| **Subtotal** | | | | | $1,002,000 |

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 4**
**(ON–SITE LANDFILLING)**
**BASE VOLUME = 8400 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| Bonds and Insurance | | 1% | | | $10,020 |
| **Subtotal** | | | | | $1,012,000 |
| Permitting and Legal | | 5% | | | $50,600 |
| Design Engineering | | 15% | | | $151,800 |
| Construction–Related Services | | 8% | | | $80,960 |
| Scope Contingency | | 20% | | | $202,400 |
| **TOTAL CAPITAL COST** | | | | | $1,498,000 |
| **ANNUAL O&M COST (Year 1–5)** | | | $166,200 | | |
| **ANNUAL O&M COST (Years 6–30)** | | | $148,200 | | |
| **ANNUAL O&M COST (After Year 30)** | | | $25,700 | | |
| **PRESENT WORTH OF O&M (Perpetual Landfill, 30–yr gw point–of–use, 6%)** | | | | | $2,200,000 |
| **GRAND TOTAL** | | | | | **$3,698,000** |

ALT4OSLB.WK3

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 4**
**(ON–SITE LANDFILLING)**
**VOLUME = 2600 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 2,600 | $24 | VQ | $62,400 |
| Ordnance Management | | 10% | | EJ | $6,240 |
| Confirmation Sampling | EA | 20 | $368 | VQ | $7,360 |
| Backfill | CY | 2,600 | $7 | VQ–Means | $18,200 |
| **Subtotal** | | | | | $94,200 |
| **LANDFILL CONSTRUCTION** | | | | | |
| Land Acquistion | LS | 1 | $20,000 | VQ | $20,000 |
| Site Fence | LS | 1 | $9,000 | Means | $9,000 |
| Excavation | CY | 3,400 | $1.86 | Means | $6,324 |
| Clay Liner | CY | 1,400 | $9.70 | VQ–Means | $13,580 |
| Geomembrane Construction | SY | 1,400 | $10 | EJ | $14,000 |
| Leachate Collection System | LS | 1 | $50,000 | EJ | $50,000 |
| Liner Geotextile | SY | 2,800 | $3.30 | EJ | $9,240 |
| Contaminated Soil Placement | CY | 2,600 | $5.50 | Means | $14,300 |
| Cap Clay Layer | CY | 1,500 | $9.70 | VQ–Means | $14,550 |
| Cap Drainage Layer | CY | 800 | $10.18 | VQ–EJ | $8,144 |
| Cap Geotextile | SY | 4,500 | $3.30 | EJ | $14,850 |
| Cap Soil Layer (Rooting Zone) | CY | 800 | $6.95 | VQ–Means | $5,560 |
| Topsoil and Spreading | CY | 400 | $5.80 | VQ–Means | $2,320 |
| Seed/Fertilize/Mulch | AC | 1 | $1,600 | Means | $1,600 |
| **Subtotal** | | | | | $183,500 |
| **MONITORING WELLS** | | | | | |
| Well Installation | EA | 5 | $10,000 | EJ | $50,000 |
| **Subtotal** | | | | | $50,000 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $385,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $19,250 |
| Mobilization/Demobilization | | 5% | | | $19,250 |
| Health & Safety | | 8% | | | $30,800 |
| Prime Contractor Fixed Fee | | 5% | | | $19,250 |
| **Subtotal** | | | | | $474,000 |

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 4**
**(ON–SITE LANDFILLING)**
**VOLUME = 2600 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| Bonds and Insurance | | 1% | | | $4,740 |
| **Subtotal** | | | | | $479,000 |
| Permitting and Legal | | 5% | | | $23,950 |
| Design Engineering | | 15% | | | $71,850 |
| Construction–Related Services | | 8% | | | $38,320 |
| Scope Contingency | | 20% | | | $95,800 |
| **TOTAL CAPITAL COST** | | | | | $709,000 |
| **ANNUAL O&M COST (Years 1–5)** | | | $159,200 | | |
| **ANNUAL O&M COST (Years 6–30)** | | | $142,200 | | |
| **ANNUAL O&M COST (After Year 30)** | | | $18,700 | | |
| **PRESENT WORTH OF O&M (Perpetual Landfill, 30–yr gw point–of–use, 6%)** | | | | | $2,083,000 |
| **GRAND TOTAL** | | | | | $2,792,000 |

ALT4OSL1.WK3

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 4**
**(ON–SITE LANDFILLING)**
**VOLUME = 12,600 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 12,600 | $24 | VQ | $302,400 |
| Ordnance Management | | 10% | | EJ | $30,240 |
| Confirmation Sampling | EA | 93 | $368 | VQ | $34,224 |
| Backfill | CY | 12,600 | $7 | VQ–Means | $88,200 |
| **Subtotal** | | | | | $455,064 |
| **LANDFILL CONSTRUCTION** | | | | | |
| Land Acquistion | LS | 1 | $20,000 | VQ | $20,000 |
| Site Fence | LS | 1 | $16,200 | Means | $16,200 |
| Excavation | CY | 15,400 | $1.86 | Means | $28,644 |
| Clay Liner | CY | 4,400 | $9.70 | VQ–Means | $42,680 |
| Geomembrane Construction | SY | 8,800 | $10 | EJ | $88,000 |
| Leachate Collection System | LS | 1 | $50,000 | EJ | $50,000 |
| Liner Geotextile | SY | 17,600 | $3.30 | EJ | $58,080 |
| Contaminated Soil Placement | CY | 12,600 | $5.50 | Means | $69,300 |
| Cap Clay Layer | CY | 3,800 | $9.70 | VQ–Means | $36,860 |
| Cap Drainage Layer | CY | 1,900 | $10.18 | VQ–EJ | $19,342 |
| Cap Geotextile | SY | 11,400 | $3.30 | EJ | $37,620 |
| Cap Soil Layer (Rooting Zone) | CY | 1,900 | $6.95 | VQ–Means | $13,205 |
| Topsoil and Spreading | CY | 1,000 | $5.80 | VQ–Means | $5,800 |
| Seed/Fertilize/Mulch | AC | 1.2 | $1,600 | Means | $1,920 |
| **Subtotal** | | | | | $487,700 |
| **MONITORING WELLS** | | | | | |
| Well Installation | EA | 5 | $10,000 | EJ | $50,000 |
| **Subtotal** | | | | | $50,000 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $1,050,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $52,500 |
| Mobilization/Demobilization | | 5% | | | $52,500 |
| Health & Safety | | 8% | | | $84,000 |
| Prime Contractor Fixed Fee | | 5% | | | $52,500 |
| **Subtotal** | | | | | $1,292,000 |

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 4**
**(ON–SITE LANDFILLING)**
**VOLUME = 12,600 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| Bonds and Insurance | | 1% | | | $12,920 |
| **Subtotal** | | | | | $1,305,000 |
| Permitting and Legal | | 5% | | | $65,250 |
| Design Engineering | | 15% | | | $195,750 |
| Construction–Related Services | | 8% | | | $104,400 |
| Scope Contingency | | 20% | | | $261,000 |
| **TOTAL CAPITAL COST** | | | | | $1,931,000 |
| **ANNUAL O&M COST (Years 1–5)** | | | $169,700 | | |
| **ANNUAL O&M COST (Years 6–30)** | | | $152,700 | | |
| **ANNUAL O&M COST (After Year 30)** | | | $29,200 | | |
| **PRESENT WORTH OF O&M (Perpetual Landfill, 30–yr gw point–of–use, 6%)** | | | | | $2,258,000 |
| **GRAND TOTAL** | | | | | $4,189,000 |

ALT4OSL2.WK3

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 4**
**(ON–SITE LANDFILLING)**
**VOLUME = 25,200 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 25,200 | $24 | VQ | $604,800 |
| Ordnance Management | | 10% | | EJ | $60,480 |
| Confirmation Sampling | EA | 187 | $368 | VQ | $68,816 |
| Backfill | CY | 25,200 | $7 | VQ–Means | $176,400 |
| **Subtotal** | | | | | $910,496 |
| **LANDFILL CONSTRUCTION** | | | | | |
| Land Acquistion | LS | 1 | $20,000 | VQ | $20,000 |
| Site Fence | LS | 1 | $27,600 | Means | $27,600 |
| Excavation | CY | 25,400 | $1.86 | Means | $47,244 |
| Clay Liner | CY | 7,300 | $9.70 | VQ–Means | $70,810 |
| Geomembrane Construction | SY | 14,700 | $10 | EJ | $147,000 |
| Leachate Collection System | SY | 14,700 | $6 | EJ | $88,200 |
| Liner Geotextile | SY | 29,400 | $3.30 | EJ | $97,020 |
| ontaminated Soil Placement | CY | 25,200 | $5.50 | Means | $138,600 |
| Cap Clay Layer | CY | 6,000 | $9.70 | VQ–Means | $58,200 |
| Cap Drainage Layer | CY | 3,000 | $10.18 | VQ–EJ | $30,540 |
| Cap Geotextile | SY | 17,300 | $3.30 | EJ | $57,090 |
| Cap Soil Layer (Rooting Zone) | CY | 3,000 | $6.95 | VQ–Means | $20,850 |
| Topsoil and Spreading | CY | 1,500 | $5.80 | VQ–Means | $8,700 |
| Seed/Fertilize/Mulch | AC | 1.8 | $1,600 | Means | $2,880 |
| **Subtotal** | | | | | $814,700 |
| **MONITORING WELLS** | | | | | |
| Well Installation | EA | 5 | $10,000 | EJ | $50,000 |
| **Subtotal** | | | | | $50,000 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $1,832,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $91,600 |
| Mobilization/Demobilization | | 5% | | | $91,600 |
| Health & Safety | | 8% | | | $146,560 |
| Prime Contractor Fixed Fee | | 5% | | | $91,600 |
| **ubtotal** | | | | | $2,253,000 |

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 4**
**(ON–SITE LANDFILLING)**
**VOLUME = 25,200 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| Bonds and Insurance | | 1% | | | $22,530 |
| **Subtotal** | | | | | $2,276,000 |
| Permitting and Legal | | 5% | | | $113,800 |
| Design Engineering | | 15% | | | $341,400 |
| Construction–Related Services | | 8% | | | $182,080 |
| Scope Contingency | | 20% | | | $455,200 |
| **TOTAL CAPITAL COST** | | | | | $3,368,000 |
| **ANNUAL O&M COST (Years 1–5)** | | | $176,800 | | |
| **ANNUAL O&M COST (Years 6–30)** | | | $159,800 | | |
| **ANNUAL O&M COST (After Year 30)** | | | $36,300 | | |
| **PRESENT WORTH OF O&M (Perpetual Landfill, 30–yr gw point–of–use, 6%)** | | | | | $2,377,000 |
| **GRAND TOTAL** | | | | | **$5,745,000** |

ALT4OSL3.WK3

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 4**
**(ON–SITE LANDFILLING)**
**VOLUME = 42,000 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 42,000 | $24 | VQ | $1,008,000 |
| Ordnance Management | | 10% | | EJ | $100,800 |
| Confirmation Sampling | EA | 312 | $368 | VQ | $114,816 |
| Backfill | CY | 42,000 | $7 | VQ–Means | $294,000 |
| **Subtotal** | | | | | $1,517,616 |
| **LANDFILL CONSTRUCTION** | | | | | |
| Land Acquistion | LS | 1 | $20,000 | VQ | $20,000 |
| Site Fence | LS | 1 | $37,800 | Means | $37,800 |
| Excavation | CY | 53,200 | $1.86 | Means | $98,952 |
| Clay Liner | CY | 11,500 | $9.70 | VQ–Means | $111,550 |
| Geomembrane Construction | SY | 23,000 | $10 | EJ | $230,000 |
| Leachate Collection System | SY | 23,000 | $6 | EJ | $138,000 |
| Liner Geotextile | SY | 46,000 | $3.30 | EJ | $151,800 |
| ontaminated Soil Placement | CY | 42,000 | $5.50 | Means | $231,000 |
| Cap Clay Layer | CY | 8,800 | $9.70 | VQ–Means | $85,360 |
| Cap Drainage Layer | CY | 4,400 | $10.18 | VQ–EJ | $44,792 |
| Cap Geotextile | SY | 26,400 | $3.30 | EJ | $87,120 |
| Cap Soil Layer (Rooting Zone) | CY | 4,400 | $6.95 | VQ–Means | $30,580 |
| Topsoil and Spreading | CY | 2,200 | $5.80 | VQ–Means | $12,760 |
| Seed/Fertilize/Mulch | AC | 2.8 | $1,600 | Means | $4,480 |
| **Subtotal** | | | | | $1,284,200 |
| **MONITORING WELLS** | | | | | |
| Well Installation | EA | 5 | $10,000 | EJ | $50,000 |
| **Subtotal** | | | | | $50,000 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $2,909,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $145,450 |
| Mobilization/Demobilization | | 5% | | | $145,450 |
| Health & Safety | | 8% | | | $232,720 |
| Prime Contractor Fixed Fee | | 5% | | | $145,450 |
| **ubtotal** | | | | | $3,578,000 |

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 4**
**(ON–SITE LANDFILLING)**
**VOLUME = 42,000 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| Bonds and Insurance | | 1% | | | $35,780 |
| **Subtotal** | | | | | $3,614,000 |
| Permitting and Legal | | 5% | | | $180,700 |
| Design Engineering | | 15% | | | $542,100 |
| Construction–Related Services | | 8% | | | $289,120 |
| Scope Contingency | | 20% | | | $722,800 |
| **TOTAL CAPITAL COST** | | | | | $5,349,000 |
| **ANNUAL O&M COST (Years 1–5)** | | | $187,700 | | |
| **ANNUAL O&M COST (Years 6–30)** | | | $170,700 | | |
| **ANNUAL O&M COST (After Year 30)** | | | $47,200 | | |
| **PRESENT WORTH OF O&M (Perpetual Landfill, 30–yr gw point–of–use, 6%)** | | | | | $2,578,000 |
| **GRAND TOTAL** | | | | | $7,927,000 |

ALT4OSL4.WK3

# ALTERNATIVE 4 (ON-SITE LANDFILL) COST ANALYSIS ASSUMPTIONS

## SOIL REMOVAL

The assumptions for soil removal for Alternative 4 are the same as for Alternative 2, with the addition of backfill of excavations. Backfill soil would be purchased and placed in areas where contaminated soil was excavated. Soil costs are from a quote from Aggregate Carriers (1992) for supply, and Means for placement and compaction.

