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Resource Conservation and Recovery Act Facility Investigation Report
for
Mine Fill A (SWMU 12)

VOLUME I OF III - TEXT

Naval Surface Warfare Center Crane
Crane, Indiana

Contract Task Order 0357

January 2006

NAVFAC
Naval Facilities Engineering Command
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29406

TETRA TECH NUS, Inc.

DEPARTMENT OF THE NAVY
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IN REPLY REFER TO:

5090/S4.7.1
Ser PRCR4/6019
30 JAN 2006

U.S. Environmental Protection Agency, Region V
Waste, Pesticides, & Toxics Division
Waste Management Branch
Corrective Action Section
77 West Jackson Blvd.
Chicago, IL 60604

Dear Mr. Ramanauskas:

Crane Division, Naval Surface Warfare Center submits the Draft RCRA Facility Investigation (RFI) Report for Mine Fill A (MFA), Solid Waste Management Unit 12. The report is presented for your review and comment as enclosure (1). The permit required Certification Statement is provided as enclosure (2).

If you require any further information, my point of contact is Mr. Thomas J. Brent, Code PRCR4-TB, at 812-854-6160, email thomas.brent@navy.mil.

Sincerely,

James M. Hunsicker

JAMES M. HUNSICKER
Manager, Environmental Protection
By direction of the Commanding Officer

Enclosures: 1. Draft MFA RFI
2. Certification Statement

Copy to:
ADMINISTRATIVE RECORD
SOUTHNAVFACENGCOM (Code ES31) (w/o encl)
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I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

James Henscike
SIGNATURE

Manager, Environmental Protection
TITLE

1/30/06
DATE

REVISION 0
JANUARY 2006

RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION REPORT FOR MINE FILL A (SWMU 12)

NAVAL SURFACE WARFARE CENTER, CRANE
CRANE, INDIANA

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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CONTRACT NUMBER N62467-94-D-0888
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JANUARY 2006

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TABLE OF CONTENTS

SECTION **PAGE NO.**

EXECUTIVE SUMMARY **ES-1**

ACRONYMS **11**

1.0 INTRODUCTION **1-1**
1.1 PURPOSE 1-1
1.2 SITE BACKGROUND 1-2
1.2.1 Site Location and Description 1-2
1.2.2 Site History 1-2
1.2.3 Previous Investigations 1-4
1.3 REPORT ORGANIZATION 1-12

2.0 FIELD INVESTIGATION **2-1**
2.1 OVERVIEW 2-1
2.2 MOBILIZATION/DEMOBILIZATION 2-1
2.3 SUBSURFACE INVESTIGATION METHODOLOGIES AND PROCEDURES 2-2
2.3.1 Drilling 2-2
2.3.2 Borehole and Sample Logging 2-3
2.3.3 Borehole Abandonment 2-4
2.4 MONITORING WELL INSTALLATION AND DEVELOPMENT 2-4
2.4.1 Well Installation 2-4
2.4.2 Monitoring Well Protection 2-5
2.4.3 Monitoring Well Repair and Development 2-5
2.5 SAMPLING OPERATIONS 2-6
2.5.1 Soil Sample Collection 2-6
2.5.2 Surface Water/Seep Sampling 2-8
2.5.3 Sediment Sampling 2-9
2.5.4 Groundwater Purging and Sampling 2-9
2.6 FIELD SAMPLE DOCUMENTATION 2-11
2.7 SAMPLE HANDLING, PACKAGING, AND SHIPPING 2-12
2.8 QUALITY CONTROL SAMPLES 2-12
2.9 FIELD INSTRUMENT MEASUREMENTS 2-13
2.9.1 Equipment Calibration 2-14
2.9.2 Field Investigation Preventive Maintenance Procedures/Schedule 2-14
2.10 SURVEYING 2-14
2.11 DECONTAMINATION 2-14
2.11.1 Major Equipment 2-15
2.11.2 Sampling Equipment 2-15
2.12 WATER LEVEL MEASUREMENTS AND AQUIFER TESTING 2-15
2.12.1 Groundwater Level Measurements 2-15
2.12.2 Staff Gauge Installation and Estimation of Stream Flow 2-16
2.12.3 Aquifer Testing 2-16
2.13 FIELD CORRECTIVE ACTION 2-17
2.14 INVESTIGATION-DERIVED WASTE HANDLING 2-17
2.15 SITE MANAGEMENT AND FACILITY SUPPORT 2-18
2.16 RECORDKEEPING 2-18
2.17 RESTORATION AND REVEGETATION 2-19

TABLE OF CONTENTS (Continued)

SECTION **PAGE NO.**

3.0 DATA PRESENTATION AND QUALITY 3-1
3.1 DATA PRESENTATION 3-1
3.1.1 Background Data Set Descriptions 3-2
3.1.2 SWMU 12 Data Set Descriptions 3-4
3.2 DATA QUALITY SUMMARY 3-8
3.2.1 Precision and Accuracy 3-8
3.2.2 Representativeness 3-11
3.2.3 Comparability and Completeness 3-11
3.2.4 Sensitivity 3-11

4.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA 4-1
4.1 PHYSIOGRAPHY AND TOPOGRAPHY 4-1
4.2 METEOROLOGY 4-2
4.3 SURFACE WATER HYDROLOGY 4-2
4.4 GEOLOGY 4-5
4.5 SOILS 4-8
4.6 HYDROGEOLOGY 4-9
4.7 DEMOGRAPHY AND LAND USE 4-13
4.8 ECOLOGY 4-14

5.0 NATURE AND EXTENT OF CONTAMINATION 5-1
5.1 BACKGROUND AND UPGRADIENT LOCATIONS 5-3
5.1.1 NSWC Crane Soil Background 5-3
5.1.2 Surface Water, Seep, and Sediment Upgradient Concentrations 5-5
5.1.3 Groundwater Upgradient Locations 5-6
5.2 SOIL CONTAMINATION 5-7
5.2.1 Explosives 5-7
5.2.2 Semivolatile Organic Compounds 5-11
5.2.3 Volatile Organic Chemicals 5-13
5.2.4 Metals and Miscellaneous Parameters 5-13
5.3 SURFACE WATER, SEEP, AND SEDIMENT CONTAMINATION 5-16
5.3.1 Explosives 5-17
5.3.2 Semivolatile Organic Compounds 5-18
5.3.3 Metals and Miscellaneous Parameters 5-18
5.4 GROUNDWATER CONTAMINATION 5-23
5.4.1 Pennsylvanian Upper Zone and Middle Zone Wells 5-24
5.4.2 Pennsylvanian Lower Zone and Mississippian Glen Dean Wells 5-32
5.4.3 Summary of Upper and Lower Well Contarnination 5-33
5.5 SUMMARY OF EXTENT OF CONTAMINATION 5-34

6.0 FATE AND TRANSPORT / CONCEPTUAL MODEL 6-1
6.1 PROPERTIES AFFECTING MOBILITY, ATTENUATION, AND PERSISTENCE 6-1
6.1.1 Solubilities and Adsorption/Desorption Properties 6-2
6.1.2 Biodegradation 6-3
6.1.3 Plant Uptake 6-4

TABLE OF CONTENTS (Continued)

SECTION **PAGE NO.**

6.2 CONCEPTUAL SITE MODEL 6-5
6.2.1 Historical Operations and Releases 6-5
6.2.2 Soil Contamination 6-6
6.2.3 Groundwater Contamination 6-8
6.2.4 Surface Water and Sediment Contamination 6-10
6.2.5 Summary of Conceptual Site Model 6-12

7.0 HUMAN HEALTH RISK ASSESSMENT 7-1
7.1 INTRODUCTION 7-1
7.2 DATA EVALUATION 7-2
7.2.1 Data Usability 7-2
7.2.2 Selection of Chemicals of Potential Concern 7-3
7.2.3 COPCs Selected for HHRA 7-8
7.2.4 Summary 7-22
7.3 EXPOSURE ASSESSMENT 7-22
7.3.1 Conceptual Site Model 7-22
7.3.2 Central Tendency Exposure Versus Reasonable Maximum Exposure 7-30
7.3.3 Exposure Point Concentrations 7-30
7.3.4 Chemical Intake Estimation 7-35
7.3.5 Exposure to Lead 7-42
7.4 TOXICITY ASSESSMENT 7-43
7.4.1 Toxicity Criteria 7-43
7.5 RISK CHARACTERIZATION 7-45
7.5.1 Quantitative Analysis 7-46
7.5.2 Results of the Risk Characterization 7-47
7.6 UNCERTAINTY ANALYSIS 7-60
7.6.1 Uncertainty in Selection of COPCs 7-62
7.6.2 Uncertainty in the Exposure Assessment 7-67
7.6.3 Uncertainty in the Toxicological Evaluation 7-71
7.6.4 Uncertainty in the Risk Characterization 7-75
7.7 SUMMARY AND CONCLUSIONS 7-75

8.0 ECOLOGICAL RISK ASSESSMENT 8-1
8.1 INTRODUCTION 8-1
8.2 SCREENING-LEVEL PROBLEM FORMULATION 8-2
8.2.1 Environmental Setting 8-2
8.2.2 Contaminants, Ecotoxicity, and Fate and Transport 8-5
8.2.3 Potential Exposure Pathways 8-5
8.2.4 Endpoints 8-8
8.3 ECOLOGICAL EFFECTS EVALUATION/SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN 8-12
8.3.1 Ecological Effects Evaluation 8-12
8.3.2 Selection of Contaminants of Potential Concern at SWMU 12 8-14
8.4 STEP 3A -REFINEMENT OF CONSERVATIVE EXPOSURE ASSUMPTIONS 8-17
8.4.1 Terrestrial Plants, Terrestrial and Aquatic Invertebrates, and Fish 8-24
8.4.2 Food-Chain Modeling 8-65

TABLE OF CONTENTS (Continued)

SECTION **PAGE NO.**

8.5 ECOLOGICAL RISK UNCERTAINTY ANALYSIS 8-77
8.5.1 Measurement and Assessment Endpoints 8-77
8.5.2 Exposure Characterization 8-78
8.5.3 Ecological Effects Data 8-80
8.5.4 Risk Characterization 8-80
8.6 ECOLOGICAL RISK SUMMARY AND CONCLUSIONS 8-80

REFERENCES R-1

APPENDICES

A PHOTOGRAPHS AND PHOTOGRAPH DIRECTION FIGURES
B BORING LOGS, MONITORING WELL CONSTRUCTION DIAGRAMS AND RELATED MATERIALS
C SAMPLE LOG SHEETS AND OTHER FIELD FORMS
D MISCELLANEOUS FIELD DOCUMENTATION
E AQUIFER CHARACTERISTICS, CALCULATIONS, AND RECORDS
F HEALTH AND SAFETY DOCUMENTATION
G ANALYTICAL DATA
H DATA QUALITY REVIEW
I HUMAN HEALTH RISK ASSESSMENT CALCULATIONS
J SUPPORTING MATERIALS FOR THE ECOLOGICAL RISK ASSESSMENT

TABLES

NUMBER

ES-1 Summary of Receptor-specific Human Risks, and Hazards and Ecological Risks, and Recommendations
1-1 Summary of Grids not Excavated to Clean-Up Goals
1-2 Average Results from Explosive Contaminant Monitoring Results for Bioremediated Soil
2-1 Installation Dates and Depths of Monitoring Wells and Soil Borings and Depths of Soil Samples Collected
2-2 Monitoring Well Construction Information and Water Level Measurements
2-3 Summary of Environmental Samples and Laboratory Analyses
2-4 Rationale for Omitted and Unscheduled Sampling
3-1 Descriptive Statistics for the Complete Background Soil Sample Data Set
3-2 Descriptive Statistics for Background Soil Group 3 - Alluvial, Mississippian, and Pennsylvanian Surface Soil

TABLES (Continued)

NUMBER

3-3 Descriptive Statistics for Background Soil Group 8 - Pennsylvanian Subsurface Clay and Silt
3-4 Descriptive Statistics for Mine Fill A Proper Surface Soil Samples, Round 1 Only
3-5 Descriptive Statistics for Battery Site Surface Soil Samples, Round 1 Only
3-6 Results for Chemicals Detected in Mine Fill A Proper Surface Soil Samples, Round 1 Only
3-7 Results for Chemicals Detected in Battery Site Surface Soil Samples, Round 1 Only
3-8 Descriptive Statistics for Mine Fill A Proper Subsurface Soil Samples, Round 1 Only
3-9 Descriptive Statistics for Battery Site Subsurface Soil Samples, Round 1 Only
3-10 Results for Chemicals Detected in Mine Fill A Proper Subsurface Soil Samples, Round 1 Only
3-11 Results for Chemicals Detected in Battery Site Subsurface Soil Samples, Round 1 Only
3-12 Descriptive Statistics for Upgradient Gully Surface Water Samples, Rounds 1 and 2
3-13 Descriptive Statistics for Upgradient East Tributary Surface Water Samples, Rounds 1 and 2
3-14 Descriptive Statistics for Upgradient Turkey Creek Main Stream Surface Water Samples, Rounds 1 and 2
3-15 Results for Chemicals Detected in Upgradient Gully Surface Water Samples, Rounds 1 and 2
3-16 Results for Chemicals Detected in Upgradient East Tributary Surface Water Samples, Rounds 1 and 2
3-17 Results for Chemicals Detected for Upgradient Turkey Creek Mainstream Surface Water Samples, Rounds 1 and 2
3-18 Descriptive Statistics for Downgradient Gully Surface Water Samples, Rounds 1 and 2
3-19 Descriptive Statistics for Downgradient Gully Surface Water Samples, Round 1 Only
3-20 Descriptive Statistics for Downgradient Gully Surface Water Samples, Round 2 Only
3-21 Descriptive Statistics for Downgradient East Tributary Surface Water Samples, Rounds 1 and 2
3-22 Descriptive Statistics for Downgradient East Tributary Surface Water Samples, Round 1 Only
3-23 Descriptive Statistics for Downgradient East Tributary Surface Water Samples, Round 2 Only
3-24 Descriptive Statistics for Downgradient Turkey Creek Mainstream Surface Water Samples, Rounds 1 And 2
3-25 Descriptive Statistics for Downgradient Turkey Creek Mainstream Surface Water Samples, Round 1 Only
3-26 Descriptive Statistics for Downgradient Turkey Creek Mainstream Surface Water Samples, Round 2 Only
3-27 Results for Chemicals Detected in Downgradient Gully Surface Water Samples, Rounds 1 and 2
3-28 Results for Chemicals Detected Downgradient East Tributary Surface Water Samples, Rounds 1 and 2
3-29 Results for Chemicals Detected in Downgradient Turkey Creek Mainstream Surface Water Samples, Rounds 1 and 2
3-30 Descriptive Statistics for Upgradient Gully Sediment Samples, Round 1 Only
3-31 Descriptive Statistics for Upgradient East Tributary Sediment Samples, Round 1 Only
3-32 Descriptive Statistics for Upgradient Turkey Creek Main Stream Sediment Samples, Round 1 Only
3-33 Results for Chemicals Detected in Upgradient Gully Sediment Samples, Round 1 Only
3-34 Results for Chemicals Detected in Upgradient East Tributary Sediment Samples, Round 1 Only
3-35 Results for Chemicals Detected in Upgradient Turkey Creek Main Stream Sediment Samples, Round 1 Only
3-36 Descriptive Statistics for Downgradient Gully Sediment Samples, Round 1 Only
3-37 Descriptive Statistics for Downgradient East Tributary Sediment Samples, Round 1 Only
3-38 Descriptive Statistics for Downgradient Turkey Creek Sediment Samples, Round 1 Only
3-39 Results for Chemicals Detected in Downgradient Gully Sediment Samples, Round 1 Only

TABLES (Continued)

NUMBER

3-40 Results for Chemicals Detected in Downgradient East Tributary Sediment Samples, Round 1 Only
3-41 Results for Chemicals Detected in Downgradient Turkey Creek Sediment Samples, Round 1 Only
3-42 Descriptive Statistics for Upgradient Pennsylvanian Upper Zone (Puz) Groundwater Samples, Rounds 1 and 2
3-43 Descriptive Statistics for Upgradient Pennsylvanian Middle Zone (Pmz) Groundwater Samples, Rounds 1 and 2
3-44 Descriptive Statistics for Upgradient Pennsylvanian Lower and Mississippian Glen Dean Zone (PlzMgd) Groundwater Samples, Rounds 1 and 2
3-45 Results for Chemicals Detected in Upgradient Pennsylvanian Upper Zone (Puz) Groundwater Samples, Rounds 1 and 2
3-46 Results for Chemicals Detected in Upgradient Pennsylvanian Middle Zone (Pmz) Groundwater Samples, Rounds 1 and 2
3-47 Results for Chemicals Detected in Upgradient Pennsylvanian Lower and Mississippian Glen Dean Zone (PlzMgd) Groundwater Samples, Rounds 1 and 2
3-48 Descriptive Statistics for Downgradient Pennsylvanian Upper Zone (Puz) Groundwater Samples, Rounds 1 and 2
3-49 Descriptive Statistics for Downgradient Pennsylvanian Upper Zone (Puz) Groundwater Samples, Round 1 Only
3-50 Descriptive Statistics for Downgradient Pennsylvanian Upper Zone (Puz) Groundwater Samples, Round 2 Only
3-51 Descriptive Statistics for Downgradient Pennsylvanian Middle Zone (Pmz) Groundwater Samples, Rounds 1 and 2
3-52 Descriptive Statistics for Downgradient Pennsylvanian Middle Zone (Pmz) Groundwater Samples, Round 1 Only
3-53 Descriptive Statistics for Downgradient Pennsylvanian Middle Zone (Pmz) Groundwater Samples, Round 2 Only
3-54 Descriptive Statistics for Downgradient Pennsylvanian Lower and Mississippian Glen Dean Zone (PlzMgd) Groundwater Samples, Rounds 1 and 2
3-55 Descriptive Statistics for Downgradient Pennsylvanian Lower and Mississippian Glen Dean Zone (PlzMgd) Groundwater Samples, Round 1 Only
3-56 Descriptive Statistics for Downgradient Pennsylvanian Lower and Mississippian Glen Dean Zone (PlzMgd) Groundwater Samples, Round 2 Only
3-57 Results for chemicals Detected in Downgradient Pennsylvanian Upper Zone (Puz) Groundwater Samples, Rounds 1 and 2
3-58 Results for Chemicals Detected in Downgradient Pennsylvanian Middle Zone (Pmz) Groundwater Samples, Rounds 1 and 2
3-59 Results for Chemicals Detected in Downgradient Pennsylvanian Lower and Mississippian Glen Dean Zone (PlzMgd) Groundwater Samples, Rounds 1 and 2
4-1 Estimated Flow Rates at Surface Water Sampling Locations and Staff Gauges
4-2 Hydraulic Conductivities of Geologic Materials Based on Slug Tests
5-1 Total Metals Ranked Data Sets for Gully Surface Water for Round 1 and Round 2
5-2 Total Metals Ranked Data Sets for Gully Sediment, Round 1 Only
5-3 Ammonia and Nitrate+Nitrite-N Ranked Data Sets for Gully Surface Water Round 1 and Round 2

TABLES (Continued)

NUMBER

6-1 Chemical and Degradation Characteristics of Site Contaminants
6-2 Partition Coefficients of Energetic Compounds
6-3 Biodegradation Characteristics of Energetic Compounds
6-4 General Levels of Contaminant Concentrations in Each Media
7-1 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Surface Soil - Direct Contact
7-2 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Surface Soil - Migration Pathways
7-3 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Subsurface Soil - Direct Contact
7-4 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Subsurface Soil - Migration Pathways
7-5 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Surface/Subsurface Soil - Direct Contact - Historical Data
7-6 Comparison of Soil Concentrations to Criteria for Migration from Soil to Groundwater - Historical Surface/Subsurface Soil
7-7 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Surface Soil - Direct Contact
7-8 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Surface Soil - Migration Pathways
7-9 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Subsurface Soil - Direct Contact
7-10 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Subsurface Soil - Migration Pathways
7-11 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Groundwater - Pennsylvania Upper Zone
7-12 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Groundwater - Pennsylvanian Middle Zone
7-13 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Groundwater - Pennsylvanian Lower and Mississippian Glen Dean Zone
7-14 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Gully Surface Water
7-15 Occurrence, Distribution and Selection of Chemicals of Potential Concern - East Tributary Surface Water
7-16 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Turkey Creek Surface Water
7-17 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Gully Sediment
7-18 Occurrence, Distribution and Selection of Chemicals of Potential Concern - East Tributary Sediment
7-19 Occurrence, Distribution and Selection of Chemicals of Potential Concern - Turkey Creek Sediment
7-20 Summary of COPCs and Exposure Point Concentrations
7-21 Receptors and Exposure Routes for Quantitative Evaluation
7-22 Summary of Exposure Input Parameters, Reasonable Maximum Exposures
7-23 Summary of Exposure Input Parameters, Central Tendency Exposures
7-24 Non-Cancer Toxicity Data - Oral/Dermal
7-25 Cancer Toxicity Data - Oral/Dermal

TABLES (Continued)

NUMBER

7-26 Summary of Cancer Risks and Hazard Indices - Reasonable Maximum Exposure
7-27 Summary of Cancer Risks and Hazard Indices - Central Tendency Exposure
8-1 Ecological COPC Selection for SWMU 12 Proper, Surface Soil Samples, Round 1 Only
8-2 Ecological COPC Selection for Battery Disposal Area, Surface Soil Samples, Round 1 Only
8-3 Ecological COPC Selection for Surface Soil Samples Collected During Remedial Activities
8-4 Ecological COPC Selection for Downgradient Gully, Sediment Samples, Round 1 Only
8-5 Ecological COPC Selection for Downgradient East Tributary, Sediment Samples, Round 1 Only
8-6 Ecological COPC Selection for Downgradient Turkey Creek, Sediment Samples, Round 1 Only
8-7 Ecological COPC Selection for Downgradient Gull7y, Surface Water Samples, Rounds 1 and 2
8-8 Ecological COPC Selection for Downgradient East Tributary, Surface Water Samples, Rounds 1 and 2
8-9 Ecological COPC Selection for Downgradient Turkey Creek, Surface Water Samples, Rounds 1 and 2
8-10 Step 3A Evaluation for Risks to Plants and Invertebrates, SWMU 12 Proper Surface Soil COPCs
8-11 Maximum and Average Ecological COPC Concentrations for Each Building - Historical Surface Soil Samples
8-12 Step 3A Evaluation for Risks to Benthic Invertebrates, Sediment COPCs
8-13 Step 3A Evaluation for Risks to Aquatic Organisms
8-14 Exposure Parameters for the Terrestrial Wildlife Model
8-15 Step 3A Evaluation for Risks to Terrestrial Wildlife, Surface Soil COPCs
8-16 Terrestrial Wildlife Model - Maximum Concentrations, Maximum BAF, and Maximum Exposure Parameters, SWMU 12 Proper Surface Soil Samples
8-17 Terrestrial Wildlife Model - Average Concentrations, Average BAFs, and Average Exposure Parameters, SWMU 12 Proper Surface Soil Samples
8-18 Terrestrial Wildlife Model - Maximum Concentrations, Maximum BAFs, and Maximum Exposure Parameters, SWMU 12 Battery Disposal Area Surface Soil Samples
8-19 Terrestrial Wildlife Model - Average Concentrations, Average BAFs, and Average Exposure Parameters, SWMU 12 Battery Disposal Area Surface Soil Samples
8-20 Terrestrial Wildlife Model - Maximum Concentrations, Maximum BAFs, and Maximum Exposure Parameters, SWMU 12 Historical Surface Soil Samples
8-21 Terrestrial Wildlife Model - Average Concentrations, Average BAFs, and Average Exposure Parameters, SWMU 12 Historical Surface Soil Samples
8-22 Terrestrial Wildlife Model, Maximum Concentrations and Maximum Inputs
8-23 Terrestrial Wildlife Model, Average Concentrations and Average Inputs

FIGURES

NUMBER

1-1 Site Location Map
1-2 Location of SWMU 12
1-3 Site Features SWMU 12
1-4 Interim Measure Post-Excavation Sampling Grid Location Map Building 152
1-5 Interim Measure Grids Backfilled With Bioremediated Soil Building 152
1-6 Interim Measure Post-Excavation Sampling Grid Location Map Buildings 153/154
1-7 Interim Measure Grids Backfilled with Bioremediated Soil Buildings 153/154
1-8 Interim Measure Post-Excavation Sampling Grid Location Map Building 157
1-9 Interim Measure Grids Backfilled with Bioremediated Soil Building 157
1-10 Interim Measure Post-Excavation Sampling Grid Location Map Buildings 158/159
1-11 Interim Measure Grids Backfilled with Bioremediated Soil Buildings 158/159
2-1 Surveyed Soil Boring Locations
2-2 Surveyed Monitoring Well Locations
2-3 Surveyed Surface Water/Sediment and Staff Gauge Locations
4-1 Five-Year Wind Rose Summary for Indianapolis, Indiana
4-2 Small Drainage Ways and Drainage Basins on West Side of Mine Fill A
4-3 Generalized Stratigraphic Column
4-4 Surficial Geology Map
4-5 Cross Section Map
4-6 Geological Cross Section A-A'
4-7 Geological Cross Section B-B'
4-8 Geological Cross Section C-C'
4-9 Geological Cross Section D-D'
4-10 Potentiometric Surface Map for the Upper Pennsylvanian Water-Bearing Zone – January 18, 2005
4-11 Potentiometric Surface Map for the Middle Pennsylvanian Water-Bearing Zone – January 18, 2005
4-12 Potentiometric Surface Map for the Glen Dean Limestone (Mississippi) Aquifer
4-13 Groundwater Elevation in Monitoring Wells Versus Well Screen Depth at SWMU12
4-14 Comparison of Groundwater Elevations In Well Pairs at SWMU 12
5-1 Total Aluminum Concentrations (mg/kg) in Soil Samples of the Mine Fill A Proper
5-2 Total Nickel Concentrations (mg/kg) in Soil Samples of the Mine Fill A Proper
5-3 Total Aluminum Concentrations (mg/kg) in Soil Samples of the Battery Site
5-4 Total Antimony Concentrations (mg/kg) in Soil Samples of the Battery Site
5-5 Total Arsenic Concentrations (mg/kg) in Soil Samples of the Battery Site
5-6 Total Barium Concentrations (mg/kg) in Soil Samples of the Battery Site
5-7 Total Chromium Concentrations (mg/kg) in Soil Samples of the Battery Site
5-8 Total Copper Concentrations (mg/kg) in Soil Samples of the Battery Site
5-9 Total Lead Concentrations (mg/kg) in Soil Samples of the Battery Site
5-10 Total Nickel Concentrations (mg/kg) in Soil Samples of the Battery Site
5-11 Total Zinc Concentrations (mg/kg) in Soil Samples of the Battery Site
5-12 Select TNT-Related Explosives Concentrations in Gully Surface Water (µg/L) and Sediment (mg/kg)
5-13 HMX and RDX-Related Explosive Concentrations in Gully Surface Water (µg/L) and Sediment (mg/kg)
5-14 Total Aluminum Concentrations in Gully Surface Water (µg/L) and Sediment (mg/kg)
5-15 Total Arsenic Concentrations in Gully Surface Water (µg/L) and Sediment (mg/kg)

FIGURES (Continued)

NUMBER

5-16 Total Cadmium Concentrations in Gully Surface Water (µg/L) and Sediment (mg/kg)
5-17 Total Iron Concentrations in Gully Surface Water (µg/L) and Sediment (mg/kg)
5-18 Total Lead Concentrations in Gully Surface Water (µg/L) and Sediment (mg/kg)
5-19 Total Manganese Concentrations in Gully Surface Water (µg/L) and Sediment (mg/kg)
5-20 Total Nickel Concentrations in Gully Surface Water (µg/L) and Sediment (mg/kg)
5-21 Total Vanadium Concentrations in Gully Surface Water (µg/L) and Sediment (mg/kg)
5-22 Nitrate Plus Nitrite Concentrations in Gully Surface Water (µg/L) and Sediment (mg/kg)
5-23 Select TNT Related Explosive Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-24 Select HMX and RDX-Related Explosive Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-25 Total Aluminum Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-26 Total Arsenic Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-27 Total Beryllium Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-28 Total Cadmium Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-29 Total Chromium Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-30 Total Cobalt Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-31 Total Iron Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-32 Total Lead Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-33 Total Manganese Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-34 Total Nickel Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-35 Total Thallium Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-36 Total Vanadium Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-37 Nitrate Plus Nitrite Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
5-38 Ammonia Nitrogen Concentrations (µg/L) in Pennsylvanian Upper and Middle Zone Monitoring Wells
6-1 Schematic Diagram of Potential Contaminant Migration Pathways
7-1 Summary of Human Health Risk Assessment Process
7-2 Human Health Conceptual Site Model
8-1 Navy Ecological Risk Assessment Tiered Approach
8-2 General ERA Process for Evaluation of Risks to Chemicals in Surface Soil
8-3 General ERA Process for Evaluation of Risks to Chemicals in Sediment
8-4 General ERA Process for Evaluation of Risks to Chemicals in Surface Water
8-5 SWMU 12 Aerial Photograph - SWMU 12 Boundary
8-6 Ecological Conceptual Site Model

ACRONYMS

°C	degrees Centigrade
°F	degrees Fahrenheit
µg/dL	microgram per deciliter
µg/L	microgram per liter
2ADNT	2-amino-4,6-dinitrotoluene
4ADNT	4-amino-2,6-dinitrotoluene
ALM	Adult Lead Model
amsl	Above mean sea level
ASTDR	Agency for Toxic Substances and Disease Registry
AVS	Acid volatile sulfides
AWQC	Ambient Water Quality Criteria
bgs	Below ground surface
BS	Battery Site
CAL EPA	California Environmental Protection Agency
C_b	Bioremediated concentration
CEC	Cation exchange capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
cm/s	centimeters per second
cm^2	square centimeters
COC	Chemical of concern
COPC	Chemical of potential concern
C_r	Residual concentration
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CTE	Central Tendency Exposure
CTO	Contract Task Order
DI	Deionized
DNX	Hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine
DO	Dissolved oxygen
DPT	Direct push technology
ECOTR	Environmental Contracting Officer Technical Representative
EMR	Environmental Monitoring Report

EPA	Environmental Protection Agency
EPC	Exposure Point Concentration
EPD	Environmental Protection Department
EU	Exposure Unit
FAQ	Frequently Asked Question
FOL	Field Operations Leader
FTMR	Field task modification request
gpm	Gallons per minute
HAS	Hollow stem auger
HASP	Health and Safety Plan
HEAST	Health Effects Summary Tables
HHRA	Human health risk assessment
HI	Hazard Index
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HQ	Hazard Quotient
IAC	Indiana Administrative Code
IAS	Initial assessment study
ICS	Initial characterization sample
IDEM	Indiana Department of Environmental Management
IDW	Investigation derived wastes
IEUBK	Integrated Exposure Uptake Biokinetic Model
ILCR	Incremental Lifetime Cancer Risk
IMR	Interim Measures Report
IRA	Interim removal action
K_d	Soil-water partition coefficients
K_{oc}	Organic matter-water partition coefficients
L/day	liters per day
LCS	Laboratory control sample
MCL	Maximum Contaminant Level
MFA	Mine Fill A
mg/kg	milligrams per kilogram
mg/kg/day	milligram per kilogram per day
mg/L	milligrams per liter
mg/m3	milligrams per cubic meter
Mgd	Mississippian Glen-Dean
MK	Morrison Knudsen

MNX	Hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine
MRL	Minimum Risk Level
MS	Matrix spike
MS/MSD	matrix spike/matrix spike duplicate
NAD83	1983 North American Datum
NAVD88	1988 North American Vertical Datum
NAVFAC EFD South	Naval Facilities Engineering Field Division South
NCEA	National Center for Environmental Assessment
NEESA	Naval Energy and Environmental Support Activity
NFA	No further action
NOAA	National Oceanic and Atmospheric Administration
NSWC	Naval Station Warfare Center
NTU	Nephelometric turbidity unit
OPPTS	Office of Prevention, Pesticides, and Toxic Substances
ORP	Oxidation-reduction potential
OSWER	Office of Solid Waste and Emergency Response
PAH	Polycyclic aromatic hydrocarbon
PEC	Probable Effects Concentration
PES	Post–Excavation Samples
PID	Photoionization detector
Plz	Lower Pennsylvanian water bearing zone
Pmz	Middle Pennsylvanian water bearing zone
PPE	Personal protective equipment
ppm	parts per million
PPRTV	Provisional Peer Reviewed Toxicity Values
PRG	Preliminary Remediation Goal
Puz	Upper Pennsylvanian water bearing zone
PVC	Polyvinyl chloride
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
RAGS	Risk Assessment Guidance for Superfund
RBC	Risk-based Concentration
RBTL	Risk-based target level
RCRA	Resource Conservation and Recovery Act
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine

RfD	Reference Dose
RFI	RCRA Facility Investigation
RISC	Risk Integrated System of Closure
RME	Reasonable Maximum Exposure
RPD	Relative percent difference
RQ	Reportable Quantity
RQD	Rock quality designation
SDWA	Safe Drinking Water Act
SEM	Simultaneously extracted metal
SERA	Screening Ecological Risk Assessment
SMWU	Solid Waste Management Unit
SOPs	Standard operating procedures
SSL	Soil Screening Level
SV	Screening value
SVOC	Semivolatile organic compound
SVOC	Semivolatile organic compound
SWMU	Solid Waste Management Unit
TCLP	Toxicity characteristic leaching procedure
TCMS	Turkey Creek Main Stream
TNT	2,4,6-trinitrotoluene
TNX	Hexahydro-1,3,5-trinitroso-1,3,5-triazine
TOC	Total organic carbon
TOM	Task Order Manager
TRW	Technical Review Workgroup
TtNUS	Tetra Tech NUS, Inc
U.S. EPA	Environmental Protection Agency
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
V_b	Volume of material that was removed and remediated
VOC	Volatile organic compound
V_r	Volume of remaining contamination

EXECUTIVE SUMMARY

This report documents the Resource Conservation and Recovery Act (RCRA) Phase III Facility Investigation (RFI) for Solid Waste Management Unit (SWMU) 12, Mine Fill A (MFA), located at the Naval Surface Warfare Center (NSWC), Crane, Indiana. Tetra Tech NUS, Inc. (TtNUS) prepared this report for the Department of the Navy (Navy) Naval Facilities Engineering Field Division South (NAVFACEFD South) under Contract Task Order (CTO) 0357, Comprehensive Long-Term Environmental Action Navy (CLEAN) III, Contract Number N62467-94-D-0888.

PURPOSE OF RFI REPORT

This report summarizes the RFI fieldwork conducted from November 2004 through March 2005, describes the current nature and extent of contamination, describes the baseline human health and ecological risk assessment processes and conclusions, and provides recommendations for future action. It also briefly recounts previous investigations and remediations to provide a context for the more recent Phase III RFI.

SWMU 12 DESCRIPTION

SWMU 12 (MFA) is located in the central portion of NSWC Crane within the Boggs and Turkey Creek Drainage Basin. This is one of the five drainage basins that carry surface water off the NSWC Crane installation and eventually drain into the East Fork of the White River and then to the Wabash River to the southwest. MFA also includes the Battery Site, which comprises the Battery Area and the Soil Area. These areas are located at the extreme south end of the SWMU.

MFA began operations when NSWC Crane was commissioned in December 1941. It was used for the production of large mines, depth charges, rocket heads, aerial bombs, and projectiles in buildings. MFA was also used during the Korean and Vietnam wars and continued to produce ordnance until 1975, when production was suspended. Ordnance production was resumed in 1980 for a short period of time. More recently, MFA has been used for producing 2,000-pound aerial bombs. In addition to ordnance production, demilitarization activities take place at Buildings 151, 155, and 160 located in MFA.

Documented chemical contaminant releases have occurred at Buildings 152, 153, and 3110. Most of these releases involved 2,4,6-trinitrotoluene (TNT) (near Buildings 151, 152, 153, 160, or 3110) or TNT plus octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) and hexahydro-1,3,5-trinitro-1,3,5-triazine

(RDX) (near Buildings 160 and 3110), or an unspecified explosive powder (in the tunnel area of Building 152) (Halliburton NUS, 1992).

Environmental Investigations and Interim Measures

Several environmental investigations have been conducted at MFA. The investigations include activities summarized in the 1992 Environmental Monitoring Reports (EMRs) as well as interim measures (IMs) that included soil sampling and analyses conducted to support bioremediation activities around Buildings 151, 152, 153/154, 157, 158/159, and 160 [Halliburton NUS, 1992a and 1992b; Morrison-Knudsen (MK), 2000 and 2002; TolTest Incorporated (TolTest) 2001, and 2002]. The IM-related activities occurred during the period 1997 to 2000, and again in 2001, and 2002 and the Phase III RFI field work was initiated in 2004.

Various early investigations identified the presence of explosives in soils, surface, water, sediment, and groundwater. Other contaminants were also detected, albeit in generally less significant quantities or extents. The earlier findings prompted IMs and subsequent environmental investigations to evaluate the extent of contamination and risks to human health and the environment.

The largest IMs required the construction of a bioremediation facility at NSWC Crane to compost explosives-contaminated soils from around operational buildings. The goal was to reduce the explosives concentrations to industrial clean-up levels and then return the composted soil to the excavations. Some explosives-contaminated soils were not excavated for various reasons. After composting, the soil volumes increased substantially so soils were returned to excavations or to holding piles. The concentrations of TNT, HMX, and RDX in all bioremediated soil were less than industrial clean-up levels and were generally less than residential clean-up levels; however, explosives concentrations in some of the soils that were not excavated exceeded industrial clean-up levels. These included areas around Buildings 152, 153/154, 157, and 158/159.

A smaller IM was conducted in 2004 at the SWMU 12 Battery Site to address metals contamination through removal of the contaminated soil. After the IM, the SWMU 12 Battery Site was found to have residual contamination at unacceptable levels. A risk assessment was conducted on the residual contaminants left in-place around operational buildings and at the Battery Site during the recent Phase III RFI.

CONCEPTUAL SITE MODEL

Explosives continue to leach from the surface and near-surface soils and migrate downhill in steep gullies on the sides of the ridge. Polycyclic aromatic hydrocarbons (PAHs) are present in site soils and gully sediments in low concentrations, but have not been detected in any surface water or groundwater samples. It is believed that PAHs are not reaching nor will they reach the tributary streams that flank the SMWU or the shallow groundwater.

The upper zone of groundwater has been contaminated with explosives, primarily RDX, and to a lesser extent HMX, TNT degradation products, and ammonium nitrate. Nearly all of the groundwater in the uppermost bedrock [i.e., the Pennsylvania Upper Water Bearing Zone (Puz)] is flowing laterally toward the upper slopes of the ridge. Some of this groundwater seeps into the gullies on the side of the ridge, and some of the contaminated groundwater is taken up by trees and other vegetation and transpired. Thus, natural phytoremediation is playing a part in controlling and reducing the rate of contaminants reaching the base of the MFA ridge. Explosives (RDX and TNT) in groundwater are degrading as evidenced by the presence of their degradation products.

Only a trace of contaminants has reached the deeper groundwater monitoring wells (i.e., Pennsylvania Middle Water Bearing Zone (Pmz) or Pennsylvania Lower Water Bearing Zone (Plz). The siltstone and shale layers between the Puz and the Pmz are effective aquitards that prevent shallow groundwater and contaminants from reaching the deeper portion of the ridge. One Pmz well located on the southeastern side of SWMU 12 and one Plz well located on the southwestern side of SWMU 12 contained relatively low concentrations of explosive compounds. This contamination is derived from contaminated surface water running down the gullies and infiltrating into the groundwater along the valley bottoms. No groundwater from SWMU 12 is flowing south or southeast under Turkey Creek. Turkey Creek is the ultimate recipient of all contaminants discharging from SWMU 12.

Concentrations of several metals (e.g., aluminum, iron, manganese, cobalt, lead, mercury, nickel, and zinc) are elevated in the uppermost groundwater monitoring zone. The only metal directly attributable to site operations in the MFA proper is aluminum; the source(s) of the other metals in the shallow groundwater are unclear. Metals appear to be leaching, in large part, directly from the bedrock (i.e., a natural source). Elevated metal concentrations in the Battery Site soils are evidently associated with disposal of large quantities of batteries of various types and sizes.

Volatile organic compounds (VOCs) have not been detected at concentrations greater than screening levels in any sample.

RISK ASSESSMENTS

A screening level human health risk assessment and a baseline ecological risk assessment were conducted. Based on those assessments, the following findings were made. Findings are summarized in Table ES-1 for each receptor group and all media to which the receptors in the groups are exposed. The findings are also described in the text below.

Screening Level Human Health Risk Assessment

- Although combined exposures to soils and other media indicate unacceptable estimated risks to humans in Table ES-1, no significant human health risks are expected for any human receptor from exposures to soil in the SWMU 12 Proper, or to surface water, or sediment throughout the SWMU. Most of the human health risks are due to groundwater exposure.

- Elevated groundwater risks were estimated for Pennsylvanian (P) upper zone (Puz), middle zone (Pmz), and lower zone (Plz) groundwater exposure, depending on receptor. Elevated risk estimates for Puz groundwater were due to exposure to select explosives, 11 metals (including lead), and nitrate/nitrite. The elevated risk estimates for Pmz groundwater were due to exposure to iron and manganese for hypothetical future residents. Elevated risk estimates for PlzMgd groundwater were due to exposure to arsenic, iron, or manganese (depending on receptor) for hypothetical future residents.

- Non-carcinogenic and carcinogenic risk estimates exceeding U.S. EPA benchmarks were estimated for exposure to surface soil at the Battery Site. The elevated risk estimates were due to exposure to antimony, arsenic, iron, or lead (depending on location and receptor) in surface soil.

Based on the RFI findings, the following contaminants are recommended for evaluation during a Corrective Measures Study:

- Antimony, arsenic, lead, and iron in surface soil at the Battery Site.
- RDX, arsenic, iron, and manganese in Puz, Pmz, and PlzMgd groundwater.

Baseline Ecological Risk Assessment

- All potential risks to sediment and aquatic receptors were acceptable.

- Potential unacceptable risks exist near Buildings 152, 153/154, 157, 158/159 or 160 and/or soil invertebrates, for plants assimilating surface soil HMX, RDX, TNT or arsenic contamination, and for herbivorous mammals that ingest HMX in food or surface soil around Building 153. However, the unacceptable risks exist to herbivorous mammals at Building 153 because of elevated levels of HMX and RDX in small areas between grid cells 27 and 28; and between grid cells 4 and 134 around Buildings 153/154 where surface soils could not be excavated. These areas represent a very small proportion of the overall home ranges for the mobile receptors and a very small proportion of vegetated areas for the vegetation.

- Plant uptake of Battery Site surface soil nutrients and ingestion of food by soil invertebrates result in potentially unacceptable risks to those receptors because of elevated antimony, copper, lead, tin, and zinc concentrations in the surface soil.

- Potential risks to herbivorous birds and small mammals from lead and silver in surface soil are unacceptable at and near the Battery Site maximum lead concentration (hot spot, 12SB21). Risks to herbivorous mammals and birds from other locations within the Battery Site are acceptable. Risks to insectivorous birds and small mammals are unacceptable from various locations within the Battery Site soil hot spot area for various metals including arsenic, chromium, lead, and mercury. Zinc soil concentrations are elevated across the Battery Site at various locations including and outside of the hot spot area. These contaminants present unacceptable risks to insectivorous birds and small mammals.

Based on the Phase III RFI findings, the following contaminants are recommended for evaluation during a Corrective Measures Study:

- Antimony, arsenic, chromium, copper, lead, mercury, silver, tin, and zinc at select locations in surface soil at the Battery Site.

- HMX, RDX, TNT, and arsenic in surface soil immediately surrounding Buildings 152, 153/154, 157, 158/159 or 160.

UNCERTAINTIES

Human health and ecological risk estimates were subject to the following key uncertainties:

- For human health risk assessments only, that the concentrations of metals in some groundwater samples appear to be associated with suspended solids and the concentrations of some groundwater metals (e.g., arsenic in the PlzMgd) appear to be within naturally occurring concentration ranges even though they contribute significantly to the estimated risks.

- For both risk assessments, that the concentrations of some soil metals appear to be within naturally occurring concentration ranges, and it was not clear in a small number of cases whether soils remaining after excavation were surface soils or subsurface soils. This is due in part because it is difficult to pinpoint the locations of soil with elevated explosives concentrations that could not be excavated or to know the precise depths of those soils. Based on descriptions of the excavations it is believed that, with minor exceptions, all surface soils have explosives concentrations that are less than industrial or residential cleanup levels.

- For both risk assessments, the risk estimates are based on factors that are most likely conservative estimators of risk and therefore, are biased toward an overestimation of risk. Although the risk estimates may be biased high, there is no way to quantify the degree of bias.

CONCLUSIONS

Data collected during the IMs and the Phase III RFI were adequate for developing screening level human health and baseline ecological risk assessments for SWMU 12 and for establishing the nature and extent of contamination to support the risk assessments. Results of the risk assessments are summarized above. Table ES-1 summarizes receptor-specific human health risks and hazards, ecological risks, critical exposure pathways, and chemicals of concern (COCs) for SWMU 12 and, where necessary, recommendations for actions. Most risks from exposure to explosives in soils around buildings 153 and 154 are limited to a few small areas of highest concentration that were not excavated during the soil IM. If the four samples of highest concentrations (MFAICS67, MFAICS70, MFAICS67 and MFAICS70) from those small areas are discounted, the estimated ecological risks in those areas decrease to acceptable levels. Soils contaminated with explosives represent a continuing groundwater contaminant source.

Conducting a CMS to evaluate possible remedial actions for reducing or eliminating the identified potential risks is recommended.

TABLE ES-1

SUMMARY OF RECEPTOR-SPECIFIC HUMAN RISKS, AND HAZARDS AND ECOLOGICAL RISKS, AND RECOMMENDATIONS
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor Population	Environmental Media	Overall Carcinogenic Risk Range[1] (Human Health)	Overall Hazard Index Range[1] (Human Health)	Lead Exposure (Human Health)	Overall Risk (Ecological)	Critical Pathways & Chemicals of Concern	Recommendations
MINE FILE A - PROPER							
Current/Future Maintenance Worker	Surface Soil, Surface Water, Sediment	1E-6 to 3E-6	0.04 to 1	No unacceptable exposure to lead	N/A	N/A	NFA
Current/Future Occupational Worker	Surface Soil, Ground Water	2E-5 to 6E-4	2 to 52	No unacceptable exposure to lead	N/A	Ingestion of RDX, cobalt, iron, manganese, and nickel in Puz ground water	Proceed to CMS
Current/Future Trespasser (Adolescent)	Surface Soil, Surface Water, Sediment	1E-6 to 3E-6	0.07 to 0.4	No unacceptable exposure to lead	N/A	N/A	NFA
Future Construction Worker	Surface and Subsurface Soil, Ground Water	3E-7 to 9E-7	0.2 to 4	No unacceptable exposure to lead	N/A	Dermal contact with manganese in Puz ground water	Proceed to CMS
Future Recreational User (Child)	Surface Soil, Surface Water, Sediment, Ground Water	6E-6 to 1E-4	2 to 53	No unacceptable exposure to lead	N/A	Ingestion of RDX, aluminum, cobalt, iron, manganese, and nickel in Puz ground water	Proceed to CMS
Future Recreational User (Adult)	Surface Soil, Surface Water, Sediment, Ground Water	4E-6 to 1E-4	0.4 to 12	No unacceptable exposure to lead	N/A	Ingestion of aluminum and manganese in Puz ground water	Proceed to CMS
Future Recreational User (Lifelong)	Surface Soil, Surface Water, Sediment, Ground Water	1E-5 to 3E-4	NA	N/A	N/A	Ingestion of RDX in Puz ground water	Proceed to CMS
Future On-Site Resident (Child)	Surface Soil, Surface Water, Sediment, Ground Water	5E-5 to 1E-3	17 to 516	Unacceptable exposure to lead in PUZ ground water	N/A	Ingestion of 2,4,6-TNT, aminodinitrotoluenes, RDX, aluminum, arsenic, beryllium, cadmium, cobalt, iron, lead, manganese, nickel, thallium, zinc, and nitrate/nitrite-N in Puz ground water. Ingestion of iron and manganese in Pmz groundwater. Ingestion of arsenic, iron, and manganese in Plz ground water	Proceed to CMS[2]
Future On-Site Resident (Adult)	Surface Soil, Surface Water, Sediment, Ground Water	5E-5 to 2E-3	5 to 150	No unacceptable exposure to lead	N/A	Ingestion of aminodinitrotoluenes, RDX, aluminum, arsenic, cadmium, cobalt, iron, manganese, nickel in Puz ground water. Ingestion of manganese in Pmz ground water. Ingestion of arsenic in Plz ground water.	Proceed to CMS[2]

TABLE ES-1

SUMMARY OF RECEPTOR-SPECIFIC HUMAN RISKS, AND HAZARDS AND ECOLOGICAL RISKS, AND RECOMMENDATIONS
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor Population	Environmental Media	Overall Carcinogenic Risk Range[1] (Human Health)	Overall Hazard Index Range[1] (Human Health)	Lead Exposure (Human Health)	Overall Risk (Ecological)	Critical Pathways & Chemicals of Concern	Recommendations
MINE FILE A - PROPER (continued)							
Future On-Site Resident (Lifelong)	Surface Soil, Surface Water, Sediment, Ground Water	1E-4 to 3E-3	NA	N/A	N/A	Ingestion of RDX and arsenic in ground water. Ingestion of arsenic in Plz ground water.	Proceed to CMS[2]
Terrestrial Plants and Invertebrates [3]	Surface Soil - SWMU 12 Proper	NA	NA	NA	Acceptable	N/A	NFA
	Surface Soil - Building 152	NA	NA	N/A	Unacceptable	Direct contact by terrestrial plants, and ingestion of soil and food by soil invertebrates from exposure to TNT.	Proceed to CMS
	Surface Soil - Building 153/154	NA	NA	NA	Unacceptable	Direct contact by terrestrial plants, and ingestion of soil and food by soil invertebrates from exposure to TNT, HMX, and RDX.	Proceed to CMS
	Surface Soil - Building 157	NA	NA	NA	Unacceptable	Direct contact by terrestrial plants, and ingestion of soil and food by soil invertebrates from exposure to TNT.	Proceed to CMS
	Surface Soil - Building 158/159	NA	NA	NA	Unacceptable	Direct contact by terrestrial plants, and ingestion of soil and food by soil invertebrates from exposure to arsenic, RDX, and TNT.	Proceed to CMS
	Surface Soil - Building 160	NA	NA	NA	Unacceptable	Direct contact by terrestrial plants, and ingestion of soil and food by soil invertebrates from exposure to arsenic and TNT.	Proceed to CMS
Mammals and Birds [3]	Surface Soil - SWMU 12 Proper	NA	NA	NA	Acceptable	N/A	NFA
	Surface Soil - Building 152	NA	NA	N/A	Acceptable	N/A	NFA
	Surface Soil - Building 153/154	NA	NA	N/A	Unacceptable	Incidental soil ingestion and ingestion of food by herbivorous mammals from exposure to HMX and RDX.	Proceed to CMS
	Surface Soil - Building 157	NA	NA	N/A	Acceptable	N/A	NFA
	Surface Soil - Building 158/159	NA	NA	N/A	Unacceptable	Incidental soil ingestion and ingestion of food by herbivorous mammals from exposure to RDX.	Proceed to CMS
	Sediment - Turkey Creek	NA	NA	N/A	Acceptable	N/A	NFA

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SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor Population	Environmental Media	Overall Carcinogenic Risk Range[1] (Human Health)	Overall Hazard Index Range[1] (Human Health)	Lead Exposure (Human Health)	Overall Risk (Ecological)	Critical Pathways & Chemicals of Concern	Recommendations
BATTERY SITE [4]							
Current/Future Maintenance Worker	Surface Soil	7E-06	0.9	Unacceptable exposure to lead	N/A	Ingestion of lead in surface soil	Proceed to CMS
Current/Future Occupational Worker	Surface Soil	8E-05	10	No unacceptable exposure to lead	N/A	Ingestion of antimony in surface soil	Proceed to CMS
Current/Future Trespasser (Adolescent)	Surface Soil	6E-06	2	Unacceptable exposure to lead	N/A	Ingestion of lead in surface soil	Proceed to CMS
Future Construction Worker	Surface Soil	6.E-06	19	Unacceptable exposure to lead	N/A	Ingestion of antimony and lead in surface soil	Proceed to CMS
	Subsurface Soil	2.E-07	0.5	No unacceptable exposure to lead	N/A	N/A	NFA
Future Recreational User (Child)	Surface Soil	2E-05	9	Unacceptable exposure to lead	N/A	Ingestion of antimony and lead in surface soil	Proceed to CMS
Future Recreational User (Adult)	Surface Soil	9E-06	1	Unacceptable exposure to lead	N/A	Ingestion of lead in surface soil	Proceed to CMS
Future Recreational User (Lifelong)	Surface Soil	3E-05	NA	N/A	N/A	Ingestion of antimony and lead in surface soil based on risks calculated for the child recreational user	Proceed to CMS
Future On-Site Resident (Child)	Surface Soil	2.E-04	125	Unacceptable exposure to lead	N/A	Ingestion of antimony, arsenic, iron, and lead in surface soil	Proceed to CMS
Future On-Site Resident (Adult)	Surface Soil	1.E-04	13	No unacceptable exposure to lead	N/A	Ingestion of antimony in surface soil	Proceed to CMS
Future On-Site Resident (Lifelong)	Surface Soil	3E-04	NA	N/A	N/A	Ingestion of arsenic in surface soil	Proceed to CMS

TABLE ES-1

SUMMARY OF RECEPTOR-SPECIFIC HUMAN RISKS, AND HAZARDS AND ECOLOGICAL RISKS, AND RECOMMENDATIONS
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor Population	Environmental Media	Overall Carcinogenic Risk Range[1] (Human Health)	Overall Hazard Index Range[1] (Human Health)	Lead Exposure (Human Health)	Overall Risk (Ecological)	Critical Pathways & Chemicals of Concern	Recommendations
BATTERY SITE (continued)							
Terrestrial Plants and Invertebrates	Surface Soil - Battery Site	NA	NA	N/A	Unacceptable	Direct contact by terrestrial plants, and ingestion of soil and food by soil invertebrates from exposure to antimony, copper, lead, tin, and zinc at locations 12SS21 through 12SS24.	Proceed to CMS
Mammals and Birds	Surface Soil - Battery Site	NA	NA	N/A	Unacceptable	Incidental soil ingestion and ingestion of food by herbivorous birds and small mammals from exposure to lead and silver at location 12SS21. Incidental soil ingestion and ingestion of food by insectivorous birds and small mammals from exposure to arsenic, chromium, lead, and mercury at locations 12SS21 through 12SS24 and zinc at various locations.	Proceed to CMS

CMS = Corrective Measures Study
NFA = no further action

1. The risk ranges presented for Mine Fill A Proper are the cumulative minimum and maximum risks across soil, groundwater, surface water and sediment. Minimum/maximum risks for soil were the sums of lowest/highest risks calculated for Mine Fill A Proper, Building 152, Building 153/154, Building 157, and Building 158/159. Minimum/maximum risks for groundwater represent the lowest/highest of risks for Puz, Pmz, and Plz groundwater. The minimum/maximum risks for surface water and sediment are sums of the lowest/highest risks for gully, East Tributary, and Turkey Creek surface water and sediment samples.
2. Concentrations of arsenic and iron were less than concentrations in the upgradient wells.
3. Risks to ecological receptors from exposure to surface soil explosives are associated primarily with some very small areas that, if discounted, result in acceptable risk levels.
4. Risks shown for Battery site human health are for exposure to soil only.

1.0 INTRODUCTION

This Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for Mine Fill A (MFA) was prepared for the Naval Surface Warfare Center (NSWC) Crane facility located in Crane, Indiana through the Naval Facilities Engineering Field Division South (NAVFAC EFD SOUTH) under Contract Task Order (CTO) 0357 for the Comprehensive Long-Term Environmental Action Navy (CLEAN) III, Contract Number N62467-94-D 0888. MFA is also known as Solid Waste Management Unit (SWMU) 12.

MFA was used for the production of large mines, depth charges, rocket heads, aerial bombs, and projectiles in buildings. MFA also includes a battery and soil disposal area that is located at the extreme south end of the SWMU. In the past, explosives powders discharged from production building roof vents that accumulated on the roofs were washed down to the ground by precipitation, resulting in the contamination of soils. Wastewaters containing explosives were discharged into ditches. An interim removal action (IRA) was conducted in which explosive-contaminated soils were removed for treatment via bioremediation. Treated soils were then placed onto the areas from which the contaminated soils were removed. MFA is currently used as a renovation facility for explosives-loaded bombs, demilitarized gas generators, and paint bombs.

In the early 1990s, the Battery Site was discovered by the NSWC Crane Environmental Protection Department (EPD). The Battery Site is located on the southern end of MFA, approximately 140 feet outside the perimeter fence and is accessible through a gate. The Battery Site consists of two areas: (1) Battery Area – where batteries were dumped on the ground surface and (2) Soil Area – an adjacent area where soil and construction debris was dumped in small mounds. The batteries were recognizable as AA household type, and their numbers were estimated to be in the thousands. Just prior to MFA Battery Site cleanup (interim measure) operations in June 2002, the batteries were all but unrecognizable, and only their inner cores were visible on the ground surface. The size of the Battery Area was approximately 3,500 square feet. The size of the Soil Area was approximately 2,355 square feet consisting of several soil mounds, none exceeding 4 feet in height. At the time of discovery, the potential for the waste from either of these areas to be a listed or characteristic waste was unknown.

1.1 PURPOSE

The purpose of this RFI Report is to describe the site investigation activities conducted at SWMU 12 and to present the results and interpretation thereof for MFA. This report provides information regarding

concentrations of organic and inorganic chemicals measured in surface soils, subsurface soils, sediment, surface water, and ground water at MFA. In addition, human health and ecological risks associated with MFA were evaluated by way of a baseline human health risk assessment (HHRA) and a screening ecological risk assessment (SERA). The risk assessments were performed using the data collected during the most recent investigation in 2004 and 2005. However, previous investigation results are presented, as appropriate, to provide perspective on current data.

1.2 SITE BACKGROUND

1.2.1 Site Location and Description

NSWC Crane is located in a rural, sparsely populated region of south-central Indiana, approximately 75 miles southwest of Indianapolis, 60 miles northwest of Louisville, Kentucky, and immediately east of Burns City and Crane Village, Indiana. A location map of the NSWC Crane facility is provided as Figure 1-1. NSWC Crane encompasses approximately 62,463 acres or approximately 98 square miles of the northern portion of Martin County and smaller portions of Greene, Daviess, and Lawrence Counties.

SWMU 12 is located in the central portion of NSWC Crane (see Figure 1-2) within the Boggs and Turkey Creek Drainage Basin, which is one of the five drainage basins that carry surface water off the installation and eventually drain into the East Fork of the White River and then to the Wabash River to the southwest. MFA, approximately 63 acres in size, can be divided into two halves along a central east-west line. The site features, including production buildings associated with MFA and the location of the Battery Site are shown in Figure 1-3.

1.2.2 Site History

MFA began operations when NSWC Crane was commissioned in December 1941 and was used for the production of large mines, depth charges, rocket heads, aerial bombs, and projectiles in buildings. The area was also used during the Korean and Vietnam wars. The manufacturing and processing operations and facilities in each half are nearly identical. MFA continued to produce ordnance until 1975, when production was suspended. Production was resumed in 1980 for a short period of time. Most recently, MFA has been used in the production of 2,000-pound aerial bombs. In addition to production, demilitarization activities take place at Buildings 151, 155, and 160. Past history at MFA indicates that demilitarization activities and documented contaminant releases also occurred at Buildings 152, 153, and 3110.

Additional details concerning contaminants known or potentially released at MFA can be found in the RCRA Facility Investigation Phase I Environmental Monitoring Report (Halliburton NUS, 1992). Most documented contaminant releases that occurred involved 2,4,6-trinitrotoluene (TNT) only (near Buildings 151, 152, 153, 160, or 3110) or TNT plus octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) near Buildings 160 and 3110, or an unspecified explosive powder (in the tunnel area of Building 152) (Halliburton NUS, 1992). Note that asbestos, once a component of the coating used on aerial bombs (AVCO), is not a concern for this investigation because the asbestos fibers were entrained in the asphalt-like AVCO matrix. In that form, the asbestos is not hazardous (ATSDR, 1997).

Bomb production at SWMU 12 included the preparation of bomb casings in Building 155. The preparation activities included cleaning the interior of the bomb shell with solvents, which was subsequently coated with the application of a "hot melt" bituminous asphalt-type compound. Excess hot melt compound was then cleaned with solvents. After preparation, some casings were also painted in Building 155. Solvents were also used to clean up painting equipment. Approximately, 100 gallons of methyl ethyl ketone, 200 gallons of toluene, and 50 gallons of naptha were used annually for cleaning. Reports indicate a variety of liquids were disposed of on-site, including oily waters, paint thinners, and solvents that were dumped behind buildings or into ravines. Waste hydraulic oil was also spread on the roads.

In the early 1990s, a battery site was discovered on the south end of SWMU 12 approximately 140 feet outside the perimeter fence. The site consisted of two areas: (1) Battery Area – where batteries were dumped on the ground surface; and (2) Soil Area – an adjacent area where soil and construction debris was dumped in small mounds. The Battery area was composed of a large number of AA household type batteries with only their inner cores visible on the ground surface. These batteries were presumed to contain metals such as lead, manganese, zinc, cadmium, and chromium. The soil area had no unusual characteristics and was assumed to contain soil that originated from installation of road culverts at SWMU 12.

On March 4, 2002, there was a 72,000-gallon release of wastewater from the scrubber building (Building 3111). The building had not been in operation for up to a year, and all of the pumps were shut off as is normal procedure when the building is not in operation. The backflow prevention device failed, which allowed potable water to flood the building to the height of the 6-inch curb. The water then flowed out of the building, across the pavement, and into a ditch along the railroad tracks. Residual TNT from within Building 3111 resulted in a small amount of TNT contamination in the water. The spilled water was sampled and the total quantity of TNT release was significantly less than the reportable quantity (RQ) of

10 pounds in any 24 hour period. The contaminated water contained in the building was transferred to Building 3110 for treatment.

Contaminants likely to be present at this SWMU include explosives, semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), and metals.

1.2.3 Previous Investigations

Several environmental investigations have been conducted at MFA (SWMU 12). The investigations include the 1992 Environmental Monitoring Reports (EMRs) and the interim measures soil sampling conducted subsequent to bioremediation activities around Buildings 151, 152, 153/154, 157, 158/159, and 160 and again in 2002 and 2004 for interim measures conducted at the Battery Site. The 1992 EMR investigation did not require independent data validation; however, data from sampling representing soils after bioremediation has been validated [Morrison Knudson (MK) Corporation, 2000a].

Surface water and effluent collected at various times around the MFA area revealed the presence of explosives contamination. Concentrations of TNT, RDX, and HMX in effluent and ground runoff samples collected around Buildings 152, 157, and 160 in 1972 exceeded Drinking Water Health Advisories, especially in samples collected around Buildings 152 and 157.

No explosives were detected in a ground water sample collected west of MFA in 1972. This groundwater sample was most likely obtained from a hand-dug well. However, ground water beneath MFA may not migrate in the direction of the monitoring well. Also, in surface water samples collected in ground runoff from Building 157 in 1972, the average concentration of TNT was 0.175 milligrams per liter (mg/L) and the concentration of RDX was 3.55 mg/L. In the same study, average concentrations of TNT in effluent from Building 152 and Building 160 ranged from 5.8 to 27.9 mg/L, and the average concentrations of RDX and HMX in effluent from Building 152 were 35.3 and 3.7 mg/L, respectively.

In 1979, the Department of the Army performed a study to characterize wastewaters from industrial operations and to determine the biological impact of discharges upon receiving streams. Water and sediment samples were collected from two major drainage channels that carried runoff from MFA to Turkey Creek. The samples were collected from storm ditches at considerable distances from the production facilities. Explosives were detected in one surface water sample at concentrations less than Drinking Water Health Advisories (the concentration of RDX was 0.05 mg/L and the concentration of HMX was 0.1 mg/L). Only HMX was detected in one sediment sample [about 1 milligram per kilogram (mg/kg)].

Under the NSWC Crane National Pollutant Discharge and Elimination System (NPDES) permit, the outfall carrying effluent from the wastewater treatment facility was regularly monitored for oil, grease, nitrate, and total explosives. Only the total explosives concentration in 1986 exceeded the discharge limit.

1.2.3.1 Initial Assessment Study

As part of the Initial Assessment Survey (IAS) [Naval Energy and Environmental Support Activity (NEESA), 1985], eight soil core samples were collected around Building 153 and Building 158 and analyzed for explosives (Halliburton NUS, 1992). The explosives concentrations in these samples were as follows: TNT ranged from 5.2 to 3,790 mg/kg, HMX ranged from 52 to 1,340 mg/kg, and RDX ranged from 349 to 15,300 mg/kg. The results indicated a "hot spot" distribution of explosives around both buildings; the highest concentrations were detected in sample MFA-2, collected near Building 153.

In 1989, a sample of Building 151 wastewater was collected and analyzed for explosives. The sample contained 0.314 parts per million (ppm) HMX, 4.2 ppm RDX, and 124.2 ppm TNT.

1.2.3.2 MFA Interim Measure Actions

In 1997, 1998, and 1999, MK and in 1999 and 2000 TolTest Incorporated performed sampling, excavation, on-site treatment through bioremedation (composting) of explosives-contaminated soil, and on-site backfilling of compost at MFA. The sampling and analysis program consisted of evaluation of initial characterization samples, post-excavation samples, and the bioremediated soil-compost. At SWMU 12, the pre-excavation sampling was conducted around Buildings 151, 152, 153/154, 157, 158/159, and 160. The initial characterization samples were collected from 124 grid sections near these buildings. Samples from an additional 82 grid sections were added to the outer limits of the areas being characterized to delineate the horizontal extent of contamination. Samples were then collected at each of the 206 grid sections for site characterization. The initial characterization sampling at each grid location consisted of three samples, including two composite samples analyzed for explosives and metals and one grab sample analyzed for VOCs. The composites were collected at depths of 0 to 12 inches and 24 to 36 inches, and the grab sample was collected from a depth of 12 inches. The analytes selected for analysis included explosives, VOCs, and metals and were based on generator knowledge of process operations and the 1992 RFI (Halliburton NUS, 1992) to ensure that solvent-contaminated soil (or other characteristic wastes) was not transported to the Bioremediation Facility for composting.

Based on the results of the initial characterization sampling, individual grids were selected for excavation and remediation. During excavation, field screening was used to test for RDX to provide quick field screening results. Following excavation, post-excavation confirmation soil samples were collected from the bottoms and sidewalls of each grid section and sent to a fixed-base laboratory. RDX and arsenic were the only constituents that exceeded clean-up goals in the post-excavation samples. Grid sections that were excavated were backfilled with the soil-compost. Samples were collected from each windrow of the remediated soil and analyzed for explosives only. Average concentrations of explosives in the remediated soil-compost were less than residential and/or industrial clean-up goals. The Interim Measures Report (IMR) for SWMU 12 evaluates the quality of the data for the bioremediation program in regard to analytical parameters such as blank contamination, duplicates, matrix spikes, etc. At least 10 percent of the data were validated.

The information on soil contamination conditions at MFA is detailed in the IMR (MK, 2000a) and the IMR Addendum #1 (Washington Group International, 2001).

The analytical results from the pre-excavation and post-excavation samples are provided in Appendices D, E, and H of the IMR and IMR Addendum #1. Appendix D provides a summary of the analytical results for all pre- and post- excavation samples and indicates samples in which clean-up criteria were exceeded. Appendix E provides the initial characterization results and Appendix F provides the post-excavation sample results. The process from initial characterization through backfilling of the bioremediated material can be followed graphically in Appendices C, G, and J of the IMR and IMR Addendum #1. Figures C1 through C6 present the results of the pre-excavation sampling by grid section compared to clean-up criteria. Figures G1 through G4 present the results of post-excavation samples by grid section compared to clean-up criteria. Figures J1 through J5 indicate the grid sections into which specific windrows at bioremediated material were deposited. Based on the information provided in the IMR and IMR Addendum #1, certain areas were excavated and others were not. The following paragraphs describe excavated and unexcavated soil concentration conditions at MFA after the implementation of the bioremediation program.

AREAS THAT WERE NOT EXCAVATED

- Soil concentrations in some grid sections were below residential and/or industrial clean-up levels. Therefore, excavation and remediation of these sections were not necessary. These grid sections are depicted in Figures 1-4 through 1-11 and in Appendices C and G of the IMR. They include the sections on the outer limits of the study areas that were used to delineate the horizontal extent of contamination.

- The soils in some grid sections exceeded clean-up levels but were not excavated for various reasons (e.g., the presence of utility or steam lines). This mainly applies to some grid sections around Buildings 153/154. Table 1-1 of this report and Table 3-2 of Addendum #1 to the IMR summarize these grid sections and provide the reasons why the soil in each grid was not excavated to clean-up levels. These grid sections are depicted (shaded red) in Figures 1-4, 1-6, 1-8 and 1-10. Chemical concentrations in these grid sections can be estimated by initial characterization or post-excavation data provided in Appendix E and Appendix H of the IMR and IMR Addendum #1.

AREAS THAT WERE EXCAVATED AND BACKFILLED WITH BIOREMEDIATED SOIL

- Soils in grid sections with contaminant concentrations exceeding clean-up levels were excavated and the excavated areas were then backfilled with material from the bioremediation facility. The concentrations of TNT, HMX, and RDX in the remediated soil were less than industrial clean-up levels and generally less than residential clean-up levels. The average concentrations of TNT, HMX, and RDX in the bioremediated soil are provided in Table 1-2, and the grids backfilled with the bioremediated soil are depicted in Figures 1-5, 1-7, 1-9, and 1-11. A more detailed description of the disposition of the treated compost soil is presented in the IMR and IMR Addendum #1.

Based on the information in the IMR and IMR Addendum #1, the following conditions exist around specific buildings in MFA:

- Building 151

Four grid sections around Building 151 were evaluated in the initial characterization of SWMU 12. Chemical concentrations in all grid sections were less than residential clean-up objectives; therefore, no excavation or remediation of soil around Building 151 was performed. The IMR recommended no further action (NFA) for the area around Building 151.

- Building 152

One grid section (72) near Building 152 (see Figure G3 of the IMR) was not excavated to clean-up objectives because a building foundation footer was encountered. The concentrations of RDX (40.3 mg/kg) and TNT (21.4 mg/kg) in the bottom of the excavation of this grid section exceeded industrial clean-up levels in a post-excavation sample. The soils were excavated to various depths (minimum of 3 feet and maximum of 19 feet) and were backfilled with bioremediated soil-compost.

Concentrations of explosives soils in the other grid sections around Building 152 meet residential and/or industrial clean-up levels. These sections either were not excavated because concentrations were less than clean-up levels or were backfilled with bioremediated soil-compost. The extent of contamination in surface soil around Buildings 152 appears to be well bounded by grid sections that meet clean-up levels. Therefore, all grid sections in and around the Building 152 study area are less than clean-up objectives or were remediated to clean-up objectives for surface soils. The IMR recommended NFA for the designated areas around Building 152.

- Buildings 153/154

Fourteen grid sections in the Building 153/154 study area (see Figure G1 of the IMR Addendum) did not meet the clean-up goals for reasons stipulated in Table 3-2 of the IMR Addendum. Twelve of these grid sections were excavated to various depths (minimum of 2 feet and maximum of 14 feet) before obstructions were encountered. The concentrations of explosives in these grid sections exceeded industrial clean-up levels in post-excavation samples located on the bottoms and sidewalls of the excavated grids. These grid sections were then backfilled with bioremediated soil, to the extent possible. For example, grid section 4 could only be excavated to a depth of 2 feet because of utility lines. The excavated portion (0 to 2 feet) of the grid was then backfilled with bioremediated soil which met cleanup goals. Therefore, surface soil in grid section 4 and most of the other 14 grids met industrial cleanup goals.

The only exceptions were grid sections 27 and 28 in which contaminated soil was left in place to support a steam line. Some portions of grid sections 27 and 28 were excavated and backfilled with bioremediated soil that met residential cleanup standards. The analytical results indicate that industrial clean-up levels have been met for surface soils in all grid sections except for grid sections 27 and 28. Contaminated soil in grids sections 27 and 28 was left in place to support a steam line. According to figures provided by TolTest in September 2001, grid sections 27 and 28 have been backfilled with bioremediated soil that meets residential clean-up standards. The bioremediated soil was placed on top of the native soil so that the concentrations in surface soil in these grid sections are less than target clean-up levels. Therefore, based on the information provided in the MFA IMR and IMR Addendum #1, it appears that the surface soil in the area around Buildings 153/154 is now bounded by soil in which the levels of HMX, RDX, and TNT meet residential or industrial clean-up objectives. The IMR and IMR Addendum #1 recommend NFA for the subject areas around Buildings 153/154.

- Building 157

Two grid sections (103 and 106) near Building 157 (see Figure G4 of the IMR) were not excavated to clean-up goals for reasons stipulated in Table 3-2 of the IMR Addendum. The concentrations of RDX in grid sections 103 and 106 exceeded industrial clean-up levels in post-excavation samples, 19.4 and 19.2 mg/kg, respectively. These soils were excavated and backfilled with bioremediated soil-compost.

Soil concentrations in the remaining grid sections were less than residential and/or industrial clean-up levels. These sections either were not excavated because concentrations were less than clean-up levels or were excavated and backfilled with bioremediated soil. The extent of contamination around Buildings 157 appears to be well bounded by grid sections that meet clean-up levels. Therefore, explosives concentrations in all grid sections in and around the Building 157 study area are less than clean-up objectives or were remediated to clean-up objectives. The IMR recommended NFA for the designated areas around this building.

- Buildings 158/159

Twelve grid sections in the eastern portion of the Building 158/159 study area (see Figure G2 of the IMR) were not excavated to clean-up goals for reasons stipulated in Table 3-2 of the IMR Addendum. The concentrations of explosives in these grid sections exceeded industrial clean-up levels in post-excavation samples located on the bottoms and sidewalls of the excavated grids. These soils were excavated to various depths (minimum of 2 feet and maximum of 14 feet) and backfilled with bioremediated soil.

Soils in grid sections north and west of the study area meet residential and/or industrial clean-up levels. These sections were either not excavated because concentrations were less than clean-up levels or were excavated and backfilled with bioremediated soil. The extent of contamination in surface soil around Buildings 158/159 appears to be well bounded by grid sections that meet clean-up levels. Therefore, all explosives concentrations grid sections in and around the Building 158/159 study area are less than clean-up objectives or were remediated to clean-up objectives for surface soils. The IMR recommended NFA for the designated areas around these buildings.

- Building 160

Five grid sections around Building 160 were evaluated in the initial characterization of SWMU 12. Chemical concentrations in four grid sections were less than residential clean-up objectives, and concentrations in the other grid section were less than industrial goals. Therefore, no excavation or

remediation of the soil around Building 160 was performed. The IMR recommended NFA for the area around Building 160.

BATTERY SITE INTERIM MEASURE

In October 2001 and June 2002, an interim measure action was conducted for the identification, removal, treatment, and/or disposal of contaminated soil from the SWMU 12 Battery Site. The Battery Site consists of two areas: (1) Battery Area – where batteries were dumped on the ground surface, and (2) Soil Area – an adjacent area where soil and construction debris was dumped in small mounds. The work was performed in conjunction with the requirements of the approved Final Interim Measures Work Plan for Mine Fill A Battery Site (Toltest, 2001). Prior to implementation of the interim measure action, pre-excavation soil samples were collected in February 2001. A report on the interim measure action was completed in December 2002 (Toltest, 2002).

Eleven pre-excavation samples were collected from the Soil Area (five samples) and from the Battery Area (six samples). Analysis of these samples indicated that contamination was present in both areas at concentrations greater than the industrial clean-up goals. Explosives contamination was present in the Soil Area, and metals contamination was present in the Battery Area.

Remedial actions in the Soil Area included excavating 18 tons of explosives-contaminated soil, treating it in compost windrow N-214 at the NSWC Crane Bioremediation Facility to less than residential clean-up levels, and subsequent backfilling of the treated soil at Mine Fill B. Post-excavation sampling and analysis of the Soil Area indicate that remaining contamination is below industrial cleanup goals. Based on the post-excavation analytical results, no further action was recommended for the Soil Area.

Remedial activities at the Battery Area included excavating 299 tons of metals-contaminated soil and disposing of it at the Waste Management Outer Loop Landfill in Louisville, Kentucky. Post-excavation sampling and analysis indicated that arsenic concentrations remaining in the area of excavation were greater than industrial clean-up goals in 15 sample locations. However, with the exception of one sample (CFS-013 at 16.7 mg/kg), arsenic concentrations in these samples were less than the maximum detection of 10.2 mg/kg in the Basewide Background Soil Investigation Report (TtNUS, 2001). The average concentration of the 19 Battery Area post-excavation samples (5.6 mg/kg) is less than the average of all results and the average of all positive detections (6.1 mg/kg) from the Basewide Background Soil Investigation Report.

Post-excavation sampling at 19 locations in the Battery Area indicated that the level of cadmium in one sample (CFS-021) was greater than residential clean-up goals but less than industrial clean-up goals, and that lead concentrations were greater than industrial clean-up goals. Analysis of these two metals performed on a leached extract indicated that cadmium did not exceed the toxic characteristic leaching procedure (TLCP) regulatory level but that lead did exceed the TLCP regulatory limit. Post-interim measure recommendations included further investigation of the lead contamination at the SWMU 12 Battery Area including expansion of the investigation area and additional sampling

In 2004, a follow-up interim measure action was performed at the Soil Area. The action was performed pursuant to the requirements of the approved Final Interim Measures Work Plan for Mine Fill A Battery Site (Toltest, 2001). Three pre-excavation samples (PES-013, PES-014, and PES-015) were collected on May 24, 2004. One sample (PES-013) was collected from the same location (base of the slope of the Soil Area) that confirmation sample CFS-021 was collected in 2002. In CFS-021, lead was detected at 58.8 mg/kg, which exceeded the regulatory limit for toxicity. The analytical results for all three pre-excavation samples indicated that arsenic were at concentrations greater than the United States Environmental Protection Agency (U.S. EPA) Region 9 Preliminary Remedial Goal (PRG) industrial Soil Screening Level (SSL). Cadmium concentrations were greater than the residential SSL but less than industrial SSL. Lead was detected in all three samples at concentrations greater than the industrial SSL and also at a level that could potentially exhibit toxic characteristics.

In September 2004, excavation activities commenced by removing small trees and boulders. Overburden soil and rock were removed from above the seam of contamination and placed to the side, which was followed by excavation of the vein of contamination. Excavation of the vein was started at the northern end of the slope and proceeded to the south. Excavation continued until about 20 tons of contaminated soil had been loaded into the dump trailer. The contaminated soil was then taken the Environmental Quality Company for disposal. The vein of contaminated soil was still visible in a trench on the southern end of the slope. The aerial extent of this contamination was not determined.

Four post-excavation soil samples were collected at depths of 0 to 2 feet below ground surface (bgs) and analyzed for metals, VOCs, SVOCs, herbicides, and explosive compounds. One sample was obtained from the vein of contamination in the trench that was dug at the southern end of the area of excavation. The analytical results (TtNUS, 2004b) indicated that the southern most soil sample (12SS210002) had the highest concentrations of most energetic and inorganic contaminants. Soil sample 12SS21002 was the only sample of the four that had detectable concentrations of the energetics RDX (6.1 mg/kg), HMX (1.7 mg/kg), and 1,3,5-trinitrobenzene (0.84 mg/kg). This same sample had a lead result of 429,000 mg/kg. The other three soil samples ranged from 366 to 3,230 mg/kg for lead. The antimony

concentration was notably higher (3,610 mg/kg) at sample 12SS210002 in comparison to the other three samples which ranged from 11.4 to 213 mg/kg. The mercury concentration of 0.31 mg/kg at 12SS210002 was higher in comparison to the other three locations, which had concentrations ranging from 0.034 to 0.069 mg/kg. The tin concentration at 12SS210002 was 838 mg/kg, while concentrations at the other three locations ranged from 12.4 to 90.7 mg/kg.

Post-excavation sampling confirmed that contaminated soil is still present at the site. Results indicated that concentrations of antimony and lead in two samples, 12SB21 and 12SB23, exceeded industrial clean-up goals. The level of arsenic in all four samples exceeded the industrial clean-up goal. Toltest recommended that additional exploration trenches be dug in an attempt to determine the horizontal extent of the vein.

1.3 REPORT ORGANIZATION

This report was prepared in the following format, standard for an RFI Report. Section 1.0 of the report is the introduction, including the purpose, site background, site description, site history, previous investigations, and report organization. Section 2.0 describes the study area field sampling activities and procedures associated with data collection. Section 3.0 discusses data presentation and data quality review. Section 4.0 describes the physical characteristics of SWMU 12. Section 5.0 presents an evaluation of the nature and extent of contamination detected at SWMU 12 in this field investigation. Section 6.0 presents a discussion on the fate and transport of the contaminants and the conceptual site model. Section 7.0 identifies the chemicals of concern (COCs) and presents the results of the HHRA. Section 8.0 presents the results of the SERA.