## LANDFILL CONSTRUCTION

The following components are included in Landfill Construction:

### Land Acquisition

It is assumed that the landfill would be located within one of the diamond areas of the NOP site load lines. It is assumed that USACE will have to purchase land within the diamond area (approximately 10 acres). At a purchase price of $2,000/acre (Aggregate Carriers 1992), the total is $20,000.

### Landfill Fence

It is assumed that the landfill area would be surrounded by a 6-foot chain link fence with two gates. Costs are based on Means.

### Excavation of Landfill Area

It is assumed that landfill area would be excavated to provide a base for placement of landfill liner components. Excavation costs are based on Means. It was assumed that excavated soil would be utilized on-site. The soil would be used for stormwater run-on/runoff control, cap construction, or miscellaneous site grading.

### Clay Liner Construction

Following excavation and surface preparation a 3-foot compacted clay layer with a compacted permeability of 1E-07 cm/sec or less would be constructed on the landfill area. Clay layer construction would consist of clay material purchase from a local borrow source (including borrow source characterization testing), loading into trucks, hauling to the site and dumping in the landfill area, spreading and compaction (including in-place quality assurance/quality control testing).

Cost estimates for local clay borrow are based on a quote from Aggregate Carriers of Mead, Nebraska. The cost quoted includes material purchase, excavation, loading, hauling, and dumping within the landfill area.

It is assumed that the clay would be spread in uniform controlled lifts with a bulldozer and compacted with a sheepsfoot roller. Spreading and compaction costs are based on Means, and are included in the "clay liner" line item cost.

It is assumed that the clay borrow source would require material inspection and characterization testing to determine its suitability. Clay borrow source characterization costs are included in the "construction related services" global allowance. Characterization will include:

- Test pits.
- Quantity verification.
- Classification.
- Index property testing.
- Moisture-density relationship (compaction) testing.
- Permeability testing.

**Geomembrane Construction**

Two layers of geomembrane (60 mil or greater thickness) are assumed to be placed as shown in Figure 4-8, Conceptual Landfill Design (located in the text of the report). Geomembrane construction would consist of geomembrane purchase and delivery to the site (including material testing), fine grading of the clay layer to prevent geomembrane damage, spreading the geomembrane, seaming the sheets of the geomembrane (including QA/QC testing), and anchoring the geomembrane in an anchor trench.

Costs for the geomembrane material and QA/QC testing are assumed through estimator judgement, based on experience with similar sites. Included in this cost is all necessary testing, which may include, but is not limited to, thickness, tensile strength, dimensional stability, low temperature resistance, density, carbon black content, and melt flow index.

Before placement of the geomembrane, surface irregularities such as abrupt changes in grade will be eliminated using a smooth roller to ensure contact between the clay surface and the geomembrane. The geomembrane is installed by deploying rolls of geomembrane across the clay layer surface and seaming adjacent rolls of geomembrane together. Non-destructive seam testing (vacuum box and air pressure) and destructive testing (shear and peel) will be performed on the completed installation. Testing is included in the cost estimate. Anchoring the geomembrane would be accomplished by inserting the end of the geomembrane into an anchor trench and backfilling the trench with soil.

**Leachate Collection System Construction**

The purpose of a leachate collection system is to minimize the hydraulic head on the liner and to remove liquids from the landfill. The leachate collection system consists of two layers of drainage media separated by a geomembrane as shown in Figure 4-8 of the text. The leachate collection system for the landfill is assumed to include the following items:

- Perforated HDPE piping.
- Nonperforated HDPE piping.



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- Sand collection layer.
- Gravel filter pack around piping.
- Geotextile filter around filter pack.
- Leachate sump/pump station.

Leachate collection system costs are based on estimator judgement from experience with similar sites.

**Geotextile Installation**

It is assumed that a geotextile with sewn seams will be placed above the leachate collection system to segregate it from placed contaminated soil. Costs are assumed by estimator judgement, based on experience with similar sites.

**Contaminated Soil (and Debris) Placement**

It is assumed that excavated soil and debris would be hauled to the landfill area and spread with a bulldozer and compacted with a sheepsfoot roller. Contaminated soil hauling, spreading, and compaction costs are from Means.

**Cap Clay Layer Construction**

It is assumed that a 2-foot clay layer would be placed over the fill to minimize infiltration and subsequent leachate generation. Clay layer construction would consist of clay material purchase from a local borrow source (including borrow characterization testing), loading into trucks, hauling to the site, placement within the cap area, spreading, and compaction (including in-place quality assurance/quality control (QA/QC) testing). Cost components and assumptions are similar to those for the clay liner.

**Drainage Layer Construction**

It is assumed that a 12-inch granular drainage layer would be constructed above the clay cap as shown in Figure 4-8, Conceptual Landfill Design. This layer would gravity drain to peripheral drainage ditches. Construction of the drainage layer involves granular material purchased from a local borrow source (Aggregate Carriers, 1992). The cost includes hauling to the site. It is assumed that the unit weight will be similar to that of native site soil. Spreading costs are based on estimator judgement, and are included in the "cap drainage layer" line item cost.

**Geotextile Installation**

It is assumed that geotextiles will be placed between layers of the cap for filtration/segregation. Costs are based on estimator judgement from experience with similar sites.

**Soil Layer Construction**

It is assumed that a layer of soil 12 inches thick would be constructed on top of the drainage layer to support the vegetative layer, to provide frost protection to the clay layer and to promote

cap drainage. Costs are from a quote from Aggregate Carriers (Aggregate Carriers, 1992) for supply, and Means for spreading.

**Topsoil and Seeding**

It is assumed that a 6-inch layer of vegetated topsoil would be placed over the soil layer. This layer is the primary erosion control layer for the cap. Topsoil placement would involve topsoil purchase, loading and hauling to the site, placement within the cap area, and grading. Vegetation establishment would include seedbed preparation, fertilizing, seeding, and mulching. Costs are from Aggregate Carriers (Aggregate Carriers, 1992) for topsoil supply, and Means for topsoil spreading, seeding, fertilizing, and mulching.

**Monitoring Well Installation**

It is assumed that monitoring wells would be installed adjacent to the landfill for long-term groundwater monitoring. The actual number and location of wells would be determined during design. This estimate assumes five monitoring wells installed at a cost of $10,000 each (estimator judgement). The cost includes field surveying, drilling, logging, well materials and installation, purging, documentation, and cleanup. Costs are based on estimator judgement from experience with similar sites.

**OPERATION AND MAINTENANCE COSTS**

It is assumed that O&M would consist of leachate removal and disposal, monitoring and maintenance of the landfill and wells, in addition to point-of-use groundwater treatment.

**Leachate Removal and Disposal**

It is assumed leachate would be pumped from a sump/pump station into trucks and hauled to an off-site licensed facility for disposal. Based on a HELP Model analysis (attached), it is estimated that a landfill of surface area 41,600 sf will yield a leachate volume of approximately 7000 gal/yr. For the sensitivity analyses, it is assumed that the quantity of leachate generated is proportional to cap surface area. Costs for disposal are from U.S. Pollution Control (U.S. Pollution Control, 1993).

Base Volume:

7000 gal/yr X $0.80/gal + $1700/truckload X 2 truckloads/year = $9000/yr.

Sensitivity Analyses:

| Soil Volume (cy) | Cap Surface area (sf) | |
|---|---|---|
| 2,600 | 12,400 | 12,400/41,600 x 7,000 gal/yr = 2,100 gal/yr |
| 12,600 | 51,100 | 51,100/41,600 x 7,000 gal/yr = 8,600 gal/yr |
| 25,200 | 77,900 | 77,900/41,600 x 7,000 gal/yr = 13,100 gal/yr |
| 42,000 | 118,700 | 118,700/41,600 x 7,000 gal/yr = 20,000 gal/yr |



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2,100 gal/yr x $0.80/gal + $1,700/truckload x 1 truckload/yr = $3,400/yr
8,600 gal/yr x $0.80/gal + $1,700/truckload x 3 truckloads/yr = $12,000/yr
13,100 gal/yr x $0.80/gal + $1,700/truckload x 4 truckloads/yr = $17,300/yr
20,000 gal/yr x $0.80/gal + $1,700/truckload x 6 truckloads/yr = $26,200/yr

Leachate Removal and Disposal Present Worth

Base Volume:

Present worth factor (perpetual, 6%) = 16.6667
PW = $9000 x 16.6667 = $150,000

Sensitivity Analyses:

Present worth factor (perpetual, 6%) = 16.6667

PW = $3,400 x 16.6667 = $56,700
$12,000 x 16.6667 = $200,000
$17,300 x 16.6667 = $288,300
$26,200 x 16.6667 = $456,700

**Monitoring**

It was assumed that monitoring would be required on a quarterly basis for years 1 through 5 and annually thereafter. Monitoring is assumed to continue perpetually. Monitoring will include:

- Groundwater Sampling and Analysis
  - Five Monitoring Wells
  - Explosives Analysis
- Cap, Fence, and Leachate Collection System Inspection
- Preparation of Annual Report

Costs for monitoring are developed below and were estimated based on estimator judgement and vendor quotes.

Cost per Monitoring Event

| | |
|---|---|
| Labor | |
| 2 persons x 2 days x 10 hrs/day x $50/hr | $2,000 |
| Transportation (local), Per Diem | |
| 2 persons x 2 days x $100/day | $400 |
| Equipment | |
| 2 days x $200/day | $400 |
| Analytical Testing (Explosives) | |
| Assume 5 samples + 1 QA/QC sample | |
| 6 samples x $335/sample (TCT, 1992) | $2,010 |



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| | |
|---|---|
| Subtotal | $4,810 |
| Administrative (10%) | $481 |
| Contingencies (10%) | $481 |
| Total Cost Per Monitoring Event | $5,800 |

Annual Monitoring Cost

| | |
|---|---|
| Annual Cost - Quarterly Monitoring | |
| 4 events x $5,800/event + $5,000 (annual report) | $28,000 |
| Annual Cost - Annual Monitoring | |
| 1 event x $5,800/event + $5,000 (annual report) | $11,000 |

Monitoring Present Worth

| | |
|---|---|
| For Years 1 through 5 | |
| Present Worth Factor (5 years, 6%) = 4.2124 | |
| PW = $28,000 x 4.2124 | $118,000 |
| For Years 6 through 30 | |
| Present Worth Factor (perpetual, 6%) = 16.6667 | |
| PW = $11,000 x (16.6667 - 4.2124) | $137,000 |
| Total Monitoring Present Worth | $255,000 |

**Maintenance**

Annual maintenance of the on-site landfill may include periodic cover repair, mowing semi-annually to retard growth of vegetation that may damage the liner collection system maintenance. Leachate collection system maintenance may consist of checks for leaks, cleaning, and repairs. Costs are based on estimator judgement from experience with similar sites.

| | |
|---|---|
| Annual cover repair | |
| Base Volume: $0.05/sf-yr x 41,300 sf = | $2,100/yr |

Sensitity Analyses:

2,600 cy - $0.05/sf yr x 12,400 sf = $600/yr
12,600 cy - $0.05/sf yr x 51,100 sf = $2,500/yr
25,200 cy - $0.05/sf yr x 81,400 sf = $4,100/yr
42,000 cy - $0.05/sf yr x 118,700 sf = $5,900/yr

| | |
|---|---|
| Semi-annual mowing | |
| Base Volume: $100/acre x 1 acre x 2/yr | $200/yr |

Sensitity Analyses:

2,600 cy - $100/acre x 1 acre x 2/yr = $200/yr



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12,600 cy - $100/acre x 1 acre x 2/yr = $200/yr
25,200 cy - $100/acre x 2 acres x 2/yr = $400/yr
42,000 cy - $100/acre x 3 acres x 2/yr = $600/yr

| | | |
|---|---|---|
| LCS maintenance | | $2,000/yr |
| Miscellaneous maintenance | | $1,500/yr |
| Totals | Base Volume: | $5,700/yr |
| | Sensitivity Analyses: | 2,600 ey - $4,300/yr<br>12,600 cy - $6,200/yr<br>25,200 cy - $8,000/yr<br>42,000 cy - $10,000/yr |

Maintenance Present Worth
Present Worth Factor (perpetual, 6%) = 16.6667
Base Volume: Present Worth = $5,700 x 16.6667 = $95,000

Sensitivity Analyses:

2,600 cy - 4,300 x 16.6667 = 71,700
12,600 cy - 6,200 x 16.6667 = 103,300
25,200 cy - 8,000 x 16.6667 = 133.300
42,000 cy - 10,000 x 16.6667 = 166.700

**O&M Totals (Base Volume)**

| | Years 1-5 | Years 6-30 | Present Worth |
|---|---|---|---|
| Leachate Removal and Disposal | $9,000 | $9,000 | $150,000 |
| Monitoring | $28,000 | $11,000 | $255,000 |
| Maintenance | $5,700 | $5,700 | $95,000 |
| Subtotal | $42,700 | $25,700 | $500,000 |
| Point-of-Use Groundwater Treatment | $123,500 | $123,500 | $1,700,000 |
| TOTAL | $166,200 | $148,200 | $2,200,000 |

**O&M Totals (Sensitivity Analyses)**

2,600 cy:

| | Years 1-5 | Years 6-30 | Present Worth |
|---|---|---|---|
| Leachate Removal and Disposal | $3,400 | $3,400 | $56,700 |
| Monitoring | $28,000 | $11,000 | $255,000 |



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| | | | |
|---|---|---|---|
| Maintenance | $4,300 | $4,300 | $71,700 |
| Subtotal | $35,700 | $18,700 | $383,400 |
| Point-of-Use Groundwater Treatment | $123,500 | $123,500 | $1,700,000 |
| TOTAL | $159,200 | $142,200 | $2,803,400 |

12,600 cy:

| | Years 1-5 | Years 6-30 | Present Worth |
|---|---|---|---|
| Leachate Removal and Disposal | $12,000 | $12,400 | $200,000 |
| Monitoring | $28,000 | $11,000 | $255,000 |
| Maintenance | $6,200 | $6,200 | $103,300 |
| Subtotal | $46,200 | $29,200 | $558,300 |
| Point-of-Use Groundwater Treatment | $123,500 | $123,500 | $1,700,000 |
| TOTAL | $169,700 | $152,700 | $2,258,300 |

25,200 cy:

| | Years 1-5 | Years 6-30 | Present Worth |
|---|---|---|---|
| Leachate Removal and Disposal | $17,300 | $17,300 | $288,300 |
| Monitoring | $28,000 | $11,000 | $255,000 |
| Maintenance | $8,000 | $8,000 | $133,300 |
| Subtotal | $53,300 | $36,300 | $677,100 |
| Point-of-Use Groundwater Treatment | $123,500 | $123,500 | $1,700,000 |
| TOTAL | $176,800 | $159,800 | $2,377,100 |

42,000 cy:

| | Years 1-5 | Years 6-30 | Present Worth |
|---|---|---|---|
| Leachate Removal and Disposal | $26,200 | $26,200 | $456,700 |
| Monitoring | $28,000 | $11,000 | $255,000 |
| Maintenance | $10,000 | $10,000 | $166,700 |
| Subtotal | $64,200 | $47,200 | $874,400 |
| Point-of-Use Groundwater Treatment | $123,500 | $123,500 | $1,700,000 |
| TOTAL | $187,700 | $170,700 | $2,578,400 |

RUST ENVIRONMENT & INFRASTRUCTURE

**CALCULATION SHEET**

PAGE ____ OF ____
PROJECT NO. 19536.211

CLIENT USACE-KC
PROJECT NOP FS

SUBJECT LANDFILL VOLUME CALCS. ALT 4

Prepared By KH Date 1/19/94
Reviewed By ____ Date ____
Approved By ____ Date ____

## LANDFILL DESIGN CALCULATIONS

PURPOSE: Calculate, for given waste volume:

- Landfill dimensions, assuming hexagonal shape to conform to "diamond area" of local line.
- Volume of soil excavated for landfill base.
- Landfill construction material quantities.
- Surface area of landfill, for the purpose of estimating leachate generation using the HELP model.

PROCEDURE: The next six pages illustrate formulae and procedures used.

This procedure was implemented for all volumes; as examples, sample calculations are included for the base volume, 8200 cy, and two sensitivity analysis volumes: 2400 cy and 12,000 cy.

SEC DONOHUE
Environment & Infrastructure

**CALCULATION SHEET**

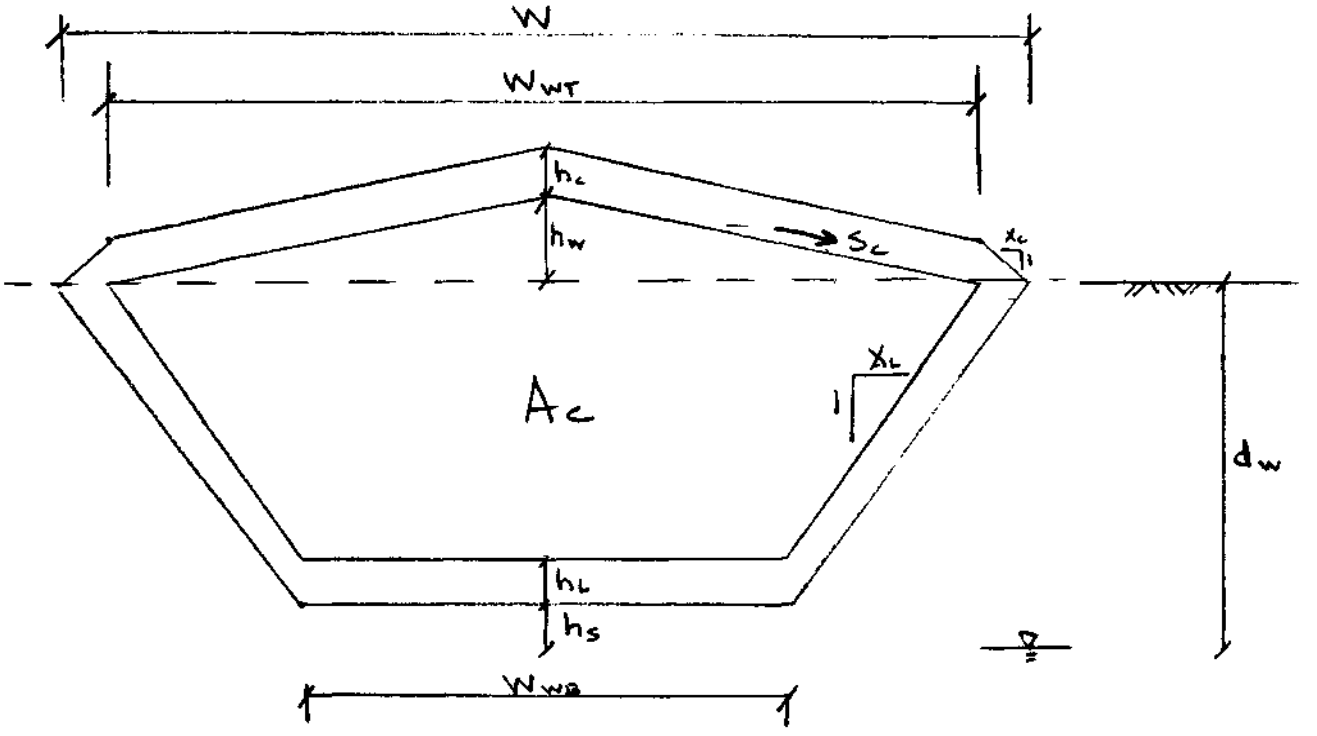


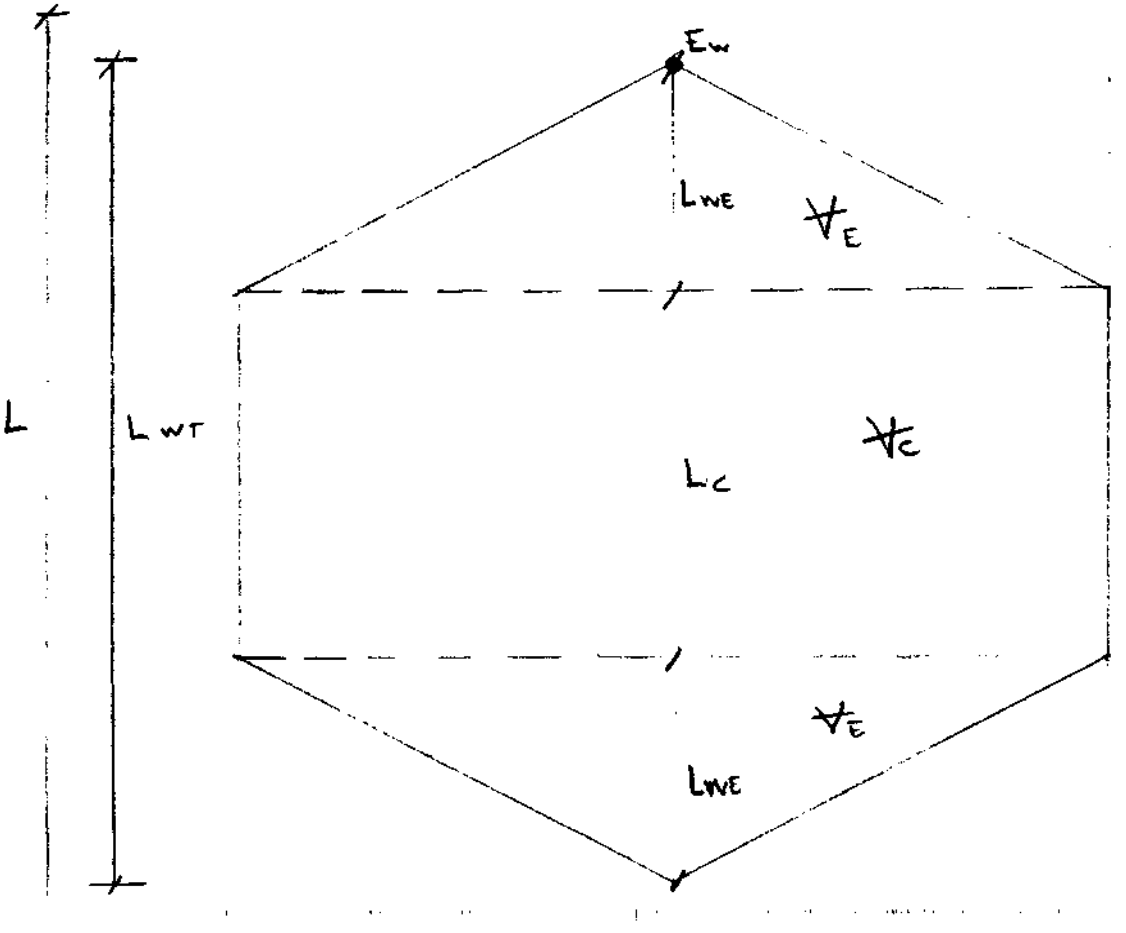
PROJECT NO. 19536.211

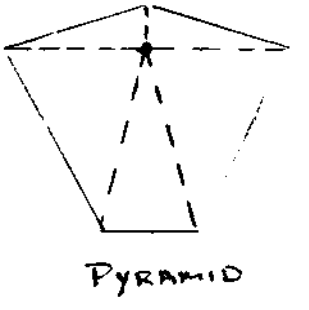
CLIENT USACE - KC
PROJECT NOP FS

SUBJECT LANDFILL VOLUME CALCS ALT 4

Prepared By GJ Date 3/23/93
Reviewed By MJW Date 3-23-93
Approved By _____ Date _____



$W$ = WIDTH OF LANDFILL, FT
$L$ = LENGTH OF LANDFILL, FT

$W_{WT}$ = WIDTH OF WASTE TOP, FT
$W_{WB}$ = WIDTH OF WASTE BOTTOM, FT
$S_c$ = SLOPE OF CAP
$d_w$ = DEPTH TO GROUNDWATER TABLE BELOW GROUND SURFACE, FT
$h_w$ = HEIGHT OF WASTE ABOVE GROUND SURFACE, FT
$h_c$ = THICKNESS OF CAP, FT
$h_L$ = THICKNESS OF LINER, FT
$h_s$ = SEPARATION BETWEEN GROUNDWATER TABLE AND BOTTOM OF LINER, FT

$A_c$ = CROSS SECTIONAL AREA ~~ALONG~~ ACROSS LENGTH $L_c$, $FT^2$

$L_{WT}$ = LENGTH OF WASTE TOP, FT
$L_E$ = LENGTH OF WASTE END, FT

$\forall_c$ = VOLUME OF WASTE WITHIN CENTER (ALONG $L_c$), $FT^3$
$\forall_E$ = VOLUME OF WASTE WITHIN ENDS, $FT^3$

WASTE VOLUME, $\forall_T$

$$\forall_T = \forall_c + 2\forall_E$$

$$\forall_c = L_c A_c$$

$$A_c = \frac{1}{2} h_w W_{WT} + \frac{1}{2}(W_{WT} + W_{WB})(d_w - h_L - h_s)$$

$$W_{WB} = W_{WT} - (d_w - h_L - h_s)(X_L)(2)$$
$$W_{WT} = W - 2h_c x_c$$
$$h_w = \frac{1}{2} W_{WT}(S_c)$$

$$\forall_E = \frac{1}{3}(L_{WE})(A_c) \qquad \text{(PYRAMID)}$$

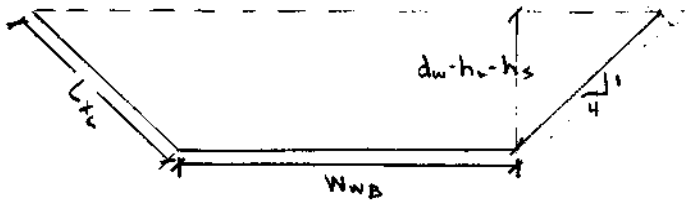
$$L_E = \frac{1}{2}[L_{WT} - L_c]$$

$$L_{WT} = L - 2h_c x_c$$

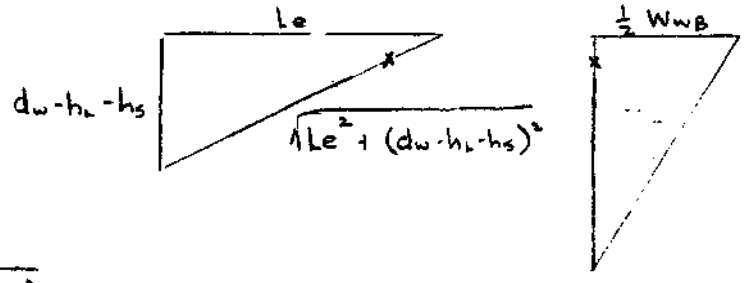
$$\forall_T = L_c A_c + 2\,\frac{1}{3} L_E A_c$$
$$= A_c\left(L_c + \frac{2}{3} L_E\right)$$

SURFACE AREA OF LINER, $A_{LS}$

$$A_1 = (L_c)\left(W_{WB} + 2\underbrace{\sqrt{(d_w - h_L - h_s)^2 + [4(d_w - h_L - h_s)]^2}}_{L_{xL}}\right)$$