Supporting documentation for this report is attached as Appendices A through G. The information included in each appendix is as follows:

- Appendix A - Field Investigation Photos and Survey Locations
- Appendix B - Boring Logs, Monitoring Well Construction Logs, and Related Materials
- Appendix C - Field Log Sheets
- Appendix D - Field Documentation (Log Books)
- Appendix E - Slug Test Data
- Appendix F - Health and Safety Forms
- Appendix G - Laboratory Data
- Appendix H - Data Quality Review Results

- Appendix I - Human Health Risk Assessment Calculations
- Appendix J - Supporting Materials for the Ecological Risk Assessment

TABLE 1-1

SUMMARY OF GRIDS NOT EXCAVATED TO CLEAN-UP GOALS
SWMU 12 - MINE FILL A
NSWC CRANE, CRANE, INDIANA

Grid Section[1]	Building	Approximate Depth of Excavation	Reason Soil Not Excavated to Clean-up Goals
2	153/154	14 feet	Encountered blast wall footer
3	153/154	14 feet	Encountered blast wall footer
4	153/154	2 feet	Encountered utility lines
5	153/154	2 feet	Encountered bedrock
10	158/159	14 feet	Encountered blast wall footer
11	158/159	14 feet	Encountered blast wall footer
12	158/159	2 feet	Encountered utility lines
17	153/154	2 feet	Railroad track prevented further soil removal
27	153/154	14 feet 0 feet (under supports)	Soil left in place was structural support for a steam line
28	153/154	14 feet 0 feet (under supports)	Soil left in place was structural support for a steam line
56	158/159	14 feet 0 feet (under supports)	Soil left in place was structural support for a steam line
58	158/159	14 feet 0 feet (under supports)	Soil left in place was structural support for a steam line
59	158/159	2 feet	Encountered utility lines
62	158/159	14 feet	Encountered blast wall footer
63	158/159	2 feet	Encountered utility lines
64	158/159	14 feet	Encountered blast wall footer
65	158/159	14 feet	Encountered blast wall footer
72	152	19 feet	Encountered footer
103	157	10 feet	Soil was excavated to a depth of 10 feet; excavation ceased per direction from NSWC Crane ECOTR
106	157	19 feet (near blast wall) 2 feet (in flat area)	Encountered overhead conveyor footers
126	153/154	2 feet	Encountered lightning mast footers
127	153/154	14 feet	Encountered blast wall footer
128	153/154	2 feet	Encountered lightning mast footers
134	153/154	2 feet	Encountered utility lines
149	158/159	2 feet	Encountered utility lines
150	158/159	2 feet	Encountered utility lines
200	153/154	2 feet	Encountered bedrock
202	153/154	2 feet	Encountered bedrock
203	153/154	2 feet	Encountered bedrock

Adapted from Table 3-2 of Addendum #1 to the IMR (Washington Group International, 2001, Interim Measures Report Removal and Bioremediation of Mine Fill A Material, Addendum #1, NSWC Crane, Crane, Indiana, January)
1 - Grid sections are shown in Figures 1-4 through 1-11.
ECOTR = Environmental Contracting Officer Technical Representative

TABLE 1-2

AVERAGE RESULTS FROM EXPLOSIVE CONTAMINANT MONITORING
RESULTS FOR BIOREMEDIATED SOIL
SWMU 12 - MINE FILL A
NSWC CRANE, CRANE, INDIANA

Windrow	HMX (mgkg)	RDX (mgkg)	TNT (mgkg)
1	2.1	1.0	0.4
2	2.3	1.4	0.3
3	2.2	1.1	0.3
4	2.1	1.0	0.4
5	2.2	1.1	0.3
6	2.2	1.0	0.3
7	2.2	1.0	0.3
8	2.2	1.1	0.3
9	2.2	1.8	0.5
10	2.2	1.0	0.3
11	2.1	1.0	0.3
12	4.9	1.6	0.4
13	2.8	1.4	1.3
14	2.2	1.0	0.3
15	1.9	1.1	0.3
16	2.0	1.2	0.2
17	1.9	1.1	0.3
18	2.3	1.1	0.3
19	2.4	1.7	0.2
20	3.3	1.6	0.3
21	2.6	2.5	0.5
22	2.1	2.3	0.3
23	4.5	3.3	0.3
24	2.6	2.0	0.4
25	2.5	3.0	0.2
26	2.4	2.3	1.0
27	1.9	1.7	0.4
28	2.8	5.9	1.5
29	2.7	2.0	1.5
30	2.1	4.9	0.3
31	2.2	3.7	0.3
32	1.7	3.0	0.2
33	2.0	2.8	0.7
34	3.1	3.2	1.5
35	3.7	6.2	0.5
36	2.8	4.2	0.3
37	2.8	6.8	0.5
38	3.8	7.2	11.0
39	5.2	13.1	1.2
40	5.8	5.2	1.1
41	5.5	8.9	0.3
42	7.1	13.9	0.4

TABLE 1-2

AVERAGE RESULTS FROM EXPLOSIVE CONTAMINANT MONITORING
RESULTS FOR BIOREMEDIATED SOIL
SWMU 12 - MINE FILL A
NSWC CRANE, CRANE, INDIANA

Windrow	HMX (mgkg)	RDX (mgkg)	TNT (mgkg)
43	2.9	8.3	0.3
44	4.7	7.2	0.3
45	3.4	4.4	0.3
46	2.8	2.9	0.3
47	2.1	1.5	0.3
48	2.4	2.1	0.3
49	2.0	1.4	0.3
50	2.6	2.8	0.3
51	2.1	1.2	0.2
52	2.9	2.0	0.3
53	3.0	6.7	5.8
54	2.1	1.1	0.2
55	2.1	1.4	0.3
56	1.9	2.2	0.2
57	2.2	2.1	4.6
58	2.1	1.0	0.3
59	2.0	2.8	0.4
60	2.0	4.9	0.4
61	2.1	3.6	4.5
62	2.2	6.3	0.7
63	2.2	3.5	0.4
64	2.6	12.4	1.8
65	2.0	5.3	1.3
66	2.1	1.9	0.3
67	2.1	4.2	0.8
68	2.2	3.0	3.6
69	2.2	6.8	2.2
70	2.1	3.0	0.4
71	2.2	1.0	22.7
72	2.1	1.7	0.2
73	2.0	2.4	5.9
74	1.9	1.5	0.4
75	2.0	3.5	0.2
76	1.8	4.3	0.3
77	3.7	7.9	0.4
78	3.9	8.0	0.5
79	2.5	4.0	0.2
80	2.2	3.3	0.5
81	2.1	1.8	0.2
82	2.6	1.8	0.2
83	1.7	2.4	0.5
84	2.5	1.8	0.2
85	2.3	2.3	0.4

TABLE 1-2

AVERAGE RESULTS FROM EXPLOSIVE CONTAMINANT MONITORING RESULTS FOR BIOREMEDIATED SOIL
SWMU 12 - MINE FILL A
NSWC CRANE, CRANE, INDIANA

Windrow	HMX (mgkg)	RDX (mgkg)	TNT (mgkg)
86	1.9	1.4	0.2
87	2.3	2.1	0.2
88	2.6	2.3	0.2
89	2.2	1.7	0.7
90	2.4	3.5	0.2
91	2.4	1.1	0.3
92	0.55	0.64	0.47
93	0.46	0.41	0.48
94	2.8	1.9	0.2
95	2.1	1.3	0.2
96	2.8	1.3	0.2
97	0.9	2.8	1.9
98	0.42	0.6	0.48
99	1.1	0.5	0.3
100	1.6	1.9	0.2
101	0.63	1.06	0.48
102	0.74	1.92	0.4
192	0.34	0.95	0.47
194	0.45	0.6	0.56
195	0.46	0.43	0.48
197	0.26	0.24	0.48
198	0.54	1.08	0.43
198	0.54	1.08	0.43

1. Data in this table were obtained from Table 4-4 of the IMR (MK, 1999) and from Table 4-3 of Addendum #1 to the IMR (TolTest, 2005) .

TABLE 1-3

INVESTIGATION SUMMARY FOR SWMU 12 BUILDINGS AND STRUCTURES
NSWC CRANE
CRANE, INDIANA

Building Number/Structure ID	Historical Investigations	RFI Investigation	Comments
151	1992 Environmental Monitoring Reports and Interim Measures soil sampling subsequent to bioremediation activities.	None	IMR recommended NFA
152	1992 Environmental Monitoring Reports and Interim Measures soil sampling subsequent to bioremediation activities.	Soil samples collected at the base of the hill on all sides of the building.	Not all contaminated soils removed for various reasons. IMR recommended NFA for designated areas around the building.
153	1992 Environmental Monitoring Reports and Interim Measures soil sampling subsequent to bioremediation activities.	Sump and sediment samples collected within the two sumps northwest of Building 153 (directly west of Building 3038). Soil samples collected on both sides of tramway east of the building.	Not all contaminated soils removed for various reasons. IMR recommended NFA for designated areas around the building.
154	1992 Environmental Monitoring Reports and Interim Measures soil sampling subsequent to bioremediation activities.	Sump and sediment samples collected within the two sumps southwest of Building 154 (directly west of Building 2195).	
157	1992 Environmental Monitoring Reports and Interim Measures soil sampling subsequent to bioremediation activities.	Sump and sediment samples collected within the sump north of Building 157. Soil samples collected at the base of the hill on north, south, and west sides of the building.	Not all contaminated soils removed for various reasons. IMR recommended NFA for designated areas around the building.

TABLE 1-3

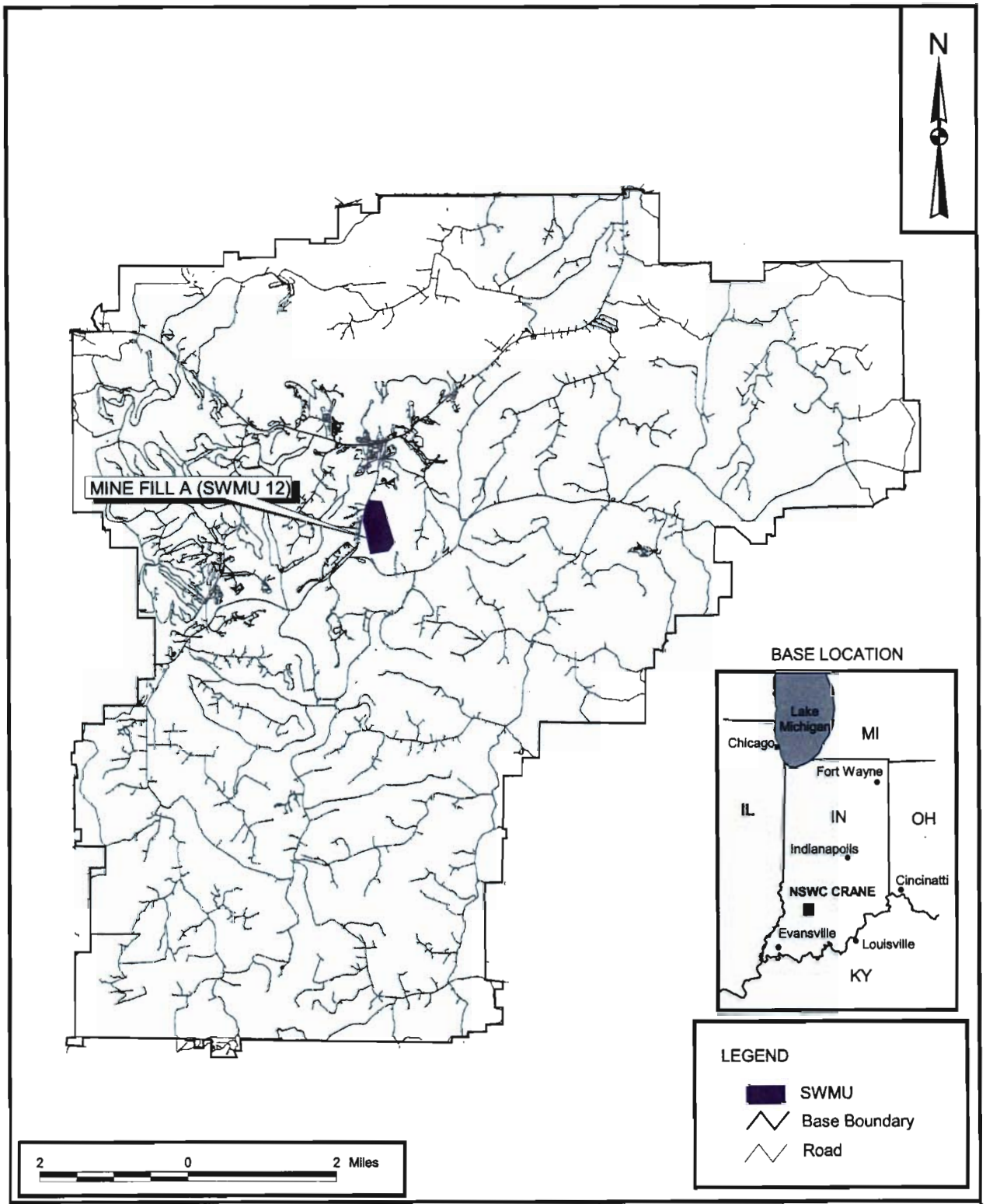
INVESTIGATION SUMMARY FOR SWMU 12 BUILDINGS AND STRUCTURES
NSWC CRANE
CRANE, INDIANA

Building Number/Structure ID	Historical Investigations	RFI Investigation	Comments
158	1992 Environmental Monitoring Reports and Interim Measures soil sampling subsequent to bioremediation activities.	Sump and sediment samples collected within the two sumps southwest of Building 158 (directly west of Building 3039). Soil samples collected on both sides of tramway east of the building.	Not all contaminated soils removed for various reasons. IMR recommended NFA for designated areas around the building.
159	1992 Environmental Monitoring Reports and Interim Measures soil sampling subsequent to bioremediation activities.	Sump and sediment samples collected within the two sumps northwest of Building 159 (directly west of Building 2193).	
160	1992 Environmental Monitoring Reports and Interim Measures soil sampling subsequent to bioremediation activities.	None	IMR recommended NFA
155	None	None	
155D	None	None	
155E	None	None	
156	None	None	
195	None	None	
197	None	None	
2193	None	None	
2195	None	None	
2512	None	Soil sample collected on east side of building in Feb, 2006.	RFI recommended a CMS.
2531	None	None	
2714	None	None	
2715	None	None	
2771	None	None	

TABLE 1-3

INVESTIGATION SUMMARY FOR SWMU 12 BUILDINGS AND STRUCTURES
NSWC CRANE
CRANE, INDIANA

Building Number/Structure ID	Historical Investigations	RFI Investigation	Comments
2792	None	Sump and sediment samples collected within lift station south of Building 2792 (directly east of Building 3039) in Feb, 2006. Soil samples collected on both sides of tramway north of building in Feb, 2006.	RFI recommended a CMS.
2793	None	Sump and sediment samples collected within lift station northwest of Building 2793 in Feb, 2006.	RFI recommended a CMS.
2794	None	Soil samples collected on north, south, and west sides of the building in Feb, 2006.	RFI recommended a CMS.
2950	None	None	
3036	None	None	
3037	None	RFI Soil samples collected around 3037 in Aug, 2004	RFI recommended a CMS.
3038	None	None	
3039	None	None	
3110	None	RFI Soil samples collected east of 3111/3167 and north of 3110 in Aug. 2004	RFI recommended a CMS.
3111/3167	None		



DRAWN BY K. PEILA — DATE 5/31/05	Tetra Tech NUS, Inc.	CONTRACT NUMBER 6878	OWNER NO. —
CHECKED BY J. LUCAS — DATE 5/31/05	SITE LOCATION MAP SWMU 12 MINE FILL A NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — DATE —	
COST/SCHEDULE-AREA		APPROVED BY — DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 1 - 1	REV 0

P:\GIS\CRANE_NSWC\MAPDOCS\APR\CRANE_REPORTFIGURES.APR SITE LOCATIONS 8/8/05 KMP

LEGEND

Installation Boundary

Major Surface Drainage Basins

I Furst Creek Drainage Basin

II Indian Creek Drainage Basin

III Sulphur Creek Complex Drainage Basin

IV Boggs & Turkey Creeks Drainage Basin

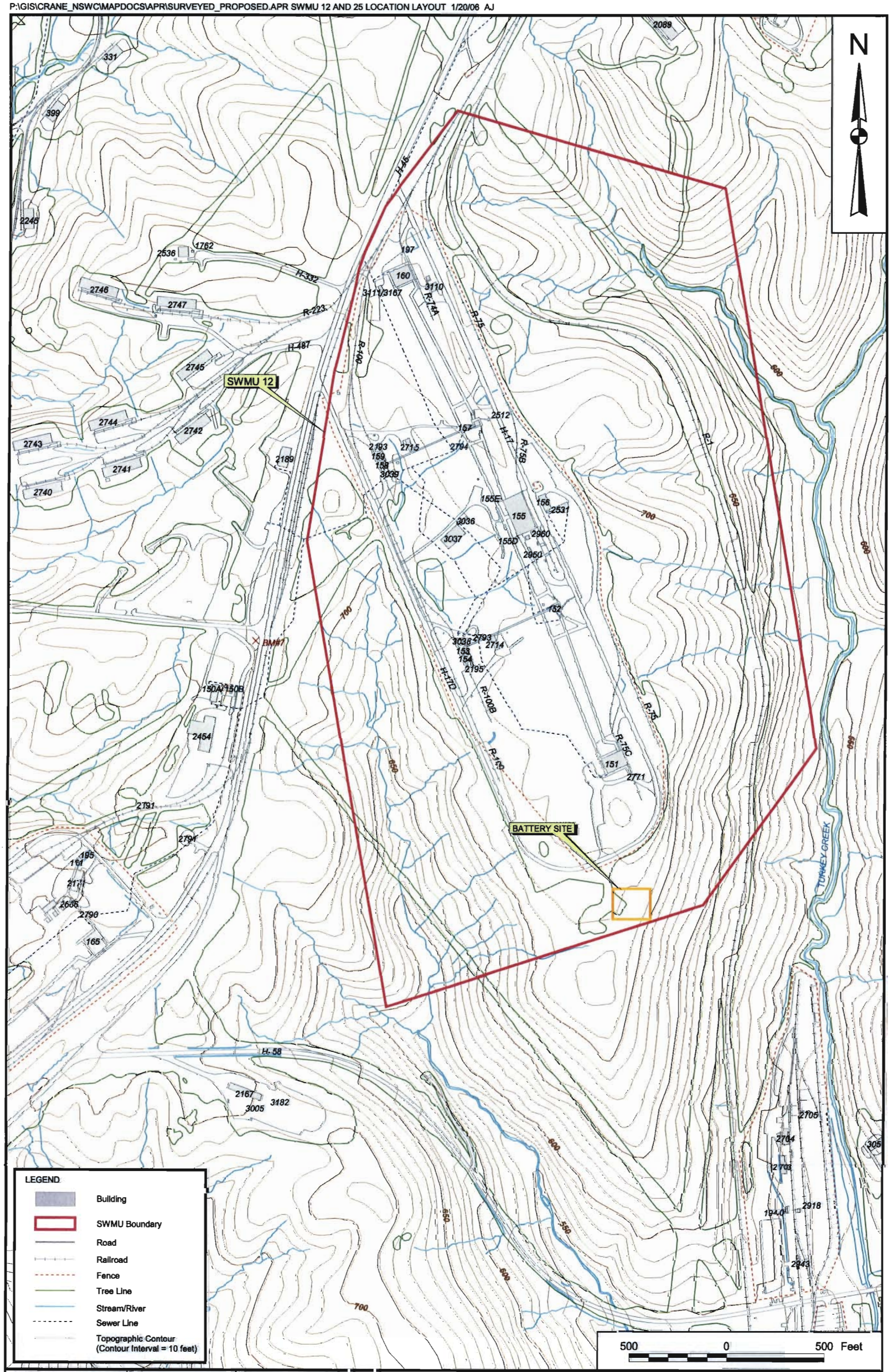
V Seed Tick Creek Drainage Basin

SOURCE: "Initial Assessment of Study of Naval Weapons Support Center Crane, Indiana." Naval Energy and Environmental Support Activity, May 1983.

DRAWN BY K. PEILA DATE 5/31/05	Tetra Tech NUS, Inc.	CONTRACT NUMBER 6878	OWNER NO. —
CHECKED BY J. LUCAS DATE 5/31/05	LOCATION OF SWMU 12 NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — DATE —	
COST/SCHEDULE-AREA		APPROVED BY — DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 1 - 2	REV 0

P:\GIS\CRANE_NSWC\MAPDOCS\APR\CRANE_REPORTFIGURES.APR DRAINAGE BASINS 10/12/05 KMP

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SURVEYED_PROPOSED.APR SWMU 12 AND 25 LOCATION LAYOUT 1/20/06 AJ



DRAWN BY K. PEILA	DATE 5/31/05	SITE FEATURES SWMU 12 - MINE FILL A NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS	DATE 1/20/06		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 1 - 3 / REV 0

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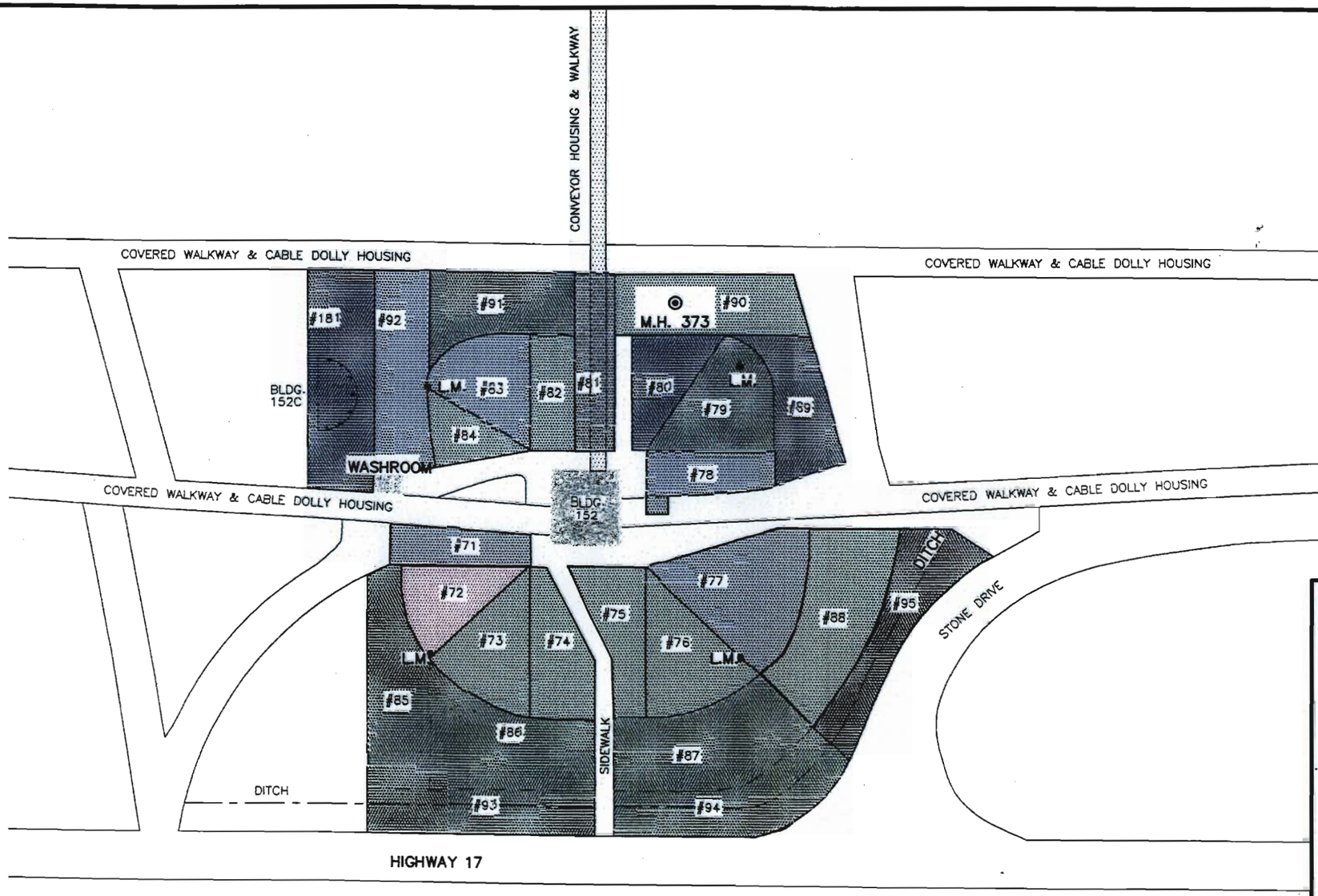
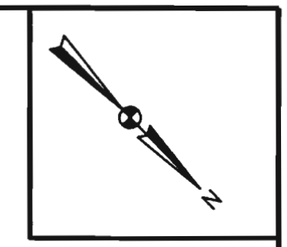




LEGEND:

- MEETS RESIDENTIAL CLEAN-UP GOALS
- MEETS INDUSTRIAL CLEAN-UP GOALS
- EXCEEDS INDUSTRIAL CLEAN-UP GOALS
- M.H. — MANHOLE
- L.M. — LIGHTING MAST

NOTE:

THIS FIGURE IS ADAPTED FROM FIGURE C3 OF THE IMR (MK, 2000a). THE CROSS HATCHING SHOWN IN THE FIGURE IS NOT RELEVANT TO THIS REPORT.

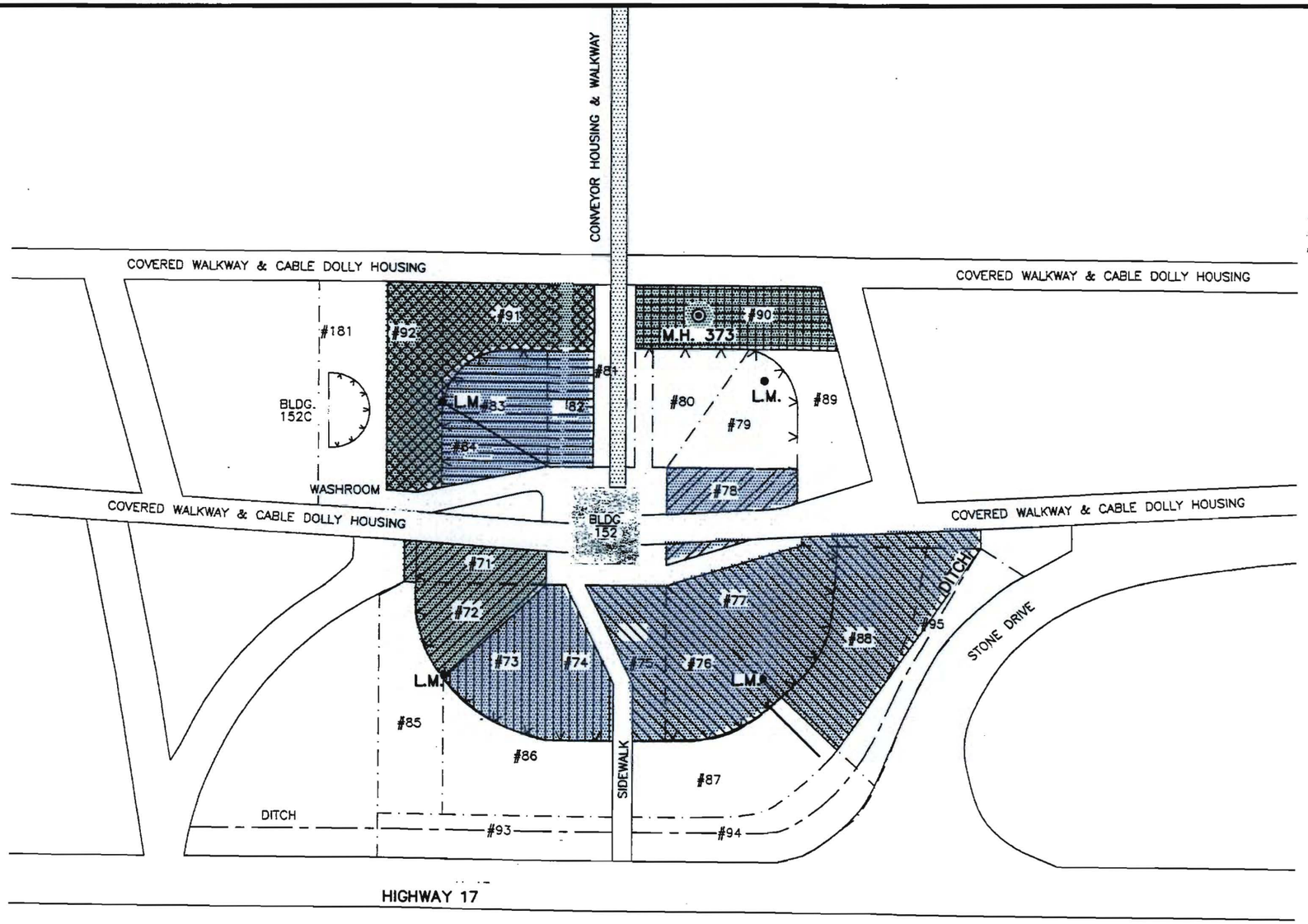
0 40 80

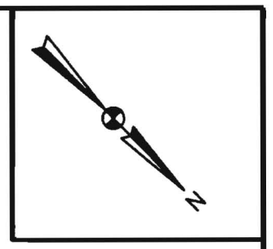
GRAPHIC SCALE IN FEET

DRAWN BY DM	DATE 2/5/05	INTERIM MEASURE POST-EXCAVATION SAMPLING GRID LOCATION MAP BUILDING 152, MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NO. 6878
CHECKED BY	DATE		OWNER NO. 0000
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 1-4 / REV. 0

FORM CADD NO. SDIV-BH.DWG - REV 1 - 9/10/98

ACAD: 6878GM04.dwg 06/03/05 HJB PIT





LEGEND:

- AVERAGE WINDROW CONCENTRATION MEETS RESIDENTIAL CLEAN-UP GOALS
- AVERAGE WINDROW CONCENTRATION MEETS INDUSTRIAL CLEAN-UP GOALS
- NOT EXCAVATED MEETS CLEAN-UP GOALS
- M.H. MANHOLE
- L.M. LIGHTING MAST

NOTE:

THIS FIGURE IS ADAPTED FROM FIGURE J3 OF THE IMR (MK, 2000a). THE CROSS HATCHING SHOWN IN THE FIGURE IS NOT RELEVANT TO THIS REPORT.

0 40 80

GRAPHIC SCALE IN FEET

DRAWN BY DM	DATE 2/5/05	INTERIM MEASURE GRIDS BACKFILLED WITH BIOREMEDIATED SOIL BUILDINGS 152, MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NO. 6878
CHECKED BY	DATE		OWNER NO. 0000
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 1-5 / REV. 0

FORM CADD NEL SDIV-BH.DWG - REV 1 - 9/10/98

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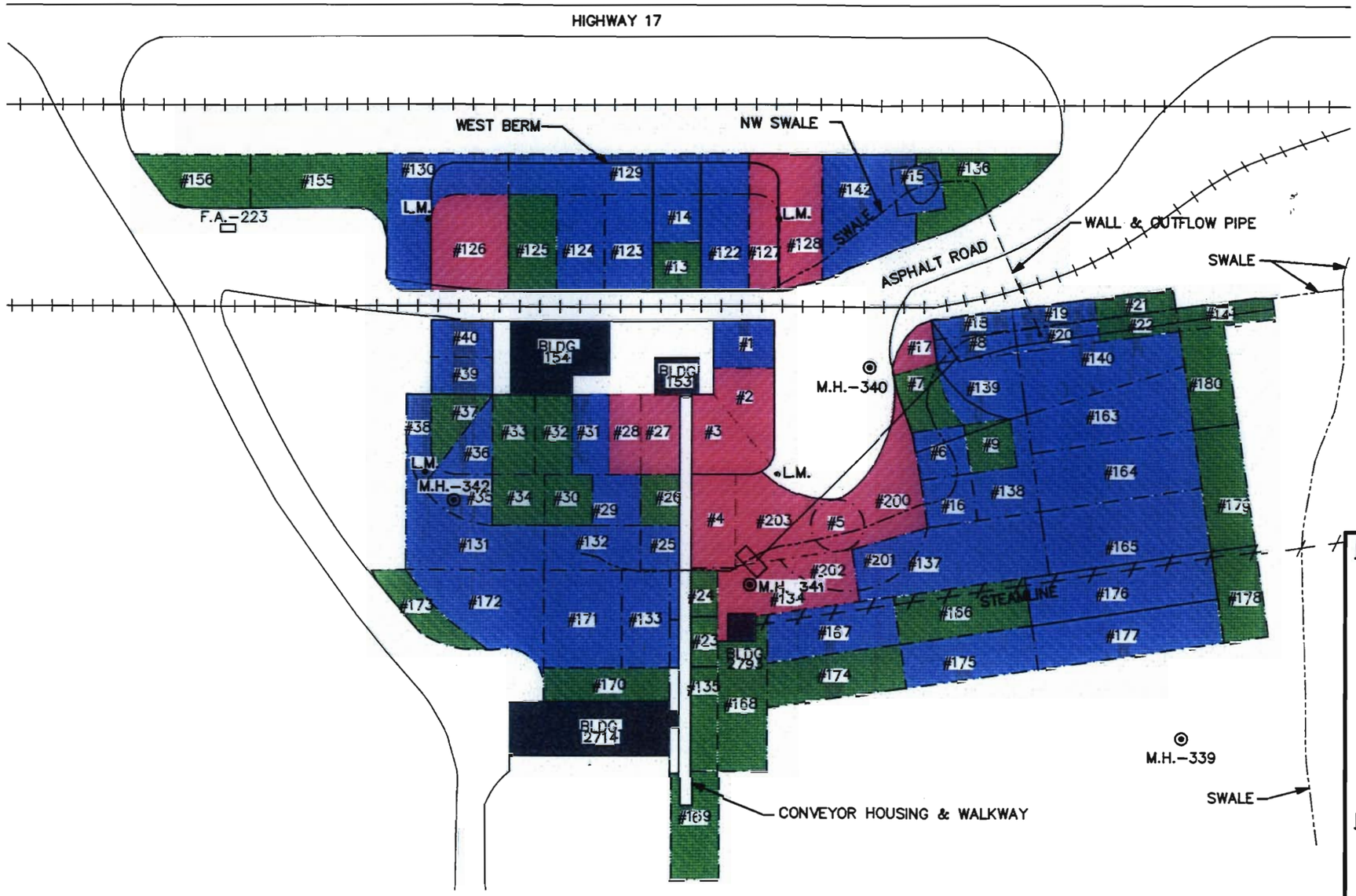

LEGEND:

- MEETS RESIDENTIAL CLEAN-UP GOALS
- MEETS INDUSTRIAL CLEAN-UP GOALS
- EXCEEDS INDUSTRIAL CLEAN-UP GOALS
- M.H. — MANHOLE
- L.M. — LIGHTING MAST
- RAILROAD TRACKS

NOTE:

THIS FIGURE IS ADAPTED FROM FIGURE G1 OF THE IMR (MK, 2000a).

0 50 100

GRAPHIC SCALE IN FEET

DRAWN BY DM	DATE 2/1/05	INTERIM MEASURE POST-EXCAVATION SAMPLING GRID LOCATION MAP BUILDINGS 153/154, MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NO. 6878
CHECKED BY	DATE		OWNER NO. 0000
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 1-6 / REV. 0

FORM CADD NCL SDIV-BHLDWG - REV 1 - 9/10/98

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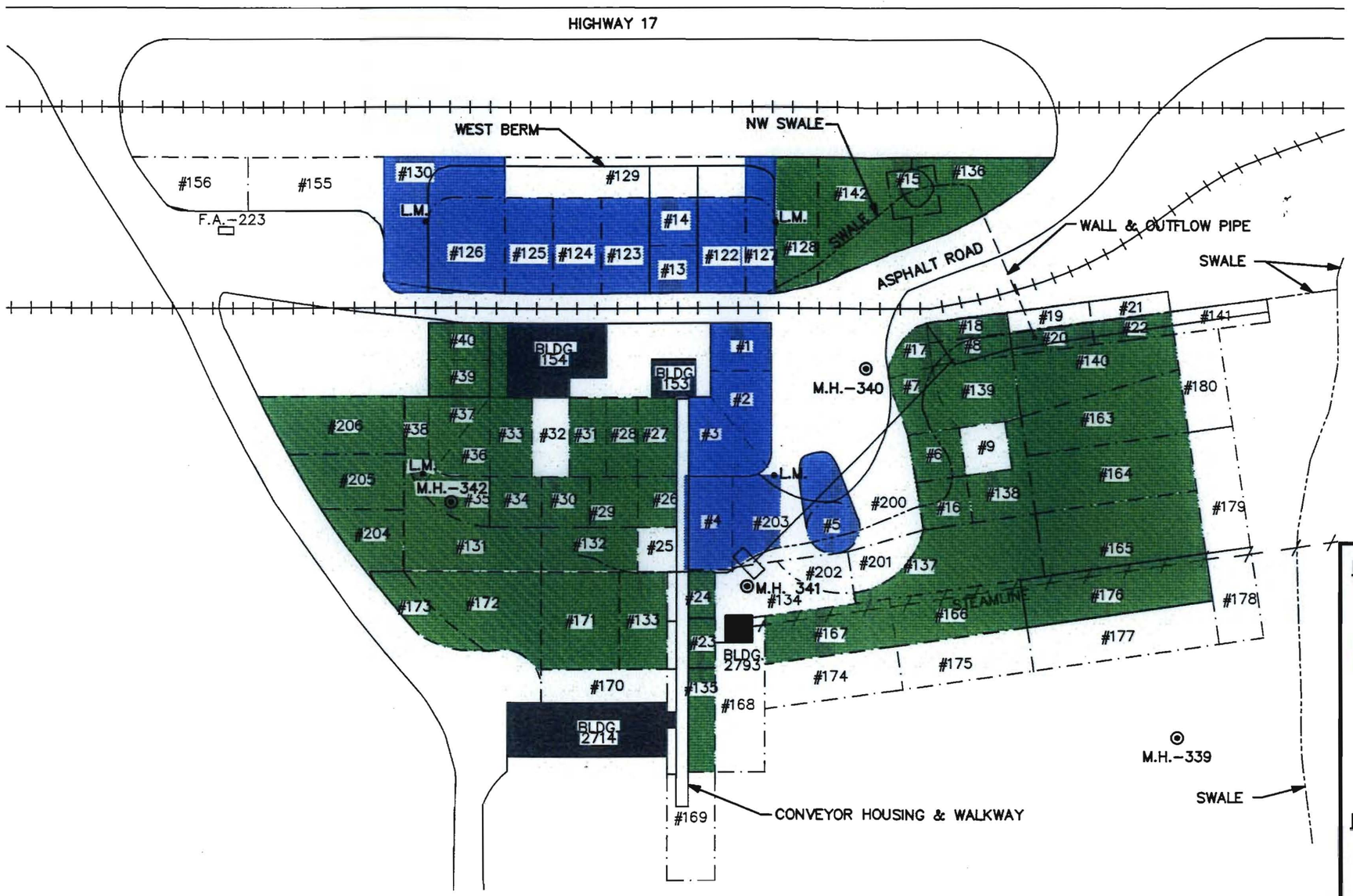

LEGEND:

- AVERAGE WINDROW CONCENTRATION MEETS RESIDENTIAL CLEAN-UP GOALS
- AVERAGE WINDROW CONCENTRATION MEETS INDUSTRIAL CLEAN-UP GOALS
- NOT EXCAVATED MEETS CLEAN-UP GOALS
- M.H. — MANHOLE
- L.M. — LIGHTING MAST

NOTE:

THIS FIGURE IS ADAPTED FROM FIGURE C1 OF THE IMR (MK, 2000a).

0 50 100

GRAPHIC SCALE IN FEET

DRAWN BY DM	DATE 2/3/05	INTERIM MEASURE GRIDS BACKFILLED WITH BIOREMEDIATED SOIL BUILDINGS 153/154, MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NO. 6878
CHECKED BY	DATE		OWNER NO. 0000
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 1-7 / REV. 0

FORM CADD NO. SDIV-BH.DWG - REV 1 - 9/10/98

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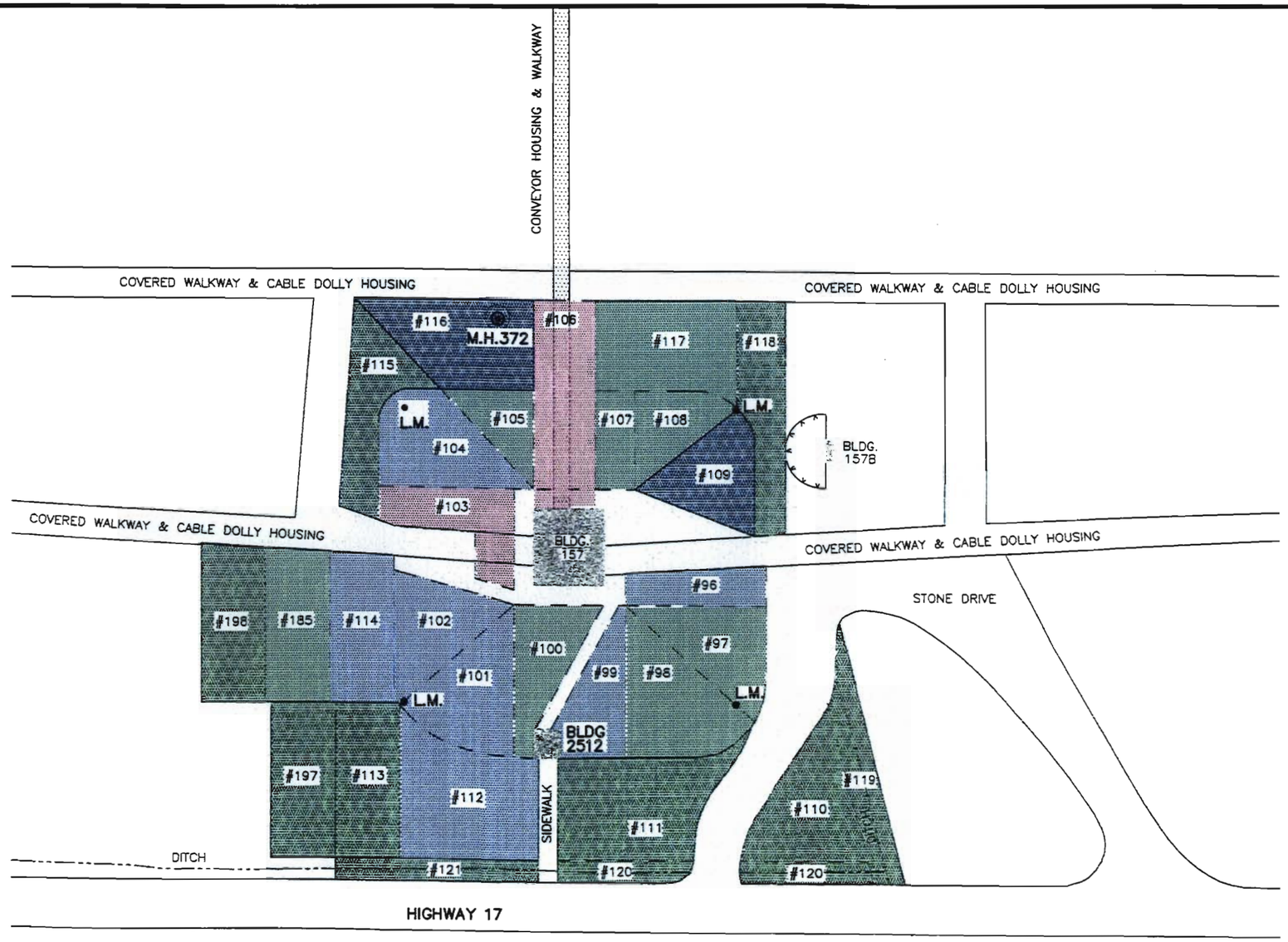


N

LEGEND:

- MEETS RESIDENTIAL CLEAN-UP GOALS
- MEETS INDUSTRIAL CLEAN-UP GOALS
- EXCEEDS INDUSTRIAL CLEAN-UP GOALS
- M.H. MANHOLE
- L.M. LIGHTING MAST

NOTE:

THIS FIGURE IS ADAPTED FROM FIGURE G4 OF THE IMR (MK, 2000a). THE CROSS HATCHING SHOWN IN THE FIGURE IS NOT RELEVANT TO THIS REPORT.

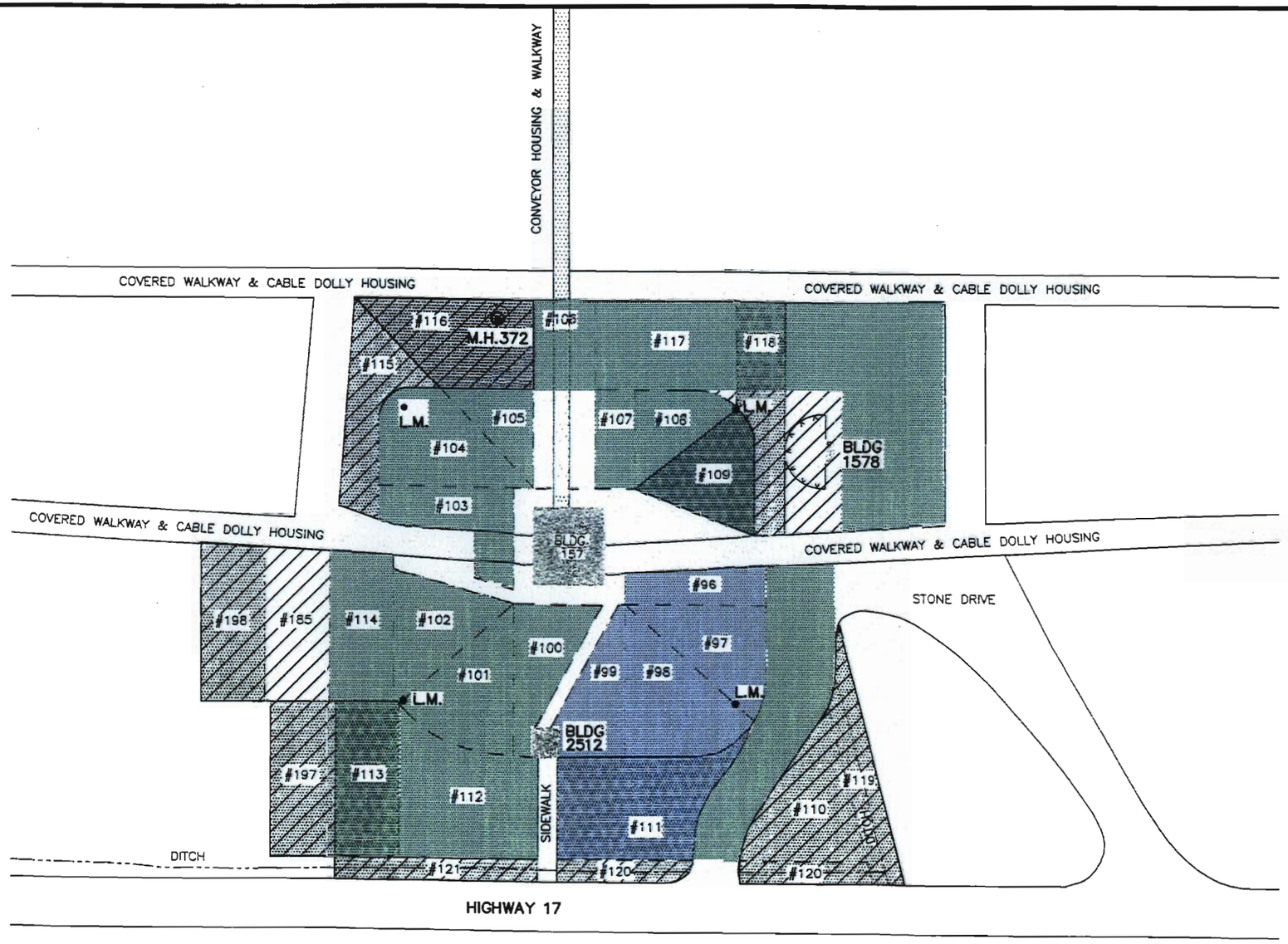
0 40 80

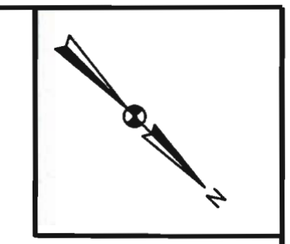
GRAPHIC SCALE IN FEET

DRAWN BY DM	DATE 2/5/05	INTERIM MEASURE POST-EXCAVATION SAMPLING GRID LOCATION MAP BUILDING 157, MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NO. 6878
CHECKED BY	DATE		OWNER NO. 0000
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 1-8 / REV. 0

FORM CADD NO. SDIV-BH.DWG - REV 1 - 9/10/98

ACAD: 6878GM03.dwg 08/03/05 HJB PIT





LEGEND:

- AVERAGE WINDROW CONCENTRATION MEETS RESIDENTIAL CLEAN-UP GOALS
- AVERAGE WINDROW CONCENTRATION MEETS INDUSTRIAL CLEAN-UP GOALS
- NOT EXCAVATED MEETS CLEAN-UP GOALS
- M.H. — MANHOLE
- L.M. — LIGHTING MAST

NOTE:

THIS FIGURE IS ADAPTED FROM FIGURE C4 OF THE IMR (MK, 2000a).

0 40 80
GRAPHIC SCALE IN FEET

DRAWN BY DM	DATE 5/13/05	INTERIM MEASURE GRIDS BACKFILLED WITH BIOREMEDIATED SOIL BUILDING 157, MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NO. 6878
CHECKED BY	DATE		OWNER NO. 0000
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 1-9 / REV. 0

FORM CADD NO. SDIV-BH.DWG - REV 1 - 9/10/98

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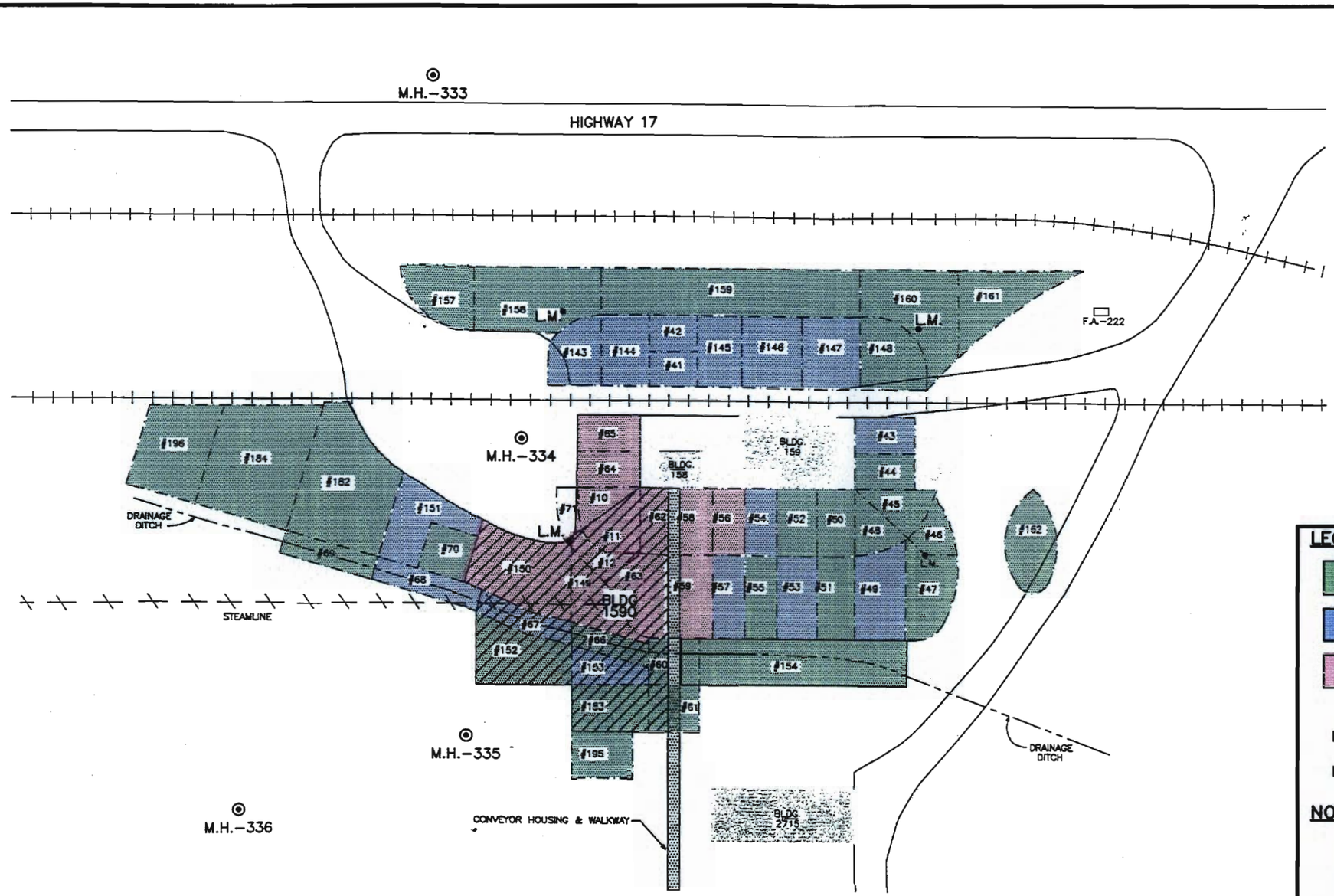


LEGEND:

- MEETS RESIDENTIAL CLEAN-UP GOALS
- MEETS INDUSTRIAL CLEAN-UP GOALS
- EXCEEDS INDUSTRIAL CLEAN-UP GOALS
- M.H. — MANHOLE
- L.M. — LIGHTING MAST

NOTE:

THIS FIGURE IS ADAPTED FROM FIGURE G2 OF THE IMR (MK, 2000a). THE CROSS HATCHING SHOWN IN THE FIGURE IS NOT RELEVANT TO THIS REPORT.

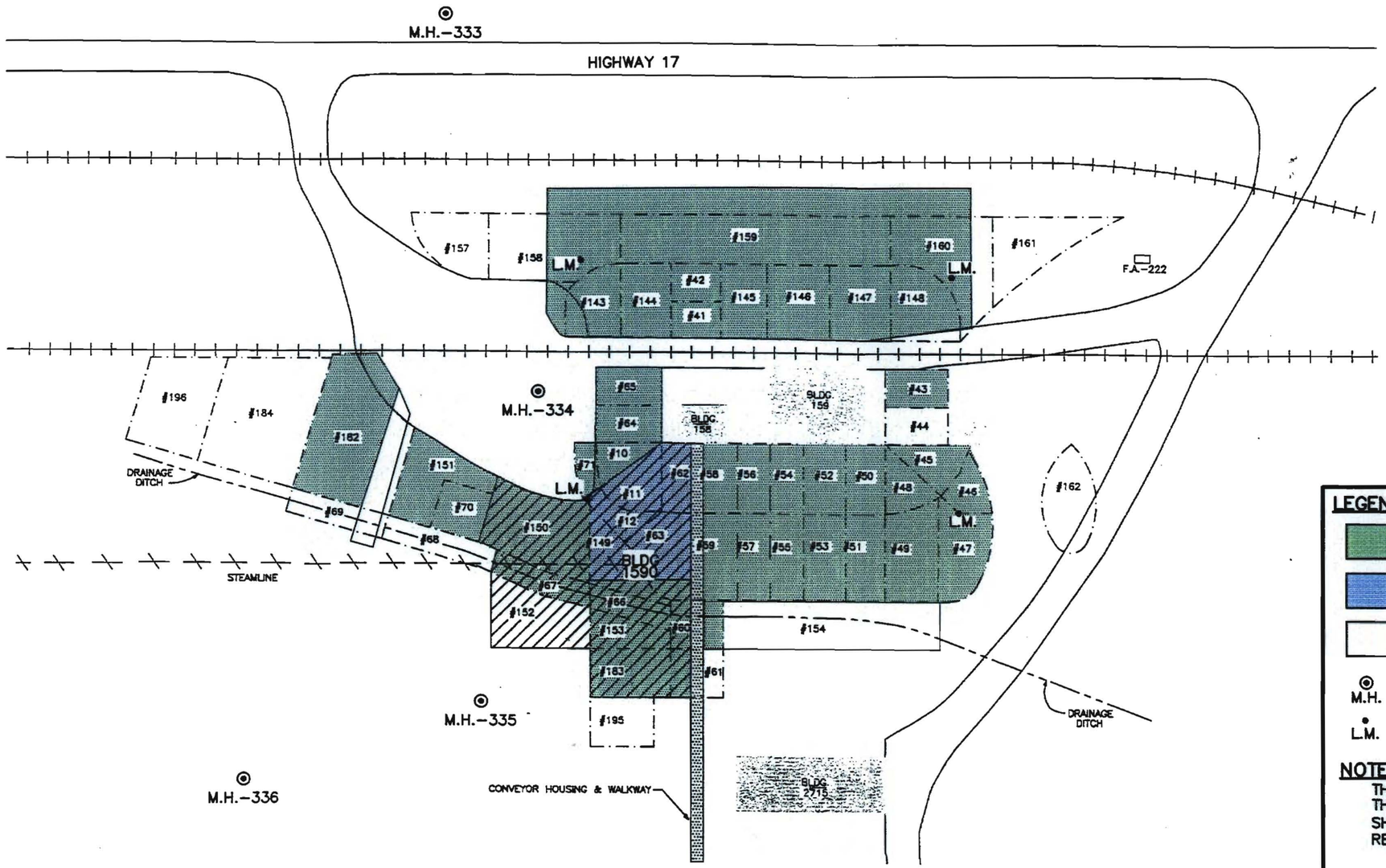
0 50 100

GRAPHIC SCALE IN FEET

DRAWN BY DM	DATE 2/5/05	INTERIM MEASURE POST-EXCAVATION SAMPLING GRID LOCATION MAP BUILDING 158/159, MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NO. 6878
CHECKED BY	DATE		OWNER NO. 0000
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 1-10 / REV. 0

FORM CADD NO. SDIV-BH.DWG - REV 1 - 9/10/98

ACAD: 6878GM06.dwg 06/03/05 HJB PIT



LEGEND:

- AVERAGE WINDROW CONCENTRATION MEETS RESIDENTIAL CLEAN-UP GOALS
- AVERAGE WINDROW CONCENTRATION MEETS INDUSTRIAL CLEAN-UP GOALS
- NOT EXCAVATED MEETS CLEAN-UP GOALS
- M.H. — MANHOLE
- L.M. — LIGHTING MAST

NOTE:

THIS FIGURE IS ADAPTED FROM FIGURE G2 OF THE IMR (MK, 2000a). THE CROSS HATCHING SHOWN IN THE FIGURE IS NOT RELEVANT TO THIS REPORT.

0 50 100

GRAPHIC SCALE IN FEET

DRAWN BY DM	DATE 2/5/06	INTERIM MEASURE GRIDS BACKFILLED WITH BIOREMEDIATED SOIL BUILDINGS 158/159, MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NO. 6878
CHECKED BY	DATE		OWNER NO. 0000
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 1-11 / REV. 0

FORM CADD NO. SDIV-BH.DWG - REV 1 - 9/10/98

2.0 FIELD INVESTIGATION

This section describes the sampling activities, procedures, and documentation utilized during the Round 1 and Round 2 field operations performed in 2004 and 2005 for NSWC Crane SWMU 12. Also included in this section are field activities associated with SWMU 25 (Highway 58 Dump Site A). SWMU 25 is located south-southwest of SWMU 12 and includes five groundwater monitoring wells installed in 1981 by the U.S. Army Corps of Engineers (USACE) around the perimeter of the dumping area.

2.1 OVERVIEW

RFI field activities for SWMU 12 were conducted from August through November 2004 (Round 1) and February through March 2005 (Round 2). The monitoring wells located at SWMU 25 were sampled during Round 2 activities. All work performed was conducted in accordance with the procedures and methodologies described in the U.S. EPA-approved quality assurance project plan (QAPP) Addendum No. 1 (TtNUS, 2003). Standard operating procedures (SOPs) that governed the field work are included in Appendix E of the approved QAPP. Select photographs of SWMU 12, copies of all field forms, records, field logbooks, and health and safety documentation associated with the Round 1 and Round 2 field investigations are provided in Appendices A through H of this document (Volume II).

2.2 MOBILIZATION/DEMOBILIZATION

Following approval of the QAPP Addendum No. 1 (TtNUS, 2003), TtNUS began mobilization activities. All field team members reviewed the approved QAPP, associated appendices, and the Health and Safety Plan (HASP) prior to the start of project activities. In addition, the Field Operations Leader (FOL) held field team orientation meetings to ensure that personnel were familiar with the scope of the field activities. Health and safety documentation is contained in Appendix F.

Prior to the initiation of fieldwork for each round, the FOL arrived at the site and began on-site mobilization activities. These activities included coordination with base personnel and utility clearance of all proposed boring locations through the NSWC Crane Public Works Office. The equipment required for the field activities was shipped to the site. At the conclusion of each round of field activities, the FOL completed the decontamination and demobilization of all equipment.

2.3 SUBSURFACE INVESTIGATION METHODOLOGIES AND PROCEDURES

2.3.1 Drilling

All borings were installed in accordance with SOP CTO166-04 and logged in accordance with SOPs CTO166-07 and CTO166-11. Boring logs can be found in Appendix B.1. Drilling methods used during each round, along with boring dates, boring depths, and depth intervals for soil sampling, are presented in Table 2-1.

Round 1

Eighteen borings for soil sampling and 51 borings for monitoring well installation were drilled at SWMU 12 using either direct-push technology (DPT) or hollow-stem auger (HSA)/air rotary methods (see Table 2-1).

Round 2

No drilling activities took place during Round 2 at SWMU 12.

2.3.1.1 Direct-Push Technology Borings

DPT, pushing small-diameter sampling tools hydraulically and/or mechanically downward into the ground to the desired depth, was used to complete all 18 soil borings at SWMU 12 during Round 1. Figure 2-1 shows the locations of all soil borings completed as part of the RFI at SWMU 12. DPT soil borings at SWMU 12 were advanced to total depth of 12 feet, to the water table, or to refusal. Actual sample depths for SWMU 12 soil samples are listed in Table 2-1. Soil samples were collected from the DPT borings for chemical analyses and for lithologic logging. All samples obtained from boreholes were screened with a photoionization detector (PID) immediately upon opening. All PID readings were recorded on the boring logs (Appendix B.1). Soil sample collection information is provided in Section 2.5.1.

2.3.1.2 Hollow-Stem Augering

A HSA drilling rig, including the use of 4.25-inch inside diameter (ID) HSAs and split-spoon samplers, was used to obtain soil samples. Split-spoon samplers had a minimum ID of 2 inches and were 2 feet long. The split-spoon sampler was driven to the required depth with a rig-mounted hammer weighing 140 pounds and falling 30 inches. All soil samples obtained from boreholes drilled using the HSA method were screened with a PID immediately upon opening. All PID readings were recorded on the boring logs (Appendix B.1). Drill cuttings were disposed in accordance with the approved QAPP Addendum No. 1

(TtNUS, 2003). See Section 2.14 for more information regarding the handling of investigation derived wastes (IDW).

Fifty-one monitoring wells were drilled and installed during the RFI. A HAS rig and split-spoons were used to core and drill through the overburden soils. Temporary steel casing was emplaced in the 6-inch diameter auger hole, and drilling then proceeded into bedrock. Continuous rock cores (2-inch diameter) were collected from 41 of the 51 borings for lithologic description purposes. Select cores were placed into labeled core boxes, photographed, and turned over to the NSWC Crane EPD for storage. All borings were reamed to about 6 inches diameter with a rotary roller bit and cleaned out prior to the installation of a monitoring well.

2.3.2 Borehole and Sample Logging

A TtNUS geologist maintained a log for each boring in accordance with SOP CTO166-07 (Borehole and Soil Sample Logging) and SOP CTO166-11 (Drilling and Geologic Logging of Boreholes in Rock). The boring logs for each round can be found in Appendix B.1 and contain the following information as appropriate:

- Well identification (where applicable).
- Boring identification.
- Name of geologist logging the boring.
- Name of drilling contractor.
- Sample number and type.
- Sample depth.
- Sample recovery and sample interval.
- Soil density or cohesiveness.
- Soil color.
- Unified Soil Classification System (USCS) material descriptions.
- Rock type and description, recovery, and rock quality designation (RQD).
- Location of boring.
- Drilling and/or well construction problems or deviations from the project-specific approved QAPP Addendum No. 1.
- Date(s) of drilling.
- Screening instrument (PID) readings.

In addition, depths of changes in lithology, sample moisture observations, depth to water, drilling methods, and total depth of each borehole were included on each log, as well as any other pertinent observations.

2.3.3 Borehole Abandonment

All soil borings at SWMU 12 were backfilled with bentonite chips and hydrated in accordance with the manufacturer's specifications. The ground surface at each boring location was restored to its original condition.

2.4 MONITORING WELL INSTALLATION AND DEVELOPMENT

2.4.1 Well Installation

Monitoring wells were installed during Round 1 RFI field operations at SWMU 12 in accordance with SOP CTO166-12. The installed wells were screened in the following water-bearing zones: Upper Pennsylvanian (Puz), Middle Pennsylvanian (Pmz), Lower Pennsylvanian (Plz), and Mississippian (Glen Dean) (Mgd). For all deep monitoring wells (greater than 45 feet bgs), a permanent steel isolation casing was installed to isolate the overburden soil and uppermost bedrock before deeper strata were cored. For shallow wells, a temporary steel casing was used to isolate the overburden while the uppermost bedrock was drilled. After each well boring was drilled to the desired depth, 2-inch-diameter polyvinyl chloride (PVC) Schedule 40 well screen and riser pipe were lowered into the boring through the steel isolation casing. Well screens ranged in length from 5 to 20 feet, depending on well depth, with a slot size of 0.20 inch. After the screen and riser pipe were set in place, the annulus of the boring was backfilled with clean silica sand from the bottom of the boring to 1 to 2 feet above the top of the well screen. A bentonite seal was then installed using bentonite pellets or chips, and the bentonite was allowed to hydrate in accordance with the manufacturer's recommendations. The remainder of the annulus of the borehole (from the bentonite seal to the ground surface) was filled with cement-bentonite grout to approximately 1 foot bgs.

The depth of the backfill materials was continuously monitored during the installation of the monitoring wells using a weighted steel tape measure to ensure that the sand pack and bentonite did not bridge during the installation process.

Indiana State well installation requirements described in 310 Indiana Administrative Code (IAC) 16 were followed for all well installation activities. Well construction logs were completed for each well and are presented in Appendix B.1. Refer to Section 2.3.1 for the drilling methods. Monitoring well construction

information and water level measurements are presented in Table 2-2 for each round. Figure 2-2 presents all SWMU 12 and SWMU 25 well locations.

2.4.2 Monitoring Well Protection

After each monitoring well was installed and the annulus grouted to the land surface, a 4-inch-square, 5-foot-long, steel protective casing with a locking cap was cemented in place over the riser pipe. This stick-up-type protective casing extended approximately 3 feet above and 2 feet below the ground surface. A drain hole was drilled into the protective casing approximately 6 inches above the ground surface. Pea gravel was used to fill the space between the outer protective casing and the riser pipe. A 4-foot-square (2-foot-square along railroad corridor due to travel restrictions) and 6-inch-thick concrete apron was cemented in place around the protective casing, and two to four safety yellow barrier posts (nominal 4-inch-diameter, 5-foot-long steel pipes buried 2 feet deep and filled with concrete) were cemented around the outside of the concrete apron. Stainless steel well plates indicating well identification number, depth, installation date, surrey data, and contact phone number were installed on the outside of each protective well casing. To maintain well security, a locking cap was placed on each well.

2.4.3 Monitoring Well Repair and Development

Repairs to monitoring wells were not required because no existing TtNUS wells were present at SWMU 12 at the initiation of the Round 1 field investigation. Four of the five wells at SWMU 25 were inspected prior to development and subsequent sampling. The riser on well WES-7-4-81, which was broken off at the ground surface, was repaired by TtNUS personnel. Monitoring well WES-7-1-81 was not proposed for sampling.

Well Development

All newly installed monitoring wells at SWMU 12 were developed by surging and pumping methods, no sooner than 24 hours after installation, to remove fine material from around the well screen and the sand pack that surrounds the well screen. The monitoring wells at SWMU 25 were also developed prior to sampling. Although the PVC riser at monitoring well WES-7-4-81 was repaired by TtNUS, debris apparently entered and blocked the well casing, and the well was not developed. The period of development for each well was approximately 1 hour. If the well was pumped dry, TtNUS personnel typically waited 20 to 30 minutes, noted the rate of recharge, and then pumped the well dry a minimum of two more times in an effort to maximize the amount of fine material removed. Development continued and was considered complete when one of the following was achieved: the development water was clear to the unaided eye, five well volumes were removed, or the well was pumped dry three times.

Wells were developed by up to three surging and purging techniques (a surge block with Whale® pump, a bailer, or a check valve method). The surge block/Whale® pump method consisted of inserting a 2-inch surge block into the well and surging over the length of the saturated screen for a minimum of 5 minutes. Immediately after surging, the Whale® pump was lowered into the well and was pumped in accordance with SOP CTO166-10. The bailer method consisted of purging the well over the length of the saturated screen and removing water and fines. The check valve method involved attaching a decontaminated foot valve to new, dedicated, ¾-inch polyethylene tubing, extending the tubing to the bottom of the well, and both surging and purging by moving the tubing in an up and down motion. On the downward stroke, the ball in the foot valve lifts and the tubing fills with water, and on the upward stroke, the ball is set and surged groundwater is forced out of the tubing and into a purge bucket. Section 2.14 describes the disposal of all IDW including development fluids.

Water-quality parameters [pH, specific conductivity, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), and turbidity], pumping rates, volumes of groundwater removed, recharge rates, and water levels were recorded on monitoring well development records. Monitoring well development records for SWMU 12 Rounds 1 and 2 and SWMU 25 can be found in Appendix C of this document.

2.5 SAMPLING OPERATIONS

This section discusses the methodology for soil, surface water, sediment, and groundwater sampling activities and aquifer testing performed at SWMU 12, and for groundwater sampling at SWMU 25. Table 2-3 provides a summary of all proposed versus actual samples collected, as well as a list of the analyses. Table 2-4 provides the reasoning as to why a proposed sample was not collected or why additional samples were collected.

2.5.1 Soil Sample Collection

During Round 1 of the RFI, 49 soil samples were collected from 18 soil borings. Soil samples were not collected during Round 2. Soil samples were collected in accordance with SOP CTO166-08. See Figure 2-1 for all soil boring locations. Soil sample log sheets for Round 1 are included in Appendix C.1 of this document.

2.5.1.1 Surface Soil Sampling

Surface soil samples were collected from the ground surface to a maximum depth of 2 feet bgs or until refusal was reached using DPT. Upon retrieval, all samples were monitored for the presence of VOCs using a PID. The results of this screening were recorded on boring logs and/or soil sample log sheets (included in Appendix B.1 and Appendix C.1, respectively, of this document). Samples for VOC analyses were collected first from between the 0.5- to 2.0-foot interval that had the highest PID reading. Samples to be analyzed for VOCs were collected using 5-gram EnCore™ samplers. Sample aliquots for the other analyses were collected from the remaining soil core within the 0- to 2-foot depth interval and placed in the appropriate containers following homogenization.

Round 1

Eighteen of the proposed 20 surface soil samples were collected at SWMU 12 during Round 1. One surface soil sample was collected from each of the 18 soil borings from the ground surface to depths of 1 to 2 feet bgs using the DPT method. Surface soil samples 12SS160002 and 12SS170002 were not collected due to encountering bedrock at the surface (Figure 2-1).

Also collected during Round 1 were surface soil samples 12SS210002, 12SS220002, 12SS230002, and 12SS240002. These samples were collected at the Battery Disposal Area within SWMU 12 as confirmation samples after soil excavation was performed by TolTest.

Round 2

No soil samples were collected during Round 2.

2.5.1.2 Subsurface Soil Sampling

Upon retrieval, all subsurface samples were monitored for the presence of VOCs using a PID. The results of this screening were recorded on the boring logs and/or soil sample log sheets. Samples for VOC analyses were collected first from the interval that had the highest PID reading using 5-gram EnCore™ samplers. The remaining soil core material was then homogenized, and soil to be analyzed for other parameters was placed into the required containers. Subsurface soil sample intervals for SWMU 12 are listed in Table 2-1.

Round 1

Subsurface soil samples were proposed at various depths at all 20 soil boring locations at SWMU 12. A minimum of one subsurface soil sample was collected at all but two of the proposed locations. Soil boring locations 12SB16 and 12SB17 (Figure 2-1) encountered bedrock at the ground surface, and therefore soil samples were not collected. Subsurface samples were collected from a 2-foot interval between 2 to 10 feet bgs using DPT. Depths of the soil borings varied depending on when refusal was encountered.

Round 2

No subsurface soil samples were collected during Round 2.

2.5.2 Surface Water/Seep Sampling

Surface water samples were collected from intermittent streams, drainage ditches, and surface runoff locations throughout SWMU 12 during both rounds. Up to five seep samples were also proposed; however, no seeps were located during the field investigations. All sample locations were marked with a labeled, wooden survey stake. Fluorescent flagging was tied to the stake and to a nearby tree (if available) to facilitate relocation of the sample location for surveying purposes. All surface water samples were collected in accordance with the approved QAPP Addendum No. 1 (TtNUS, 2003). All pertinent field data, including water-quality parameters, sarnpling methods, and locations, were recorded on a surface water sample log sheet (see Appendix C). See Figure 2-3 for all surface water sampling locations.

Round 1

All 30 proposed surface water samples were collected at SWMU 12 during Round 1. Twenty of the 30 locations were initially found to be dry during the sampling period in early October 2004. However, after significant rainfalls over a 2-week period, the locations were revisited in November 2004, and the remaining 20 samples were collected.

Round 2

Twenty-three of the original 30 Round 1 surface water sample locations were again sampled during Round 2. Samples were not collected at locations 12SW/SD07, 15, 19, 21, 22, 29, and 30 due to the absence of water at the time of sampling. In addition, six discretionary surface water locations (12SW/SD31 through 12SW/SD36) were sampled to help delineate potential sources of contamination at SWMU 12.

2.5.3 Sediment Sampling

Sediment samples were collected from intermittent streams, drainage ditches, and surface runoff locations at SWMU 12 during Round 1. The samples were collected in depositional areas that contained predominantly fine (clay and silt) particles. All sediment samples were collected at a depth of 0 to 4 inches bgs. Round 1 sediment samples were collected in accordance with the approved QAPP Addendum No. 1 (TtNUS, 2003). All locations were marked with a labeled, wooden survey stake. Fluorescent flagging was tied to the stake and to a nearby tree (if available) to facilitate relocation of the sample location for surveying purposes. All pertinent field data, including sampling methods, depths, descriptions, and locations, were recorded on sediment sample log sheets (see Appendix C.2). See Figure 2-3 for all sediment sampling locations.

Round 1

Thirty sediment samples were collected at SWMU 12 during Round 1 (Table 2-3).

Round 2

No sediment samples were collected during Round 2.

2.5.4 Groundwater Purging and Sampling

Purging and stabilization of wells prior to sampling was accomplished using low-flow techniques in accordance with SOP CTO166-15. Sampling was accomplished in accordance with SOP CTO166-05. Sample analytes are provided in Table 2-3.

Wells were purged prior to sampling using a peristaltic pump or bladder pump, depending on the static water level, well depth, and recharge information obtained during well development. In general, bladder pumps were used to sample wells with a static water level greater than 28 feet bgs, and peristaltic pumps were used to sample wells with a static water level less than 28 feet bgs.

Groundwater quality parameters including pH, specific conductance, temperature, DO, and ORP were measured during purging at 5- to 10-minute intervals using a YSI Model 600 series multi-parameter water-quality meter and flow-through cell. Longer intervals were used for slower pumping wells. Turbidity readings were measured using a LaMotte 2020 turbidity meter. Water levels and pumping rates were also measured during purging at 5- to 10-minute intervals. Purging continued until a minimum of one well

volume was removed and the above parameters stabilized, or until the well had been purged for 4 hours, in accordance with SOP CTO166-16 and SOP CTO166-15. To the extent possible, the pumping rates were adjusted to prevent drawdown from exceeding 0.3 foot during purging. Copies of the monitoring well low-flow purge data sheets and groundwater sample log sheets for Rounds 1 and 2 are provided in Appendix C.4 of this document.

Monitoring wells were sampled with the same pump (peristaltic or bladder) and tubing used during well purging. Immediately following the purging process and before sampling, the temperature, pH, specific conductance, DO, ORP, and turbidity were measured and recorded on the groundwater sample log sheets (included in Appendix C.4).

Sample containers were filled by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence. VOC samples were collected and immediately sealed in 40-mL vials so that no headspace existed. Samples for SVOCs, explosives, explosive picrates, total metals, total mercury, ammonia, nitrate, dissolved metals, and dissolved mercury were collected next and in the order listed (when applicable). Samples with turbidity values greater than 10 nephelometric turbidity units (NTUs) were field filtered for dissolved metals analyses prior to sample preservation using a 0.45-micron in-line filter. All pertinent field data, including sampling methods, purge information, pump intake depths, and locations, were recorded on low-flow purge data sheets and groundwater sample log sheets (see Appendix C). See Figure 2-2 for all groundwater sampling locations.

During Round 1, several wells were also sampled for natural attenuation field parameters including DO, alkalinity, carbon dioxide, ferrous iron, hydrogen sulfide, sulfide, nitrite, and manganese.

Round 1

Forty-seven of the 51 groundwater monitoring wells installed at SWMU 12 during Round 1 were sampled. Well location 12MWT24, installed at a depth of 31 feet, was found to be dry. As a result, well 12MWT24A was installed next to it at a depth of 54 feet. Monitoring wells 12MWT30, 49, and 50 did not produce sufficient water for sample collection during Round 1. Monitoring well 12MWT34 went dry after the collection of a 1-liter explosives sample. Monitoring wells 12MWT14, 37, 39, and 48 were very slow to recharge, and sampling of these wells took place over a period of several days. See Figure 2-2 for monitoring well locations.

Round 2

SWMU 12

Forty-seven groundwater monitoring wells were sampled at SWMU 12 during Round 2. Monitoring wells 12MWT24, 30, 37, and 50 were found to be dry. As in Round 1, monitoring well 12MWT34 went dry after the collection of a 1-liter explosives sample and did not recharge. Monitoring well 12MWT19 was slow to recharge, and the samples were collected over several days. Due to monitoring well 12MWT14 being a very slow recharging well, the purge water was collected for possible analysis. After purging was complete, a 1-liter sample bottle (for explosives and miscellaneous explosives) analysis was collected prior to the well going dry. The purge water was used for the metals and nitrate samples, as noted on the groundwater sample log sheet.

SWMU 25

Three of the four proposed monitoring wells were sampled at SWMU 25. Monitoring well WES-7-4-81 was found to have some sort of blockage or casing failure and therefore unable to be sampled. Monitoring well WES-7-1-81 was not proposed for sampling due to being historically dry.

2.6 FIELD SAMPLE DOCUMENTATION

Sample documentation consisted of the completion of boring logs, matrix-specific sample log sheets, sample bottle tags, chain-of-custody records, field task modification request (FTMR) forms, equipment calibration log sheets, field logbooks, and health and safety documentation. Field documentation was completed as per SOP CTO 166-03. The sample log sheets contain information such as sample location and sample identification number, container requirements and analyses to be performed, sample type, time, date, and method of sample collection. Any unusual circumstances encountered during sample collection were noted on the form. Sample log sheets can be found in Appendix C of this document. Chain-of-custody records (see Appendix C.5) were used to track each sample from collection to receipt and analysis at the laboratory. FTMRs (see Appendix C.10) were used to document deviations from the approved QAPP Addendum No. 1. Equipment calibration log sheets are discussed in Section 2.9.1 and can be found in Appendix C.9 of this document. Upon completion of sample analyses, sample bottle tags were forwarded by laboratory personnel to the NSWC Crane EPD for storage.

2.7 SAMPLE HANDLING, PACKAGING, AND SHIPPING

Sample handling activities included field-related considerations concerning the selection of sample containers, preservatives, allowable holding times, sample custody, and maintaining samples at the appropriate storage temperature. Sampling containers were sealed in Ziploc® plastic bags, and glass containers were wrapped in plastic bubble wrap to minimize the possibility of breakage during transport. The sample containers were then placed in a cooler lined with a large plastic garbage bag. The cooler was packed with a cushioning material (bubble wrap) to prevent container breakage. Samples were cooled immediately after collection with ice placed over the sample containers. A temperature blank was placed in each cooler prior to shipment. The plastic garbage bag was sealed with a knot, and the chain-of-custody form was sealed in a Ziploc® bag and taped to the inside of the cooler lid. A signed and dated custody seal was applied to each end of the cooler and then covered with strapping tape to provide a tamper-evident seal. A Federal Express® airbill was applied to the shipping cooler. TtNUS maintained custody of the samples until they were relinquished to Federal Express®. The Federal Express® tracking number (airbill number) was recorded on the chain-of-custody form, and the sender's copy of the airbill was maintained for shipment tracking, if needed. All samples were shipped to the laboratory for overnight delivery and were received within sample holding times. Sample bottle tags were removed from each sample bottle by laboratory personnel and forwarded to the NSWC EPD.

2.8 QUALITY CONTROL SAMPLES

Quality assurance (QA)/quality control (QC) samples were generated and collected during sampling activities to monitor both field and laboratory procedures. These procedures are detailed in the approved QAPP and QAPP Addenda. QA/QC samples included field duplicates, equipment rinsate blanks, trip blanks, source water blanks, and temperature blanks. Field duplicate results are tabulated in Appendix G (Analytical Data) of this document. These types of QA/QC samples are briefly described below.

- Field Duplicates - Field duplicates consisted of two samples collected either independently at a sampling location at approximately the same time in the case of soil or sediment VOC samples, groundwater, and surface water or as a single sample split into two portions in the case of non-VOC soil and sediment samples. Field duplicates were collected at the rate of 1 in 20 per medium during Rounds 1 and 2 and were used to assess the overall precision of the sampling and analysis program.

- Equipment Rinsate Blanks - Equipment rinsate blanks were obtained under representative field conditions by collecting the rinse water generated by running analyte-free water through or over sample collection equipment after decontamination and before use. When pre-cleaned, dedicated, or

disposable sampling equipment was used (no decontamination was required), one equipment rinsate blank was collected as a batch blank. Additionally, bladder pump equipment rinsate blanks were collected at a rate of one equipment rinsate blank for every five samples. Equipment rinsate blanks were analyzed for the same chemical constituents as the associated environmental samples.

- Trip blanks - Trip blanks were used to determine whether contamination of VOC samples had occurred during transit or storage. Trip blanks consisted of analyte-free water taken from the laboratory to the site and returned to the laboratory. One trip blank was submitted to the laboratory in each cooler that contained samples for VOC analyses and was analyzed for VOCs only.

- Source water blanks - Source water blanks were obtained by sampling the analyte-free water and potable water source(s) used for decontamination of sampling equipment. Source water blanks were used to determine whether analyte-free water or potable water (used for steam cleaning, etc.) contributed to sample contamination.

- Temperature blanks - Temperature blanks were used to determine if samples were adequately cooled during shipment. Temperature blanks consisted of analyte-free water poured into a clean sample container at the site or supplied by the fixed-based laboratory. One temperature blank was submitted to the laboratory in each cooler, and the temperature was checked upon receipt at the laboratory.

2.9 FIELD INSTRUMENT MEASUREMENTS

Field measurements taken and recorded during field sampling operations included water temperature, pH, specific conductance, ORP, DO, turbidity, and groundwater level measurements. Ambient air measurements included monitoring of organic vapors in the breathing zone during intrusive field investigation activities and monitoring of organic vapors emanating from site sources such as soil samples and well casings. Several instruments were used during field activities to obtain these measurements including the following:

- PID
- YSI Model 6 series, multi-parameter, water-quality meter
- LaMotte 2020 turbidity meter
- M-scope water level indicator

2.9.1 Equipment Calibration

Instruments used in the field were calibrated daily prior to use according to manufacturers' requirements and in accordance with applicable SOPs. Equipment calibration logs can be found in Appendix C.9.

2.9.2 Field Investigation Preventive Maintenance Procedures/Schedule

Field instruments for this project included the PID, YSI water-quality meter, LaMotte 2020 turbidity meter, and water level indicator. The specific preventive maintenance procedures followed for field equipment were those recommended by the equipment manufacturers.

An appropriate maintenance check was performed daily on each piece of equipment. If damaged or defective parts were identified during the maintenance check, and it was determined that the damage could have an impact on the instrument's performance, the instrument was removed from service until the defective parts were repaired or replaced. Critical spare parts were kept on site to reduce downtime. Spare parts included batteries, a DO probe membrane kit (membranes and a bottle of solution), and air particle filters for the PID. Back-up instruments and equipment were available on site or were shipped within 1 day via overnight courier to avoid delays in the field schedule.

2.10 SURVEYING

All monitoring well, soil boring, surface water/sediment, and staff gauge locations were surveyed. The top of the riser pipe (where the uncapped well riser is marked), the top of the protective casing, and the ground surface at each monitoring well location were surveyed to within 0.01-foot vertical accuracy. For all other locations (soil boring, sediment, seeps, vegetation, and staff gauges), the ground surface elevation was surveyed to the nearest 0.10 foot. Staff gauge reference point elevations were also surveyed to the nearest 0.01 foot. Vertical elevations were referenced to the 1988 North American Vertical Datum (NAVD88). Existing survey monuments at NSWC Crane were used as reference points. Horizontal locations of samples, borings, wells, and sump pumps were surveyed to Indiana State Plane coordinates to the nearest 0.10 foot and referenced to the 1983 North American Datum (NAD83). All surveying was performed by a surveyor professionally licensed in the State of Indiana. Copies of the survey data can be found in Appendix D.3.

2.11 DECONTAMINATION

The nondedicated, nondisposable equipment involved in field sampling activities was decontaminated before beginning work, during drilling and sampling activities, and at the completion of each round of RFI

activities in accordance with SOP CTO166-16. This equipment included drilling rigs, down-hole tools, augers, and soil and water sampling equipment.

2.11.1 Major Equipment

All down-hole equipment, including down-hole drilling tools, were steam cleaned with high-pressure hot water prior to beginning work, between borings, and at the conclusion of each shift of drilling. Well riser pipe and screens were supplied at the site in certified-clean packaging. All decontamination activities took place at a designated area within NSWC Crane.

2.11.2 Sampling Equipment

All nondedicated (reusable) equipment used for collecting samples was decontaminated before field sampling, between sample collections, and at the end of each sampling event. This equipment included stainless steel trowels, stainless steel mixing bowls, bladder pumps, etc. The following decontamination steps were taken:

- Potable water and phosphate-free detergent wash (scrub if necessary)
- Potable water rinse
- Deionized (DI) water rinse
- Air dry (if possible)
- Wrap in aluminum foil (if not to be used immediately)

An isopropanol rinse was not necessary because no oily residue was evident on the sampling equipment.

Field analytical equipment such as pH, conductivity, and temperature probes were rinsed first with analyte-free water then with the sample prior to making measurements. Water level measurement devices were rinsed with DI water.

2.12 WATER LEVEL MEASUREMENTS AND AQUIFER TESTING

2.12.1 Groundwater Level Measurements

Water level measurements were obtained from each monitoring well prior to development and purging. In addition, complete synoptic rounds of water levels including all existing wells were taken at the end of each round of field activities. Each round of synoptic water level measurements was obtained within a 24-hour time period. Measurements were taken with an electrical water level indicator (M-scope), using

the top of the riser pipe as the reference point to determine water depth for monitoring wells and using a surveyed mark for staff gauge measurements. All measurements were taken in accordance with SOP CTO166-17. A mark was placed at the top of the riser pipe to ensure that measurements were taken from a consistent reference point. Water level measurements and staff gauge measurements were recorded to the nearest 0.01 foot on groundwater level measurement forms, which are provided in Appendix C.8 of this document. Table 2-2 contains water level/elevation data SWMU 12 and SWMU 25.

2.12.2 Staff Gauge Installation and Estimation of Stream Flow

A total of 12 staff gauges were installed at the culverts of drainage ditches and intermittent streams where flowing water was observed as either a metal stake or painted mark on the concrete culvert. Marks were placed on each of these permanent structures denoting the staff gauge number and the point where measurements would be taken. Refer to Figure 2-3 for staff gauge locations at SWMU 12.

Stream flow rates were estimated (based on visual observations) or measured; these data can be found in Appendices C.3 and C.8. Due to shallow depths, dense grassy cover, and/or natural features interfering with adequate unrestricted stream/drainage ditch runs, stream flow measurement SOP CTO166-20 could not be followed at many sampling locations.

2.12.3 Aquifer Testing

Slug tests were performed at SWMU 12 to determine the hydraulic characteristics of the formation in the immediate vicinity of the wells. Slug tests were performed at 19 monitoring wells at SWMU 12. See Appendix E for well locations and calculations. Slug test data evaluation results are discussed in Section 4.6.

During slug testing, the change in water level in the wells was induced by withdrawing (rising head) or introducing (falling head) a solid PVC slug with a volume equivalent to approximately 2 to 3 feet of displacement in a 2-inch well. In some instances, one or two bailers (one bailer induces approximately 1.5 feet of displacement in a 2-inch well) were used to withdraw water to initiate the water level change. Monitoring wells with a water level below the top of the well screen were tested using the rising head method and in most cases using a bailer to induce the water level change. Monitoring wells with 3 feet or less of standing water were not slug tested.

Prior to performing each slug test, the static water level in the monitoring well was measured using an electronic water level indicator. Water levels were recorded with a pressure transducer at linear and

logarithmic intervals of time via a programmed electronic data logger as the water level returned to the original static water level. The time and rate of change required for the water level to return to the original static water level are functions of the transmissivity and hydraulic conductivity of the aquifer. The resulting drawdown data from the slug tests were evaluated using the Hvorslev Method (Fetter, 1998). The results of the slug tests are presented in Section 4 (see Table 4-2).

2.13 FIELD CORRECTIVE ACTION

Corrective action includes the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or "out of QC" performance that can affect data quality, and the process of modifying procedures to address unexpected/unusual field conditions encountered.

Corrective action in the field resulted when substantive changes were made to the sampling network (i.e., more/fewer samples collected, sampling locations other than those specified, etc.) and when sampling procedures or field analytical procedures required modification. Project personnel reported all suspected technical or QA nonconformance or suspected deficiencies of any activity or issued document to the FOL or designee. The Task Order Manager (TOM) was responsible for assessing the suspected problems in consultation with the project QA/QC Manager and for making a decision based on the potential for the situation to affect the quality of the resulting data. If it was determined that the situation warranted a reportable nonconformance requiring corrective action, a nonconformance report was initiated by the TOM.

No nonconformances or suspected deficiencies occurred during either round of field investigations. However, one deviation occurred from the approved QAPP (TtNUS, 2004). Deviations were addressed using FTMR forms, copies of which are included in Appendix C.

2.14 INVESTIGATION-DERIVED WASTE HANDLING

The field investigations generated several types of potentially contaminated wastes including personal protective equipment (PPE) and decontamination fluids (from the drill rig and sampling equipment), DPT plastic sleeves, development and purge water, and soil cuttings. Management of each residue was performed as follows:

PPE, Pump Tubing, and DPT Plastic Sleeves – All PPE, tubing, and plastic sleeves were decontaminated, double bagged, and placed in NSWC Crane trash receptacles (i.e., dumpsters).

Purge Water, Development Water, Drill and Sampling Equipment Decontamination Fluids – All well development and purge waters and equipment decontamination fluids were collected and discharged to the NSWC Crane permitted waste treatment plant.

Waste Cuttings and Rock Cores from Drilling Activities – For each boring, the cuttings produced were scanned for VOCs. VOC readings were at background levels for all borings, and cuttings were therefore used as backfill if the boring terminated above the water table. Any remaining cuttings were spread on the ground in the immediate vicinity of the boring.

Additional requirements for IDW handling can be found in the specific IDW SOP contained in the appendix of each respective QAPP.

2.15 SITE MANAGEMENT AND FACILITY SUPPORT

The FOL was designated as the lead in coordinating all day-to-day activities during the investigation. The FOL was responsible for ensuring that all field team members (including subcontractors) were familiar with the approved QAPP and the HASP that was in effect during each round. Additionally, the FOL was responsible for all sampling operations, QA/QC, field documentation requirements, and field change orders. The FOL reported to the TOM on a daily basis regarding the status of fieldwork.

All site preparation, mobilization/demobilization, and sampling activities were coordinated through NSWC Crane personnel through pre-visit communication and daily meetings during field work.

2.16 RECORDKEEPING

Various hardcover, bound record books were maintained for each field activity in accordance with SOP CTO166-03. The Master Site Logbook served as the overall record of field activities. Information recorded daily in the Master Site Logbook included daily field activities, weather conditions, identity and arrival and departure times of personnel, management issues, etc. Various field notebooks were also maintained. For example, the site geologist supervising monitoring well installation operations maintained a field notebook. Copies of field log books are included in Appendix D.

The FOL was responsible for the maintenance and security of all field records. Eventually, all field records, chain-of-custody forms, sample log sheets, field forms, log books, and notebooks were docketed and incorporated in the central project file for CTO 0357.

2.17 RESTORATION AND REVEGETATION

At the conclusion of Rounds 1 and 2 field activities, TtNUS performed basic site restoration and revegetation in some of the areas impacted by drilling activities and/or heavy equipment (i.e., backhoe and bulldozer) operations at SWMU 12. The TtNUS FOL also met with Crane personnel at the conclusion of Round 2 activities to discuss areas needing additional site restoration, which is currently planned for the spring of 2005.

TABLE 2-1

INSTALLATION DATES AND DEPTHS OF MONITORING WELLS AND SOIL BORINGS
AND DEPTHS OF SOIL SAMPLES COLLECTED
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Boring or Well No.	Total Depth (feet bgs)	Drilling Method[1]	Date Drilled	Depth Interval(s) of Soil Sample (feet bgs)
SWMU 12 - Round 1				
12MWT01	35.0	HSA/AR	24-Jul-04	NA
12MWT02	29.0	HSA/AR	25-Jul-04	NA
12MWT03	26.0	HSA/AR	31-Aug-04	NA
12MWT04	25.0	HSA/AR	10-Sep-04	NA
12MWT05	25.0	HSA/AR	8-Sep-04	NA
12MWT06	24.0	HSA/AR	15-Aug-04	NA
12MWT07	25.0	HSA/AR	27-Aug-04	NA
12MWT08	24.0	HSA/AR	25-Jul-04	NA
12MWT09	25.0	HSA/AR	29-Aug-04	NA
12MWT10	25.0	HSA/AR	11-Aug-04	NA
12MWT11	25.0	HSA/AR	14-Aug-04	NA
12MWT12	25.0	HSA/AR	14-Aug-04	NA
12MWT13	21.0	HSA/AR	31-Jul-04	NA
12MWT14	26.0	HSA/AR	1-Aug-04	NA
12MWT15	25.0	HSA/AR	31-Aug-04	NA
12MWT16	25.0	HSA/AR	14-Aug-04	NA
12MWT17	26.0	HSA/AR	15-Aug-04	NA
12MWT18	26.0	HSA/AR	27-Aug-04	NA
12MWT19	27.0	HSA/AR	28-Aug-04	NA
12MWT20	26.0	HSA/AR	1-Sep-04	NA
12MWT21	25.0	HSA/AR	12-Sep-04	NA
12MWT22	25.0	HSA/AR	11-Sep-04	NA
12MWT23	31.0	HSA/AR	10-Aug-04	NA
12MWT24	31.0	HSA/AR	16-Aug-04	NA
12MWT24A	54.0	HSA/AR	10-Aug-04	NA
12MWT25	26.0	HSA/AR	12-Sep-04	NA
12MWT26	25.0	HSA/AR	12-Sep-04	NA
12MWT27	26.0	HSA/AR	2-Sep-04	NA
12MWT28	26.0	HSA/AR	30-Aug-04	NA
12MWT29	89.0	HSA/AR	10-Sep-04	NA
12MWT30	90.5	HSA/AR	29-Aug-04	NA
12MWT31	89.0	HSA/AR	30-Aug-04	NA
12MWT32	100.0	HSA/AR	1-Sep-04	NA
12MWT33	95.0	HSA/AR	2-Sep-04	NA
12MWT34	87.0	HSA/AR	13-Aug-04	NA
12MWT35	27.0	HSA/AR	27-Aug-04	NA
12MWT36	26.0	HSA/AR	27-Aug-04	NA

TABLE 2-1

INSTALLATION DATES AND DEPTHS OF MONITORING WELLS AND SOIL BORINGS AND DEPTHS OF SOIL SAMPLES COLLECTED
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Boring or Well No.	Total Depth (feet bgs)	Drilling Method[1]	Date Drilled	Depth Interval(s) of Soil Sample (feet bgs)
12MWT37	25.0	HSA/AR	29-Aug-04	NA
12MWT38	25.0	HSA/AR	11-Sep-04	NA
12MWT39	35.0	HSA/AR	30-Aug-04	NA
12MWT40	29.0	HSA/AR	12-Aug-04	NA
12MWT41	35.0	HSA/AR	27-Oct-04	NA
12MWT42	29.0	HSA/AR	01-Sep-04	NA
12MWT43	81.0	HSA/AR	12-Nov-04	NA
12MWT44	35.5	HSA/AR	27-Oct-04	NA
12MWT45	25.0	HSA/AR	29-Oct-04	NA
12MWT46	24.5	HSA/AR	30-Oct-04	NA
12MWT47	25.0	HSA/AR	31-Oct-04	NA
12MWT48	30.0	HSA/AR	09-Nov-04	NA
12MWT49	30.0	HSA/AR	10-Nov-04	NA
12MWT50	35.0	HSA/AR	29-Oct-04	NA
12SB01	9.0	DPT	15-Aug-04	0-2, 6-9
12SB02	9.0	DPT	15-Aug-04	0-2, 6-8
12SB03	7.5	DPT	15-Aug-04	0-2, 6-8
12SB04	12.0	DPT	15-Aug-04	0-2, 2-7, 7-12
12SB05	9.0	DPT	15-Aug-04	0-2, 2-4, 5-9
12SB06	9.0	DPT	15-Aug-04	0-2, 2-5, 5-9
12SB07	10.0	DPT	15-Aug-04	0-2, 2-6, 6-10
12SB08	7.0	DPT	15-Aug-04	0-2, 2-4, 5-7
12SB09	8.0	DPT	15-Aug-04	0-2, 2-5, 5-8
12SB10	8.0	DPT	15-Aug-04	0-2, 2-5, 5-8
12SB11	6.5	DPT	15-Aug-04	0-2, 2-5, 5-7
12SB12	6.0	DPT	13-Aug-04	0-2, 2-4
12SB13	6.5	DPT	13-Aug-04	0-2, 2-4, 6-7
12SB14	7.0	DPT	13-Aug-04	0-2, 2-4, 6-7
12SB15	6.5	DPT	13-Aug-04	0-2, 2-4, 6-7
12SB16	0.0	NA	NA	Refusal at surface
12SB17	0.0	NA	NA	Refusal at surface
12SB18	9.0	DPT	15-Aug-04	0-2, 2-4, 6-8
12SB19	4.0	DPT	15-Aug-04	0-2, 2-4
12SB20	8.0	DPT	15-Aug-04	0-2, 2-4, 6-8

1 DPT = Direct-push technology, HSA = Hollow stem auger, AR = air rotary.
NA - Not applicable.
bgs - Below ground surface.

TABLE 2-2

MONITORING WELL CONSTRUCTION INFORMATION AND WATER LEVEL MEASUREMENTS
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Well or Gauge Number	Installation Date	Northing (feet)	Easting (feet)	Ground Elevation (feet amsl)	Top of Riser or Reference Point Elevation (feet amsl)	Total Depth (feet bgs)(1)	Screened Interval				Water-Bearing Zone	October 17, 2004		December 15, 2004		January 18, 2005	
							Top (feet bgs)	Bottom (feet bgs)	Top (feet amsl)	Bottom (feet amsl)		Depth to Water (feet btor)	Water Elevation (feet amsl)	Depth to Water (feet btor)	Water Elevation (feet amsl)	Depth to Water (feet btor)	Water Elevation (feet amsl)
MONITORING WELLS																	
12MWT01	7/24/04	1312852.79	3026150.48	724.06	726.87	35.0	24.00	34.00	700.06	690.06	Puz	11.10	715.77	9.68	717.19	9.34	717.53
12MWT02	7/25/04	1312701.31	3026218.56	723.57	725.64	29.0	18.00	28.00	705.57	695.57	Puz	10.02	715.62	8.63	717.01	8.32	717.32
12MWT03	8/31/04	1312747.34	3026026.90	732.39	734.44	26.0	15.00	25.00	717.39	707.39	Puz	16.91	717.53	16.21	718.23	16.00	718.44
12MWT04	9/10/04	1312647.57	3026082.64	728.62	730.74	25.0	14.00	24.00	714.62	704.62	Puz	14.94	715.80	13.67	717.07	13.35	717.39
12MWT05	9/8/04	1312511.09	3026137.13	722.90	725.36	25.0	14.00	24.00	708.90	698.90	Puz	10.12	715.24	8.72	716.64	8.41	716.95
12MWT06	8/15/04	1311833.50	3026562.65	724.59	726.70	24.0	13.00	23.00	711.59	701.59	Puz	9.54	717.16	10.51	716.19	10.75	715.95
12MWT07	8/27/04	1311707.13	3026615.62	726.03	728.40	25.0	14.00	24.00	712.03	702.03	Puz	11.80	716.60	13.05	715.35	13.42	714.98
12MWT08	7/25/04	1311609.35	3026660.10	726.73	728.83	24.0	13.00	23.00	713.73	703.73	Puz	12.03	716.80	13.05	715.78	13.19	715.64
12MWT09	8/29/04	1311595.76	3026580.09	725.78	728.00	25.0	14.00	24.00	711.78	701.78	Puz	13.44	714.56	13.60	714.40	13.40	714.60
12MWT10	8/11/04	1311456.81	3026649.95	723.84	726.68	25.0	14.00	24.00	709.84	699.84	Puz	15.17	711.51	14.67	712.01	14.19	712.49
12MWT11	8/14/04	1313014.33	3026776.15	738.45	740.79	25.0	14.00	24.00	724.45	714.45	Puz	15.55	725.24	12.96	727.83	12.88	727.91
12MWT12	8/14/04	1312972.30	3026791.19	739.51	741.66	25.0	14.00	24.00	725.51	715.51	Puz	13.03	728.63	10.61	731.05	9.95	731.71
12MWT13	7/31/04	1313060.01	3026835.37	733.55	735.81	21.0	10.00	20.00	723.55	713.55	Puz	8.21	727.60	5.30	730.51	4.63	731.18
12MWT14	8/31/04	1312965.79	3026875.34	734.54	736.67	26.0	15.00	25.00	719.54	709.54	Puz	19.51	717.16	20.05	716.62	20.75	715.92
12MWT15	8/31/04	1312876.08	3026906.85	734.40	736.74	25.0	14.00	24.00	720.40	710.40	Puz	16.32	720.42	18.52	718.22	19.17	717.57
12MWT16	8/14/04	1312096.13	3027182.94	743.63	745.97	25.0	14.00	24.00	729.63	719.63	Puz	20.97	725.00	21.95	724.02	22.13	723.84
12MWT17	8/15/04	1312047.38	3027205.14	744.84	747.23	26.0	15.00	25.00	729.84	719.84	Puz	22.79	724.44	24.11	723.12	24.63	722.60
12MWT18	8/27/04	1312114.82	3027253.63	743.93	745.94	26.0	15.00	25.00	728.93	718.93	Puz	21.55	724.39	22.61	723.33	23.06	722.88
12MWT19	8/28/04	1312026.45	3027292.38	744.55	746.89	27.0	16.00	26.00	728.55	718.55	Puz	25.83	721.06	27.06	719.83	27.77	719.12
12MWT20	9/1/04	1311919.40	3027337.61	744.40	746.56	26.0	15.00	25.00	729.40	719.40	Puz	23.86	722.70	24.97	721.59	25.35	721.21
12MWT21	9/12/04	1312878.00	3026436.50	735.16	737.72	25.0	14.00	24.00	721.16	711.16	Puz	21.42	716.30	19.92	717.80	19.54	718.18
12MWT22	9/11/04	1311937.84	3026901.94	737.50	739.74	25.0	14.00	24.00	723.50	713.50	Puz	16.56	723.18	17.40	722.34	17.71	722.03
12MWT23	8/10/04	1311150.87	3027466.57	737.29	739.75	31.0	20.00	30.00	717.29	707.29	Puz	27.20	712.55	28.22	711.53	28.65	711.10
12MWT24	8/10/04	1310974.75	3027184.02	738.28	740.60	31.0	20.00	30.00	718.28	708.28	Puz	32.07	708.53	32.38	708.22	32.34	708.26

TABLE 2-2

MONITORING WELL CONSTRUCTION INFORMATION AND WATER LEVEL MEASUREMENTS
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Well or Gauge Number	Installation Date	Northing (feet)	Easting (feet)	Ground Elevation (feet amsl)	Top of Riser or Reference Point Elevation (feet amsl)	Total Depth (feet bgs)[1]	Screened Interval				Water-Bearing Zone	October 17, 2004		December 15, 2004		January 18, 2005	
							Top (feet bgs)	Bottom (feet bgs)	Top (feet amsl)	Bottom (feet amsl)		Depth to Water (feet btor)	Water Elevation (feet amsl)	Depth to Water (feet btor)	Water Elevation (feet amsl)	Depth to Water (feet btor)	Water Elevation (feet amsl)
12MWT24A	8/16/04	1310968.91	3027192.97	737.99	740.53	54.0	44.00	54.00	693.99	683.99	Puz	34.68	705.85	35.00	705.53	35.23	705.30
12MWT25	9/12/04	1313924.59	3026269.42	746.55	748.66	26.0	15.00	25.00	731.55	721.55	Puz	17.80	730.86	17.35	731.31	17.35	731.31
12MWT26	9/12/04	1313638.57	3025981.12	741.64	743.72	25.0	14.00	24.00	727.64	717.64	Puz	10.56	733.16	10.91	732.81	11.01	732.71
12MWT27	9/2/04	1313736.63	3026477.23	738.42	740.52	26.0	15.00	25.00	723.42	713.42	Puz	10.96	729.56	9.35	731.17	9.24	731.28
12MWT28	8/30/04	1313506.96	3026352.09	743.27	745.53	26.0	15.00	25.00	728.27	718.27	Puz	12.96	732.57	12.78	732.75	12.78	732.75
12MWT29	9/10/04	1312653.54	3026079.78	729.13	731.23	89.0	70.00	88.00	659.13	641.13	Pmz	59.97	671.26	61.20	670.03	61.34	669.89
12MWT30	8/29/04	1311604.34	3026576.32	725.67	727.59	90.5	70.00	90.00	655.67	635.67	Pmz	92.71	634.88	92.74	634.85	92.69	634.90
12MWT31	8/30/04	1312970.99	3026872.87	734.55	736.75	89.0	68.00	88.00	666.55	646.55	Pmz	68.55	668.20	68.86	667.89	68.72	668.03
12MWT32	9/1/04	1312015.49	3027297.24	744.51	747.44	100.0	79.00	99.00	665.51	645.51	Pmz	85.17	662.27	85.93	661.51	86.11	661.33
12MWT33	9/2/04	1313725.86	3026481.26	738.32	740.49	95.0	74.00	94.00	664.32	644.32	Pmz	44.99	695.50	42.44	698.05	41.80	698.69
12MWT34	8/13/04	1310967.35	3027183.73	738.02	740.52	87.0	76.00	86.00	662.02	652.02	Pmz	88.42	652.10	88.32	652.20	88.12	652.40
12MWT35	8/27/04	1312711.38	3027111.95	732.17	734.64	27.0	16.00	26.00	716.17	706.17	Puz	12.33	722.31	12.53	722.11	12.70	721.94
12MWT36	8/27/04	1312466.54	3027186.16	736.51	738.63	26.0	15.00	25.00	721.51	711.51	Puz	13.15	725.48	14.19	724.44	14.58	724.05
12MWT37	7/29/04	1311630.57	3027496.41	736.35	738.77	25.0	14.00	24.00	722.35	712.35	Puz	22.20	716.57	25.74	713.03	26.24	712.53
12MWT38	9/11/04	1312353.89	3026531.17	726.05	728.03	25.0	14.00	24.00	712.05	702.05	Puz	10.03	718.00	10.64	717.39	10.63	717.40
12MWT39	7/30/04	1311015.63	3027662.97	735.33	737.64	35.0	24.00	34.00	711.33	701.33	Puz	35.83	701.81	36.05	701.59	35.82	701.82
12MWT40	8/12/04	1310616.56	3027037.67	725.37	727.50	29.0	18.00	28.00	707.37	697.37	Puz	22.23	705.27	23.11	704.39	23.18	704.32
12MWT41	10/27/04	1310642.00	3026376.75	621.30	622.97	35.0	24.00	34.00	597.30	587.30	Mgd	NA	NA	20.33	602.64	20.42	602.55
12MWT42	9/1/04	1312364.70	3026127.28	717.93	720.22	29.0	13.00	28.00	704.93	689.93	Puz	15.03	705.19	13.02	707.20	12.13	708.09
12MWT43	11/12/04	1310955.52	3026125.55	677.03	679.01	81.0	65.00	80.00	612.03	597.03	Plz	NA	NA	78.15	600.86	78.56	600.45
12MWT44	10/27/04	1310276.64	3026617.87	624.81	626.69	35.5	25.00	35.00	599.81	589.81	Mgd	NA	NA	26.25	600.44	26.58	600.11
12MWT45	10/29/04	1313384.30	3027614.01	688.37	691.07	25.0	14.00	24.00	674.37	664.37	Pmz	NA	NA	17.07	674.00	16.03	675.04
12MWT46	10/30/04	1312828.63	3027864.12	673.31	675.67	24.5	14.00	24.00	659.31	649.31	Pmz	NA	NA	16.07	659.60	16.02	659.65
12MWT47	10/31/04	1312455.99	3028025.00	660.79	663.12	25.0	14.00	24.00	646.79	636.79	Pmz	NA	NA	12.85	650.27	12.67	650.45
12MWT48	11/9/04	1312052.61	3028122.50	647.84	650.05	30.0	19.00	29.00	628.84	618.84	Pmz	NA	NA	30.50	619.55	30.41	619.64

TABLE 2-2

MONITORING WELL CONSTRUCTION INFORMATION AND WATER LEVEL MEASUREMENTS
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Well or Gauge Number	Installation Date	Northing (feet)	Easting (feet)	Ground Elevation (feet amsl)	Top of Riser or Reference Point Elevation (feet amsl)	Total Depth (feet bgs)(1)	Screened Interval				Water-Bearing Zone	October 17, 2004		December 15, 2004		January 18, 2005	
							Top (feet bgs)	Bottom (feet bgs)	Top (feet amsl)	Bottom (feet amsl)		Depth to Water (feet btor)	Water Elevation (feet amsl)	Depth to Water (feet btor)	Water Elevation (feet amsl)	Depth to Water (feet btor)	Water Elevation (feet amsl)
12MWT49	11/10/04	1310956.27	3028138.17	616.96	619.25	30.0	19.00	29.00	597.96	587.96	Mgd	NA	NA	30.03	589.22	25.66	593.59
12MWT50	10/29/04	1310582.27	3028100.87	606.85	609.01	35.0	24.00	34.00	582.85	572.85	Mgd	NA	NA	DRY	NA	35.34	573.67
WES-7-1-81	10/3/81	1309481.87	3026477.49	628.95	631.95	41.5	27.02	36.20	601.93	592.75	Plz	NA	NA	NA	NA	20.41	611.54
WES-7-2-81	10/6/81	1309501.85	3026589.93	601.72	604.72	35.0	20.27	29.62	581.45	572.10	Mgd	NA	NA	NA	NA	34.26	570.46
WES-7-3-81	10/6/81	1309677.40	3026457.16	596.22	599.22	38.0	23.40	32.72	572.82	563.50	Mgd	NA	NA	NA	NA	28.82	570.40
WES-7-4-81	10/12/81	1309586.54	3026531.10	595.22	598.22	39.0	24.31	33.64	570.91	561.58	Mgd	NA	NA	NA	NA	26.53	571.69
WES-7-5-81	11/5/81	1309640.94	3026503.16	593.50	596.50	39.0	24.30	33.65	569.20	559.85	Mgd	NA	NA	NA	NA	24.25	572.25
STAFF GAUGES																	
12SG01	10/14/04	1313149.25	3026817.59	NA	730.97	NA	NA	NA	NA	NA	NA	NA	NA	3.19	727.78	Dry	NA
12SG02	10/14/04	1312731.07	3027125.37	NA	731.64	NA	NA	NA	NA	NA	NA	NA	NA	Dry	NA	Dry	NA
12SG03	10/14/04	1312335.43	3027317.19	NA	735.03	NA	NA	NA	NA	NA	NA	NA	NA	1.87	733.16	Dry	NA
12SG04	10/14/04	1311657.15	3027481.28	NA	736.72	NA	NA	NA	NA	NA	NA	NA	NA	4.50	732.22	Dry	NA
12SG05	10/14/04	1310844.41	3026971.44	NA	724.28	NA	NA	NA	NA	NA	NA	NA	NA	Dry	NA	Dry	NA
12SG06	10/14/04	1312141.14	3026445.52	NA	713.38	NA	NA	NA	NA	NA	NA	NA	NA	3.75	709.63	3.95	709.43
12SG07	10/14/04	1312447.98	3026302.90	NA	713.45	NA	NA	NA	NA	NA	NA	NA	NA	4.28	709.17	4.26	709.19
12SG08	10/14/04	1316378.17	3028951.05	NA	668.56	NA	NA	NA	NA	NA	NA	NA	NA	5.05	663.51	5.23	663.33
12SG09	10/14/04	1308584.68	3028722.93	NA	529.35	NA	NA	NA	NA	NA	NA	NA	NA	17.24	512.11	17.40	511.95
12SG10	10/14/04	1307698.34	3029600.29	NA	517.21	NA	NA	NA	NA	NA	NA	NA	NA	14.58	502.63	14.69	502.52
12SG11	10/14/04	1305640.98	3027744.30	NA	513.47	NA	NA	NA	NA	NA	NA	NA	NA	20.00	493.47	19.94	493.53
12SG12	10/14/04	1308475.83	3027438.49	NA	538.45	NA	NA	NA	NA	NA	NA	NA	NA	6.02	532.43	6.05	532.40

Notes:
1 = Total depth of boring, total depth of well may be less.
bgs = Below ground surface.
btor = Below top of riser/reference point.
amsl = Above mean sea level (NAVD88).
NA = Not applicable.
NAVD = North American Vertical Datum

Puz = Upper Pennsylvanian water-bearing zone
Pmz = Middle Pennsylvanian water-bearing zone
Plz = Lower Pennsylvanian water-bearing zone
Mgd = Mississippian (Glen Dean) aquifer

TABLE 2-3

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Sample Number	ANALYSES											
	AVS/SEM	CEC	EXP	Hg	METALS	NH^3	NTIA	SVOCs	VOCs	Cyanide	TOC	MNA
SWMU 12 Groundwater (Round 1)												
12GWT0101			X	X	X	X	X				X	X
12GWT0201			X	X	X	X	X					X
12GWT0301			X	X	X	X	X					
12GWT0401			X	X	X	X	X					X
12GWT0501			X	X	X	X	X					
12GWT0601			X	X	X	X	X					X
12GWT0701			X	X	X	X	X					X
12GWT0801			X	X	X	X	X					
12GWT0901			X	X	X	X	X					X
12GWT1001			X	X	X	X	X					
12GWT1101			X	X	X	X	X					X
12GWT1201			X	X	X	X	X					X
12GWT1301			X	X	X	X	X					
12GWT1401			X	X	X	X	X					X
12GWT1401-F				X	X							
12GWT1501			X	X	X	X	X					
12GWT1601			X	X	X	X	X					X
12GWT1601-F				X	X							
12GWT1701			X	X	X	X	X					X
12GWT1701-F				X	X							
12GWT1801			X	X	X	X	X					
12GWT1901			X	X	X	X	X					X
12GWT2001			X	X	X	X	X					X
12GWT2101			X	X	X	X	X					X
12GWT2201			X	X	X	X	X					X
12GWT2301			X	X	X	X	X					X
12GWT2401			O	O	O	O	O					O
12GWT24A01			X	X	X	X	X					X
12GWT2501			X	X	X	X	X					
12GWT2601			X	X	X	X	X				X	X
12GWT2601-F				X	X							
12GWT2701			X	X	X	X	X					X
12GWT2801			X	X	X	X	X					
12GWT2901			X	X	X	X	X					X
12GWT2901-F				X	X							
12GWT3001			O	O	O	O	O					O
12GWT3101			X	X	X	X	X					X
12GWT3101-F				X	X							
12GWT3201			X	X	X	X	X					X

TABLE 2-3

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Sample Number	ANALYSES											
	AVS/SEM	CEC	EXP	Hg	METALS	NH^3	NTIA	SVOCs	VOCs	Cyanide	TOC	MNA
SWMU 12 Groundwater (Round 1) (Continued)												
12GWT3201-F				X	X							
12GWT3301			X	X	X	X	X				X	X
12GWT3401			X	O	O	O	O					O
12GWT3501			X	X	X	X	X					
12GWT3501-F				X	X							
12GWT3601			X	X	X	X	X					
12GWT3701			X	X	X	X	X					
12GWT3701-F				X	X							
12GWT3801			X	X	X	X	X					
12GWT3901			X	X	X	X	X					
12GWT3901-F				X	X							
12GWT4001			X	X	X	X	X					
12GWT4001-F				X	X							
12GWT4101			X	X	X	X	X					
12GWT4201			X	X	X	X	X					
12GWT4301			X	X	X	X	X					
12GWT4401			X	X	X	X	X					
12GWT4401-F				X	X							
12GWT4501			X	X	X	X	X					
12GWT4601			X	X	X	X	X					
12GWT4701			X	X	X	X	X					
12GWT4801			X	X	X	X	X					
12GWT4801-F				X	X							
12GWT4901			O	O	O	O	O					
12GWT5001			O	O	O	O	O					
Analyzed	**0**	**0**	**47**	**59**	**59**	**46**	**46**	**0**	**0**	**0**	**3**	**23**
Unscheduled	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Omitted	**0**	**0**	**4**	**5**	**5**	**5**	**5**	**0**	**0**	**0**	**0**	**3**
TOTALS	**0**	**0**	**47**	**59**	**59**	**46**	**46**	**0**	**0**	**0**	**3**	**23**
SWMU 12 Groundwater (Round 2)												
12GWT0102			X	X	X	X	X					1
12GWT0202			X	X	X	X	X				X	1
12GWT0302			X	X	X	X	X					
12GWT0402			X	X	X	X	X					1
12GWT0502			X	X	X	X	X					
12GWT0602			X	X	X	X	X					1
12GWT0702			X	X	X	X	X					1
12GWT0802			X	X	X	X	X					
12GWT0902			X	X	X	X	X					1

TABLE 2-3

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Sample Number	ANALYSES											
	AVS/SEM	CEC	EXP	Hg	METALS	NH^3	NTIA	SVOCs	VOCs	Cyanide	TOC	MNA
SWMU 12 Groundwater (Round 2) (Continued)												
12GWT1002			X	X	X	X	X					
12GWT1102			X	X	X	X	X					
12GWT1202			X	X	X	X	X					1
12GWT1302			X	X	X	X	X					
12GWT1402			X	X	X	X	X					1
12GWT1402-F				X	X							
12GWT1502			X	X	X	X	X					
12GWT1602			X	X	X	X	X					1
12GWT1602-F				X	X							
12GWT1702			X	X	X	X	X					1
12GWT1702-F				X	X							
12GWT1802			X	X	X	X	X					
12GWT1802-F				X	X							
12GWT1902			X	X	X	X	X					1
12GWT1902-F				X	X							
12GWT2002			X	X	X	X	X					
12GWT2102			X	X	X	X	X					1
12GWT2202			X	X	X	X	X					1
12GWT2302			X	X	X	X	X					1
12GWT2402			O	O	O	O	O					1
12GWT24A02			X	X	X	X	X					1
12GWT2502			X	X	X	X	X					
12GWT2602			X	X	X	X	X				X	1
12GWT2702			X	X	X	X	X					1
12GWT2802			X	X	X	X	X					
12GWT2902			X	X	X	X	X					1
12GWT2902-F				X	X							
12GWT3002			O	O	O	O	O					1
12GWT3102			X	X	X	X	X					1
12GWT3102-F				X	X							
12GWT3202			X	X	X	X	X					1
12GWT3202-F				X	X							
12GWT3302			X	X	X	X	X				X	1
12GWT3402			X	O	O	O	O					1
12GWT3502			X	X	X	X	X					
12GWT3602			X	X	X	X	X					
12GWT3702			O	O	O	O	O					
12GWT3802			X	X	X	X	X					
12GWT3902			X	X	X	X	X					

TABLE 2-3

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Sample Number	ANALYSES											
	AVS/SEM	CEC	EXP	Hg	METALS	NH^3	NTIA	SVOCs	VOCs	Cyanide	TOC	MNA
SWMU 12 Groundwater (Round 2) (Continued)												
12GWT3902-F				X	X							
12GWT4002			X	X	X	X	X					
12GWT4002-F				X	X							
12GWT4102			X	X	X	X	X					
12GWT4202			X	X	X	X	X					
12GWT4302			X	X	X	X	X					
12GWT4302-F				X	X							
12GWT4402			X	X	X	X	X					
12GWT4502			X	X	X	X	X					
12GWT4502-F				X	X							
12GWT4602			X	X	X	X	X					
12GWT4602-F				X	X							
12GWT4702			X	X	X	X	X					
12GWT4802			X	X	X	X	X					
12GWT4802-F				X	X							
12GWT4901			X	X	X	X	X					
12GWT4901-F				X	X							
12GWT5001			O	O	O	O	O					
Analyzed	**0**	**0**	**47**	**61**	**61**	**46**	**46**	**0**	**0**	**0**	**3**	**0**
Unscheduled	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Omitted	**0**	**0**	**4**	**5**	**5**	**5**	**5**	**0**	**0**	**0**	**0**	**0**
TOTALS	**0**	**0**	**47**	**61**	**61**	**46**	**46**	**0**	**0**	**0**	**3**	**0**
SWMU 25 Groundwater (Round 2)												
25GW0101			O	O	O							
25GW0201			X	X	X							
25GW0201-F				X	X							
25GW0301			X	X	X							
25GW0401			O	O	O							
25GW0501			X	X	X							
Analyzed	**0**	**0**	**3**	**4**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Unscheduled	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Omitted	**0**	**0**	**2**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
TOTALS	**0**	**0**	**3**	**4**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SWMU 12 Surface Soil (Round 1)												
12SS010002			X	X	X			X	X	X		
12SS020002		X				X					X	
12SS030002		X				X					X	
12SS040002			X	X	X							
12SS050002			X	X	X							

TABLE 2-3

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Sample Number	ANALYSES											
	AVS/SEM	CEC	EXP	Hg	METALS	NH^3	NTIA	SVOCs	VOCs	Cyanide	TOC	MNA
SWMU 12 Surface Soil (Round 1) (Continued)												
12SS060002			X	X	X							
12SS070002			X	X	X							
12SS080002			X	X	X							
12SS090002			X	X	X							
12SS100002			X	X	X							
12SS110002			X	X	X							
12SS120002			X	X	X			X	X			
12SS130002			X	X	X			X	X			
12SS140002			X	X	X			X	X			
12SS150002			X	X	X			X	X			
12SS160002			O	O	O			O	O			
12SS170002			O	O	O			O	O			
12SS180002			X	X	X			X	X			
12SS190002			X	X	X			X	X			
12SS200002			X	X	X			X	X			
12SS210002(1)			X	X	X			X	X			
12SS220002(1)			X	X	X			X	X			
12SS230002(1)			X	X	X			X	X			
12SS240002(1)			X	X	X			X	X			
Analyzed	**0**	**2**	**20**	**20**	**20**	**2**	**0**	**12**	**12**	**1**	**2**	**0**
Unscheduled	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Omitted	**0**	**0**	**2**	**2**	**2**	**0**	**0**	**2**	**2**	**0**	**0**	**0**
TOTALS	**0**	**2**	**20**	**20**	**20**	**2**	**0**	**12**	**12**	**1**	**2**	**0**
SWMU 12 Subsurface Soil (Round 1)												
12SB010609			X	X	X			X	X	X		
12SB020608		X				X					X	
12SB030608		X				X					X	
12SB040207			X	X	X							
12SB040712			X	X	X							
12SB050204			X	X	X							
12SB050509			X	X	X							
12SB060205			X	X	X							
12SB060509			X	X	X							
12SB070206			X	X	X							
12SB070610			X	X	X							
12SB080204			X	X	X							
12SB080507			X	X	X							
12SB090205			X	X	X							
12SB090508			X	X	X							

TABLE 2-3

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Sample Number	ANALYSES											
	AVS/SEM	CEC	EXP	Hg	METALS	NH^3	NTIA	SVOCs	VOCs	Cyanide	TOC	MNA
SWMU 12 Subsurface Soil (Round 1) (Continued)												
12SB100205			X	X	X							
12SB100508			X	X	X							
12SB110205			X	X	X							
12SB110507			X	X	X							
12SB120204			X	X	X			X	X			
12SB120608			O	O	O			O	O			
12SB130204			X	X	X			X	X			
12SB130607			X	X	X			X	X			
12SB140204			X	X	X			X	X			
12SB140607			X	X	X			X	X			
12SB150204			X	X	X			X	X			
12SB150607			X	X	X			X	X			
12SB160204			O	O	O			O	O			
12SB160608			O	O	O			O	O			
12SB170204			O	O	O			O	O			
12SB170608			O	O	O			O	O			
12SB180204			X	X	X			X	X			
12SB180608			X	X	X			X	X			
12SB190204			X	X	X			X	X			
12SB190608			O	O	O			O	O			
12SB200204			X	X	X			X	X			
12SB200608			X	X	X			X	X			
Analyzed	**0**	**2**	**29**	**29**	**29**	**2**	**0**	**13**	**13**	**1**	**2**	**0**
Unscheduled	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Omitted	**0**	**0**	**6**	**6**	**6**	**0**	**0**	**6**	**6**	**0**	**0**	**0**
TOTALS	**0**	**2**	**29**	**29**	**29**	**2**	**0**	**13**	**13**	**1**	**2**	**0**
SWMU 12 Surface Water (Round 1)												
12SW0101			X	X	X	X	X					
12SW0101-F				X	X							
12SW0201			X	X	X	X	X					
12SW0201-F				X	X							
12SW0301			X	X	X	X	X	X				
12SW0301-F				X	X							
12SW0401			X	X	X	X	X					
12SW0401-F				X	X							
12SW0501			X	X	X	X	X					
12SW0501-F				X	X							
12SW0601			X	X	X	X	X					
12SW0601-F				X	X							
12SW0701			X	X	X	X	X					

TABLE 2-3

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Sample Number	ANALYSES											
	AVS/SEM	CEC	EXP	Hg	METALS	NH^3	NTIA	SVOCs	VOCs	Cyanide	TOC	MNA
SWMU 12 Surface Water (Round 1) (Continued)												
12SW0701-F				X	X							
12SW0801			X	X	X	X	X					
12SW0801-F				X	X							
12SW0901			X	X	X	X	X					
12SW0901-F				X	X							
12SW1001-F			X	X	X	X	X					
12SW1001-F				X	X							
12SW1101			X	X	X	X	X					
12SW1101-F				X	X							
12SW1201			X	X	X	X	X					
12SW1201-F				X	X							
12SW1301			X	X	X	X	X					
12SW1301-F				X	X							
12SW1401			X	X	X	X	X					
12SW1401-F				X	X							
12SW1501			X	X	X	X	X					
12SW1501-F				X	X							
12SW1601			X	X	X	X	X					
12SW1601-F				X	X							
12SW1701			X	X	X	X	X					
12SW1701-F				X	X							
12SW1801			X	X	X	X	X					
12SW1801-F				X	X							
12SW1901			X	X	X	X	X					
12SW1901-F				X	X							
12SW2001			X	X	X	X	X					
12SW2001-F				X	X							
12SW2101			X	X	X	X	X					
12SW2101-F				X	X							
12SW2201			X	X	X	X	X					
12SW2201-F				X	X							
12SW2301			X	X	X	X	X					
12SW2301-F				X	X							
12SW2401			X	X	X	X	X					
12SW2401-F				X	X							
12SW2501			X	X	X	X	X					
12SW2501-F				X	X							
12SW2601			X	X	X	X	X					
12SW2601-F				X	X							

TABLE 2-3

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Sample Number	ANALYSES											
	AVS/SEM	CEC	EXP	Hg	METALS	NH^3	NTIA	SVOCs	VOCs	Cyanide	TOC	MNA
SWMU 12 Surface Water (Round 1) (Continued)												
12SW2701			X	X	X	X	X					
12SW2701-F				X	X							
12SW2801			X	X	X	X	X					
12SW2801-F				X	X							
12SW2901			X	X	X	X	X					
12SW2901-F				X	X							
12SW3001			X	X	X	X	X					
12SW3001-F				X	X							
Analyzed	**0**	**0**	**30**	**60**	**60**	**30**	**30**	**1**	**0**	**0**	**0**	**0**
Unscheduled	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Omitted	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
TOTALS	**0**	**0**	**30**	**60**	**60**	**30**	**30**	**1**	**0**	**0**	**0**	**0**
SWMU 12 Surface Water (Round 2)												
12SW0102			X	X	X	X	X					
12SW0102-F				X	X							
12SW0202			X	X	X	X	X					
12SW0202-F				X	X							
12SW0302			X	X	X	X	X	X				
12SW0302-F				X	X							
12SW0402			X	X	X	X	X					
12SW0402-F				X	X							
12SW0502			X	X	X	X	X					
12SW0502-F				X	X							
12SW0602			X	X	X	X	X					
12SW0602-F				X	X							
12SW0702			O	O	O	O	O					
12SW0802			X	X	X	X	X					
12SW0802-F				X	X							
12SW0902			X	X	X	X	X					
12SW0902-F				X	X							
12SW1002			X	X	X	X	X					
12SW1002-F				X	X							
12SW1102			X	X	X	X	X					
12SW1102-F				X	X							
12SW1202			X	X	X	X	X					
12SW1202-F				X	X							
12SW1302			X	X	X	X	X					
12SW1302-F				X	X							
12SW1402			X	X	X	X	X					

TABLE 2-3

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Sample Number	ANALYSES											
	AVS/SEM	CEC	EXP	Hg	METALS	NH^3	NTIA	SVOCs	VOCs	Cyanide	TOC	MNA
SWMU 12 Surface Water (Round 2) (Continued)												
12SW1402-F				X	X							
12SW1502			O	O	O	O	O					
12SW1602			X	X	X	X	X					
12SW1602-F				X	X							
12SW1702			X	X	X	X	X					
12SW1702-F				X	X							
12SW1802			X	X	X	X	X					
12SW1802-F				X	X							
12SW1902			O	O	O	O	O					
12SW2002			X	X	X	X	X					
12SW2002-F				X	X							
12SW2102			O	O	O	O	O					
12SW2202			O	O	O	O	O					
12SW2302			X	X	X	X	X					
12SW2302-F				X	X							
12SW2402			X	X	X	X	X					
12SW2402-F				X	X							
12SW2502			X	X	X	X	X					
12SW2502-F				X	X							
12SW2602			X	X	X	X	X					
12SW2602-F				X	X							
12SW2702			X	X	X	X	X					
12SW2702-F				X	X							
12SW2802			X	X	X	X	X					
12SW2802-F				X	X							
12SW2902			O	O	O	O	O					
12SW3002			O	O	O	O	O					
12SW3102			X	X	X	X	X					
12SW3102-F				X	X							
12SW3201			X	X	X	X	X					
12SW3201-F				X	X							
12SW3301			X	X	X	X	X					
12SW3301-F				X	X							
12SW3401			X	X	X	X	X					
12SW3401-F				X	X							
12SW3501			X	X	X	X	X					
12SW3501-F				X	X							
12SW3601			X	X	X	X	X					
12SW3601-F				X	X							

TABLE 2-3

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Sample Number	ANALYSES											
	AVS/SEM	CEC	EXP	Hg	METALS	NH^3	NTIA	SVOCs	VOCs	Cyanide	TOC	MNA
SWMU 12 Surface Water (Round 2) (Continued)												
12SW3701			0	0	0	0	0					
12SW3801			0	0	0	0	0					
12SW3901			0	0	0	0	0					
12SW4001			0	0	0	0	0					
Analyzed	**0**	**0**	**29**	**58**	**58**	**29**	**29**	**1**	**0**	**0**	**0**	**0**
Unscheduled	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Omitted	**0**	**0**	**7**	**7**	**7**	**7**	**7**	**0**	**0**	**0**	**0**	**0**
TOTALS	**0**	**0**	**29**	**58**	**58**	**29**	**29**	**1**	**0**	**0**	**0**	**0**
SWMU 12 Seep (Round 1)												
12SP0101				O	O	O	O					
12SP0101-F				O	O							
12SP0201				O	O							
12SP0201-F				O	O							
12SP0301				O	O	O	O					
12SP0301-F				O	O							
12SP0401				O	O							
12SP0401-F				O	O							
12SP0501				O	O	O	O					
12SP0501-F				O	O							
Analyzed	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Unscheduled	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Omitted	**0**	**0**	**0**	**10**	**10**	**3**	**3**	**0**	**0**	**0**	**0**	**0**
TOTALS	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
SWMU 12 Sediment (Round 1)												
12SD010004	X	O	X	X	X						O	
12SD020004			X	X	X							
12SD030004			X	X	X			X				
12SD040004	X	O	X	X	X						O	
12SD050004			X	X	X							
12SD060004			X	X	X							
12SD070004		U	X	X	X			X			U	
12SD080004			X	X	X							
12SD090004			X	X	X			X				
12SD100004	X	X	X	X	X						X	
12SD110004			X	X	X							
12SD120004			X	X	X							
12SD130004	X	X	X	X	X						X	
12SD140004			X	X	X							
12SD150004			X	X	X							

TABLE 2-3

SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSES
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Sample Number	ANALYSES											
	AVS/SEM	CEC	EXP	Hg	METALS	NH^3	NTIA	SVOCs	VOCs	Cyanide	TOC	MNA
SWMU 12 Sediment (Round 1) (Continued)												
12SD160004	X	X	X	X	X						X	
12SD170004			X	X	X							
12SD180004			X	X	X							
12SD190004	X	X	X	X	X						X	
12SD200004			X	X	X							
12SD210004			X	X	X							
12SD220004	X	X	X	X	X						X	
12SD230004			X	X	X							
12SD240004			X	X	X							
12SD250004			X	X	X							
12SD260004			X	X	X							
12SD270004			X	X	X							
12SD280004			X	X	X							
12SD290004			X	X	X							
12SD300004			X	X	X							
Analyzed	**7**	**5**	**30**	**30**	**30**	**0**	**0**	**3**	**0**	**0**	**5**	**0**
Unscheduled	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**
Omitted	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**
TOTALS	**7**	**6**	**30**	**30**	**30**	**0**	**0**	**3**	**0**	**0**	**6**	**0**

1 - Confirmation sample after Toltest excavation (Battery Disposal Area).
X = Analyzed.
U = Unscheduled.
O = Omitted (See Table 2-4 for reason).
AVS/SEM - Acid volatile/simultaneously extracted metals.
CEC - Cation exchange capacity.
EXP - Explosives.
Hg - Mercury.
NH^3 - Ammonia.
NTIA - Nitrite/nitrate.
SVOCs - Semivolatile organic compounds including pentachlorophenol and hexachlorophene.
VOCs - Volatile organic compounds.
TOC - Total organic carbon.
MNA - Monitored natural attenuation.
Water samples with a -F designation were filtered in the field prior to preparation.
Metals - U.S. EPA Contract Laboratory Program Target Analyte List Metals.

TABLE 2-4

RATIONALE FOR OMITTED AND USCHEDULED SAMPLING
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

Sample Number	Analytical Fraction												REASON
	AVS/SEM	CEC	EXP	Hg	METALS	NH^3	NTIA	SVOCs	VOCs	Cyanide	TOC	MNA	
SWMU 12 Groundwater (Round 1)													
12GWT2401			O	O	O	O	O					O	Dry well
12GWT3001			O	O	O	O	O					O	Dry well
12GWT3401				O	O	O	O					O	Well went dry during sampling
12GWT4901			O	O	O	O	O						Well went dry during sampling
12GWT5001			O	O	O	O	O						Dry well
SWMU 12 Groundwater (Round 2)													
12GWT2402			O	O	O	O	O					O	Dry well
12GWT3002			O	O	O	O	O					O	Dry well
12GWT3402				O	O	O	O					O	Well went dry
12GWT3702			O	O	O	O	O						Dry well
12GWT5001			O	O	O	O	O						Dry well
SWMU 25 Groundwater													
25GW0101			O	O	O								Not proposed; historically dry
25GW0401			O	O	O								Well casing obstructed
SWMU 12 Surface Soil (Round 1)													
12SS160002			O	O	O			O	O				Refusal at surface
12SS170002			O	O	O			O	O				Refusal at surface
SWMU 12 Subsurface Soil (Round 1)													
12SB120608			O	O	O			O	O				Refusal at 4 feet
12SB160204			O	O	O			O	O				Refusal at surface
12SB160608			O	O	O			O	O				Refusal at surface
12SB170204			O	O	O			O	O				Refusal at surface
12SB170608			O	O	O			O	O				Refusal at surface
12SB190608			O	O	O			O	O				Refusal at 4 feet
SWMU 12 Surface Water (Round 2)													
12SW0702			O	O	O	O	O						Dry
12SW1502			O	O	O	O	O						Dry
12SW1902			O	O	O	O	O						Dry
12SW2102			O	O	O	O	O						Dry
12SW2202			O	O	O	O	O						Dry
12SW2902			O	O	O	O	O						Dry
12SW3002			O	O	O	O	O						Dry
12SW3701			O	O	O	O	O						Discretionary
12SW3801			O	O	O	O	O						Discretionary
12SW3901			O	O	O	O	O						Discretionary
12SW4001			O	O	O	O	O						Discretionary
SWMU 12 Seep (Round 1)													
12SP0101				O	O	O	O						Not located
12SP0101-F				O	O								Not located
12SP0201				O	O								Not located
12SP0201-F				O	O								Not located
12SP0301				O	O	O	O						Not located
12SP0301-F				O	O								Not located
12SP0401				O	O								Not located
12SP0401-F				O	O								Not located
SWMU 12 Seep (Round 1) (Continued)													

TABLE 2-4

RATIONALE FOR OMITTED AND USCHEDULED SAMPLING
SWMU 12 - MINE FILL A
ROUNDS 1 AND 2
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction												REASON
	AVS/SEM	CEC	EXP	Hg	METALS	NH^3	NTIA	SVOCs	VOCs	Cyanide	TOC	MNA	
12SP0501				O	O	O	O						Not located
12SP0501-F				O	O								Not located
SWMU 12 Sediment (Round 1)													
12SD010004		O									O		Missed sample
12SD040004		O						O			O		Missed sample
12SD060004								O					Missed sample
12SD070004		U									U		Extra sample collected

U - Unscheduled sample.
O - Omitted sample.
AVS/SEM - Acid volatile/simultaneously extracted metals.
CEC - Cation exchange capacity.
EXP - Explosives.
F - Filtered.
Hg - Mercury.
MNA - Monitored natural attenuation.
NH^3 - Ammonia.
NTIA - Nitrite/nitrate.
SVOCs - Semivolatile organic comounds including pentachlorophenol and hexachlorophene.
VOCs - Volatile organic compounds.
TOC - Total organic carbon.

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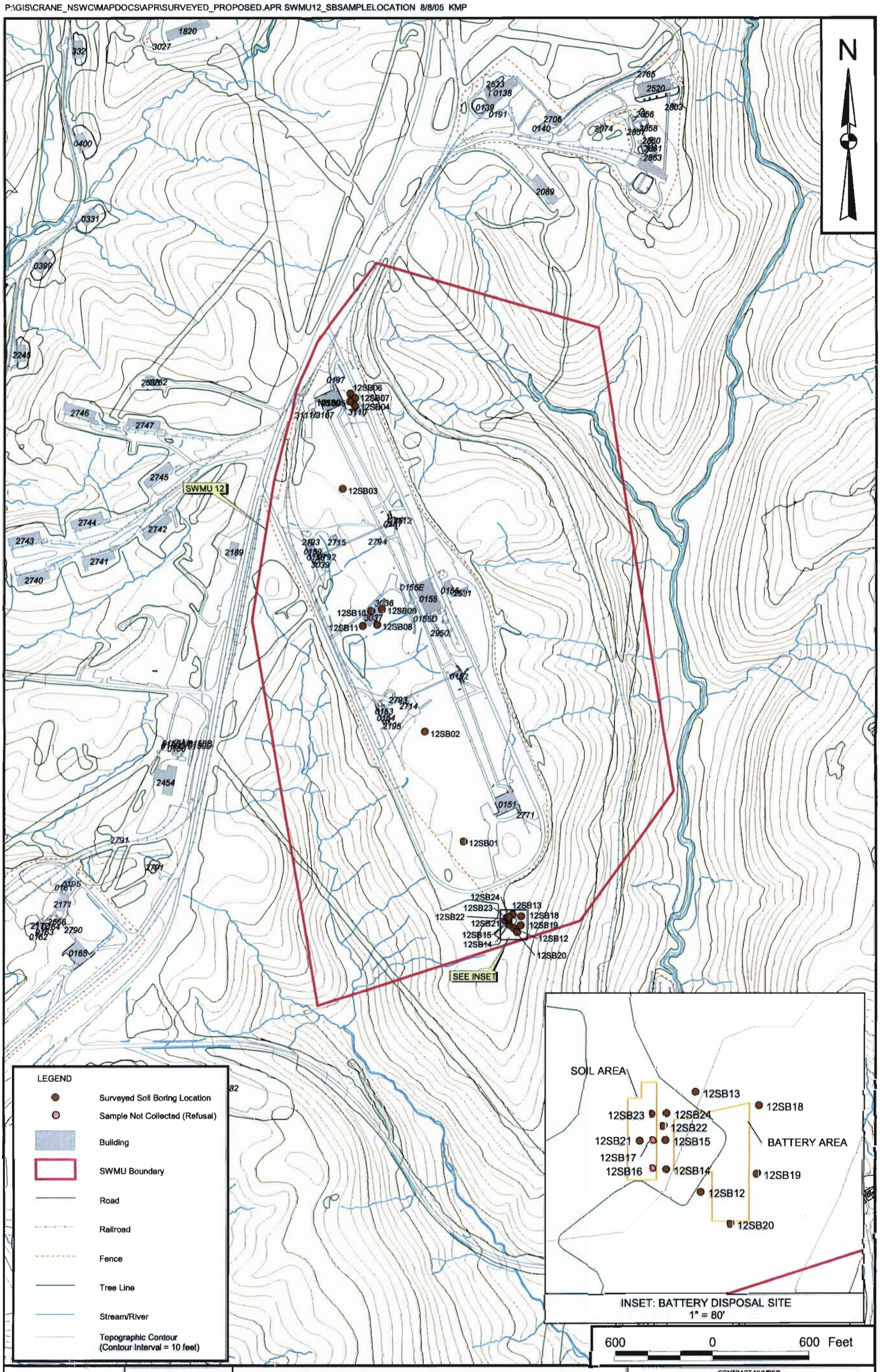

DRAWN BY	DATE
K. PEILA	6/17/05
CHECKED BY	DATE
J. LUCAS	6/17/05
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

NAVFAC

SURVEYED SOIL BORING LOCATIONS
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER	
6878	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 2 - 1	0

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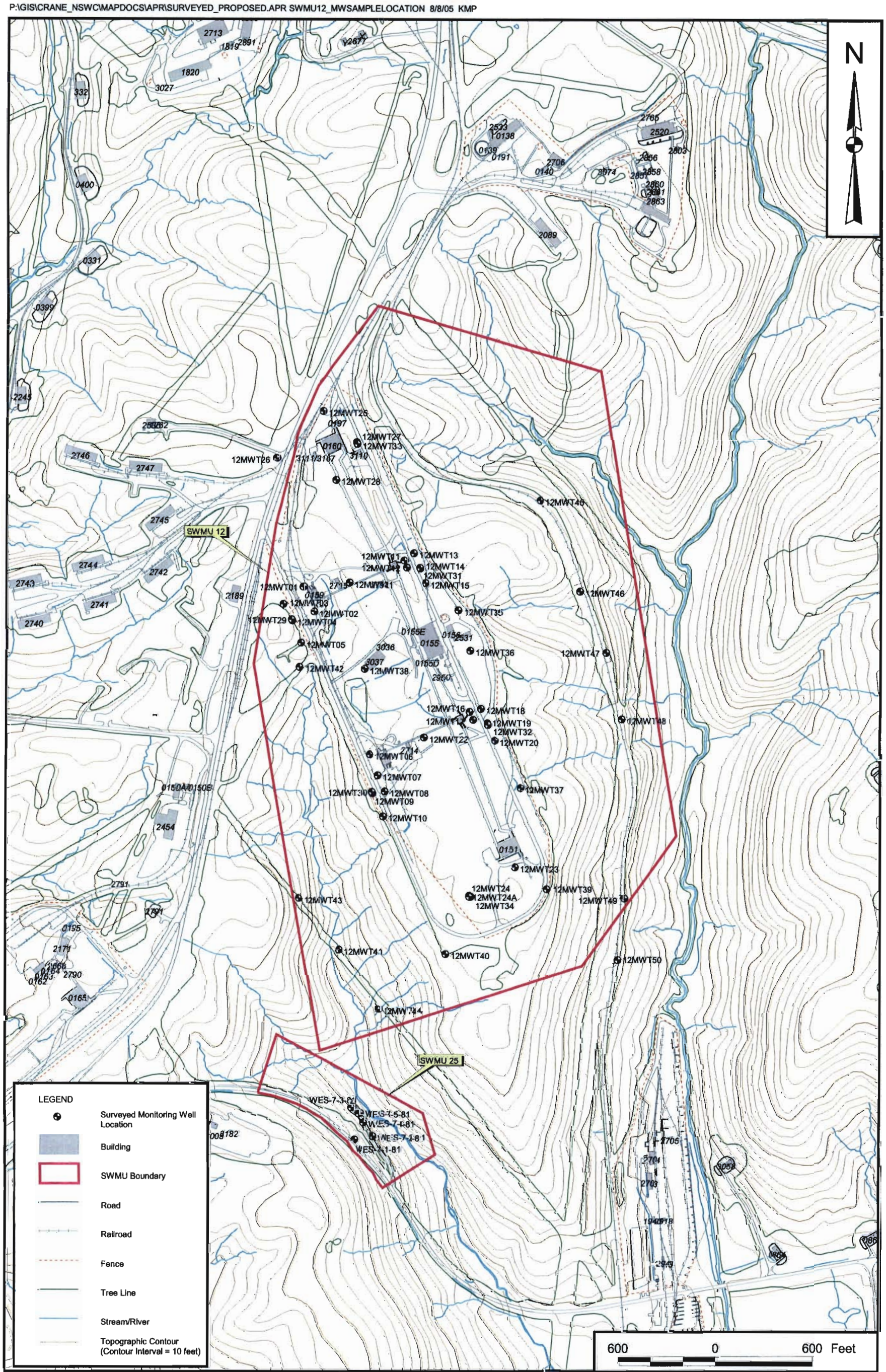


DRAWN BY	DATE
K. PEILA	3/23/05
CHECKED BY	DATE
J. GOERDT	3/23/05
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

NAVFAC

SURVEYED MONITORING WELL LOCATIONS

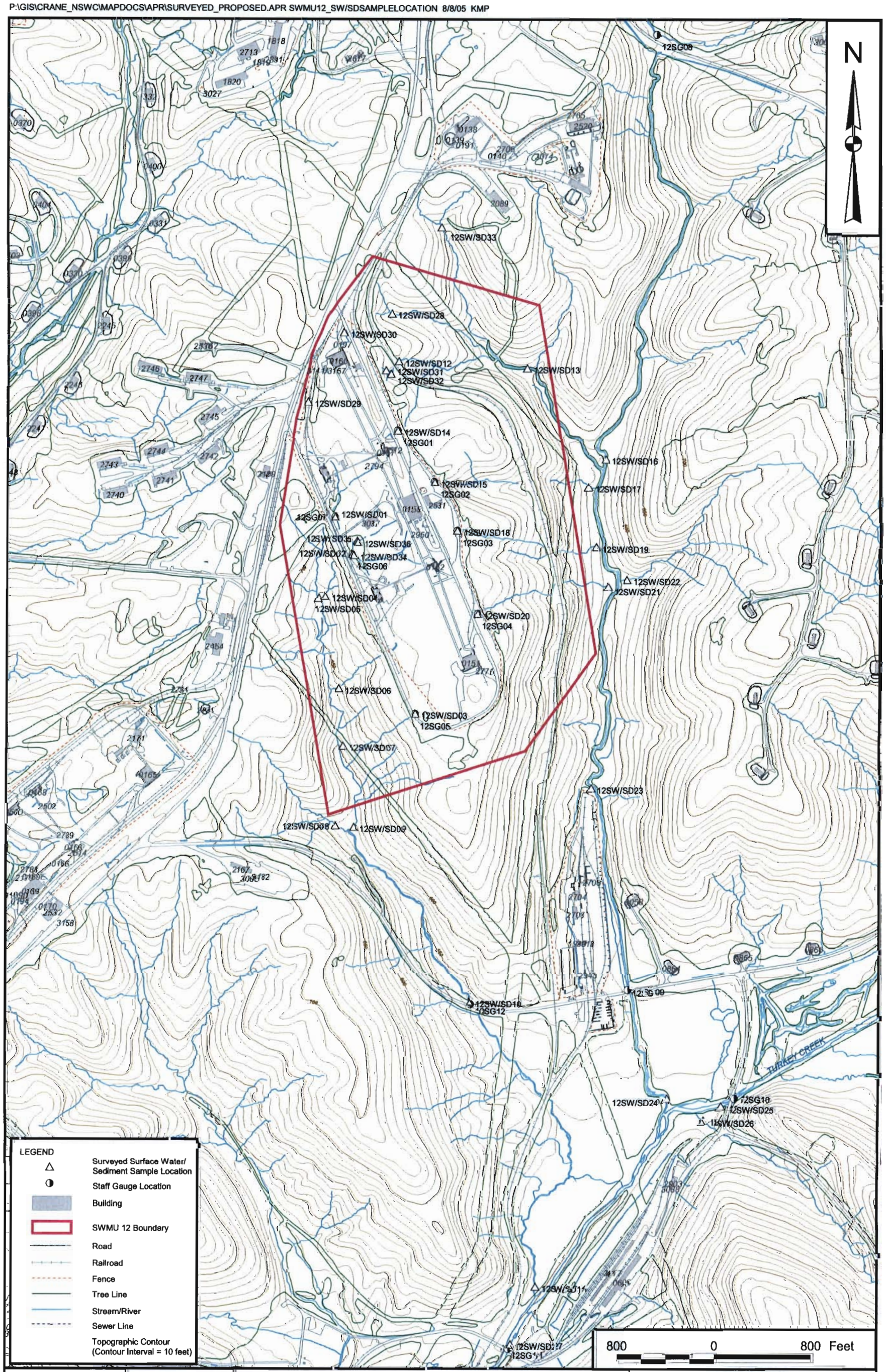
SWMU 12 - MINE FILL A AND SWMU 25 - HIGHWAY 58 DUMP SITE A

NSWC CRANE

CRANE, INDIANA

CONTRACT NUMBER	
6878	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 2 - 2	0

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SURVEYED_PROPOSED.APR SWMU12_SW/SDSAMPLELOCATION 8/8/05 KMP



DRAWN BY K. PEILA	DATE 5/31/05	SURVEYED SURFACE WATER/SEDIMENT SAMPLE AND STAFF GAUGE LOCATIONS SWMU 12 - MINE FILL A NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	CONTRACT NUMBER 6878
CHECKED BY J. LUCAS	DATE 5/31/05		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 2 - 3 REV 0

3.0 DATA PRESENTATION AND QUALITY

This section describes the data and summarizes the data quality for four separate data sets. Data presentation is provided in Section 3.1; data quality is described in Section 3.2.

3.1 DATA PRESENTATION

MK collected samples in support of a bioremediation effort designed to reduce the concentrations of explosives in the soil. Soil was excavated from areas around select buildings and was composted. The areas to be excavated were determined using ICSs. Most samples were collected by MK from February 19, 1997 to October 20, 1998. Toltest supported this effort by also collecting samples. The last Toltest sample was collected on September 20, 2000. The bioremediated soil was used to replace excavated soil, but not necessarily from the same location from which it was originally obtained. The last backfilling of excavations with composted soil was completed on January 31, 2001. Concentrations of select VOCs, metals, and explosives were measured before, during, and after the bioremediation operations. The draft IMR and addendum for SWMU 12 present a summary of the data quality for the bioremediation program (MK, 2000a and 2002). More than 10 percent of the data were validated, and no significant problems were identified. No attempt by TtNUS was made to perform additional validation of the data, in part, because the data were not available in electronic form and also because no problems were identified with the validation that was conducted. The majority of IMR data are presented in a draft IMR (MK, 2000a). The addendum to the draft IMR was issued in January 2002.

Excavation activities also took place at the SWMU 12 Battery Site on September 27, 2001 and June 18, 2002. The areas of excavation are depicted in the inset of Figure 2-1. The soil was either disposed off site or was incorporated into bioremediation windrows for Mine Fill B. The Mine Fill B windrows were used for bioremediating soils from Mine Fill B and were composted in a manner similar to SWMU 12 (MFA) soils. The materials excavated from the Battery Site were used to fill excavations associated with the Mine Fill B explosives bioremediation. Therefore, data and data quality for the excavated soil from the Battery Site of SMWU 12 are not discussed further. Data remaining at the Battery Site after excavations are presented in this report.

The surface and subsurface soils for the explosives excavations were first characterized using field screening and laboratory confirmation analyses. After identifying areas of unacceptably high explosives concentrations, soil was excavated from the areas of contamination and sent to the composting facility at NSWC Crane that was built specifically for the treatment of explosives in soils. After treatment and

verification that explosives concentrations had been satisfactorily reduced, the soils were returned to the SWMU 12 excavations. Southwest Laboratory of Oklahoma, Inc. and Quanterra, Inc. of California conducted the laboratory analyses for bioremediation operations at SWMU 12. The resulting data were validated independently. Details of these operations are provided in the IMR (MK, 2000a and 2002).

RFI data were collected by TtNUS in two rounds as described in Section 2.0 of this report. Samples collected at the SWMU proper were collected from locations 12SB01 through 12SB11. Soil samples collected at the Battery Site of SWMU 12 were collected from locations 12SB12 through 12SB24. A complete list of samples collected and scheduled samples that were not collected is presented in Table 2-3. Table 2-4 presents reasons for not collecting scheduled samples. Laucks Testing Laboratory conducted the analyses, which are summarized for each sample in Table 2-3. Validation and quality review of the data were conducted by TtNUS as described in Section 3.2. The subsections immediately below present descriptions of available background data and SWMU 12 site data.

3.1.1 Background Data Set Descriptions

3.1.1.1 SWMU 12 Surface Soil Background Concentrations

In addition to the bioremediation and RFI data collections described above, soil samples were previously collected and analyzed in an effort to establish the concentrations of metals representative of the entire NSWC Crane complex (TtNUS, 2001). All metals likely to be included in NSWC Crane environmental investigations were analyzed in that effort. The intent was to provide background soil data sets that could be used to gain perspective on whether observed metals concentrations in SWMU soils are indicative of background concentrations.

Soil samples were classified into Soil Groups that uniquely represent the chemical and physical soil characteristics that cause the various Crane soils to differ. Those characteristics are as follows:

- Geological parent material (referred to as Depositional Environment in the Final Basewide Background Soil Investigation Report (TtNUS, 2001)
- Depth (surface or subsurface)
- Grain size (subsurface only)

The details of sample collection and data generation are provided in TtNUS, 2001. For SWMU 12, there is one Depositional Environment (Pennsylvanian) and two depths (surface and subsurface). In the subsurface, there are two distinct grain size classifications. The classifications are "sand" and "silt/clay."

After chemical analyses and extensive statistical testing, one distinct Soil Group emerged as representing SWMU 12 surface soils:

- Soil Group 3 – Alluvial, Mississippian, and Pennsylvanian surface soil

Tables 3-1 and 3-2 of this RFI report present summaries of the NSWC Crane surface soil background data (TtNUS, 2001). Table 3-1 shows concentration ranges and related statistics for all NSWC Crane soils, regardless of Depositional Environment, depth, or grain size. This table helps the data user understand how an individual SWMU-specific background data set compares to the data set for all of NSWC Crane. Table 3-2 presents surface soil background data summaries specific to SWMU 12 (Alluvial, Mississippian, and Pennsylvanian surface soil)

The tables indicate the metals that were analyzed, the frequencies of detection, the measured concentration ranges, simple summary statistics, an estimate of the statistical distribution shape, and an estimate of the concentration that encompasses 95 percent of the data, on average (95 percent upper tolerance limit).

3.1.1.2 SWMU 12 Subsurface Soil Background Concentrations

Similar to surface soils, the NSWC Crane basewide background soil collection effort yielded one distinct Soil Group that represents SWMU 12 subsurface soil metals concentrations:

- Soil Group 8 – Pennsylvanian Subsurface Clay and Silt

Table 3-3 presents the data associated with this Soil Group.

3.1.1.3 SWMU 12 Surface Water, Sediment, and Groundwater Upgradient Concentrations

For mobile environmental media such as surface water, sediment, and groundwater, "background" concentrations are represented by upgradient locations and data. These locations represent concentrations of chemicals that are unaffected by SWMU operations. The upgradient locations are not necessarily free from contamination, but they do represent locations that are free from site-related contamination for the site of interest (in this case, SWMU 12).

During this investigation, groundwater wells were identified as being upgradient to SWMU 12 for different water-bearing geologic units. Wells 12MWT25, 12MWT26, 12MWT27, and 12MWT28 are upgradient in

the Puz, well 12MWT33 is upgradient in the Pmz wells, and well 12MWT43, which is more sidegradient than upgradient, is representative of upgradient conditions for the Plz and Mgd wells. The Plz and Mgd wells are treated as a single group. Locations 12SW/SD08, 12SW/SD22, 12SW/SD26, 12SW/SD28, 12SW/SD29, 12SW/SD30, and 12SW/SD33 are upgradient of steam channels classified as gully channels. For the east tributary to Turkey Creek, there is one location (12SW/SD16) representative of upgradient conditions. For Turkey Creek, location 12SW/SD25 is representative of upgradient conditions. These two locations are upgradient of their respective site sampling locations and were selected because they are in areas that appear to be free of influence from SWMU 12 operations. The gullies are on steeper slopes and drain more quickly than the TCMS areas. In the Appendix G tables, each upgradient sample is identified as such.

The maximum observed chemical concentrations are almost certain to be contained in the site (i.e., SWMU 12) surface water and sediment data (rather than the upgradient data) even if the SWMU 12 data represent the same material as the upgradient data. This is a result of having far fewer upgradient samples than downgradient samples. Nevertheless, the available upgradient data do provide some insight into conditions upgradient of SMWU 12, when one considers the relative sizes of the site and upgradient data sets. The significance of this is case specific and is addressed where appropriate throughout this report.

3.1.2 SWMU 12 Data Set Descriptions

3.1.2.1 SWMU 12 Surface Soil Site Data

Surface soil samples were analyzed extensively for energetic compounds and to a lesser extent for metals and VOCs during the bioremediation operations. Surface soil data generated during the bioremediation operations are summarized in the draft IMR and IMR addendum (MK, 2000a and 2002). Graphical representations of the soil explosives concentrations left in place at the completion of the composting effort are provided in Section 1.0.

In RFI Round 1, select surface soil samples were collected for explosives, metals, SVOC, VOC, and miscellaneous analyses as described in Section 2.0. Surface soils were analyzed in RFI Round 1 only (See Table 2-3).

The Round 1 data for SMWU 12 surface soils are summarized in Tables 3-4 through 3-7. Table 3-4 and 3-5 present data for surface soil of the Mine Fill A Proper and Battery Site, respectively, that were generated during Round 1 of the RFI. Table 3-6 contains data for surface soil from the Battery Site

collected to delineate metal contamination in October 2005 and again in October 2006. Table 3-7 contains surface soil data from across the Mine Fill A Proper collected during the external sump and drainage investigation. Tables 3-4 through 3-7 indicate how often each chemical was detected, the locations of maximum concentrations, etc. Appendix Tables G-1 through G-3 provide all surface and subsurface soil sample data collected for the RFI. The samples in these appendix tables are marked as to which area and phase of the RFI they belong (MFA and BDA for Mine Fill A and Battery Disposal Area data from Round 1 of the RFI, MCD for the metals contamination delineation, and ES/DI for the external sump/drainage investigation). Tables 3-4 through 3-7 indicate how often each chemical was detected, the locations of maximum concentrations, etc. Tables 3-8 through 3-11 are similar to Table G-1 but display results only for chemicals that were detected at least once in surface or subsurface soil. For each chemical that falls into this category, all results, including non-detects and rejected values, if applicable, are shown in Tables 3-8 through 3-11.

3.1.2.2 SWMU 12 Subsurface Soil Site Data

Subsurface soil samples were analyzed extensively for energetic compounds and to a lesser extent for metals and VOCs during the composting operations. Subsurface soil data generated during the composting operations are summarized in the draft IMR and IMR addendum (MK, 2000a, and 2002). Graphical representations of the soil explosives concentrations left in place at the completion of the composting effort are provided in Section 1.0.

In RFI Round 1, select subsurface soil samples were collected for explosives, metals, SVOC, VOC, and miscellaneous analyses as described in Section 2.0. Subsurface soils were analyzed in RFI Round 1 only (See Table 2-3).

Some subsurface soil samples were not collected as scheduled. Explanations for why certain samples were not collected and why other samples were collected in addition to the scheduled samples are provided in Section 2.0 and Table 2-4. The Round 1 data for SMWU 12 subsurface soils are summarized in Tables 3-12 through 3-15. These tables indicate how often each chemical was detected, the locations of maximum concentrations, etc. Appendix Tables G-1 through G-3 provide analytical results of all surface and subsurface soil samples collected during Round 1. Tables 3-16 through 3-19 are similar to Table G-1 but display results only for chemicals that were detected at least once in surface or subsurface soil. For each chemical that falls into this category, all results, including non-detects and rejected values, if applicable, are shown.

3.1.2.3 SWMU 12 Drainage Channel Surface Water and Seep Site Data

Surface water samples were not collected during the bioremediation operation. Data from surface water samples collected in RFI Rounds 1 and 2 are presented in Tables 3-20 through 3-34. The surface water samples were analyzed for various combinations of explosives, total and dissolved metals, ammonia, nitrate, nitrite, and water quality parameters (e.g., temperature and pH) in both rounds of sampling. One sampling location (12SW/SD03) was sampled for SVOCs in both rounds. This sample location was selected to monitor releases from the unidentified asphalt pad location. No information is available regarding operations conducted at the unidentified asphalt pad. As a result, samples collected at this location were selected for a full range of parameters, including SVOCs. Select seep water samples were scheduled for collection, but no seep samples were collected. Details of the analytical scheme are presented in Table 2-3.