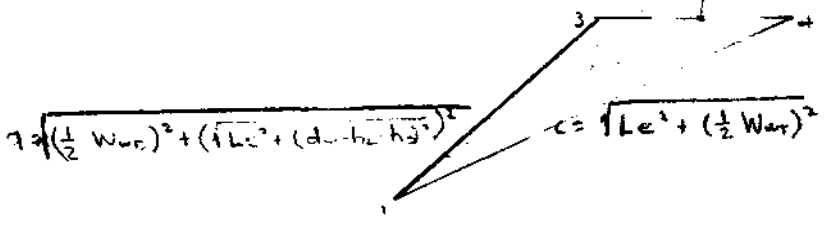

$$A_2 = \frac{1}{2}\left(\frac{1}{2}W_{WB}\right)\left(\sqrt{L_e^2 + (d_w - h_L - h_s)^2}\right)$$




$$A_3 = \sqrt{s(s-a)(s-b)(s-c)}$$

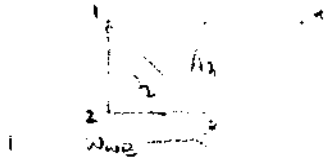
$$b = \sqrt{\left(\frac{1}{2}(W_{WT} - W_{WB})\right)^2 + (d_w - h_L - h_s)^2}$$

$$s = \frac{1}{2}(a+b+c)$$

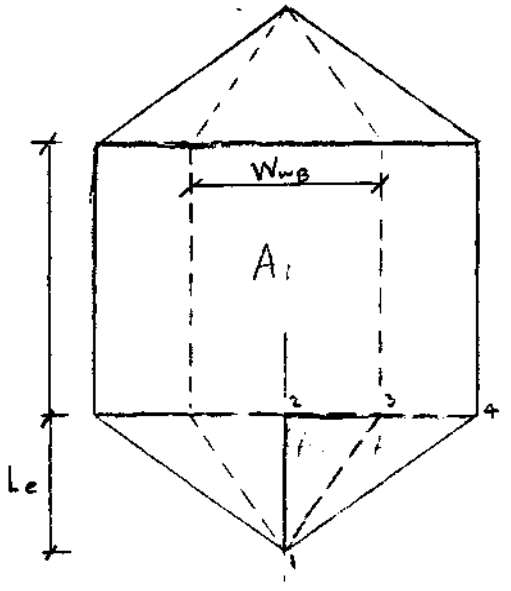



$$A_{LS} = A_1 + 4A_2 + 4A_3$$

END VIEW




TOP VIEW



**RUST** ENVIRONMENT & INFRASTRUCTURE

**CALCULATION SHEET**



PROJECT NO. 19536

CLIENT USACE-KC

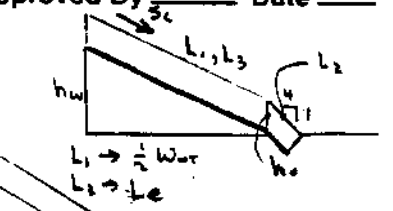
SUBJECT CAP AREA AND VOLUMES ALT 4

Prepared By GT Date 4/15/93

Reviewed By M. [illegible] Date 4-19-93

Approved By _____ Date _____

SURFACE AREA OF CAP, $A_{cs}$




$$L_1 = \sqrt{h_w^2 + \left(\tfrac{1}{2} W_{wt}\right)^2}$$

$$= \sqrt{\left(\tfrac{1}{2} W_{wt} S_c\right)^2 + \left(\tfrac{1}{2} W_{wt}\right)^2}$$

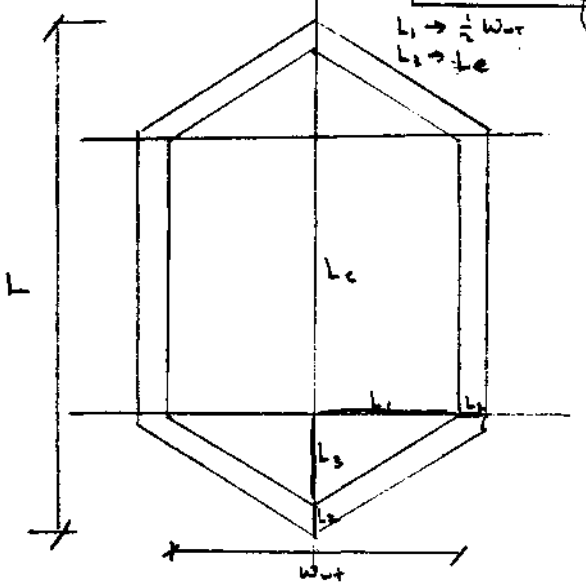
$$= \sqrt{\tfrac{1}{4} W_{wt}^2 \left(S_c^2 + 1\right)}$$

$$L_1 = \tfrac{1}{2} W_{wt} \sqrt{\left(S_c^2 + 1\right)}$$

$$L_2 = \sqrt{h_c^2 + (4h_c)^2}$$

$$= h_c \sqrt{17}$$

$$L_3 = \sqrt{h_w^2 + L_c^2}$$




$$A_{cs} = 2(L_1 + L_2) L_c + 2 (L_1 + L_2)(L_3 + L_2)$$

**RUST** ENVIRONMENT & INFRASTRUCTURE

**CALCULATION SHEET**

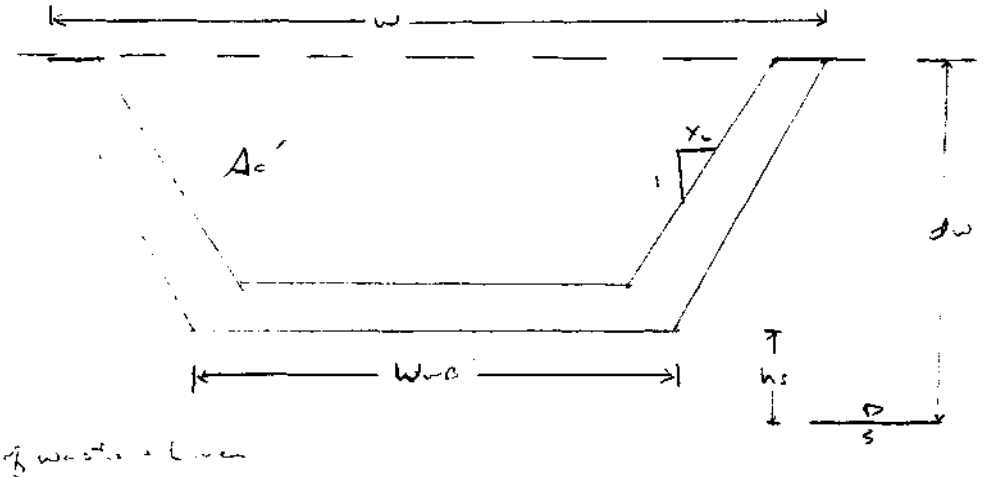
PAGE 1 OF 1
PROJECT NO. 19526

CLIENT USACE-KC
PROJECT NOP FS

SUBJECT LANDFILL
VOLUME CALCS
ALT 4

Prepared By [illegible] Date 8/26/92
Reviewed By SGL Date 8/26/92
Approved By ____ Date ____

EXCAVATION VOLUME




$A_c'$ = Area of waste + liner
$W_{wb}'$ = width of waste + liner at bottom

$$W_{wb}' = W - (d_w - h_s)(X_c)2$$

$$A_c' = \tfrac{1}{2}(W + W_{wb}')(d_w - h_s)$$

$$\forall_E' = (\text{end volume}) = \tfrac{1}{3}(L_c)(A_c')$$

$$\forall_{BA}' = (\text{total excavation volume}) = A_c'(L_c) + 2\forall_E$$

**RUST** ENVIRONMENT & INFRASTRUCTURE

**CALCULATION SHEET**

PAGE 1 OF 3
PROJECT NO. 19536

CLIENT USACE KC
SUBJECT ALT 4
Prepared By SAH Date 8/11/93
PROJECT NOP FS
DESIGN CALCS.
Reviewed By GLT Date 8-19-93
Approved By ____ Date ____

# ALTERNATIVE 4

LANDFILL DESIGN

PURPOSE: SIZE LANDFILL, DETERMINE MATERIAL QUANTITIES, SURFACE AREA FOR LEACHATE GENERATION

$\forall = 8200$ cy

Assume $h_c = 4.5$ ft, $S_c = 0.03$, $x_c = 4$, $x_c = 4$

$h_c = 5.0$, dw = 10 ft, $h_s = 25$ ft

$d_w = h_c + h_s = 10$ ft ✓

Trial: $L = 300$ ft, $L_c = 165$ ft, $w = 175$ ft

$W_{WT} = w - 2(h_c)(x_c) = 175 - 2(4.5)(4) = 139$ ft ✓

$W_{w2} = W_{WT} - (d_w - h_c)(x_c)2 = 139 - (10)(4)(2) = 59$ ft ✓

$h_w = \frac{1}{2} \cdot W_{WT} / S_c = \frac{1}{2}(139)(0.03) = 2.09$ ft ✓

$A_c = \frac{1}{2} \cdot W_{WT}(h_w) + \frac{1}{2}$ [illegible]

$= \frac{1}{2}(139)(2.09) + \frac{1}{2}(139 + 59)(10) = 1135$ sf ✓

$L_w = L - 2h_c x_c = 300 - 2(4.5)(4) = 264$ ft ✓

$L_c = \frac{1}{2}(L_w - L_c) = \frac{1}{2}(264 - 165) = 49.5$ ft ✓

$\forall_T = A_c(L_c + \frac{2}{3} L_c) = 1135(165 + \frac{2}{3}(49.5)) = 224{,}730$ cf ✓

$= 8323$ cy

$\rightarrow$ 8300 cy OK ✓

CAP SURFACE AREA

$L_1 = \frac{1}{2} w_{WB} \sqrt{S_c^2 + 1} = \frac{1}{2}(139)\sqrt{0.03^2+1} = 70$ ft ✓

$L_2 = h_c\sqrt{17} = 4.5\sqrt{17} = 19$ ft ✓

$L_3 = \sqrt{h_w^2 - [\frac{1}{2}(L-L_c) - 4h_c]^2}$

$= \sqrt{2.09^2 + [\frac{1}{2}(300-165) - 4(4.5)]^2} = 49.5$ ft ✓

$A_s = 2(L_1+L_2)L_c + 2(L_1+L_2)(L_3+L_2)$

$2(70+19)(165) + 2(70+19)(49.5+19)$

$= 41{,}563$ sf → **41,600 sf** ✓

CAP MATERIAL VOLUMES

$V_{TOPSOIL} = (41{,}600\text{sf})(0.5\text{ ft})/27 = 770$ cy → 800 cy ✓

$V_{SOIL} = (41{,}600\text{sf})(1\text{ ft})/27 = 1541$ cy → 1500 cy ✓

$V_{CLAY} = (41{,}600\text{sf})(2\text{ ft})/27 = 3081$ cy → 3100 cy ✓

$V_{SAND} = (41{,}600\text{sf})(1.0\text{ ft})/27 = 1541$ cy → 1500 cy ✓

LINER SURFACE AREA

$A_1 = L_c(w_{WB} + 2\sqrt{(d_w - h_w - h_s)^2 + [4(d_w - h_c - h_s)]^2})$

$= 165(59 + 2\sqrt{(10)^2 + (4(10))^2}) = 23{,}341$ sf ✓

$A_2 = \frac{1}{2}(2 w_{WB} \sqrt{L_c^2 + (d_w - h_w - h_s)^2})$

$\frac{1}{2}(\frac{1}{2}(59)\sqrt{(49.5)^2 + 10^2}) = 745$ sf ✓

$A_3 = \sqrt{s(s-a)(s-b)(s-c)}$

$a = \sqrt{(\frac{1}{2} w_{WB})^2 + (\sqrt{L_c^2 + (d_w - h_w - h_s)^2})^2}$

$= \sqrt{(\frac{1}{2} \cdot 59)^2 + (\sqrt{(49.5)^2 + 10^2})^2} = 58$ ✓

LINER SURFACE AREA (CONT)

$$b = \sqrt{\left(\tfrac{1}{2}(w_{wt} - w_{wb})\right)^2 + (d_w - h_c - h_s)^2}$$

$$\sqrt{\left(\tfrac{1}{2}(139 - 59)\right)^2 + 10^2} = 41$$

$$c = \sqrt{L_c^2 + \left(\tfrac{1}{2} w_{wt}\right)^2} = \sqrt{(49.5)^2 + \left(\tfrac{1}{2} \cdot 139\right)^2} = 85$$

$$s = \tfrac{1}{2}(a+b+c) = \tfrac{1}{2}(58 + 41 + 85) = 92$$

$$A_3 = \sqrt{92(92-58)(92-41)(92-85)} = 1057$$

$$A_s = A_1 + 4A_2 + 4A_3 = 23{,}341 + 4(745) + 4(1057) = 30{,}549 \text{ sf}$$

$$\rightarrow \underline{\underline{30{,}500 \text{ sf}}}$$

LINER MATERIAL VOLUME

$V_{CLAY}$ 30,500 sf (3 ft)/27 = 3389 cy → 3400 cy

$V_{GRANULAR}$ 30,500 sf (2 ft)/27 = 2259 cy → 2300 cy

EXCAVATION VOLUME

$$w_{wb}' = w - (d_w - h_s)(x_c)(2)$$
$$= 175 - (40-25)(4)(2) = 55 \text{ ft}$$

$$A_c' = \tfrac{1}{2}(w_{wt} + w_{wb}')(d_w - h_s)$$
$$= \tfrac{1}{2}(175 + 55)(40-25) = 1725 \text{ sf}$$

$$V_E' = \tfrac{1}{3}(L_c)(A_c') = \tfrac{1}{3}(49.5)(1725) = 28{,}462 \text{ cf}$$

$$V_{BG} = A_c'(L_c) + V_E' = 1725(165) + 28{,}462 = 313{,}087 \text{ cf}$$
$$= 11{,}596 \text{ cy}$$

$$\rightarrow \underline{\underline{11{,}600 \text{ cy}}}$$

ALTERNATIVE 4
LANDFILL DESIGN

PURPOSE: SIZE LANDFILL, DETERMINE MATERIAL QUANTITIES, AREA.