After data collection, the surface water sample data were divided into three data sets. One data set (gullies) represents samples collected on the steeper hillsides and generally represents drainage channels that are typically dry except for storm events. Frequencies of detection and other descriptive statistics for these data are presented in Table 3-20 (upgradient) and in Tables 3-26 through 3-28 (downgradient). Individual results are provided in Tables 3-23 (upgradient) and 3-35 (downgradient). The second data subset encompasses data from samples collected in the east tributary to Turkey Creek. Turkey Creek, which has more frequent occurrences of flowing water, is represented by the third data set. Similar statistics and individual results for these second and third divisions are presented in Tables 3-29 through 3-34, and Tables 3-36 and 3-37.

The summary formats for surface water and seeps are similar to those described for surface and subsurface soils (See Sections 3.1.2.1 and 3.1.2.2). A complete printout of all Round 1 through Round 2 surface water data is presented in Appendix Table G-4.

3.1.2.4 SWMU 12 Drainage Channel Sediment Site Data

Sediment samples were not collected during the bioremediation operation. Select sediment samples were analyzed for various combinations of acid volatile sulfide (AVS)/simultaneously extracted metal (SEM), energetic compounds, metals, SVOCs, and total organic carbon (TOC) (See Table 2-3) during RFI Round 1. These data are presented in Tables 3-38 through 3-49 for the same groupings as described for surface water in the previous section: gullies, east tributary, and TCMS. The summary formats are similar to those described for surface and subsurface soils (See Sections 3.1.2.1 and

3.1.2.2). Appendix Table G-5 presents all sediment data generated during Round 1. Upgradient samples are appropriately labeled to indicate that they are upgradient of the other SWMU 12 samples.

3.1.2.5 SWMU 12 External Sump/Drainage Channel Investigation Water Data

To better detect contaminant sources and delineate contamination, especially related to explosives, an attempt was made to collect water samples from several operationally related sumps. At the time of sampling, only three sumps contained enough water to be sampled. Data for these samples are presented in Tables 3-50 (descriptive statistics) and 3-51 (results in all sump water samples for chemicals detected in any of the three sump water samples). Appendix Table G-6 presents all of the data for these samples (there are no upgradient data associated with this category of sample).

3.1.2.6 SWMU 12 External Sump/Drainage Channel investigation Sediment Data

To better detect contaminant sources and delineate contamination, especially related to explosives, an attempt was made to collect sediment from several operationally related sumps. Sump sediment was more plentiful than sump water and 11 sediment samples were collected. Data for these sediment samples are presented in Tables 3-52 (descriptive statistics) and 3-53 (results in all sump water samples for chemicals detected in any of the three sump water samples). Appendix Table G-7 presents all of the data for these samples (there are no upgradient data associated with this category of sample).

3.1.2.7 SWMU 12 Groundwater Site Data

No groundwater data were collected during the bioremediation operation. During RFI Rounds 1 and 2, samples were collected from an increasing number of SWMU 12 wells until a total of 50 wells in SWMU 12 proper were sampled in Round 2. In addition, samples were collected from three wells located at SWMU 25. Two other SWMU 25 wells were dry and could not be sampled. SWMU 25 wells are easily distinguishable from SWMU 12 wells because their identification numbers begin with "WES" rather than "12MW," and groundwater sample numbers from SWMU 25 are easily distinguishable from SWMU 12 samples because their sample numbers begin with "25GW" rather than "12GW."

SWMU 25 is located south of SWMU 12. The SWMU 25 wells were useful for establishing regional water levels and groundwater flow directions, as well as providing an indication of whether non-SWMU 12 contaminant sources are present in that area. These wells did not yield data useful for determining whether contamination is present at SWMU 12.

Depending on the sampling round, groundwater samples were analyzed for various combinations of energetic compounds, total and dissolved metals, natural attenuation parameters, and water quality parameters. See Table 2-3 for a summary of the analytical scheme.

The groundwater wells are identified as Puz, Plz, or Plz/Mgd on Table 2-2. The largest group of wells is the Puz wells, which represent shallow groundwater on or near to the ridge top and down the side slopes of the ridge toward the valley. The Plz wells represent deeper groundwater underneath the Puz wells. The Plz/Mgd wells represent shallow groundwater immediately beneath the "valley" floor near the mainstream surface water channels. These latter wells are screened in the Mississippian limestone and therefore represent groundwater with significantly different characteristics than water in the Pennsylvanian geologic units.

During the External Sump/Drainage Investigation, groundwater samples were collected from temporary wells installed in the soil overburden at various soil borings. These samples were collected at the bottom of the borings where soil and bedrock meet. Water at this interface represents recharge water that has had the opportunity to percolate through the soil thus accumulating contaminants as it moves vertically downward and along the interface. Tables 3-54 (descriptive statistics) and 3-55 (results in all samples for chemicals detected in at least one sample) present the data for these samples.

Summary statistics for groundwater data from permanent wells collected in Rounds 1 and 2 are presented in Tables 3-56 through 3-58 (upgradient) and Tables 3-62 through 3-70 (downgradient). Data for all chemicals detected at least once in groundwater are presented in Tables 3-59 through 3-61 (upgradient) and Tables 3-71 through 3-73 (downgradient). Appendix Table G-8 presents all groundwater data generated during Rounds 1 through 2, including the overburden temporary well groundwater data. These data are arranged so that sequential rounds of data for each permanent well location are side by side to facilitate an understanding of temporal concentration trends within each well.

The rest of this report is devoted to an interpretation of the data for purposes of completing the RFI. This interpretation begins in Section 3.2 with a summary of the data quality.

3.2 DATA QUALITY SUMMARY

A tabulation of data quality characteristics and detailed QC data review for the Rounds 1 and 2 of RFI data generation at SWMU 12 are presented in Appendix H of this report. Composting data quality is summarized in detail in Toltest, 2005 and summarized in text below. Data from the External Sump/Drainage Investigation (ES/DI) and Metals Contamination Delineation (MCD) were less

comprehensive in terms of analytes measured. Therefore the data quality was assessed by inspection only. The data quality indicators (DQIs) of the ES/DI and MCD were compared visually to the DQIs for the Rounds 1 and 2 data.

Based on the reviews in Appendix H, the following summaries (Sections 3.2.1 through 3.2.4) were prepared about SWMU 12 data quality. Sample collection and analysis completeness was generally satisfactory with a few exceptions (See Appendix H, Section H.4.1). Based on the data quality summaries (Toltest, 2005), composting data were of sufficient quality to support the composting operation and the risk assessments included in this RFI. The Round 1 and 2 data were generally of sufficient quality to support this RFI. The same laboratory was used for all analyses from RFI Round 1 through the MCD and there was no discernible difference in the quality between the Rounds 1 and 2 data and the ES/DI and MCD data. Therefore, all RFI data quality discussions below, though they focus on Rounds 1 and 2 data and are supported by the DQI summaries for Rounds 1 and 2 data in Appendix H, apply to the latter data collection events as well.

3.2.1 Precision and Accuracy

Composting Data

Explosives – These data were satisfactory. One QC batch had a very low RDX recovery of 16 percent in a matrix spike (MS) sample, but only three samples were affected and the affected samples do not represent final soil concentrations.

Volatile Organic Chemicals – These data were satisfactory. VOC field and laboratory blank concentrations were generally very low, indicating no significant VOC contamination.

Metals – Analytical performance for the metals analyses was generally within expectations. Relative percent difference (RPD) values, which reflect analytical precision (laboratory duplicates) or field precision (field duplicates), occasionally exceeded the 50 percent point of reference; however, there was no consistent indication of an analytical problem with respect to accuracy, precision, or any other QC measure. No metals results from the composting operation were rejected as a result of the data validation conducted by Toltest.

Details of composting data quality are provided in Appendix H and in THE IMR and IMR Addendum reports (MK, 2000a and 2002).

RFI Rounds 1 and 2 and ES/DI and MCD Data

The samples for Rounds 1 and 2 were collected during a 7-month time span (August 13, 2004 to March 12, 2005). ES/DI samples were collected in February 2006 and MCD samples were collected in October/November 2005 and in October 2006. Because all samples were analyzed by the same laboratory over a relatively short time span, QC data for Rounds 1 and 2 were grouped and evaluated together.

Explosives – Completeness goals were satisfied except that several soil and surface water samples could not be collected because refusal was encountered or no surface water was present at or near the selected sampling location. Some permanent and temporary groundwater monitoring wells were also dry, and no seep samples were collected. A slight but insignificant high bias was observed for all explosives in solid sample matrices, and virtually no bias was observed in aqueous samples, with just a few exceptions. The RDX degradation product, 4,4'-TN-AZOXY, in aqueous samples had average laboratory control sample (LCS) and matrix spike/matrix spike duplicate (MS/MSD) recoveries of approximately 40 percent in aqueous samples. A slight to moderate low bias (average percent recovery = 59.2 for MS and MSD and 88.4 for LCS) was also reported for aqueous RDX concentrations. The low bias indicates that reported 4,4'-TN-AZOXY and RDX concentrations are, on average, less than actual site concentrations. Results for other explosive compounds in aqueous and solid sample matrices were not biased significantly low and may be biased slightly high in some cases, although not significantly.

Herbicides – Hexachlorophene and pentachlorophenol are not herbicides, but these compounds were analyzed in Rounds 1 and 2 by an herbicide analytical method to obtain lower detection limits than could be obtained with the normally used SVOC analytical method. The analytical fraction listed in Table 2-3 for analysis of these compounds is SVOC. Sample collection completeness goals were achieved for all matrices except sediment. Two of three scheduled sediment samples were not collected; however, an additional sediment sample was collected elsewhere to yield a completeness of 50 percent. The additional sample improved the representativeness of the sediment sampling beyond what would have been achieved with just one sample; however, the representativeness is not comprehensive. One surface water sample was analyzed for these compounds in Round 1, but no groundwater samples were analyzed. Sensitivity goals were achieved, although the goals consistently did not permit the attainment of ecological risk-based target levels (RBTLs) for sediment and soil. This is not an analytical deficiency but should be considered when evaluating data relative to RBTLs. The hexachlorophene and pentachlorophenol results exhibited a severe low bias (approximately 10 to 90 percent recoveries in MS and MSD) in solid samples and a moderate to severe low bias (approximately 20 to 107 percent recoveries in MS/MSD) in surface water samples. Herbicides were not analyzed in any matrix during

Round 2. Precision for pentachlorophenol was erratic in solid samples, and the hexachlorophene precision measure (55 percent RPD) exceeded the target range of 0 to 30 percent in the Round 1 surface water sample. Generally, the analytical performance for these two compounds was poor, with erratic precision and moderate to severe low biases. Because rejections for the ES/DI and MCD sampling events are not tabulated, it is worth noting here that the only rejections of explosives data associated with those events were as follows: 16 R ug/L 3-nitrotoluene in sample 12GWTW002, 0.5 R 2,4-diamino-6-nitrotoluene in sample 12SB610204, and 0.38 R mg/kg 1,3,5-trinitrobenzene in sample 12SL0030010006.

Metals (including SEM) - The sample collection goal (90 percent complete) was attained. Solid matrices were not analyzed for metals in Round 2. , No metal results were rejected in either round or during the two MCD events in any matrix, except for eight dissolved thallium (surface water) and three total mercury results (subsurface soil) during Round1. Metals were not analyzed during the ES/DI. Some percent recoveries (bias indicators) were unusually high or low for a few isolated samples, but the metals results, overall, exhibited no bias. Several soil and sediment RPD results exceeded the reference point of 50 percent; however, the laboratory precision was equal to or better than field duplicate precision, as expected. This indicates that the greater proportion of uncertainty is associated with natural sample heterogeneity. Nevertheless, several metals exhibited some high RPD values (e.g., greater than 100 percent) and sporadically high or low bias indicators that represent an occasional large degree of heterogeneity or evidence of laboratory contamination. Refer to Appendix H for details.

Miscellaneous Parameters [Ammonia, AVS, Cation Exchange Capacity (CEC), Nitrite/Nitrate and TOC] – These data are generally of acceptable quality, although the ammonia results exhibited a slight low bias and occasionally exhibited an uncertainty that was greater than expected. No results for these parameters were rejected during data validation.

SVOCs – Recoveries in LCSs, MSs, and MSDs were generally biased low, especially for solid matrix samples. Recoveries of some SVOC analytes were zero. Sixty-seven results for select compounds in field samples were rejected for low LCS/LCSD recoveries, low MS/MSD recoveries, and calibration non-compliances. The results rejected in soil were for the compounds 2,4-dinitrophenol, 2,4-dimethylhenol, 3,3'-dichlorobenzidine, 3-nitroaniline, 4-chloroaniline, 4-nitroquinoline-1-oxide, 4,6-dinitro-2-methylphenol, diphenylamine, and N-nitrosodiphenylamine. For aqueous samples, the rejections were for 4-nitroquinoline-1-oxide (two samples) and kepone (one sample). All rejections occurred in RFI Round 1. The compounds that were rejected are, as a group, of minor importance to the project. Overall, the semivolatile compounds, including PAHs, show a slight to moderately low bias in solid matrices, with results for compounds identified above having been rejected in some samples. In soils, a high degree of uncertainty exists for 4-chloroaniline, but uncertainty for other compounds is not indicated even though

low MSs were observed for compounds other than 4-chloroaniline. In aqueous matrices, a slight to moderate low bias also exists, but there were very few rejections and no notable precision problems. No compounds that are of primary importance to this project had rejected results, but the rejections and low biases reported for other compounds must be considered when using the data.

VOCs – VOCs were analyzed in select surface and subsurface samples during Round 1 only. The compounds acrolein, 2-butanone, acetone, acrylonitrile, and methacrylonitrile are only parameters for which results were rejected for VOC analyses. These data rejected in RFI Round 1 were rejected because of poor analytical responses. This is a systematic problem that occurred for one or more of these compounds in the majority of the samples analyzed from MFA. These compounds, however, are not likely to be site related contaminants, based on site history and patterns of detected chemicals.

3.2.2 Representativeness

All samples appear to be representative of the intended environmental matrix. Lack of data where samples could not be collected or where data have been rejected, however, should be considered when evaluating representativeness of the areas or volumes of environmental media that were characterized. In addition, some significant disparities were noted between dissolved metals concentrations and associated total metals concentrations. Dissolved metals concentrations should not exceed total metal concentrations, but this condition was violated for a relatively few metals in a few surface water and groundwater samples. Details are provided in Appendix H, Section H3.6. Total and dissolved metals concentrations are presented in tables at the end of this section.

3.2.3 Comparability and Completeness

Sample collection deviated slightly from the proposed sampling strategy in both RFI rounds and during the ES/DI and MCD events, but the deviations were a reflection of site conditions rather than investigative deficiencies. Uncollected samples were generally not collected because drainage channel surface water or sump water was not available at all planned locations or refusal was encountered during soil boring advancement. The percent completeness for sediment sample collection during RFI Rounds 1 and 2 was less than 90 percent for CEC and TOC (compare sample collection ratios in Table H-1). These parameters were not measured in subsequent field events. A completeness goal of at least 90 percent was achieved for all other parameters. The lack of data from the planned locations as well as locations where data have been rejected for quality reasons should be considered when interpreting the results of the investigation.

Use of consistent and appropriate sampling and analysis methods for the composting and RFI efforts and collection of samples from the intended locations ensured that comparability was maintained among sampling rounds.

3.2.4 Sensitivity

Sensitivity was typical of fixed-base laboratory analyses and was acceptable for this project. Many parameters had non-detect values that were greater than one or more of the targeted threshold values, the laboratory reporting limits, or the RBTLs presented in the SWMU 12 QAPP (TtNUS, 2003). The exceedances occurred during both sampling rounds and generally affected all analytical fractions and all matrices in some manner. With few exceptions, the exceedances fell into one of the following categories: (1) the RBTL was so low as to be unachievable through routine analyses (as already defined in the QAPP) or (2) the affected results reflect a sample dilution that was required, for example, to circumvent chemical interferences during analysis. Appendix H presents more detail, including tabulations for RFI Rounds 1 and 2 showing the exceedances. Analytical performance for the ES/DI and MCD events was comparable based on inspection of the data.

Non-detect values that are significantly greater than the nominal threshold value were a result of sample dilutions, laboratory blank contamination, or other causes that reflect the current technology regarding laboratory analyses for the selected parameters in the matrices of interest. In cases of RBTL exceedances, the exceedances are not considered to represent deficiencies with the selected analytical process. It would have been impracticable and unnecessary to seek or develop analytical methods with lower detection limits; however, the inability to achieve the target concentrations must be considered when evaluating the data because the significance may change with data use. Therefore, these situations should be reviewed prior to data use (See Section H.4.2 and Tables H-3 through H-6).

TABLE 3-1

DESCRIPTIVE STATISTICS FOR THE COMPLETE BACKGROUND SOIL SAMPLE DATA SET
SWMU 12 - MINE FILL A[1]
NSWC CRANE
CRANE, INDIANA

Metal (mg/kg)	Frequency of Detection	Minimum Detection	Maximum Detection	Average of All Results	Average of Positive Detections	Distribution of Data	95% Upper Tolerance Limit
ALUMINUM	67/67	5,020	17,400	11,290	11,100	NORMAL	17,400
ANTIMONY	8/67	0.49	11.3	0.86	4.36	LOGNORMAL	2.88
ARSENIC	67/67	1.1	10.2	5.28	5.20	NORMAL	9.60
BARIUM	67/67	24.8	155	69.7	68.8	LOGNORMAL	147
BERYLLIUM	14/67	0.3	0.82	0.36	0.47	LOGNORMAL	0.85
CADMIUM	34/67	0.05	3.6	0.36	0.62	LOGNORMAL	2.05
CALCIUM	66/67	53.6	35,300	997	1,010	LOGNORMAL	3,350
CHROMIUM	67/67	7.7	30.6	16.4	16.1	LOGNORMAL	29.1
COBALT	67/67	1.8	27.1	8.70	8.62	LOGNORMAL	21.7
COPPER	67/67	3.5	23.8	10.2	10.0	LOGNORMAL	21.4
IRON	67/67	7,140	40,800	18,100	17,800	LOGNORMAL	34,500
LEAD	67/67	6.4	21.5	11.9	11.7	LOGNORMAL	19.7
LITHIUM	66/66	7.8	46.6	16.1	15.7	LOGNORMAL	29.4
MAGNESIUM	67/67	496	2,870	1,410	1,390	LOGNORMAL	3,060
MANGANESE	67/67	23.2	3,040	599	590	LOGNORMAL	3,270
MERCURY	17/67	0.04	0.14	0.033	0.062	LOGNORMAL	0.072
NICKEL	67/67	4.6	23.7	11.9	11.7	NORMAL	18.7
POTASSIUM	67/67	280	1,650	856	833	NORMAL	1,370
SELENIUM	15/67	0.28	0.88	0.33	0.53	LOGNORMAL	0.83
SILVER	48/67	0.04	0.11	0.049	0.055	LOGNORMAL	0.10
SODIUM	32/67	3.7	205	33.0	56.2	LOGNORMAL	232
STRONTIUM	66/66	4.2	63.2	12.3	12.1	LOGNORMAL	25.3
THALLIUM	66/67	0.05	0.31	0.18	0.18	NORMAL	0.29
TIN	0/67	NA	NA	0.32[2]	NA	NA	NA
THORIUM	66/66	4.1	11.7	7.24	7.11	LOGNORMAL	10.9
VANADIUM	67/67	14.1	48.5	26.5	26.2	LOGNORMAL	45.8
ZINC	50/67	9.4	60.2	28.1	32.0	NORMAL	54.0

NA - Not available

1- Taken from Table 4-1 of the Final Basewide Background Soil Investigation Report, Naval Surface Warfare Center Crane, Crane, Indiana, January, 2001.

2 - This value is the average of all detected and non-detected values. Non-detected values were represented by using one-half the detection limit. This value was used for statistical analysis when no detections were encountered.

TABLE 3-2

DESCRIPTIVE STATISTICS FOR BACKGROUND SOIL GROUP 3 - ALLUVIAL, MISSISSIPPIAN, AND PENNSYLVANIAN SURFACE SOIL
SWMU 12 - MINE FILL A[1]
NSWC CRANE
CRANE, INDIANA

Metal (mg/kg)	Frequency of Detection	Minimum Detection	Maximum Detection	Average of All Results	Average of Positive Detections	Distribution of Data	95% Upper Tolerance Limit
ALUMINUM	15/15	6,770	17,400	10,238	10,238	LOGNORMAL	19,900
ANTIMONY	2/15	1.4	5.6	0.83	3.50	LOGNORMAL	6.9
ARSENIC	15/15	2.4	10.2	6.11	6.11	NORMAL	11.83
BARIUM	15/15	46.1	153	89.0	89.0	LOGNORMAL	211
BERYLLIUM	1/15	0.49	0.49	0.40	0.49	LOGNORMAL	0.93
CADMIUM	10/15	0.1	3.6	0.63	0.88	LOGNORMAL	6.05
CALCIUM	14/15	115	35,300	2,730	2,920	LOGNORMAL	55,200
CHROMIUM	15/15	8.5	21.7	14.6	14.6	LOGNORMAL	28.7
COBALT	15/15	6	27.1	12.9	12.9	LOGNORMAL	32.4
COPPER	15/15	5.4	17.1	8.85	8.85	LOGNORMAL	17.6
IRON	15/15	10,700	36,200	16,800	16,800	LOGNORMAL	37,400
LEAD	15/15	9.4	21.5	15.0	15.0	LOGNORMAL	27.0
LITHIUM	14/14	9.1	29.9	14.8	14.8	LOGNORMAL	30.0
MAGNESIUM	15/15	620	2,250	1,200	1,200	LOGNORMAL	2,800
MANGANESE	15/15	268	3,040	1,140	1,140	LOGNORMAL	5,700
MERCURY	7/15	0.04	0.07	0.037	0.051	NORMAL	0.077
NICKEL	15/15	9.2	20	13.4	13.4	LOGNORMAL	22.1
POTASSIUM	15/15	418	1,490	847	847	LOGNORMAL	1,970
SELENIUM	5/15	0.51	0.64	0.48	0.58	NORMAL	0.81
SILVER	15/15	0.05	0.11	0.065	0.065	LOGNORMAL	0.130
SODIUM	6/15	9.4	23.7	8.11	15.6	NORMAL	28
STRONTIUM	14/14	7.4	63.2	14.3	14.3	LOGNORMAL	46.4
THALLIUM	15/15	0.1	0.27	0.19	0.19	NORMAL	0.31
TIN	0/15	NA	NA	0.36[2]	NA	NA	NA
THORIUM	14/14	5.3	8.5	6.86	6.86	LOGNORMAL	10.2
VANADIUM	15/15	17.1	40	25.4	25.4	LOGNORMAL	51.2
ZINC	14/15	24.4	60.2	37.0	38.6	NORMAL	65.6

NA - Not available

1- Taken from Table 4-4 of the Final Basewide Background Soil Investigation Report, Naval Surface Warfare Center Crane, Crane, Indiana, January, 2001.

2 - This value is the average of all detected and non-detected values. Non-detected values were represented by using one half the detection limit. This value was used for statistical analysis when no detections were encountered.

TABLE 3-3

DESCRIPTIVE STATISTICS FOR BACKGROUND SOIL GROUP 8 - PENNSYLVANIAN SUBSURFACE CLAY AND SILT
SWMU 12 - MINE FILL A[1]
NSWC CRANE
CRANE, INDIANA

Metal (mg/kg)	Frequency of Detection	Minimum Detection	Maximum Detection	Average of All Results	Average of Positive Detections	Distribution of Data	95% Upper Tolerance Limit
ALUMINUM	9/9	9,070	16,200	13,019	13,019	NORMAL	20,600
ANTIMONY	1/9	11.3	11.3	1.83	11.30	LOGNORMAL	40.3
ARSENIC	9/9	1.4	8.5	5.51	5.51	NORMAL	12.5
BARIUM	9/9	25.1	83.4	57.0	57.0	NORMAL	115
BERYLLIUM	0/9	NA	NA	0.36 [2]	NA	NA	NA
CADMIUM	8/9	0.05	0.64	0.26	0.28	NORMAL	0.8
CALCIUM	9/9	85.2	970	470	470	LOGNORMAL	4,640
CHROMIUM	9/9	14.2	27.1	19.9	19.9	NORMAL	33.0
COBALT	9/9	5.2	12.5	8.32	8.32	LOGNORMAL	21.2
COPPER	9/9	11	23.8	15.3	15.3	LOGNORMAL	33.3
IRON	9/9	14,800	40,800	24,422	24,422	LOGNORMAL	60,200
LEAD	9/9	8.6	15.2	11.8	11.8	NORMAL	19.6
LITHIUM	9/9	13.7	46.6	23.2	23.2	LOGNORMAL	80.0
MAGNESIUM	9/9	1,100	2,870	1,958	1,958	NORMAL	3,410
MANGANESE	9/9	29	457	263	263	NORMAL	704
MERCURY	1/9	0.14	0.14	0.037	0.140	LOGNORMAL	0.18
NICKEL	9/9	10	23.7	13.6	13.6	LOGNORMAL	29.6
POTASSIUM	9/9	718	1290	974	974	LOGNORMAL	1,890
SELENIUM	8/9	0.37	0.88	0.47	0.51	NORMAL	1.07
SILVER	8/9	0.05	0.1	0.053	0.056	LOGNORMAL	0.14
SODIUM	6/9	10	205	64.0	79.1	LOGNORMAL	1,070
STRONTIUM	9/9	10	20.3	13.8	13.8	LOGNORMAL	30.9
THALLIUM	9/9	0.14	0.25	0.20	0.20	LOGNORMAL	0.33
TIN	0/9	NA	NA	0.35 [2]	NA	NA	NA
THORIUM	9/9	7.1	11.7	9.02	9.02	NORMAL	14.9
VANADIUM	9/9	20.9	48.5	33.2	33.2	LOGNORMAL	69.1
ZINC	9/9	24.3	58.2	37.1	37.1	LOGNORMAL	83.3

NA - Not available

1- Taken from Table 4-9 of the Final Basewide Background Soil Investigation Report, Naval Surface Warfare Center Crane, Crane, Indiana, January, 2001.

2 - This value is the average of all detected and non-detected values. Non-detected values were represented by using one half the detection limit. This value was used for statistical analysis when no detections were encountered.

TABLE 3-4

DESCRIPTIVE STATISTICS FOR MINE FILL A PROPER
SURFACE SOIL SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HRHA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Inorganics (mg/kg)									
ALUMINUM	8.3	NA	9/9	17500 J	29800 J	---	23378	23378	12SS070002
ANTIMONY	0.27	0.27	5/9	0.35 J	1.4 J	0.29 - 0.49	0.448	0.648	12SS070002
ARSENIC	0.29	18	9/9	4 J	9 J	---	6.76	6.76	12SS010002
BARIUM	82	330	9/9	50.2 J	128 J	---	90.5	90.5	12SS010002
BERYLLIUM	3.2	21	8/9	0.53 J	0.98 J	0.5	0.738	0.799	12SS080002
CALCIUM	NA	NA	9/9	285 J	26000 J	---	4525	4525	12SS060002
CHROMIUM	2.1	26	9/9	18.1 J	26.9 J	---	24.0	24.0	12SS050002
COBALT	0.17	13	9/9	4.6 J	15.7 J	---	8.52	8.52	12SS010002
COPPER	310	5.4	9/9	8.1 J	19 J	---	13.1	13.1	12SS070002
IRON	2300	NA	9/9	18800 J	30600 J	---	24389	24389	12SS050002
LEAD	81	11	9/9	10.7 J	31.2 J	---	16.1	16.1	12SS070002
MAGNESIUM	NA	NA	9/9	1360 J	3050 J	---	2293	2293	12SS060002
MANGANESE	110	NA	9/9	140 J	1080 J	---	404	404	12SS010002
MERCURY	2.1	0.1	9/9	0.009 J	0.041 J	---	0.0250	0.0250	12SS040002
NICKEL	14	13.6	9/9	12.1 J	21.4 J	---	16.9	16.9	12SS050002
POTASSIUM	NA	NA	9/9	1130 J	2120 J	---	1714	1714	12SS070002
SILVER	1.6	4.04	1/9	0.21 J	0.21 J	0.042 - 0.14	0.0502	0.210	12SS080002
SODIUM	NA	NA	1/9	59.8 J	59.8 J	26.9 - 62.6	28.2	59.8	12SS060002
TIN	4700	7.62	2/9	0.58 J	0.61 J	0.38 - 0.6	0.321	0.595	12SS080002
VANADIUM	7.8	7.8	9/9	28.4 J	48.6 J	---	39.4	39.4	12SS070002
ZINC	680	6.62	9/9	23.3 J	165 J	---	53.5	53.5	12SS070002
Miscellaneous Parameters (mg/kg)									
AMMONIA	NA	NA	2/2	0.82 J	0.98 J	---	0.900	0.900	12SS020002
CATION EXCHANGE CAPACITY (MEQ/1)	NA	NA	2/2	14	15	---	14.5	14.5	12SS030002
PH (S.U.)	NA	NA	2/2	6	7.7	---	6.85	6.85	12SS030002
TOTAL ORGANIC CARBON	NA	NA	2/2	2200	11000	---	6600	6600	12SS020002

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological Risk Assessment.
mg/kg - milligrams per kilogram.
NA - No applicable criteria.
MEQ/1 - milliequivalents per 100 grams.
S.U. - Standard units.

TABLE 3-5

DESCRIPTIVE STATISTICS FOR BATTERY SITE
SURFACE SOIL SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Volatile Organics (ug/kg)									
DICHLORODIFLUOROMETHANE	9400	39500	9/11	2 J	15	1.14 - 1.25	7.02	8.44	12SS210002
METHYLENE CHLORIDE	1.2	4050	3/11	1 J	2 J	0.921 - 1.6	0.866	1.67	12SS220002, 12SS230002
Semivolatile Organics (ug/kg)									
ACENAPHTHENE	31000	682000	1/11	4 J	4 J	3.47 - 3.82	2.04	4.00	12SS150002
ACENAPHTHYLENE	18000	682000	1/11	19	19	3.47 - 3.82	3.40	19.0	12SS150002
ANTHRACENE	51000	1480000	1/11	21	21	3.47 - 3.82	3.58	21.0	12SS150002
BENZO(A)ANTHRACENE	160	5210	5/11	5 J	98	3.63 - 3.82	13.8	28.2	12SS150002
BENZO(A)PYRENE	62	1520	4/11	12	110	3.47 - 3.82	15.1	38.3	12SS150002
BENZO(B)FLUORANTHENE	490	59800	5/11	13	150	3.63 - 3.82	24.0	50.6	12SS150002
BENZO(G,H,I)PERYLENE	16000	119000	5/11	13	93	3.63 - 3.82	15.4	31.6	12SS150002
BENZO(K)FLUORANTHENE	490	148000	5/11	4 J	90	3.63 - 3.82	12.0	24.2	12SS150002
BIS(2-ETHYLHEXYL)PHTHALATE	35000	925	1/11	1300	1300	70.4 - 77.5	152	1300	12SS150002
CHRYSENE	160	4730	5/11	12	110	3.63 - 3.82	23.9	50.4	12SS210002
DI-N-BUTYL PHTHALATE	250000	150	1/11	170 J	170 J	73.6 - 77.5	49.7	170	12SS210002
DIBENZO(A,H)ANTHRACENE	62	18400	1/11	21	21	3.47 - 3.82	3.58	21.0	12SS150002
FLUORANTHENE	230000	122000	5/11	11	140	3.63 - 3.82	22.1	46.4	12SS150002
FLUORENE	41000	122000	1/11	4 J	4 J	3.47 - 3.82	2.04	4.00	12SS150002
INDENO(1,2,3-CD)PYRENE	620	109000	5/11	11	80	3.63 - 3.82	12.8	26.0	12SS150002
ISOSAFROLE	NA	9940	2/11	2300	8400	70.4 - 77.5	1003	5350	12SS180002
NAPHTHALENE	700	99.4	3/11	4 J	38	3.63 - 3.82	5.80	16.3	12SS210002
PHENANTHRENE	13000	45700	5/11	9 J	140 J	3.63 - 3.82	19.6	41.0	12SS210002
PYRENE	230000	78500	5/11	19	180	3.63 - 3.82	26.4	55.8	12SS150002
Energetics (mg/kg)									
1,3,5-TRINITROBENZENE	0.25	0.376	1/11	0.84	0.84	0.25	0.190	0.840	12SS210002
HMX	310	NA	1/11	1.7	1.7	0.25	0.268	1.70	12SS210002
RDX	4.4	NA	1/11	6.1	6.1	0.25	0.668	6.10	12SS210002
Inorganics (mg/kg)									
ALUMINUM	8.3	NA	11/11	8780 J	23700	---	16825	16825	12SS190002
ANTIMONY	0.27	0.27	5/11	0.38 J	3610 J	0.12 - 0.95	352	774	12SS210002
ARSENIC	0.29	18	11/11	2.6 J	158 J	---	27.4	27.4	12SS240002
BARIUM	82	330	11/11	54.1 J	505 J	---	158	158	12SS210002
BERYLLIUM	3.2	21	7/11	0.72 J	1.5 J	0.35 - 1	0.818	1.05	12SS130002, 12SS140002
CADMIUM	0.38	0.36	2/11	5.8 J	6.3 J	0.2 - 0.81	1.26	6.05	12SS220002
CALCIUM	NA	NA	11/11	299 J	17800 J	---	4350	4350	12SS150002
CHROMIUM	2.1	26	11/11	18.3 J	51.7 J	---	32.7	32.7	12SS240002
COBALT	0.17	13	11/11	5 J	13.6 J	---	9.22	9.22	12SS220002
COPPER	310	5.4	11/11	8.7 J	345 J	---	70.7	70.7	12SS210002

TABLE 3-6

DESCRIPTIVE STATISTICS FOR BATTERY SITE
SURFACE SOIL SAMPLES, METAL CONTAMINATION DELINEATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detction
Inorganics (mg/kg)									
ALUMINUM	8.3	NA	37/37	8430	23700	0	15200	15200	12SS190002
ANTIMONY	0.27	0.27	19/37	0.38 J	3610 J	0.058 - 1.2	107	208	12SS210002
ARSENIC	0.29	18	37/37	1.23	158 J	0	12.5	12.5	12SS240002
BARIUM	82	330	37/37	41.1 J	505 J	0	126	126	12SS210002
BERYLLIUM	3.2	21	33/37	0.4 J	1.7 J	0.35 - 1	0.88	0.94	12SS340001
CADMIUM	0.38	0.36	28/37	0.322	49.3 J	0.2 - 0.81	3.1	4.0	12SS260001
CALCIUM	NA	NA	37/37	299 J	206000 J	0	15000	15000	12SS760002
CHROMIUM	2.1	26	37/37	18.3 J	122 J	0	38.8	38.8	12SS250001
COBALT	0.17	13	37/37	3 J	22.6	0	9.4	9.4	12SS850002
COPPER	310	5.4	37/37	8.7 J	1460 J	0	131	131	12SS260001
IRON	2300	NA	37/37	7160 J	65900 J	0	29300	29300	12SS130002
LEAD	81	11	37/37	8.2 J	429000 J	0	11900	11900	12SS210002
MAGNESIUM	NA	NA	37/37	687 J	13200 J	0	2060	2060	12SS290001
MANGANESE	110	NA	37/37	68.7 J	9680 J	0	804	804	12SS260001
MERCURY	23	NA	9/11	0.009 J	0.31	0.007	0.052	0.063	12SS210002
NICKEL	14	13.6	37/37	11.5 J	44.6 J	0	23.7	23.7	12SS130002
POTASSIUM	NA	NA	37/37	558 J	4370 J	0	1890	1890	12SS140002
SELENIUM	0.26	0.0276	26/37	0.247	0.74	0.13 - 0.56	0.34	0.41	12SS260001
SILVER	1.6	4.04	25/37	0.0487	18.5 J	0.042 - 0.72	0.73	1.0	12SS210002
SODIUM	NA	NA	3/37	78.2 J	370 J	20.5 - 199	61.3	249	12SS220002
THALLIUM	0.056	NA	12/37	0.0967	6.4 J	0.14 - 0.34	0.3	0.69	12SS210002
TIN	47000	NA	4/11	12.4 J	838 J	0.46 - 2.3	89.9	247	12SS210002
TITANIUM	100000	NA	11/11	21.3 J	313 J	0	88.8	88.8	12SS720002
VANADIUM	7.8	7.8	37/37	16.5 J	56.6	0	29.7	29.7	12SS810002
ZINC	680	6.62	37/37	31 J	23100 J	0	1300	1300	12SS260001

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
mg/kg - milligrams per kilogram.
NA - No applicable criterion.

TABLE 3-7

DESCRIPTIVE STATISTICS FOR
SURFACE SOIL SAMPLES, EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (mg/kg)									
1,3,5-TRINITROBENZENE	0.25	0.376	1/32	0.43 J	0.43 J	0.25 - 0.25	0.13	0.43	12SS500002
2,4,6-TRINITROTOLUENE	3.1	NA	9/32	0.28 J	65	0.25 - 0.25	2.4	8.3	12SS500002
2-AMINO-4,6-DINITROTOLUENE	12	NA	7/32	0.39 J	3.7	0.25 - 0.25	0.33	1.0	12SS500002
4-AMINO-2,6-DINITROTOLUENE	12	NA	9/32	0.28 J	32 J	0.25 - 0.25	1.4	4.8	12SS500002
HMX	310	NA	9/32	0.26 J	800	0.25 - 0.25	68	242	12SS500002
RDX	4.4	NA	9/32	0.4 J	4800	0.25 - 0.25	201	713	12SS500002

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
mg/kg - milligrams per kilogram.
NA - No applicable criterion.

TABLE 3-8

RESULTS FOR CHEMICALS DETECTED IN MINE FILL A PROPER
SURFACE SOIL SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND			01	01	01	01	01	01	01	01	01
LOCATION	HHRA	ERA	12SB01	12SB02	12SB03	12SB04	12SB05	12SB06	12SB07	12SB08	12SB09
SAMPLE NUMBER	CRITERIA	CRITERIA	12SS010002	12SS020002	12SS030002	12SS040002	12SS050002	12SS060002	12SS070002	12SS080002	12SS090002
SOIL CLASSIFICATION			3	3	3	3	3	3	3	3	3
SAMPLE CODE			NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE (feet)			0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
SAMPLE DATE			8/15/2004	8/15/2004	8/15/2004	8/15/2004	8/15/2004	8/15/2004	8/15/2004	8/15/2004	8/15/2004
Inorganics (mg/kg)											
ALUMINUM	8.3	NA	22100			23700 J	22800 J	25300	29800 J	22100 J	23300 J
ANTIMONY	0.27	0.27	0.49 U			0.59 J	0.49 J	0.49 U	1.4 J	0.41 J	0.32 U
ARSENIC	0.29	18	9 J			6.8 J	8 J	6.5 J	8.2 J	5 J	8 J
BARIUM	82	330	128 J			98.5 J	109 J	101 J	115 J	88 J	60.1 J
BERYLLIUM	3.2	21	0.89 J			0.84 J	0.94 J	0.9	0.69 J	0.98 J	0.62 J
CALCIUM	NA	NA	957 J			7390 J	1990 J	26000 J	285 J	1560 J	971 J
CHROMIUM	2.1	26	25.8 J			23.4 J	26.9 J	23.6 J	24.8 J	25.7 J	25.6 J
COBALT	0.17	13	15.7 J			8.9 J	13.6 J	9 J	6.3 J	7.5 J	5.9 J
COPPER	310	5.4	12.5 J			14.2 J	15.9 J	13.5 J	19 J	10.9 J	11.9 J
IRON	2300	NA	23800 J			26600 J	30600 J	26400 J	24800 J	20200 J	26200 J
LEAD	81	11	18.1 J			14.7 J	17.4 J	12.5 J	31.2 J	13 J	14.9 J
MAGNESIUM	NA	NA	2270 J			3030 J	2490 J	3050 J	2480 J	1690 J	2190 J
MANGANESE	110	NA	1080 J			473 J	688 J	509 J	255 J	140 J	141 J
MERCURY	2.1	0.1	0.028 J			0.041 J	0.035 J	0.017 J	0.032 J	0.014 J	0.009 J
NICKEL	14	13.6	17.7 J			18.1 J	21.4 J	18.4 J	19.7 J	17.8 J	13.5 J
POTASSIUM	NA	NA	1470 J			1860 J	1850 J	1830 J	2120 J	1930 J	1710 J
SILVER	1.6	4.04	0.05 U			0.05 U	0.05 U	0.06 U	0.042 U	0.21 J	0.048 U
SODIUM	NA	NA	46.8 U			51.1 U	26.9 U	59.8 J	37.2 U	62.6 U	61.2 U
TIN	4700	7.62	0.6 U			0.48 U	0.52 U	0.6 U	0.58 J	0.61 J	0.39 U
VANADIUM	7.8	7.8	44.9 J			38.6 J	39.6 J	39.2 J	48.6 J	31.8 J	45.3 J
ZINC	680	6.62	47.7 J			47.7 J	57.8 J	45.6 J	165 J	33.5 J	30.2 J
Miscellaneous Parameters (mg/kg)											
AMMONIA-N	NA	NA		0.98 J	0.82 J						
CATION EXCHANGE CAPACITY (MEQ/1)	NA	NA		14	15						
PH (S.U.)	NA	NA		6	7.7						
TOTAL ORGANIC CARBON	NA	NA		11000	2200						

TABLE 3-9

RESULTS FOR CHEMICALS DETECTED IN BATTERY SITE
SURFACE SOIL SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA	ERA	01	01	01	01	01	01	01	01	01
LOCATION	CRITERIA	CRITERIA	12SB12	12SB13	12SB14	12SB15	12SB16	12SB17	12SB18	12SB19	12SB20
SAMPLE NUMBER			12SS120002	12SS130002	12SS140002	12SS150002	12SS160002	12SS170002	12SS180002	12SS190002	12SS200002
SOIL CLASSIFICATION			3	3	3	3	3	3	3	3	3
SAMPLE CODE			NORMAL	NORMAL	NORMAL	NORMAL	REFUSAL	REFUSAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE (feet)			0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
SAMPLE DATE			8/13/2004	8/13/2004	8/13/2004	8/13/2004	8/13/2004	8/13/2004	8/15/2004	8/15/2004	8/15/2004
Volatile Organics (ug/kg)											
DICHLORODIFLUOROMETHANE	9400	39500	14 J	3 J	6 J	7 J			1.25 U	2 J	1.14 UJ
METHYLENE CHLORIDE	1.2	4050	0.994 UJ	0.921 UJ	1.05 UJ	0.961 UJ			1.25 UJ	1.14 UJ	1.14 UJ
Semivolatile Organics (ug/kg)											
ACENAPHTHENE	31000	682000	3.82 U	3.66 U	3.76 U	4 J			3.63 U	3.67 U	3.63 U
ACENAPHTHYLENE	18000	682000	3.82 U	3.66 U	3.76 U	19			3.63 U	3.67 U	3.63 U
ANTHRACENE	51000	1480000	3.82 U	3.66 U	3.76 U	21			3.63 U	3.67 U	3.63 U
BENZO(A)ANTHRACENE	160	5210	3.82 U	3.66 U	3.76 U	98			3.63 U	3.67 U	3.63 U
BENZO(A)PYRENE	62	1520	3.82 U	3.66 U	3.76 U	110			3.63 U	3.67 U	3.63 U
BENZO(B)FLUORANTHENE	490	59800	3.82 U	3.66 U	3.76 U	150			3.63 U	3.67 U	3.63 U
BENZO(G,H,I)PERYLENE	16000	119000	3.82 U	3.66 U	3.76 U	93			3.63 U	3.67 U	3.63 U
BENZO(K)FLUORANTHENE	490	148000	3.82 U	3.66 U	3.76 U	90			3.63 U	3.67 U	3.63 U
BIS(2-ETHYLHEXYL)PHTHALATE	35000	925	77.5 UJ	74.4 U	76.4 UJ	1300			73.7 U	74.6 U	73.6 U
CHRYSENE	160	4730	3.82 U	3.66 U	3.76 U	100			3.63 U	3.67 U	3.63 U
DI-N-BUTYL PHTHALATE	250000	150	77.5 UJ	74.4 UJ	76.4 UJ	77.5 UJ			73.7 U	74.6 U	73.6 U
DIBENZO(A,H)ANTHRACENE	62	18400	3.82 U	3.66 U	3.76 U	21			3.63 U	3.67 U	3.63 U
FLUORANTHENE	230000	122000	3.82 U	3.66 U	3.76 U	140			3.63 U	3.67 U	3.63 U
FLUORENE	41000	122000	3.82 U	3.66 U	3.76 U	4 J			3.63 U	3.67 U	3.63 U
INDENO(1,2,3-CD)PYRENE	620	109000	3.82 U	3.66 U	3.76 U	80			3.63 U	3.67 U	3.63 U
ISOSAFROLE	NA	9940	77.5 UJ	74.4 U	76.4 UJ	77.5 U			8400	2300	73.6 U
NAPHTHALENE	700	99.4	3.82 U	3.66 U	3.76 U	4 J			3.63 U	3.67 U	3.63 U
PHENANTHRENE	13000	45700	3.82 U	3.66 U	3.76 U	30			3.63 U	3.67 U	3.63 U
PYRENE	230000	78500	3.82 U	3.66 U	3.76 U	180			3.63 U	3.67 U	3.63 U
Energetics (mg/kg)											
1,3,5-TRINITROBENZENE	0.25	0.376	0.25 U	0.25 U	0.25 U	0.25 U			0.25 U	0.25 U	0.25 U
HMX	310	NA	0.25 U	0.25 U	0.25 U	0.25 U			0.25 U	0.25 U	0.25 U
RDX	4.4	NA	0.25 U	0.25 U	0.25 U	0.25 U			0.25 U	0.25 U	0.25 U
Inorganics (mg/kg)											
ALUMINUM	8.3	NA	15300 J	15300 J	20000 J	18000 J			17300	23700	15200
ANTIMONY	0.27	0.27	0.2 U	0.26 U	0.12 U	0.38 J			0.95 U	0.51 U	0.35 U
ARSENIC	0.29	18	2.8 J	4.1 J	2.6 J	4.4 J			7.1 J	9.2 J	5.7 J
BARIUM	82	330	76.5 J	54.1 J	104 J	71.6 J			166 J	112 J	86 J
BERYLLIUM	3.2	21	1.1 J	1.5 J	1.5 J	0.97 J			0.77 J	0.8 J	0.72 J
CADMIUM	0.38	0.36	0.23 U	0.47 U	0.23 U	0.26 U			0.3 U	0.32 U	0.2 U
CALCIUM	NA	NA	644 J	877 J	859 J	17800 J			1800 J	883 J	299 J
CHROMIUM	2.1	26	22.4 J	40.3 J	36.1 J	30.3 J			20 J	22.5 J	19.6 J
COBALT	0.17	13	5.8 J	7.2 J	7.7 J	5 J			11.5 J	9.1 J	10.4 J
COPPER	310	5.4	8.7 J	22.9 J	9.8 J	9.9 J			10.6 J	15.8 J	9.1 J

TABLE 3-9

RESULTS FOR CHEMICALS DETECTED IN BATTERY SITE
SURFACE SOIL SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA CRITERIA	ERA CRITERIA	01	01	01	01
LOCATION			12SB21	12SB22	12SB23	12SB24
SAMPLE NUMBER			12SS210002	12SS220002	12SS230002	12SS240002
SOIL CLASSIFICATION			3	3	3	3
SAMPLE CODE			NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE			0 - 2	0 - 2	0 - 2	0 - 2
SAMPLE DATE			9/21/2004	9/21/2004	9/21/2004	9/21/2004
Volatile Organics (ug/kg)						
DICHLORODIFLUOROMETHANE	9400	39500	15	10	14	5
METHYLENE CHLORIDE	1.2	4050	1.6 UJ	2 J	2 J	1 J
Semivolatile Organics (ug/kg)						
ACENAPHTHENE	31000	682000	3.47 U	3.73 U	3.76 U	3.65 U
ACENAPHTHYLENE	18000	682000	3.47 U	3.73 U	3.76 U	3.65 U
ANTHRACENE	51000	1480000	3.47 U	3.73 U	3.76 U	3.65 U
BENZO(A)ANTHRACENE	160	5210	5 J	14	16	8
BENZO(A)PYRENE	62	1520	3.47 U	14	17	12
BENZO(B)FLUORANTHENE	490	59800	54	13	17	19
BENZO(G,H,I)PERYLENE	16000	119000	13	14	13	25
BENZO(K)FLUORANTHENE	490	148000	6 J	11	10	4 J
BIS(2-ETHYLHEXYL)PHTHALATE	35000	925	70.4 UJ	75.7 UJ	76.4 UJ	74.1 UJ
CHRYSENE	160	4730	110	14	16	12
DI-N-BUTYL PHTHALATE	250000	150	170 J	75.7 UJ	76.4 UJ	74.1 UJ
DIBENZO(A,H)ANTHRACENE	62	18400	3.47 U	3.73 U	3.76 U	3.65 U
FLUORANTHENE	230000	122000	45	13	23	11
FLUORENE	41000	122000	3.47 U	3.73 U	3.76 U	3.65 U
INDENO(1,2,3-CD)PYRENE	620	109000	11	11	11	17
ISOSAFROLE	NA	9940	70.4 UJ	75.7 UJ	76.4 UJ	74.1 UJ
NAPHTHALENE	700	99.4	38	7 J	3.76 U	3.65 U
PHENANTHRENE	13000	45700	140 J	9 J	15 J	11 J
PYRENE	230000	78500	22	22	36	19
Energetics (mg/kg)						
1,3,5-TRINITROBENZENE	0.25	0.376	0.84	0.25 U	0.25 U	0.25 U
HMX	310	NA	1.7	0.25 U	0.25 U	0.25 U
RDX	4.4	NA	6.1	0.25 U	0.25 U	0.25 U
Inorganics (mg/kg)						
ALUMINUM	8.3	NA	8780 J	13200 J	18700 J	19600 J
ANTIMONY	0.27	0.27	3610 J	11.4 J	34.1 J	213 J
ARSENIC	0.29	18	94.2 J	5.4 J	7.6 J	158 J
BARIUM	82	330	505 J	313 J	147 J	97.3 J
BERYLLIUM	3.2	21	0.35 U	0.96 U	0.96 U	1 U
CADMIUM	0.38	0.36	5.8 J	6.3 J	0.81 U	0.75 U
CALCIUM	NA	NA	5400 J	9150 J	2550 J	7590 J
CHROMIUM	2.1	26	48.5 J	50.2 J	18.3 J	51.7 J
COBALT	0.17	13	6.2 J	13.6 J	12.9 J	12 J
COPPER	310	5.4	345 J	292 J	26.2 J	27.9 J

TABLE 3-10

RESULTS FOR CHEMICALS DETECTED IN SURFACE SOIL SAMPLES
DURING METAL CONTIMINATION DELINEATION AT THE BATTERY SITE
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND			01	01	01	01	
LOCATION			12SB12	12SB13	12SB14	12SB15	12SB16
SAMPLE NUMBER			12SS120002	12SS130002	12SS140002	12SS150002	12SS160002
SAMPLE	HHRA	ERA	12SS120002	12SS130002	12SS140002	12SS150002	12SS160002
SUBMATRIX	CRITERIA	CRITERIA	SS	SS	SS	SS	SS
SAMPLE CODE			NORMAL	NORMAL	NORMAL	NORMAL	--
DEPTH RANGE			(0 - 2)	(0 - 2)	(0 - 2)	(0 - 2)	REFUSAL
SAMPLE DATE			20040813	20040813	20040813	20040813	--
Inorganics (mg/kg)							
ALUMINUM	8.3	NA	**15300 J [H]**	**15300 J [H]**	**20000 J [H]**	**18000 J [H]**	--
ANTIMONY	0.27	0.27	0.20 U	0.26 U	0.12 U	**0.38 J [H] [E]**	--
ARSENIC	0.29	18	**2.8 J [H]**	**4.1 J [H]**	**2.6 J [H]**	**4.4 J [H]**	--
BARIUM	82	330	76.5 J	54.1 J	**104 J [H]**	71.6 J	--
BERYLLIUM	3.2	21	1.1 J	1.5 J	1.5 J	0.97 J	--
CADMIUM	0.38	0.36	0.23 U	0.47 U [H] [E]	0.23 U	0.26 U	--
CALCIUM	NA	NA	644 J	877 J	859 J	17800 J	--
CHROMIUM	2.1	26	**22.4 J [H]**	**40.3 J [H] [E]**	**36.1 J [H] [E]**	**30.3 J [H] [E]**	--
COBALT	0.17	13	**5.8 J [H]**	**7.2 J [H]**	**7.7 J [H]**	**5.0 J [H]**	--
COPPER	310	5.4	**8.7 J [E]**	**22.9 J [E]**	**9.8 J [E]**	**9.9 J [E]**	--
IRON	2300	NA	**7160 J [H]**	**65900 J [H]**	**16700 J [H]**	**15900 J [H]**	--
LEAD	81	11	10.6 J	**30.7 J [E]**	8.3 J	8.2 J	--
MAGNESIUM	NA	NA	1280 J	940 J	1660 J	2050 J	--
MANGANESE	110	NA	68.7 J	**200 J [H]**	**157 J [H]**	90.6 J	--
MERCURY	23	NA	0.007 U	0.02 J	0.007 U	0.009 J	--
NICKEL	14	13.6	**25.4 J [H] [E]**	**44.6 J [H] [E]**	**31.7 J [H] [E]**	**19.8 J [H] [E]**	--
POTASSIUM	NA	NA	2940 J	2210 J	4370 J	3570 J	--
SELENIUM	0.26	0.0276					--
SILVER	1.6	4.04	0.042 U	0.042 U	0.045 U	0.08 U	--
SODIUM	NA	NA	153 U	109 U	136 U	132 U	--
THALLIUM	0.056	NA					--
TIN	47000	NA	0.77 U	2.3 U	0.46 U	0.52 U	--
TITANIUM	100000	NA	--	--	--	--	--
VANADIUM	7.8	7.8	**21.6 J [H] [E]**	**33.5 J [H] [E]**	**26.0 J [H] [E]**	**29.3 J [H] [E]**	--
ZINC	680	6.62	**102 J [E]**	**206 J [E]**	**41.2 J [E]**	**31.0 J [E]**	--

Data qualifiers (e.g. U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
mg/kg - milligrams per kilogram.
MCD - Metals Contamination Delineation.
NA - No applicable criterion.
Chemicals detected at concentrations greater than either HHRA or ERA criteria are identified by bold formatting.
-- Analyses not performed/sample not taken.

TABLE 3-10

RESULTS FOR CHEMICALS DETECTED IN SURFACE SOIL SAMPLES
DURING METAL CONTIMINATION DELINEATION AT THE BATTERY SITE
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA CRITERIA	ERA CRITERIA	01	01	01	MCD	MCD
LOCATION			12SB22	12SB23	12SB24	12SB25	12SB26
SAMPLE NUMBER			12SS220002	12SS230002	12SS240002	12SS250001	12SS260001
SAMPLE			12SS220002	12SS230002	12SS240002	12SS250001	12SS260001
SUBMATRIX			SS	SS	SS	SS	SS
SAMPLE CODE			NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE			(0 - 2)	(0 - 2)	(0 - 2)	(0 - 1)	(0 - 1)
SAMPLE DATE			20040921	20040921	20040921	20051031	20051031
Inorganics (mg/kg)							
ALUMINUM	8.3	NA	13200 J [H]	18700 J [H]	19600 J [H]	12500 J [H]	12700 J [H]
ANTIMONY	0.27	0.27	11.4 J [H] [E]	34.1 J [H] [E]	213 J [H] [E]	3.8 J [H] [E]	4.4 J [H] [E]
ARSENIC	0.29	18	5.4 J [H]	7.6 J [H]	158 J [H] [E]	7.7 J [H]	12.3 J [H]
BARIUM	82	330	313 J [H]	147 J [H]	97.3 J [H]	263 J [H]	217 J [H]
BERYLLIUM	3.2	21	0.96 U	0.96 U	1 U	0.71 J	0.80 J
CADMIUM	0.38	0.36	6.3 J [H] [E]			20.2 J [H] [E]	49.3 J [H] [E]
CALCIUM	NA	NA	9150 J	2550 J	7590 J	5730 J	2710 J
CHROMIUM	2.1	26	50.2 J [H] [E]	18.3 J [H]	51.7 J [H] [E]	122 J [H] [E]	78.7 J [H] [E]
COBALT	0.17	13	13.6 J [H] [E]	12.9 J [H]	12 J [H]	14.3 J [H] [E]	14 J [H] [E]
COPPER	310	5.4	292 J [E]	26.2 J [E]	27.9 J [E]	903 J [H] [E]	1460 J [H] [E]
IRON	2300	NA	32200 J [H]	18700 J [H]	51200 J [H]	61100 J [H]	59000 J [H]
LEAD	81	11	506 J [H] [E]	3230 J [H] [E]	366 J [H] [E]	627 J [H] [E]	989 J [H] [E]
MAGNESIUM	NA	NA	2750 J	1580 J	1710 J	1610 J	1500 J
MANGANESE	110	NA	1340 [H]	1400 [H]	451 [H]	1650 J [H]	9680 J [H]
MERCURY	23	NA	0.069 J	0.042 J	0.034 J	--	--
NICKEL	14	13.6	30.5 J [H] [E]	15.9 J [H] [E]	23.9 J [H] [E]	27.6 [H] [E]	30.7 [H] [E]
POTASSIUM	NA	NA	2000 J	1160 J	1980 J	1300 J	1570 J
SELENIUM	0.26	0.0276		0.49 J [H] [E]	0.61 J [H] [E]	0.54 [H] [E]	0.74 [H] [E]
SILVER	1.6	4.04	0.72 U	0.24 U	0.08 U	0.90	1.8 [H]
SODIUM	NA	NA	370 J	51 U	78.2 J	165 U	119 U
THALLIUM	0.056	NA					
TIN	47000	NA	90.7 J	12.4 J	45.2 J	--	--
TITANIUM	100000	NA	--	--	--	--	--
VANADIUM	7.8	7.8	23.5 J [H] [E]	31.4 J [H] [E]	42.7 J [H] [E]	23.8 J [H] [E]	26 J [H] [E]
ZINC	680	6.62	2490 J [H] [E]	156 J [E]	206 J [E]	5110 J [H] [E]	23100 J [H] [E]

Data qualifiers (e.g. U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
mg/kg - milligrams per kilogram.
MCD - Metals Contamination Delineation.
NA - No applicable criterion.
Chemicals detected at concentrations greater than either HHRA c
-- Analyses not performed/sample not taken.

TABLE 3-10

RESULTS FOR CHEMICALS DETECTED IN SURFACE SOIL SAMPLES
DURING METAL CONTIMINATION DELINEATION AT THE BATTERY SITE
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA CRITERIA	ERA CRITERIA	MCD	MCD	MCD	MCD	MCD
LOCATION			12SB31	12SB32	12SB33	12SB34	12SB35
SAMPLE NUMBER			12SS310001	12SS320001	12SS330001	12SS340001	12SS350001
SAMPLE			12SS310001	12SS320001	12SS330001	12SS340001	12SS350001
SUBMATRIX			SS	SS	SS	SS	SS
SAMPLE CODE			NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE			(0 - 1)	(0 - 1)	(0 - 1)	(0 - 1)	(0 - 1)
SAMPLE DATE			20051031	20051031	20051031	20051031	20051031
Inorganics (mg/kg)							
ALUMINUM	8.3	NA	12400 [H]	23600 [H]	21300 [H]	13900 [H]	23500 [H]
ANTIMONY	0.27	0.27	6.6 J [H] [E]		1.9 J [H] [E]	1.4 J [H] [E]	4.2 J [H] [E]
ARSENIC	0.29	18	1.7 J [H]	5.3 J [H]	8.9 J [H]	15.1 J [H]	11.2 J [H]
BARIUM	82	330	54.1 J	97.7 J [H]	111 J [H]	104 J [H]	230 J [H]
BERYLLIUM	3.2	21	1.2 J	0.66 J	0.82 J	1.7 J	0.75 J
CADMIUM	0.38	0.36	0.40 J [H] [E]	0.59 [H] [E]	0.88 [H] [E]	1.2 [H] [E]	5.7 [H] [E]
CALCIUM	NA	NA	1090 J	18600 J	4980 J	1740 J	7740 J
CHROMIUM	2.1	26	27.9 J [H] [E]	24.8 J [H]	28.7 J [H] [E]	36.9 J [H] [E]	77 J [H] [E]
COBALT	0.17	13	4.8 J [H]	5.7 J [H]	8.6 J [H]	13.8 J [H] [E]	6.6 J [H]
COPPER	310	5.4	25.6 J [E]	34.9 J [E]	46.7 J [E]	60 J [E]	402 J [H] [E]
IRON	2300	NA	13600 J [H]	19000 J [H]	25800 J [H]	32000 J [H]	38400 J [H]
LEAD	81	11	54.6 J [E]	34.4 J [E]	155 J [H] [E]	142 J [H] [E]	690 J [H] [E]
MAGNESIUM	NA	NA	1130 J	2180 J	2230 J	1070 J	2320 J
MANGANESE	110	NA	140 J [H]	551 J [H]	637 J [H]	525 J [H]	676 J [H]
MERCURY	23	NA	--	--	--	--	--
NICKEL	14	13.6	22.4 J [H] [E]	15.2 J [H] [E]	22.4 J [H] [E]	33.6 J [H] [E]	21.2 J [H] [E]
POTASSIUM	NA	NA	2660 J	1180 J	1520 J	2570 J	1680 J
SELENIUM	0.26	0.0276	0.29 J [H] [E]	0.31 J [H] [E]	0.46 J [H] [E]	0.54 [H] [E]	0.45 J [H] [E]
SILVER	1.6	4.04	0.044 U	0.10 J	0.08 J	0.12 J	1.2
SODIUM	NA	NA	64.3 U	53.6 U	65.2 U	65.9 U	199 U
THALLIUM	0.056	NA					
TIN	47000	NA	--	--	--	--	--
TITANIUM	100000	NA	--	--	--	--	--
VANADIUM	7.8	7.8	19.9 J [H] [E]	35.3 J [H] [E]	35.7 J [H] [E]	26 J [H] [E]	47.5 J [H] [E]
ZINC	680	6.62	498 J [E]	155 J [E]	303 J [E]	1080 J [H] [E]	1370 J [H] [E]

Data qualifiers (e.g. U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
mg/kg - milligrams per kilogram.
MCD - Metals Contamination Delineation.
NA - No applicable criterion.
Chemicals detected at concentrations greater than either HHRA c
-- Analyses not performed/sample not taken.

TABLE 3-10

RESULTS FOR CHEMICALS DETECTED IN SURFACE SOIL SAMPLES
DURING METAL CONTIMINATION DELINEATION AT THE BATTERY SITE
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND							
LOCATION			12SB73	12SB74	12SB75	12SB76	12SB76
SAMPLE NUMBER			12SS730001	12SS740002	12SS750001	12SS760002	12SS760002-D
SAMPLE	HHRA	ERA	12SS730001	12SS740002	12SS750001	12SS760002	12SS760002-D
SUBMATRIX	CRITERIA	CRITERIA	SS	SS	SS	SS	SS
SAMPLE CODE			--	NORMAL	--	ORIG	DUP
DEPTH RANGE			--	(0 - 2)	E & H	(0 - 2)	(0 - 2)
SAMPLE DATE			E & H	20061010	--	20061010	20061010
Inorganics (mg/kg)							
ALUMINUM	8.3	NA	--	**16800 [H]**	--	**8430 [H]**	**8540 [H]**
ANTIMONY	0.27	0.27	--	**1.5 [H] [E]**	--		
ARSENIC	0.29	18	--	**10.3 [H]**	--	**2.47 [H]**	**2.95 [H]**
BARIUM	82	330	--	**119 J [H]**	--	62.1 J	71.7 J
BERYLLIUM	3.2	21	--	0.819	--	0.473	0.527
CADMIUM	0.38	0.36	--	**0.890 [H] [E]**	--	**0.874 [H] [E]**	**1.11 [H] [E]**
CALCIUM	NA	NA	--	8780 J	--	206000 J	121000 J
CHROMIUM	2.1	26	--	**32.2 [H] [E]**	--	**26.1 [H] [E]**	**27.4 [H] [E]**
COBALT	0.17	13	--	**8.17 [H]**	--	**6.95 [H]**	**7.28 [H]**
COPPER	310	5.4	--	**34.0 [E]**	--	**28.0 [E]**	**42.7 [E]**
IRON	2300	NA	--	**27100 [H]**	--	**20100 [H]**	**19600 [H]**
LEAD	81	11	--	**82.7 J [H] [E]**	--	**105 J [H] [E]**	**64.3 J [E]**
MAGNESIUM	NA	NA	--	1670 J	--	5530 J	2880 J
MANGANESE	110	NA	--	**302 [H]**	--	**244 [H]**	**235 [H]**
MERCURY	23	NA	--	--	--	--	--
NICKEL	14	13.6	--	**22.9 [H] [E]**	--	**28.1 [H] [E]**	**23.4 [H] [E]**
POTASSIUM	NA	NA	--	1660	--	1580	1260
SELENIUM	0.26	0.0276	--	**0.327 [H] [E]**	--	**0.470 [H] [E]**	**0.271 [H] [E]**
SILVER	1.6	4.04	--	0.219	--	0.250	0.296
SODIUM	NA	NA	--	105 U	--	119 U	73.9 U
THALLIUM	0.056	NA	--	**0.219 [H]**	--	**0.105 [H]**	**0.112 [H]**
TIN	47000	NA	--	--	--	--	--
TITANIUM	100000	NA	--	219 J	--	43.4 J	36.5 J
VANADIUM	7.8	7.8	--	**34.0 [H] [E]**	--	**20.5 [H] [E]**	**21.0 [H] [E]**
ZINC	680	6.62	--	**222 [E]**	--	**237 [E]**	**321 [E]**

Data qualifiers (e.g. U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
mg/kg - milligrams per kilogram.
MCD - Metals Contamination Delineation.
NA - No applicable criterion.
Chemicals detected at concentrations greater than either HHRA c
-- Analyses not performed/sample not taken.

TABLE 3-10

RESULTS FOR CHEMICALS DETECTED IN SURFACE SOIL SAMPLES
DURING METAL CONTIMINATION DELINEATION AT THE BATTERY SITE
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE SUBMATRIX SAMPLE CODE DEPTH RANGE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	12SB82 12SS820002 12SS820002 SS NORMAL (0 - 2) 20061010	12SB83 12SS830001 12SS830001 SS -- E & H --	12SB84 12SS840002 12SS840002 SS NORMAL (0 - 2) 20061010	12SB85 12SS850002 12SS850002 SS NORMAL (0 - 2) 20061010
Inorganics (mg/kg)						
ALUMINUM	8.3	NA	**16700 [H]**	--	**9620 [H]**	**12600 [H]**
ANTIMONY	0.27	0.27		--	0.058 U	0.11 U
ARSENIC	0.29	18	**3.23 [H]**	--	**1.33 [H]**	**1.23 [H]**
BARIUM	82	330	**98.0 J [H]**	--	41.1 J	65.9 J
BERYLLIUM	3.2	21	1.31	--	1.24	1.30
CADMIUM	0.38	0.36	**1.40 [H] [E]**	--	0.322	**0.522 [H] [E]**
CALCIUM	NA	NA	1750 J	--	953 J	1080 J
CHROMIUM	2.1	26	**38.3 [H] [E]**	--	**30.9 [H] [E]**	**33.0 [H] [E]**
COBALT	0.17	13	**10.5 [H]**	--	**14.5 [H] [E]**	**22.6 [H] [E]**
COPPER	310	5.4	**57.7 [E]**	--	**16.1 [E]**	**16.7 [E]**
IRON	2300	NA	**19800 [H]**	--	**37900 [H]**	**22100 [H]**
LEAD	81	11	**44.4 J [E]**	--	**14.2 J [E]**	**19.6 J [E]**
MAGNESIUM	NA	NA	1390 J	--	776 J	1120 J
MANGANESE	110	NA	**323 [H]**	--	**392 [H]**	**708 [H]**
MERCURY	23	NA	--	--	--	--
NICKEL	14	13.6	**21.5 [H] [E]**	--	**33.3 [H] [E]**	**38.5 [H] [E]**
POTASSIUM	NA	NA	3660	--	2370	3050
SELENIUM	0.26	0.0276	**0.271 [H] [E]**	--		
SILVER	1.6	4.04	0.185	--	0.0487	0.0680
SODIUM	NA	NA	118 U	--	65.2 U	121 U
THALLIUM	0.056	NA	**0.209 [H]**	--	**0.127 [H]**	**0.144 [H]**
TIN	47000	NA	--	--	--	--
TITANIUM	100000	NA	39.3 J	--	21.3 J	26.1 J
VANADIUM	7.8	7.8	**35.8 [H] [E]**	--	**21.9 [H] [E]**	**26.1 [H] [E]**
ZINC	680	6.62	**761 [H] [E]**	--	**75.2 [E]**	**136 [E]**

Data qualifiers (e.g. U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
mg/kg - milligrams per kilogram.
MCD - Metals Contamination Delineation.
NA - No applicable criterion.
Chemicals detected at concentrations greater than either HHRA c
-- Analyses not performed/sample not taken.

TABLE 3-11

RESULTS FOR CHEMICALS DETECTED IN SURFACE SOIL
SAMPLES DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND			ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION			12SB40	12SB41	12SB42	12SB43	12SB44	12SB45	12SB46	12SB47	12SB48	12SB49
SAMPLE NUMBER	HHRA	ERA	12SS400002	12SS410002	12SS420002	12SS430002	12SS440002	12SS450002	12SS460002	12SS470002	12SS480002	12SS490002
SAMPLE CODE	CRITERIA	CRITERIA	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE			0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
SAMPLE DATE			38764	38768	38768	38768	38764	38764	38765	38765	38765	38765
1,3,5-TRINITROBENZENE	0.25	0.376	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	NA	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	1	1.6	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	NA	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.62 J	0.85 J	0.25 U
4-AMINO-2,6-DINITROTOLUENE	12	NA	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	2.5	1.2	0.25 U
HMX	310	NA	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	11	0.66	0.25 U
RDX	4.4	NA	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	2.6	0.77	0.25 U

TABLE 3-11

RESULTS FOR CHEMICALS DETECTED IN SURFACE SOIL
SAMPLES DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND			ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION			12SB61	12SB62	12SB63	12SB64	12SB65	12SB66	12SB67	12SB68	12SB69	12SB70	12SB71
SAMPLE NUMBER	HHRA	ERA	12SS610002	12SS620002	12SS630002	12SS640002	12SS650002	12SS660002	12SS670002	12SS680002	12SS690002	12SS700002	12SS710002
SAMPLE CODE	CRITERIA	CRITERIA	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE			0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
SAMPLE DATE			38765	38765	38765	38765	38765	38765	38766	38764	38764	38764	38769
1,3,5-TRINITROBENZENE	0.25	0.376	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	NA	1.8	2.5	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.71	0.25 U	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	NA	0.66 J	0.63 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.39 J	0.25 U	0.25 U
4-AMINO-2,6-DINITROTOLUENE	12	NA	3.2 J	2.2 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.77	0.25 U	0.25 U
HMX	310	NA	**560 J**	**600 J**	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	1.2	0.39 J	0.25 U
RDX	4.4	NA	**1100**	**390**	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	3.6	0.4 J	0.25 U

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
ES/DI - External Sump/Drainage Investigation.
mg/kg - milligrams per kilogram.
NA - No applicable criterion.
Chemicals detected at concentrations greater than either HHRA or ERA criteria are identified by bold formatting.

TABLE 3-12

DESCRIPTIVE STATISTICS FOR MINE FILL A PROPER
SUBSURFACE SOIL SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Inorganics (mg/kg)								
ALUMINUM	8.3	17/17	11900 J	37000 J	---	23871	23871	12SB110205
ANTIMONY	0.27	6/17	0.38 J	0.71 J	0.13 - 0.87	0.275	0.500	12SB070206
ARSENIC	0.29	17/17	2.5 J	12.3 J	---	6.30	6.30	12SB080507
BARIUM	82	17/17	45.2 J	568 J	---	133	133	12SB070610
BERYLLIUM	3.2	17/17	0.47 J	2 J	---	1.04	1.04	12SB090508
CALCIUM	NA	17/17	357 J	8100 J	---	1346	1346	12SB050204
CHROMIUM	2.1	17/17	21.2 J	38.7 J	---	27.1	27.1	12SB110205
COBALT	0.17	17/17	2.2 J	27 J	---	9.31	9.31	12SB070610
COPPER	310	17/17	4 J	22.9 J	---	13.4	13.4	12SB090508
IRON	2300	17/17	8380 J	49600 J	---	29481	29481	12SB060509
LEAD	81	17/17	8.8 J	39.4 J	---	15.4	15.4	12SB080507
MAGNESIUM	NA	17/17	911 J	4560 J	---	2334	2334	12SB040712
MANGANESE	110	17/17	12.5 J	1600 J	---	304	304	12SB050204
MERCURY	2.1	12/15	0.007 J	0.13	0.007	0.0242	0.0294	12SB040207
NICKEL	14	17/17	8.4 J	47.3 J	---	20.7	20.7	12SB090508
POTASSIUM	NA	17/17	894 J	2490 J	---	1914	1914	12SB100508
SELENIUM	0.26	3/17	0.21 J	0.38 J	0.04 - 0.6	0.141	0.297	12SB080507
SODIUM	NA	5/17	62.1 J	179 J	53.3 - 101	57.5	97.2	12SB040712
TIN	4700	3/17	0.49 J	0.66 J	0.27 - 0.7	0.291	0.583	12SB110205
VANADIUM	7.8	17/17	17.4 J	50.5 J	---	37.3	37.3	12SB080507
ZINC	680	17/17	9.8 J	99.2 J	---	45.7	45.7	12SB090508
Miscellaneous Parameters (mg/kg)								
AMMONIA-N	NA	2/2	0.16 J	0.9 J	---	0.530	0.530	12SB020608
CATION EXCHANGE CAPACITY (MEQ/1)	NA	2/2	9.2	16	---	12.6	12.6	12SB020608
PH (S.U.)	NA	2/2	6.05	6.1	---	6.08	6.08	12SB030608

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
mg/kg - milligrams per kilogram.
MEQ/1 - milliequivalents per 100 grams.
S.U. - Standard units.
NA - No applicable criterion.

TABLE 3-13

DESCRIPTIVE STATISTICS FOR BATTERY SITE
SUBSURFACE SOIL SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Volatile Organics (ug/kg)								
DICHLORODIFLUOROMETHANE	9400	9/12	3 J	6 J	0.865 - 1.13	3.37	4.33	12SB150204, 12SB130607
Semivolatile Organics (ug/kg)								
BENZO(A)ANTHRACENE	160	1/12	8	8	3.56 - 3.88	2.36	8.00	12SB140607
BENZO(B)FLUORANTHENE	490	1/12	16	16	3.56 - 3.88	3.03	16.0	12SB140607
BIS(2-ETHYLHEXYL)PHTHALATE	35000	1/12	440 J	440 J	72.4 - 78.8	71.1	440	12SB140607
CHRYSENE	160	1/12	14	14	3.56 - 3.88	2.86	14.0	12SB140607
FLUORANTHENE	230000	1/12	11	11	3.56 - 3.88	2.61	11.0	12SB140607
ISOSAFROLE	NA	2/12	260 J	690	73.4 - 78.8	111	475	12SB180204
Inorganics (mg/kg)								
ALUMINUM	8.3	12/12	12700 J	24700 J	---	17717	17717	12SB140607
ANTIMONY	0.27	2/12	0.3 J	0.31 J	0.1 - 1.2	0.214	0.305	12SB130607
ARSENIC	0.29	12/12	0.95 J	6.4 J	---	3.04	3.04	12SB190204
BARIUM	82	12/12	32 J	792 J	---	119	119	12SB200204
BERYLLIUM	3.2	12/12	0.51 J	1.7 J	---	1.24	1.24	12SB140204
CALCIUM	NA	12/12	287 J	1160 J	---	641	641	12SB180608
CHROMIUM	2.1	12/12	18.6 J	38.8 J	---	30.0	30.0	12SB150607
COBALT	0.17	12/12	3.3 J	24.2 J	---	9.80	9.80	12SB130204
COPPER	310	12/12	5.4 J	23.9 J	---	12.2	12.2	12SB130607
IRON	2300	12/12	6580 J	93300 J	---	41098	41098	12SB130204
LEAD	81	12/12	10.8 J	25.4 J	---	17.0	17.0	12SB130204
MAGNESIUM	NA	12/12	824 J	1910 J	---	1287	1287	12SB190204
MANGANESE	110	12/12	22.6 J	796 J	---	210	210	12SB130204
MERCURY	2.1	7/11	0.008 J	1 J	0.007	0.103	0.160	12SB190204
NICKEL	14	12/12	10.7 J	72.6 J	---	33.7	33.7	12SB130204
POTASSIUM	NA	12/12	1010 J	5130 J	---	2731	2731	12SB140607
SELENIUM	0.26	2/12	0.67 J	2.3 J	0.13 - 0.88	0.417	1.49	12SB130607
SODIUM	NA	4/12	56.8 J	505 J	37.4 - 246	140	247	12SB200608
VANADIUM	7.8	12/12	20.6 J	34 J	---	27.3	27.3	12SB190204
ZINC	680	12/12	17.8 J	128 J	---	52.6	52.6	12SB130204

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ug/kg - micrograms per kilogram.
mg/kg - milligrams per kilogram.
NA - No applicable criterion.

TABLE 3-14

DESCRIPTIVE STATISTICS FOR BATTERY SITE
SUBSURFACE SOIL SAMPLES, METAL CONTAMINATION DELINEATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA Criteria	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Inorganics (mg/kg)								
ALUMINUM	8.3	41/41	8630	28100	0	15000	15000	12SB330406
ANTIMONY	0.27	4/41	0.3 J	8.1 J	0.049 - 1.2	0.39	2.6	12SB330406
ARSENIC	0.29	41/41	0.71 J	45.2 J	0	5.4	5.4	12SB220204
BARIUM	82	41/41	23.4 J	792 J	0	90.4	90.4	12SB200204
BERYLLIUM	3.2	41/41	0.32 J	2.9 J	0	1.4	1.4	12SB280204
CADMIUM	0.38	22/41	0.04 J	73.2 J	0.12 - 0.32	2.0	3.6	12SB330406
CALCIUM	NA	33/41	192 J	5010 J	491 - 852	670	751	12SB330406
CHROMIUM	2.1	41/41	18.6 J	116 J	0	31.9	31.9	12SB330406
COBALT	0.17	41/41	1.3 J	82.7 J	0	15.4	15.4	12SB800204
COPPER	310	41/41	3.9 J	1100 J	0	39.1	39.1	12SB330406
IRON	2300	41/41	6580 J	125000 J	0	41900	41900	12SB280204
LEAD	81	41/41	8.01 J	1440 J	0	51.3	51.3	12SB330406
MAGNESIUM	NA	41/41	602 J	2090 J	0	1160	1160	12SB330406
MANGANESE	110	41/41	12.7 J	3310	0	442	442	12SB800204
MERCURY	23	7/11	0.008 J	1 J	0.007	0.1	0.16	12SB190204
NICKEL	14	41/41	5.8 J	254 J	0	42.5	42.5	12SB330406
POTASSIUM	NA	41/41	830 J	5130 J	0	2240	2240	12SB140607
SELENIUM	0.26	31/41	0.12 J	2.3 J	0.13 - 0.88	0.55	0.66	12SB130607
SILVER	1.6	11/41	0.04 J	1.3	0.04 - 0.26	0.068	0.18	12SB330406
SODIUM	NA	14/41	56.8 J	556 J	3.09 - 296	121	219	12SB330406
THALLIUM	0.056	8/41	0.128 J	0.537 J	0.15 - 0.42	0.14	0.22	12SB800204
TITANIUM	100000	8/8	15.4 J	38.3 J	0	23.3	23.3	12SB760406-D
VANADIUM	7.8	41/41	15.9 J	43.5 J	0	26.5	26.5	12SB280204
ZINC	680	40/41	8.7 J	2340 J	58.7 - 58.8	120	122	12SB330406

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
mg/kg - milligrams per kilogram.
NA - No applicable criterion.

TABLE 3-15

DESCRIPTIVE STATISTICS FOR
SUBSURFACE SOIL SAMPLES, EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (mg/kg)								
1,3,5-TRINITROBENZENE	0.25	1/61	4.2	4.2	0.25 - 0.25	0.19	4.2	12SB600406
2,4,6-TRINITROTOLUENE	3.1	9/61	0.42 J	12	0.25 - 0.25	0.45	2.3	12SB600406
2-AMINO-4,6-DINITROTOLUENE	12	3/61	0.27 J	0.41 J	0.25 - 0.25	0.14	0.34	12SB480204
4,4'-TN-AZOXY	NA	1/32	1.3	1.3	0.25 - 0.25	0.28	1.3	12SB610204
4-AMINO-2,6-DINITROTOLUENE	12	3/61	0.38 J	0.9	0.25 - 0.25	0.15	0.67	12SB610204
HMX	310	21/61	0.28 J	40	0.25 - 0.25	1.3	3.4	12SB610204
MNX	NA	1/32	0.52	0.52	0.25 - 0.25	0.14	0.52	12SB610204
RDX	4.4	23/61	0.25 J	62	0.25 - 0.25	1.6	4.2	12SB610204
TNX	NA	1/32	0.39 J	0.39 J	0.25 - 0.25	0.13	0.39	12SB610204

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
mg/kg - milligrams per kilogram.
NA - No applicable criterion.