$\forall$ = 12,300 cy

ASSUME: $h_c = 4.5$ ft  $h_c = 5.0$  $d_w - h_c - h_s = 15$ ft
$S_c = 0.03$  $d_w = 40$ ft
$x_c = 4$  $h_s = 20$ ft
$x_c = 4$

TRIAL: $L = 380$ ft
$L_c = 180$ ft
$W = 180$ ft

$W_{WT} = W - 2(h_c)(x_c) = 180 - 2(4.5)(4) = 144$ ft ✓
$W_{WB} = W_{WT} - (d_w - h_c - h_s)(x_c)2 = 144 - 15(4)(2) = 24$ ft ✓
$h_w = \frac{1}{2} W_{WT}(S_c) = \frac{1}{2}(144)(0.03) = 2.16$ ft ✓
$A_c = \frac{1}{2} W_{WT}(h_w) + \frac{1}{2}(W_{WT} + W_{WB})(d_w - h_c - h_s)$
$= \frac{1}{2}(144)(2.16) + \frac{1}{2}(144 + 24)(15) = 1415$ sf ✓
$L_{WT} = L - 2h_c x_c = 380 - 2(4.5)(4) = 344$ ft ✓
$L_e = \frac{1}{2}(L_{WT} - L_c) = \frac{1}{2}(344 - 180) = 82$ ft ✓

$\forall_T = A_c(L_c + \frac{2}{3}L_e) = 1415(180 + \frac{2}{3}(82)) = 332{,}053$ cf ✓
$= 12{,}298$ cy ✓
$\rightarrow$ 12,300 cy ok

CAP SURFACE AREA

$L_1 = \frac{1}{2} W_{wT}\sqrt{S_c^2+1} = \frac{1}{2}(144)\sqrt{10.0^2} = 72$ ft ✓

$L_2 = h_c\sqrt{17} = 4.5\sqrt{17} = 19$ ft ✓

$L_3 = \sqrt{h_w^2 + [\frac{1}{2}(L-L_c) - 4h_c]^2}$

$= \sqrt{2.16^2 + [\frac{1}{2}(380-180) - 4(4.5)]^2} = 82$ ft ✓

$A_s = 2(L_1+L_2)L_c + 2(L_1+L_2)(L+L_2)$

$= 2(72+19)(180) + 2(72+19)(82+19)$

$= 51,142$ sf → **51,100 sf** ✓

CAP MATERIAL VOLUMES

$V_{TOPSOIL} = 51,100$ sf $(0.5$ ft$)/27 = 900$ cy

$V_{SOIL} = 51,100$ sf $(1.0$ ft$)/27 = 1900$ cy

$V_{CLAY} = 51,100$ sf $(2.0$ ft$)/27 = 3800$ cy

$V_{SAND} = 51,100$ sf $(1.0$ ft$)/27 = 1900$ cy

LINER SURFACE AREA

$A_1 = L_c(W_{wB} + 2\sqrt{(d_w+h_w+h_s)^2 + [(d_w+h_w+h_s)\cdot S_c]^2})$

$= 180(24 + 2\sqrt{15^2 + (4(15))^2}) = 26,585$ sf ✓

$A_2 = \frac{1}{2}(\frac{1}{2}W_{wB})\sqrt{L_c^2 + (d_w+h_w+h_s)^2}$

$= \frac{1}{2}(\frac{1}{2}\cdot 24)\sqrt{82^2 + 15^2} = 500$ sf ✓

$A_3 = \sqrt{s(s-a)(s-b)(s-c)}$

$a = \sqrt{(\frac{1}{2}W_{wB})^2 + (\sqrt{L_c^2 + (d_w+h_w+h_s)^2})^2}$

$= \sqrt{(\frac{1}{2}\cdot 24)^2 + (\sqrt{82^2+15^2})^2} = 84$ sf ✓

LINER SURFACE AREA (cont.)

$$b = \sqrt{\left(\tfrac{1}{2}(W_{WT} - W_{WB})\right)^2 + (d_w - h_s)^2}$$
$$= \sqrt{\left(\tfrac{1}{2}(144-24)\right)^2 + 15^2} = 62 \checkmark$$

$$c = \sqrt{L_c^2 + \left(\tfrac{1}{2}W_{WT}\right)^2} = \sqrt{82^2 + \left(\tfrac{1}{2}\cdot 144\right)^2} = 109 \checkmark$$
$$s = \tfrac{1}{2}(a+b+c) = \tfrac{1}{2}(84+62+109) = 128 \checkmark$$

$$A_3 = \sqrt{128\,\underbrace{(128-84)}_{44}\,\underbrace{(128-62)}_{66}\,\underbrace{(128-109)}_{19}} = 2658 \text{ sf} \checkmark$$

$$A_s = A_1 + 4A_2 + 4A_3 = 26{,}585 + 4(502) + 4(2658) = 39{,}217 \text{ sf} \checkmark$$
$$\rightarrow \underline{39{,}200 \text{ sf}} \checkmark$$

LINER MATERIAL VOLUME

$$V_{CLAY} = 39{,}200 \cdot (3\text{ft})/27 = 4355 \text{ cy} \rightarrow 4{,}400 \text{ cy} \checkmark$$

$$V_{GRANULAR} = 39{,}200 \cdot (2\text{ft})/27 = 2904 \text{ cy} \rightarrow 2{,}900 \text{ cy} \checkmark$$

EXCAVATION VOLUME

$$W_{WB}' = W - (d_w - h_s)(x_c)(2)$$
$$= 180 - (40-20)(4)(2) = 20 \text{ ft} \checkmark$$
$$A_c' = \tfrac{1}{2}(W + W_B')(d_w - h_s)$$
$$= \tfrac{1}{2}(180+20)(40-20) = 2000 \text{ sf} \checkmark$$
$$V_E' = \tfrac{1}{3}(L_c)(A_c') = \tfrac{1}{3}(82)(2000) = 54{,}667 \text{ cf} \checkmark$$

$$V_{BG}' = A_c'(L_c) + V_E' = 2000(180) + 54{,}667 = 414{,}667 \text{ cf} \checkmark$$
$$= 15{,}358 \text{ cy} \checkmark$$
$$\rightarrow \underline{15{,}400 \text{ cy}} \checkmark$$

RUST ENVIRONMENT & INFRASTRUCTURE

**CALCULATION SHEET**

PAGE 1 OF 1
PROJECT NO. 19536

CLIENT USACE KC
PROJECT NUP FS

SUBJECT Site 4
[illegible] Calc.

Prepared By [illegible] Date 8/[illegible]
Reviewed By GLT Date 8/20
Approved By ____ Date ____

OPERATION AND MONITORING (O&M) COSTS

MONITORING: PW = $255,100

MAINTENANCE:

Annual LF Cover Repair
$0.05/sq.yr · 41,300 sf = 2100/yr

Semi-annual Mowing
$50/mow × 1 acre × 2/yr = 100/yr

LCS Maintenance = 2000/yr

Annual Miscellaneous Maintenance = 1500/yr

MAINTENANCE SUBTOTAL 5700/yr

MAINTENANCE PRESENT WORTH 5700 × 16.6667 = $95,000 ✓

LEACHATE REMOVAL AND DISPOSAL: PW = 150,000

POINT-OF-USE GROUNDWATER TREATMENT O&M PW = 1,700,000

TOTAL O&M PRESENT WORTH

| | |
|---|---|
| MONITORING | 255,100 |
| MAINTENANCE | 95,000 |
| LEACHATE REMOVAL/DISPOSAL | 150,000 |
| POINT-OF-USE GW TREATMENT | 1,700,000 |
| TOTAL | 2,200,000 |

RUST ENVIRONMENT & INFRASTRUCTURE

**CALCULATION SHEET**

PAGE 1 OF 1
PROJECT NO. 15736

CLIENT USACE KC
SUBJECT ALT 4
Prepared By [illegible] Date [illegible]
PROJECT NOP FS
COST BACKUP
Reviewed By GLT Date 8/20/93
Approved By ____ Date ____

IMPLEMENTATION TIME
FOR LANDFILL CONSTRUCTION

| | |
|---|---|
| site preparation | 2 months |
| soil removal | 1 month |
| excavation | 1 month |
| liner construction | 1 month |
| soil placement | 1 month |
| cap construction | 1 month |
| site restoration | 1 month |
| | 8 months |

**RUST** ENVIRONMENT & INFRASTRUCTURE

**CALCULATION SHEET**

PAGE 1 OF 2
PROJECT NO. 17536

CLIENT USACE
PROJECT NOP FS

SUBJECT small volume cost estimate

Prepared By [illegible] Date 5/[illegible]
Reviewed By [illegible] Date 3/30/03
Approved By ____ Date ____

ALT 4

LANDFILL DESIGN

$V = 2440$ cy

Assume $h_c = 4.5$ ft, $S_c = 0.03$, $x_c = 4$, $x_L = 4$

$h_L = 5.0$, $d_w = 40$ ft, $h_s = 25$ ft

$d_w - h_L - h_s = 10$ ft

TRIAL $L = 200$ ft, $L_c = 90$ ft, $W = 130$ ft

$W_{WT} = 130 - 2(4.5)4 = 94$

$W_{WB} = 4 - (4/4)(4.5) = 14$

$b_w = \frac{1}{2}(94)(0.03) = 1.41$

$A_c = \frac{1}{2}(94)1.41 + \frac{1}{2}(94+14)4.5 = 606.27$ sf

$L_{WT} = 200 - 2(4.5)(4) = 164$

$L_e = \frac{1}{2}(164 - 90) = 37$

$V_T = 606.27(40 + 2.5(4.5)) = 69519$ cf
$= 2575$ cy OK

cap surface

$L_1 = \frac{1}{2}(94)\sqrt{0.03^2 + 1} = 47$

$L_2 = 4.5\sqrt{17} = 19$

$L_3 = \sqrt{1.41^2 + [\frac{1}{2}(200-90) + 4.5]^2} = 46$

$A_s = 2(47)(90) + 2(46)(47+14) = 20{,}400$ sf

cap mat'l:

$V_{topsoil} = 378 \rightarrow 400$ cy, $V_{clay} = 1516 \rightarrow 1500$

$V_{soil} = 758 \rightarrow 800$ cy, $V_{sand} = 758 \rightarrow 800$ cy

CLIENT USACE
PROJECT NOP FS

SUBJECT Small volume cost estimate

Prepared By [illegible] Date 8/29
Reviewed By [illegible] Date 9/30/[illegible]
Approved By ____ Date ____

liner surface

$A_1 = 90\,(10 + 2\sqrt{10^2 + 10^2}) = 8682$

$A_2 = 4 \cdot 14\sqrt{[illegible]} = 134$

$a = \sqrt{6^2 + (\sqrt{[illegible]})^2} = 39$

$b = \sqrt{(2 \cdot 94 - 14)^2 + [illegible]} = 41$

$c = \sqrt{[illegible] - (2 \cdot 94)^2} = 60$

$s = \frac{1}{2}(39 + 41 + 60) = 70$

$A_3 = \sqrt{70(70-60)[illegible]} = 793$

$A = 8682 + 4(134) + 4(793) = 12{,}390 \rightarrow 12{,}400$ SF

liner matl's.

$V_{clay} = 1400$ cy

excavation vol.

$V_{WB}' = 120 - (40 \cdot 2)4(2) = 0$ ✓

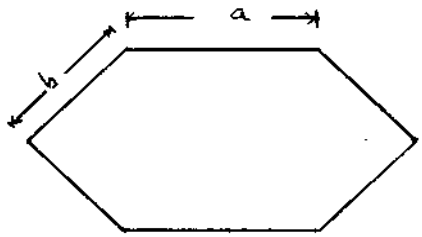
$A_c' = \frac{1}{2}(170 + [illegible])(40 \cdot [illegible]) = 900$ ✓

$V_c' = \frac{1}{3}([illegible])(900) = 11{,}100$ ✓

$V_{tot} = 900(9 \cdot [illegible]) + 11{,}100 = [illegible]$ cf $= [illegible]$ cy

$\rightarrow [illegible]$

SITE FENCE




fence dimensions: a = 110'
b = 133'

| | | | |
|---|---|---|---|
| fence length = | 490' @ 14.75/ft = | | 7,228 |
| corner posts | 6 @ 86.50/each | | 519 |
| brace every 20' | 25 @ 32/each | | 800 |
| gates | 2 @ 218/each | | 436 |
| | | | $ 8,983 |

ALTERNATIVE 4

LANDFILL DESIGN

PURPOSE: SIZE LANDFILL, DETERMINE MATERIAL QUANTITICS, AREA.