TABLE 3-16

RESULTS FOR CHEMICALS DETECTED IN MINE FILL A PROPER
SUBSURFACE SOIL SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		01	01	01	01	01	01	01	01	01	01	01
LOCATION	HHRA	12SB01	12SB02	12SB03	12SB04	12SB04	12SB05	12SB05	12SB06	12SB06	12SB07	12SB07
SAMPLE NUMBER	CRITERIA	12SB010609	12SB020608	12SB030608	12SB040207	12SB040712	12SB050204	12SB050509	12SB060205	12SB060509	12SB070206	12SB070610
SOIL CLASSIFICATION		8	8	8	8	8	8	8	8	8	8	8
SAMPLE CODE		NORMAL	ORIG	NORMAL	NORMAL	NORMAL	ORIG	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE (feet)		6 - 9	6 - 8	6 - 8	2 - 7	7 - 12	2 - 4	5 - 9	2 - 5	5 - 9	2 - 6	6 - 10
SAMPLE DATE		8/15/2004	8/15/2004	8/15/2004	8/15/2004	8/15/2004	8/15/2004	8/15/2004	8/15/2004	8/15/2004	8/15/2004	8/15/2004
Inorganics (mg/kg)												
ALUMINUM	8.3	12500			33700 J	18700 J	24600 J	25800	22300	27400	28000 J	30100 J
ANTIMONY	0.27	0.25 U			0.38 J	0.22 U	0.53 J	0.34 U	0.87 U	0.35 U	0.71 J	0.33 U
ARSENIC	0.29	4.1 J			7 J	2.5 J	5.4 J	7 J	10.1 J	5.1 J	9 J	4.1 J
BARIUM	82	51.7 J			80.5 J	50.1 J	138 J	71.6 J	67.1 J	99.7 J	121 J	568 J
BERYLLIUM	3.2	0.47 J			0.62 J	1.1 J	0.99 J	0.73 J	0.69 J	1.4	0.92 J	1.5 J
CALCIUM	NA	515 J			882 J	1380 J	8100 J	644 J	738 J	650 J	2140 J	1040 J
CHROMIUM	2.1	26 J			27.7 J	24.1 J	22.9 J	24.6 J	24.1 J	32.5 J	23.4 J	30.6 J
COBALT	0.17	2.2 J			4 J	9.9 J	12.1 J	4.8 J	5.2 J	10.5 J	12.4 J	27 J
COPPER	310	4 J			20.8 J	16.9 J	13.3 J	15.8 J	16.9 J	13.3 J	12.8 J	13.4 J
IRON	2300	23400 J			26000 J	26800 J	19100 J	26800 J	31100 J	49600 J	26500 J	48200 J
LEAD	81	9.3 J			12 J	10.9 J	17.5 J	11 J	14.9 J	20.3 J	16.8 J	16.2 J
MAGNESIUM	NA	991 J			3360 J	4560 J	2530 J	2940 J	3040 J	2800 J	2660 J	2940 J
MANGANESE	110	15.6 J			142 J	196 J	1600 J	88.6 J	218 J	668 J	694 J	617 J
MERCURY	2.1	0.008 J			0.13	0.023 J	0.022 J	0.007 UR	0.013 J	0.007 UR	0.05 J	0.013 J
NICKEL	14	8.4 J			14.9 J	26.8 J	19.6 J	14.7 J	14.8 J	22.2 J	19.3 J	26.2 J
POTASSIUM	NA	894 J			2400 J	2130 J	1880 J	1860 J	1910 J	1980 J	2020 J	1790 J
SELENIUM	0.26	0.12 U			0.17 U	0.08 U	0.3 J	0.27 U	0.3 U	0.24 U	0.44 U	0.1 U
SODIUM	NA	81.5 J			77.7 U	179 J	99 U	92.9 J	62.1 J	70.4 J	93.4 U	101 U
TIN	4700	0.41 U			0.49 U	0.49 J	0.44 U	0.65 U	0.7 U	0.67 U	0.6 J	0.53 U
VANADIUM	7.8	28.1 J			49 J	23.6 J	42 J	37.5 J	42.6 J	47.5 J	47.4 J	43.7 J
ZINC	680	9.8 J			55.2 J	66.7 J	50.4 J	45.8 J	52.4 J	48.3 J	52.2 J	52 J
Miscellaneous Parameters (mg/kg)												
AMMONIA-N	NA		0.9 J	0.16 J								
CATION EXCHANGE CAPACITY (MEQ/1)	NA		16	9.2								
PH (S.U.)	NA		6.05	6.1								

TABLE 3-17

RESULTS FOR CHEMICALS DETECTED IN BATTERY SITE
SUBSURFACE SOIL SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

SAMPLING ROUND	HHRA CRITERIA	01	01	01	01	01	01	01	01	01
LOCATION		12SB12	12SB12	12SB13	12SB13	12SB14	12SB14	12SB15	12SB15	12SB16
SAMPLE NUMBER		12SB120204	12SB120608	12SB130204	12SB130607	12SB140204	12SB140607	12SB150204	12SB150607	12SB160204
SOIL CLASSIFICATION		8	8	8	8	8	8	8	8	8
SAMPLE CODE		NORMAL	REFUSAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	REFUSAL
DEPTH RANGE (feet)		2 - 4	6 - 8	2 - 4	6 - 7	2 - 4	6 - 7	2 - 4	6 - 7	2 - 4
SAMPLE DATE		8/13/2004	8/13/2004	8/13/2004	8/13/2004	8/13/2004	8/13/2004	8/13/2004	8/13/2004	8/13/2004
Volatile Organics (ug/kg)										
DICHLORODIFLUOROMETHANE	9400	3 J		5 J	6 J	4	4 J	6 J	4 J	
Semivolatile Organics (ug/kg)										
BENZO(A)ANTHRACENE	160	3.69 U		3.71 U	3.76 U	3.7 U	8	3.71 U	3.88 U	
BENZO(B)FLUORANTHENE	490	3.69 U		3.71 U	3.76 U	3.7 U	16	3.71 U	3.88 U	
BIS(2-ETHYLHEXYL)PHTHALATE	35000	74.9 UJ		75.4 UJ	76.3 UJ	75.2 UJ	440 J	75.4 U	78.8 UJ	
CHRYSENE	160	3.69 U		3.71 U	3.76 U	3.7 U	14	3.71 U	3.88 U	
FLUORANTHENE	230000	3.69 U		3.71 U	3.76 U	3.7 U	11	3.71 U	3.88 U	
ISOSAFROLE	NA	74.9 UJ		75.4 UJ	76.3 UJ	75.2 UJ	77.4 UJ	75.4 U	78.8 UJ	
Inorganics (mg/kg)										
ALUMINUM	8.3	12700 J		16300 J	20100 J	15400 J	24700 J	16200 J	24200 J	
ANTIMONY	0.27	0.1 U		0.19 U	0.31 J	0.3 J	0.18 U	0.22 U	0.12 U	
ARSENIC	0.29	0.95 J		1.9 J	2.8 J	3.6 J	2.2 J	2.7 J	1.8 J	
BARIUM	82	49.6 J		32 J	40.8 J	53.8 J	109 J	33.7 J	96.8 J	
BERYLLIUM	3.2	1.1 J		1.4 J	1.6 J	1.7 J	1.4 J	1.4 J	1.6 J	
CALCIUM	NA	557 J		492 J	726 J	578 J	713 J	658 J	902 J	
CHROMIUM	2.1	18.6 J		33.4 J	38 J	29.8 J	35.7 J	34.1 J	38.8 J	
COBALT	0.17	10.8 J		24.2 J	4.6 J	8.6 J	4.3 J	13.1 J	11.3 J	
COPPER	310	7.8 J		15.3 J	23.9 J	7.3 J	5.4 J	8.1 J	22.5 J	
IRON	2300	26600 J		93300 J	60000 J	32000 J	6580 J	81400 J	43500 J	
LEAD	81	20.4 J		25.4 J	19.7 J	14 J	14.2 J	17.4 J	19.4 J	
MAGNESIUM	NA	824 J		904 J	1150 J	946 J	1550 J	896 J	1490 J	
MANGANESE	110	299 J		796 J	65.1 J	191 J	22.6 J	397 J	205 J	
MERCURY	2.1	0.007 U		0.007 U	0.068 J	0.007 U	0.007 U	0.008 J	0.014 J	
NICKEL	14	39.7 J		72.6 J	25 J	32 J	24 J	48.3 J	43.6 J	
POTASSIUM	NA	2340 J		2640 J	3520 J	2930 J	5130 J	2520 J	4550 J	
SELENIUM	0.26	0.25 U		0.54 U	2.3 J	0.88 U	0.71 U	0.33 U	0.43 U	
SODIUM	NA	191 U		140 U	235 U	155 U	246 U	141 U	229 U	
VANADIUM	7.8	23 J		23.9 J	20.6 J	25.3 J	26.9 J	25.2 J	30 J	
ZINC	680	59.7 J		128 J	53.5 J	54.8 J	36.1 J	61 J	63.3 J	

TABLE 3-18

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING METAL CONTAMINATION DELINEATION AT THE BATTERY SITE
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLE ROUND		01		01	01	01	01	01	01			
LOCATION		12SB12	12SB12	12SB13	12SB13	12SB14	12SB14	12SB15	12SB15	12SB16	12SB16	12SB17
SAMPLE NUMBER		12SB120204	12SB120608	12SB130204	12SB130607	12SB140204	12SB140607	12SB150204	12SB150607	12SB160204	12SB160608	12SB170204
SAMPLE	HHRA	12SB120204	12SB120608	12SB130204	12SB130607	12SB140204	12SB140607	12SB150204	12SB150607	12SB160204	12SB160608	12SB170204
SUBMATRIX	CRITERIA	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB
SAMPLE CODE		NORMAL	--	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	--	--	--
DEPTH RANGE		(2 - 4)	REFUSAL	(2 - 4)	(6 - 7)	(2 - 4)	(6 - 7)	(2 - 4)	(6 - 7)	REFUSAL	REFUSAL	REFUSAL
SAMPLE DATE		20040813	--	20040813	20040813	20040813	20040813	20040813	20040813	--	--	--
Inorganics (mg/kg)												
ALUMINUM	8.3	12700 J [H]	--	16300 J [H]	20100 J [H]	15400 J [H]	24700 J [H]	16200 J [H]	24200 J [H]	--	--	--
ANTIMONY	0.27	0.10 U	--	0.19 U	0.31 J [H]	0.30 J [H]	0.18 U	0.22 U	0.12 U	--	--	--
ARSENIC	0.29	0.95 J [H]	--	1.9 J [H]	2.8 J [H]	3.6 J [H]	2.2 J [H]	2.7 J [H]	1.8 J [H]	--	--	--
BARIUM	82	49.6 J	--	32.0 J	40.8 J	53.8 J	109 J [H]	33.7 J	96.8 J [H]	--	--	--
BERYLLIUM	3.2	1.1 J	--	1.4 J	1.6 J	1.7 J	1.4 J	1.4 J	1.6 J	--	--	--
CADMIUM	0.38	0.12 U	--	0.29 U	0.32 U	0.20 U	0.17 U	0.19 U	0.17 U	--	--	--
CALCIUM	NA	557 J	--	492 J	726 J	578 J	713 J	658 J	902 J	--	--	--
CHROMIUM	2.1	18.6 J [H]	--	33.4 J [H]	38.0 J [H]	29.8 J [H]	35.7 J [H]	34.1 J [H]	38.8 J [H]	--	--	--
COBALT	0.17	10.8 J [H]	--	24.2 J [H]	4.6 J [H]	8.6 J [H]	4.3 J [H]	13.1 J [H]	11.3 J [H]	--	--	--
COPPER	310	7.8 J	--	15.3 J	23.9 J	7.3 J	5.4 J	8.1 J	22.5 J	--	--	--
IRON	2300	26600 J [H]	--	93300 J [H]	60000 J [H]	32000 J [H]	6580 J [H]	81400 J [H]	43500 J [H]	--	--	--
LEAD	81	20.4 J	--	25.4 J	19.7 J	14.0 J	14.2 J	17.4 J	19.4 J	--	--	--
MAGNESIUM	NA	824 J	--	904 J	1150 J	946 J	1550 J	896 J	1490 J	--	--	--
MANGANESE	110	299 J [H]	--	796 J [H]	65.1 J	191 J [H]	22.6 J	397 J [H]	205 J [H]	--	--	--
MERCURY	23	0.007 U	--	0.007 U	0.068 J	0.007 U	0.007 U	0.008 J	0.014 J	--	--	--
NICKEL	14	39.7 J [H]	--	72.6 J [H]	25.0 J [H]	32.0 J [H]	24.0 J [H]	48.3 J [H]	43.6 J [H]	--	--	--
POTASSIUM	NA	2340 J	--	2640 J	3520 J	2930 J	5130 J	2520 J	4550 J	--	--	--
SELENIUM	0.26	0.25 U	--	0.54 U [H]	2.3 J [H]	0.88 U [H]	0.71 U [H]	0.33 U [H]	0.43 U [H]	--	--	--
SILVER	1.6	0.043 U	--	0.044 U	0.26 U	0.046 U	0.06 U	0.041 U	0.044 U	--	--	--
SODIUM	NA	191 U	--	140 U	235 U	155 U	246 U	141 U	229 U	--	--	--
THALLIUM	0.056	0.15 U [H]	--	0.20 U [H]	0.42 U [H]	0.21 U [H]	0.34 U [H]	0.20 U [H]	0.28 U [H]	--	--	--
TIN	47000	0.26 U		0.42 U	0.52 U	0.26 U	0.33 U	0.30 U	0.37 U	--	--	--
TITANIUM	100000	--	--	--	--	--	--	--	--	--	--	--
VANADIUM	7.8	23.0 J [H]	--	23.9 J [H]	20.6 J [H]	25.3 J [H]	26.9 J [H]	25.2 J [H]	30.0 J [H]	--	--	--
ZINC	680	59.7 J	--	128 J	53.5 J	54.8 J	36.1 J	61.0 J	63.3 J	--	--	--

TABLE 3-18

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING METAL CONTAMINATION DELINEATION AT THE BATTERY SITE
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLE ROUND		MCD				MCD	MCD		MCD	MCD	MCD
LOCATION		12SB22	12SB22	12SB23	12SB23	12SB24	12SB24	12SB24	12SB25	12SB25	12SB25
SAMPLE NUMBER		12SB220204	12SB220608	12SB230204	12SB230608	12SB240204	12SB240204-D	12SB240608	12SB250204	12SB250204-D	12SB250405
SAMPLE	HHRA	12SB220204	12SB220608	12SB230204	12SB230608	12SB240204	12FD11010502	12SB240608	12SB250204	12FD11010501	12SB250405
SUBMATRIX	CRITERIA	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB
SAMPLE CODE		NORMAL	--	--	--	ORIG	DUP	--	ORIG	DUP	NORMAL
DEPTH RANGE		(2 - 4)	REFUSAL	REFUSAL	REFUSAL	(2 - 4)	(2 - 4)	REFUSAL	(2 - 4)	(2 - 4)	(4 - 5)
SAMPLE DATE		20051101	--	--	--	20051101	20051101	--	20051101	20051101	20051101
Inorganics (mg/kg)											
ALUMINUM	8.3	16000 [H]	--	--	--	14400 [H]	13100 [H]	--	12200 J [H]	8630 [H]	12000 [H]
ANTIMONY	0.27	0.73 U [H]	--	--	--	0.30 U [H]	0.13 U	--	0.38 U [H]	0.48 U [H]	0.17 U
ARSENIC	0.29	45.2 J [H]	--	--	--	2 J [H]	1.3 J [H]	--	9 J [H]	12.5 J [H]	2.5 J [H]
BARIUM	82	45.1 J	--	--	--	40.9 J	45.3 J	--	47.9 J	47.3 J	30.5 J
BERYLLIUM	3.2	2.3 J	--	--	--	1.5 J	1.1 J	--	1.6 J	1.7 J	0.98 J
CADMIUM	0.38	0.10 J	--	--	--	0.05 J	0.04 J	--	0.23 U	0.20 U	0.18 U
CALCIUM	NA	645 J	--	--	--	672 J	680 J	--	612 J	592 J	685 J
CHROMIUM	2.1	49.5 J [H]	--	--	--	25.4 J [H]	25.4 J [H]	--	31.5 J [H]	31.3 J [H]	24.7 J [H]
COBALT	0.17	4.7 J [H]	--	--	--	5.6 J [H]	3 J [H]	--	59.1 J [H]	30.5 J [H]	6.2 J [H]
COPPER	310	18.2 J	--	--	--	6.9 J	4.8 J	--	14.5 J	16.8 J	11.7 J
IRON	2300	67600 J [H]	--	--	--	30200 J [H]	17700 J [H]	--	39100 J [H]	50000 J [H]	25400 J [H]
LEAD	81	23.5 J	--	--	--	11.3 J	8.9 J	--	15 J	12.2 J	14.6 J
MAGNESIUM	NA	1010 J	--	--	--	924 J	942 J	--	976 J	718 J	939 J
MANGANESE	110	227 J [H]	--	--	--	123 J [H]	57.3 J	--	519 J [H]	348 J [H]	108 J
MERCURY	23	--	--	--	--	--	--	--	--	--	--
NICKEL	14	38 J [H]	--	--	--	31.5 J [H]	22.7 J [H]	--	33.6 [H]	36.5 J [H]	24.9 J [H]
POTASSIUM	NA	2730 J	--	--	--	2290 J	2360 J	--	2570 J	1890 J	2270 J
SELENIUM	0.26	1.9 [H]	--	--	--	0.52 [H]	0.44 [H]	--	0.60 [H]	0.72 [H]	0.51 [H]
SILVER	1.6	0.043 U	--	--	--	0.041 U	0.04 J	--	0.045 U	0.042 U	0.042 U
SODIUM	NA	170 U	--	--	--	208 U	244 U	--	175 U	128 J	182 J
THALLIUM	0.056	0.22 U [H]	--	--	--	0.18 U [H]	0.16 U [H]	--	0.29 U [H]	0.23 U [H]	0.23 U [H]
TIN	47000	--	--	--	--	--	--	--	--	--	--
TITANIUM	100000	--	--	--	--	--	--	--	--	--	--
VANADIUM	7.8	28.3 J [H]	--	--	--	18.9 J [H]	15.9 J [H]	--	29.4 J [H]	24.8 J [H]	16.6 J [H]
ZINC	680	96.8 J	--	--	--	58.8 U	29.2 J	--	35.5 J	54.4 J	34.4 J

TABLE 3-18

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING METAL CONTAMINATION DELINEATION AT THE BATTERY SITE
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLE ROUND		MCD		MCD		MCD	MCD	MCD		MCD	
LOCATION		12SB31	12SB31	12SB32	12SB32	12SB33	12SB33	12SB34	12SB34	12SB35	12SB35
SAMPLE NUMBER		12SB310204	12SB310608	12SB320103	12SB320608	12SB330204	12SB330406	12SB340204	12SB340608	12SB350204	12SB350608
SAMPLE	HHRA	12SB310204	12SB310608	12SB320103	12SB320608	12SB330204	12SB330406	12SB340204	12SB340608	12SB350204	12SB350608
SUBMATRIX	CRITERIA	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB
SAMPLE CODE		NORMAL	--	NORMAL	--	NORMAL	NORMAL	NORMAL	--	NORMAL	--
DEPTH RANGE		(2 - 4)	REFUSAL	(1 - 3)	REFUSAL	(2 - 4)	(4 - 6)	(2 - 4)	REFUSAL	(2 - 4)	REFUSAL
SAMPLE DATE		20051101	--	20051101	--	20051101	20051101	20051101	--	20051101	--
Inorganics (mg/kg)											
ALUMINUM	8.3	13300 [H]	--	12700 [H]	--	16800 [H]	28100 [H]	12800 [H]	--	13200 [H]	--
ANTIMONY	0.27	0.21 U	--	0.26 U	--	0.57 U [H]	8.1 J [H]	0.27 U	--	0.42 U [H]	--
ARSENIC	0.29	2.3 J [H]	--	2.4 J [H]	--	12.8 J [H]	7.6 J [H]	2.3 J [H]	--	7.4 J [H]	--
BARIUM	82	29.6 J	--	208 J [H]	--	91.1 J [H]	281 J [H]	34.2 J	--	23.4 J	--
BERYLLIUM	3.2	2 J	--	0.32 J	--	0.85 J	0.69 J	1.5 J	--	0.53 J	--
CADMIUM	0.38	0.16 J	--	0.08 J	--	0.45 [H]	73.2 J [H]	0.15 J	--	0.11 J	--
CALCIUM	NA	446 J	--	330 J	--	1790 J	5010 J	523 J	--	418 J	--
CHROMIUM	2.1	33 J [H]	--	21.7 J [H]	--	20.3 J [H]	116 J [H]	25.9 J [H]	--	39.6 J [H]	--
COBALT	0.17	23.4 J [H]	--	1.3 J [H]	--	13.7 J [H]	7.7 J [H]	6.1 J [H]	--	1.6 J [H]	--
COPPER	310	12.9 J	--	4.3 J	--	15.3 J	1100 J [H]	7.7 J	--	9.2 J	--
IRON	2300	90200 J [H]	--	11800 J [H]	--	30300 J [H]	33300 J [H]	44900 J [H]	--	39200 J [H]	--
LEAD	81	15 J	--	9.4 J	--	26.3 J	1440 J [H]	13.6 J	--	10.9 J	--
MAGNESIUM	NA	773 J	--	901 J	--	2060 J	2090 J	945 J	--	916 J	--
MANGANESE	110	520 J [H]	--	13.9 J	--	844 J [H]	552 J [H]	181 J [H]	--	16.1 J	--
MERCURY	23	--	--	--	--	--	--	--	--	--	--
NICKEL	14	83.2 J [H]	--	5.8 J	--	19.2 J [H]	254 J [H]	30.6 J [H]	--	7.8 J	--
POTASSIUM	NA	2070 J	--	830 J	--	1370 J	1650 J	2250 J	--	941 J	--
SELENIUM	0.26	1.1 [H]	--	0.12 J	--	0.31 J [H]	0.31 J [H]	0.55 [H]	--	0.37 J [H]	--
SILVER	1.6	0.044 U	--	0.044 U	--	0.04 U	1.3	0.05 J	--	0.045 U	--
SODIUM	NA	93.1 U	--	3.36 U	--	3.09 U	556 J	71.5 U	--	21.6 U	--
THALLIUM	0.056	0.18 U [H]	--	0.16 U [H]	--	0.24 U [H]	0.28 U [H]	0.23 U [H]	--	0.18 U [H]	--
TIN	47000	--	--	--	--	--	--	--	--	--	--
TITANIUM	100000	--	--	--	--	--	--	--	--	--	--
VANADIUM	7.8	23.5 J [H]	--	23.6 J [H]	--	30.1 J [H]	30 J [H]	20 J [H]	--	35.7 J [H]	--
ZINC	680	131 J	--	8.7 J	--	255 J	2340 J [H]	40.6 J	--	13.3 J	--

TABLE 3-18

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING METAL CONTAMINATION DELINEATION AT THE BATTERY SITE
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLE ROUND										
LOCATION		12SB73	12SB73	12SB74	12SB74	12SB75	12SB75	12SB75	12SB76	12SB76
SAMPLE NUMBER		12SB730204	12SB730406	12SB740204	12SB740406	12SB750204	12SB750406	12SB750608	12SB760204	12SB760406
SAMPLE	HHRA	12SB730204	12SB730406	12SB740204	12SB740406	12SB750204	12SB750406	12SB750608	12SB760204	12SB760406
SUBMATRIX	CRITERIA	SB	SB	SB	SB	SB	SB	SB	SB	SB
SAMPLE CODE		--	--	--	--	--	--	--	NORMAL	ORIG
DEPTH RANGE		E & H	E & H	REFUSAL	REFUSAL	E & H	E & H	E & H	(2 - 4)	(4 - 6)
SAMPLE DATE		--	--	--	--	--	--	--	20061018	20061018
Inorganics (mg/kg)										
ALUMINUM	8.3	--	--	--	--	--	--	--	**9400 [H]**	**11900 [H]**
ANTIMONY	0.27	--	--	--	--	--	--	--	0.28 U [H]	0.049 U
ARSENIC	0.29	--	--	--	--	--	--	--	**1.59 [H]**	**0.973 [H]**
BARIUM	82	--	--	--	--	--	--	--	51.2 J	50.8 J
BERYLLIUM	3.2	--	--	--	--	--	--	--	2.66 J	1.03 J
CADMIUM	0.38	--	--	--	--	--	--	--	**0.478 [H]**	0.221
CALCIUM	NA	--	--	--	--	--	--	--	491 U	672 U
CHROMIUM	2.1	--	--	--	--	--	--	--	**30.1 J [H]**	**24.1 J [H]**
COBALT	0.17	--	--	--	--	--	--	--	**36.8 J [H]**	**30.1 J [H]**
COPPER	310	--	--	--	--	--	--	--	16	8.23
IRON	2300	--	--	--	--	--	--	--	**58400 [H]**	**11800 [H]**
LEAD	81	--	--	--	--	--	--	--	13.5 J	8.01 J
MAGNESIUM	NA	--	--	--	--	--	--	--	1050	1460
MANGANESE	110	--	--	--	--	--	--	--	**741 [H]**	**411 [H]**
MERCURY	23	--	--	--	--	--	--	--	--	--
NICKEL	14	--	--	--	--	--	--	--	**68.2 J [H]**	**26.2 J [H]**
POTASSIUM	NA	--	--	--	--	--	--	--	2180	2160
SELENIUM	0.26	--	--	--	--	--	--	--	**0.674 [H]**	**0.512 [H]**
SILVER	1.6	--	--	--	--	--	--	--	0.0577 J	0.0426 J
SODIUM	NA	--	--	--	--	--	--	--	212 U	254 U
THALLIUM	0.056	--	--	--	--	--	--	--	**0.128 J [H]**	**0.131 J [H]**
TIN	47000	--	--	--	--	--	--	--	--	--
TITANIUM	100000	--	--	--	--	--	--	--	23.9 J	19.1 J
VANADIUM	7.8	--	--	--	--	--	--	--	**33.8 J [H]**	**17.2 J [H]**
ZINC	680	--	--	--	--	--	--	--	170	30.8

TABLE 3-19

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION		12SB40	12SB40	12SB41	12SB41	12SB42	12SB42	12SB43	12SB43	12SB44
SAMPLE NUMBER	HHRA	12SB400305	12SB400507	12SB410507	12SB410709	12SB420406	12SB420810	12SB430204	12SB430608	12SB440305
SAMPLE CODE	CRITERIA	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE		3 - 5	5 - 7	5 - 7	7 - 9	4 - 6	8 - 10	2 - 4	6 - 8	3 - 5
SAMPLE DATE		2/16/2006	2/16/2006	2/20/2006	2/20/2006	2/20/2006	2/20/2006	2/20/2006	2/20/2006	2/16/2006
Energetics (mg/kg)										
1,3,5-TRINITROBENZENE	0.25	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
4,4'-TN-AZOXY	NA		0.5 U		0.5 U		0.5 U		0.5 U	
4-AMINO-2,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
HMX	310	0.25 U	0.25 U	0.25 U	0.25 U	0.43 J	0.25 U	0.25 U	0.25 U	0.25 U
MNX	NA		0.25 U		0.25 U		0.25 U		0.25 U	
RDX	4.4	0.25 U	0.25 U	0.25 U	0.25 U	3.4 J	0.25 U	0.25 U	0.25 U	0.25 U
TNX	NA		0.25 U		0.25 U		0.25 U		0.25 U	

TABLE 3-19

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION		12SB49	12SB49	12SB50	12SB50	12SB51	12SB51	12SB52	12SB52	12SB53
SAMPLE NUMBER	HHRA	12SB490608	12SB490810	12SB500608	12SB500810	12SB510406	12SB510608	12SB520204	12SB520507	12SB530204
SAMPLE CODE	CRITERIA	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE		6 - 8	8 - 10	6 - 8	8 - 10	4 - 6	6 - 8	2 - 4	4 - 5	2 - 4
SAMPLE DATE		2/17/2006	2/17/2006	2/17/2006	2/17/2006	2/16/2006	2/16/2006	2/16/2006	2/16/2006	2/16/2006
Energetics (mg/kg)										
1,3,5-TRINITROBENZENE	0.25	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	0.42 J	0.25 U	1.4	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	0.25 U	0.27 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
4,4'-TN-AZOXY	NA		0.5 U		0.5 U		0.5 U		0.5 U	
4-AMINO-2,6-DINITROTOLUENE	12	0.25 U	0.38 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
HMX	310	1.2	1.1	1.7	0.43 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
MNX	NA		0.25 U		0.25 U		0.25 U		0.25 U	
RDX	4.4	0.92	1.6	4.2	0.48 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
TNX	NA		0.25 U		0.25 U		0.25 U		0.25 U	

TABLE 3-19

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE DEPTH RANGE SAMPLE DATE	HHRA CRITERIA	ES/DI 12SB57 12SB570507 NORMAL 5 - 7 2/20/2006	ES/DI 12SB58 12SB580305 NORMAL 3 - 5 2/20/2006	ES/DI 12SB58 12SB580507 NORMAL 5 - 7 2/20/2006	ES/DI 12SB59 12SB590406 NORMAL 4 - 6 2/16/2006	ES/DI 12SB59 12SB590607 NORMAL 6 - 7 2/16/2006	ES/DI 12SB60 12SB600406 NORMAL 4 - 6 2/16/2006	ES/DI 12SB60 12SB600608 NORMAL 6 - 8 2/16/2006	ES/DI 12SB61 12SB610204 NORMAL 2 - 4 2/17/2006	ES/DI 12SB62 12SB620406 NORMAL 4 - 6 2/17/2006
Energetics (mg/kg)										
1,3,5-TRINITROBENZENE	0.25	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	**4.2**	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	0.25 U	0.25 U	0.25 U	0.49 J	0.25 U	**12**	0.25 U	1.1	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.35 J	0.25 U
4,4'-TN-AZOXY	NA	0.5 U		0.5 U		0.5 U		0.5 U	1.3	
4-AMINO-2,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.9	0.25 U
HMX	310	5.4	0.25 U	0.25 U	0.25 U	0.72	0.25 U	0.25 U	40	2.8 J
MNX	NA	0.25 U		0.25 U		0.25 U		0.25 U	0.52	
RDX	4.4	1.3	0.25 U	0.25 U	0.34 J	1.9	0.55	0.25 U	**62**	2.5
TNX	NA	0.25 U		0.25 U		0.25 U		0.25 U	0.39 J	

TABLE 3-19

RESULTS FOR CHEMICALS DETECTED IN SUBSURFACE SOIL SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION		12SB67	12SB67	12SB68	12SB69	12SB70	12SB70	12SB70	12SB71
SAMPLE NUMBER	HHRA	12SB670810	12SB670608	12SB680204	12SB690204	12SB700406	12SB700810	12SB701012	12SB710406
SAMPLE CODE	CRITERIA	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE		8 - 10	6 - 8	2 - 4	2 - 4	4 - 6	8 - 10	10 - 12	4 - 6
SAMPLE DATE		2/20/2006	2/20/2006	2/16/2006	2/16/2006	2/16/2006	2/16/2006	2/16/2006	2/21/2006
Energetics (mg/kg)									
1,3,5-TRINITROBENZENE	0.25	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	3.1	0.25 U	0.25 U	2.7	0.25 U	1	0.25 U	0.25 U	0.25 U
2-AMINO-4,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
4,4'-TN-AZOXY	NA	0.5 U		0.5 U	0.5 U			0.5 U	0.5 U
4-AMINO-2,6-DINITROTOLUENE	12	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
HMX	310	0.25 U	0.25 U	1.4	0.4 J	0.25 U	0.25 U	0.25 U	0.25 U
MNX	NA	0.25 U		0.25 U	0.25 U			0.25 U	0.25 U
RDX	4.4	0.25 U	0.25 U	4.2	0.82	0.25 U	0.25 U	0.25 U	0.25 U
TNX	NA	0.25 U		0.25 U	0.25 U			0.25 U	0.25 U

Data qualifiers (e.g., U, J) are defined in Appendix H.
ES/DI - External Sump/Drainage Investigation.
HHRA - Human health risk assessment.
mg/kg - milligrams per kilogram.
NA - No applicable criterion.
Samples listed in Table 2-3 are not shown if last four characters of sample number is "xxxx".

TABLE 3-20

DESCRIPTIVE STATISTICS FOR UPGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Total Metals (ug/L)									
ALUMINUM	3600	87	9/10	102 J	8920 J	169	1275	1407	12SW3001
ARSENIC	0.045	148	5/10	0.21 J	8.6	0.07 - 0.21	1.18	2.29	12SW3001
BARIUM	260	220	10/10	33.9 J	112 J	---	56.4	56.4	12SW3001
BERYLLIUM	4	3.6	2/10	0.03 J	0.31 J	0.02 - 0.45	0.0670	0.170	12SW3301
CADMIUM	1.8	0.15	3/10	0.11 J	1.6	0.039 - 1.4	0.316	0.613	12SW3001
CALCIUM	NA	NA	10/10	19100 J	75500 J	---	38340	38340	12SW3001
CHROMIUM	11	42	2/10	3 J	13.9 J	0.48 - 1.2	1.98	8.45	12SW3001
COBALT	73	24	10/10	0.23 J	9.2 J	---	2.20	2.20	12SW3301
COPPER	150	1.58	6/10	0.74 J	20.6 J	0.46 - 2.1	3.24	5.02	12SW3001
IRON	1100	1000	10/10	178 J	14300 J	---	2018	2018	12SW3001
LEAD	15	1.17	7/10	0.08 J	25.3	0.26 - 0.34	2.87	4.03	12SW3001
MAGNESIUM	NA	NA	10/10	5720 J	11100	---	7062	7062	12SW3001
MANGANESE	88	NA	10/10	8.3 J	347 J	---	82.1	82.1	12SW3301
MERCURY	1.1	0.0013	1/10	0.66	0.66	0.03	0.0795	0.660	12SW0802
NICKEL	73	28.9	10/10	0.57 J	20.5 J	---	5.70	5.70	12SW3301
POTASSIUM	NA	NA	10/10	551 J	2240 J	---	1496	1496	12SW0801
SELENIUM	18	5	1/10	0.73 J	0.73 J	0.16 - 0.61	0.219	0.730	12SW3001
SODIUM	NA	NA	10/10	2260 J	24000 J	---	9797	9797	12SW3001
THALLIUM	0.24	10	6/10	0.05 J	0.21 J	0.043	0.0626	0.0900	12SW3001
VANADIUM	3.6	12	2/10	2.9	21.6	1.14	2.91	12.3	12SW3001
ZINC	1100	65.7	6/10	5.3 J	532 J	1.4 - 7.4	61.2	101	12SW3001
Dissolved Metals (ug/L)									
ALUMINUM	3600	87	4/10	24.7 J	138 J	8.35 - 40.7	32.2	61.7	12SW2201-F
ARSENIC	0.045	148	3/10	0.11 J	1	0.047 - 0.16	0.221	0.620	12SW2901-F
BARIUM	260	220	10/10	36.5 J	72 J	---	49.0	49.0	12SW2201-F
BERYLLIUM	4	3.6	1/10	0.1 J	0.1 J	0.02 - 0.03	0.0195	0.100	12SW3301-F
CADMIUM	1.8	0.15	2/10	0.06 J	0.16 J	0.039 - 0.62	0.101	0.110	12SW3001-F
CALCIUM	NA	NA	10/10	19200 J	57500 J	---	32680	32680	12SW3001-F
CHROMIUM	11	42	1/10	0.92 J	0.92 J	0.26 - 1	0.335	0.920	12SW3301-F
COBALT	73	24	9/10	0.12 J	8.9 J	0.12	1.11	1.22	12SW3301-F
COPPER	150	1.58	10/10	0.5 J	3.6 J	---	1.38	1.38	12SW2901-F
IRON	1100	1000	10/10	125 J	868 J	---	258	258	12SW3301-F
LEAD	15	1.17	9/10	0.12 J	0.28 J	0.184	0.191	0.202	12SW2201-F
MAGNESIUM	NA	NA	10/10	5620 J	8490 J	---	6848	6848	12SW3001-F
MANGANESE	88	NA	9/10	1 J	235 J	0.752	34.7	38.5	12SW3301-F
NICKEL	73	28.9	10/10	1.7 J	20.6 J	---	4.46	4.46	12SW3301-F
POTASSIUM	NA	NA	10/10	553 J	2270 J	---	1271	1271	12SW0801-F
SODIUM	NA	NA	10/10	2100 J	27800 J	---	10399	10399	12SW3001-F
THALLIUM	0.24	10	1/9	0.06 J	0.06 J	0.043 - 0.08	0.0318	0.0600	12SW3001-F
ZINC	1100	65.7	7/10	2.2 J	41.2 J	3.1 - 5.7	9.55	12.7	12SW3301-F

TABLE 3-21

DESCRIPTIVE STATISTICS FOR UPGRADIENT EAST TRIBUTARY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)									
DNX	NA	NA	1/2	0.66 J	0.66 J	0.25	0.393	0.660	12SW1601
HMX	180	330	1/2	0.36 J	0.36 J	0.26	0.245	0.360	12SW1602
MNX	NA	NA	1/2	0.68	0.68	0.25	0.403	0.680	12SW1601
Total Metals (ug/L)									
ALUMINUM	3600	87	1/2	102	102	45.3	62.3	102	12SW1601
BARIUM	260	220	2/2	39 J	41.8 J	---	40.4	40.4	12SW1601
BERYLLIUM	4	3.6	1/2	0.02 J	0.02 J	0.02	0.0150	0.0200	12SW1601
CALCIUM	NA	NA	2/2	47200 J	63500 J	---	55350	55350	12SW1602
COBALT	73	24	1/2	0.18 J	0.18 J	0.22	0.145	0.180	12SW1602
COPPER	150	1.58	2/2	0.89 J	1.5 J	---	1.20	1.20	12SW1601
IRON	1100	1000	2/2	337 J	345 J	---	341	341	12SW1601
LEAD	15	1.17	1/2	0.28 J	0.28 J	0.24	0.200	0.280	12SW1602
MAGNESIUM	NA	NA	2/2	9130 J	11100 J	---	10115	10115	12SW1602
MANGANESE	88	NA	2/2	2.1 J	7.5 J	---	4.80	4.80	12SW1601
NICKEL	73	28.9	2/2	1.9 J	2.4 J	---	2.15	2.15	12SW1602
POTASSIUM	NA	NA	2/2	1170 J	2730 J	---	1950	1950	12SW1601
SODIUM	NA	NA	2/2	19700 J	28000 J	---	23850	23850	12SW1602
THALLIUM	0.24	10	2/2	0.06 J	0.09 J	---	0.0750	0.0750	12SW1602
Dissolved Metals (ug/L)									
BARIUM	260	220	2/2	43.2 J	44.8 J	---	44.0	44.0	12SW1602-F
CALCIUM	NA	NA	2/2	49300 J	50700 J	---	50000	50000	12SW1602-F
CHROMIUM	11	42	1/2	1.4 J	1.4 J	1.5	1.08	1.40	12SW1602-F
COBALT	73	24	1/2	0.18 J	0.18 J	0.17	0.133	0.180	12SW1602-F
COPPER	150	1.58	1/2	0.89 J	0.89 J	1.4	0.795	0.890	12SW1602-F
IRON	1100	1000	2/2	251 J	321 J	---	286	286	12SW1602-F
LEAD	15	1.17	1/2	0.24 J	0.24 J	0.24	0.180	0.240	12SW1602-F
MAGNESIUM	NA	NA	2/2	9370 J	12300 J	---	10835	10835	12SW1602-F
MANGANESE	88	NA	1/2	1.2 J	1.2 J	5.9	2.08	1.20	12SW1602-F
NICKEL	73	28.9	2/2	2.7 J	3.3 J	---	3.00	3.00	12SW1602-F
POTASSIUM	NA	NA	2/2	1330 J	2820 J	---	2075	2075	12SW1601-F
SODIUM	NA	NA	2/2	21900 J	24100 J	---	23000	23000	12SW1602-F
THALLIUM	0.24	10	1/2	0.07 J	0.07 J	0.09	0.0575	0.0700	12SW1601-F
ZINC	1100	65.7	1/2	1.5 J	1.5 J	4	1.75	1.50	12SW1602-F
Field Parameters									
DISSOLVED OXYGEN (mg/L)	NA	NA	2/2	2.09	8.86	---	5.48	5.48	12SW1601
OXIDATION-REDUCTION POTENTIAL (MV)	NA	NA	2/2	38.9	100	---	69.5	69.5	12SW1602
PH (S.U.)	NA	NA	2/2	7.36	7.73	---	7.55	7.55	12SW1602
SPECIFIC CONDUCTANCE (MS/CM)	NA	NA	2/2	0.204	0.286	---	0.245	0.245	12SW1601
TEMPERATURE (°C)	NA	NA	1/1	6.52	6.52	---	6.52	6.52	12SW1602
TURBIDITY (NTU)	NA	NA	2/2	3.5	5.1	---	4.30	4.30	12SW1601

TABLE 3-22

DESCRIPTIVE STATISTICS FOR UPGRADIENT TURKEY CREEK MAIN STREAM
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Total Metals (ug/L)									
ALUMINUM	3600	87	1/2	59.3	59.3	98.6	54.3	59.3	12SW2501
BARIUM	260	220	2/2	35.4 J	75 J	---	55.2	55.2	12SW2501
BERYLLIUM	4	3.6	1/2	0.04 J	0.04 J	0.02	0.0250	0.0400	12SW2501
CALCIUM	NA	NA	2/2	31100 J	61000 J	---	46050	46050	12SW2501
COBALT	73	24	1/2	0.15 J	0.15 J	0.3	0.150	0.150	12SW2502
IRON	1100	1000	2/2	230 J	510 J	---	370	370	12SW2501
MAGNESIUM	NA	NA	2/2	4260 J	9410 J	---	6835	6835	12SW2501
MANGANESE	88	NA	2/2	22 J	77.3 J	---	49.7	49.7	12SW2501
NICKEL	73	28.9	1/2	2 J	2 J	0.1	1.03	2.00	12SW2501
POTASSIUM	NA	NA	2/2	663 J	1670 J	---	1167	1167	12SW2501
SODIUM	NA	NA	2/2	3570 J	10300 J	---	6935	6935	12SW2501
Dissolved Metals (ug/L)									
ALUMINUM	7.3	87	1/2	9.9 J	9.9 J	8.6	7.10	9.90	12SW2502-F
BARIUM	260	220	2/2	34.7 J	59.5 J	---	47.1	47.1	12SW2501-F
CALCIUM	NA	NA	2/2	23900 J	57700 J	---	40800	40800	12SW2501-F
COPPER	150	1.58	1/2	0.3 J	0.3 J	0.49	0.273	0.300	12SW2502-F
IRON	1100	1000	2/2	149 J	249 J	---	199	199	12SW2501-F
MAGNESIUM	NA	NA	2/2	5250 J	8210 J	---	6730	6730	12SW2501-F
MANGANESE	88	NA	2/2	18 J	49.2 J	---	33.6	33.6	12SW2501-F
NICKEL	73	28.9	1/2	1.5 J	1.5 J	1.5	1.13	1.50	12SW2502-F
POTASSIUM	NA	NA	2/2	741 J	1490 J	---	1116	1116	12SW2501-F
SODIUM	NA	NA	2/2	4640 J	9090 J	---	6865	6865	12SW2501-F
ZINC	1100	65.7	1/2	3.9 J	3.9 J	3.3	2.78	3.90	12SW2502-F
Field Parameters									
DISSOLVED OXYGEN (mg/L)	NA	NA	2/2	2.97	8.89	---	5.93	5.93	12SW2501
OXIDATION-REDUCTION POTENTIAL (MV)	NA	NA	2/2	116	260.5	---	188	188	12SW2501
PH (S.U.)	NA	NA	2/2	6.92	7.13	---	7.03	7.03	12SW2502
SPECIFIC CONDUCTANCE (MS/CM)	NA	NA	2/2	0.078	0.282	---	0.180	0.180	12SW2501
TEMPERATURE (°C)	NA	NA	2/2	5.25	12.58	---	8.92	8.92	12SW2501
TURBIDITY (NTU)	NA	NA	2/2	2.4	3.76	---	3.08	3.08	12SW2502

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
MV - millivolts.
S.U. - Standard units.
MS/CM - milliSiemens per centimeter.
C - Celsius.
NTU - nephelometric turbidity units.
NA - No applicable criterion.

TABLE 3-23

RESULTS FOR CHEMICALS DETECTED IN UPGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	01 12SW/SD08 12SW0801 NORMAL 10/27/2004	01 12SW/SD08 12SW0801-F NORMAL 10/27/2004	02 12SW/SD08 12SW0802 NORMAL 3/6/2005	02 12SW/SD08 12SW0802-F NORMAL 3/6/2005	01 12SW/SD22 12SW2201 NORMAL 10/29/2004	01 12SW/SD22 12SW2201-F NORMAL 10/29/2004	02 12SW/SD22 12SW2202 DRY 3/5/2005	01 12SW/SD26 12SW2601 NORMAL 10/27/2004	01 12SW/SD26 12SW2601-F NORMAL 10/27/2004	02 12SW/SD26 12SW2602 NORMAL 3/5/2005
Total Metals (ug/L)												
ALUMINUM	3600	87	181 J		255 J		260 J			424 J		264 J
ARSENIC	0.045	148	0.22 J		0.21 U		0.15 U			0.4 J		0.07 U
BARIUM	260	220	61.8 J		48.8 J		76.9 J			45.2 J		49.1 J
BERYLLIUM	4	3.6	0.02 U		0.02 U		0.02 U			0.02 U		0.02 U
CADMIUM	1.8	0.15	1.4 U		0.039 U		0.83 U			0.25 U		0.039 U
CALCIUM	NA	NA	29700		30700 J		31200			34700		54900 J
CHROMIUM	11	42	0.69 U		0.75 U		0.56 U			0.97 U		1.2 U
COBALT	73	24	0.29 J		0.32 J		0.23 J			0.29 J		0.3 J
COPPER	150	1.58	2.1 U		0.79 J		1.2 J			1.4 U		0.46 U
IRON	1100	1000	461 J		315 J		334 J			766 J		505 J
LEAD	15	1.17	0.27 U		0.315 J		0.26 U			0.34 U		0.2 J
MAGNESIUM	NA	NA	5870 J		5950 J		8320			5720 J		6790 J
MANGANESE	88	NA	10 J		12.4 J		12 J			8.3 J		11.2 J
MERCURY	1.1	0.0013	0.03 U		0.66		0.03 U			0.03 U		0.03 U
NICKEL	73	28.9	2.9 J		1.5 J		1.8 J			2.7 J		0.57 J
POTASSIUM	NA	NA	2240 J		849 J		1900 J			1790 J		1050 J
SELENIUM	18	5	0.39 U		0.26 U		0.28 U			0.61 U		0.27 U
SODIUM	NA	NA	15100 J		16100 J		2260 J			3450 J		5740 J
THALLIUM	0.24	10	0.043 U		0.09 J		0.043 U			0.043 U		0.06 J
VANADIUM	3.6	12	1.14 U		1.14 U		1.14 U			1.14 U		1.14 U
ZINC	1100	65.7	1.4 U		5.3 J		4.7 U			7.4 U		3.6 U
Dissolved Metals (ug/L)												
ALUMINUM	3600	87		24.2 U		8.35 U		138 J			40.7 U	
ARSENIC	0.045	148		0.11 U		0.047 U		0.1 U			0.16 U	
BARIUM	260	220		58.4 J		41.1 J		72 J			46.8 J	
BERYLLIUM	4	3.6		0.02 U		0.02 U		0.02 U			0.02 U	
CADMIUM	1.8	0.15		0.32 U		0.039 U		0.37 U			0.62 U	
CALCIUM	NA	NA		29500		21600 J		30600			33600	
CHROMIUM	11	42		0.37 U		0.46 U		0.36 U			0.47 U	
COBALT	73	24		0.13 J		0.12 U		0.12 J			0.15 J	
COPPER	150	1.58		1.9 J		0.6 J		0.83 J			1.1 J	
IRON	1100	1000		187 J		179 J		192 J			231 J	
LEAD	15	1.17		0.22 J		0.184 U		0.28 J			0.2 J	
MAGNESIUM	NA	NA		6080 J		5900 J		7740 J			5620 J	
MANGANESE	88	NA		1.3 J		0.752 U		2.4 J			4.2 J	
NICKEL	73	28.9		2.3 J		1.7 J		1.8 J			2.1 J	
POTASSIUM	NA	NA		2270 J		800 J		1820 J			1680 J	
SODIUM	NA	NA		15300 J		16400 J		2100 J			3370 J	
THALLIUM	0.24	10		0.043 U		0.08 U		0.043 UR			0.043 U	
ZINC	1100	65.7		4 U		3.6 J		5.7 U			3.1 U	

TABLE 3-23

RESULTS FOR CHEMICALS DETECTED IN UPGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA	ERA	02	01	01	02	02	01	01	02	01
LOCATION	CRITERIA	CRITERIA	12SW/SD26	12SW/SD28	12SW/SD28	12SW/SD28	12SW/SD28	12SW/SD29	12SW/SD29	12SW/SD29	12SW/SD30
SAMPLE NUMBER			12SW2602-F	12SW2801	12SW2801-F	12SW2802	12SW2802-F	12SW2901	12SW2901-F	12SW2902	12SW3001
SAMPLE CODE			NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DRY	NORMAL
SAMPLE DATE			3/5/2005	10/30/2004	10/30/2004	3/6/2005	3/6/2005	11/1/2004	11/1/2004	3/6/2005	11/1/2004
Total Metals (ug/L)											
ALUMINUM	3600	87		102 J		169 U		1660 J			8920 J
ARSENIC	0.045	148		0.21 J		0.14 U		2			8.6
BARIUM	260	220		46.1 J		36.1 J		53.7 J			112 J
BERYLLIUM	4	3.6		0.03 U		0.03 J		0.08 U			0.45 U
CADMIUM	1.8	0.15		0.039 U		0.039 U		0.11 J			1.6
CALCIUM	NA	NA		32300 J		19100 J		39100 J			75500 J
CHROMIUM	11	42		0.64 U		0.49 U		3 J			13.9 J
COBALT	73	24		0.44 J		0.73 J		1.2 J			9
COPPER	150	1.58		0.91 J		0.56 U		5.9 J			20.6 J
IRON	1100	1000		178 J		192 J		1930 J			14300 J
LEAD	15	1.17		0.08 J		0.127 J		2			25.3
MAGNESIUM	NA	NA		7280		5810 J		6250			11100
MANGANESE	88	NA		33.4		51.5 J		46.3			289
MERCURY	1.1	0.0013		0.03 U		0.03 U		0.03 U			0.03 U
NICKEL	73	28.9		2.6 J		3.5 J		3.3 J			17.6 J
POTASSIUM	NA	NA		1580 J		551 J		1960 J			2070 J
SELENIUM	18	5		0.28 U		0.16 U		0.3 U			0.73 J
SODIUM	NA	NA		9630 J		6640 J		3450 J			24000 J
THALLIUM	0.24	10		0.06 J		0.05 J		0.043 U			0.21 J
VANADIUM	3.6	12		1.14 U		1.14 U		2.9			21.6
ZINC	1100	65.7		5.7 J		7.7 J		11.4 J			532 J
Dissolved Metals (ug/L)											
ALUMINUM	3600	87	24.7 J		29.7 U		37.4 J		11.4 U		
ARSENIC	0.045	148	0.12 U		0.11 J		0.11 U		1		
BARIUM	260	220	49.2 J		46.2 J		36.5 J		45.3 J		
BERYLLIUM	4	3.6	0.02 U		0.03 U		0.02 U		0.02 U		
CADMIUM	1.8	0.15	0.039 U		0.06 J		0.039 U		0.039 U		
CALCIUM	NA	NA	41100 J		34000 J		19200 J		39900 J		
CHROMIUM	11	42	0.51 U		0.26 U		0.84 U		1 U		
COBALT	73	24	0.15 J		0.6 J		0.64 J		0.16 J		
COPPER	150	1.58	0.6 J		1.2 J		0.5 J		3.6 J		
IRON	1100	1000	274 J		152 J		125 J		153 J		
LEAD	15	1.17	0.201 J		0.18 J		0.209 J		0.12 J		
MAGNESIUM	NA	NA	8230 J		7340 J		5860 J		6030 J		
MANGANESE	88	NA	1 J		43.5		45.1 J		10.7		
NICKEL	73	28.9	2.4 J		3.8 J		4 J		2.5 J		
POTASSIUM	NA	NA	1090 J		1270 J		553 J		1470 J		
SODIUM	NA	NA	6950 J		10500 J		6860 J		3410 J		
THALLIUM	0.24	10	0.06 U		0.043 U		0.06 U		0.043 U		
ZINC	1100	65.7	3.2 J		4.2 J		6.9 J		2.2 J		

TABLE 3-23

RESULTS FOR CHEMICALS DETECTED IN UPGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	01 12SW/SD30 12SW3001-F NORMAL 11/1/2004	02 12SW/SD30 12SW3002 DRY 3/6/2005	02 12SW/SD33 12SW3301 NORMAL 3/6/2005	02 12SW/SD33 12SW3301-F NORMAL 3/6/2005
Total Metals (ug/L)						
ALUMINUM	3600	87			598 J	
ARSENIC	0.045	148			0.15 U	
BARIUM	260	220			33.9 J	
BERYLLIUM	4	3.6			0.31 J	
CADMIUM	1.8	0.15			0.13 J	
CALCIUM	NA	NA			36200 J	
CHROMIUM	11	42			0.48 U	
COBALT	73	24			9.2 J	
COPPER	150	1.58			0.74 J	
IRON	1100	1000			1200 J	
LEAD	15	1.17			0.207 J	
MAGNESIUM	NA	NA			7530 J	
MANGANESE	88	NA			347 J	
MERCURY	1.1	0.0013			0.03 U	
NICKEL	73	28.9			20.5 J	
POTASSIUM	NA	NA			965 J	
SELENIUM	18	5			0.37 U	
SODIUM	NA	NA			11600 J	
THALLIUM	0.24	10			0.07 J	
VANADIUM	3.6	12			1.14 U	
ZINC	1100	65.7			41.3 J	
Dissolved Metals (ug/L)						
ALUMINUM	3600	87	36.5 U			46.8 J
ARSENIC	0.045	148	0.75 J			0.05 U
BARIUM	260	220	46.7 J			47.8 J
BERYLLIUM	4	3.6	0.02 U			0.1 J
CADMIUM	1.8	0.15	0.16 J			0.12 U
CALCIUM	NA	NA	57500 J			19800 J
CHROMIUM	11	42	0.59 U			0.92 J
COBALT	73	24	0.17 J			8.9 J
COPPER	150	1.58	2.8 J			0.68 J
IRON	1100	1000	219 J			868 J
LEAD	15	1.17	0.2 J			0.207 J
MAGNESIUM	NA	NA	8490 J			7190 J
MANGANESE	88	NA	3.3 J			235 J
NICKEL	73	28.9	3.4 J			20.6 J
POTASSIUM	NA	NA	853 J			899 J
SODIUM	NA	NA	27800 J			11300 J
THALLIUM	0.24	10	0.06 J			0.08 U
ZINC	1100	65.7	27.8 J			41.2 J

TABLE 3-24

RESULTS FOR CHEMICALS DETECTED IN UPGRADIENT EAST TRIBUTARY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	01 12SW/SD16 12SW1601 NORMAL 10/13/2004	01 12SW/SD16 12SW1601-F NORMAL 10/13/2004	02 12SW/SD16 12SW1602 NORMAL 3/5/2005	02 12SW/SD16 12SW1602-F NORMAL 3/5/2005
Energetics (ug/L)						
DNX	NA	NA	0.66 J		0.25 U	
HMX	180	330	0.26 U		0.36 J	
MNX	NA	NA	0.68		0.25 U	
Total Metals (ug/L)						
ALUMINUM	3600	87	**102**		45.3 U	
BARIUM	260	220	41.8 J		39 J	
BERYLLIUM	4	3.6	0.02 J		0.02 U	
CALCIUM	NA	NA	47200 J		63500 J	
COBALT	73	24	0.22 U		0.18 J	
COPPER	150	1.58	1.5 J		0.89 J	
IRON	1100	1000	345 J		337 J	
LEAD	15	1.17	0.24 U		0.28 J	
MAGNESIUM	NA	NA	9130 J		11100 J	
MANGANESE	88	NA	7.5 J		2.1 J	
NICKEL	73	28.9	1.9 J		2.4 J	
POTASSIUM	NA	NA	2730 J		1170 J	
SODIUM	NA	NA	19700 J		28000 J	
THALLIUM	0.24	10	0.06 J		0.09 J	
Dissolved Metals (ug/L)						
BARIUM	260	220		43.2 J		44.8 J
CALCIUM	NA	NA		49300 J		50700 J
CHROMIUM	11	42		1.5 U		1.4 J
COBALT	73	24		0.17 U		0.18 J
COPPER	150	1.58		1.4 U		0.89 J
IRON	1100	1000		251 J		321 J
LEAD	15	1.17		0.24 U		0.24 J
MAGNESIUM	NA	NA		9370 J		12300 J
MANGANESE	88	NA		5.9 U		1.2 J
NICKEL	73	28.9		2.7 J		3.3 J
POTASSIUM	NA	NA		2820 J		1330 J
SODIUM	NA	NA		21900 J		24100 J
THALLIUM	0.24	10		0.07 J		0.09 U
ZINC	1100	65.7		4 U		1.5 J
Field Parameters						
DISSOLVED OXYGEN (mg/L)	NA	NA	8.86		2.09	
OXIDATION-REDUCTION POTENTIAL (MV)	NA	NA	38.9		100	
PH (S.U.)	NA	NA	7.36		7.73	
SPECIFIC CONDUCTANCE (MS/CM)	NA	NA	0.286		0.204	
TEMPERATURE (°C)	NA	NA			6.52	
TURBIDITY (NTU)	NA	NA	5.1		3.5	
Miscellaneous Parameter (mg/L)						
AMMONIA-N	NA	NA	0.12 J		0.005 U	
NITRITE/NITRATE-N	1	NA	0.1		0.1 J	

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
MV - millivolts.
S.U. - standard units.
MS/CM - milliSiemens per centimeter.
C - Celsius.
NTU - nephelometric turbidity units.
NA - No applicable criterion.
Chemicals detected above either HHRA or ERA criteria values are identified by bold formatting.

TABLE 3-25

RESULTS FOR CHEMICALS DETECTED FOR UPGRADIENT TURKEY CREEK MAINSTREAM
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	01 12SW/SD25 12SW2501 ORIG 10/11/2004	01 12SW/SD25 12SW2501-F ORIG 10/11/2004	02 12SW/SD25 12SW2502 NORMAL 3/5/2005	02 12SW/SD25 12SW2502-F NORMAL 3/5/2005
Total Metals (ug/L)						
ALUMINUM	3600	87	59.3		98.6 U	
BARIUM	260	220	75 J		35.4 J	
BERYLLIUM	4	3.6	0.04 J		0.02 U	
CALCIUM	NA	NA	61000 J		31100 J	
COBALT	73	24	0.3 U		0.15 J	
IRON	1100	1000	510 J		230 J	
MAGNESIUM	NA	NA	9410 J		4260 J	
MANGANESE	88	NA	77.3 J		22 J	
NICKEL	73	28.9	2 J		0.1 UJ	
POTASSIUM	NA	NA	1670 J		663 J	
SODIUM	NA	NA	10300 J		3570 J	
Dissolved Metals (ug/L)						
ALUMINUM	7.3	3.6		8.6 U		**9.9 J**
BARIUM	260	220		59.5 J		34.7 J
CALCIUM	NA	NA		57700 J		23900 J
COPPER	150	1.58		0.49 U		0.3 J
IRON	1100	1000		249 J		149 J
MAGNESIUM	NA	NA		8210 J		5250 J
MANGANESE	88	NA		49.2 J		18 J
NICKEL	73	28.9		1.5 U		1.5 J
POTASSIUM	NA	NA		1490 J		741 J
SODIUM	NA	NA		9090 J		4640 J
ZINC	1100	65.7		3.3 U		3.9 J
Field Parameters						
DISSOLVED OXYGEN (mg/L)	NA	NA	8.89		2.97	
OXIDATION-REDUCTION POTENTIAL (MV)	NA	NA	260.5		116	
PH (S.U.)	NA	NA	6.92		7.13	
SPECIFIC CONDUCTANCE (MS/CM)	NA	NA	0.282		0.078	
TEMPERATURE (°C)	NA	NA	12.58		5.25	
TURBIDITY (NTU)	NA	NA	2.4		3.76	

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
MV - millivolts.
S.U. - standard units.
MS/CM - milliSiemens per centimeter.
C - Celsius.
NTU - nephelometric turbidity units.
NA - No applicable criterion.
Field duplicate samples are excluded from these summaries because they are considered to be field QC samples.
Chemicals detected above either HHRA or ERA criteria values are identified by bold formatting.

TABLE 3-26

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample of Maximum Detect
Energetics (ug/L)									
1,3,5-TRINITROBENZENE	110	11	1/39	0.96 J	0.96 J	0.238 - 0.278	0.148	0.960	12SW3101
2,4,6-TRINITROTOLUENE	1.8	90	4/39	0.56	79	0.238 - 0.278	3.08	28.9	12SW3101
2,4-DIAMINO-6-NITROTOLUENE	NA	NA	3/39	0.79 J	1.6 J	0.238 - 0.278	0.217	1.30	12SW3101
2,4-DINITROTOLUENE	7.3	44	3/39	0.27 J	0.47 J	0.238 - 0.278	0.145	0.367	12SW1201
2,6-DIAMINO-4-NITROTOLUENE	NA	NA	1/39	0.27 J	0.27 J	0.238 - 0.278	0.131	0.270	12SW3601
2,6-DINITROTOLUENE	3.6	81	1/39	0.27 J	0.27 J	0.238 - 0.278	0.131	0.270	12SW1201
2-AMINO-4,6-DINITROTOLUENE	0.73	20	12/39	0.27 J	19 J	0.238 - 0.278	1.34	4.07	12SW1201
3,5-DINITROANILINE	NA	60	3/39	0.6	1.9	0.238 - 0.278	0.212	1.23	12SW1301
3-NITROTOLUENE	12	NA	1/39	0.71 J	0.71 J	0.238 - 0.278	0.142	0.710	12SW1401
4-AMINO-2,6-DINITROTOLUENE	0.73	NA	17/39	0.28 J	74	0.238 - 0.278	3.65	8.22	12SW1201
HMX	180	330	29/39	0.9	98	0.24 - 0.264	8.08	10.8	12SW3401
MNX	NA	NA	10/39	0.32 J	1.9	0.238 - 0.278	0.310	0.844	12SW3401
RDX	0.61	190	30/39	0.36 J	140	0.24 - 0.264	15.3	19.8	12SW3401
Total Metals (ug/L)									
ALUMINUM	3600	87	33/39	90.6	67700	32 - 163	3491	4116	12SW3501
ARSENIC	0.045	148	35/39	0.16 J	20.3	0.11 - 0.32	2.58	2.86	12SW3501
BARIUM	260	220	38/39	17.9 J	589 J	0.37	92.9	95.4	12SW3501
BERYLLIUM	4	3.6	19/39	0.02 J	5.2	0.02 - 0.17	0.231	0.455	12SW3501
CADMIUM	1.8	0.15	18/39	0.06 J	43.7 J	0.039 - 1.5	1.67	3.38	12SW3501
CALCIUM	NA	NA	39/39	1100 J	119000 J	---	44296	44296	12SW3501
CHROMIUM	11	42	17/39	1.6 J	105 J	0.08 - 2	4.90	10.6	12SW3501
COBALT	73	24	39/39	0.14 J	123	---	5.87	5.87	12SW3501
COPPER	150	1.58	38/39	0.74 J	1650 J	0.98	48.5	49.7	12SW3501
IRON	1100	1000	39/39	161 J	95400 J	---	5229	5229	12SW3501
LEAD	15	1.17	30/39	0.095 J	458	0.069 - 0.77	15.0	19.4	12SW3501
MAGNESIUM	NA	NA	39/39	315	34500	---	8688	8688	12SW3501
MANGANESE	88	NA	39/39	1.7 J	24200 J	---	1125	1125	12SW0101
MERCURY	1.1	0.0013	4/39	0.06 J	1.7	0.03	0.0665	0.518	12SW3501
NICKEL	73	28.9	39/39	1.6 J	140 J	---	9.05	9.05	12SW3501
POTASSIUM	NA	NA	38/39	107 J	167000 J	5.55	22013	22593	12SW1401
SELENIUM	18	5	3/39	1 J	9.6 J	0.11 - 0.92	0.507	3.93	12SW3501
SILVER	18	0.12	1/39	2.6 J	2.6 J	0.028 - 0.18	0.0834	2.60	12SW3501
SODIUM	NA	NA	36/39	571 J	30900 J	897 - 28100	10200	10629	12SW1401
THALLIUM	0.24	10	22/39	0.05 J	0.67 J	0.043	0.0809	0.127	12SW3501
TIN	2200	180	1/39	2.1 J	2.1 J	0.048 - 0.56	0.142	2.10	12SW3501
VANADIUM	3.6	12	23/39	1.3 J	138	1.14	7.65	12.6	12SW3501
ZINC	1100	65.7	27/39	1.6 J	5220	1.3 - 8.9	158	228	12SW3501
Dissolved Metals (ug/L)									
ALUMINUM	3600	87	16/39	9.9 J	966	8.35 - 137	67.8	147	12SW0202-F
ARSENIC	0.045	148	24/39	0.06 J	16.2 J	0.047 - 0.56	1.41	2.23	12SW1701-F
BARIUM	260	220	39/39	17.1 J	227 J	---	55.1	55.1	12SW1101-F
BERYLLIUM	4	3.6	3/39	0.03 J	0.14 J	0.02 - 0.09	0.0162	0.0767	12SW1301-F

TABLE 3-27

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)									
2,4,6-TRINITROTOLUENE	1.8	90	1/19	16	16	0.24 - 0.264	0.961	16.0	12SW1201
2,4-DIAMINO-6-NITROTOLUENE	NA	NA	2/19	0.79 J	1.5 J	0.24 - 0.264	0.233	1.15	12SW1201
2,4-DINITROTOLUENE	7.3	44	1/19	0.47 J	0.47 J	0.24 - 0.264	0.144	0.470	12SW1201
2,6-DINITROTOLUENE	3.6	81	1/19	0.27 J	0.27 J	0.24 - 0.264	0.133	0.270	12SW1201
2-AMINO-4,6-DINITROTOLUENE	0.73	20	4/19	0.38 J	19 J	0.24 - 0.264	1.59	7.07	12SW1201
3,5-DINITROANILINE	NA	60	1/19	1.9	1.9	0.24 - 0.264	0.219	1.90	12SW1301
3-NITROTOLUENE	12	NA	1/19	0.71 J	0.71 J	0.24 - 0.264	0.156	0.710	12SW1401
4-AMINO-2,6-DINITROTOLUENE	0.73	NA	7/19	0.46 J	74	0.24 - 0.264	5.03	13.4	12SW1201
HMX	180	330	12/19	0.9	25	0.24 - 0.264	4.50	7.06	12SW0201
MNX	NA	NA	6/19	0.32 J	1.6	0.24 - 0.264	0.341	0.810	12SW0201
RDX	0.61	190	13/19	0.36 J	68	0.24 - 0.264	12.4	18.0	12SW0201
Total Metals (ug/L)									
ALUMINUM	3600	87	18/19	128	17900 J	107	1862	1963	12SW0301
ARSENIC	0.045	148	18/19	0.38 J	11.2 J	0.32	2.92	3.07	12SW0201
BARIUM	260	220	19/19	17.9 J	428 J	---	108	108	12SW0101
BERYLLIUM	4	3.6	5/19	0.03 J	0.57 J	0.02 - 0.17	0.0745	0.220	12SW0301
CADMIUM	1.8	0.15	9/19	0.09 J	3.9	0.07 - 1.5	0.868	1.42	12SW1501
CALCIUM	NA	NA	19/19	3560 J	115000	---	47777	47777	12SW0901
CHROMIUM	11	42	9/19	1.7 J	14.6 J	0.39 - 2	2.37	4.43	12SW0301
COBALT	73	24	19/19	0.26 J	21.6 J	---	2.91	2.91	12SW0101
COPPER	150	1.58	18/19	1.8 J	32.4 J	0.98	8.40	8.84	12SW0301
IRON	1100	1000	19/19	345 J	23000 J	---	3360	3360	12SW0301
LEAD	15	1.17	11/19	0.56 J	36 J	0.15 - 0.77	4.21	7.10	12SW0301
MAGNESIUM	NA	NA	19/19	1460	15200 J	---	8083	8083	12SW1301
MANGANESE	88	NA	19/19	5.1 J	24200 J	---	1842	1842	12SW0101
NICKEL	73	28.9	19/19	1.7 J	20.2 J	---	6.13	6.13	12SW0301
POTASSIUM	NA	NA	19/19	1160 J	167000 J	---	35807	35807	12SW1401
SELENIUM	18	5	2/19	1 J	1.2 J	0.12 - 0.92	0.335	1.10	12SW0201
SODIUM	NA	NA	16/19	1530 J	30900 J	897 - 28100	10178	11139	12SW1401
THALLIUM	0.24	10	7/19	0.05 J	0.21 J	0.043	0.0467	0.0900	12SW0301
VANADIUM	3.6	12	12/19	1.3 J	38.1	1.14	4.87	7.38	12SW0301
ZINC	1100	65.7	12/19	6.1 J	178 J	1.9 - 8.9	30.2	46.4	12SW0301
Dissolved Metals (ug/L)									
ALUMINUM	3600	87	7/19	20.9 J	589 J	8.9 - 137	74.5	167	12SW0701-F
ARSENIC	0.045	148	14/19	0.31 J	16.2 J	0.11 - 0.32	2.37	3.18	12SW1701-F
BARIUM	260	220	19/19	17.1 J	227 J	---	67.3	67.3	12SW1101-F
BERYLLIUM	4	3.6	2/19	0.03 J	0.14 J	0.02 - 0.09	0.0197	0.0850	12SW1301-F
CADMIUM	1.8	0.15	5/19	0.07 J	1	0.07 - 0.64	0.244	0.436	12SW1801-F
CALCIUM	NA	NA	19/19	3080 J	86600 J	---	41178	41178	12SW1101-F
COBALT	73	24	17/19	0.1 J	2.6 J	0.23 - 0.27	0.621	0.679	12SW1101-F

TABLE 3-28

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUND 2 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)									
1,3,5-TRINITROBENZENE	110	11	1/20	0.96 J	0.96 J	0.238 - 0.278	0.170	0.960	12SW3101
2,4,6-TRINITROTOLUENE	1.8	90	3/20	0.56	79	0.238 - 0.278	5.09	33.2	12SW3101
2,4-DIAMINO-6-NITROTOLUENE	NA	NA	1/20	1.6 J	1.6 J	0.238 - 0.278	0.202	1.60	12SW3101
2,4-DINITROTOLUENE	7.3	44	2/20	0.27 J	0.36 J	0.238 - 0.278	0.147	0.315	12SW3101
2,6-DIAMINO-4-NITROTOLUENE	NA	NA	1/20	0.27 J	0.27 J	0.238 - 0.278	0.136	0.270	12SW3601
2-AMINO-4,6-DINITROTOLUENE	0.73	20	8/20	0.27 J	11 J	0.238 - 0.278	1.10	2.57	12SW3101
3,5-DINITROANILINE	NA	60	2/20	0.6	1.2	0.238 - 0.278	0.206	0.900	12SW3101
4-AMINO-2,6-DINITROTOLUENE	0.73	NA	10/20	0.28 J	24	0.238 - 0.278	2.35	4.57	12SW3101
HMX	180	330	17/20	0.92	98	0.25 - 0.264	11.5	13.5	12SW3401
MNX	NA	NA	4/20	0.41 J	1.9	0.238 - 0.278	0.282	0.895	12SW3401
RDX	0.61	190	17/20	1.9	140	0.25 - 0.264	18.0	21.2	12SW3401
Total Metals (ug/L)									
ALUMINUM	3600	87	15/20	90.6	67700	32 - 163	5039	6699	12SW3501
ARSENIC	0.045	148	17/20	0.16 J	20.3	0.11 - 0.19	2.26	2.64	12SW3501
BARIUM	260	220	19/20	20.6 J	589 J	0.37	78.3	82.5	12SW3501
BERYLLIUM	4	3.6	14/20	0.02 J	5.2	0.02	0.381	0.539	12SW3501
CADMIUM	1.8	0.15	9/20	0.06 J	43.7 J	0.039 - 0.34	2.43	5.34	12SW3501
CALCIUM	NA	NA	20/20	1100 J	119000 J	---	40990	40990	12SW3501
CHROMIUM	11	42	8/20	1.6 J	105 J	0.08 - 2	7.30	17.6	12SW3501
COBALT	73	24	20/20	0.14 J	123	---	8.67	8.67	12SW3501
COPPER	150	1.58	20/20	0.74 J	1650 J	---	86.5	86.5	12SW3501
IRON	1100	1000	20/20	161 J	95400 J	---	7005	7005	12SW3501
LEAD	15	1.17	19/20	0.095 J	458	0.069	25.2	26.5	12SW3501
MAGNESIUM	NA	NA	20/20	315	34500	---	9263	9263	12SW3501
MANGANESE	88	NA	20/20	1.7 J	3330	---	445	445	12SW3501
MERCURY	1.1	0.0013	4/20	0.06 J	1.7	0.03	0.116	0.518	12SW3501
NICKEL	73	28.9	20/20	1.6 J	140 J	---	11.8	11.8	12SW3501
POTASSIUM	NA	NA	19/20	107 J	43800 J	5.55	8909	9378	12SW0502
SELENIUM	18	5	1/20	9.6 J	9.6 J	0.11 - 0.91	0.670	9.60	12SW3501
SILVER	18	0.12	1/20	2.6 J	2.6 J	0.028 - 0.05	0.145	2.60	12SW3501
SODIUM	NA	NA	20/20	571 J	26900 J	---	10221	10221	12SW3401
THALLIUM	0.24	10	15/20	0.06 J	0.67 J	0.043	0.113	0.144	12SW3501
TIN	2200	180	1/20	2.1 J	2.1 J	0.048 - 0.56	0.182	2.10	12SW3501
VANADIUM	3.6	12	11/20	1.3 J	138	1.14	10.3	18.3	12SW3501
ZINC	1100	65.7	15/20	1.6 J	5220	1.3 - 2.7	280	373	12SW3501
Dissolved Metals (ug/L)									
ALUMINUM	3600	87	9/20	9.9 J	966	8.35	61.4	131	12SW0202-F
ARSENIC	0.045	148	10/20	0.06 J	3.5	0.047 - 0.56	0.492	0.896	12SW3401-F
BARIUM	260	220	20/20	19.8	75.8	---	43.6	43.6	12SW3401-F
BERYLLIUM	4	3.6	1/20	0.06 J	0.06 J	0.02 - 0.03	0.0128	0.0600	12SW0202-F
CADMIUM	1.8	0.15	10/20	0.11 J	1.2	0.039 - 0.14	0.370	0.711	12SW1402-F
CALCIUM	NA	NA	20/20	17100 J	103000 J	---	39020	39020	12SW1802-F
CHROMIUM	11	42	9/20	0.96 J	1.4 J	0.53 - 1.9	0.786	1.15	12SW1702-F, 12SW3101-F

TABLE 3-29

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT EAST TRIBUTARY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)							
4-AMINO-2,6-DINITROTOLUENE	3/4	0.252 J	0.56	0.245	0.339	0.411	12SW2401
HMX	3/4	0.28 J	0.55	0.245	0.333	0.403	12SW2401
RDX	3/4	0.39 J	0.8	0.245	0.471	0.587	12SW2401
Total Metals (ug/L)							
ALUMINUM	2/4	40.7 J	257 J	52.8 - 85.1	91.7	149	12SW2401
ARSENIC	1/4	0.33 J	0.33 J	0.11 - 0.24	0.140	0.330	12SW2401
BARIUM	4/4	38.2 J	64.2 J	---	49.1	49.1	12SW2301
CALCIUM	4/4	40400	59300 J	---	50000	50000	12SW2301
COBALT	3/4	0.15 J	0.26 J	0.2	0.170	0.193	12SW2401
COPPER	2/4	1.4 J	3.4 J	0.58 - 1.4	1.45	2.40	12SW2401
IRON	4/4	252 J	584 J	---	359	359	12SW2401
LEAD	1/4	0.136 J	0.136 J	0.069 - 0.48	0.139	0.136	12SW2402
MAGNESIUM	4/4	6740 J	10400 J	---	8395	8395	12SW2301
MANGANESE	4/4	1.2 J	7.1 J	---	4.40	4.40	12SW2301
NICKEL	4/4	1.6 J	2.4 J	---	1.90	1.90	12SW2401
POTASSIUM	4/4	1140 J	2940 J	---	1953	1953	12SW2301
SODIUM	4/4	11600 J	25000 J	---	15625	15625	12SW2301
THALLIUM	3/4	0.07 J	0.07 J	0.043	0.0579	0.0700	12SW2301, 12SW2302, 12SW2402
Dissolved Metals (ug/L)							
ALUMINUM	2/4	8.7 J	9.6 J	8.6 - 18.6	7.98	9.15	12SW2302-F
ARSENIC	1/4	0.21 J	0.21 J	0.1 - 0.16	0.104	0.210	12SW2401-F
BARIUM	4/4	44.4 J	66.8 J	---	51.9	51.9	12SW2301-F
CALCIUM	4/4	36200 J	57500 J	---	42800	42800	12SW2301-F
CHROMIUM	2/4	1.2 J	1.6 J	0.65 - 0.82	0.884	1.40	12SW2302-F
COBALT	2/4	0.17 J	0.17 J	0.14 - 0.17	0.124	0.170	12SW2302-F, 12SW2401-F
COPPER	3/4	1.3 J	2.8 J	1.3	1.56	1.87	12SW2401-F
IRON	4/4	229 J	305 J	---	278	278	12SW2301-F
LEAD	2/4	0.2 J	0.254 J	0.198 - 0.39	0.187	0.227	12SW2302-F
MAGNESIUM	4/4	6920 J	10600 J	---	8703	8703	12SW2301-F
MANGANESE	3/4	0.82 J	3.5 J	4.2	2.01	1.97	12SW2401-F
NICKEL	4/4	2.2 J	2.8 J	---	2.45	2.45	12SW2302-F
POTASSIUM	4/4	1240 J	3040 J	---	2093	2093	12SW2301-F
SODIUM	4/4	12000 J	23800 J	---	16550	16550	12SW2301-F
THALLIUM	1/4	0.07 J	0.07 J	0.043 - 0.11	0.0454	0.0700	12SW2301-F
ZINC	2/4	2.1 J	5.2 J	3.3 - 6.5	3.05	3.65	12SW2402-F

TABLE 3-30

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT EAST TRIBUTARY
SURFACE WATER SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)							
4-AMINO-2,6-DINITROTOLUENE	1/2	0.56	0.56	0.245	0.341	0.560	12SW2401
HMX	1/2	0.55	0.55	0.245	0.336	0.550	12SW2401
RDX	1/2	0.8	0.8	0.245	0.461	0.800	12SW2401
Total Metals (ug/L)							
ALUMINUM	2/2	40.7 J	257 J	---	149	149	12SW2401
ARSENIC	1/2	0.33 J	0.33 J	0.24	0.225	0.330	12SW2401
BARIUM	2/2	51.2 J	64.2 J	---	57.7	57.7	12SW2301
CALCIUM	2/2	40400	59300 J	---	49850	49850	12SW2301
COBALT	1/2	0.26 J	0.26 J	0.2	0.180	0.260	12SW2401
COPPER	1/2	3.4 J	3.4 J	1.4	2.05	3.40	12SW2401
IRON	2/2	340 J	584 J	---	462	462	12SW2401
MAGNESIUM	2/2	6740 J	10400 J	---	8570	8570	12SW2301
MANGANESE	2/2	6 J	7.1 J	---	6.55	6.55	12SW2301
NICKEL	2/2	1.9 J	2.4 J	---	2.15	2.15	12SW2401
POTASSIUM	2/2	2470 J	2940 J	---	2705	2705	12SW2301
SODIUM	2/2	11600 J	25000 J	---	18300	18300	12SW2301
THALLIUM	1/2	0.07 J	0.07 J	0.043	0.0458	0.0700	12SW2301
Dissolved Metals (ug/L)							
ARSENIC	1/2	0.21 J	0.21 J	0.16	0.145	0.210	12SW2401-F
BARIUM	2/2	52 J	66.8 J	---	59.4	59.4	12SW2301-F
CALCIUM	2/2	40100	57500 J	---	48800	48800	12SW2301-F
COBALT	1/2	0.17 J	0.17 J	0.17	0.128	0.170	12SW2401-F
COPPER	1/2	2.8 J	2.8 J	1.3	1.73	2.80	12SW2401-F
IRON	2/2	292 J	305 J	---	299	299	12SW2301-F
LEAD	1/2	0.2 J	0.2 J	0.39	0.198	0.200	12SW2401-F
MAGNESIUM	2/2	6920 J	10600 J	---	8760	8760	12SW2301-F
MANGANESE	1/2	3.5 J	3.5 J	4.2	2.80	3.50	12SW2401-F
NICKEL	2/2	2.2 J	2.5 J	---	2.35	2.35	12SW2401-F
POTASSIUM	2/2	2560 J	3040 J	---	2800	2800	12SW2301-F
SODIUM	2/2	12000 J	23800 J	---	17900	17900	12SW2301-F
THALLIUM	1/2	0.07 J	0.07 J	0.043	0.0458	0.0700	12SW2301-F

TABLE 3-31

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT EAST TRIBUTARY
SURFACE WATER SAMPLES, ROUND 2 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)							
4-AMINO-2,6-DINITROTOLUENE	2/2	0.252 J	0.42 J	---	0.336	0.336	12SW2302
HMX	2/2	0.28 J	0.38 J	---	0.330	0.330	12SW2302
RDX	2/2	0.39 J	0.57	---	0.480	0.480	12SW2302
Total Metals (ug/L)							
BARIUM	2/2	38.2 J	42.7 J	---	40.5	40.5	12SW2402
CALCIUM	2/2	48400 J	51900 J	---	50150	50150	12SW2302
COBALT	2/2	0.15 J	0.17 J	---	0.160	0.160	12SW2402
COPPER	1/2	1.4 J	1.4 J	0.58	0.845	1.40	12SW2402
IRON	2/2	252 J	258 J	---	255	255	12SW2402
LEAD	1/2	0.136 J	0.136 J	0.069	0.0853	0.136	12SW2402
MAGNESIUM	2/2	7860 J	8580 J	---	8220	8220	12SW2302
MANGANESE	2/2	1.2 J	3.3 J	---	2.25	2.25	12SW2402
NICKEL	2/2	1.6 J	1.7 J	---	1.65	1.65	12SW2302
POTASSIUM	2/2	1140 J	1260 J	---	1200	1200	12SW2302
SODIUM	2/2	11700 J	14200 J	---	12950	12950	12SW2302
THALLIUM	2/2	0.07 J	0.07 J	---	0.0700	0.0700	12SW2302, 12SW2402
Dissolved Metals (ug/L)							
ALUMINUM	2/2	8.7 J	9.6 J	---	9.15	9.15	12SW2302-F
BARIUM	2/2	44.4 J	44.5 J	---	44.5	44.5	12SW2402-F
CALCIUM	2/2	36200 J	37400 J	---	36800	36800	12SW2302-F
CHROMIUM	2/2	1.2 J	1.6 J	---	1.40	1.40	12SW2302-F
COBALT	1/2	0.17 J	0.17 J	0.14	0.120	0.170	12SW2302-F
COPPER	2/2	1.3 J	1.5 J	---	1.40	1.40	12SW2302-F
IRON	2/2	229 J	284 J	---	257	257	12SW2302-F
LEAD	1/2	0.254 J	0.254 J	0.198	0.177	0.254	12SW2302-F
MAGNESIUM	2/2	8450 J	8840 J	---	8645	8645	12SW2302-F
MANGANESE	2/2	0.82 J	1.6 J	---	1.21	1.21	12SW2402-F
NICKEL	2/2	2.3 J	2.8 J	---	2.55	2.55	12SW2302-F
POTASSIUM	2/2	1240 J	1530 J	---	1385	1385	12SW2302-F
SODIUM	2/2	13000 J	17400 J	---	15200	15200	12SW2302-F
ZINC	2/2	2.1 J	5.2 J	---	3.65	3.65	12SW2402-F
Field Parameters							
DISSOLVED OXYGEN (mg/L)	2/2	2.79	2.92	---	2.86	2.86	12SW2302
OXIDATION-REDUCTION POTENTIAL (MV)	2/2	113	126	---	120	120	12SW2402
PH (S.U.)	2/2	7.1	7.36	---	7.23	7.23	12SW2302
SPECIFIC CONDUCTANCE (MS/CM)	2/2	0.14	0.154	---	0.147	0.147	12SW2302
TEMPERATURE (°C)	2/2	5.59	6.1	---	5.85	5.85	12SW2302
TURBIDITY (NTU)	2/2	3.1	3.5	---	3.30	3.30	12SW2302

Data qualifiers (e.g., U, J) are defined in Appendix H.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
MV - millivolts.
S.U. - standard units.
MS/CM - milliSiemens per centimeter.
C - Celsius.
NTU - nephelometric turbidity units.

TABLE 3-32

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT TURKEY CREEK MAINSTREAM
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Total Metals (ug/L)									
ALUMINUM	3600	87	1/2	24.1 J	24.1 J	49.7	24.5	24.1	12SW2701
BARIUM	260	220	2/2	41 J	69.8 J	---	55.4	55.4	12SW2701
BERYLLIUM	4	3.6	1/2	0.02 J	0.02 J	0.02	0.0150	0.0200	12SW2701
CALCIUM	NA	NA	2/2	34800 J	54500 J	---	44650	44650	12SW2701
COBALT	73	24	1/2	0.22 J	0.22 J	0.31	0.188	0.220	12SW2702
IRON	1100	1000	2/2	275 J	456 J	---	366	366	12SW2701
MAGNESIUM	NA	NA	2/2	5120 J	9220 J	---	7170	7170	12SW2701
MANGANESE	88	NA	2/2	43.1 J	131 J	---	87.1	87.1	12SW2701
NICKEL	73	28.9	1/2	1.7 J	1.7 J	0.1	0.875	1.70	12SW2701
POTASSIUM	NA	NA	2/2	915 J	1600 J	---	1258	1258	12SW2701
SODIUM	NA	NA	2/2	4630 J	9630 J	---	7130	7130	12SW2701
Dissolved Metals (ug/L)									
BARIUM	260	220	2/2	36.9 J	64.4 J	---	50.7	50.7	12SW2701-F
CALCIUM	NA	NA	2/2	25500 J	53900 J	---	39700	39700	12SW2701-F
COBALT	73	24	1/2	0.18 J	0.18 J	0.28	0.160	0.180	12SW2702-F
COPPER	150	1.58	1/2	0.41 J	0.41 J	0.78	0.400	0.410	12SW2702-F
IRON	1100	1000	2/2	172 J	288 J	---	230	230	12SW2701-F
MAGNESIUM	NA	NA	2/2	5800 J	8900 J	---	7350	7350	12SW2701-F
MANGANESE	88	NA	2/2	33.5 J	124 J	---	78.8	78.8	12SW2701-F
NICKEL	73	28.9	2/2	1.7 J	1.8 J	---	1.75	1.75	12SW2702-F
POTASSIUM	NA	NA	2/2	875 J	1600 J	---	1238	1238	12SW2701-F
SODIUM	NA	NA	2/2	5240 J	9440 J	---	7340	7340	12SW2701-F
ZINC	1100	65.7	1/2	1.9 J	1.9 J	2.7	1.63	1.90	12SW2702-F
Field Parameters									
DISSOLVED OXYGEN (mg/L)	NA	NA	2/2	1.95	7.44	---	4.70	4.70	12SW2701
OXIDATION-REDUCTION POTENTIAL (MV)	NA	NA	2/2	113	266.2	---	190	190	12SW2701
PH (S.U.)	NA	NA	2/2	6.76	6.81	---	6.79	6.79	12SW2701
SPECIFIC CONDUCTANCE (MS/CM)	NA	NA	2/2	0.092	0.267	---	0.180	0.180	12SW2701
TEMPERATURE (°C)	NA	NA	2/2	5.21	13.55	---	9.38	9.38	12SW2701
TURBIDITY (NTU)	NA	NA	1/1	9.15	9.15	---	9.15	9.15	12SW2702
Miscellaneous Parameter (mg/L)									
AMMONIA-N	NA	NA	1/2	0.18 J	0.18 J	0.005	0.0913	0.180	12SW2701

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
MV - millivolts.
S.U. - standard units.
MS/CM - milliSiemens per centimeter.
C - Celsius.
NTU - nephelometric turbidity units.
NA - No applicable criterion.

TABLE 3-33

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT TURKEY CREEK MAINSTREAM
SURFACE WATER SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Samplewithf Maximum Detection
Total Metals (ug/L)									
ALUMINUM	3600	87	1/1	24.1 J	24.1 J	---	24.1	24.1	12SW2701
BARIUM	260	220	1/1	69.8 J	69.8 J	---	69.8	69.8	12SW2701
BERYLLIUM	4	3.6	1/1	0.02 J	0.02 J	---	0.0200	0.0200	12SW2701
CALCIUM	NA	NA	1/1	54500 J	54500 J	---	54500	54500	12SW2701
IRON	1100	1000	1/1	456 J	456 J	---	456	456	12SW2701
MAGNESIUM	NA	NA	1/1	9220 J	9220 J	---	9220	9220	12SW2701
MANGANESE	88	NA	1/1	131 J	131 J	---	131	131	12SW2701
NICKEL	73	28.9	1/1	1.7 J	1.7 J	---	1.70	1.70	12SW2701
POTASSIUM	NA	NA	1/1	1600 J	1600 J	---	1600	1600	12SW2701
SODIUM	NA	NA	1/1	9630 J	9630 J	---	9630	9630	12SW2701
Dissolved Metals (ug/L)									
BARIUM	260	220	1/1	64.4 J	64.4 J	---	64.4	64.4	12SW2701-F
CALCIUM	NA	NA	1/1	53900 J	53900 J	---	53900	53900	12SW2701-F
IRON	1100	1000	1/1	288 J	288 J	---	288	288	12SW2701-F
MAGNESIUM	NA	NA	1/1	8900 J	8900 J	---	8900	8900	12SW2701-F
MANGANESE	88	NA	1/1	124 J	124 J	---	124	124	12SW2701-F
NICKEL	73	28.9	1/1	1.7 J	1.7 J	---	1.70	1.70	12SW2701-F
POTASSIUM	NA	NA	1/1	1600 J	1600 J	---	1600	1600	12SW2701-F
SODIUM	NA	NA	1/1	9440 J	9440 J	---	9440	9440	12SW2701-F
Field Parameters									
DISSOLVED OXYGEN (mg/L)	NA	NA	1/1	7.44	7.44	---	7.44	7.44	12SW2701
OXIDATION-REDUCTION POTENTIAL (MV)	NA	NA	1/1	266.2	266.2	---	266	266	12SW2701
PH (S.U.)	NA	NA	1/1	6.81	6.81	---	6.81	6.81	12SW2701
SPECIFIC CONDUCTANCE (MS/CM)	NA	NA	1/1	0.267	0.267	---	0.267	0.267	12SW2701
TEMPERATURE (°C)	NA	NA	1/1	13.55	13.55	---	13.6	13.6	12SW2701
Miscellaneous Parameter (mg/L)									
AMMONIA-N	NA	NA	1/1	0.18 J	0.18 J	---	0.180	0.180	12SW2701

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
MV - millivolts.
S.U. - standard units.
MS/CM - milliSiemens per centimeter.
C - Celsius.
NTU - nephelometric turbidity units.
NA - No applicable criterion.

TABLE 3-34

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT TURKEY CREEK MAINSTREAM
SURFACE WATER SAMPLES, ROUND 2 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Total Metals (ug/L)							
BARIUM	1/1	41 J	41 J	---	41.0	41.0	12SW2702
CALCIUM	1/1	34800 J	34800 J	---	34800	34800	12SW2702
COBALT	1/1	0.22 J	0.22 J	---	0.220	0.220	12SW2702
IRON	1/1	275 J	275 J	---	275	275	12SW2702
MAGNESIUM	1/1	5120 J	5120 J	---	5120	5120	12SW2702
MANGANESE	1/1	43.1 J	43.1 J	---	43.1	43.1	12SW2702
POTASSIUM	1/1	915 J	915 J	---	915	915	12SW2702
SODIUM	1/1	4630 J	4630 J	---	4630	4630	12SW2702
Dissolved Metals (ug/L)							
BARIUM	1/1	36.9 J	36.9 J	---	36.9	36.9	12SW2702-F
CALCIUM	1/1	25500 J	25500 J	---	25500	25500	12SW2702-F
COBALT	1/1	0.18 J	0.18 J	---	0.180	0.180	12SW2702-F
COPPER	1/1	0.41 J	0.41 J	---	0.410	0.410	12SW2702-F
IRON	1/1	172 J	172 J	---	172	172	12SW2702-F
MAGNESIUM	1/1	5800 J	5800 J	---	5800	5800	12SW2702-F
MANGANESE	1/1	33.5 J	33.5 J	---	33.5	33.5	12SW2702-F
NICKEL	1/1	1.8 J	1.8 J	---	1.80	1.80	12SW2702-F
POTASSIUM	1/1	875 J	875 J	---	875	875	12SW2702-F
SODIUM	1/1	5240 J	5240 J	---	5240	5240	12SW2702-F
ZINC	1/1	1.9 J	1.9 J	---	1.90	1.90	12SW2702-F
Field Parameters							
DISSOLVED OXYGEN (mg/L)	1/1	1.95	1.95	---	1.95	1.95	12SW2702
OXIDATION REDUCTION POTENTIAL (MV)	1/1	113	113	---	113	113	12SW2702
PH (S.U.)	1/1	6.76	6.76	---	6.76	6.76	12SW2702
SPECIFIC CONDUCTANCE (MS/CM)	1/1	0.092	0.092	---	0.0920	0.0920	12SW2702
TEMPERATURE (C)	1/1	5.21	5.21	---	5.21	5.21	12SW2702
TURBIDITY (NTU)	1/1	9.15	9.15	---	9.15	9.15	12SW2702

Data qualifiers (e.g., U, J) are defined in Appendix H.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
MV - millivolts.
S.U. - standard units.
MS/CM - milliSiemens per centimeter.
C - Celsius.
NTU - nephelometric turbidity units.

TABLE 3-35

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	01 12SW/SD01 12SW0101 NORMAL 10/12/2004	01 12SW/SD01 12SW0101-F NORMAL 10/12/2004	02 12SW/SD01 12SW0102 NORMAL 3/7/2005	02 12SW/SD01 12SW0102-F NORMAL 3/7/2005	01 12SW/SD02 12SW0201 NORMAL 10/28/2004	01 12SW/SD02 12SW0201-F NORMAL 10/28/2004	02 12SW/SD02 12SW0202 ORIG 3/6/2005	02 12SW/SD02 12SW0202-F ORIG 3/6/2005	01 12SW/SD03 12SW0301 ORIG 10/28/2004
Energetics (ug/L)											
1,3,5-TRINITROBENZENE	110	11	0.248 U		0.271 U		0.255 U		0.269 U		0.24 U
2,4,6-TRINITROTOLUENE	1.8	90	0.248 U		0.271 U		0.255 U		0.269 U		0.24 U
2,4-DIAMINO-6-NITROTOLUENE	NA	NA	0.248 U		0.271 U		0.255 U		0.269 U		0.24 U
2,4-DINITROTOLUENE	7.3	44	0.248 U		0.271 U		0.255 U		0.269 U		0.24 U
2,6-DIAMINO-4-NITROTOLUENE	NA	NA	0.248 U		0.271 U		0.255 U		0.269 U		0.24 U
2,6-DINITROTOLUENE	3.6	81	0.248 U		0.271 U		0.255 U		0.269 U		0.24 U
2-AMINO-4,6-DINITROTOLUENE	0.73	20	0.248 U		0.271 U		0.38 J		0.35 J		0.24 U
3,5-DINITROANILINE	NA	60	0.248 U		0.271 U		0.255 U		0.269 U		0.24 U
3-NITROTOLUENE	12	NA	0.248 U		0.271 U		0.255 U		0.269 U		0.24 U
4-AMINO-2,6-DINITROTOLUENE	0.73	NA	0.248 U		0.271 U		0.84		0.64 J		0.24 U
HMX	180	330	1.8		5.7		25		41 J		0.24 U
MNX	NA	NA	0.248 U		0.271 U		1.6		0.75 J		0.24 U
RDX	0.61	190	0.46 J		7.2		68		52 J		0.24 U
Total Metals (ug/L)											
ALUMINUM	3600	87	3970		701		1320 J		5550		17900 J
ARSENIC	0.045	148	11 J		1.1		11.2 J		3.6		7.3 J
BARIUM	260	220	428 J		26.8 J		91.5 J		81.5 J		252 J
BERYLLIUM	4	3.6	0.25 J		0.03 J		0.05 U		0.36 J		0.57 J
CADMIUM	1.8	0.15	0.33 J		0.04 U		1.6 J		0.29 U		2.4 J
CALCIUM	NA	NA	38000 J		25300 J		50400		41500 J		53600
CHROMIUM	11	42	5 J		1.1 U		2.9 J		6.4 J		14.6 J
COBALT	73	24	21.6 J		2		1.7		6.7 J		12.5
COPPER	150	1.58	11.2 J		3.1 J		17.7 J		12.8 J		32.4 J
IRON	1100	1000	12600 J		1490 J		1820 J		6580 J		23000 J
LEAD	15	1.17	5.4 J		0.935 J		1.7 J		8.5 J		36 J
MAGNESIUM	NA	NA	7100 J		6410		14000		10300		4680
MANGANESE	88	NA	24200 J		983		37.2 J		276 J		1310 J
MERCURY	1.1	0.0013	0.03 U		0.03 U		0.03 U		0.03 U		0.03 U
NICKEL	73	28.9	9 J		2.4 J		9.2 J		12.3 J		20.2 J
POTASSIUM	NA	NA	12800 J		9330 J		134000 J		29200 J		3240 J
SELENIUM	18	5	0.92 U		0.4 U		1.2 J		0.61 U		0.91 U
SILVER	18	0.12	0.028 U		0.028 U		0.18 U		0.028 U		0.028 U
SODIUM	NA	NA	10700 J		8740 J		28100 U		10500 J		3450 J
THALLIUM	0.24	10	0.12 J		0.043 U		0.05 J		0.12 J		0.21 J
TIN	2200	180	0.25 U		0.048 U		0.43 U		0.3 U		0.52 U
VANADIUM	3.6	12	9.8		1.6 J		9.2		10.9		38.1
ZINC	1100	65.7	41.8 J		6.1 J		55.7 J		54.4 J		178 J

TABLE 3-35

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA CRITERIA	ERA CRITERIA	01	02	02	01	01	02	02	01	01
LOCATION			12SW/SD03	12SW/SD03	12SW/SD03	12SW/SD04	12SW/SD04	12SW/SD04	12SW/SD04	12SW/SD05	12SW/SD05
SAMPLE NUMBER			12SW0301-F	12SW0302	12SW0302-F	12SW0401	12SW0401-F	12SW0402	12SW0402-F	12SW0501	12SW0501-F
SAMPLE CODE			NORMAL	ORIG	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE			10/28/2004	3/7/2005	3/7/2005	10/12/2004	10/12/2004	3/6/2005	3/6/2005	10/28/2004	10/28/2004
Energetics (ug/L)											
1,3,5-TRINITROBENZENE	110	11		0.25 U		0.258 U		0.238 U		0.264 U	
2,4,6-TRINITROTOLUENE	1.8	90		0.25 U		0.258 U		0.238 U		0.264 U	
2,4-DIAMINO-6-NITROTOLUENE	NA	NA		0.25 U		0.258 U		0.238 U		0.264 U	
2,4-DINITROTOLUENE	7.3	44		0.25 U		0.258 U		0.238 U		0.264 U	
2,6-DIAMINO-4-NITROTOLUENE	NA	NA		0.25 U		0.258 U		0.238 U		0.264 U	
2,6-DINITROTOLUENE	3.6	81		0.25 U		0.258 U		0.238 U		0.264 U	
2-AMINO-4,6-DINITROTOLUENE	0.73	20		0.25 U		0.258 U		0.238 U		0.264 U	
3,5-DINITROANILINE	NA	60		0.25 U		0.258 U		0.238 U		0.264 U	
3-NITROTOLUENE	12	NA		0.25 U		0.258 U		0.238 U		0.264 U	
4-AMINO-2,6-DINITROTOLUENE	0.73	NA		0.25 U		0.258 U		0.238 U		0.54	
HMX	180	330		0.25 U		0.9		4.9		18	
MNX	NA	NA		0.25 U		0.258 U		0.238 U		1.2	
RDX	0.61	190		0.25 U		0.47 J		6		50	
Total Metals (ug/L)											
ALUMINUM	3600	87		1520		253		283		568 J	
ARSENIC	0.045	148		0.52 J		0.92 J		0.47 J		5.8 J	
BARIUM	260	220		52.1 J		17.9 J		20.6 J		78.6 J	
BERYLLIUM	4	3.6		0.05 J		0.03 J		0.02 U		0.02 U	
CADMIUM	1.8	0.15		0.07 U		0.07 U		0.039 U		0.61 U	
CALCIUM	NA	NA		49200 J		35300 J		25400 J		48500	
CHROMIUM	11	42		2 U		1.1 U		0.79 U		1.7 U	
COBALT	73	24		0.61 J		0.49 J		0.42 J		1.1	
COPPER	150	1.58		2.1 J		2.6 J		1.2 J		12.1 J	
IRON	1100	1000		1640 J		550 J		559 J		1120 J	
LEAD	15	1.17		1		0.31 U		0.351 J		0.9 J	
MAGNESIUM	NA	NA		5450		7290 J		6980		12800	
MANGANESE	88	NA		19.3		34.6 J		27.7		24.6 J	
MERCURY	1.1	0.0013		0.03 U		0.03 U		0.03 U		0.03 U	
NICKEL	73	28.9		3.4 J		2.6 J		2.3 J		7.7 J	
POTASSIUM	NA	NA		902 J		10800 J		7860 J		94400 J	
SELENIUM	18	5		0.58 U		0.58 U		0.37 U		0.91 U	
SILVER	18	0.12		0.028 U		0.028 U		0.028 U		0.028 U	
SODIUM	NA	NA		8350 J		9280 J		9760 J		18000 J	
THALLIUM	0.24	10		0.043 U		0.043 U		0.043 U		0.043 U	
TIN	2200	180		0.048 U		0.11 U		0.048 U		0.1 U	
VANADIUM	3.6	12		2.8		1.14 U		1.14 U		4.9	
ZINC	1100	65.7		7.6 J		4.3 U		1.6 J		18.6 J	

TABLE 3-35

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA	ERA	02	02	01	01	02	02	01	01	02
LOCATION	CRITERIA	CRITERIA	12SW/SD05	12SW/SD05	12SW/SD06	12SW/SD06	12SW/SD06	12SW/SD06	12SW/SD07	12SW/SD07	12SW/SD07
SAMPLE NUMBER			12SW0502	12SW0502-F	12SW0601	12SW0601-F	12SW0602	12SW0602-F	12SW0701	12SW0701-F	12SW0702
SAMPLE CODE			ORIG	ORIG	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DRY
SAMPLE DATE			3/6/2005	3/6/2005	10/28/2004	10/28/2004	3/6/2005	3/6/2005	11/1/2004	11/1/2004	3/6/2005
Energetics (ug/L)											
1,3,5-TRINITROBENZENE	110	11	0.25 U		0.24 U		0.24 U		0.245 U		
2,4,6-TRINITROTOLUENE	1.8	90	0.25 U		0.24 U		0.24 U		0.245 U		
2,4-DIAMINO-6-NITROTOLUENE	NA	NA	0.25 U		0.24 U		0.24 U		0.245 U		
2,4-DINITROTOLUENE	7.3	44	0.25 U		0.24 U		0.24 U		0.245 U		
2,6-DIAMINO-4-NITROTOLUENE	NA	NA	0.25 U		0.24 U		0.24 U		0.245 U		
2,6-DINITROTOLUENE	3.6	81	0.25 U		0.24 U		0.24 U		0.245 U		
2-AMINO-4,6-DINITROTOLUENE	0.73	20	0.27 J		0.24 U		0.24 U		0.245 U		
3,5-DINITROANILINE	NA	60	0.25 U		0.24 U		0.24 U		0.245 U		
3-NITROTOLUENE	12	NA	0.25 U		0.24 U		0.24 U		0.245 U		
4-AMINO-2,6-DINITROTOLUENE	0.73	NA	0.59		0.24 U		0.24 U		0.245 U		
HMX	180	330	29		1.1		1.3		0.245 U		
MNX	NA	NA	0.52		0.24 U		0.24 U		0.245 U		
RDX	0.61	190	32		0.37 J		1.9		0.245 U		
Total Metals (ug/L)											
ALUMINUM	3600	87	163 U		346 J		377 J		2680 J		
ARSENIC	0.045	148	1.8 J		1.2 J		0.73 J		1.2		
BARIUM	260	220	35.5 J		73.8 J		40.6 J		46 J		
BERYLLIUM	4	3.6	0.02 U		0.02 U		0.02 J		0.17 U		
CADMIUM	1.8	0.15	0.039 U		1.4 U		0.1 J		0.21 J		
CALCIUM	NA	NA	49300 J		31100		18800 J		3560 J		
CHROMIUM	11	42	1 U		0.84 U		0.97 U		3 J		
COBALT	73	24	0.27 J		0.65 J		0.43 J		1.6		
COPPER	150	1.58	2.8 J		5.4 J		1.6 J		11.5 J		
IRON	1100	1000	355 J		612 J		459 J		2830 J		
LEAD	15	1.17	0.17 J		0.34 U		0.245 J		2.6		
MAGNESIUM	NA	NA	10500 J		9960		9800 J		1460		
MANGANESE	88	NA	2.6 J		10 J		8.1 J		69.9		
MERCURY	1.1	0.0013	0.03 U		0.03 U		0.03 U		0.03 U		
NICKEL	73	28.9	2.7 J		4.6 J		2.5 J		5.6 J		
POTASSIUM	NA	NA	43800 J		68600 J		37800 J		2900 J		
SELENIUM	18	5	0.43 U		0.64 U		0.45 U		0.2 U		
SILVER	18	0.12	0.028 U		0.028 U		0.028 U		0.028 U		
SODIUM	NA	NA	13000 J		13200 J		11500 J		1530 J		
THALLIUM	0.24	10	0.08 J		0.043 U		0.07 J		0.043 U		
TIN	2200	180	0.17 U		0.08 U		0.13 U		0.38 U		
VANADIUM	3.6	12	1.4 J		1.3 J		1.14 U		5.3		
ZINC	1100	65.7	2.3 U		3 U		2.7 U		21.5 J		

TABLE 3-35

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	01 12SW/SD09 12SW0901 NORMAL 10/27/2004	01 12SW/SD09 12SW0901-F NORMAL 10/27/2004	02 12SW/SD09 12SW0902 NORMAL 3/6/2005	02 12SW/SD09 12SW0902-F NORMAL 3/6/2005	01 12SW/SD10 12SW1001 NORMAL 10/27/2004	01 12SW/SD10 12SW1001-F NORMAL 10/27/2004	02 12SW/SD10 12SW1002 NORMAL 3/6/2005	02 12SW/SD10 12SW1002-F NORMAL 3/6/2005	01 12SW/SD11 12SW1101 NORMAL 10/12/2004
Energetics (ug/L)											
1,3,5-TRINITROBENZENE	110	11	0.264 U		0.258 U		0.26 U		0.26 U		0.24 UJ
2,4,6-TRINITROTOLUENE	1.8	90	0.264 U		0.258 U		0.26 U		0.26 U		0.24 UJ
2,4-DIAMINO-6-NITROTOLUENE	NA	NA	0.264 U		0.258 U		0.26 U		0.26 U		0.24 UJ
2,4-DINITROTOLUENE	7.3	44	0.264 U		0.258 U		0.26 U		0.26 U		0.24 UJ
2,6-DIAMINO-4-NITROTOLUENE	NA	NA	0.264 U		0.258 U		0.26 U		0.26 U		0.24 UJ
2,6-DINITROTOLUENE	3.6	81	0.264 U		0.258 U		0.26 U		0.26 U		0.24 UJ
2-AMINO-4,6-DINITROTOLUENE	0.73	20	0.264 U		0.258 U		0.26 U		0.26 U		0.24 UJ
3,5-DINITROANILINE	NA	60	0.264 U		0.258 U		0.26 U		0.26 U		0.24 UJ
3-NITROTOLUENE	12	NA	0.264 U		0.258 U		0.26 U		0.26 U		0.24 UJ
4-AMINO-2,6-DINITROTOLUENE	0.73	NA	0.61		0.36 J		0.46 J		0.26 U		0.24 UJ
HMX	180	330	6.4		5.1		4.1		2.5		2.4 J
MNX	NA	NA	0.52 J		0.258 U		0.38 J		0.26 U		0.24 UJ
RDX	0.61	190	19		8.3		13		4.3		5.6 J
Total Metals (ug/L)											
ALUMINUM	3600	87	344 J		85.1 U		107 U		32 U		128
ARSENIC	0.045	148	0.97 J		0.45 J		0.41 J		0.11 U		5.1 J
BARIUM	260	220	66.7 J		35.5 J		63.6 J		42.3 J		265 J
BERYLLIUM	4	3.6	0.02 U		0.02 U		0.02 U		0.02 U		0.02 U
CADMIUM	1.8	0.15	1.1 U		0.039 U		1.1 U		0.039 U		0.11 U
CALCIUM	NA	NA	115000		18200 J		27700		27000 J		84000 J
CHROMIUM	11	42	0.86 U		0.53 U		0.55 U		0.43 U		0.39 U
COBALT	73	24	0.48 J		0.18 J		0.26 J		0.14 J		2.2 J
COPPER	150	1.58	5.3 J		1.1 J		3.2 J		0.74 J		0.98 U
IRON	1100	1000	587 J		185 J		345 J		161 J		9390 J
LEAD	15	1.17	0.34 U		0.095 J		0.15 U		0.069 U		0.69 U
MAGNESIUM	NA	NA	7590 J		7120 J		6920 J		8040 J		14000 J
MANGANESE	88	NA	10.9 J		3.6 J		5.1 J		1.7 J		7460 J
MERCURY	1.1	0.0013	0.03 U		0.03 U		0.03 U		0.03 U		0.03 U
NICKEL	73	28.9	4.2 J		1.6 J		3.6 J		1.6 J		3.3 J
POTASSIUM	NA	NA	122000 J		9370 J		17300 J		6100 J		10800 J
SELENIUM	18	5	0.49 U		0.22 U		0.39 U		0.15 U		0.42 U
SILVER	18	0.12	0.028 U		0.028 U		0.028 U		0.028 U		0.028 U
SODIUM	NA	NA	8870 J		7940 J		8850 J		9800 J		5380 J
THALLIUM	0.24	10	0.043 U		0.06 J		0.043 U		0.07 J		0.043 U
TIN	2200	180	0.08 U		0.048 U		0.08 U		0.048 U		0.08 U
VANADIUM	3.6	12	1.3 J		1.14 U		1.14 U		1.14 U		1.14 U
ZINC	1100	65.7	7 U		1.7 U		1.9 U		1.3 U		6 U

TABLE 3-35

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	01 12SW/SD11 12SW1101-F NORMAL 10/12/2004	02 12SW/SD11 12SW1102 NORMAL 3/5/2005	02 12SW/SD11 12SW1102-F NORMAL 3/5/2005	01 12SW/SD12 12SW1201 NORMAL 10/13/2004	01 12SW/SD12 12SW1201-F NORMAL 10/13/2004	02 12SW/SD12 12SW1202 NORMAL 3/5/2005	02 12SW/SD12 12SW1202-F NORMAL 3/5/2005	01 12SW/SD13 12SW1301 NORMAL 10/13/2004	01 12SW/SD13 12SW1301-F NORMAL 10/13/2004
Energetics (ug/L)											
1,3,5-TRINITROBENZENE	110	11		0.24 U		0.242 U		0.266 U		0.25 U	
2,4,6-TRINITROTOLUENE	1.8	90		0.24 U		16		20		0.25 U	
2,4-DIAMINO-6-NITROTOLUENE	NA	NA		0.24 U		1.5 J		0.266 U		0.79 J	
2,4-DINITROTOLUENE	7.3	44		0.24 U		0.47 J		0.27 J		0.25 U	
2,6-DIAMINO-4-NITROTOLUENE	NA	NA		0.24 U		0.242 U		0.266 U		0.25 U	
2,6-DINITROTOLUENE	3.6	81		0.24 U		0.27 J		0.266 U		0.25 U	
2-AMINO-4,6-DINITROTOLUENE	0.73	20		0.24 U		19 J		5.8 J		6.8 J	
3,5-DINITROANILINE	NA	60		0.24 U		0.242 U		0.6		1.9	
3-NITROTOLUENE	12	NA		0.24 U		0.242 U		0.266 U		0.25 U	
4-AMINO-2,6-DINITROTOLUENE	0.73	NA		0.24 U		74		13		12	
HMX	180	330		1.3		12		3.7		6.5	
MNX	NA	NA		0.24 U		0.84 J		0.266 U		0.32 J	
RDX	0.61	190		1.9		52		9		7.7	
Total Metals (ug/L)											
ALUMINUM	3600	87		151 U		417		331 J		616	
ARSENIC	0.045	148		0.18 U		0.52 J		0.32 J		0.38 J	
BARIUM	260	220		54.6 J		26.5 J		27.3 J		91.8 J	
BERYLLIUM	4	3.6		0.02 U		0.03 J		0.11 J		0.22 J	
CADMIUM	1.8	0.15		0.06 J		0.11 U		0.07 J		0.27 U	
CALCIUM	NA	NA		29700 J		34700 J		40800 J		48600 J	
CHROMIUM	11	42		0.57 U		2.6 J		0.73 U		1.1 U	
COBALT	73	24		0.75 J		0.95 J		6.7 J		3.1 J	
COPPER	150	1.58		0.79 J		4.1 J		1.5 J		2.4 J	
IRON	1100	1000		587 J		657 J		1110 J		791 J	
LEAD	15	1.17		0.202 J		0.66 U		0.479 J		0.77 U	
MAGNESIUM	NA	NA		6680 J		6450 J		6850 J		15200 J	
MANGANESE	88	NA		161 J		79 J		974 J		1140 J	
MERCURY	1.1	0.0013		0.03 U		0.03 U		0.03 U		0.03 U	
NICKEL	73	28.9		1.9 J		2.6 J		7 J		14.1 J	
POTASSIUM	NA	NA		3930 J		1950 J		569 J		5440 J	
SELENIUM	18	5		0.21 U		0.51 U		0.44 U		0.63 U	
SILVER	18	0.12		0.028 U		0.028 U		0.028 U		0.028 U	
SODIUM	NA	NA		6790 J		10200 J		10600 J		29500 J	
THALLIUM	0.24	10		0.06 J		0.05 J		0.06 J		0.06 J	
TIN	2200	180		0.1 U		0.08 U		0.14 U		0.14 U	
VANADIUM	3.6	12		1.14 U		1.14 U		1.14 U		1.14 U	
ZINC	1100	65.7		2.1 U		8.9 U		21.1 J		26.9 J	

TABLE 3-35

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	02 12SW/SD13 12SW1302 NORMAL 3/5/2005	02 12SW/SD13 12SW1302-F NORMAL 3/5/2005	01 12SW/SD14 12SW1401 NORMAL 11/1/2004	01 12SW/SD14 12SW1401-F NORMAL 11/1/2004	02 12SW/SD14 12SW1402 NORMAL 3/7/2005	02 12SW/SD14 12SW1402-F NORMAL 3/7/2005	01 12SW/SD15 12SW1501 NORMAL 11/1/2004	01 12SW/SD15 12SW1501-F NORMAL 11/1/2004	02 12SW/SD15 12SW1502 DRY 3/5/2005	01 12SW/SD17 12SW1701 NORMAL 10/29/2004
Energetics (ug/L)												
1,3,5-TRINITROBENZENE	110	11	0.275 U		0.24 U		0.248 U		0.258 U			0.242 U
2,4,6-TRINITROTOLUENE	1.8	90	0.56		0.24 U		0.248 U		0.258 U			0.242 U
2,4-DIAMINO-6-NITROTOLUENE	NA	NA	0.275 U		0.24 U		0.248 U		0.258 U			0.242 U
2,4-DINITROTOLUENE	7.3	44	0.275 U		0.24 U		0.248 U		0.258 U			0.242 U
2,6-DIAMINO-4-NITROTOLUENE	NA	NA	0.275 U		0.24 U		0.248 U		0.258 U			0.242 U
2,6-DINITROTOLUENE	3.6	81	0.275 U		0.24 U		0.248 U		0.258 U			0.242 U
2-AMINO-4,6-DINITROTOLUENE	0.73	20	1 J		2.1 J		0.65 J		0.258 U			0.242 U
3,5-DINITROANILINE	NA	60	0.275 U		0.24 U		0.248 U		0.258 U			0.242 U
3-NITROTOLUENE	12	NA	0.275 U		0.71 J		0.248 U		0.258 U			0.242 U
4-AMINO-2,6-DINITROTOLUENE	0.73	NA	3		5.6		1.3		0.258 U			0.242 U
HMX	180	330	0.92		4.5		14		0.258 U			0.242 U
MNX	NA	NA	0.275 U		0.24 U		0.41 J		0.258 U			0.242 U
RDX	0.61	190	2.6		12		55		0.258 U			0.242 U
Total Metals (ug/L)												
ALUMINUM	3600	87	145 U		1570 J		90.6		1810 J			392 J
ARSENIC	0.045	148	0.19 U		4.1		0.16 J		1.7			0.68 J
BARIUM	260	220	34.4 J		85.3 J		0.37 U		79 J			90.8 J
BERYLLIUM	4	3.6	0.02 J		0.07 U		0.25 J		0.09 U			0.02 U
CADMIUM	1.8	0.15	0.039 U		0.53 J		0.34 U		3.9			2.2 J
CALCIUM	NA	NA	19000 J		69100 J		1100 J		38000 J			62700
CHROMIUM	11	42	0.6 U		3.3 J		0.08 U		3.6 J			3.2 J
COBALT	73	24	0.45 J		2.1		0.6 J		1.2			3.1
COPPER	150	1.58	0.84 J		21.6 J		1 J		9.1 J			4.3 J
IRON	1100	1000	297 J		2160 J		405 J		2430 J			962 J
LEAD	15	1.17	0.233 J		5.7		0.451 J		6.1			16.7 J
MAGNESIUM	NA	NA	7790 J		14900		315		3690			6220
MANGANESE	88	NA	17.7 J		95.3		26.8		33.6			297 J
MERCURY	1.1	0.0013	0.03 U		0.03 U		0.11 J		0.03 U			0.03 U
NICKEL	73	28.9	2 J		9.1 J		2		3.7 J			4.8 J
POTASSIUM	NA	NA	2630 J		167000 J		107 J		1170 J			1970 J
SELENIUM	18	5	0.21 U		1 J		0.11 U		0.16 U			0.46 U
SILVER	18	0.12	0.028 U		0.05 U		0.03 U		0.028 U			0.028 U
SODIUM	NA	NA	8120 J		30900 J		571 J		897 U			7720 J
THALLIUM	0.24	10	0.043 U		0.07 J		0.31 J		0.043 U			0.043 U
TIN	2200	180	0.12 U		0.56 U		0.34 U		0.11 U			0.35 U
VANADIUM	3.6	12	1.14 U		8		1.14 U		4.7			1.14 U
ZINC	1100	65.7	6.7 J		56.9 J		19.4		29.5 J			103 J

TABLE 3-35

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	01 12SW/SD17 12SW1701-F NORMAL 10/29/2004	02 12SW/SD17 12SW1702 NORMAL 3/5/2005	02 12SW/SD17 12SW1702-F NORMAL 3/5/2005	01 12SW/SD18 12SW1801 NORMAL 11/1/2004	01 12SW/SD18 12SW1801-F NORMAL 11/1/2004	02 12SW/SD18 12SW1802 NORMAL 3/7/2005	02 12SW/SD18 12SW1802-F NORMAL 3/7/2005	01 12SW/SD19 12SW1901 NORMAL 10/29/2004	01 12SW/SD19 12SW1901-F NORMAL 10/29/2004	02 12SW/SD19 12SW1902 DRY 3/7/2005
Energetics (ug/L)												
1,3,5-TRINITROBENZENE	110	11		0.264 U		0.264 U		0.26 U		0.245 U		
2,4,6-TRINITROTOLUENE	1.8	90		0.264 U		0.264 U		0.26 U		0.245 U		
2,4-DIAMINO-6-NITROTOLUENE	NA	NA		0.264 U		0.264 U		0.26 U		0.245 U		
2,4-DINITROTOLUENE	7.3	44		0.264 U		0.264 U		0.26 U		0.245 U		
2,6-DIAMINO-4-NITROTOLUENE	NA	NA		0.264 U		0.264 U		0.26 U		0.245 U		
2,6-DINITROTOLUENE	3.6	81		0.264 U		0.264 U		0.26 U		0.245 U		
2-AMINO-4,6-DINITROTOLUENE	0.73	20		0.264 U		0.264 U		0.26 U		0.245 U		
3,5-DINITROANILINE	NA	60		0.264 U		0.264 U		0.26 U		0.245 U		
3-NITROTOLUENE	12	NA		0.264 U		0.264 U		0.26 U		0.245 U		
4-AMINO-2,6-DINITROTOLUENE	0.73	NA		0.264 U		0.264 U		0.26 U		0.245 U		
HMX	180	330		0.264 U		0.264 U		0.26 U		0.245 U		
MNX	NA	NA		0.264 U		0.264 U		0.26 U		0.245 U		
RDX	0.61	190		0.264 U		0.264 U		0.26 U		0.245 U		
Total Metals (ug/L)												
ALUMINUM	3600	87		218 J		557 J		6240		1140 J		
ARSENIC	0.045	148		0.35 J		0.91 J		2.9		0.68 J		
BARIUM	260	220		35.4 J		47.6 J		124 J		105 J		
BERYLLIUM	4	3.6		0.02 U		0.02 U		0.27 J		0.07 U		
CADMIUM	1.8	0.15		0.17 J		1.5		3.1 J		1.5 U		
CALCIUM	NA	NA		43800 J		52600 J		111000 J		33100		
CHROMIUM	11	42		1.6 J		1.1 U		8.1 J		2 U		
COBALT	73	24		0.72 J		0.37 J		3.2		1.2		
COPPER	150	1.58		1.3 J		5.4 J		8.7 J		3.3 J		
IRON	1100	1000		401 J		793 J		7380 J		1820 J		
LEAD	15	1.17		3.2 J		0.56 J		6.7		1.8 J		
MAGNESIUM	NA	NA		4890 J		3660		9910		4570		
MANGANESE	88	NA		25.5 J		11.9		188		119		
MERCURY	1.1	0.0013		0.03 U		0.03 U		0.2		0.03 U		
NICKEL	73	28.9		1.9 J		3.2 J		8.9 J		3.7 J		
POTASSIUM	NA	NA		789 J		1160 J		1120 J		1990 J		
SELENIUM	18	5		0.29 U		0.12 U		0.61 U		0.32 U		
SILVER	18	0.12		0.028 U		0.028 U		0.05 U		0.028 U		
SODIUM	NA	NA		5580 J		1800 J		6760 J		1320 U		
THALLIUM	0.24	10		0.043 U		0.043 U		0.14 J		0.043 U		
TIN	2200	180		0.048 U		0.13 U		0.33 U		0.08 U		
VANADIUM	3.6	12		1.14 U		1.5 J		12.1		2.6		
ZINC	1100	65.7		16.9 J		6.1 J		47 J		9.5 J		

TABLE 3-35

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA CRITERIA	ERA CRITERIA	01	01	02	02	01	01	02	02	02	02
LOCATION			12SW/SD20	12SW/SD20	12SW/SD20	12SW/SD20	12SW/SD21	12SW/SD21	12SW/SD21	12SW/SD31	12SW/SD31	12SW/SD32
SAMPLE NUMBER			12SW2001	12SW2001-F	12SW2002	12SW2002-F	12SW2101	12SW2101-F	12SW2102	12SW3101	12SW3101-F	12SW3201
SAMPLE CODE			ORIG	ORIG	NORMAL	NORMAL	NORMAL	NORMAL	DRY	NORMAL	NORMAL	NORMAL
SAMPLE DATE			10/30/2004	10/30/2004	3/7/2005	3/7/2005	10/29/2004	10/29/2004	3/5/2005	3/5/2005	3/5/2005	3/3/2005
Energetics (ug/L)												
1,3,5-TRINITROBENZENE	110	11	0.255 U		0.238 U		0.25 U			0.96 J		0.255 U
2,4,6-TRINITROTOLUENE	1.8	90	0.255 U		0.238 U		0.25 U			79		0.255 U
2,4-DIAMINO-6-NITROTOLUENE	NA	NA	0.255 U		0.238 U		0.25 U			1.6 J		0.255 U
2,4-DINITROTOLUENE	7.3	44	0.255 U		0.238 U		0.25 U			0.36 J		0.255 U
2,6-DIAMINO-4-NITROTOLUENE	NA	NA	0.255 U		0.238 U		0.25 U			0.258 U		0.255 U
2,6-DINITROTOLUENE	3.6	81	0.255 U		0.238 U		0.25 U			0.258 U		0.255 U
2-AMINO-4,6-DINITROTOLUENE	0.73	20	0.255 U		0.238 U		0.25 U			11 J		0.65 J
3,5-DINITROANILINE	NA	60	0.255 U		0.238 U		0.25 U			1.2		0.255 U
3-NITROTOLUENE	12	NA	0.255 U		0.238 U		0.25 U			0.258 U		0.255 U
4-AMINO-2,6-DINITROTOLUENE	0.73	NA	0.255 U		0.28 J		0.25 U			24		0.84
HMX	180	330	2		2.7		0.25 U			4.2		2.3
MNX	NA	NA	0.255 U		0.238 U		0.25 U			0.258 U		0.255 U
RDX	0.61	190	5.1		7		0.36 J			20		4.5
Total Metals (ug/L)												
ALUMINUM	3600	87	1040 J		3320		277 J			2190 J		1060 J
ARSENIC	0.045	148	1.2		1.8		0.32 U			1.3 J		0.46 J
BARIUM	260	220	89.6 J		86 J		58 J			34.4 J		35.8 J
BERYLLIUM	4	3.6	0.02 U		0.16 J		0.02 U			0.11 J		0.16 J
CADMIUM	1.8	0.15	0.09 J		0.23 U		1.2 U			0.37 J		0.11 J
CALCIUM	NA	NA	60000 J		56800 J		21800			17500 J		40500 J
CHROMIUM	11	42	1.7 J		4.1 J		0.66 U			3.5 J		1.1 U
COBALT	73	24	0.5 J		1.8		0.28 J			3.6 J		9.7 J
COPPER	150	1.58	5.7 J		6.2 J		1.8 J			9.3 J		2 J
IRON	1100	1000	925 J		4080 J		450 J			2650 J		4270 J
LEAD	15	1.17	0.66 J		3.8		0.3 U			3.4 J		0.977 J
MAGNESIUM	NA	NA	9520		11800		3560			3910 J		7740 J
MANGANESE	88	NA	12.9		57		38.6 J			463 J		1630 J
MERCURY	1.1	0.0013	0.03 U		0.03 U		0.03 U			0.03 U		0.03 U
NICKEL	73	28.9	3.5 J		5.6 J		1.7 J			4.7 J		7.5 J
POTASSIUM	NA	NA	17000 J		9900 J		5810 J			649 J		590 J
SELENIUM	18	5	0.4 U		0.51 U		0.27 U			0.22 U		0.39 U
SILVER	18	0.12	0.04 U		0.028 U		0.028 U			0.028 U		0.028 U
SODIUM	NA	NA	14400 J		19000 J		4450 J			6180 J		12600 J
THALLIUM	0.24	10	0.07 J		0.08 J		0.043 U			0.09 J		0.07 J
TIN	2200	180	0.17 U		0.16 U		0.08 U			0.12 U		0.048 U
VANADIUM	3.6	12	1.9 J		6		1.14 U			3.9 J		1.3 J
ZINC	1100	65.7	8.7 J		38.9		3.5 U			29.8 J		16.3 J

TABLE 3-35

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA CRITERIA	ERA CRITERIA	02	02	02	02	02	02	02
LOCATION			12SW/SD32	12SW/SD34	12SW/SD34	12SW/SD35	12SW/SD35	12SW/SD36	12SW/SD36
SAMPLE NUMBER			12SW3201-F	12SW3401	12SW3401-F	12SW3501	12SW3501-F	12SW3601	12SW3601-F
SAMPLE CODE			NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE			3/5/2005	3/6/2005	3/6/2005	3/6/2005	3/6/2005	3/6/2005	3/6/2005
Energetics (ug/L)									
1,3,5-TRINITROBENZENE	110	11		0.271 U		0.278 U		0.258 U	
2,4,6-TRINITROTOLUENE	1.8	90		0.271 U		0.278 U		0.258 U	
2,4-DIAMINO-6-NITROTOLUENE	NA	NA		0.271 U		0.278 U		0.258 U	
2,4-DINITROTOLUENE	7.3	44		0.271 U		0.278 U		0.258 U	
2,6-DIAMINO-4-NITROTOLUENE	NA	NA		0.271 U		0.278 U		0.27 J	
2,6-DINITROTOLUENE	3.6	81		0.271 U		0.278 U		0.258 U	
2-AMINO-4,6-DINITROTOLUENE	0.73	20		0.8 J		0.278 U		0.258 U	
3,5-DINITROANILINE	NA	60		0.271 U		0.278 U		0.258 U	
3-NITROTOLUENE	12	NA		0.271 U		0.278 U		0.258 U	
4-AMINO-2,6-DINITROTOLUENE	0.73	NA		1.7		0.278 U		0.258 U	
HMX	180	330		98		5.1		7.3	
MNX	NA	NA		1.9		0.278 U		0.258 U	
RDX	0.61	190		140		2.1		6.5	
Total Metals (ug/L)									
ALUMINUM	3600	87		2550		67700		8360	
ARSENIC	0.045	148		5.7		20.3		2.9	
BARIUM	260	220		109 J		589 J		102 J	
BERYLLIUM	4	3.6		0.13 J		5.2		0.68 J	
CADMIUM	1.8	0.15		0.16 U		43.7 J		0.35 J	
CALCIUM	NA	NA		49300 J		119000 J		36600 J	
CHROMIUM	11	42		3.9 J		105 J		8.4 J	
COBALT	73	24		2.4		123		9.8	
COPPER	150	1.58		11.5 J		1650 J		12.4 J	
IRON	1100	1000		3010 J		95400 J		9080 J	
LEAD	15	1.17		2.7		458		13	
MAGNESIUM	NA	NA		19300		34500		6970	
MANGANESE	88	NA		72.5		3330		628	
MERCURY	1.1	0.0013		0.06 J		1.7		0.03 U	
NICKEL	73	28.9		9.6 J		140 J		16.7 J	
POTASSIUM	NA	NA		5.55 UJ		10900 J		2640 J	
SELENIUM	18	5		0.91 U		9.6 J		0.5 U	
SILVER	18	0.12		0.05 U		2.6 J		0.04 U	
SODIUM	NA	NA		26900 J		16800 J		4920 J	
THALLIUM	0.24	10		0.12 J		0.67 J		0.16 J	
TIN	2200	180		0.56 U		2.1 J		0.27 U	
VANADIUM	3.6	12		8		138		14.8	
ZINC	1100	65.7		37 J		5220		66.4	

TABLE 3-36

RESULTS FOR CHEMICALS DETECTED DOWNGRADIENT EAST TRIBUTARY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	01 12SW/SD23 12SW2301 NORMAL 10/13/2004	01 12SW/SD23 12SW2301-F NORMAL 10/13/2004	02 12SW/SD23 12SW2302 NORMAL 3/5/2005	02 12SW/SD23 12SW2302-F NORMAL 3/5/2005	01 12SW/SD24 12SW2401 NORMAL 10/27/2004	01 12SW/SD24 12SW2401-F NORMAL 10/27/2004	02 12SW/SD24 12SW2402 NORMAL 3/5/2005	02 12SW/SD24 12SW2402-F NORMAL 3/5/2005
Energetics (ug/L)										
4-AMINO-2,6-DINITROTOLUENE	0.73	NA	0.245 U		0.42 J		0.56		0.252 J	
HMX	180	330	0.245 U		0.38 J		0.55		0.28 J	
RDX	0.61	190	0.245 U		0.57		0.8		0.39 J	
Total Metals (ug/L)										
ALUMINUM	3600	87	40.7 J		85.1 U		257 J		52.8 U	
ARSENIC	0.045	148	0.24 U		0.11 U		0.33 J		0.11 U	
BARIUM	260	220	64.2 J		38.2 J		51.2 J		42.7 J	
CALCIUM	NA	NA	59300 J		51900 J		40400		48400 J	
COBALT	73	24	0.2 U		0.15 J		0.26 J		0.17 J	
COPPER	150	1.58	1.4 U		0.58 U		3.4 J		1.4 J	
IRON	1100	1000	340 J		252 J		584 J		258 J	
LEAD	15	1.17	0.29 U		0.069 U		0.48 U		0.136 J	
MAGNESIUM	NA	NA	10400 J		8580 J		6740 J		7860 J	
MANGANESE	88	NA	7.1 J		1.2 J		6 J		3.3 J	
NICKEL	73	28.9	1.9 J		1.7 J		2.4 J		1.6 J	
POTASSIUM	NA	NA	2940 J		1260 J		2470 J		1140 J	
SODIUM	NA	NA	25000 J		14200 J		11600 J		11700 J	
THALLIUM	0.24	10	0.07 J		0.07 J		0.043 U		0.07 J	
Dissolved Metals (ug/L)										
ALUMINUM	3600	87		8.6 U		9.6 J		18.6 U		8.7 J
ARSENIC	0.045	148		0.16 U		0.1 U		0.21 J		0.15 U
BARIUM	260	220		66.8 J		44.4 J		52 J		44.5 J
CALCIUM	NA	NA		57500 J		37400 J		40100		36200 J
CHROMIUM	11	42		0.82 U		1.6 J		0.65 U		1.2 J
COBALT	73	24		0.17 U		0.17 J		0.17 J		0.14 U
COPPER	150	1.58		1.3 U		1.5 J		2.8 J		1.3 J
IRON	1100	1000		305 J		284 J		292 J		229 J
LEAD	15	1.17		0.39 U		0.254 J		0.2 J		0.198 U
, FILTERED	NA	NA		10600 J		8840 J		6920 J		8450 J
MANGANESE	88	NA		4.2 U		0.82 J		3.5 J		1.6 J
NICKEL	73	28.9		2.2 J		2.8 J		2.5 J		2.3 J
POTASSIUM	NA	NA		3040 J		1530 J		2560 J		1240 J
SODIUM	NA	NA		23800 J		17400 J		12000 J		13000 J
THALLIUM	0.24	10		0.07 J		0.11 U		0.043 U		0.07 U
ZINC	1100	65.7		3.3 U		2.1 J		6.5 U		5.2 J

TABLE 3-37

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT TURKEY CREEK MAIN STREAM
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	01 12SW/SD27 12SW2701 NORMAL 10/12/2004	01 12SW/SD27 12SW2701-F NORMAL 10/12/2004	02 12SW/SD27 12SW2702 NORMAL 3/5/2005	02 12SW/SD27 12SW2702-F NORMAL 3/5/2005
Total Metals (ug/L)						
ALUMINUM	3600	87	24.1 J		49.7 U	
BARIUM	260	220	69.8 J		41 J	
BERYLLIUM	4	3.6	0.02 J		0.02 U	
CALCIUM	NA	NA	54500 J		34800 J	
COBALT	73	24	0.31 U		0.22 J	
IRON	1100	1000	456 J		275 J	
MAGNESIUM	NA	NA	9220 J		5120 J	
MANGANESE	88	NA	**131 J**		43.1 J	
NICKEL	73	28.9	1.7 J		0.1 UJ	
POTASSIUM	NA	NA	1600 J		915 J	
SODIUM	NA	NA	9630 J		4630 J	
Dissolved Metals (ug/L)						
BARIUM	260	220		64.4 J		36.9 J
CALCIUM	NA	NA		53900 J		25500 J
COBALT	73	24		0.28 U		0.18 J
COPPER	150	1.58		0.78 U		0.41 J
IRON	1100	1000		288 J		172 J
MAGNESIUM	NA	NA		8900 J		5800 J
MANGANESE	88	NA		**124 J**		33.5 J
NICKEL	73	28.9		1.7 J		1.8 J
POTASSIUM	NA	NA		1600 J		875 J
SODIUM	NA	NA		9440 J		5240 J
ZINC, FILTERED	1100	65.7		2.7 U		1.9 J
Field Parameters						
DISSOLVED OXYGEN (mg/L)	NA	NA	7.44		1.95	
OXIDATION-REDUCTION POTENTIAL (MV)	NA	NA	266.2		113	
PH (S.U.)	NA	NA	6.81		6.76	
SPECIFIC CONDUCTANCE (MS/CM)	NA	NA	0.267		0.092	
TEMPERATURE (°C)	NA	NA	13.55		5.21	
TURBIDITY (NTU)	NA	NA			9.15	
Miscellaneous Parameter (mg/L)						
AMMONIA-N	NA	NA	0.18 J		0.005 U	

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
MV - millivolts.
S.U. - standard units.
MS/CM - milliSiemens per centimeter.
C - Celsius.
NTU - nephelometric turbidity units.
NA - No applicable criterion.
Chemicals detected above either HHRA or ERA criteria values are identified by bold formatting.

TABLE 3-38

DESCRIPTIVE STATISTICS FOR UPGRADIENT GULLY
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Inorganics (mg/kg)									
ALUMINUM	7600	NA	6/6	12900 J	23800 J	---	16867	16867	12SD290004
ARSENIC	0.39	9.79	6/6	12.2 J	34.5 J	---	22.8	22.8	12SD260004
BARIUM	540	NA	6/6	70.1 J	196 J	---	131	131	12SD080004
CALCIUM	NA	NA	6/6	1610 J	46900 J	---	10323	10323	12SD300004
CHROMIUM	210	43.4	6/6	22.1 J	72.6 J	---	50.4	50.4	12SD260004
COBALT	140	50	6/6	7.9 J	65.9 J	---	30.9	30.9	12SD080004
COPPER	310	31.6	6/6	14.8 J	41.9 J	---	20.1	20.1	12SD260004
IRON	2300	NA	6/6	22900 J	210000 J	---	95933	95933	12SD260004
LEAD	400	35.8	6/6	23.9 J	43.9 J	---	34.3	34.3	12SD080004
MAGNESIUM	NA	NA	6/6	1130 J	4670 J	---	2312	2312	12SD300004
MANGANESE	180	NA	6/6	253 J	4430 J	---	2257	2257	12SD080004
MERCURY	2.3	0.174	6/6	0.029 J	0.059 J	---	0.0395	0.0395	12SD220004
NICKEL	160	22.7	6/6	16.1 J	63.9 J	---	40.0	40.0	12SD260004
POTASSIUM	NA	NA	6/6	866 J	2200 J	---	1499	1499	12SD290004
VANADIUM	7.8	NA	6/6	29.6 J	62.4 J	---	47.4	47.4	12SD260004
ZINC	2300	121	4/6	57.6 J	363 J	154 - 188	127	148	12SD300004
AVS/SEM (UMO/G)									
COPPER	NA	NA	1/1	0.043	0.043	---	0.0430	0.0430	12SD220004
LEAD	NA	NA	1/1	0.079	0.079	---	0.0790	0.0790	12SD220004
MERCURY	NA	NA	1/1	0.0019	0.0019	---	0.00190	0.00190	12SD220004
NICKEL	NA	NA	1/1	0.18	0.18	---	0.180	0.180	12SD220004
ZINC	NA	NA	1/1	0.21 J	0.21 J	---	0.210	0.210	12SD220004
Miscellaneous Parameters									
CATION EXCHANGE CAPACITY (MEQ/1)	NA	NA	1/1	8.2 J	8.2 J	---	8.20	8.20	12SD220004
PH (S.U.)	NA	NA	1/1	7.3	7.3	---	7.30	7.30	12SD220004
TOTAL ORGANIC CARBON (mg/kg)	NA	NA	1/1	10000 J	10000 J	---	10000	10000	12SD220004

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
mg/kg - milligrams per kilogram.
AVS - acid volatile sulfide.
SEM - simultaneously extracted metals.
UMO/G - micromoles per gram.
MEQ/1 - milliequivalents per 100 grams.
S.U. - standard units.
NA - No applicable criterion.

TABLE 3-39

DESCRIPTIVE STATISTICS FOR UPGRADIENT EAST TRIBUTARY
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Inorganics (mg/kg)									
ALUMINUM	7600	NA	1/1	10900 J	10900 J	---	10900	10900	12SD160004
ANTIMONY	3.1	NA	1/1	0.81 J	0.81 J	---	0.810	0.810	12SD160004
ARSENIC	0.39	9.79	1/1	15.3 J	15.3 J	---	15.3	15.3	12SD160004
BARIUM	540	NA	1/1	108 J	108 J	---	108	108	12SD160004
CALCIUM	NA	NA	1/1	9270 J	9270 J	---	9270	9270	12SD160004
CHROMIUM	210	43.4	1/1	29 J	29 J	---	29.0	29.0	12SD160004
COBALT	140	50	1/1	28.3 J	28.3 J	---	28.3	28.3	12SD160004
COPPER	310	31.6	1/1	11.5 J	11.5 J	---	11.5	11.5	12SD160004
IRON	2300	NA	1/1	44600 J	44600 J	---	44600	44600	12SD160004
LEAD	400	35.8	1/1	25.2 J	25.2 J	---	25.2	25.2	12SD160004
MAGNESIUM	NA	NA	1/1	2090 J	2090 J	---	2090	2090	12SD160004
MANGANESE	180	NA	1/1	2060 J	2060 J	---	2060	2060	12SD160004
MERCURY	2.3	0.174	1/1	0.027 J	0.027 J	---	0.0270	0.0270	12SD160004
NICKEL	160	22.7	1/1	31.3 J	31.3 J	---	31.3	31.3	12SD160004
POTASSIUM	NA	NA	1/1	1200 J	1200 J	---	1200	1200	12SD160004
VANADIUM	7.8	NA	1/1	30.7 J	30.7 J	---	30.7	30.7	12SD160004
ZINC	2300	121	1/1	71.2 J	71.2 J	---	71.2	71.2	12SD160004
AVS/SEM (UMO/G)									
COPPER	NA	NA	1/1	0.067	0.067	---	0.0670	0.0670	12SD160004
LEAD	NA	NA	1/1	0.068 J	0.068 J	---	0.0680	0.0680	12SD160004
MERCURY	NA	NA	1/1	0.00016	0.00016	---	0.000160	0.000160	12SD160004
NICKEL	NA	NA	1/1	0.14 J	0.14 J	---	0.140	0.140	12SD160004
ZINC	NA	NA	1/1	0.32 J	0.32 J	---	0.320	0.320	12SD160004
Miscellaneous Parameters									
CATION EXCHANGE CAPACITY (MEQ/1)	NA	NA	1/1	6.6 J	6.6 J	---	6.60	6.60	12SD160004
PH (S.U.)	NA	NA	1/1	8.1	8.1	---	8.10	8.10	12SD160004
TOTAL ORGANIC CARBON (mg/kg)	NA	NA	1/1	10900	10900	---	10900	10900	12SD160004

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
ug/kg - micrograms per kilogram.
mg/kg - milligrams per kilogram.
AVS - Acid volatile sulfide.
SEM - Simultaneously extracted metals.
UMO/G - micromoles per gram.
MEQ/1 - milliequivalents per 100 grams.
S.U. - standard units.
NA - No applicable criterion.

TABLE 3-40

DESCRIPTIVE STATISTICS FOR UPGRADIENT TURKEY CREEK MAIN STREAM
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Inorganics (mg/kg)									
ALUMINUM	7600	NA	1/1	6760 J	6760 J	---	6760	6760	12SD250004
BARIUM	540	NA	1/1	45.1 J	45.1 J	---	45.1	45.1	12SD250004
CALCIUM	NA	NA	1/1	64000 J	64000 J	---	64000	64000	12SD250004
CHROMIUM	210	43.4	1/1	26.4 J	26.4 J	---	26.4	26.4	12SD250004
IRON	2300	NA	1/1	40000 J	40000 J	---	40000	40000	12SD250004
LEAD	400	35.8	1/1	12.4 J	12.4 J	---	12.4	12.4	12SD250004
MAGNESIUM	NA	NA	1/1	6620 J	6620 J	---	6620	6620	12SD250004
MANGANESE	180	NA	1/1	708 J	708 J	---	708	708	12SD250004
NICKEL	160	22.7	1/1	22.8 J	22.8 J	---	22.8	22.8	12SD250004
POTASSIUM	NA	NA	1/1	903 J	903 J	---	903	903	12SD250004
VANADIUM	7.8	NA	1/1	24.8 J	24.8 J	---	24.8	24.8	12SD250004
ZINC	2300	121	1/1	55.6 J	55.6 J	---	55.6	55.6	12SD250004

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
mg/kg - milligrams per kilogram.
NA - No applicable criteria.

TABLE 3-41

RESULTS FOR CHEMICALS DETECTED IN UPGRADIENT GULLY
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA CRITERIA	ERA CRITERIA	01	01	01	01	01	01
LOCATION			12SW/SD08	12SW/SD22	12SW/SD26	12SW/SD28	12SW/SD29	12SW/SD30
SAMPLE NUMBER			12SD080004	12SD220004	12SD260004	12SD280004	12SD290004	12SD300004
SAMPLE CODE			NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	ORIG
DEPTH RANGE (feet)			0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33
SAMPLE DATE			10/11/2004	10/12/2004	10/11/2004	10/14/2004	10/13/2004	10/13/2004
Inorganics (mg/kg)								
ALUMINUM	7600	NA	**17000 J**	**15500 J**	**12900 J**	**14200 J**	**23800 J**	**17800 J**
ARSENIC	0.39	9.79	**21.6 J**	**21.9 J**	**34.5 J**	**26.2 J**	**20.2 J**	**12.2 J**
BARIUM	540	NA	196 J	83.8 J	129 J	138 J	172 J	70.1 J
CALCIUM	NA	NA	1610 J	2930 J	3360 J	3490 J	3650 J	46900 J
CHROMIUM	210	43.4	**59.7 J**	**60.3 J**	**72.6 J**	**64.7 J**	22.8 J	22.1 J
COBALT	140	50	**65.9 J**	23.3 J	41 J	31.7 J	15.7 J	7.9 J
COPPER	310	31.6	14.8 J	15.4 J	**41.9 J**	15.4 J	17.9 J	15.3 J
IRON	2300	NA	**87000 J**	**104000 J**	**210000 J**	**121000 J**	**30700 J**	**22900 J**
LEAD	400	35.8	**43.9 J**	35.7 J	30.5 J	**41.5 J**	23.9 J	30.2 J
MAGNESIUM	NA	NA	1230 J	1830 J	1960 J	1130 J	3050 J	4670 J
MANGANESE	180	NA	**4430 J**	**2000 J**	**3310 J**	**2470 J**	**1080 J**	**253 J**
MERCURY	2.3	0.174	0.039 J	0.059 J	0.037 J	0.039 J	0.034 J	0.029 J
NICKEL	160	22.7	**50.5 J**	**34.1 J**	**63.9 J**	**48.1 J**	**27.2 J**	16.1 J
POTASSIUM	NA	NA	1370 J	1680 J	866 J	1340 J	2200 J	1540 J
VANADIUM	7.8	NA	**54.4 J**	**54.3 J**	**62.4 J**	**53.2 J**	**29.6 J**	**30.4 J**
ZINC	2300	121	84.9 J	57.6 J	188 U	154 U	85.2 J	**363 J**
AVS/SEM (UMO/G)								
COPPER	NA	NA		0.043				
LEAD	NA	NA		0.079				
MERCURY	NA	NA		0.0019				
NICKEL	NA	NA		0.18				
ZINC	NA	NA		0.21 J				
Miscellaneoud Parameters								
CATION EXCHANGE CAPACITY (MEQ/1)	NA	NA		8.2 J				
PH (S.U.)	NA	NA		7.3				
TOTAL ORGANIC CARBON (mg/kg)	NA	NA		10000 J				

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
mg/kg - milligrams per kilogram.
AVS - Acid volatile sulfide.
SEM - Simultaneously extracted metals.
UMO/G - micromoles per gram.
MEQ/1 - milliequivalents per 100 grams.
S.U. - standard units.
NA - No applicable criterion.

Field duplicate samples are excluded from these summaries because they are considere to be field QC samples.
Chemicals detected above either HHRA or ERA criteria values are identified by bold formatting.

TABLE 3-42

RESULTS FOR CHEMICALS DETECTED IN UPGRADIENT EAST TRIBUTARY
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE DEPTH RANGE (feet) SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	01 12SW/SD16 12SD160004 NORMAL 0 - 0.33 10/13/2004
Inorganics (mg/kg)			
ALUMINUM	7600	NA	10900 J
ANTIMONY	3.1	NA	0.81 J
ARSENIC	0.39	9.79	15.3 J
BARIUM	540	NA	108 J
CALCIUM	NA	NA	9270 J
CHROMIUM	210	43.4	29 J
COBALT	140	50	28.3 J
COPPER	310	31.6	11.5 J
IRON	2300	NA	44600 J
LEAD	400	35.8	25.2 J
MAGNESIUM	NA	NA	2090 J
MANGANESE	180	NA	2060 J
MERCURY	2.3	0.174	0.027 J
NICKEL	160	22.7	31.3 J
POTASSIUM	NA	NA	1200 J
VANADIUM	7.8	NA	30.7 J
ZINC	2300	121	71.2 J
AVS/SEM (UMO/G)			
COPPER	NA	NA	0.067
LEAD	NA	NA	0.068 J
MERCURY	NA	NA	0.00016
NICKEL	NA	NA	0.14 J
ZINC	NA	NA	0.32 J
Miscellaneous Parameters			
CATION EXCHANGE CAPACITY (MEQ/1)	NA	NA	6.6 J
PH (S.U.)	NA	NA	8.1
TOTAL ORGANIC CARBON (mg/kg)	NA	NA	10900

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
mg/kg - milligrams per kilogram.
AVS - Acid volatile sulfide.
SEM - Simultaneously extracted metals.
UMO/G - micromoles per gram.
MEQ/1 - milliequivalents per 100 grams.
S.U. - standard units.
NA - No applicable criterion.

TABLE 3-43

RESULTS FOR CHEMICALS DETECTED IN
UPGRADIENT TURKEY CREEK MAIN STREAM SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE DEPTH RANGE (feet) SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	01 12SW/SD25 12SD250004 NORMAL 0 - 0.33 10/11/2004
Inorganics (mg/kg)			
ALUMINUM	7600	NA	6760 J
BARIUM	540	NA	45.1 J
CALCIUM	NA	NA	64000 J
CHROMIUM	210	43.4	26.4 J
IRON	2300	NA	**40000 J**
LEAD	400	35.8	12.4 J
MAGNESIUM	NA	NA	6620 J
MANGANESE	180	NA	**708 J**
NICKEL	160	22.7	**22.8 J**
POTASSIUM	NA	NA	903 J
VANADIUM	7.8	NA	**24.8 J**

Data qualifiers (e.g., U, J) are defined in Appendix A.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
mg/kg - milligrams per kilogram.
NA - No applicable criterion.
Chemicals detected above either HHRA or ERA criteria values are identified by bold formatting.

TABLE 3-44

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT GULLY
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Semivolatile Organics (ug/kg)							
BENZO(A)ANTHRACENE	1/3	9	9	3.65 - 4.28	4.32	9.00	12SD030004
BENZO(A)PYRENE	1/3	10	10	3.65 - 4.28	4.66	10.0	12SD030004
BENZO(B)FLUORANTHENE	1/3	15	15	3.65 - 4.28	6.32	15.0	12SD030004
BENZO(K)FLUORANTHENE	1/3	7 J	7 J	3.65 - 4.28	3.66	7.00	12SD030004
BIS(2-ETHYLHEXYL)PHTHALATE	1/3	340 J	340 J	74.1 - 85.7	140	340	12SD070004
CHRYSENE	1/3	11	11	3.65 - 4.28	4.99	11.0	12SD030004
FLUORANTHENE	3/3	4 J	15	---	8.67	8.67	12SD030004
NAPHTHALENE	1/3	7 J	7 J	3.65 - 4.22	3.65	7.00	12SD070004
PHENANTHRENE	2/3	6 J	10	3.65	5.94	8.00	12SD030004
PYRENE	2/3	6 J	18	3.65	8.61	12.0	12SD030004
Energetics (mg/kg)							
2,4,6-TRINITROTOLUENE	4/19	0.4 J	2.4 J	0.25	0.301	0.960	12SD020004
Inorganics (mg/kg)							
ALUMINUM	19/19	10300 J	25700 J	---	16563	16563	12SD120004
ANTIMONY	4/19	0.85 J	4.2 J	0.24 - 2.3	0.811	2.21	12SD130004
ARSENIC	12/19	9.3 J	36 J	5.1 - 15.5	16.1	22.8	12SD170004
BARIUM	16/19	64.6 J	182 J	138 - 220	111	114	12SD090004
CADMIUM	2/19	6.2 J	7.4 J	0.37 - 4.9	1.17	6.80	12SD150004
CALCIUM	19/19	893 J	65300 J	---	9290	9290	12SD030004
CHROMIUM	16/19	19.1 J	141 J	14.7 - 17.8	42.7	49.2	12SD210004
COBALT	14/19	5.5 J	108 J	6.9 - 17.3	26.1	33.1	12SD130004
COPPER	14/19	10.6 J	22.5 J	10.5 - 13.9	14.3	17.3	12SD140004, 12SD170004
IRON	19/19	14100 J	217000 J	---	69958	69958	12SD100004
LEAD	19/19	12.6 J	178 J	---	36.3	36.3	12SD170004
MAGNESIUM	19/19	670 J	8190 J	---	1832	1832	12SD140004
MANGANESE	17/19	217 J	6780 J	473 - 545	2097	2313	12SD130004
MERCURY	19/19	0.019 J	0.063 J	---	0.0386	0.0386	12SD140004
NICKEL	16/19	14.9 J	80.9 J	11.7 - 13.5	27.3	31.2	12SD130004
POTASSIUM	19/19	969 J	2440 J	---	1487	1487	12SD140004
SODIUM	2/19	89.7 J	102 J	25.5 - 154	31.5	95.9	12SD020004
TIN	3/19	2.6 J	3.1 J	0.33 - 0.63	0.643	2.80	12SD100004
VANADIUM	17/19	23.4 J	71 J	19.3 - 133	43.5	44.2	12SD090004
ZINC	16/19	46.1 J	263 J	121 - 528	106	102	12SD120004
AVS/SEM (UMO/G)							
ACID VOLATILE SULFIDE	2/6	0.47 J	3.08 J	0.26 - 0.46	0.724	1.78	12SD010004
CADMIUM	3/6	0.0025	0.0044	0.0013 - 0.0016	0.00196	0.00320	12SD130004
COPPER	6/6	0.035	0.14	---	0.0828	0.0828	12SD070004, 12SD010004
LEAD	6/6	0.03	0.058 J	---	0.0447	0.0447	12SD010004, 12SD130004
MERCURY	4/6	0.00014	0.00028	0.00016 - 0.00026	0.000163	0.000193	12SD010004

TABLE 3-45

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT EAST TRIBUTARY
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Inorganics (mg/kg)							
ALUMINUM	2/2	8080 J	17200 J	---	12640	12640	12SD230004
ANTIMONY	1/2	1.2 J	1.2 J	1.5	0.975	1.20	12SD230004
ARSENIC	1/2	10.9 J	10.9 J	15.5	9.33	10.9	12SD230004
BARIUM	1/2	65 J	65 J	177	76.8	65.0	12SD240004
CALCIUM	2/2	897 J	1920 J	---	1409	1409	12SD230004
CHROMIUM	2/2	26.8 J	32.8 J	---	29.8	29.8	12SD240004
COBALT	2/2	19.4 J	40.4 J	---	29.9	29.9	12SD230004
COPPER	2/2	13 J	29.4 J	---	21.2	21.2	12SD240004
IRON	2/2	31900 J	70700 J	---	51300	51300	12SD240004
LEAD	2/2	22.8 J	58.2 J	---	40.5	40.5	12SD240004
MAGNESIUM	2/2	710 J	1340 J	---	1025	1025	12SD230004
MANGANESE	2/2	1480 J	2910 J	---	2195	2195	12SD230004
MERCURY	2/2	0.012 J	0.038 J	---	0.0250	0.0250	12SD230004
NICKEL	2/2	26 J	32.1 J	---	29.1	29.1	12SD230004
POTASSIUM	2/2	838 J	1210 J	---	1024	1024	12SD230004
VANADIUM	2/2	31 J	36 J	---	33.5	33.5	12SD240004
ZINC	1/2	75.7 J	75.7 J	158	77.4	75.7	12SD230004

Data qualifiers (e.g., U, J) are defined in Appendix H.
mg/kg - milligrams per kilogram.