$\forall = 25{,}200$ cy

ASSUME: $h_c = 4.5$ FT  $h_L = 5.0$ FT  $d_w - h_L - h_s = 15$ FT

$S_c = 0.03$  $d_w = 40$ FT

$x_c = 4$  $h_s = 20$ FT

$x_L = 4$

TRIAL: $L = 465$ FT

$L_c = 235$ FT

$W = 230$ FT

$W_{WT} = W - 2(h_c)(x_c) = 230 - 2(4.5)(4) = 194$ FT ✓

$W_{WB} = W_{WT} - (d_w - h_L - h_s)(x_c)\,2 = 194 - 15(4)(2) = 74$ FT ✓

$h_w = \frac{1}{2} W_{WT}(S_c) = \frac{1}{2}(194)(0.03) = 2.91$ FT ✓

$A_c = \frac{1}{2} W_{WT}(h_w) + \frac{1}{2}(W_{WT} + W_{WB})(d_w - h_L - h_s)$

$= \frac{1}{2}(194)(2.91) + \frac{1}{2}(194 + 74)(15) = 2292$ SF ✓

$L_{WT} = L - 2h_c x_c = 465 - 2(4.5)(4) = 429$ FT ✓

$L_e = \frac{1}{2}(L_{WT} - L_c) = \frac{1}{2}(429 - 235) = 97$ ✓

$\forall_T = A_c(L_c + \frac{2}{3}L_e) = 2292(235 + \frac{2}{3}(97)) = 686{,}836$ CF ✓

$= 25{,}438$ CY ✓

$\longrightarrow$ 25,400 CY  OK

CAP SURFACE AREA

$L_1 = \frac{1}{2} W_{WT} \sqrt{S_c^2 + 1} = \frac{1}{2}(194)\sqrt{(0.03)^2+1} = 97$ FT ✓

$L_2 = h_c\sqrt{17} = 4.5\sqrt{17} = 19$ FT ✓

$L_3 = \sqrt{h_c^2 + [\frac{1}{2}(L-L_c) - 4h_c]^2}$

$= \sqrt{2.91^2 + [\frac{1}{2}(465-235) - 4(4.5)]^2} = 97$ FT ✓

$A_s = 2(L_1+L_2)L_c + 2(L_1+L_2)(L_3+L_2)$

$= 2(97+19)(235) + 2(97+19)(97+19) = 81{,}432$ SF ✓

$\rightarrow$ 81,400 SF ✓

CAP MATERIAL VOLUMES

$\forall_{TOPSOIL} = 81{,}400\ (0.5\text{ FT})/27 = 1500$ CY ✓

$\forall_{SOIL} = 81{,}400\ (1.0\text{ FT})/27 = 3000$ CY ✓

$\forall_{CLAY} = 81{,}400\ (2.0\text{ FT})/27 = 6000$ CY ✓

$\forall_{SAND} = 81{,}400\ (1.0\text{ FT})/27 = 3000$ CY ✓

LINER SURFACE AREA

$A_1 = L_c\left(W_{WB} + 2\sqrt{(d_w - h_w - h_s)^2 + [4(d_w - h_w - h_s)]^2}\right)$

$= 235\left(74 + 2\sqrt{15^2 + [4(15)]^2}\right) = 46{,}458$ SF ✓

$A_2 = \frac{1}{2}\left(\frac{1}{2} W_{WB}\right)\sqrt{L_e^2 + (d_w - h_w - h_s)^2}$

$= \frac{1}{2}\left(\frac{1}{2}\cdot 74\right)\sqrt{97^2 + 15^2} = 1816$ SF ✓

$A_3 = \sqrt{s(s-a)(s-b)(s-c)}$

$a = \sqrt{(\frac{1}{2} W_{WB})^2 + (\sqrt{L_e^2 + (d_w - h_w - h_s)^2})^2}$

$= \sqrt{(\frac{1}{2}\cdot 74)^2 + (\sqrt{97^2 + 15^2})^2} = 105$ ✓

$b = \sqrt{(\frac{1}{2}(W_{WT} - W_{WB}))^2 + (d_w - h_w - h_s)^2}$

$= \sqrt{(\frac{1}{2}(194 - 74))^2 + 15^2} = 62$ ✓

LINER SURFACE AREA (CONT.)

$$c = \sqrt{L_e^2 + (\tfrac{1}{2} W_{WT})^2} = \sqrt{97^2 + (\tfrac{1}{2} \cdot 144)^2} = 137 \checkmark$$

$$s = \tfrac{1}{2}(a+b+c) = \tfrac{1}{2}(105+62+137) = 152 \checkmark$$

$$A_3 = \sqrt{152(152-105)(152-62)(152-137)} = 3106 \text{ SF} \checkmark$$

$$A_S = A_1 + 4A_2 + 4A_3 = 46{,}458 + 4(1816) + 4(3106) = 66{,}146 \text{ SF} \checkmark$$

$$\longrightarrow \underline{66{,}100 \text{ SF}} \checkmark$$

LINER MATERIAL VOLUME

$$V_{CLAY} = 66{,}100 \ (3\text{FT})/27 = 7344 \rightarrow 7300 \text{ CY} \checkmark$$

$$V_{GRANULAR} = 66{,}100 \ (2\text{FT})/27 = 4896 \rightarrow 4900 \text{ CY} \checkmark$$

EXCAVATION VOLUME

$$W_{WB}' = W - (d_w - h_s)(x_c)2$$
$$= 230 - (40-20)(4)(2) = 70 \text{ FT} \checkmark$$

$$A_c' = \tfrac{1}{2}(W + W_{WB}')(d_w - h_s)$$
$$= \tfrac{1}{2}(230 + 70)(40-20) = 3000 \text{ SF} \checkmark$$

$$V_E' = \tfrac{1}{3}(L_c)(A_c') = \tfrac{1}{3}(97)(3000) = 97{,}000 \text{ CF} \checkmark$$

$$V_{BG}' = A_c'(L_c) + 2V_E' = 3000(235) + 2(97{,}000)$$
$$= 899{,}000 \text{ CF} \checkmark$$
$$= 33{,}296 \text{ CY} \checkmark$$
$$\underline{33{,}300 \text{ CY}} \checkmark$$

ALTERNATIVE 4

LANDFILL DESIGN

PURPOSE: SIZE LANDFILL, DETERMINE MATERIAL QUANTITIES, AREA.

$\forall = 42{,}000$ cy

ASSUME: $h_c = 4.5$ FT  $h_L = 5.0$ FT  $d_w - h_c - h_s = 15$ FT

$S_c = 0.03$  $d_w = 40$ FT

$X_c = 4$  $h_s = 20$ FT

$X_L = 4$

TRIAL: $L = 640$ FT

$L_c = 280$ FT

$W = 265$ FT

$W_{WT} = W - 2(h_c)(x_c) = 265 - 2(4.5)(4) = 229$ FT ✓

$W_{WB} = W_{WT} - (d_w - h_c - h_s)(x_c)(2) = 229 - (15)(4)(2) = 109$ FT ✓

$h_w = \frac{1}{2} W_{WT}(S_c) = \frac{1}{2}(229)(0.03) = 3.435$ FT ✓

$A_c = \frac{1}{2} W_{WT}(h_w) + \frac{1}{2}(W_{WT} + W_{WB})(d_w - h_c - h_s)$

$= \frac{1}{2}(229)(3.435) + \frac{1}{2}(229 + 109)(15) = 2928$ SF ✓

$L_{WT} = L - 2h_c x_c = 640 - 2(4.5)(4) = 604$ FT ✓

$L_e = \frac{1}{2}(L_{WT} - L_c) = \frac{1}{2}(604 - 280) = 162$ FT ✓

$\forall_T = A_c(L_c + \frac{2}{3} L_e) = 2928(280 + \frac{2}{3}(162)) = 1{,}136{,}064$ CF ✓

$= 42{,}076$ CY ✓

$\rightarrow$ 42,000 CY OK

CAP SURFACE AREA

$L_1 = \frac{1}{2} W_{WT} \sqrt{S_c^2+1} = \frac{1}{2}(229)\sqrt{(0.03)^2+1} = 115$ FT ✓

$L_2 = h_c\sqrt{17} = 4.5\sqrt{17} = 19$ FT ✓

$L_3 = \sqrt{h_w^2 + [\frac{1}{2}(L-L_2) - 4h_c]^2}$

$= \sqrt{3.435^2 + [\frac{1}{2}(640-280) - 4(4.5)]^2} = 144$ FT

$A_S = 2(L_1+L_2)L_c + 2(L_1+L_2)(L_3+L_2)$

$= 2(115+19)280 + 2(115+19)(144+19) = 118,724$ SF ✓

$\longrightarrow$ 118,700 SF ✓

CAP MATERIAL VOLUMES

$V_{TOPSOIL} = 118,700 \times 0.5\text{ FT}/27 = 2200$ CY ✓

$V_{SOIL} = 118,700 \times 1.0\text{ FT}/27 = 4400$ CY ✓

$V_{CLAY} = 118,700 \times 2.0\text{ FT}/27 = 8800$ CY ✓

$V_{SAND} = 118,700 \times 1.0\text{ FT}/27 = 4400$ CY ✓

LINER SURFACE AREA

$A_1 = L_c\left(W_{WB} + 2\sqrt{(d_w-h_w-h_s)^2 + [4(d_w-h_w-h_s)]^2}\right)$

$= 280(109 + 2\sqrt{15^2 + [4(15)]^2}) = 65,154$ SF ✓

$A_2 = \frac{1}{2}(\frac{1}{2}W_{WB})\sqrt{L_e^2 + (d_w-h_w-h_s)^2}$

$= \frac{1}{2}(\frac{1}{2}(109)\sqrt{162^2+15^2}) = 4433$ SF ✓

$A_3 = \sqrt{s(s-a)(s-b)(s-c)}$

$a = \sqrt{(\frac{1}{2}W_{WB})^2 + (\sqrt{L_e^2 + (d_w-h_w-h_s)^2})^2}$

$\sqrt{(\frac{1}{2}\cdot 109)^2 + (\sqrt{162^2+15^2})^2} = 171$ ✓

$b = \sqrt{(\frac{1}{2}(W_{WT}-W_{WB}))^2 + (d_w-h_w-h_s)^2}$

$\sqrt{(\frac{1}{2}(229-109))^2 + 15^2} = 62$ ✓

$c = \sqrt{L_e^2 + (\frac{1}{2}W_{WT})^2} = \sqrt{162^2 + (\frac{1}{2}\cdot 229)^2} = 198$ ✓

$s = \frac{1}{2}(a+b+c) = \frac{1}{2}(171+62+198) = 216$ ✓

LINER SURFACE AREA (CONT.)

$$A_3 = \sqrt{216(216-171)(216-62)(216-158)} = 5191 \text{ SF}$$

$$A_S = A_1 + 4A_2 + 4A_3 = 65,154 + 4(4433) + 4(5191)$$
$$= 103,650 \text{ SF}$$
$$\longrightarrow \underline{103,600 \text{ SF}}$$

LINER MATERIAL VOLUMES

$$\forall_{CLAY} = 103,600 \times 3FT/27 = 11,511 \rightarrow 11,500 \text{ CY}$$
$$\forall_{GRANULAR} \; 103,600 \times 2FT/27 = 7,674 \rightarrow 7700 \text{ CY}$$

EXCAVATION VOLUME

$$W_{WD}' = W - (d_w - h_s)(x_c)2$$
$$= 265 - (40-20)(4)(2) = 105 \text{ FT}$$

$$A_c' = \tfrac{1}{2}(W + W_{WD}')(d_w - h_s)$$
$$= \tfrac{1}{2}(265+105)(40-20) = 3700 \text{ SF}$$

$$\forall_E = \tfrac{1}{3}(L_c)(A_c') = \tfrac{1}{3}(162)(3700) = 199,800 \text{ CF}$$

$$\forall_{BG} = A_c'(L_c) + 2\forall_E' = 3700(280) + 2(199,800)$$
$$= 1,435,600 \text{ CF}$$
$$= 53,170 \text{ CY}$$
$$= \underline{53,200 \text{ CY}}$$

CONCEPTUAL COST ESTIMATE
ON-SITE LANDFILL
ANNUAL LEACHATE GENERATION

GIVEN: CAP CONFIGURATION

| |
|---|
| 6" TOPSOIL LAYER |
| 12" ROOTING MAT'L LAYER |
| 12" SAND DRAINAGE LAYER |
| 24" CLAY LAYER |

SURFACE SLOPE = 3%

CAP AREA
BASE ESTIMATE: 41,600 SF
SENSITIVITY = 47,500 SF

ASSUME: GOOD VEGETATION ESTABLISHMENT
CLIMATOLOGICAL DATA FROM GRAND ISLAND, NEBRASKA
(SYNTHETICALLY GENERATED WITH HELP MODEL)
DEFAULT SOIL DATA FROM HELP MODEL

| LAYER | TEXTURE * |
|---|---|
| TOPSOIL | Loam (8) |
| ROOTING ZONE | Silty Loam (9) |
| DRAINAGE | Sand (2) |
| CLAY | Barrier (16) |

* DEFAULT CHARACTERISTICS ARE ATTACHED

RESULTS: HELP OUTPUT ATTACHED FOR BASE ESTIMATE AND SENSITIVITY ANALYSIS

BASE: $904 \frac{ft^3}{yr} \times 7.48 \frac{gal}{ft^3} = 6{,}762 \frac{gal}{yr}$ SAY $7{,}000 \frac{gal}{yr}$

SENSITIVITY: $1033 \times 7.48 = 7{,}727 \frac{gal}{yr}$ SAY $8{,}000 \frac{gal}{yr}$