TABLE 3-46

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT TURKEY CREEK
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample of Maximum Detect
Inorganics (mg/kg)									
ALUMINUM	7600	NA	3/3	5360 J	11400 J	---	7427	7427	12SD270004
ARSENIC	0.39	9.79	3/3	4.5 J	27.8 J	---	12.4	12.4	12SD270004
BARIUM	540	NA	3/3	51.6 J	82.4 J	---	62.0	62.0	12SD270004
BERYLLIUM	15	NA	2/3	0.43 J	0.49 J	2.6	0.740	0.460	13SD4401
CADMIUM	3.7	0.99	2/3	0.17 J	0.19 J	0.81	0.255	0.180	13SD4401
CALCIUM	NA	NA	3/3	703 J	1830 J	---	1123	1123	12SD270004
CHROMIUM	210	43.4	3/3	11.8 J	70.4 J	---	31.4	31.4	12SD270004
COBALT	140	50	3/3	7 J	27.1 J	---	15.1	15.1	12SD270004
COPPER	310	31.6	3/3	6.3 J	19.8 J	---	11.2	11.2	12SD270004
IRON	2300	NA	3/3	14100 J	157000 J	---	62267	62267	12SD270004
LEAD	400	35.8	3/3	9.4 J	39.6 J	---	19.9	19.9	12SD270004
MAGNESIUM	NA	NA	3/3	565 J	748 J	---	642	642	12SD270004
MANGANESE	180	NA	3/3	444	1760 J	---	923	923	12SD270004
MERCURY	2.3	0.174	1/1	0.01 J	0.01 J	---	0.0100	0.0100	12SD270004
NICKEL	160	22.7	3/3	10.7 J	52.1 J	---	25.5	25.5	12SD270004
POTASSIUM	NA	NA	3/3	748 J	810 J	---	782	782	12SD270004
SELENIUM	39	NA	2/3	0.13 J	0.16 J	0.54	0.187	0.145	13SD4401
VANADIUM	7.8	NA	3/3	14 J	57.8 J	---	28.8	28.8	12SD270004
ZINC	2300	121	2/3	27.2 J	32 J	204	53.7	29.6	13SD4401

Data qualifiers (e.g., U, J) are defined in section 3 of the text.
HHRA - human health risk assessment
ERA - ecological risk assessment
mg/kg - milligrams per kilogram
NA - No applicable criteria

TABLE 3-47

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT GULLY
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA CRITERIA	ERA CRITERIA	01	01	01	01	01	01	01	01	01	01
LOCATION			12SW/SD01	12SW/SD02	12SW/SD03	12SW/SD04	12SW/SD05	12SW/SD06	12SW/SD07	12SW/SD09	12SW/SD10	12SW/SD11
SAMPLE NUMBER			12SD010004	12SD020004	12SD030004	12SD040004	12SD050004	12SD060004	12SD070004	12SD090004	12SD100004	12SD110004
SAMPLE CODE			NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	ORIG	NORMAL	NORMAL	NORMAL
DEPTH RANGE (feet)			0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33
SAMPLE DATE			10/12/2004	10/12/2004	10/12/2004	10/12/2004	10/12/2004	10/12/2004	10/11/2004	10/11/2004	10/11/2004	10/12/2004
Semivolatile Organics (ug/kg)												
BENZO(A)ANTHRACENE	620	108			9				4.28 U	3.65 U		
BENZO(A)PYRENE	62	150			10				4.28 U	3.65 U		
BENZO(B)FLUORANTHENE	620	10400			15				4.28 U	3.65 U		
BENZO(K)FLUORANTHENE	6200	240			7 J				4.28 U	3.65 U		
BIS(2-ETHYLHEXYL)PHTHALATE	35	182			85.7 U				340 J	74.1 U		
CHRYSENE	62000	166			11				4.28 U	3.65 U		
FLUORANTHENE	230000	423			15				7 J	4 J		
NAPHTHALENE	5600	176			4.22 U				7 J	3.65 U		
PHENANTHRENE	230000	204			10				6 J	3.65 U		
PYRENE	230000	195			18				6 J	3.65 U		
Energetics (mg/kg)												
2,4,6-TRINITROTOLUENE	16	NA	0.25 U	2.4 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.4 J
Inorganics (mg/kg)												
ALUMINUM	7600	NA	10300 J	18200 J	17300 J	14600 J	12000 J	12100 J	15400 J	13700 J	12800 J	13400 J
ANTIMONY	3.1	NA	1 U	0.45 U	0.5 U	0.51 U	0.84 U	0.24 U	0.42 U	1.8 U	2.3 U	0.93 U
ARSENIC	0.39	9.79	9.6 U	9.4 U	15.5 U	12.6 U	9.5 U	5.2 U	5.1 U	32.6 J	30.6 J	23.6 J
BARIUM	540	NA	149 J	108 J	69.7 J	150 J	81 J	103 J	153 J	182 J	73.1 J	143 J
CADMIUM	3.7	0.99	1.7 U	0.74 U	0.71 U	0.4 U	0.37 U	0.38 U	0.6 U	0.66 U	0.64 U	0.59 U
CALCIUM	NA	NA	3900 J	3880 J	65300 J	1580 J	1040 J	2860 J	1730 J	897 J	1330 J	1470 J
CHROMIUM	210	43.4	17.8 U	23.6 J	41 J	19.1 J	25 J	14.7 U	16.8 U	82 J	84 J	39.6 J
COBALT	140	50	17.3 U	8.9 U	6.9 U	32.5 J	20.8 J	15.7 U	13.3 U	32.6 J	25.2 J	24.1 J
COPPER	310	31.6	11.3 U	17.7 J	11.3 U	11.8 U	10.5 U	13.9 U	18.3 J	16.9 J	15.2 J	15.5 J
IRON	2300	NA	24800 J	24200 J	39800 J	34000 J	61300 J	14100 J	15700 J	171000 J	217000 J	95700 J
LEAD	400	35.8	14.2 J	17.3 J	24.6 J	20.3 J	22.6 J	12.6 J	17.3 J	44.7 J	36.5 J	23.8 J
MAGNESIUM	NA	NA	1300 J	1790 J	2150 J	1210 J	1290 J	1320 J	1330 J	937 J	670 J	1130 J
MANGANESE	180	NA	2610 J	545 U	473 U	3000 J	2270 J	972 J	1250 J	3130 J	2400 J	1620 J
MERCURY	2.3	0.174	0.029 J	0.037 J	0.035 J	0.043 J	0.019 J	0.036 J	0.04 J	0.044 J	0.029 J	0.021 J
NICKEL	160	22.7	11.7 U	13.5 U	12.2 U	27.5 J	22.9 J	16.6 J	16.9 J	39.7 J	43.1 J	40.3 J
POTASSIUM	NA	NA	1140 J	2360 J	1270 J	1230 J	1730 J	1770 J	1370 J	1150 J	969 J	1640 J
SODIUM	NA	NA	46.2 U	102 J	89.7 J	28.9 U	41.2 U	37.2 U	42.6 U	28.6 U	32.3 U	39.7 U
TIN	4700	NA	0.48 U	0.53 U	0.63 U	0.43 U	0.33 U	0.45 U	0.5 U	0.38 U	3.1 J	0.5 U
VANADIUM	7.8	NA	23.4 J	34.3 J	55.8 J	28.2 J	33.5 J	19.3 U	24.3 J	71 J	67 J	41.7 J
ZINC	2300	121	73.8 J	70.7 J	61.9 J	70.5 J	61.9 J	46.1 J	46.6 J	121 U	138 U	95.8 J

TABLE 3-47

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT GULLY
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA	ERA	01	01	01	01	01	01	01	01	01
LOCATION	CRITERIA	CRITERIA	12SW/SD12	12SW/SD13	12SW/SD14	12SW/SD15	12SW/SD17	12SW/SD18	12SW/SD19	12SW/SD20	12SW/SD21
SAMPLE NUMBER			12SD120004	12SD130004	12SD140004	12SD150004	12SD170004	12SD180004	12SD190004	12SD200004	12SD210004
SAMPLE CODE			NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE			0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33
SAMPLE DATE			10/13/2004	10/13/2004	10/13/2004	10/13/2004	10/13/2004	10/13/2004	10/12/2004	10/13/2004	10/12/2004
Semivolatile Organics (ug/kg)											
BENZO(A)ANTHRACENE	620	108									
BENZO(A)PYRENE	62	150									
BENZO(B)FLUORANTHENE	620	10400									
BENZO(K)FLUORANTHENE	6200	240									
BIS(2-ETHYLHEXYL)PHTHALATE	35	182									
CHRYSENE	62000	166									
FLUORANTHENE	230000	423									
NAPHTHALENE	5600	176									
PHENANTHRENE	230000	204									
PYRENE	230000	195									
Energetics (mg/kg)											
2,4,6-TRINITROTOLUENE	16	NA	0.44 J	0.6	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
Inorganics (mg/kg)											
ALUMINUM	7600	NA	25700 J	17200 J	23400 J	24500 J	14500 J	24700 J	12900 J	14800 J	17200 J
ANTIMONY	3.1	NA	2.2 J	4.2 J	0.58 U	0.49 U	1.6 J	0.85 J	1.3 U	0.55 U	1.2 U
ARSENIC	0.39	9.79	16.1 J	25.7 J	12.2 J	11.1 J	36 J	9.3 J	25.6 J	21.1 J	29.3 J
BARIUM	540	NA	183 U	220 U	88.5 J	85.3 J	138 U	138 J	82.3 J	64.6 J	160 J
CADMIUM	3.7	0.99	1.1 U	1.2 U	0.87 U	7.4 J	6.2 J	4.9 U	0.77 U	0.63 U	0.87 U
CALCIUM	NA	NA	2030 J	1130 J	40700 J	19600 J	3060 J	9630 J	893 J	14300 J	1180 J
CHROMIUM	210	43.4	34.4 J	41.5 J	35.9 J	29.9 J	83.9 J	24.5 J	45.4 J	36.7 J	141 J
COBALT	140	50	98.6 J	108 J	10.2 J	5.5 J	29.7 J	13.6 J	15.9 J	12.2 J	35.1 J
COPPER	310	31.6	17.1 J	16.9 J	22.5 J	18.6 J	22.5 J	15.9 J	17.1 J	10.6 J	17.1 J
IRON	2300	NA	51800 J	100000 J	30000 J	28700 J	88700 J	24400 J	77700 J	67300 J	163000 J
LEAD	400	35.8	38.4 J	39.5 J	42.3 J	25.9 J	178 J	19.8 J	26.7 J	25.4 J	60.3 J
MAGNESIUM	NA	NA	1920 J	956 J	8190 J	2520 J	1310 J	2670 J	803 J	2330 J	977 J
MANGANESE	180	NA	5730 J	6780 J	1090 J	217 J	2690 J	1200 J	1310 J	366 J	2690 J
MERCURY	2.3	0.174	0.053 J	0.049 J	0.063 J	0.034 J	0.048 J	0.038 J	0.051 J	0.022 J	0.042 J
NICKEL	160	22.7	35.6 J	80.9 J	16 J	14.9 J	32.7 J	15.9 J	32.9 J	17.9 J	45.4 J
POTASSIUM	NA	NA	1680 J	1120 J	2440 J	1630 J	1300 J	1880 J	1250 J	1160 J	1160 J
SODIUM	NA	NA	62.8 U	27.5 U	154 U	52.8 U	49.3 U	49.9 U	25.5 U	66.6 U	28.6 U
TIN	4700	NA	2.6 J	0.47 U	0.59 U	0.57 U	2.7 J	0.59 U	0.41 U	0.41 U	0.37 U
VANADIUM	7.8	NA	48.7 J	47.3 J	42.1 J	38.1 J	63.2 J	39.6 J	43.8 J	49.2 J	133 U
ZINC	2300	121	263 J	175 J	261 J	87.6 J	528 U	79.7 J	71.7 J	78.9 J	84.1 J

TABLE 3-48

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT EAST TRIBUTARY
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE DEPTH RANGE (feet) SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	01 12SW/SD23 12SD230004 NORMAL 0 - 0.33 10/13/2004	01 12SW/SD24 12SD240004 NORMAL 0 - 0.33 10/11/2004
Inorganics (mg/kg)				
ALUMINUM	7600	NA	**17200 J**	**8080 J**
ANTIMONY	3.1	NA	1.2 J	1.5 U
ARSENIC	0.39	9.79	**10.9 J**	15.5 U
BARIUM	540	NA	177 U	65 J
CALCIUM	NA	NA	1920 J	897 J
CHROMIUM	210	43.4	26.8 J	32.8 J
COBALT	140	50	40.4 J	19.4 J
COPPER	310	31.6	13 J	29.4 J
IRON	2300	NA	**31900 J**	**70700 J**
LEAD	400	35.8	22.8 J	**58.2 J**
MAGNESIUM	NA	NA	1340 J	710 J
MANGANESE	180	NA	**2910 J**	**1480 J**
MERCURY	2.3	0.174	0.038 J	0.012 J
NICKEL	160	22.7	**32.1 J**	**26 J**
POTASSIUM	NA	NA	1210 J	838 J
VANADIUM	7.8	NA	**31 J**	**36 J**
ZINC	2300	121	75.7 J	158 U

Data qualifiers (e.g., U, J) are defined in Appendix H.
mg/kg - milligrams per kilogram.
NA - No applicable criterion.
Chemicals detected above either HHRA or ERA criteria values are identified by bold formatting.

TABLE 3-49

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT TURKEY CREEK
SEDIMENT SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE DEPTH RANGE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	01 12SW/SD27 12SD270004 NORMAL 0 - 0.33 10/12/2004	02 13SW/SD44 13SD4401 NORMAL 0 - 0.33 5/17/2005	02 13SW/SD45 13SD4501 NORMAL 0 - 0.33 5/17/2005
Inorganics (mg/kg)					
ALUMINUM	7600	NA	11400 J	5520 J	5360 J
ARSENIC	0.39	9.79	27.8 J	5 J	4.5 J
BARIUM	540	NA	82.4 J	51.6 J	52.1 J
BERYLLIUM	15	NA	2.6 U	0.49 J	0.43 J
CADMIUM	3.7	0.99	0.81 U	0.19 J	0.17 J
CALCIUM	NA	NA	1830 J	835 J	703 J
CHROMIUM	210	43.4	70.4 J	12.1 J	11.8 J
COBALT	140	50	27.1 J	11.3 J	7 J
COPPER	310	31.6	19.8 J	7.5 J	6.3 J
IRON	2300	NA	157000 J	15700 J	14100 J
LEAD	400	35.8	39.6 J	10.6 J	9.4 J
MAGNESIUM	NA	NA	748 J	612 J	565 J
MANGANESE	180	NA	1760 J	564	444
MERCURY	2.3	0.174	0.01 J		
NICKEL	160	22.7	52.1 J	13.7 J	10.7 J
POTASSIUM	NA	NA	810 J	788 J	748 J
SELENIUM	39	NA	0.54 U	0.16 J	0.13 J
VANADIUM	7.8	NA	57.8 J	14.5 J	14 J
ZINC	2300	121	204 U	32 J	27.2 J

Data qualifiers (e.g., U, J) are defined in section 3 of the text.
HHRA - human health risk assessment
ERA - ecological risk assessment
mg/kg - milligrams per kilogram
NA - No applicable criteria

TABLE 3-50

DESCRIPTIVE STATISTICS FOR
SUMP WATER SAMPLES, EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energietics (ug/L)									
2,4,6-TRINITROTOLUENE	1.8	90	1/3	8	8	0.2 - 0.3	3	8	12SU00801
2-AMINO-4,6-DINITROTOLUENE	0.73	20	1/3	9 J	9 J	0.2 - 0.3	3	9	12SU00801
4-AMINO-2,6-DINITROTOLUENE	0.73	NA	1/3	18	18	0.2 - 0.3	6	18	12SU00801
HMX	180	330	3/3	5	19	--	13	13	12SU00801
RDX	0.61	190	3/3	13	95	--	42	42	12SU00801

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
ug/L = migrogram per liter.
NA - No applicable criterion.

TABLE 3-51

RESULTS FOR CHEMICALS DETECTED IN SUMP WATER SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

CLASSIFICATION STREAM ORDER SAMPLING ORDER LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ERA CRITERIA	SUMP WATER -- ES/DI 12SU/SL001 12SU00101 NORMAL 2/19/2006	SUMP WATER -- ES/DI 12SU/SL005 12SU00501 NORMAL 2/19/2006	SUMP WATER -- ES/DI 12SU/SL008 12SU00801 NORMAL 2/19/2006
Energietics (ug/L)					
2,4,6-TRINITROTOLUENE	1.8	90	0.264 U	0.242 U	**7.7**
2-AMINO-4,6-DINITROTOLUENE	0.73	20	0.264 U	0.242 U	**9.4 J**
4-AMINO-2,6-DINITROTOLUENE	0.73	NA	0.264 U	0.242 U	**18**
HMX	180	330	4.7	15 J	19
RDX	0.61	190	**13**	**18**	**95**

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
ug/L - micrograms per liter.
NA - No applicable criterion.

TABLE 3-52

DESCRIPTIVE STATISTICS FOR
SUMP SEDIMENT SAMPLES, EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	ERA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (mg/kg)									
1,3-DINITROBENZENE	0.61	NA	1/11	0.25 J	0.25 J	0.25 - 0.25	0.14	0.25	12SL003010006
2,4,6-TRINITROTOLUENE	16	NA	11/11	0.47 J	160	--	22.32	22.32	12SL003010006
2-AMINO-4,6-DINITROTOLUENE	12	NA	5/11	0.27 J	2.3	0.25 - 0.25	0.45	0.83	12SL003010006
4-AMINO-2,6-DINITROTOLUENE	12	NA	2/11	0.98 J	1.2 J	0.25 - 0.25	0.30	1.09	12SL004010006
HMX	310	NA	8/11	0.47 J	4	0.25 - 0.25	1.22	1.63	12SL003010006
RDX	4.4	NA	8/11	0.39 J	16	0.25 - 0.25	3.62	4.92	12SL003010006

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ERA - Ecological risk assessment.
mg/kg - milligrams per kilogram.
NA - No applicable criterion.

TABLE 3-53

RESULTS FOR CHEMICALS DETECTED IN SUMP SEDIMENT SAMPLES
DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

CLASSIFICATION			DOWNGRAD	DOWNGRAD	DOWNGRAD	DOWNGRAD	DOWNGRAD	DOWNGRAD
STREAM ORDER			--	--	--	--	--	--
SAMPLING ROUND			ES/DI	ES/DI	ES/DI	ES/DI	ES/DI	ES/DI
LOCATION	HHRA	ERA	12SU/SL001	12SU/SL002	12SU/SL003	12SU/SL004	12SU/SL005	12SU/SL006
SAMPLE NUMBER	CRITERIA	CRITERA	12SL001010006	12SL002010006	12SL003010006	12SL004010006	12SL005010006	12SL006010006
SAMPLE CODE			NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE			-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999	-9999 - -9999
SAMPLE DATE			2/19/2006	2/19/2006	2/19/2006	2/19/2006	2/19/2006	2/19/2006
Energetics (mg/kg)								
1,3-DINITROBENZENE	0.61	NA	0.25 U	0.25 U	0.25 J	0.25 U	0.25 U	0.25 U
2,4,6-TRINITROTOLUENE	16	NA	11	0.94	**160**	**39**	0.47 J	1.4
2-AMINO-4,6-DINITROTOLUENE	12	NA	0.25 U	0.25 U	2.3	0.79 J	0.25 U	0.25 U
4-AMINO-2,6-DINITROTOLUENE	12	NA	0.25 U	0.25 U	0.25 U	1.2 J	0.25 U	0.25 U
HMX	310	NA	1	0.25 U	4	2.5	0.25 U	0.47 J
RDX	4.4	NA	3.6	0.25 U	**16**	**6.1**	0.25 U	1.9

TABLE 3-54

DESCRIPTIVE STATISTICS FOR OVERBURDEN GROUNDWATER SAMPLES, EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)								
1,3,5-TRINITROBENZENE	110	1/14	2.3 J	2.3 J	0.2 - 0.3	0.3	2	12GWTW006
2,4,6-TRINITROTOLUENE	1.8	5/14	0.76	30 J	0.2 - 0.3	4	12	12GWTW006
2,6-DINITROTOLUENE	3.6	1/14	0.76 J	0.76 J	0.2 - 0.3	0.2	0.8	12GWTW008
2-AMINO-4,6-DINITROTOLUENE	0.73	8/14	1.2 J	38 J	0.2 - 0.3	4	7	12GWTW003
3-NITROTOLUENE	12	1/13	3.9 J	3.9 J	0.2 - 0.3	0.4	4	12GWTW007
4-AMINO-2,6-DINITROTOLUENE	0.73	8/14	2 J	160 J	0.2 - 0.3	15	26	12GWTW003
HMX	180	12/14	1.2 J	870	0.2 - 0.3	113	132	12GWTW012
RDX	0.61	13/14	0.7	12000	0.3 - 0.3	1043	1123	12GWTW012
Field Parameters								
DISSOLVED OXYGEN (MG/L)	NA	3/3	0	11.02	--	5	5	12GWTW011
OXIDATION REDUCTION POTENTIAL (MV)	NA	3/3	-68.5	159	--	30	30	12GWTW011
PH (S.U.)	NA	3/3	0	7.53	--	5	5	12GWTW011
SPECIFIC CONDUCTANCE (MS/CM)	NA	3/3	0	1.87	--	0.7	0.7	12GWTW002
TEMPERATURE (C)	NA	3/3	0	7.39	--	4	4	12GWTW002
TURBIDITY (NTU)	NA	3/3	25	277	--	151	151	12GWTW009

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ug/L = micrograms per liter.
NA - No applicable criterion.
MG/L - milligram per liter.
MV - millivolt.
S.U. - standard unit.
MS/CM - milliSeimens per centimeter.
C - celcius.
NTU - nephelometric turbudity units.

TABLE 3-55

RESULTS FOR CHEMICALS DETECTED IN OVERBURDEN GROUNDWATER DURING THE EXTERNAL SUMP/DRAINAGE INVESTIGATION
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	ES/DI 12TW001 12GWTW001 NORMAL 2/18/2006	ES/DI 12TW002 12GWTW002 NORMAL 2/18/2006	ES/DI 12TW003 12GWTW003 NORMAL 2/19/2006	ES/DI 12TW004 12GWTW004 NORMAL 2/18/2006	ES/DI 12TW006 12GWTW006 NORMAL 2/18/2006	ES/DI 12TW007 12GWTW007 NORMAL 2/18/2006	ES/DI 12TW008 12GWTW008 NORMAL 2/28/2006	ES/DI 12TW009 12GWTW009 NORMAL 2/19/2006	ES/DI 12TW010 12GWTW010 NORMAL 2/19/2006	ES/DI 12TW011 12GWTW011 NORMAL 2/20/2006
Energetics (ug/L)											
1,3,5-TRINITROBENZENE	110	0.291 UJ	0.269 U	0.284 UJ	0.271 UJ	2.3 J	0.294 UJ	0.27 U	0.248 UJ	0.294 UJ	0.24 U
2,4,6-TRINITROTOLUENE	1.8	0.291 UJ	1.6	**27 J**	0.271 UJ	**30 J**	0.294 UJ	0.79	0.248 UJ	0.294 UJ	0.24 U
2,6-DINITROTOLUENE	3.6	0.291 UJ	0.269 U	0.284 UJ	0.271 UJ	0.301 UJ	0.294 UJ	0.76 J	0.248 UJ	0.294 UJ	0.24 U
2-AMINO-4,6-DINITROTOLUENE	0.73	0.291 UJ	**2.6 J**	**38 J**	**1.3 J**	**6.7 J**	**1.7 J**	**4.7 J**	**1.2 J**	0.294 UJ	0.24 U
3-NITROTOLUENE	12	0.291 UJ	16 R	0.284 UJ	0.271 UJ	0.301 UJ	3.9 J	0.27 U	0.248 UJ	0.294 UJ	0.24 U
4-AMINO-2,6-DINITROTOLUENE	0.73	0.291 UJ	**5.2**	**160 J**	**2 J**	**19 J**	**3.9 J**	**12**	**3.6 J**	0.294 UJ	0.24 U
HMX	180	40 J	33	110 J	1.2 J	92 J	120 J	16	**280**	11 J	0.24 U
RDX	0.61	**27 J**	**170**	**720 J**	**1.5 J**	**370 J**	**530 J**	**1.7**	**730 J**	**36 J**	**0.7**
Field Parameters											
DISSOLVED OXYGEN (MG/L)	NA		4.27						0		11.02
PH (S.U.)	NA		6.62						0		7.53
SPECIFIC CONDUCTANCE (MS/CM)	NA		1.87						0		0.184
TEMPERATURE (C)	NA		7.39						0		3.40
TURBIDITY (NTU)	NA		25						277		150

TABLE 3-56

DESCRIPTIVE STATISTICS FOR UPGRADIENT PENNSYLVANIAN UPPER ZONE (Puz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)								
RDX	0.61	1/6	0.49	0.49	0.24 - 0.275	0.189	0.490	12GWT2502
Total Metals (ug/L)								
ALUMINUM	3600	5/6	126 J	565 J	57.9	291	344	12GWT2601
ARSENIC	0.045	2/6	1.1 J	2.3 J	0.15 - 0.67	0.693	1.70	12GWT2601
BARIUM	260	5/6	17.5 J	38.4 J	12.8	22.6	25.8	12GWT2601
BERYLLIUM	4	1/6	0.1 J	0.1 J	0.02 - 0.07	0.0325	0.100	12GWT2501
CALCIUM	NA	6/6	77900 J	216000 J	---	136083	136083	12GWT2501
CHROMIUM	11	1/6	1.7 J	1.7 J	0.51 - 1.4	0.641	1.70	12GWT2601
COBALT	73	5/6	5.6 J	53.2 J	1.4	20.6	24.6	12GWT2501
COPPER	150	5/6	0.84 J	4 J	0.59	2.51	2.95	12GWT2802
IRON	1100	6/6	307 J	2990 J	---	1603	1603	12GWT2601
LEAD	15	1/6	0.08 J	0.08 J	0.157 - 0.66	0.210	0.0800	12GWT2801
MAGNESIUM	NA	6/6	50000 J	233000 J	---	141333	141333	12GWT2801
MANGANESE	88	6/6	287 J	6000 J	---	2823	2823	12GWT2801
NICKEL	73	6/6	12.4 J	103 J	---	43.1	43.1	12GWT2501
POTASSIUM	NA	6/6	1630 J	5320 J	---	3343	3343	12GWT2501
SELENIUM	18	4/6	0.99 J	3.4 J	0.28 - 0.65	1.31	1.85	12GWT2501
SODIUM	NA	6/6	116000 J	167000 J	---	144167	144167	12GWT2801
THALLIUM	0.24	1/6	0.08 J	0.08 J	0.043 - 0.08	0.0358	0.0800	12GWT2501
ZINC	1100	5/6	8 J	26.1 J	5.1	13.2	15.3	12GWT2502
Dissolved Metals (ug/L)								
ARSENIC	0.045	1/1	2.5 J	2.5 J	---	2.50	2.50	12GWT2601-F
BARIUM	260	1/1	38.8 J	38.8 J	---	38.8	38.8	12GWT2601-F
CALCIUM	NA	1/1	107000 J	107000 J	---	107000	107000	12GWT2601-F
COBALT	73	1/1	41.4 J	41.4 J	---	41.4	41.4	12GWT2601-F
COPPER	150	1/1	1.3 J	1.3 J	---	1.30	1.30	12GWT2601-F
IRON	1100	1/1	2830 J	2830 J	---	2830	2830	12GWT2601-F
MAGNESIUM	NA	1/1	80600 J	80600 J	---	80600	80600	12GWT2601-F
MANGANESE	88	1/1	3350 J	3350 J	---	3350	3350	12GWT2601-F
NICKEL	73	1/1	76.1 J	76.1 J	---	76.1	76.1	12GWT2601-F
POTASSIUM	NA	1/1	4130 J	4130 J	---	4130	4130	12GWT2601-F
SODIUM	NA	1/1	170000 J	170000 J	---	170000	170000	12GWT2601-F
ZINC	1100	1/1	12.9 J	12.9 J	---	12.9	12.9	12GWT2601-F
Field Parameters								
DISSOLVED OXYGEN (mg/L)	NA	6/6	0.84	7.29	---	3.18	3.18	12GWT2801
OXIDATION-REDUCTION POTENTIAL (MV)	NA	6/6	38.3	82.7	---	53.3	53.3	12GWT2802
PH (S.U.)	NA	6/6	5.92	7.22	---	6.39	6.39	12GWT2601
SPECIFIC CONDUCTANCE (MS/CM)	NA	6/6	0.774	2.265	---	1.60	1.60	12GWT2501
TEMPERATURE (°C)	NA	6/6	11.54	17.98	---	15.5	15.5	12GWT2601
TURBIDITY (NTU)	NA	6/6	3	13.8	---	9.96	9.96	12GWT2502

TABLE 3-57

DESCRIPTIVE STATISTICS FOR UPGRADIENT PENNSYLVANIAN MIDDLE ZONE (Pmz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Total Metals (ug/L)								
ALUMINUM	3600	1/2	200 J	200 J	37.1	109	200	12GWT3302
ARSENIC	0.045	1/2	2.7 J	2.7 J	1.2	1.65	2.70	12GWT3301
BARIUM	260	1/2	13.2 J	13.2 J	15.6	10.5	13.2	12GWT3301
BERYLLIUM	4	2/2	1.3 J	2.2 J	---	1.75	1.75	12GWT3302
CALCIUM	NA	2/2	56400 J	61100 J	---	58750	58750	12GWT3301
COBALT	73	2/2	40 J	44.4 J	---	42.2	42.2	12GWT3301
COPPER	150	2/2	0.7 J	2.5 J	---	1.60	1.60	12GWT3302
IRON	1100	2/2	41700 J	41800 J	---	41750	41750	12GWT3301
MAGNESIUM	NA	2/2	27200 J	33500 J	---	30350	30350	12GWT3301
MANGANESE	88	2/2	1680 J	3010 J	---	2345	2345	12GWT3301
NICKEL	73	2/2	110 J	131 J	---	121	121	12GWT3301
POTASSIUM	NA	2/2	4520 J	4770 J	---	4645	4645	12GWT3302
SODIUM	NA	2/2	32200 J	40300 J	---	36250	36250	12GWT3301
ZINC	1100	2/2	96 J	128 J	---	112	112	12GWT3302
Field Parameters								
DISSOLVED OXYGEN (mg/L)	NA	2/2	0.57	2.35	---	1.46	1.46	12GWT3301
OXIDATION-REDUCTION POTENTIAL (MV)	NA	2/2	44	187.3	---	116	116	12GWT3301
PH (S.U.)	NA	2/2	4.72	5.28	---	5.00	5.00	12GWT3302
SPECIFIC CONDUCTANCE (MS/CM)	NA	2/2	0.634	0.646	---	0.640	0.640	12GWT3301
TEMPERATURE (°C)	NA	2/2	13.49	15.89	---	14.7	14.7	12GWT3301
TURBIDITY (NTU)	NA	2/2	2.6	10	---	6.30	6.30	12GWT3302
Miscellaneous Parameters (mg/L)								
AMMONIA-N	NA	2/2	0.35 J	0.54 J	---	0.445	0.445	12GWT3302
TOTAL ORGANIC CARBON	NA	1/2	2	2	1	1.25	2.00	12GWT3302

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
MV - millivolts.
S.U. - standard units.
MS/CM - milliSiemens per centimeter.
C - Celsius.
NTU - nephelometric turbidity units.
NA - No applicable criterion.

TABLE 3-58

DESCRIPTIVE STATISTICS FOR UPGRADIENT PENNSYLVANIAN LOWER AND MISSISSIPPIAN GLEN DEAN ZONE (Plz/Mgd)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Total Metals (ug/L)								
ALUMINUM	3600	2/2	18000 J	31600 J	---	24800	24800	12GWT4302
ARSENIC	0.045	2/2	17.6 J	19.7	---	18.7	18.7	12GWT4302
BARIUM	260	2/2	1360 J	1950 J	---	1655	1655	12GWT4302
BERYLLIUM	4	2/2	1.6 J	2.2 J	---	1.90	1.90	12GWT4302
CADMIUM	1.8	1/2	0.71 J	0.71 J	1.4	0.705	0.710	12GWT4302
CALCIUM	NA	2/2	27200	33100	---	30150	30150	12GWT4302
CHROMIUM	11	2/2	28.4 J	78.9 J	---	53.7	53.7	12GWT4302
COBALT	73	2/2	39.1 J	54.3	---	46.7	46.7	12GWT4302
COPPER	150	2/2	45.1 J	58.5	---	51.8	51.8	12GWT4302
IRON	1100	2/2	46100 J	84200 J	---	65150	65150	12GWT4302
LEAD	15	2/2	35.6 J	39.5	---	37.6	37.6	12GWT4302
MAGNESIUM	NA	2/2	7580 J	17300	---	12440	12440	12GWT4302
MANGANESE	88	2/2	1340	1790	---	1565	1565	12GWT4302
MERCURY	1.1	1/2	0.056 J	0.056 J	0.03	0.0355	0.0560	12GWT4302
NICKEL	73	2/2	92.1 J	132	---	112	112	12GWT4302
POTASSIUM	NA	2/2	6290 J	10800 J	---	8545	8545	12GWT4302
SELENIUM	18	2/2	1.5 J	2.2 J	---	1.85	1.85	12GWT4302
SODIUM	NA	2/2	152000 J	208000 J	---	180000	180000	12GWT4302
THALLIUM	0.24	2/2	0.21 J	0.42 J	---	0.315	0.315	12GWT4302
TIN	2200	2/2	1.9 J	2.4 J	---	2.15	2.15	12GWT4302
VANADIUM	3.6	2/2	39.9 J	58.5	---	49.2	49.2	12GWT4302
ZINC	1100	2/2	158 J	244	---	201	201	12GWT4302
Dissolved Metals (ug/L)								
ALUMINUM	3600	1/2	861 J	861 J	8.35	433	861	12GWT4301-F
ANTIMONY	1.5	2/2	3.5 J	3.5 J	---	3.50	3.50	12GWT4301-F, 12GWT4302-F
ARSENIC	0.045	2/2	3.4	5.3 J	---	4.35	4.35	12GWT4301-F
BARIUM	260	2/2	552 J	735 J	---	644	644	12GWT4302-F
CALCIUM	NA	2/2	8860	12600 J	---	10730	10730	12GWT4301-F
CHROMIUM	11	1/2	2.7 J	2.7 J	0.21	1.40	2.70	12GWT4301-F
COBALT	73	2/2	0.64 J	1.8	---	1.22	1.22	12GWT4301-F
COPPER	150	2/2	2.4	5 J	---	3.70	3.70	12GWT4301-F
IRON	1100	1/2	1870 J	1870 J	6.15	937	1870	12GWT4301-F
LEAD	15	2/2	0.274 J	1.5 J	---	0.887	0.887	12GWT4301-F
MAGNESIUM	NA	2/2	3240 J	3960 J	---	3600	3600	12GWT4301-F
MANGANESE	88	2/2	65.6 J	134	---	99.8	99.8	12GWT4302-F
NICKEL	73	2/2	3.4	6 J	---	4.70	4.70	12GWT4301-F
POTASSIUM	NA	2/2	2910 J	3970 J	---	3440	3440	12GWT4301-F
SELENIUM	18	2/2	0.68 J	0.94 J	---	0.810	0.810	12GWT4301-F
SODIUM	NA	2/2	171000 J	207000 J	---	189000	189000	12GWT4302-F
TIN	2200	1/2	1.1 J	1.1 J	0.048	0.562	1.10	12GWT4301-F
VANADIUM	3.6	1/2	2.3 J	2.3 J	1.14	1.44	2.30	12GWT4301-F
ZINC	1100	2/2	3.8 J	29 J	---	16.4	16.4	12GWT4301-F

TABLE 3-59

RESULTS FOR CHEMICALS DETECTED IN UPGRADIENT PENNSYLVANIAN UPPER ZONE (Puz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	01 12MWT25 12GWT2501 NORMAL 10/10/2004	02 12MWT25 12GWT2502 NORMAL 2/4/2005	01 12MWT26 12GWT2601 NORMAL 9/26/2004	01 12MWT26 12GWT2601-F NORMAL 9/26/2004	02 12MWT26 12GWT2602 NORMAL 2/17/2005	01 12MWT28 12GWT2801 NORMAL 9/13/2004	02 12MWT28 12GWT2802 NORMAL 2/15/2005
Energetics (ug/L)								
RDX	0.61	0.258 U	0.49	0.275 U		0.24 U	0.269 U	0.242 U
Total Metals (ug/L)								
ALUMINUM	3600	479	192 J	565 J		126 J	57.9 U	356 J
ARSENIC	0.045	1.1 J	0.27 U	2.3 J		0.67 U	0.42 U	0.15 U
BARIUM	260	26.2 J	21.8 J	38.4 J		12.8 U	25.2 J	17.5 J
BERYLLIUM	4	0.1 J	0.04 U	0.07 U		0.03 U	0.02 U	0.03 U
CALCIUM	NA	216000 J	125000 J	92600 J		77900 J	201000 J	104000 J
CHROMIUM	11	1.4 U	0.74 U	1.7 J		0.72 U	0.51 U	0.92 U
COBALT	73	53.2 J	12.9 J	31.3 J		5.6 J	19.8 J	1.4 U
COPPER	150	3 J	3.4 J	0.84 J		3.5 J	0.59 U	4 J
IRON	1100	1920 J	1110 J	2990 J		2010 J	307 J	1280 J
LEAD	15	0.66 U	0.425 U	0.53 U		0.157 U	0.08 J	0.585 U
MAGNESIUM	NA	229000 J	153000 J	70000 J		50000 J	233000 J	113000 J
MANGANESE	88	4910 J	2200 J	2520 J		1020 J	6000 J	287 J
NICKEL	73	103 J	32 J	60.1 J		12.8 J	38.2 J	12.4 J
POTASSIUM	NA	5320 J	3320 J	3740 J		1630 J	3940 J	2110 J
SELENIUM	18	3.4 J	1.9 J	0.28 U		0.99 J	0.65 U	1.1 J
SODIUM	NA	152000 J	116000 J	165000 J		143000 J	167000 J	122000 J
THALLIUM	0.24	0.08 J	0.08 U	0.043 U		0.06 U	0.043 U	0.043 U
ZINC	1100	20.8 J	26.1 J	12.1 J		8 J	9.5 J	5.1 U
Dissolved Metals (ug/L)								
ARSENIC	0.045				2.5 J			
BARIUM	260				38.8 J			
CALCIUM	NA				107000 J			
COBALT	73				41.4 J			
COPPER	150				1.3 J			
IRON	1100				2830 J			
MAGNESIUM	NA				80600 J			
MANGANESE	88				3350 J			
NICKEL	73				76.1 J			
POTASSIUM	NA				4130 J			
SODIUM	NA				170000 J			
ZINC	1100				12.9 J			
Field Parameters								
DISSOLVED OXYGEN (mg/L)	NA	1.72	0.84	3.38		1.7	7.29	4.17
OXIDATION-REDUCTION POTENTIAL (MV)	NA	46.4	38.9	38.3		38.5	75	82.7
PH (S.U.)	NA	5.92	6.28	7.22		6.18	6.33	6.41
SPECIFIC CONDUCTANCE (MS/CM)	NA	2.265	1.952	1.4888		0.774	1.937	1.208
TEMPERATURE (°C)	NA	16.35	14.57	17.98		11.54	16.31	16.17
TURBIDITY (NTU)	NA	3	13.8	13.3		9.81	10.83	9.03

TABLE 3-60

RESULTS FOR CHEMICALS DETECTED IN UPGRADIENT PENNSYLVANIAN MIDDLE ZONE (Pmz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	01 12MWT33 12GWT3301 ORIG 9/26/2004	02 12MWT33 12GWT3302 NORMAL 2/18/2005
Total Metals (ug/L)			
ALUMINUM	3600	37.1 U	200 J
ARSENIC	0.045	**2.7 J**	1.2 U
BARIUM	260	13.2 J	15.6 U
BERYLLIUM	4	1.3 J	2.2 J
CALCIUM	NA	61100 J	56400 J
COBALT	73	44.4 J	40 J
COPPER	150	0.7 J	2.5 J
IRON	1100	**41800 J**	**41700 J**
MAGNESIUM	NA	33500 J	27200 J
MANGANESE	88	**3010 J**	**1680 J**
NICKEL	73	**131 J**	**110 J**
POTASSIUM	NA	4520 J	4770 J
SODIUM	NA	40300 J	32200 J
ZINC	1100	96 J	128 J
Field Parameters			
DISSOLVED OXYGEN (mg/L)	NA	2.35	0.57
OXIDATION-REDUCTION POTENTIAL (MV)	NA	187.3	44
PH (S.U.)	NA	4.72	5.28
SPECIFIC CONDUCTANCE (MS/CM)	NA	0.646	0.634
TEMPERATURE (°C)	NA	15.89	13.49
TURBIDITY (NTU)	NA	2.6	10
Miscellaneous Parameters (mg/L)			
AMMONIA-N	NA	0.35 J	0.54 J
TOTAL ORGANIC CARBON	NA	1 U	2

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - human health risk assessment
ug/L - micrograms per liter
mg/L - milligrams per liter
MV - millivolts
S.U. - standard units
MS/CM - milliSiemens per centimeter
C - Celsius
NTU - nephelometric turbidity units
NA - No applicable criteria
Field duplicate samples are excluded from these summaries because they are considered to be field QC samples.
Chemicals detected above either HHRA or ERA criteria values are identified by bold formatting.

TABLE 3-61

RESULTS FOR CHEMICALS DETECTED IN UPGRADIENT PENNSYLVANIAN LOWER AND MISSISSIPPIAN GLEN DEAN ZONE (Plz/Mgd)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	01 12MWT43 12GWT4301 NORMAL 11/16/2004	01 12MWT43 12GWT4301-F NORMAL 11/17/2004	02 12MWT43 12GWT4302 NORMAL 3/3/2005	02 12MWT43 12GWT4302-F NORMAL 3/4/2005
Total Metals (ug/L)					
ALUMINUM	3600	18000 J		31600 J	
ARSENIC	0.045	17.6 J		19.7	
BARIUM	260	1360 J		1950 J	
BERYLLIUM	4	1.6 J		2.2 J	
CADMIUM	1.8	1.4 U		0.71 J	
CALCIUM	NA	27200		33100	
CHROMIUM	11	28.4 J		78.9 J	
COBALT	73	39.1 J		54.3	
COPPER	150	45.1 J		58.5	
IRON	1100	46100 J		84200 J	
LEAD	15	35.6 J		39.5	
MAGNESIUM	NA	7580 J		17300	
MANGANESE	88	1340		1790	
MERCURY	1.1	0.03 U		0.056 J	
NICKEL	73	92.1 J		132	
POTASSIUM	NA	6290 J		10800 J	
SELENIUM	18	1.5 J		2.2 J	
SODIUM	NA	152000 J		208000 J	
THALLIUM	0.24	0.21 J		0.42 J	
TIN	2200	1.9 J		2.4 J	
VANADIUM	3.6	39.9 J		58.5	
ZINC	1100	158 J		244	
Dissolved Metals (ug/L)					
ALUMINUM	3600		861 J		8.35 U
ANTIMONY	1.5		3.5 J		3.5 J
ARSENIC	0.045		5.3 J		3.4
BARIUM	260		552 J		735 J
CALCIUM	NA		12600 J		8860
CHROMIUM	11		2.7 J		0.21 U
COBALT	73		1.8		0.64 J
COPPER	150		5 J		2.4
IRON	1100		1870 J		6.15 U
LEAD	15		1.5 J		0.274 J
MAGNESIUM	NA		3960 J		3240 J
MANGANESE	88		65.6 J		134
NICKEL	73		6 J		3.4
POTASSIUM	NA		3970 J		2910 J
SELENIUM	18		0.94 J		0.68 J
SODIUM	NA		171000 J		207000 J
TIN	2200		1.1 J		0.048 U
VANADIUM	3.6		2.3 J		1.14 U
ZINC	1100		29 J		3.8 J
Field Parameters					
DISSOLVED OXYGEN (mg/L)	NA	6.84		6.64	
OXIDATION-REDUCTION POTENTIAL (MV)	NA	85		-7	
PH (S.U.)	NA	8.07		7.66	
SPECIFIC CONDUCTANCE (MS/CM)	NA	0.422		0.471	
TEMPERATURE (°C)	NA	12.3		11.96	
TURBIDITY (NTU)	NA	1000		1000 >	
Miscellaneous Parameters (mg/L)					
AMMONIA-N	NA	0.83 J		0.9	

Data qualifiers (e.g., U, J) are defined in Appendix H.
Plz - Pennsylvania Lower Water Bearing Zone.
Mgd - Mississippi Glen Dean Zone.
HHRA - Human health risk assessment.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
MV - millivolts.
S.U. - standard units.
MS/CM - milliSiemens per centimeter.
C - Celsius.
NTU - nephelometric turbidity units.
NA - No applicable criterion.
Chemicals detected above either HHRA or ERA criteria values are identified by bold formatting.

TABLE 3-62

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT PENNSYLVANIAN UPPER ZONE (Puz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)								
1,3,5-TRINITROBENZENE	110	9/63	0.66 J	110	0.238 - 0.305	4.26	29.1	12GWT1101, 12GWT1102
1,3-DINITROBENZENE	0.36	8/63	0.28 J	8.9	0.238 - 0.305	0.569	3.59	12GWT0602
2,4,6-TRINITROTOLUENE	1.8	10/63	0.26 J	170	0.238 - 0.305	10.6	66.1	12GWT0602
2,4-DIAMINO-6-NITROTOLUENE	NA	12/63	0.42 J	75 J	0.238 - 0.305	2.74	13.8	12GWT1102
2,4-DINITROTOLUENE	7.3	4/63	0.3 J	2.8 J	0.238 - 0.305	0.219	1.56	12GWT1101
2,6-DINITROTOLUENE	3.6	11/63	0.27 J	9.8 J	0.238 - 0.305	0.536	2.46	12GWT0601
2-AMINO-4,6-DINITROTOLUENE	0.73	17/63	0.47 J	100 J	0.238 - 0.305	6.42	23.4	12GWT1602
2-NITROTOLUENE	0.049	2/63	0.3 J	0.45 J	0.238 - 0.305	0.136	0.375	12GWT1101
3,5-DINITROANILINE	NA	10/63	0.63 J	12 J	0.238 - 0.305	0.865	4.76	12GWT1102
3-NITROTOLUENE	12	4/63	0.68 J	1.7 J	0.238 - 0.305	0.198	1.22	12GWT1301
4-AMINO-2,6-DINITROTOLUENE	0.73	18/63	0.26 J	190	0.238 - 0.305	10.7	37.2	12GWT1602
4-NITROTOLUENE	0.66	1/63	5.8 J	5.8 J	0.238 - 0.305	0.219	5.80	12GWT0602
DNX	NA	10/63	0.36 J	22	0.238 - 0.305	1.02	5.73	12GWT1601
HMX	180	37/63	0.32 J	530	0.238 - 0.305	56.8	96.6	12GWT0602, 12GWT1102
MNX	NA	23/63	0.33 J	250	0.238 - 0.305	10.5	28.6	12GWT1601
RDX	0.61	46/63	0.75	7400	0.238 - 0.305	700	959	12GWT1602
TNX	NA	7/63	0.54 J	11 J	0.238 - 0.305	0.584	4.23	12GWT1102
Total Metals (ug/L)								
ALUMINUM	3600	54/63	27.6 J	190000 J	8.35 - 172	14252	16624	12GWT24A02
ANTIMONY	1.5	1/63	1.7 J	1.7 J	0.085 - 2.7	0.122	1.70	12GWT24A01
ARSENIC	0.045	37/63	0.07 J	91.2 J	0.14 - 2	6.15	10.2	12GWT0501
BARIUM	260	56/63	7.9 J	212 J	9 - 18.8	35.4	38.8	12GWT3901
BERYLLIUM	4	34/63	0.11 J	97.4 J	0.02 - 3.2	7.59	13.8	12GWT2301
CADMIUM	1.8	30/63	0.04 J	83.4 J	0.039 - 3.4	5.29	10.8	12GWT2302
CALCIUM	NA	62/63	2100 J	589000 J	25300	109062	110617	12GWT0702
CHROMIUM	11	27/63	0.75 J	35.2 J	0.14 - 1.8	2.59	5.50	12GWT3901
COBALT	73	61/63	1	6060 J	1.2 - 44	434	448	12GWT2302
COPPER	150	57/63	0.67 J	93.3 J	0.17 - 1.1	10.2	11.2	12GWT2302
IRON	1100	56/63	134 J	209000 J	14.5 - 144	19138	21526	12GWT24A02
LEAD	15	39/63	0.07 J	104 J	0.069 - 4.4	7.05	11.1	12GWT2302
MAGNESIUM	NA	63/63	2530 J	1160000 J	---	156529	156529	12GWT0702
MANGANESE	88	62/63	31.6 J	138000 J	41.8	9290	9440	12GWT24A02
MERCURY	1.1	21/63	0.03 J	7.3	0.03 - 0.094	0.437	1.27	12GWT0602
NICKEL	73	62/63	3.3	14600 J	57.8	1021	1037	12GWT2302
POTASSIUM	NA	63/63	352 J	17800 J	---	4232	4232	12GWT3901
SELENIUM	18	32/63	0.62 J	24.7 J	0.094 - 3	2.50	4.67	12GWT2302
SODIUM	NA	61/63	11300 J	789000 J	6.79 - 307	101502	104828	12GWT0702
THALLIUM	0.24	18/63	0.05 J	6 J	0.043 - 1.5	0.302	0.718	12GWT2302
TIN	2200	6/63	0.08 J	1.4 J	0.048 - 1.1	0.139	0.447	12GWT3901
VANADIUM	3.6	15/63	1.3 J	22.9	1.14	1.76	5.55	12GWT3901
ZINC	1100	57/63	2.8 J	18000	3.1 - 357	1364	1504	12GWT2302

TABLE 3-63

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT PENNSYLVANIAN UPPER ZONE (Puz)
GROUNDWATER SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)								
1,3,5-TRINITROBENZENE	110	5/32	0.66 J	110	0.242 - 0.275	4.18	26.1	12GWT1101
1,3-DINITROBENZENE	0.36	4/32	0.43 J	8	0.242 - 0.275	0.518	3.23	12GWT0601
2,4,6-TRINITROTOLUENE	1.8	4/32	1.4	160	0.242 - 0.275	11.6	91.9	12GWT0601
2,4-DIAMINO-6-NITROTOLUENE	NA	6/32	0.57 J	69 J	0.242 - 0.275	2.58	13.2	12GWT1101
2,4-DINITROTOLUENE	7.3	3/32	0.73	2.8 J	0.242 - 0.275	0.304	1.98	12GWT1101
2,6-DINITROTOLUENE	3.6	7/32	0.29 J	9.8 J	0.242 - 0.275	0.825	3.31	12GWT0601
2-AMINO-4,6-DINITROTOLUENE	0.73	9/32	0.61 J	76	0.242 - 0.275	5.85	20.5	12GWT1601
2-NITROTOLUENE	0.049	2/32	0.3 J	0.45 J	0.242 - 0.275	0.146	0.375	12GWT1101
3,5-DINITROANILINE	NA	5/32	0.63 J	11	0.242 - 0.275	0.670	3.58	12GWT1101
3-NITROTOLUENE	12	2/32	0.68 J	1.7 J	0.242 - 0.275	0.197	1.19	12GWT1301
4-AMINO-2,6-DINITROTOLUENE	0.73	8/32	4.4	160	0.242 - 0.275	10.3	40.7	12GWT1601
DNX	NA	5/32	0.39 J	22	0.242 - 0.275	1.02	5.80	12GWT1601
HMX	180	17/32	0.35 J	490	0.242 - 0.275	52.5	98.8	12GWT1101
MNX	NA	10/32	0.34 J	250	0.242 - 0.275	10.6	33.8	12GWT1601
RDX	0.61	22/32	0.75	6300 J	0.25 - 0.275	635	924	12GWT0601, 12GWT1601
TNX	NA	2/32	1.3 J	7.8	0.242 - 0.275	0.407	4.55	12GWT1601
Total Metals (ug/L)								
ALUMINUM	3600	27/32	162 J	187000 J	8.35 - 128	14087	16692	12GWT24A01
ANTIMONY	1.5	1/32	1.7 J	1.7 J	0.085 - 0.97	0.150	1.70	12GWT24A01
ARSENIC	0.045	22/32	0.75 J	91.2 J	0.14 - 0.79	9.15	13.2	12GWT0501
BARIUM	260	32/32	8.3 J	212 J	---	42.2	42.2	12GWT3901
BERYLLIUM	4	20/32	0.11 J	97.4 J	0.02 - 1.5	8.06	12.8	12GWT2301
CADMIUM	1.8	16/32	0.14 J	67.2 J	0.039 - 1.2	5.46	10.7	12GWT2301
CALCIUM	NA	31/32	3180 J	396000 J	25300	100275	103102	12GWT0701
CHROMIUM	11	20/32	0.75 J	35.2 J	0.3 - 1.3	3.74	5.75	12GWT3901
COBALT	73	31/32	5.5 J	5460 J	44	333	343	12GWT2301
COPPER	150	28/32	0.67 J	90.8 J	0.17 - 0.56	10.5	12.0	12GWT2301
IRON	1100	27/32	236 J	191000 J	14.5 - 144	18440	21849	12GWT24A01
LEAD	15	22/32	0.07 J	51.2 J	0.069 - 1	7.11	10.2	12GWT0501
MAGNESIUM	NA	32/32	2870 J	948000 J	---	125840	125840	12GWT24A01
MANGANESE	88	31/32	80.8 J	130000 J	41.8	8435	8707	12GWT24A01
MERCURY	1.1	8/32	0.065 J	4.5 J	0.03 - 0.094	0.397	1.53	12GWT3901
NICKEL	73	31/32	8.9 J	14000 J	57.8	798	823	12GWT2301
POTASSIUM	NA	32/32	917 J	17800 J	---	4372	4372	12GWT3901
SELENIUM	18	10/32	2 J	10.6 J	0.094 - 3	1.67	4.71	12GWT2001
SODIUM	NA	31/32	11300 J	366000 J	6.79	97238	100374	12GWT2301
THALLIUM	0.24	8/32	0.05 J	1.5 J	0.043 - 0.84	0.203	0.488	12GWT2301
TIN	2200	3/32	0.16 J	1.4 J	0.048 - 1.1	0.165	0.613	12GWT3901
VANADIUM	3.6	8/32	1.3 J	22.9	1.14	2.44	8.04	12GWT3901
ZINC	1100	28/32	11.3 J	17500 J	3.1 - 357	1005	1142	12GWT2301

TABLE 3-64

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT PENNSYLVANIAN UPPER ZONE (Puz)
GROUNDWATER SAMPLES, ROUND 2 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)								
1,3,5-TRINITROBENZENE	110	4/31	0.82 J	110	0.238 - 0.305	4.34	32.8	12GWT1102
1,3-DINITROBENZENE	0.36	4/31	0.28 J	8.9	0.238 - 0.305	0.621	3.96	12GWT0602
2,4,6-TRINITROTOLUENE	1.8	6/31	0.26 J	170	0.238 - 0.305	9.58	48.9	12GWT0602
2,4-DIAMINO-6-NITROTOLUENE	NA	6/31	0.42 J	75 J	0.238 - 0.305	2.91	14.5	12GWT1102
2,4-DINITROTOLUENE	7.3	1/31	0.3 J	0.3 J	0.238 - 0.305	0.133	0.300	12GWT1602
2,6-DINITROTOLUENE	3.6	4/31	0.27 J	1.7 J	0.238 - 0.305	0.237	0.978	12GWT1602
2-AMINO-4,6-DINITROTOLUENE	0.73	8/31	0.47 J	100 J	0.238 - 0.305	7.01	26.8	12GWT1602
3,5-DINITROANILINE	NA	5/31	0.92 J	12 J	0.238 - 0.305	1.07	5.94	12GWT1102
3-NITROTOLUENE	12	2/31	0.88 J	1.6 J	0.238 - 0.305	0.199	1.24	12GWT1202
4-AMINO-2,6-DINITROTOLUENE	0.73	10/31	0.26 J	190	0.238 - 0.305	11.2	34.5	12GWT1602
4-NITROTOLUENE	0.66	1/31	5.8 J	5.8 J	0.238 - 0.305	0.310	5.80	12GWT0602
DNX	NA	5/31	0.36 J	18	0.238 - 0.305	1.02	5.65	12GWT1602
HMX	180	20/31	0.32 J	530	0.238 - 0.305	61.2	94.8	12GWT0602, 12GWT1102
MNX	NA	13/31	0.33 J	200	0.238 - 0.305	10.4	24.6	12GWT1602
RDX	0.61	24/31	0.81	7400	0.238 - 0.305	767	991	12GWT1602
TNX	NA	5/31	0.54 J	11 J	0.238 - 0.305	0.768	4.10	12GWT1102
Total Metals (ug/L)								
ALUMINUM	3600	27/31	27.6 J	190000 J	8.35 - 172	14423	16555	12GWT24A02
ARSENIC	0.045	15/31	0.07 J	37.7 J	0.21 - 2	3.04	5.87	12GWT0102
BARIUM	260	24/31	7.9 J	174 J	9 - 18.8	28.3	34.2	12GWT1202
BERYLLIUM	4	14/31	0.14 J	88.9 J	0.02 - 3.2	7.10	15.2	12GWT2302
CADMIUM	1.8	14/31	0.04 J	83.4 J	0.039 - 3.4	5.13	10.9	12GWT2302
CALCIUM	NA	31/31	2100 J	589000 J	---	118132	118132	12GWT0702
CHROMIUM	11	7/31	2.1 J	9.7 J	0.14 - 1.8	1.41	4.80	12GWT2302
COBALT	73	30/31	1	6060 J	1.2	538	556	12GWT2302
COPPER	150	29/31	1 J	93.3 J	0.69 - 1.1	9.85	10.5	12GWT2302
IRON	1100	29/31	134 J	209000 J	23.8 - 103	19858	21225	12GWT24A02
LEAD	15	17/31	0.296 J	104 J	0.069 - 4.4	7.00	12.3	12GWT2302
MAGNESIUM	NA	31/31	2530 J	1160000 J	---	188208	188208	12GWT0702
MANGANESE	88	31/31	31.6 J	138000 J	---	10173	10173	12GWT24A02
MERCURY	1.1	13/31	0.03 J	7.3	0.03 - 0.056	0.478	1.12	12GWT0602
NICKEL	73	31/31	3.3	14600 J	---	1251	1251	12GWT2302
POTASSIUM	NA	31/31	352 J	12600 J	---	4087	4087	12GWT1202
SELENIUM	18	22/31	0.62 J	24.7 J	0.1 - 0.85	3.36	4.65	12GWT2302
SODIUM	NA	30/31	12600 J	789000 J	307	105905	109430	12GWT0702
THALLIUM	0.24	10/31	0.06 J	6 J	0.043 - 1.5	0.405	0.903	12GWT2302
TIN	2200	3/31	0.08 J	0.39 J	0.048 - 0.63	0.112	0.280	12GWT1402
VANADIUM	3.6	7/31	1.3 J	5.1	1.14	1.05	2.71	12GWT3902
ZINC	1100	29/31	2.8 J	18000	3.3 - 4.2	1733	1853	12GWT2302

TABLE 3-65

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT PENNSYLVANIAN MIDDLE ZONE (Pmz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)								
HMX	180	1/16	0.52	0.52	0.24 - 0.446	0.161	0.520	12GWT4802
RDX	0.61	2/16	1.3 J	4.2 J	0.24 - 0.446	0.462	2.75	12GWT4802
Total Metals (ug/L)								
ALUMINUM	3600	12/14	95.6 J	31000 J	50.2 - 72.9	5615	6546	12GWT4801
ANTIMONY	1.5	3/14	2 J	2.9 J	0.085 - 0.41	0.552	2.37	12GWT3101
ARSENIC	0.045	14/14	0.17 J	11.4 J	---	3.89	3.89	12GWT4801
BARIUM	260	14/14	10.6 J	214 J	---	67.6	67.6	12GWT4802
BERYLLIUM	4	4/14	0.2 J	1.2 J	0.02 - 1.5	0.250	0.495	12GWT4801
CADMIUM	1.8	5/14	0.07 J	2.3 J	0.039 - 1.3	0.502	1.03	12GWT4801
CALCIUM	NA	14/14	12300 J	194000 J	---	57986	57986	12GWT3202
CHROMIUM	11	8/14	3.9 J	47.9 J	0.27 - 0.91	9.76	16.9	12GWT4802
COBALT	73	12/14	0.14 J	79.7 J	1.8	20.9	24.2	12GWT4801
COPPER	150	14/14	0.68 J	24.3 J	---	7.69	7.69	12GWT4801
IRON	1100	14/14	424 J	48900 J	---	12887	12887	12GWT4801
LEAD	15	11/14	0.089 J	24.7 J	0.11 - 1.8	5.92	7.43	12GWT4802
MAGNESIUM	NA	14/14	4080 J	121000 J	---	48426	48426	12GWT3202
MANGANESE	88	14/14	1.5 J	7570	---	1365	1365	12GWT4601
MERCURY	1.1	1/14	0.057 J	0.057 J	0.03 - 0.034	0.0183	0.0570	12GWT4802
NICKEL	73	13/14	3.2 J	178	5.5	57.4	61.6	12GWT4502
POTASSIUM	NA	14/14	1380 J	11200 J	---	4436	4436	12GWT3202
SELENIUM	18	9/14	0.98 J	7.7 J	0.54 - 2.1	1.44	1.93	12GWT3201
SODIUM	NA	14/14	10000 J	161000 J	---	57643	57643	12GWT2901
THALLIUM	0.24	3/14	0.06 J	0.32 J	0.043 - 0.5	0.0747	0.157	12GWT4801
TIN	2200	4/14	0.08 J	1.1 J	0.048 - 1.6	0.348	0.628	12GWT4801
VANADIUM	3.6	8/14	3.4	49.4 J	1.14	9.74	16.6	12GWT4801
ZINC	1100	12/14	2.5 J	262	3.4 - 4.8	67.9	78.9	12GWT4502
Dissolved Metals (ug/L)								
ALUMINUM	3600	2/10	9.1 J	210 J	9.1 - 140	36.2	110	12GWT4502-F
ANTIMONY	1.5	2/10	2.3 J	3.2 J	0.085 - 1.6	0.732	2.75	12GWT3101-F
ARSENIC	0.045	8/10	0.15 J	3.7 J	0.28 - 1.6	1.54	1.80	12GWT3101-F
BARIUM	260	10/10	11.2 J	68 J	---	33.3	33.3	12GWT3201-F
CADMIUM	1.8	5/10	0.06 J	1.7 J	0.039 - 0.17	0.294	0.554	12GWT4801-F
CALCIUM	NA	10/10	12600 J	237000	---	73710	73710	12GWT3201-F
CHROMIUM	11	1/10	0.81 J	0.81 J	0.14 - 0.78	0.278	0.810	12GWT3101-F
COBALT	73	6/10	1.9	29.2	0.13 - 0.98	8.90	14.7	12GWT3201-F
COPPER	150	6/10	0.99 J	3.5	0.16 - 0.33	1.19	1.90	12GWT2901-F
IRON	1100	5/10	295 J	1250	6.2 - 120	383	741	12GWT3201-F
LEAD	15	3/10	0.12 J	0.315 J	0.069 - 0.45	0.148	0.205	12GWT4502-F
MAGNESIUM	NA	10/10	3650 J	139000 J	---	47648	47648	12GWT3201-F
MANGANESE	88	9/10	27.2 J	3300	25.4	757	839	12GWT4602-F
NICKEL	73	7/10	6.8 J	178	0.68 - 2.1	38.0	54.0	12GWT4502-F

TABLE 3-66

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT PENNSYLVANIAN MIDDLE ZONE (Pmz)
GROUNDWATER SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)								
RDX	0.61	1/8	1.3 J	1.3 J	0.248 - 0.446	0.288	1.30	12GWT4801
Total Metals (ug/L)								
ALUMINUM	3600	6/7	198 J	31000 J	72.9	5464	6369	12GWT4801
ANTIMONY	1.5	3/7	2 J	2.9 J	0.085	1.04	2.37	12GWT3101
ARSENIC	0.045	7/7	0.38 J	11.4 J	---	3.82	3.82	12GWT4801
BARIUM	260	7/7	10.6 J	173 J	---	62.6	62.6	12GWT4801
BERYLLIUM	4	4/7	0.2 J	1.2 J	0.02 - 0.09	0.292	0.495	12GWT4801
CADMIUM	1.8	3/7	0.18 J	2.3 J	0.039 - 1.3	0.775	1.43	12GWT4801
CALCIUM	NA	7/7	12900	182000	---	53771	53771	12GWT3201
CHROMIUM	11	4/7	4.7 J	34.1 J	0.64 - 0.91	7.95	13.6	12GWT4801
COBALT	73	6/7	0.26 J	79.7 J	1.8	21.3	24.7	12GWT4801
COPPER	150	7/7	0.83 J	24.3 J	---	6.75	6.75	12GWT4801
IRON	1100	7/7	546 J	48900 J	---	12806	12806	12GWT4801
LEAD	15	5/7	0.36 J	23.4 J	0.11 - 0.3	5.24	7.29	12GWT4801
MAGNESIUM	NA	7/7	4210 J	112000	---	45340	45340	12GWT3201
MANGANESE	88	7/7	5.4 J	7570	---	1604	1604	12GWT4601
NICKEL	73	6/7	3.2 J	141 J	5.5	59.7	69.1	12GWT4501
POTASSIUM	NA	7/7	1550 J	10400 J	---	4269	4269	12GWT3201
SELENIUM	18	4/7	0.98 J	7.7 J	0.69 - 2.1	1.92	2.82	12GWT3201
SODIUM	NA	7/7	10000 J	161000 J	---	57857	57857	12GWT2901
THALLIUM	0.24	2/7	0.09 J	0.32 J	0.043	0.0739	0.205	12GWT4801
TIN	2200	3/7	0.45 J	1.1 J	0.08 - 0.72	0.446	0.810	12GWT4801
VANADIUM	3.6	4/7	4	49.4 J	1.14	9.97	17.0	12GWT4801
ZINC	1100	5/7	15.4 J	183 J	3.4 - 4.8	64.3	89.1	12GWT4501
Dissolved Metals (ug/L)								
ANTIMONY	1.5	2/4	2.3 J	3.2 J	0.25 - 1.6	1.61	2.75	12GWT3101-F
ARSENIC	0.045	4/4	0.22 J	3.7 J	---	2.07	2.07	12GWT3101-F
BARIUM	260	4/4	15.7 J	68 J	---	37.8	37.8	12GWT3201-F
CADMIUM	1.8	3/4	0.11 J	1.7 J	0.039	0.495	0.653	12GWT4801-F
CALCIUM	NA	4/4	13400 J	237000	---	83300	83300	12GWT3201-F
CHROMIUM	11	1/4	0.81 J	0.81 J	0.67 - 0.78	0.480	0.810	12GWT3101-F
COBALT	73	3/4	1.9	29.2	0.24	10.6	14.1	12GWT3201-F
COPPER	150	4/4	0.99 J	3.5	---	1.95	1.95	12GWT2901-F
IRON	1100	3/4	295 J	1250	120	477	615	12GWT3201-F
LEAD	15	1/4	0.12 J	0.12 J	0.069 - 0.3	0.0874	0.120	12GWT3201-F
MAGNESIUM	NA	4/4	4040 J	139000 J	---	44933	44933	12GWT3201-F
MANGANESE	88	4/4	33.5 J	1310	---	428	428	12GWT3201-F
NICKEL	73	3/4	6.8 J	102 J	0.88	36.9	49.0	12GWT3201-F
POTASSIUM	NA	4/4	1160 J	11900 J	---	5375	5375	12GWT3201-F
SELENIUM	18	1/4	7.6 J	7.6 J	0.83 - 2.4	2.47	7.60	12GWT3201-F
SODIUM	NA	4/4	12600 J	171000 J	---	89625	89625	12GWT2901-F
ZINC	1100	3/4	4.2 J	19.6 J	1.7	8.59	11.2	12GWT4801-F

TABLE 3-67

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT PENNSYLVANIAN MIDDLE ZONE (Pmz)
GROUNDWATER SAMPLES, ROUND 2 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)								
HMX	180	1/8	0.52	0.52	0.24 - 0.275	0.177	0.520	12GWT4802
RDX	0.61	1/8	4.2 J	4.2 J	0.24 - 0.275	0.637	4.20	12GWT4802
Total Metals (ug/L)								
ALUMINUM	3600	6/7	95.6 J	25700 J	50.2	5767	6723	12GWT4802
ARSENIC	0.045	7/7	0.17 J	9.6 J	---	3.97	3.97	12GWT4802
BARIUM	260	7/7	11.2 J	214 J	---	72.7	72.7	12GWT4802
CADMIUM	1.8	2/7	0.07 J	0.79 J	0.039 - 0.8	0.229	0.430	12GWT4502
CALCIUM	NA	7/7	12300 J	194000 J	---	62200	62200	12GWT3202
CHROMIUM	11	4/7	3.9 J	47.9 J	0.27 - 0.86	11.6	20.1	12GWT4802
COBALT	73	6/7	0.14 J	74.9 J	1.8	20.4	23.6	12GWT4802
COPPER	150	7/7	0.68 J	23.4 J	---	8.64	8.64	12GWT4802
IRON	1100	7/7	424 J	46200 J	---	12968	12968	12GWT4802
LEAD	15	6/7	0.089 J	24.7 J	1.8	6.60	7.55	12GWT4802
MAGNESIUM	NA	7/7	4080 J	121000 J	---	51511	51511	12GWT3202
MANGANESE	88	7/7	1.5 J	3270	---	1126	1126	12GWT4602
MERCURY	1.1	1/7	0.057 J	0.057 J	0.03	0.0210	0.0570	12GWT4802
NICKEL	73	7/7	5.1	178	---	55.2	55.2	12GWT4502
POTASSIUM	NA	7/7	1380 J	11200 J	---	4603	4603	12GWT3202
SELENIUM	18	5/7	0.98 J	1.9 J	0.54 - 0.84	0.966	1.21	12GWT4602
SODIUM	NA	7/7	13100 J	143000 J	---	57429	57429	12GWT2902
THALLIUM	0.24	1/7	0.06 J	0.06 J	0.043 - 0.5	0.0754	0.0600	12GWT4502
TIN	2200	1/7	0.08 J	0.08 J	0.048 - 1.6	0.250	0.0800	12GWT4502
VANADIUM	3.6	4/7	3.4	38	1.14	9.52	16.2	12GWT4802
ZINC	1100	7/7	2.5 J	262	---	71.5	71.5	12GWT4502
Dissolved Metals (ug/L)								
ALUMINUM	3600	2/6	9.1 J	210 J	9.6 - 19	40.6	110	12GWT4502-F
ARSENIC	0.045	4/6	0.15 J	3 J	0.28 - 1.6	1.18	1.54	12GWT3102-F
BARIUM	260	6/6	11.2 J	43.4 J	---	30.4	30.4	12GWT3102-F
CADMIUM	1.8	2/6	0.06 J	0.75 J	0.039 - 0.17	0.161	0.405	12GWT4502-F
CALCIUM	NA	6/6	12600 J	234000 J	---	67317	67317	12GWT3202-F
COBALT	73	3/6	10.5	23.3	0.13 - 0.98	7.76	15.2	12GWT4602-F
COPPER	150	2/6	1.3 J	2.3	0.16 - 0.33	0.682	1.80	12GWT4502-F
IRON	1100	2/6	859 J	1000 J	6.2 - 104	321	930	12GWT4602-F
LEAD	15	2/6	0.181 J	0.315 J	0.26 - 0.45	0.188	0.248	12GWT4502-F
MAGNESIUM	NA	6/6	3650 J	126000 J	---	49458	49458	12GWT3202-F
MANGANESE	88	5/6	27.2 J	3300	25.4	976	1168	12GWT4602-F
NICKEL	73	4/6	9.9	178	0.68 - 2.1	38.7	57.8	12GWT4502-F
POTASSIUM,	NA	6/6	908 J	10800 J	---	3951	3951	12GWT3202-F
SELENIUM	18	2/6	0.99 J	1.6 J	0.17 - 0.41	0.516	1.30	12GWT4602-F
SODIUM	NA	6/6	15000 J	165000 J	---	70117	70117	12GWT2902-F
THALLIUM	0.24	1/6	0.06 J	0.06 J	0.043 - 0.13	0.0363	0.0600	12GWT4502-F
ZINC	1100	3/6	4.7 J	234	3.1 - 6.4	43.8	85.0	12GWT4502-F

TABLE 3-68

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT PENNSYLVANIAN LOWER AND MISSISSIPPIAN GLEN DEAN ZONE (PlzMgd)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)								
2,4,6-TRINITROTOLUENE	1.8	1/5	4.2	4.2	0.24 - 0.266	0.942	4.20	12GWT4401
4-AMINO-2,6-DINITROTOLUENE	0.73	1/5	0.65	0.65	0.24 - 0.266	0.232	0.650	12GWT4401
HMX	180	1/5	0.28 J	0.28 J	0.24 - 0.266	0.158	0.280	12GWT4401
RDX	0.61	1/5	3.9	3.9	0.24 - 0.266	0.882	3.90	12GWT4401
Total Metals (ug/L)								
ALUMINUM	3600	3/5	165 J	2540 J	8.35 - 55.4	623	1027	12GWT4901
ANTIMONY	1.5	1/5	3.1 J	3.1 J	0.085 - 0.9	0.736	3.10	12GWT4101
ARSENIC	0.045	4/5	1.7 J	9.5 J	2.1	3.81	4.50	12GWT4102
BARIUM	260	4/5	24.8 J	79.3 J	20.5	42.8	50.9	12GWT4901
CALCIUM	NA	5/5	106000 J	201000 J	---	147000	147000	12GWT4402
CHROMIUM	11	1/5	6.6 J	6.6 J	0.58 - 2	1.77	6.60	12GWT4901
COBALT	73	4/5	5.3 J	14.7 J	1.2	8.28	10.2	12GWT4402
COPPER	150	4/5	1.2 J	6.4 J	1.4	3.24	3.88	12GWT4901
IRON	1100	5/5	914 J	7150 J	---	3847	3847	12GWT4901
LEAD	15	2/5	0.53 J	10.5 J	0.069 - 0.35	2.28	5.52	12GWT4901
MAGNESIUM	NA	5/5	13000 J	171000 J	---	84520	84520	12GWT4402
MANGANESE	88	5/5	531	2190 J	---	1259	1259	12GWT4402
NICKEL	73	5/5	6.3 J	44.2 J	---	25.6	25.6	12GWT4401
POTASSIUM	NA	5/5	2550 J	9660 J	---	5896	5896	12GWT4402
SELENIUM	18	4/5	1.2 J	2 J	0.77	1.22	1.43	12GWT4401
SODIUM	NA	5/5	6380 J	158000 J	---	60876	60876	12GWT4401
TIN	2200	1/5	4.2 J	4.2 J	0.1 - 0.73	0.985	4.20	12GWT4901
VANADIUM	3.6	1/5	4.9	4.9	1.14	1.44	4.90	12GWT4901
ZINC	1100	4/5	9.1 J	40 J	7.5	14.6	17.3	12GWT4901
Dissolved Metals (ug/L)								
ARSENIC	0.045	1/2	1.8 J	1.8 J	0.6	1.05	1.80	12GWT4401-F
BARIUM	260	2/2	56.4 J	65 J	---	60.7	60.7	12GWT4901-F
CALCIUM	NA	2/2	150000 J	168000 J	---	159000	159000	12GWT4901-F
COBALT	73	2/2	5.5 J	15.5	---	10.5	10.5	12GWT4401-F
COPPER	150	1/2	3.6 J	3.6 J	0.3	1.88	3.60	12GWT4401-F
IRON	1100	1/2	1130 J	1130 J	10.6	568	1130	12GWT4401-F
MAGNESIUM	NA	2/2	14600 J	112000 J	---	63300	63300	12GWT4401-F
MANGANESE	88	2/2	580 J	1240 J	---	910	910	12GWT4901-F
NICKEL	73	2/2	21.8 J	73.9 J	---	47.9	47.9	12GWT4401-F
POTASSIUM	NA	2/2	2260 J	7940 J	---	5100	5100	12GWT4401-F
SELENIUM	18	1/2	1.9 J	1.9 J	0.45	1.06	1.90	12GWT4401-F
SODIUM	NA	2/2	8390 J	172000 J	---	90195	90195	12GWT4401-F
TIN	2200	1/2	1 J	1 J	1.6	0.900	1.00	12GWT4401-F
ZINC	1100	1/2	8 J	8 J	7.1	5.78	8.00	12GWT4401-F

TABLE 3-69

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT PENNSYLVANIAN LOWER AND MISSISSIPPIAN GLEN DEAN ZONE (Plz/Mgd)
GROUNDWATER SAMPLES, ROUND 1 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Energetics (ug/L)								
2,4,6-TRINITROTOLUENE	1.8	1/2	4.2	4.2	0.266	2.17	4.20	12GWT4401
4-AMINO-2,6-DINITROTOLUENE	0.73	1/2	0.65	0.65	0.266	0.392	0.650	12GWT4401
HMX	180	1/2	0.28 J	0.28 J	0.266	0.207	0.280	12GWT4401
RDX	0.61	1/2	3.9	3.9	0.266	2.02	3.90	12GWT4401
Total Metals (ug/L)								
ALUMINUM	3600	1/2	377 J	377 J	55.4	202	377	12GWT4401
ANTIMONY	1.5	1/2	3.1 J	3.1 J	0.9	1.78	3.10	12GWT4101
ARSENIC	0.045	2/2	1.7 J	3.8 J	---	2.75	2.75	12GWT4101
BARIUM	260	2/2	24.8 J	63.4 J	---	44.1	44.1	12GWT4401
CALCIUM	NA	2/2	136000	138000	---	137000	137000	12GWT4401
COBALT	73	2/2	5.3 J	12.1 J	---	8.70	8.70	12GWT4401
COPPER	150	2/2	1.2 J	3.8 J	---	2.50	2.50	12GWT4401
IRON	1100	2/2	914 J	2290 J	---	1602	1602	12GWT4401
LEAD	15	1/2	0.53 J	0.53 J	0.35	0.353	0.530	12GWT4401
MAGNESIUM	NA	2/2	77700 J	101000 J	---	89350	89350	12GWT4401
MANGANESE	88	2/2	531	1220	---	876	876	12GWT4101
NICKEL	73	2/2	17.9 J	44.2 J	---	31.1	31.1	12GWT4401
POTASSIUM	NA	2/2	5510 J	7530 J	---	6520	6520	12GWT4401
SELENIUM	18	2/2	1.3 J	2 J	---	1.65	1.65	12GWT4401
SODIUM	NA	2/2	69000 J	158000 J	---	113500	113500	12GWT4401
ZINC	1100	1/2	9.1 J	9.1 J	7.5	6.43	9.10	12GWT4401
Dissolved Metals (ug/L)								
ARSENIC	0.045	1/1	1.8 J	1.8 J	---	1.80	1.80	12GWT4401-F
BARIUM	260	1/1	56.4 J	56.4 J	---	56.4	56.4	12GWT4401-F
CALCIUM	NA	1/1	150000 J	150000 J	---	150000	150000	12GWT4401-F
COBALT	73	1/1	15.5	15.5	---	15.5	15.5	12GWT4401-F
COPPER	150	1/1	3.6 J	3.6 J	---	3.60	3.60	12GWT4401-F
IRON	1100	1/1	1130 J	1130 J	---	1130	1130	12GWT4401-F
MAGNESIUM	NA	1/1	112000 J	112000 J	---	112000	112000	12GWT4401-F
MANGANESE	88	1/1	580 J	580 J	---	580	580	12GWT4401-F
NICKEL	73	1/1	73.9 J	73.9 J	---	73.9	73.9	12GWT4401-F
POTASSIUM	NA	1/1	7940 J	7940 J	---	7940	7940	12GWT4401-F
SELENIUM	18	1/1	1.9 J	1.9 J	---	1.90	1.90	12GWT4401-F
SODIUM	NA	1/1	172000 J	172000 J	---	172000	172000	12GWT4401-F
TIN	2200	1/1	1 J	1 J	---	1.00	1.00	12GWT4401-F
ZINC	1100	1/1	8 J	8 J	---	8.00	8.00	12GWT4401-F
Field Parameters								
DISSOLVED OXYGEN (mg/L)	NA	2/2	2.8	3.62	---	3.21	3.21	12GWT4401
OXIDATION-REDUCTION POTENTIAL (MV)	NA	2/2	71	92	---	81.5	81.5	12GWT4401
PH (S.U.)	NA	2/2	6.85	6.94	---	6.90	6.90	12GWT4401
SPECIFIC CONDUCTANCE (MS/CM)	NA	2/2	0.922	1.475	---	1.20	1.20	12GWT4401
TEMPERATURE (°C)	NA	2/2	14.12	15.27	---	14.7	14.7	12GWT4401
TURBIDITY (NTU)	NA	2/2	4	44	---	24.0	24.0	12GWT4401

TABLE 3-70

DESCRIPTIVE STATISTICS FOR DOWNGRADIENT PENNSYLVANIAN LOWER AND MISSISSIPPIAN GLEN DEAN ZONE (Plz/Mgd)
GROUNDWATER SAMPLES, ROUND 2 ONLY
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Parameter	HHRA CRITERIA	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection
Total Metals (ug/L)								
ALUMINUM	3600	2/3	165 J	2540 J	8.35	903	1353	12GWT4901
ARSENIC	0.045	2/3	3 J	9.5 J	2.1	4.52	6.25	12GWT4102
BARIUM	260	2/3	36 J	79.3 J	20.5	41.9	57.7	12GWT4901
CALCIUM	NA	3/3	106000 J	201000 J	---	153667	153667	12GWT4402
CHROMIUM	11	1/3	6.6 J	6.6 J	0.58 - 1.3	2.51	6.60	12GWT4901
COBALT	73	2/3	8.7 J	14.7 J	1.2	8.00	11.7	12GWT4402
COPPER	150	2/3	4.1 J	6.4 J	1.4	3.73	5.25	12GWT4901
IRON	1100	3/3	2900 J	7150 J	---	5343	5343	12GWT4901
LEAD	15	1/3	10.5 J	10.5 J	0.069 - 0.295	3.56	10.5	12GWT4901
MAGNESIUM	NA	3/3	13000 J	171000 J	---	81300	81300	12GWT4402
MANGANESE	88	3/3	885 J	2190 J	---	1515	1515	12GWT4402
NICKEL	73	3/3	6.3 J	37 J	---	22.0	22.0	12GWT4901
POTASSIUM	NA	3/3	2550 J	9660 J	---	5480	5480	12GWT4402
SELENIUM	18	2/3	1.2 J	1.2 J	0.77	0.928	1.20	12GWT4402, 12GWT4901
SODIUM	NA	3/3	6380 J	54200 J	---	25793	25793	12GWT4102
TIN	2200	1/3	4.2 J	4.2 J	0.1 - 0.36	1.48	4.20	12GWT4901
VANADIUM	3.6	1/3	4.9	4.9	1.14	2.01	4.90	12GWT4901
ZINC	1100	3/3	10 J	40 J	---	20.0	20.0	12GWT4901
Dissolved Metals (ug/L)								
BARIUM	260	1/1	65 J	65 J	---	65.0	65.0	12GWT4901-F
CALCIUM	NA	1/1	168000 J	168000 J	---	168000	168000	12GWT4901-F
COBALT	73	1/1	5.5 J	5.5 J	---	5.50	5.50	12GWT4901-F
MAGNESIUM	NA	1/1	14600 J	14600 J	---	14600	14600	12GWT4901-F
MANGANESE	88	1/1	1240 J	1240 J	---	1240	1240	12GWT4901-F
NICKEL	73	1/1	21.8 J	21.8 J	---	21.8	21.8	12GWT4901-F
POTASSIUM	NA	1/1	2260 J	2260 J	---	2260	2260	12GWT4901-F
SODIUM	NA	1/1	8390 J	8390 J	---	8390	8390	12GWT4901-F
Field Parameters								
DISSOLVED OXYGEN (mg/L)	NA	3/3	1.24	2.92	---	1.81	1.81	12GWT4901
OXIDATION-REDUCTION POTENTIAL (MV)	NA	3/3	-60	188	---	29.7	29.7	12GWT4901
PH (S.U.)	NA	3/3	6.73	6.78	---	6.76	6.76	12GWT4102,
SPECIFIC CONDUCTANCE (MS/CM)	NA	3/3	0.652	1.668	---	1.02	1.02	12GWT4402
TEMPERATURE (°C)	NA	3/3	8.99	13.87	---	11.0	11.0	12GWT4901
TURBIDITY (NTU)	NA	3/3	3.6	380	---	133	133	12GWT4901
Miscellaneous Parameters (mg/L)								
AMMONIA-N	NA	3/3	0.32	0.5 J	---	0.427	0.427	12GWT4402

Data qualifiers (e.g., U, J) are defined in Appendix H.
HHRA - Human health risk assessment.
Plz - Pennsylvania Lower Water Bearing Zone.
Mgd - Mississippi Glen Dean Zone.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
MV - millivolts.
S.U. - standard units.
MS/CM - milliSiemens per centimeter.
C - Celsius.
NTU - nephelometric turbidity units.
NA - No applicable criterion.