TABLE 4. DEFAULT SOIL CHARACTERISTICS

| Soil Texture Class | | | Total | Resid. | Bubbl. | Pore-Size | Field | Wilt. | Sat. Hyd. Cond. | | Min. Inf. | Evap. Coef. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HELP | USDA | USCS | Poros. | Sat. | Press. (cm) | Dist. Index | Cap. | Pt. | cm/s | in/hr | Rate in/hr | $mm/day^{0.5}$ |
| 1 | CoS | GS | 0.417 | 0.015 | 6.53 | 0.651 | 0.045 | 0.018 | 1.0E-02 | 14.173 | 0.500 | 3.3 |
| 2 | S | SW | 0.437 | 0.020 | 7.26 | 0.592 | 0.062 | 0.024 | 5.8E-03 | 8.220 | 0.400 | 3.3 |
| 3 | FS | SM | 0.457 | 0.025 | 7.99 | 0.533 | 0.083 | 0.033 | 3.1E-03 | 4.394 | 0.390 | 3.3 |
| 4 | LS | SM | 0.437 | 0.035 | 8.69 | 0.474 | 0.105 | 0.047 | 1.7E-03 | 2.409 | 0.380 | 3.3 |
| 5 | LFS | SM | 0.457 | 0.040 | 9.56 | 0.425 | 0.131 | 0.058 | 1.0E-03 | 1.417 | 0.340 | 3.3 |
| 6 | SL | SM | 0.453 | 0.041 | 14.66 | 0.322 | 0.190 | 0.085 | 7.2E-04 | 1.020 | 0.300 | 5.1 |
| 7 | FSL | SM | 0.473 | 0.046 | 16.13 | 0.290 | 0.222 | 0.104 | 5.2E-04 | 0.737 | 0.250 | 5.1 |
| 8 | L | ML | 0.463 | 0.027 | 11.15 | 0.220 | 0.232 | 0.116 | 3.7E-04 | 0.524 | 0.200 | 3.9 |
| 9 | SiL | ML | 0.501 | 0.015 | 20.76 | 0.211 | 0.284 | 0.135 | 1.9E-04 | 0.269 | 0.170 | 5.1 |
| 10 | SCL | SC | 0.398 | 0.068 | 28.08 | 0.250 | 0.244 | 0.136 | 1.2E-04 | 0.170 | 0.110 | 5.1 |
| 11 | CL | CL | 0.464 | 0.075 | 25.89 | 0.194 | 0.310 | 0.187 | 6.4E-05 | 0.091 | 0.090 | 5.1 |
| 12 | SiCL | CL | 0.471 | 0.040 | 32.56 | 0.151 | 0.342 | 0.210 | 4.2E-05 | 0.060 | 0.070 | 5.1 |
| 13 | SC | CH | 0.430 | 0.109 | 29.17 | 0.168 | 0.321 | 0.221 | 3.3E-05 | 0.047 | 0.060 | 4.5 |
| 14 | SiC | CH | 0.479 | 0.056 | 34.19 | 0.127 | 0.371 | 0.251 | 2.5E-05 | 0.035 | 0.020 | 5.1 |
| 15 | C | CH | 0.475 | 0.090 | 37.30 | 0.131 | 0.378 | 0.265 | 1.7E-05 | 0.024 | 0.010 | 4.6 |
| 16 | Barrier | | 0.430 | 0.120 | 45.00 | 0.113 | 0.366 | 0.280 | 1.0E-07 | 0.000 | 0.002 | 3.3 |
| 17 | Barrier | | 0.400 | 0.140 | 50.00 | 0.096 | 0.356 | 0.290 | 1.0E-08 | 0.000 | 0.001 | 3.3 |
| 18 | Mun. Waste | | 0.520 | 0.015 | 20.76 | 0.211 | 0.294 | 0.140 | 2.0E-04 | 0.283 | 0.230 | 5.1 |

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NOP FS - ON-SITE LANDFILL
ESTIMATE OF ANNUAL LEACHATE GENERATION
CONCEPTUAL COST ESTIMATE (BASE)

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GOOD GRASS

LAYER 1 - TOPSOIL LAYER

VERTICAL PERCOLATION LAYER

| | | |
|---|---|---|
| THICKNESS | = | 6.00 INCHES |
| POROSITY | = | 0.4630 VOL/VOL |
| FIELD CAPACITY | = | 0.2320 VOL/VOL |
| WILTING POINT | = | 0.1157 VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.1191 VOL/VOL |
| SATURATED HYDRAULIC CONDUCTIVITY | = | 0.001553999959 CM/SEC |

LAYER 2 - ROOTING MAT'L LAYER

VERTICAL PERCOLATION LAYER

| | | |
|---|---|---|
| THICKNESS | = | 12.00 INCHES |
| POROSITY | = | 0.4096 VOL/VOL |
| FIELD CAPACITY | = | 0.2466 VOL/VOL |
| WILTING POINT | = | 0.1353 VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.1253 VOL/VOL |
| SATURATED HYDRAULIC CONDUCTIVITY | = | 0.000009500000 CM/SEC |

LAYER 3 - SAND DRAINAGE LAYER

LATERAL DRAINAGE LAYER

| | | |
|---|---|---|
| THICKNESS | = | 12.00 INCHES |
| POROSITY | = | 0.3339 VOL/VOL |
| FIELD CAPACITY | = | 0.0529 VOL/VOL |

| | | |
|---|---|---|
| WILTING POINT | = | 0.0245 VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.0447 VOL/VOL |
| SATURATED HYDRAULIC CONDUCTIVITY | = | 0.000289999996 CM/SEC |
| SLOPE | = | 3.00 PERCENT |
| DRAINAGE LENGTH | = | 100.0 FEET |

## LAYER 4 - CLAY LAYER

### BARRIER SOIL LINER

| | | |
|---|---|---|
| THICKNESS | = | 24.00 INCHES |
| POROSITY | = | 0.4300 VOL/VOL |
| FIELD CAPACITY | = | 0.3663 VOL/VOL |
| WILTING POINT | = | 0.2802 VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.4300 VOL/VOL |
| SATURATED HYDRAULIC CONDUCTIVITY | = | 0.000000100000 CM/SEC |

## GENERAL SIMULATION DATA

| | | |
|---|---|---|
| SCS RUNOFF CURVE NUMBER | = | 72.00 |
| TOTAL AREA OF COVER | = | 41600. SQ FT |
| EVAPORATIVE ZONE DEPTH | = | 25.00 INCHES |
| UPPER LIMIT VEG. STORAGE | = | 10.0305 INCHES |
| INITIAL VEG. STORAGE | = | 2.4893 INCHES |

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

## CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR GRAND ISLAND NEBRASKA

| | | |
|---|---|---|
| MAXIMUM LEAF AREA INDEX | = | 3.30 |
| START OF GROWING SEASON (JULIAN DATE) | = | 123 |
| END OF GROWING SEASON (JULIAN DATE) | = | 284 |

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 22.30 | 27.70 | 35.50 | 49.90 | 60.70 | 70.70 |
| 76.30 | 75.00 | 64.40 | 53.70 | 38.20 | 27.00 |

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 0.50 | 0.80 | 0.85 | 2.15 | 3.42 | 4.68 |
| | 2.84 | 2.91 | 2.20 | 0.95 | 0.41 | 0.68 |
| STD. DEVIATIONS | 0.37 | 0.55 | 0.32 | 1.51 | 1.67 | 1.99 |
| | 1.65 | 2.08 | 1.61 | 0.53 | 0.34 | 0.53 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.000 | 0.000 | 0.000 | 0.042 | 0.012 | 0.030 |
| | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 |
| STD. DEVIATIONS | 0.000 | 0.000 | 0.000 | 0.182 | 0.054 | 0.126 |
| | 0.000 | 0.008 | 0.000 | 0.000 | 0.000 | 0.000 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 0.404 | 0.607 | 1.112 | 1.651 | 2.780 | 5.254 |
| | 3.616 | 2.637 | 1.928 | 1.016 | 0.565 | 0.409 |
| STD. DEVIATIONS | 0.146 | 0.228 | 0.467 | 0.830 | 0.804 | 1.683 |
| | 1.679 | 1.572 | 1.337 | 0.442 | 0.308 | 0.347 |
| **ATERAL DRAINAGE FROM LAYER 3** | | | | | | |
| TOTALS | 0.0021 | 0.0016 | 0.0013 | 0.0011 | 0.0036 | 0.0101 |
| | 0.0065 | 0.0049 | 0.0039 | 0.0035 | 0.0029 | 0.0025 |
| STD. DEVIATIONS | 0.0051 | 0.0038 | 0.0032 | 0.0023 | 0.0121 | 0.0291 |
| | 0.0148 | 0.0111 | 0.0094 | 0.0085 | 0.0071 | 0.0062 |
| **PERCOLATION FROM LAYER 4** | | | | | | |
| TOTALS | 0.0170 | 0.0155 | 0.0170 | 0.0240 | 0.0297 | 0.0320 |
| | 0.0282 | 0.0240 | 0.0213 | 0.0179 | 0.0170 | 0.0173 |
| STD. DEVIATIONS | 0.0415 | 0.0377 | 0.0399 | 0.0430 | 0.0482 | 0.0559 |
| | 0.0516 | 0.0493 | 0.0446 | 0.0437 | 0.0416 | 0.0422 |

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

| | (INCHES) | | (CU. FT.) | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 22.39 | ( 5.969) | 77629. | 100.00 |
| RUNOFF | 0.086 | ( 0.227) | 297. | 0.38 |
| EVAPOTRANSPIRATION | 21.978 | ( 5.471) | 76192. | 98.15 |

| | | | |
|---|---|---|---|
| LATERAL DRAINAGE FROM LAYER 3 | 0.0439 ( 0.0968) | 152. | 0.20 |
| PERCOLATION FROM LAYER 4 | 0.2609 ( 0.4205) | 904. | 1.16 |
| CHANGE IN WATER STORAGE | 0.024 ( 1.066) | 83. | 0.11 |

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

| | (INCHES) | (CU. FT.) |
|---|---|---|
| PRECIPITATION | 3.26 | 11301.3 |
| RUNOFF | 0.816 | 2829.4 |
| LATERAL DRAINAGE FROM LAYER 3 | 0.0070 | 24.2 |
| PERCOLATION FROM LAYER 4 | 0.0069 | 23.8 |
| HEAD ON LAYER 4 | 24.7 | |
| SNOW WATER | 1.23 | 4277.9 |

| | |
|---|---|
| MAXIMUM VEG. SOIL WATER (VOL/VOL) | 0.3583 |
| MINIMUM VEG. SOIL WATER (VOL/VOL) | 0.0995 |

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FINAL WATER STORAGE AT END OF YEAR 20

| LAYER | (INCHES) | (VOL/VOL) |
|---|---|---|
| 1 | 0.75 | 0.1252 |
| 2 | 1.80 | 0.1497 |
| 3 | 0.54 | 0.0447 |
| 4 | 10.32 | 0.4300 |
| SNOW WATER | 0.15 | |

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NOP FS - ON-SITE LANDFILL
ESTIMATE OF ANNUAL LEACHATE GENERATION
CONCEPTUAL COST ESTIMATE - SENSITIVITY ANALYSIS

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GOOD GRASS

LAYER 1 - TOPSOIL LAYER

VERTICAL PERCOLATION LAYER

| | | |
|---|---|---|
| THICKNESS | = | 6.00 INCHES |
| POROSITY | = | 0.4630 VOL/VOL |
| FIELD CAPACITY | = | 0.2320 VOL/VOL |
| WILTING POINT | = | 0.1157 VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.1191 VOL/VOL |
| SATURATED HYDRAULIC CONDUCTIVITY | = | 0.001553999959 CM/SEC |

LAYER 2 - ROOTING MAT'L LAYER

VERTICAL PERCOLATION LAYER

| | | |
|---|---|---|
| THICKNESS | = | 12.00 INCHES |
| POROSITY | = | 0.4096 VOL/VOL |
| FIELD CAPACITY | = | 0.2466 VOL/VOL |
| WILTING POINT | = | 0.1353 VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.1253 VOL/VOL |
| SATURATED HYDRAULIC CONDUCTIVITY | = | 0.000009500000 CM/SEC |

LAYER 3 - SAND DRAINAGE LAYER

LATERAL DRAINAGE LAYER

| | | |
|---|---|---|
| THICKNESS | = | 12.00 INCHES |
| POROSITY | = | 0.3339 VOL/VOL |
| FIELD CAPACITY | = | 0.0529 VOL/VOL |

| | | |
|---|---|---|
| WILTING POINT | = | 0.0245 VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.0447 VOL/VOL |
| SATURATED HYDRAULIC CONDUCTIVITY | = | 0.000289999996 CM/SEC |
| SLOPE | = | 3.00 PERCENT |
| DRAINAGE LENGTH | = | 100.0 FEET |

## LAYER 4 -CLAY LAYER

### BARRIER SOIL LINER

| | | |
|---|---|---|
| THICKNESS | = | 24.00 INCHES |
| POROSITY | = | 0.4300 VOL/VOL |
| FIELD CAPACITY | = | 0.3663 VOL/VOL |
| WILTING POINT | = | 0.2802 VOL/VOL |
| INITIAL SOIL WATER CONTENT | = | 0.4300 VOL/VOL |
| SATURATED HYDRAULIC CONDUCTIVITY | = | 0.000000100000 CM/SEC |

## GENERAL SIMULATION DATA

| | | |
|---|---|---|
| SCS RUNOFF CURVE NUMBER | = | 72.00 |
| TOTAL AREA OF COVER | = | 47500. SQ FT |
| EVAPORATIVE ZONE DEPTH | = | 25.00 INCHES |
| UPPER LIMIT VEG. STORAGE | = | 10.0305 INCHES |
| INITIAL VEG. STORAGE | = | 2.4893 INCHES |

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

## CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR GRAND ISLAND NEBRASKA

| | | |
|---|---|---|
| MAXIMUM LEAF AREA INDEX | = | 3.30 |
| START OF GROWING SEASON (JULIAN DATE) | = | 123 |
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NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/[illegible] |
|---|---|---|---|---|---|
| 22.30 | 27.70 | 35.50 | 49.90 | 60.70 | 70.70 |
| 76.30 | 75.00 | 64.40 | 53.70 | 38.20 | 27.[illegible] |

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 0.50 | 0.80 | 0.85 | 2.15 | 3.42 | 4.68 |
| | 2.84 | 2.91 | 2.20 | 0.95 | 0.41 | 0.68 |
| STD. DEVIATIONS | 0.37 | 0.55 | 0.32 | 1.51 | 1.67 | 1.99 |
| | 1.65 | 2.08 | 1.61 | 0.53 | 0.34 | 0.53 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.000 | 0.000 | 0.000 | 0.042 | 0.012 | 0.030 |
| | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 |
| STD. DEVIATIONS | 0.000 | 0.000 | 0.000 | 0.182 | 0.054 | 0.126 |
| | 0.000 | 0.008 | 0.000 | 0.000 | 0.000 | 0.000 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 0.404 | 0.607 | 1.112 | 1.651 | 2.780 | 5.254 |
| | 3.616 | 2.637 | 1.928 | 1.016 | 0.565 | 0.409 |
| STD. DEVIATIONS | 0.146 | 0.228 | 0.467 | 0.830 | 0.804 | 1.683 |
| | 1.679 | 1.572 | 1.337 | 0.442 | 0.308 | 0.147 |
| **ATERAL DRAINAGE FROM LAYER 3** | | | | | | |
| TOTALS | 0.0021 | 0.0016 | 0.0013 | 0.0011 | 0.0036 | 0.0101 |
| | 0.0065 | 0.0049 | 0.0039 | 0.0035 | 0.0029 | 0.0025 |
| STD. DEVIATIONS | 0.0051 | 0.0038 | 0.0032 | 0.0023 | 0.0121 | 0.0291 |
| | 0.0148 | 0.0111 | 0.0094 | 0.0085 | 0.0071 | 0.0062 |
| **PERCOLATION FROM LAYER 4** | | | | | | |
| TOTALS | 0.0170 | 0.0155 | 0.0170 | 0.0240 | 0.0297 | 0.0320 |
| | 0.0282 | 0.0240 | 0.0213 | 0.0179 | 0.0170 | 0.0173 |
| STD. DEVIATIONS | 0.0415 | 0.0377 | 0.0399 | 0.0430 | 0.0482 | 0.0559 |
| | 0.0516 | 0.0493 | 0.0446 | 0.0437 | 0.0416 | 0.0422 |

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

| | (INCHES) | | (CU. FT.) | PERCENT |
|---|---|---|---|---|
| RECIPITATION | 22.39 | ( 5.969) | 88639. | 100.00 |
| RUNOFF | 0.086 | ( 0.227) | 339. | 0.38 |
| EVAPOTRANSPIRATION | 21.978 | ( 5.471) | 86998. | 98.15 |

| | | | |
|---|---|---|---|
| LATERAL DRAINAGE FROM LAYER 3 | 0.0439 ( 0.0968) | 174. | 0.20 |
| PERCOLATION FROM LAYER 4 | 0.2609 ( 0.4205) | 1033. | 1.16 |
| CHANGE IN WATER STORAGE | 0.024 ( 1.066) | 95. | 0.11 |

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 20

| | (INCHES) | (CU. FT.) |
|---|---|---|
| PRECIPITATION | 3.26 | 12904.2 |
| RUNOFF | 0.816 | 3230.7 |
| LATERAL DRAINAGE FROM LAYER 3 | 0.0070 | 27.7 |
| PERCOLATION FROM LAYER 4 | 0.0069 | 27.2 |
| HEAD ON LAYER 4 | 24.7 | |
| SNOW WATER | 1.23 | 4884.6 |

| | |
|---|---|
| MAXIMUM VEG. SOIL WATER (VOL/VOL) | 0.3583 |
| MINIMUM VEG. SOIL WATER (VOL/VOL) | 0.0995 |

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FINAL WATER STORAGE AT END OF YEAR 20

| LAYER | (INCHES) | (VOL/VOL) |
|---|---|---|
| 1 | 0.75 | 0.1252 |
| 2 | 1.80 | 0.1497 |
| 3 | 0.54 | 0.0447 |
| 4 | 10.32 | 0.4300 |
| SNOW WATER | 0.15 | |

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# APPENDIX F4

# ALTERNATIVE 5 COST SUMMARY

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 5**
**(OFF–SITE LANDFILLING)**
**BASE VOLUME = 8400 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 8,400 | $24 | VQ | $201,600 |
| Ordnance Management | | 10% | | EJ | $20,160 |
| Confirmation Sampling | EA | 63 | $368 | VQ | $23,184 |
| Backfill | CY | 8,400 | $7 | VQ–Means | $58,800 |
| **Subtotal** | | | | | $303,744 |
| **OFF–SITE DISPOSAL** | | | | | |
| Hauling and Disposal | CY | 8,400 | $200 | VQ | $1,680,000 |
| **Subtotal** | | | | | $1,680,000 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $2,041,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $102,050 |
| Mobilization/Demobilization | | 2% | | | $40,820 |
| Health & Safety | | 8% | | | $163,280 |
| Prime Contractor Fixed Fee | | 5% | | | $102,050 |
| **Subtotal** | | | | | $2,449,000 |
| Bonds and Insurance | | 1% | | | $24,490 |
| **Subtotal** | | | | | $2,473,000 |
| Permitting and Legal | | 5% | | | $123,650 |
| Design Engineering | | 2% | | | $49,460 |
| Construction–Related Services | | 3% | | | $74,190 |
| Scope Contingency | | 20% | | | $494,600 |
| **TOTAL CAPITAL COST** | | | | | $3,215,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 yrs, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | **$4,915,000** |

ALT5OSLB.WK3

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 5**
**(OFF–SITE LANDFILLING)**
**VOLUME = 2600 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 2,600 | $24 | VQ | $62,400 |
| Ordnance Management | | 10% | | EJ | $6,240 |
| Confirmation Sampling | EA | 20 | $368 | VQ | $7,360 |
| Backfill | CY | 2,600 | $7 | VQ–Means | $18,200 |
| **Subtotal** | | | | | $94,200 |
| **OFF–SITE DISPOSAL** | | | | | |
| Hauling and Disposal | CY | 2,600 | $240 | VQ | $624,000 |
| **Subtotal** | | | | | $624,000 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $775,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $38,750 |
| Mobilization/Demobilization | | 2% | | | $15,500 |
| Health & Safety | | 8% | | | $62,000 |
| Prime Contractor Fixed Fee | | 5% | | | $38,750 |
| **Subtotal** | | | | | $930,000 |
| Bonds and Insurance | | 1% | | | $9,300 |
| **Subtotal** | | | | | $939,000 |
| Permitting and Legal | | 5% | | | $46,950 |
| Design Engineering | | 2% | | | $18,780 |
| Construction–Related Services | | 3% | | | $28,170 |
| Scope Contingency | | 20% | | | $187,800 |
| **TOTAL CAPITAL COST** | | | | | $1,221,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 yrs, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | **$2,921,000** |

ALT5OSL1.WK3

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 5**
**(OFF–SITE LANDFILLING)**
**VOLUME = 12,600 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 12,600 | $24 | VQ | $302,400 |
| Ordnance Management | | 10% | | EJ | $30,240 |
| Confirmation Sampling | EA | 93 | $368 | VQ | $34,224 |
| Backfill | CY | 12,600 | $7 | VQ–Means | $88,200 |
| **Subtotal** | | | | | $455,064 |
| **OFF–SITE DISPOSAL** | | | | | |
| Hauling and Disposal | CY | 12,600 | $200 | VQ | $2,520,000 |
| **Subtotal** | | | | | $2,520,000 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $3,032,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $151,600 |
| Mobilization/Demobilization | | 2% | | | $60,640 |
| Health & Safety | | 8% | | | $242,560 |
| Prime Contractor Fixed Fee | | 5% | | | $151,600 |
| **Subtotal** | | | | | $3,638,000 |
| Bonds and Insurance | | 1% | | | $36,380 |
| **Subtotal** | | | | | $3,674,000 |
| Permitting and Legal | | 5% | | | $183,700 |
| Design Engineering | | 2% | | | $73,480 |
| Construction–Related Services | | 3% | | | $110,220 |
| Scope Contingency | | 20% | | | $734,800 |
| **TOTAL CAPITAL COST** | | | | | $4,776,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 yrs, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | **$6,476,000** |

ALT5OSL2.WK3

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 5**
**(OFF–SITE LANDFILLING)**
**VOLUME = 25,200 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 25,200 | $24 | VQ | $604,800 |
| Ordnance Management | | 10% | | EJ | $60,480 |
| Confirmation Sampling | EA | 187 | $368 | VQ | $68,816 |
| Backfill | CY | 25,200 | $7 | VQ–Means | $176,400 |
| **Subtotal** | | | | | $910,496 |
| **OFF–SITE DISPOSAL** | | | | | |
| Hauling and Disposal | CY | 25,200 | $170 | VQ | $4,284,000 |
| **Subtotal** | | | | | $4,284,000 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $5,251,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $262,550 |
| Mobilization/Demobilization | | 2% | | | $105,020 |
| Health & Safety | | 8% | | | $420,080 |
| Prime Contractor Fixed Fee | | 5% | | | $262,550 |
| **Subtotal** | | | | | $6,301,000 |
| Bonds and Insurance | | 1% | | | $63,010 |
| **Subtotal** | | | | | $6,364,000 |
| Permitting and Legal | | 5% | | | $318,200 |
| Design Engineering | | 2% | | | $127,280 |
| Construction–Related Services | | 3% | | | $190,920 |
| Scope Contingency | | 20% | | | $1,272,800 |
| **TOTAL CAPITAL COST** | | | | | $8,273,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 yrs, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | **$9,973,000** |

ALT5OSL3.WK3

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 5**
**(OFF–SITE LANDFILLING)**
**VOLUME = 42,000 CY**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 42,000 | $24 | VQ | $1,008,000 |
| Ordnance Management | | 10% | | EJ | $100,800 |
| Confirmation Sampling | EA | 312 | $368 | VQ | $114,816 |
| Backfill | CY | 42,000 | $7 | VQ–Means | $294,000 |
| **Subtotal** | | | | | $1,517,616 |
| **OFF–SITE DISPOSAL** | | | | | |
| Hauling and Disposal | CY | 42,000 | $150 | VQ | $6,300,000 |
| **Subtotal** | | | | | $6,300,000 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $7,875,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $393,750 |
| Mobilization/Demobilization | | 2% | | | $157,500 |
| Health & Safety | | 8% | | | $630,000 |
| Prime Contractor Fixed Fee | | 5% | | | $393,750 |
| **Subtotal** | | | | | $9,450,000 |
| Bonds and Insurance | | 1% | | | $94,500 |
| **Subtotal** | | | | | $9,545,000 |
| Permitting and Legal | | 5% | | | $477,250 |
| Design Engineering | | 2% | | | $190,900 |
| Construction–Related Services | | 3% | | | $286,350 |
| Scope Contingency | | 20% | | | $1,909,000 |
| **TOTAL CAPITAL COST** | | | | | $12,409,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 yrs, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | **$14,109,000** |

ALT5OSL4.WK3

**FS COST ESTIMATE**
**FORMER NOP SITE – OU1**
**ALTERNATIVE 5**
**(OFF–SITE LANDFILLING)**
**(SENSITIVITY ANALYSIS BASE VOLUME, HAULING AND DISPOSING x 1.5)**

| ITEM | UNIT | QUANTITY | UNIT COST | SOURCE | TOTAL |
|---|---|---|---|---|---|
| **CAPITAL COSTS** | | | | | |
| **SOIL REMOVAL** | | | | | |
| Excavation | CY | 8,400 | $24 | VQ | $201,600 |
| Ordnance Management | | 10% | | EJ | $20,160 |
| Confirmation Sampling | EA | 63 | $368 | VQ | $23,184 |
| Backfill | CY | 8,400 | $7 | VQ–Means | $58,800 |
| **Subtotal** | | | | | $303,744 |
| **OFF–SITE DISPOSAL** | | | | | |
| Hauling and Disposal | CY | 8,400 | $308 | VQ | $2,587,200 |
| **Subtotal** | | | | | $2,587,200 |
| **GROUNDWATER TREATMENT** | | | | | |
| Point–of–Use System | EA | 19 | $3,000 | VQ | $57,000 |
| **Subtotal** | | | | | $57,000 |
| **SUBTOTAL – CAPITAL COSTS** | | | | | $2,948,000 |
| **GLOBAL MARKUPS** | | | | | |
| Site Preparation/Restoration | | 5% | | | $147,400 |
| Mobilization/Demobilization | | 2% | | | $58,960 |
| Health & Safety | | 8% | | | $235,840 |
| Prime Contractor Fixed Fee | | 5% | | | $147,400 |
| **Subtotal** | | | | | $3,538,000 |
| Bonds and Insurance | | 1% | | | $35,380 |
| **Subtotal** | | | | | $3,573,000 |
| Permitting and Legal | | 5% | | | $178,650 |
| Design Engineering | | 2% | | | $71,460 |
| Construction–Related Services | | 3% | | | $107,190 |
| Scope Contingency | | 20% | | | $714,600 |
| **TOTAL CAPITAL COST** | | | | | $4,645,000 |
| **ANNUAL O&M COST** | | | $123,500 | | |
| **PRESENT WORTH OF O&M (30 yrs, 6%)** | | | | | $1,700,000 |
| **GRAND TOTAL** | | | | | $6,345,000 |

ALT5OSHD.WK3

## ALTERNATIVE 5 (OFF-SITE DISPOSAL) COST ANALYSIS ASSUMPTIONS

### SOIL REMOVAL

Soil removal and excavation backfill for Alternative 5 is assumed to be the same as for Alternative 4 .

### OFF-SITE DISPOSAL

It is assumed that excavated soil and debris would be disposed of in an off-site Subtitle C landfill. Costs for disposal are based on 1993 cost data for hazardous waste disposal provided by Chemical Waste Management, Inc. (Chemical Waste Management, 1993). This cost includes disposal, taxes, and transportation.

| | | |
|---|---|---|
| 2600 cy: | $175/ton x 100 lb/cf x 27 cf/cy x ton/2,000 lb = $236.25/cy | Say $240/cy |
| 8400 cy: | $150/ton x 100 lb/cf x 27 cf/cy x ton/2,000 lb = $202.50/cy | Say $200/cy |
| 12,600 cy: | $150/ton x 100 lb/cf x 27 cf/cy x ton/2,000 lb = $202.50/cy | Say $200/cy |
| 25,200 cy: | $125/ton x 100 lb/cf x 27 cf/cy x ton/2,000 lb = $168.75/cy | Say $170/cy |
| 42,000 cy: | $110/ton x 100 lb/cf x 27 cf/cy x ton/2,000 lb = $148.50/cy | Say $150/cy |