TABLE 3-71

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT PENNSYLVANIAN UPPER ZONE (Puz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		01	02	01	02	01	02	01	02	01	02	01
LOCATION	HHRA	12MWT01	12MWT01	12MWT02	12MWT02	12MWT03	12MWT03	12MWT04	12MWT04	12MWT05	12MWT05	12MWT06
SAMPLE NUMBER	CRITERIA	12GWT0101	12GWT0102	12GWT0201	12GWT0202	12GWT0301	12GWT0302	12GWT0401	12GWT0402	12GWT0501	12GWT0502	12GWT0601
SAMPLE CODE		ORIG	NORMAL	NORMAL	ORIG	NORMAL	NORMAL	NORMAL	ORIG	NORMAL	NORMAL	NORMAL
SAMPLE DATE		9/11/2004	2/6/2005	9/12/2004	2/17/2005	9/27/2004	3/3/2005	9/28/2004	3/3/2005	9/14/2004	2/3/2005	9/14/2004
Energetics (ug/L)												
1,3,5-TRINITROBENZENE	110	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.258 U	16
1,3-DINITROBENZENE	0.36	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.258 U	8
2,4,6-TRINITROTOLUENE	1.8	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.258 U	160
2,4-DIAMINO-6-NITROTOLUENE	NA	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.258 U	4.9 J
2,4-DINITROTOLUENE	7.3	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.258 U	2.4 J
2,6-DINITROTOLUENE	3.6	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.258 U	9.8 J
2-AMINO-4,6-DINITROTOLUENE	0.73	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.258 U	32 J
2-NITROTOLUENE	0.049	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.258 U	0.255 U
3,5-DINITROANILINE	NA	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.258 U	4.6
3-NITROTOLUENE	12	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.258 U	0.255 U
4-AMINO-2,6-DINITROTOLUENE	0.73	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.258 U	34
4-NITROTOLUENE	0.66	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.258 U	0.255 U
DNX	NA	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.258 U	1.6 J
HMX	180	0.25 U	0.24 U	0.68	0.45 J	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.32 J	400
MNX	NA	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.33 J	0.264 U	0.258 U	23
RDX	0.61	0.25 U	0.24 U	3.4 J	1.2	0.27 U	0.284 U	0.252 U	2.7	0.264 U	2.4	6300 J
TNX	NA	0.25 U	0.24 U	0.25 U	0.264 U	0.27 U	0.284 U	0.252 U	0.284 U	0.264 U	0.258 U	0.255 U
Total Metals (ug/L)												
ALUMINUM	3600	1550 J	2620 J	4130 J	4040 J	162 J	153 J	36.1 U	21.2 U	4540 J	3450 J	34 U
ANTIMONY	1.5	0.12 U	0.085 U	0.085 U	0.085 U	0.51 U	0.085 U	0.085 UJ	0.085 U	0.085 U	0.085 U	0.085 U
ARSENIC	0.045	66 J	37.7 J	22.7 J	9.1 J	2.6 J	1.3	1.1 J	0.97 J	91.2 J	16.8 J	0.14 U
BARIUM	260	10.8 J	9.1 J	24.5 J	18.8 U	20.5 J	15.6 J	9.1 J	9.5 J	24.8 J	16.5 J	50.9 J
BERYLLIUM	4	1.6 J	2 U	2.3 J	2.2 J	0.18 U	0.17 U	0.14 J	0.13 U	1.8 J	1.5 U	0.11 U
CADMIUM	1.8	0.39 U	0.28 U	4.9 J	2.5 J	0.1 U	0.11 J	0.14 J	0.04 J	7.7 J	1.8 U	0.22 U
CALCIUM	NA	127000 J	118000 J	10400 J	13300 J	129000 J	144000	149000	141000	28500 J	24500 J	17400 J
CHROMIUM	11	1.1 J	1.1 U	3.3 J	2.5 J	0.67 U	0.42 U	0.43 U	0.22 U	2.7 J	1.6 U	0.42 U
COBALT	73	95.1 J	64.2 J	66.9 J	56.5 J	16.4 J	12.4	20.1	18.5	138 J	64.3 J	25.2 J
COPPER	150	0.17 U	2.2 J	0.56 U	1.1 U	0.35 U	1.9 J	1.6 J	1.7 J	2.9 J	0.69 U	1.1 J
IRON	1100	77400 J	80800 J	10000 J	10100 J	14300 J	18000 J	36100	37100 J	22100 J	19800 J	14.5 U
LEAD	15	9 J	3.6 U	12.8 J	11.3 J	0.26 U	0.296 J	0.07 J	0.069 U	51.2 J	22.7 J	0.2 U
MAGNESIUM	NA	96700 J	92200 J	10400 J	7850 J	118000 J	117000	130000	112000	26400 J	20420 J	11600 J
MANGANESE	88	4310 J	4360 J	1180 J	1220 J	3440 J	3440	5110	4760	1700 J	1420 J	80.8 J
MERCURY	1.1	0.03 UJ	0.03 U	0.03 UJ	0.056 U	0.04 U	0.03 U	0.03 U	0.03 U	0.03 UJ	0.03 U	1.2 J
NICKEL	73	394 J	250 J	124 J	109 J	55.3 J	39.6	54.2 J	49.9	235 J	117 J	41.5 J
POTASSIUM	NA	3110 J	3330 J	1390 J	1730 J	3130 J	3260 J	2710 J	2560 J	2230 J	1640 J	1220 J
SELENIUM	18	0.14 U	0.85 U	0.094 U	0.57 U	0.19 U	3.2 J	2.3 J	3.1 J	0.14 U	0.53 U	0.17 U
SODIUM	NA	69300 J	60700 J	12800 J	13200 J	102000 J	82100 J	83500 J	68200 J	31700 J	19400 J	31200 J
THALLIUM	0.24	0.1 U	0.09 U	0.58 U	0.46 U	0.043 U	0.06 J	0.043 U	0.06 J	0.67 J	0.71 U	0.07 U
TIN	2200	0.048 U	0.048 U	0.05 U	0.14 U	0.11 U	0.37 J	0.048 U	0.048 U	0.048 U	0.048 U	0.048 U
VANADIUM	3.6	1.4 J	1.8 J	4.6	2.1	1.14 U	1.14 U	1.14 U	1.14 U	5.8	3	1.14 U
ZINC	1100	192 J	281 J	254 J	199	20.7 J	23.5 J	60.2 J	52.6 J	237 J	189 J	43.9 J

TABLE 3-71

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT PENNSYLVANIAN UPPER ZONE (Puz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA CRITERIA	02	01	02	01	02	01	02	01	02	01	02
LOCATION		12MWT06	12MWT07	12MWT07	12MWT08	12MWT08	12MWT09	12MWT09	12MWT10	12MWT10	12MWT11	12MWT11
SAMPLE NUMBER		12GWT0602	12GWT0701	12GWT0702	12GWT0801	12GWT0802	12GWT0901	12GWT0902	12GWT1001	12GWT1002	12GWT1101	12GWT1102
SAMPLE CODE		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE		2/21/2005	9/9/2004	2/21/2005	8/30/2004	2/21/2005	9/10/2004	3/2/2005	9/25/2004	2/7/2005	9/13/2004	2/22/2005
Energetics (ug/L)												
1,3,5-TRINITROBENZENE	110	19	0.242 U	0.264 U	0.275 U	0.24 U	0.264 U	0.271 U	0.27 U	0.264 U	110	110
1,3-DINITROBENZENE	0.36	8.9	0.242 U	0.264 U	0.275 U	0.24 U	0.264 U	0.271 U	0.27 U	0.264 U	4	6.3
2,4,6-TRINITROTOLUENE	1.8	170	0.242 U	0.264 U	0.275 U	0.24 U	0.264 U	0.271 U	0.27 U	0.264 U	110	110
2,4-DIAMINO-6-NITROTOLUENE	NA	7.8 J	0.242 U	0.264 U	0.275 U	0.42 J	0.264 U	0.271 U	0.27 U	0.264 U	69 J	75 J
2,4-DINITROTOLUENE	7.3	0.24 U	0.242 U	0.264 U	0.275 U	0.24 U	0.264 U	0.271 U	0.27 U	0.264 U	2.8 J	0.24 U
2,6-DINITROTOLUENE	3.6	0.24 U	0.242 U	0.264 U	0.35 J	0.27 J	0.264 U	0.34 J	0.27 U	0.264 U	8.1 J	0.24 U
2-AMINO-4,6-DINITROTOLUENE	0.73	40 J	0.242 U	0.264 U	5.1 J	3.7 J	5.4 J	4 J	0.27 U	0.264 U	39 J	31 J
2-NITROTOLUENE	0.049	0.24 U	0.242 U	0.264 U	0.275 U	0.24 U	0.264 U	0.271 U	0.27 U	0.264 U	0.45 J	0.24 U
3,5-DINITROANILINE	NA	9.4	0.242 U	0.264 U	0.275 U	0.24 U	0.264 U	0.271 U	0.27 U	0.264 U	11	12 J
3-NITROTOLUENE	12	0.24 U	0.242 U	0.264 U	0.275 U	0.24 U	0.264 U	0.271 U	0.27 U	0.264 U	0.266 U	0.24 U
4-AMINO-2,6-DINITROTOLUENE	0.73	53	0.242 U	0.264 U	4.4	3.3	7.3	5.2	0.27 U	0.264 U	78 J	43
4-NITROTOLUENE	0.66	5.8 J	0.242 U	0.264 U	0.275 U	0.24 U	0.264 U	0.271 U	0.27 U	0.264 U	0.266 U	0.24 U
DNX	NA	1.9 J	0.242 U	0.264 U	0.275 U	0.24 U	0.264 U	0.271 U	0.27 U	0.264 U	0.266 U	1.9 J
HMX	180	530	0.242 U	1.1 J	61	58	65	64	6.6	7.6 J	490	530
MNX	NA	30	0.242 U	0.264 U	0.5 J	0.38 J	0.264 U	0.33 J	0.39 J	0.33 J	10 J	2.4 J
RDX	0.61	7200	17 J	13	360	340	480 J	510	22	30	3900 J	4900
TNX	NA	0.74 J	0.242 U	0.264 U	0.275 U	0.24 U	0.264 U	0.271 U	0.27 U	0.264 U	0.266 U	11 J
Total Metals (ug/L)												
ALUMINUM	3600	27.6 J	56300 J	39500 J	452 J	388 J	1280 J	745 J	1950 J	2460 J	2280 J	2550 J
ANTIMONY	1.5	0.085 U	0.61 U	0.085 U	0.085 U	0.085 U	0.085 U	0.085 U	0.085 U	0.085 U	0.085 U	0.085 U
ARSENIC	0.045	0.34 U	11.6 J	2.4 J	0.63 U	0.21 U	0.57 U	0.17 J	0.92 J	0.38 U	0.76 U	0.48 U
BARIUM	260	73.7 J	13.3 J	9 U	69.6 J	25.5 J	37.7 J	25.7 J	25.6 J	11.7 J	36.2 J	32.6 J
BERYLLIUM	4	0.14 U	28.4 J	29.4 J	1.5 U	1.3 J	2.4 J	1.9 J	3.7 J	3.2 U	2.9 J	2.4 U
CADMIUM	1.8	0.48 U	16.5 J	11.9 J	1.2 U	1.1 J	0.64 U	0.62 J	1.3 J	0.99 U	0.63 U	0.57 U
CALCIUM	NA	28500 J	396000 J	589000 J	30400 J	22000 J	25400 J	21100	43700 J	39200 J	11100 J	12300 J
CHROMIUM	11	0.63 U	5.2 J	3.4 J	1.3 U	0.6 U	0.75 J	0.72 U	1.3 J	1.1 U	0.84 J	0.14 U
COBALT	73	30.9 J	1680 J	3160 J	95.2 J	87.5 J	111 J	89.3	226 J	225 J	115 J	112 J
COPPER	150	1.7 J	29.4 J	39.4 J	3.1 J	3.2 J	4.5 J	3.5	27.5 J	32 J	2.7 J	1.9 J
IRON	1100	134 J	14300 J	136000 J	144 U	103 U	356 J	266 J	2860 J	4510 J	728 J	612 J
LEAD	15	0.252 U	18.3 J	15.8 J	1 U	2.1 J	3.7 J	2.8	3 J	6.3 J	0.38 U	0.25 U
MAGNESIUM	NA	18800 J	342000 J	1160000 J	25500 J	18300 J	19000 J	14300	34900 J	35100 J	13000 J	15300 J
MANGANESE	88	91.5 J	8360 J	46600 J	837 J	580 J	294 J	238	787 J	494 J	5250 J	4610 J
MERCURY	1.1	7.3	0.03 UJ	0.03 U	0.06 U	0.03 U	0.73 J	0.88	0.03 U	0.03 U	0.87 J	1.2 J
NICKEL	73	54 J	3800 J	6010 J	242 J	183 J	210 J	172	398 J	350 J	115 J	107 J
POTASSIUM	NA	1290 J	6480 J	6470 J	2200 J	1570 J	917 J	774 J	1080 J	413 J	1280 J	1170 J
SELENIUM	18	1.1 J	3.6 J	7.1 J	0.094 U	0.61 U	0.17 U	0.78 J	0.26 U	1.1 J	0.15 U	0.1 U
SODIUM	NA	31400 J	308000 J	789000 J	45600 J	31900 J	34300 J	25900 J	79500 J	70100 J	11300 J	12600 J
THALLIUM	0.24	0.22 U	0.85 J	1.5 J	0.16 U	0.24 U	0.21 U	0.14 J	0.043 U	0.22 U	0.043 U	0.14 U
TIN	2200	0.17 U	0.59 U	0.12 U	0.18 U	0.2 U	0.048 U	0.048 U	0.048 U	0.048 U	0.048 U	0.048 U
VANADIUM	3.6	1.14 U	1.14 U	1.14 U	1.14 U	1.14 U	1.14 U	1.14 U	1.14 U	1.14 U	1.14 U	1.14 U
ZINC	1100	55.2 J	5560 J	9880 J	134 J	113 J	147 J	141	736 J	1020 J	177 J	280 J

TABLE 3-71

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT PENNSYLVANIAN UPPER ZONE (Puz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA CRITERIA	01	02	01	02	01	01	02	02	01	02	01
LOCATION		12MWT12	12MWT12	12MWT13	12MWT13	12MWT14	12MWT14	12MWT14	12MWT14	12MWT15	12MWT15	12MWT16
SAMPLE NUMBER		12GWT1201	12GWT1202	12GWT1301	12GWT1302	12GWT1401	12GWT1401-F	12GWT1402	12GWT1402-F	12GWT1501	12GWT1502	12GWT1601
SAMPLE CODE		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE		9/14/2004	2/22/2005	8/30/2004	3/4/2005	9/25/2004	9/24/2004	3/2/2005	3/2/2005	9/27/2004	2/8/2005	9/12/2004
Energetics (ug/L)												
1,3,5-TRINITROBENZENE	110	0.26 U	0.24 U	0.266 U	0.278 U	0.27 U		0.305 U		0.25 U	0.238 U	1.1 J
1,3-DINITROBENZENE	0.36	0.26 U	0.24 U	0.266 U	0.278 U	0.27 U		0.305 U		0.25 U	0.238 U	0.271 U
2,4,6-TRINITROTOLUENE	1.8	1.4	2.9	0.266 U	0.278 U	0.27 U		0.305 U		0.25 U	0.238 U	0.271 U
2,4-DIAMINO-6-NITROTOLUENE	NA	0.67 J	0.24 U	0.266 U	0.278 U	0.27 U		0.305 U		0.25 U	0.238 U	1.6 J
2,4-DINITROTOLUENE	7.3	0.26 U	0.24 U	0.266 U	0.278 U	0.27 U		0.305 U		0.25 U	0.238 U	0.271 U
2,6-DINITROTOLUENE	3.6	0.29 J	0.24 U	0.266 U	0.278 U	0.27 U		0.305 U		0.25 U	0.238 U	1.8
2-AMINO-4,6-DINITROTOLUENE	0.73	6.1 J	5.3 J	0.61 J	0.47 J	0.27 U		0.305 U		0.25 U	0.238 U	76
2-NITROTOLUENE	0.049	0.26 U	0.24 U	0.266 U	0.278 U	0.3 J		0.305 U		0.25 U	0.238 U	0.271 U
3,5-DINITROANILINE	NA	0.91 J	0.92 J	0.266 U	0.278 U	0.27 U		0.305 U		0.25 U	0.238 U	0.271 U
3-NITROTOLUENE	12	0.26 U	1.6 J	1.7 J	0.88 J	0.27 U		0.305 U		0.25 U	0.238 U	0.68 J
4-AMINO-2,6-DINITROTOLUENE	0.73	6.9	6.4	0.266 U	0.51 J	0.27 U		0.305 U		0.25 U	0.238 U	160
4-NITROTOLUENE	0.66	0.26 U	0.24 U	0.266 U	0.278 U	0.27 U		0.305 U		0.25 U	0.238 U	0.271 U
DNX	NA	1.3 J	0.36 J	0.266 U	0.278 U	0.27 U		0.305 U		0.25 U	0.238 U	22
HMX	180	120	89 J	13	14 J	0.27 U		0.305 U		0.25 U	0.238 U	370
MNX	NA	7.8	4.8	0.266 U	0.53 J	0.27 U		0.305 U		0.25 U	0.238 U	250
RDX	0.61	480 J	380	87	79	0.27 U		0.305 U		0.25 U	0.238 U	6300 J
TNX	NA	0.26 U	0.54 J	0.266 U	0.278 U	0.27 U		0.305 U		0.25 U	0.238 U	7.8
Total Metals (ug/L)												
ALUMINUM	3600	9.4 U	24.4 U	293 J	172 U	8830 J		928 J		128 U	793 J	615 J
ANTIMONY	1.5	0.085 U	0.51 U	0.66 U	0.085 U	0.21 U		0.085 U		0.085 U	0.085 U	0.15 U
ARSENIC	0.045	0.34 U	0.65 U	2.2 J	0.76 J	8.3 J		1.2		1.6 J	1.2 U	0.79 U
BARIUM	260	139 J	174 J	24.2 J	24 J	140 J		19.8 J		16 J	10.4 J	51.5 J
BERYLLIUM	4	0.02 UJ	0.26 U	0.65 U	0.14 J	1.6 J		1.3 J		0.68 U	6.4 J	0.19 U
CADMIUM	1.8	0.06 U	0.039 UJ	0.47 U	0.039 U	1.6 J		0.67 J		3.5 J	3.4 U	0.66 U
CALCIUM	NA	66400 J	83500 J	3180 J	3190 J	278000 J		274000		175000 J	213000 J	81200 J
CHROMIUM	11	0.57 U	0.2 U	1.1 U	0.8 U	25.6 J		2.4 J		0.85 J	0.68 U	1.3 J
COBALT	73	5.5 J	9.1 J	6.7 J	5.4 J	504 J		474		248 J	377 J	62 J
COPPER	150	1.2 J	2.3 J	1.4 J	1 J	16.9 J		7		1.1 J	9.4 J	1.6 J
IRON	1100	45.3 U	1230 J	13000 J	9260 J	108000 J		54400 J		1500 J	1670 J	946 J
LEAD	15	0.069 U	0.47 U	0.98 U	0.3 J	18.4 J		2.8		0.59 U	1.7 U	1.1 J
MAGNESIUM	NA	40500 J	46300 J	2870 J	2530 J	209000 J		211000		123000 J	155000 J	47600 J
MANGANESE	88	409 J	609 J	41.8 U	31.6 J	22700 J		28000		2630 J	2950 J	480 J
MERCURY	1.1	3.4 J	0.88 J	0.066 U	0.03 U	0.036 U		0.03 U		0.057 U	0.03 U	0.03 UJ
NICKEL	73	8.9 J	12.6 J	16.6 J	10.6 J	1170 J		1160		602 J	868 J	116 J
POTASSIUM	NA	5220 J	12600 J	5080 J	5730 J	12800 J		11700 J		5740 J	7220 J	3620 J
SELENIUM	18	0.31 U	0.38 U	0.23 U	0.13 U	3 U		4.7 J		4.7 J	5.7 J	0.63 U
SODIUM	NA	50600 J	58400 J	37500 J	38200 J	190000 J		132000 J		213000 J	190000 J	57900 J
THALLIUM	0.24	0.043 U	0.29 U	0.78 U	0.29 J	0.21 U		0.16 J		0.12 U	0.33 U	0.07 U
TIN	2200	0.048 U	0.26 U	0.48 U	0.18 U	0.57 U		0.39 J		0.05 U	0.048 U	0.29 U
VANADIUM	3.6	1.14 U	1.14 U	1.14 U	1.14 U	19.8		1.4 J		1.14 U	1.14 U	1.14 U
ZINC	1100	3.1 U	4.9 J	11.2 U	4.2 U	860 J		753		577 J	1280 J	128 J

TABLE 3-71

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT PENNSYLVANIAN UPPER ZONE (Puz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND	HHRA CRITERIA	01	02	02	01	01	02	02	01	02	02	01
LOCATION		12MWT16	12MWT16	12MWT16	12MWT17	12MWT17	12MWT17	12MWT17	12MWT18	12MWT18	12MWT18	12MWT19
SAMPLE NUMBER		12GWT1601-F	12GWT1602	12GWT1602-F	12GWT1701	12GWT1701-F	12GWT1702	12GWT1702-F	12GWT1801	12GWT1802	12GWT1802-F	12GWT1901
SAMPLE CODE		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE		9/12/2004	2/16/2005	2/16/2005	9/11/2004	9/11/2004	2/17/2005	2/17/2005	9/26/2004	3/3/2005	3/3/2005	9/25/2004
Energetics (ug/L)												
1,3,5-TRINITROBENZENE	110		1.3 J		0.66 J		0.82 J		0.27 U	0.25 U		0.271 U
1,3-DINITROBENZENE	0.36		0.245 U		0.43 J		0.34 J		0.27 U	0.28 J		0.271 U
2,4,6-TRINITROTOLUENE	1.8		8.2		0.255 UJ		2.3		0.27 U	0.25 U		0.271 U
2,4-DIAMINO-6-NITROTOLUENE	NA		1.8 J		0.57 J		1.4 J		0.27 U	0.25 U		0.271 U
2,4-DINITROTOLUENE	7.3		0.3 J		0.255 UJ		0.258 U		0.27 U	0.25 U		0.271 U
2,6-DINITROTOLUENE	3.6		1.7 J		0.82 J		1.6		0.27 U	0.25 U		0.271 U
2-AMINO-4,6-DINITROTOLUENE	0.73		100 J		14 J		30 J		0.27 U	0.25 U		0.271 U
2-NITROTOLUENE	0.049		0.245 U		0.255 UJ		0.258 U		0.27 U	0.25 U		0.271 U
3,5-DINITROANILINE	NA		5.8		0.78 J		1.6		0.27 U	0.25 U		0.271 U
3-NITROTOLUENE	12		0.245 U		0.255 UJ		0.258 U		0.27 U	0.25 U		0.271 U
4-AMINO-2,6-DINITROTOLUENE	0.73		190		25 J		43		0.27 U	0.25 U		0.271 U
4-NITROTOLUENE	0.66		0.245 U		0.255 UJ		0.258 U		0.27 U	0.25 U		0.271 U
DNX	NA		18		3.7 J		6.1		0.27 U	0.25 U		0.271 U
HMX	180		400		76 J		130		0.48 J	1 J		0.271 U
MNX	NA		200		44 J		79		0.27 U	0.25 U		0.271 U
RDX	0.61		7400		1600 J		2600		20	32		0.75
TNX	NA		6.2		1.3 J		2		0.27 U	0.25 U		0.271 U
Total Metals (ug/L)												
ALUMINUM	3600		1390 J		5410 J		1530 J		5330 J	9060 J		419 J
ANTIMONY	1.5		0.085 U		0.12 U		0.085 U		0.085 U	0.085 U		0.085 U
ARSENIC	0.045		0.78 U		3.7 J		1.3 U		2.5 J	0.93 J		0.77 U
BARIUM	260		52.5 J		45.1 J		37.2 J		18.5 J	7.9 J		26.7 J
BERYLLIUM	4		0.19 U		3.7 J		0.53 U		3.5 J	4.3 J		0.06 U
CADMIUM	1.8		0.13 U		3.9 J		1 J		5 J	6.7		0.23 U
CALCIUM	NA		33200 J		209000 J		69100 J		265000 J	292000		203000 J
CHROMIUM	11		2.1 J		2.1 J		1.7 U		1.2 J	0.78 U		1.5 J
COBALT	73		10.1 J		333 J		84.9 J		200 J	320		38.1 J
COPPER	150		3.4 J		4.9 J		5.3 J		5.2 J	8.6		2.5 J
IRON	1100		1360 J		1520 J		1290 J		116 U	2090 J		529 J
LEAD	15		1.6 U		6 J		2.5 J		5.2 J	8		1.2 J
MAGNESIUM	NA		31000 J		142000 J		50600 J		223000 J	210000		221000 J
MANGANESE	88		145 J		1850 J		635 J		1960 J	2420		1800 J
MERCURY	1.1		0.071 J		0.065 J		1.8 J		0.38 J	0.043 J		0.03 U
NICKEL	73		22.4 J		643 J		172 J		758 J	799		95.1 J
POTASSIUM	NA		2090 J		4570 J		3380 J		5290 J	5010 J		5290 J
SELENIUM	18		1.1 J		1.6 U		1.5 J		5.1 J	6.3 J		0.61 U
SODIUM	NA		30400 J		126000 J		81800 J		189000 J	157000 J		196000 J
THALLIUM	0.24		0.15 U		0.42 U		0.33 U		0.41 U	0.62 J		0.28 U
TIN	2200		0.25 U		0.13 U		0.32 U		0.14 U	0.048 U		0.42 U
VANADIUM	3.6		1.3 J		1.3 J		1.14 U		1.14 U	1.14 U		1.14 U
ZINC	1100		28.1 J		1030 J		254 J		1030 J	1190		24.7 J

TABLE 3-71

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT PENNSYLVANIAN UPPER ZONE (Puz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		02	02	01	02	01	02	01	02	01	02	01
LOCATION	HHRA	12MWT19	12MWT19	12MWT20	12MWT20	12MWT21	12MWT21	12MWT22	12MWT22	12MWT23	12MWT23	12MWT24
SAMPLE NUMBER	CRITERIA	12GWT1902	12GWT1902-F	12GWT2001	12GWT2002	12GWT2101	12GWT2102	12GWT2201	12GWT2202	12GWT2301	12GWT2302	12GWT2401
SAMPLE CODE		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DRY
SAMPLE DATE		2/18/2005	2/19/2005	9/27/2004	2/7/2005	10/9/2004	3/4/2005	10/10/2004	2/21/2005	9/10/2004	2/20/2005	9/23/2004
Energetics (ug/L)												
1,3,5-TRINITROBENZENE	110	0.252 U		0.245 U	0.238 U	0.266 U	0.264 U	2.6	0.24 U	0.258 U	0.24 U	
1,3-DINITROBENZENE	0.36	0.252 U		0.245 U	0.238 U	0.266 U	0.264 U	0.49 J	0.24 U	0.258 U	0.24 U	
2,4,6-TRINITROTOLUENE	1.8	0.252 U		0.245 U	0.238 U	0.266 U	0.264 U	96	0.26 J	0.258 U	0.24 U	
2,4-DIAMINO-6-NITROTOLUENE	NA	0.252 U		0.245 U	0.238 U	0.266 U	0.264 U	2.3 J	0.48 J	0.258 U	0.24 U	
2,4-DINITROTOLUENE	7.3	0.252 U		0.245 U	0.238 U	0.266 U	0.264 U	0.73	0.24 U	0.258 U	0.24 U	
2,6-DINITROTOLUENE	3.6	0.252 U		0.245 U	0.238 U	0.266 U	0.264 U	2	0.24 U	0.258 U	0.24 U	
2-AMINO-4,6-DINITROTOLUENE	0.73	0.252 U		0.245 U	0.238 U	0.266 U	0.264 U	5.9	0.24 U	0.258 U	0.24 U	
2-NITROTOLUENE	0.049	0.252 U		0.245 U	0.238 U	0.266 U	0.264 U	0.266 U	0.24 U	0.258 U	0.24 U	
3,5-DINITROANILINE	NA	0.252 U		0.245 U	0.238 U	0.266 U	0.264 U	0.63 J	0.24 U	0.258 U	0.24 U	
3-NITROTOLUENE	12	0.252 U		0.245 U	0.238 U	0.266 U	0.264 U	0.266 U	0.24 U	0.258 U	0.24 U	
4-AMINO-2,6-DINITROTOLUENE	0.73	0.252 U		0.245 U	0.238 U	0.266 U	0.264 U	9.6	0.62	0.258 U	0.24 U	
4-NITROTOLUENE	0.66	0.252 U		0.245 U	0.238 U	0.266 U	0.264 U	0.266 U	0.24 U	0.258 U	0.24 U	
DNX	NA	0.252 U		0.245 U	0.238 U	0.266 U	0.264 U	0.266 U	0.24 U	0.258 U	0.24 U	
HMX	180	0.252 U		0.245 U	0.238 U	12	22	32	5	0.258 U	0.24 U	
MNX	NA	0.252 U		0.245 U	0.238 U	0.34 J	0.264 U	0.81	0.43 J	0.258 U	0.24 U	
RDX	0.61	3		1.4	3.1	61	130	590	34	0.258 U	0.24 U	
TNX	NA	0.252 U		0.245 U	0.238 U	0.266 U	0.264 U	0.266 U	0.24 U	0.258 U	0.24 U	
Total Metals (ug/L)												
ALUMINUM	3600	336 J		2200 J	2790 J	1700	5250 J	172	361 J	146000 J	167000 J	
ANTIMONY	1.5	0.085 U		0.085 UJ	0.085 U	0.085 U	0.085 U	0.085 U	0.085 U	0.17 U	0.085 U	
ARSENIC	0.045	1.3 U		1.7 J	2 U	7.8 J	0.07 J	0.75 J	0.67 U	24.5 J	7 J	
BARIUM	260	18.7 U		16 J	13.5 J	22.3 J	19.9 J	32 J	27.9 J	13.1 J	16.1 U	
BERYLLIUM	4	0.07 U		2.2	2.5 U	2.3	2.5 J	0.11 J	0.05 U	97.4 J	88.9 J	
CADMIUM	1.8	1.4 J		3.5	2.8 U	0.45 J	0.53 J	0.45 J	0.27 U	67.2 J	83.4 J	
CALCIUM	NA	243000 J		294000	242000 J	19600 J	32900	12200 J	8900 J	393000 J	417000 J	
CHROMIUM	11	1.6 U		0.7 U	0.78 U	1.1 U	1.1 U	1.3 U	1.2 U	10.8 J	9.7 J	
COBALT	73	51.5 J		280	214 J	78.8 J	76.8	19.3 J	7.9 J	5460 J	6060 J	
COPPER	150	6.3 J		5.5	6.6 J	6.2 J	5.1	1.9 J	2.4 J	90.8 J	93.3 J	
IRON	1100	1440 J		1160	1280 J	16100 J	3210 J	236 J	268 J	29200 J	6550 J	
LEAD	15	0.967 U		2.2	2 U	4.5 J	2.7	0.39 U	0.477 U	31.5 J	104 J	
MAGNESIUM	NA	1140000 J		249000	239000 J	12600 J	14200	5050 J	5860 J	796000 J	995000 J	
MANGANESE	88	1790 J		2230	1770 J	2540 J	1780	351 J	81.1 J	65700 J	66700 J	
MERCURY	1.1	0.32 J		1.1 J	0.34	0.043 U	0.03 J	0.036 U	0.03 U	0.03 UJ	0.03 U	
NICKEL	73	166 J		657	470 J	141 J	132	50.3 J	21.5 J	14000 J	14600 J	
POTASSIUM	NA	6360 J		5410 J	5810 J	2230 J	1490 J	2830 J	1430 J	10200 J	8550 J	
SELENIUM	18	4.2 J		10.6 J	12.1 J	0.62 U	0.62 J	2.3 J	1.6 J	9.6 J	24.7 J	
SODIUM	NA	211000 J		6.79 U	212000 J	14700 J	15800 J	61200 J	307 U	366000 J	379000 J	
THALLIUM	0.24	0.49 U		0.34 J	0.69 U	0.11 J	0.11 J	0.11 J	0.09 U	1.5 J	6 J	
TIN	2200	0.56 U		0.28 J	0.21 U	0.08 U	0.048 U	0.4 U	0.32 U	0.09 U	0.63 U	
VANADIUM	3.6	1.14 U		1.14 U	1.14 U	1.14 U	1.14 U	1.14 U	1.14 U	1.14 U	1.14 U	
ZINC	1100	54.9 J		665 J	803 J	320 J	336	38.3 J	23.6 J	17500 J	18000	

TABLE 3-71

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT PENNSYLVANIAN UPPER ZONE (Puz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		02	01	02	01	02	01	01	02	01	02	01
LOCATION	HHRA	12MWT24	12MWT24A	12MWT24A	12MWT27	12MWT27	12MWT35	12MWT35	12MWT35	12MWT36	12MWT36	12MWT37
SAMPLE NUMBER	CRITERIA	12GWT2402	12GWT24A01	12GWT24A02	12GWT2701	12GWT2702	12GWT3501	12GWT3501-F	12GWT3502	12GWT3601	12GWT3602	12GWT3701
SAMPLE CODE		DRY	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	ORIG	NORMAL
SAMPLE DATE		2/16/2005	9/23/2004	2/16/2005	9/25/2004	2/7/2005	9/22/2004	9/22/2004	2/16/2005	9/24/2004	3/4/2005	9/26/2004
Energetics (ug/L)												
1,3,5-TRINITROBENZENE	110		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	0.252 U	0.24 U	0.275 U
1,3-DINITROBENZENE	0.36		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	0.252 U	0.24 U	0.275 U
2,4,6-TRINITROTOLUENE	1.8		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	0.252 U	0.24 U	0.275 U
2,4-DIAMINO-6-NITROTOLUENE	NA		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	0.252 U	0.24 U	0.275 U
2,4-DINITROTOLUENE	7.3		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	0.252 U	0.24 U	0.275 U
2,6-DINITROTOLUENE	3.6		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	0.252 U	0.24 U	0.275 U
2-AMINO-4,6-DINITROTOLUENE	0.73		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	0.252 U	0.24 U	0.275 U
2-NITROTOLUENE	0.049		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	0.252 U	0.24 U	0.275 U
3,5-DINITROANILINE	NA		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	0.252 U	0.24 U	0.275 U
3-NITROTOLUENE	12		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	0.252 U	0.24 U	0.275 U
4-AMINO-2,6-DINITROTOLUENE	0.73		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	0.252 U	0.26 J	0.275 U
4-NITROTOLUENE	0.66		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	0.252 U	0.24 U	0.275 U
DNX	NA		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	0.39 J	0.24 U	0.275 U
HMX	180		0.264 U	0.258 U	0.25 U	0.32 J	8.4		8.2	6.1	6.9	0.275 U
MNX	NA		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	1.1	1.1	0.275 U
RDX	0.61		2	2.7	0.91 J	0.81	9.2		6.5	41	42	0.275 U
TNX	NA		0.264 U	0.258 U	0.25 U	0.24 U	0.264 U		0.245 U	0.252 U	0.24 U	0.275 U
Total Metals (ug/L)												
ALUMINUM	3600		187000 J	190000 J	323 J	205 J	338 J		246 J	8.35 U	8.35 U	3140 J
ANTIMONY	1.5		1.7 J	0.085 U	0.22 U	0.1 U	0.15 U		0.085 U	0.085 U	0.085 U	0.17 U
ARSENIC	0.045		18.2 J	4.8 J	0.58 U	0.22 U	0.48 U		0.31 U	0.32 U	0.21 J	3.9 J
BARIUM	260		8.3 J	9.9 J	39.1 J	20.6 J	51.6 J		55.4 J	40.3 J	38.7 J	48.8 J
BERYLLIUM	4		90.3 J	64.3 J	0.03 U	0.02 U	0.44 U		1 U	0.02 U	0.02 U	0.32 U
CADMIUM	1.8		50.9 J	40.7 J	0.05 U	0.04 U	0.42 U		0.16 U	0.039 U	0.039 U	0.41 U
CALCIUM	NA		25300 U	427000 J	21200 J	16300 J	7170 J		2100 J	46900 J	51300	27800 J
CHROMIUM	11		4.6 J	4.6 J	1.2 J	0.62 U	1.2 J		0.42 U	0.53 U	0.28 U	12.4 J
COBALT	73		44 U	4640 J	11.2 J	1.2 U	27.5 J		14.8 J	9 J	1	18.2 J
COPPER	150		38.7 J	30.3 J	0.67 J	2 J	3 J		3.1 J	0.53 U	1.1 J	16.9 J
IRON	1100		191000 J	209000 J	482 J	396 J	583 J		1280 J	19.3 U	23.8 U	5410 J
LEAD	15		22.1 J	18.6 J	0.37 U	0.42 U	0.97 J		0.781 U	0.21 U	0.069 U	6.6 J
MAGNESIUM	NA		948000 J	985000 J	16400 J	16500 J	5670 J		4340 J	21600 J	21300	14600 J
MANGANESE	88		130000 J	138000 J	701 J	160 J	400 J		102 J	197 J	33.5	335 J
MERCURY	1.1		0.03 U	0.03 U	0.03 U	0.03 U	0.03 U		0.11 J	0.03 U	0.03 U	0.042 U
NICKEL	73		57.8 U	12100 J	30.7 J	7.3 J	47.4 J		27.6 J	16.6 J	3.3	55.5 J
POTASSIUM	NA		11000 J	11900 J	3710 J	1080 J	994 J		352 J	1570 J	958 J	2890 J
SELENIUM	18		3.3 J	7.9 J	0.61 U	0.37 U	0.38 U		0.38 U	0.77 U	1.8 J	1.3 U
SODIUM	NA		195000 J	164000 J	53600 J	39200 J	31900 J		31600 J	91500 J	64400 J	74600 J
THALLIUM	0.24		0.84 U	1.5 U	0.043 U	0.043 U	0.043 U		0.12 U	0.043 U	0.09 J	0.17 U
TIN	2200		0.18 U	0.048 U	0.69 U	0.15 U	0.33 U		0.048 U	0.33 U	0.08 J	1.1 U
VANADIUM	3.6		2.4	4.3	1.14 U	1.14 U	1.14 U		1.14 U	1.14 U	1.14 U	6.1
ZINC	1100		357 U	17600 J	11.3 J	3.3 U	73.6 J		61.3 J	5.6 U	2.8 J	82.2 J

TABLE 3-71

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT PENNSYLVANIAN UPPER ZONE (Puz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		01	02	01	02	01	01	02	02	01	01	02
LOCATION	HHRA	12MWT37	12MWT37	12MWT38	12MWT38	12MWT39	12MWT39	12MWT39	12MWT39	12MWT40	12MWT40	12MWT40
SAMPLE NUMBER	CRITERIA	12GWT3701-F	12GWT3702	12GWT3801	12GWT3802	12GWT3901	12GWT3901-F	12GWT3902	12GWT3902-F	12GWT4001	12GWT4001-F	12GWT4002
SAMPLE CODE		NORMAL	DRY	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE		9/28/2004	2/20/2005	10/9/2004	2/20/2005	9/24/2004	9/24/2004	2/15/2005	2/17/2005	9/27/2004	9/27/2004	2/18/2005
Energetics (ug/L)												
1,3,5-TRINITROBENZENE	110			0.25 U	0.242 U	0.264 U		0.245 U		0.264 U		0.255 U
1,3-DINITROBENZENE	0.36			0.25 U	0.242 U	0.264 U		0.245 U		0.264 U		0.255 U
2,4,6-TRINITROTOLUENE	1.8			0.25 U	0.242 U	0.264 U		0.245 U		0.264 U		0.255 U
2,4-DIAMINO-6-NITROTOLUENE	NA			0.25 U	0.242 U	0.264 U		0.245 U		0.264 U		0.255 U
2,4-DINITROTOLUENE	7.3			0.25 U	0.242 U	0.264 U		0.245 U		0.264 U		0.255 U
2,6-DINITROTOLUENE	3.6			0.25 U	0.242 U	0.264 U		0.245 U		0.264 U		0.255 U
2-AMINO-4,6-DINITROTOLUENE	0.73			0.25 U	0.242 U	0.264 U		0.245 U		0.264 U		0.255 U
2-NITROTOLUENE	0.049			0.25 U	0.242 U	0.264 U		0.245 U		0.264 U		0.255 U
3,5-DINITROANILINE	NA			0.25 U	0.242 U	0.264 U		0.245 U		0.264 U		0.255 U
3-NITROTOLUENE	12			0.25 U	0.242 U	0.264 U		0.245 U		0.264 U		0.255 U
4-AMINO-2,6-DINITROTOLUENE	0.73			0.25 U	0.242 U	0.264 U		0.245 U		0.264 U		0.255 U
4-NITROTOLUENE	0.66			0.25 U	0.242 U	0.264 U		0.245 U		0.264 U		0.255 U
DNX	NA			0.25 U	0.242 U	0.264 U		0.245 U		0.264 U		0.255 U
HMX	180			0.35 J	0.71 J	0.264 U		0.245 U		0.264 U		0.255 U
MNX	NA			0.25 U	0.36 J	0.264 U		0.245 U		0.264 U		0.255 U
RDX	0.61			42	52 J	0.264 U		0.245 U		0.264 U		0.255 U
TNX	NA			0.25 U	0.242 U	0.264 U		0.245 U		0.264 U		0.255 U
Total Metals (ug/L)												
ALUMINUM	3600			2220	4120 J	12200 J		3280 J		556 J		635 J
ANTIMONY	1.5			0.63 U	0.085 U	0.97 U		2.7 U		0.085 U		0.085 U
ARSENIC	0.045			0.85 J	0.33 U	14.9 J		4.7 J		1.1 J		1.9 U
BARIUM	260			30.3 J	18.4 U	212 J		88.6 J		18.9 J		15.1 U
BERYLLIUM	4			4.3	2.8 J	1.6 J		0.39 U		2.7 J		2.8 J
CADMIUM	1.8			2.8 J	2 J	0.6 U		0.32 U		0.58 U		0.72 U
CALCIUM	NA			30500 J	20400 J	18400 J		16700 J		30000 J		31800 J
CHROMIUM	11			1.1 U	1.2 U	35.2 J		8.9 J		1.8 J		1.8 U
COBALT	73			261 J	186 J	54 J		17.6 J		132 J		115 J
COPPER	150			17 J	8.9 J	25.8 J		9.8 J		4.3 J		7.3 J
IRON	1100			1810 J	3320 J	39500 J		8700 J		492 J		657 J
LEAD	15			3.6 J	2.8 J	19.8 J		4.4 U		2.1 J		2.9 J
MAGNESIUM	NA			30200 J	18900 J	15100 J		9550 J		45000 J		39100 J
MANGANESE	88			1500 J	1240 J	972 J		354 J		434 J		451 J
MERCURY	1.1			0.03 U	0.03 U	4.5 J		1.5		0.094 U		0.03 U
NICKEL	73			556 J	353 J	86.5 J		37.4 J		170 J		162 J
POTASSIUM	NA			3530 J	3190 J	17800 J		11600 J		1440 J		1490 J
SELENIUM	18			2 J	0.93 J	0.76 U		5.8 J		0.26 U		5.7 J
SODIUM	NA			53500 J	34200 J	76900 J		65900 J		167000 J		134000 J
THALLIUM	0.24			0.27 J	0.43 U	0.41 U		0.25 U		0.043 U		0.17 U
TIN	2200			0.25 U	0.14 U	1.4 J		0.52 U		0.048 U		0.28 U
VANADIUM	3.6			1.14 U	1.14 U	22.9		5.1		1.14 U		1.14 U
ZINC	1100			1150 J	689	132 J		50.8 J		78.8 J		105 J

TABLE 3-71

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT PENNSYLVANIAN UPPER ZONE (Puz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	02 12MWT40 12GWT4002-F NORMAL 2/18/2005	01 12MWT42 12GWT4201 NORMAL 9/28/2004	02 12MWT42 12GWT4202 NORMAL 2/19/2005
Energetics (ug/L)				
1,3,5-TRINITROBENZENE	110		0.266 U	0.245 U
1,3-DINITROBENZENE	0.36		0.266 U	0.245 U
2,4,6-TRINITROTOLUENE	1.8		0.266 U	0.245 U
2,4-DIAMINO-6-NITROTOLUENE	NA		0.266 U	0.245 U
2,4-DINITROTOLUENE	7.3		0.266 U	0.245 U
2,6-DINITROTOLUENE	3.6		0.266 U	0.245 U
2-AMINO-4,6-DINITROTOLUENE	0.73		0.266 U	0.245 U
2-NITROTOLUENE	0.049		0.266 U	0.245 U
3,5-DINITROANILINE	NA		0.266 U	0.245 U
3-NITROTOLUENE	12		0.266 U	0.245 U
4-AMINO-2,6-DINITROTOLUENE	0.73		0.266 U	0.245 U
4-NITROTOLUENE	0.66		0.266 U	0.245 U
DNX	NA		0.266 U	0.245 U
HMX	180		18	27
MNX	NA		0.266 U	0.245 U
RDX	0.61		**11**	**19**
TNX	NA		0.266 U	0.245 U
Total Metals (ug/L)				
ALUMINUM	3600		1290 J	3140 J
ANTIMONY	1.5		0.085 UJ	0.15 U
ARSENIC	0.045		**2.1 J**	0.38 U
BARIUM	260		33.8 J	18.4 U
BERYLLIUM	4		2.8	**4.5 J**
CADMIUM	1.8		1.4	0.5 U
CALCIUM	NA		46700	31800 J
CHROMIUM	11		0.3 U	0.66 U
COBALT	73		**307**	**93.2 J**
COPPER	150		17.2	3.9 J
IRON	1100		307	805 J
LEAD	15		1.8	2.5 J
MAGNESIUM	NA		31200	28000 J
MANGANESE	88		**1370**	**286 J**
MERCURY	1.1		0.038 U	0.05 J
NICKEL	73		**627**	**200 J**
POTASSIUM	NA		2930 J	553 J
SELENIUM	18		3.6 J	1.2 J
SODIUM	NA		56500 J	39500 J
THALLIUM	0.24		0.05 J	0.07 U
TIN	2200		0.16 J	0.27 U
VANADIUM	3.6		1.14 U	1.14 U
ZINC	1100		724 J	255 J

TABLE 3-72

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT PENNSYLVANIAN MIDDLE ZONE (Pmz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		01	01	02	02	01	02	01	01	02	02
LOCATION	HHRA	12MWT29	12MWT29	12MWT29	12MWT29	12MWT30	12MWT30	12MWT31	12MWT31	12MWT31	12MWT31
SAMPLE NUMBER	CRITERIA	12GWT2901	12GWT2901-F	12GWT2902	12GWT2902-F	12GWT3001	12GWT3002	12GWT3101	12GWT3101-F	12GWT3102	12GWT3102-F
SAMPLE CODE		NORMAL	NORMAL	NORMAL	NORMAL	DRY	DRY	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE		9/28/2004	9/28/2004	2/20/2005	2/20/2005	9/28/2004	2/15/2005	9/27/2004	9/27/2004	2/7/2005	2/7/2005
Energetics (ug/L)											
HMX	180	0.275 U		0.264 U				0.27 U		0.275 U	
RDX	0.61	0.275 U		0.264 U				0.27 U		0.275 U	
Total Metals (ug/L)											
ALUMINUM	3600	2010 J		9940 J				1550 J		1490 J	
ANTIMONY	1.5	2 J		0.085 U				2.9 J		0.41 U	
ARSENIC	0.045	2.4 J		8.6 J				4 J		3.3 J	
BARIUM	260	59 J		139 J				54.6 J		55.3 J	
BERYLLIUM	4	0.2 J		0.69 U				0.09 U		0.13 U	
CADMIUM	1.8	0.039 U		0.39 U				0.039 U		0.05 U	
CALCIUM	NA	61500		60900 J				13800 J		12300 J	
CHROMIUM	11	6.6 J		21.5 J				4.7 J		3.9 J	
COBALT	73	5.1		12.8 J				1.8 U		1.8 U	
COPPER	150	8.3		20.5 J				3 J		6.9 J	
IRON	1100	5910		31500 J				2190 J		2630 J	
LEAD	15	3.8		14.8 J				1.4 J		1.8 U	
MAGNESIUM	NA	27600		23800 J				4210 J		4080 J	
MANGANESE	88	265		966 J				44.6 J		70.3 J	
MERCURY	1.1	0.03 U		0.03 U				0.034 U		0.03 U	
NICKEL	73	15.8 J		37.1 J				5.5 U		5.8 J	
POTASSIUM	NA	5080 J		6200 J				3680 J		2840 J	
SELENIUM	18	1.5 U		1.1 J				2.1 U		0.54 U	
SODIUM	NA	161000 J		143000 J				139000 J		116000 J	
THALLIUM	0.24	0.043 U		0.14 U				0.043 U		0.05 U	
TIN	2200	0.88 J		0.91 U				0.72 U		0.48 U	
VANADIUM	3.6	4.8		16.7				4		3.4	
ZINC	1100	31.5 J		75.5 J				15.4 J		19.3 J	
Dissolved Metals (ug/L)											
ALUMINUM	3600		25.9 U		9.1 J				62.5 U		19 U
ANTIMONY	1.5		0.25 U		0.37 U				3.2 J		0.76 U
ARSENIC	0.045		0.75 J		1.6 U				3.7 J		3 J
BARIUM	260		31.7 J		40.7 J				35.6 J		43.4 J
CADMIUM	1.8		0.15 J		0.039 U				0.039 U		0.039 U
CALCIUM	NA		62600		54100 J				13400 J		12600 J
CHROMIUM	11		0.67 U		0.15 U				0.81 J		0.28 U
COBALT	73		1.9		0.8 U				0.24 U		0.13 U
COPPER	150		3.5		0.16 U				1.1 J		0.3 U
IRON	1100		301		6.2 U				120 U		11.1 U
LEAD	15		0.069 U		0.27 U				0.09 U		0.26 U
MAGNESIUM	NA		27500 J		24800 J				4040 J		3650 J
MANGANESE	88		110 J		169				33.5 J		27.2 J

TABLE 3-72

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT PENNSYLVANIAN MIDDLE ZONE (Pmz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		01	01	02	02	01	02	01	02	02	01
LOCATION	HHRA	12MWT32	12MWT32	12MWT32	12MWT32	12MWT34	12MWT34	12MWT45	12MWT45	12MWT45	12MWT46
SAMPLE NUMBER	CRITERIA	12GWT3201	12GWT3201-F	12GWT3202	12GWT3202-F	12GWT3401	12GWT3402	12GWT4501	12GWT4502	12GWT4502-F	12GWT4601
SAMPLE CODE		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
SAMPLE DATE		9/28/2004	9/28/2004	2/8/2005	2/8/2005	10/30/2004	2/15/2005	11/13/2004	3/3/2005	3/3/2005	11/13/2004
Energetics (ug/L)											
HMX	180	0.248 U		0.242 U		0.446 UJ	0.25 U	0.255 U	0.24 U		0.255 U
RDX	0.61	0.248 U		0.242 U		0.446 UJ	0.25 U	0.255 U	0.24 U		0.255 U
Total Metals (ug/L)											
ALUMINUM	3600	3080 J		2880 J				198 J	235 J		72.9 U
ANTIMONY	1.5	2.2 J		0.085 U				0.085 U	0.085 U		0.085 U
ARSENIC	0.045	7.3 J		5.4 J				0.64 J	0.2 J		0.59 J
BARIUM	260	95.1 J		43.1 J				18.1 J	11.2 J		27.9 J
BERYLLIUM	4	0.33 J		0.28 U				0.25 J	0.24 U		0.02 U
CADMIUM	1.8	0.18 J		0.2 U				1.8 J	0.79 J		1.3 U
CALCIUM	NA	182000		194000 J				53100	71400		12900
CHROMIUM	11	9.1 J		7 J				0.74 U	0.39 U		0.64 U
COBALT	73	30		15.8 J				7 J	10.7		26.2 J
COPPER	150	7.3		5.1 J				2.1 J	2.4		0.83 J
IRON	1100	9920		7110 J				546 J	693 J		21600 J
LEAD	15	7.5		4.9 J				0.36 J	0.342 J		0.11 U
MAGNESIUM	NA	112000		121000 J				94300 J	105000		16300 J
MANGANESE	88	1260		926 J				770	1680		7570
MERCURY	1.1	0.033 U		0.03 U				0.03 U	0.03 U		0.03 U
NICKEL	73	108 J		43 J				141 J	178		7.8 J
POTASSIUM	NA	10400 J		11200 J				3590 J	4210 J		1720 J
SELENIUM	18	7.7 J		1.1 J				0.98 J	0.99 J		1.4 J
SODIUM	NA	19900 J		29900 J				42600 J	47000 J		12400 J
THALLIUM	0.24	0.09 J		0.16 U				0.043 U	0.06 J		0.043 U
TIN	2200	0.45 J		0.25 U				0.3 U	0.08 J		0.28 U
VANADIUM	3.6	9.9		6.8				1.14 U	1.14 U		1.14 U
ZINC	1100	47.8 J		27.5 J				183 J	262		4.8 U
Dissolved Metals (ug/L)											
ALUMINUM	3600		9.1 U		9.8 U					210 J	
ANTIMONY	1.5		2.3 J		0.09 U					0.085 U	
ARSENIC	0.045		3.6 J		2.6 J					0.15 J	
BARIUM	260		68 J		22.6 J					11.2 J	
CADMIUM	1.8		0.11 J		0.06 U					0.75 J	
CALCIUM	NA		237000		234000 J					64900	
CHROMIUM	11		0.78 U		0.27 U					0.23 U	
COBALT	73		29.2		11.8 J					10.5	
COPPER	150		2.2		0.19 U					2.3	
IRON	1100		1250		859 J					104 U	
LEAD	15		0.12 J		0.28 U					0.315 J	
MAGNESIUM	NA		139000 J		126000 J					108000 J	
MANGANESE	88		1310		745 J					1600	

TABLE 3-72

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT PENNSYLVANIAN MIDDLE ZONE (Pmz)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND LOCATION SAMPLE NUMBER SAMPLE CODE SAMPLE DATE	HHRA CRITERIA	02 12MWT46 12GWT4602 NORMAL 3/3/2005	02 12MWT46 12GWT4602-F NORMAL 3/3/2005	01 12MWT47 12GWT4701 ORIG 11/13/2004	02 12MWT47 12GWT4702 NORMAL 3/2/2005	01 12MWT48 12GWT4801 NORMAL 11/14/2004	01 12MWT48 12GWT4801-F NORMAL 11/15/2004	02 12MWT48 12GWT4802 NORMAL 2/15/2005	02 12MWT48 12GWT4802-F NORMAL 2/15/2005
Energetics (ug/L)									
HMX	180	0.26 U		0.255 U	0.264 U	0.305 U		0.52	
RDX	0.61	0.26 U		0.255 U	0.264 U	1.3 J		4.2 J	
Total Metals (ug/L)									
ALUMINUM	3600	50.2 U		376 J	95.6 J	31000 J		25700 J	
ANTIMONY	1.5	0.085 U		0.085 U	0.085 U	0.085 U		0.085 U	
ARSENIC	0.045	0.49 J		0.38 J	0.17 J	11.4 J		9.6 J	
BARIUM	260	34.4 J		10.6 J	11.6 J	173 J		214 J	
BERYLLIUM	4	0.04 U		0.02 U	0.02 U	1.2 J		1.5 U	
CADMIUM	1.8	0.07 J		0.91 U	0.039 U	2.3 J		0.8 U	
CALCIUM	NA	18200		35300	53800	17800		24800 J	
CHROMIUM	11	0.27 U		0.91 U	0.86 U	34.1 J		47.9 J	
COBALT	73	27.5		0.26 J	0.14 J	79.7 J		74.9 J	
COPPER	150	1.5 J		1.4 J	0.68 J	24.3 J		23.4 J	
IRON	1100	2220 J		575 J	424 J	48900 J		46200 J	
LEAD	15	0.455 J		0.3 U	0.089 J	23.4 J		24.7 J	
MAGNESIUM	NA	20700		53100 J	71400	9870 J		14600 J	
MANGANESE	88	3270		5.4 J	1.5 J	1310		971 J	
MERCURY	1.1	0.03 U		0.03 U	0.03 U	0.03 U		0.057 J	
NICKEL	73	11.5		3.2 J	5.1	139 J		106 J	
POTASSIUM	NA	1380 J		1550 J	1780 J	3860 J		4610 J	
SELENIUM	18	1.9 J		0.69 U	0.98 J	1.2 J		0.84 U	
SODIUM	NA	27000 J		20100 J	26000 J	10000 J		13100 J	
THALLIUM	0.24	0.043 U		0.043 U	0.043 U	0.32 J		0.5 U	
TIN	2200	0.048 U		0.08 U	0.048 U	1.1 J		1.6 U	
VANADIUM	3.6	1.14 U		1.14 U	1.14 U	49.4 J		38	
ZINC	1100	4 J		3.4 U	2.5 J	168 J		110 J	
Dissolved Metals (ug/L)									
ALUMINUM	3600		9.6 U				140 U		10.1 U
ANTIMONY	1.5		0.085 U				1.6 U		0.4 U
ARSENIC	0.045		0.4 J				0.22 J		0.28 U
BARIUM	260		37.6 J				15.7 J		26.8 J
CADMIUM	1.8		0.06 J				1.7 J		0.17 U
CALCIUM	NA		18400				20200 J		19900 J
CHROMIUM	11		0.14 U				0.77 U		0.64 U
COBALT	73		23.3				11.2		0.98 U
COPPER	150		1.3 J				0.99 J		0.33 U
IRON	1100		1000 J				295 J		12 U
LEAD	15		0.181 J				0.3 U		0.45 U
MAGNESIUM	NA		21700 J				9190 J		12600 J
MANGANESE	88		3300				259 J		25.4 U

TABLE 3-73

RESULTS FOR CHEMICALS DETECTED IN DOWNGRADIENT PENNSYLVANIAN LOWER AND MISSISSIPPIAN GLEN DEAN ZONE (Plz/Mgd)
GROUNDWATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

SAMPLING ROUND		01	02	01	01	02	01	02	02	01	02
LOCATION	HHRA	12MWT41	12MWT41	12MWT44	12MWT44	12MWT44	12MWT49	12MWT49	12MWT49	12MWT50	12MWT50
SAMPLE NUMBER	CRITERIA	12GWT4101	12GWT4102	12GWT4401	12GWT4401-F	12GWT4402	12GWT4901	12GWT4901	12GWT4901-F	12GWT5001	12GWT5002
SAMPLE CODE		NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DRY	NORMAL	NORMAL	DRY	DRY
SAMPLE DATE		11/10/2004	2/19/2005	11/10/2004	11/10/2004	2/19/2005	11/10/2004	2/15/2005	2/15/2005	11/10/2004	2/15/2005
Energetics (ug/L)											
2,4,6-TRINITROTOLUENE	1.8	0.266 U	0.255 U	4.2		0.26 U		0.24 U			
4-AMINO-2,6-DINITROTOLUENE	0.73	0.266 U	0.255 U	0.65		0.26 U		0.24 U			
HMX	180	0.266 U	0.255 U	0.28 J		0.26 U		0.24 U			
RDX	0.61	0.266 U	0.255 U	3.9		0.26 U		0.24 U			
Total Metals (ug/L)											
ALUMINUM	3600	55.4 U	8.35 UJ	377 J		165 J		2540 J			
ANTIMONY	1.5	3.1 J	0.085 U	0.9 U		0.085 U		0.085 U			
ARSENIC	0.045	3.8 J	9.5 J	1.7 J		2.1 U		3 J			
BARIUM	260	24.8 J	20.5 U	63.4 J		36 J		79.3 J			
CALCIUM	NA	136000	106000 J	138000		201000 J		154000 J			
CHROMIUM	11	0.64 U	0.58 U	2 U		1.3 U		6.6 J			
COBALT	73	5.3 J	1.2 U	12.1 J		14.7 J		8.7 J			
COPPER	150	1.2 J	1.4 U	3.8 J		4.1 J		6.4 J			
IRON	1100	914 J	2900 J	2290 J		5980 J		7150 J			
LEAD	15	0.35 U	0.069 U	0.53 J		0.295 U		10.5 J			
MAGNESIUM	NA	77700 J	59900 J	101000 J		171000 J		13000 J			
MANGANESE	88	1220	885 J	531		2190 J		1470 J			
NICKEL	73	17.9 J	6.3 J	44.2 J		22.7 J		37 J			
POTASSIUM	NA	5510 J	4230 J	7530 J		9660 J		2550 J			
SELENIUM	18	1.3 J	0.77 U	2 J		1.2 J		1.2 J			
SODIUM	NA	69000 J	54200 J	158000 J		16800 J		6380 J			
TIN	2200	0.26 U	0.1 U	0.73 U		0.36 U		4.2 J			
VANADIUM	3.6	1.14 U	1.14 U	1.14 U		1.14 U		4.9			
ZINC	1100	7.5 U	10 J	9.1 J		10.1 J		40 J			
Dissolved Metals (ug/L)											
ARSENIC	0.045				1.8 J				0.6 U		
BARIUM	260				56.4 J				65 J		
CALCIUM	NA				150000 J				168000 J		
COBALT	73				15.5				5.5 J		
COPPER	150				3.6 J				0.3 U		
IRON	1100				1130 J				10.6 U		
MAGNESIUM	NA				112000 J				14600 J		
MANGANESE	88				580 J				1240 J		
NICKEL	73				73.9 J				21.8 J		
POTASSIUM	NA				7940 J				2260 J		
SELENIUM	18				1.9 J				0.45 U		
SODIUM	NA				172000 J				8390 J		
TIN	2200				1 J				1.6 U		
ZINC	1100				8 J				7.1 U		

4.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

4.1 PHYSIOGRAPHY AND TOPOGRAPHY

MFA is located on top of a ridge that was flattened to some extent in the 1940s in preparation for site development (roads, rail lines, buildings, parking lots). The areas that lie between roads and buildings are mostly grass covered. The active operations of MFA lie within a trapezoidal area that is elongated in a northwest-southeast direction (Figure 1-3). A primary road (Highway 45) and the main rail line run along the northwest side of MFA. Rail spurs and paved roads also run along the length of MFA on the northeast and southwest sides. The main loading activities took place in buildings 0151 through 0154 and 0157 through 0159 (Figure 1-3).

Within the MFA, most of the land area slopes to the southwest. Therefore, most surface water runoff from the buildings, the conveyors, the vegetated soil surfaces, roads, and parking lots are draining to the southwest. MFA is surrounded by a chain-link fence and a perimeter road (Figure 1-3). The land surface drops in elevation rather abruptly on the northeast and southwest sides of MFA, and decreases gradually south of MFA. Slopes on the northeast and southwest sides of MFA (outside of the fenced area) range from about 15 to 20 percent. Slopes south of MFA are more gradual (about 6 to 12 percent).

A large unnamed tributary of Turkey Creek (east tributary) flows north to south, about 1000 to 1500 feet east of the MFA fenceline. Another smaller, unnamed tributary (west tributary) lies 200 to 800 feet west of MFA, and it too flows southward into Turkey Creek. Turkey Creek is one of the main creeks within NSWC Crane and it drains a large central section of the facility (Figure 1-2). The main stem of Turkey Creek lies approximately 3,600 feet south-southeast of MFA (Figure 2-3). The land is heavily forested between MFA and the unnamed tributaries and Turkey Creek.

Elevations throughout the MFA ridgetop range from about 720 to 750 feet amsl. The maximum elevations at MFA (745-750 feet amsl) generally occur near the buildings along the northeast side of MFA (e.g., 3110, 2512, and 0152). Most of the land surface of MFA slopes gently to the southwest. The elevations along the small unnamed tributary (west tributary) range from 700 feet amsl up near the top of the ridge down to about 615 feet amsl where it enters Turkey Creek (Figure 2-3), a drop of 185 feet in elevation. The larger, eastern tributary is more deeply incised into the ridge and drops in elevation from about 600 feet amsl at 12SW/SD13 down to approximately 520 feet amsl where the tributary enters Turkey Creek. The total topographic relief around MFA is about 240 feet.

4.2 METEOROLOGY

NSWC Crane is located in a warm, temperate climatic zone. In general, the summers are warm and humid, and winters are mild with occasional short cold periods. The temperature ranges from an average maximum July temperature of 89 degrees Fahrenheit (°F) to an average minimum January temperature of 26°F. Precipitation is fairly evenly distributed throughout the calendar year; the maximum precipitation occurs during the spring and early summer. The average annual precipitation at the facility is 44 inches and consists of 42 inches of rain and 15 inches of snow. The average humidity ranges from 40 to 90 percent in summer and 60 to 90 percent in winter. Long-term climatological records for the area indicate that the monthly prevailing wind direction is from the southwest from April through December and from the northwest during January through March [National Oceanic and Atmospheric Administration (NOAA), 1988]. The annual prevailing wind direction for the region is from the southwest, and the annual average wind speed for the area is about 9.6 miles per hour. Figure 4-1 is a wind rose summarizing the mean wind direction and wind speed distribution at the Indianapolis International Airport over a 5-year period (1985 to 1989).

4.3 SURFACE WATER HYDROLOGY

The topography at MFA consists of a ridge that lies on the east side of Highway 45 and runs in a northeast-southwest orientation. The slopes across the MFA ridgetop are very gradual. The crest of the ridge is more on the northeastern side of the ridge and runs through Buildings 151, 155, and 160. Hence, surface water runoff from most of the buildings, conveyors, grassy areas, railroad tracks, roads, and parking lots drains to the southwestern side of SWMU 12. The ditches and storm sewers within the SWMU 12 fenced area lead to larger drainageways and gullies that flow down both sides of the ridge in northeast and southwest directions. The sides of the ridge consist of steeper slopes that lead down to the adjacent stream valleys.

Figure 4-2 shows the northern and central portions of the MFA area. This figure includes the small drainageways mapped by NSWC Crane and included as part of their hydrography database. The western side of MFA drains to the west and south via four primary gullies. Based on a qualitative field reconnaissance, the area on the northwestern side of MFA has been subdivided into small drainage basins 1 and 2. In drainage basin 1, runoff water from the far northern end of the facility flows southwestward in a ditch along the side of the railroad tracks and enters a larger drainage ditch (drainageway A). Drainageway A drains southeastward between Buildings 159 and 2715, joins drainageway B, and continues southward to sampling point 12SW/SD01 and staff gauge 12SG07. Drainageway B drains southwestward and collects runoff from the western side of Building 157, Building

2794, and portions of the conveyor system. Drainageway C runs along the road and railroad tracks and drains northwestward. Together, surface runoff from drainageways A, B, and C coalesce at 12SG07 and flows westward under the railroad tracks and perimeter road. This drainageway then cuts southward down the side of the ridge toward sampling point 08SW/SD04.

The second drainage basin mapped in Figure 4-2 (drainage basin 2) includes runoff water from three small drainages (D, E, and F). Sampling location 12SW/SD36 is located on drainageway D; samples from this point represent runoff water from drainageway D. Sampling point 12SW/SD35 is the outfall of a 6-inch-diameter clay tile pipe that is located in the middle of a grassy field. The source of this drainage pipe is currently unknown. Drainage from the pipe joins drainageway D and flows west and south. Surface runoff in drainageways E and F join together in a wooded area and drain northwestward. This combined drainage was sampled at location 12SW/SD34. Together, the three main drainages from drainage basin 2 coalesce at sampling point 12SW/SD02 and staff gauge 12SG06. The drainage basin then discharges westward under the tracks and road into drainageway G. From there, the drainageway runs south-southwest down the hillside to sampling point 12SW/SD05. Water draining drainage basins 1 and 2 comes together a short distance south of sampling stations 12SW/SD04 and 12SW/SD05 to form the "western tributary" as shown in Figure 2-3.

Moving southward, the third main drainage basin on the western side has been sampled at 12SW/SD06. The fourth drainage basin draining the western side of MFA has been sampled at 12SW/SD03 (see Figure 2-3).

Staff gauges 12SG07, 12SG06, and 12SG05 were installed on the first, second, and fourth drainage basins, respectively, on the western side of MFA where they drain beneath the perimeter road to better estimate the flow rates of surface water leaving the SWMU during storm events. These gullies all empty into the unnamed western tributary creek, which has been sampled from north to south at stations 12SW/SD07, 12SW/SD09, 12SW/SD10, and 12SW/SD11. A staff gauge (12SG12) was also collocated with sampling station 12SW/SD10 to better estimate flow rates at specific points in time.

Drainage from the eastern side of the ridge crest flows to the northeast, down the side of the ridge, and into another unnamed tributary of Turkey Creek ("eastern tributary", Figure 2-3). Drainage ditches and gullies on the far northeastern side of MFA (e.g., sampling locations 12SW/SD28, 12SW/SD30, 12SW/SD12, 12SW/SD31, 12SW/SD32 and 12SW/SD14, see Figure 2-3) flow eastward and coalesce prior to reaching 12SW/SD13. The gully then proceeds southeastward down the hillside where it joins the primary tributary stream near sampling point 12SW/SD16. Three other gullies drain the eastern side of MFA (sampling points 12SW/SD15, 12SW/SD18, and 12SW/SD20, Figure 2-3). Staff gauges 12SG02,

12SG03, and 12SG04, respectively, were also installed at these locations to measure flow rates more accurately. These gullies drain eastward down the hillside where they were sampled again at stations 12SW/SD17, 12SW/SD18, and 12SW/SD20, respectively, just prior to entering the main tributary creek.

Staff gauges 12SG09 and 12SG12 were installed to estimate flow rates and water elevations in the eastern and western unnamed tributaries, respectively, just before they enter Turkey Creek (Figure 2-3). In addition, sampling stations 12SW/SD24 and 12SW/SD11 were established to sample the tributaries just prior to their confluences with Turkey Creek.

Staff gauge 12SG10 and sampling station 12SW/SD25 were established to measure flow rates and collect representative surface water and sediment samples in Turkey Creek upstream of any SWMU 12 influences (Figure 2-3). Staff gauge 12SG11 and sampling station 12SW/SD27 were established to measure flow rates and collect representative surface water and sediment samples in Turkey Creek downstream of SWMU 12.

Two rounds of surface water sampling and flow measurements were conducted during the RFI. Based on visual observations and measurements, estimates of surface water flow were made at each surface water sampling station and at each staff gauge on one or more occasions during the two rounds (Table 4-1). Even during the fall and winter months (e.g., during Rounds 1 and 2 sampling) when surface flow should be more likely, there was very little or no surface flow at many of the sampling stations or staff gauges in the gullies near the ridgetop (e.g., 12SW/SD01, 12SW/SD03, 12SW/SD04, 12SW/SD06, 12SW/SD14, 12SW/SD18 through 22, 12SW/SD28 through 36, and 12SG01 through 12SG05). It is likely that the gullies and the upper reaches of the unnamed tributary creeks are not flowing much of the year, especially in summer and fall months.

During Round 1 (October through December 2004), the flow rates measured near the mouth of the eastern tributary (stations 12SG09 and 12SW/SD24) were about 250 to 300 gallons per minute (gpm) and were about 75 to 150 gpm near the mouth of the western unnamed tributary (stations 12SG12 and 12SW/SD10, Table 4-1). During Round 2 (March 2005), the flow rates in these two tributaries of Turkey Creek were in the range of 200 to 300 gpm. These are relatively low flow rates compared to the 4,000 to 9,000 gpm that was estimated to be flowing in Turkey Creek at the time. Turkey Creek is probably flowing a large proportion of the year where it receives drainage from SWMU 12.

4.4 GEOLOGY

Bedrock underlying NSWC Crane consists of sedimentary rocks from the Lower Pennsylvanian-age Mansfield Formation of the Raccoon Creek Group and the underlying Upper Mississippian-age Stephensport and West Baden Groups (Figure 4-3). The Pennsylvanian-age sandstones, siltstone, shales, coal beds, and thin limestone units of the Mansfield Formation can reach thicknesses of 250 to 300 feet at NSWC Crane in the central and western portions of the facility. Because the pre-Pennsylvanian bedrock is dipping to the west-southwest toward the center of the Illinois structural basin, the Mississippian-age rocks are closer to the surface and crop out along the stream valleys and lower slopes on the eastern side of NSWC Crane (Figure 4-4). On the eastern side of NSWC Crane (e.g., near the Dye Burial Ground, Ammunition Burning Ground, and Rockeye), Pennsylvanian bedrock is confined to the uppermost portions of hills and ridges. At SWMU 9 (Pest Control Area), which lies about 1,000 feet west of the northern end of SWMU 12, the USACE drilled a well (09C01) through the top of the ridge to a total depth of 150 feet. This well penetrated 13 feet of overburden soil and 132.5 feet of Pennsylvanian (Mansfield) shales, sandstones, siltstone, and coal seams. The boring also encountered 5.5 feet of Mississippian limestone at the bottom, which the USACE and Indiana Geological Survey identified as the Glen Dean Limestone (Barnhill and Hansley, 1993). The elevation of the Pennsylvanian-Mississippian unconformity at this location (SWMU 9) is approximately 575 feet above mean seal level (amsl). Five monitoring wells were installed at Dump Site A (SWMU 25) in 1981 (Figure 4-5). Four of these wells (WES-7-2-81 through WES-7-5-81) are screened in sandstone, shale, and limestone which appear to be right at the Pennsylvanian-Mississippian unconformity. Based on the limestone present in WES-7-3-81, the elevation of the unconformity at this location is estimated to at 592 feet amsl. At SWMU 12, Mississippian limestone (presumably Glen Dean Formation) was encountered in monitoring wells 12MWT41, 12MWT44, and 12MWT49 at elevations of 595.10, 590.81, and 607.96 feet amsl, respectively. These elevations show that the Pennsylvanian-Mississippian unconformity is dipping in general from east (12MWT49, 607.96 feet amsl) to the west (09C01, 575 feet amsl), which is consistent with the mapping performed by Barnhill (1993) and Kvale and Barnhill (1994) that shows the paleoerosion surface dipping to the west in Section 23 (R4W, T5N).

SWMU 9 lies on the eastern side of a pre-Pennsylvanian valley that trends north-south (Kvale and Barnhill, 1994). The Pennsylvanian Mansfield Formation subsequently filled in the paleo-valley, meaning that the Pennsylvanian-age rocks thicken to the west toward the centerline of the paleo-valley. Using a basal elevation of about 600 feet amsl, the Pennsylvanian rock at SWMU 12 is up to 140 feet thick.

Below the Pennsylvanian rocks lie Mississippian-age limestone and sandstone formations of the Stephensport Group, including the Glen Dean, Golconda, and Beech Creek Limestones, the Big Clifty

Sandstone, and the Hardinsburg Formation (siltstone and shale) (Figure 4-3). Only the uppermost Glen Dean Limestone has been penetrated by drilling at SWMUs 9 and 12. Altogether, there is vertically about 60 to 70 feet of Mississippian rocks from the unconformity down to creek level on the eastern side of SWMU 12. According to geologic mapping performed throughout NSWC Crane (see Figure 4-4), the Big Clifty Formation (sandstone member) is the uppermost bedrock in the bottom of the tributary valley on the eastern side of SWMU 12. The upper surface of the Beech Creek Limestone should therefore lie a short distance below the creek level.

During the RFI of SWMU 12, a total of 51 monitoring wells were installed. The date of installation, the total depth, the ground surface elevation, the screen elevations, and other physical characteristics of each of the 51 monitoring wells are listed in Table 2-2. The boring logs and well construction logs for these wells are included in Appendix B. The locations of the 51 monitoring wells are shown on Figure 2-2. Figure 4-5 illustrates the locations of four hydrogeological cross sections that have been prepared, including select borings, through SWMU 12. Figures 4-6 through 4-9 show hydrogeologic cross sections A-A', B-B', C-C', and D-D', respectively.

The ridgetop containing SWMU 12 is blanketed with residual soils and reworked soils that range from 2.5 to 14.5 feet thick. The bulk of the ridge is composed of Pennsylvanian bedrock, which consists of discontinuous layers of siltstones, sandstones, shales, and coal seams up to 140 feet thick near the center of the ridge. These rock units extend from the ridgetop down to about 590 to 600 feet amsl (see Figures 4-6 through 4-9). The approximate location of the Pennsylvanian-Mississippian unconformity is shown on each cross section.

The SWMU 12 ridge is capped by silty sandstone and sandstone (Figures 4-6 through 4-9). The upper half of this sandstone unit is weathered, oxidized (brown to tan in color), and generally soft. The lower half is gray (less weathered) and medium hard. The basal elevation of the sandstone cap generally runs from about 700 to 710 feet amsl; however, in places the base of the sandstone runs a little deeper (e.g., 688 feet amsl in 12MWT42, see Figure 4-6). Altogether, this uppermost sandstone is about 20 to 40 feet thick. Groundwater was consistently encountered in the ridge-capping sandstone unit. Since it is the shallowest water-bearing geologic unit and is present everywhere under SWMU 12, groundwater contamination if present should be encountered most frequently in this unit. As a result, the majority of monitoring wells were installed in the upper sandstone. This unit is referred to as the Upper Pennsylvanian water-bearing zone (Puz) in Section 4.6. Of the 51 monitoring wells that have been installed at SWMU 12, 36 wells are screened in the upper water-bearing unit (i.e., Puz, Table 2-2). In the northern and central portion of SWMU 12, a thin coal seam was encountered directly below the upper sandstone. Because coals are usually permeable and appeared to produce water during drilling (see

boring log for 12MWT03, Appendix B), this coal seam was also included in the upper water-bearing unit (Puz).

Beneath the upper sandstone and silty sandstone unit (Puz) lies about 22 to 27 feet of shale, silty shale, mudstone, and interbedded sandstone and shale. This stratigraphic interval is a mixture of finer-grained sedimentary deposits and appears to extend beneath the entire MFA area (see Figures 4-6 through 4-9). The shale is interlayered with discontinuous siltstone and sandstone lenses. The top of the siltstone/shale unit was encountered at approximately 684 to 695 feet amsl (see Figures 4-6 through 4-9) and the bottom of the siltstone/shale unit lies at about 658 to 673 feet amsl. The total thickness of the siltstone/shale unit is about 25 feet. This siltstone/shale unit is considered to be an aquitard and greatly restricts the downward movement of groundwater (as discussed in Section 4.6).

A sandstone layer was the next lithologic unit encountered beneath the interlayered shale and siltstone unit. The top of this sandstone unit was encountered at approximately 658 to 673 feet amsl. However, the contact between the aquitard above and the sandstone below is not sharp; it is in most cases a gradual transition. Six monitoring wells located within the MFA fenced area (12MWT29 through 12MWT34) were drilled down to this interface and penetrated as much as 32 feet into the underlying sandstone. None of these six monitoring wells, however, penetrated completely through the sandstone (see Figures 4-6 through 4-9). Four additional wells (12MWT45 through 12MWT48) were installed along the railroad right-of-way partway down the hillside on the east side of SWMU 12. The ground surface at these well locations ranged from 648 up to 688 feet amsl. These borings penetrated a deeper part of the same sandstone unit (see Figures 4-8 and 4-9). Wells 12MWT30 and 12MWT48 were drilled to the lowest elevation (635.17 and 617.84 feet amsl, respectively) of the ten wells screened in the second sandstone unit; the bottom of both of these boreholes were still in the sandstone unit at those elevations. Thus, the second major sandstone unit extends down to at least 618 feet amsl and possibly a little deeper. The second sandstone unit is referred to as the middle Pennsylvanian water-bearing zone (Pmz) in Section 4.6 and the remainder of this report. It is roughly 50 feet thick.

Three monitoring wells (12MWT41, 12MWT43, and 12MWT44) were installed along a right-of-way on the southwest side of SWMU 12 close to the unnamed tributary creek (Figure 4-5). In addition, five older monitoring wells (WES-7-1-81 through WES-7-5-81) were installed around Dump Site A (a historical disposal area, SWMU 25) by the USACE in 1981. All eight of these wells are shown on Figure 4-5. Each of these wells were drilled through the lowest part of the Pennsylvanian rock strata. Monitoring well 12MWT43 is located on the right-of-way on the side of the ridge to the west-southwest of the SWMU 12 ridge. Here, the second sandstone unit is only about 17 feet thick and the interval between 606 and 647 feet amsl is occupied by 41 feet of shale and siltstone (Figure 4-8). In the eight wells southwest of

MFA, the interval between approximately 606 down to about 590 feet amsl is occupied by thin beds of sandstone, hard claystone, and coal seams (Figure 4-9). Two of the eight monitoring wells (12MWT43 and WES-7-1-81) on the southwest side of SWMU 12 are screened above 590 feet amsl in the lowermost strata of Pennsylvanian rocks. These two wells are considered to be monitoring the lower Pennsylvanian water-bearing zone (Plz).

The other six wells in this area around Dump Site A extend down into the Glen Dean Limestone or right to the Pennsylvanian-Mississippian unconformity. The unconformity is an undulatory surface, based on a cross-sectional sketch prepared by the USACE for Dump Site A (Dunbar, 1982). Well WES-7-4-81 encountered limestone at an elevation of 591.5 feet amsl while thin coal seams were logged in wells WES-7-1-81 and WES-7-3-81 at approximately the same elevation (see logs in Appendix B and Figure 4-9). Pennsylvanian-age coal, clay, and sandstone lenses filled in and draped over the irregular post-Mississippian erosion surface. Two other wells (12MWT49 and 12MWT50) are located on the southeast side of SWMU 12 and they were drilled down into Mississippian limestone. In well 12MWT49, the top of the limestone was encountered at an elevation of 608 feet amsl, which is approximately 16 feet higher in elevation than at Dump Site A. As described previously, the Pennsylvanian-Mississippian unconformity decreases in elevation toward the west. The six wells on the southwest side of SWMU 12 and the two wells on the southeast side of SWMU 12 together are grouped together as wells that monitor the Glen Dean Limestone of Mississippian age (Mgd).

The Glen Dean Limestone is only about 20 to 30 feet thick at the most, when it was not eroded at the Pennsylvanian-Mississippian unconformity or as a result of post-Pennsylvanian erosion (Figure 4-3). Based on the general geology of NSWC Crane, the Big Clifty Sandstone and Beech Creek Limestone should be present in the deepest parts of the unnamed creeks and Turkey Creek valley bottom. The valley bottom also has a veneer of alluvium that overlies the Mississippian rock (see Figure 4-4), but the thickness and the coarseness of the alluvial deposits are unknown.

4.5 SOILS

A veneer of natural soil blankets the top and the sideslopes of the MFA ridge. The soils are the result of Pennsylvanian-age rocks (mostly sandstone, shales, and siltstone) weathering in place. These residual soils derived from Pennsylvanian rock are the most prevalent soils at NSWC Crane. The maximum thickness of residual soil (14.5 to 17 feet) was found at monitoring wells 12MWT40 and 12MWT44 on the southwest side of SWMU 12 (Figure 4-6). The residual soils on the ridgetop and sideslopes consist predominantly of fine materials, including varying amounts of clay, silt, and sand.

4.6 HYDROGEOLOGY

The maximum thickness of soil encountered on the ridgetop or sideslopes of MFA was 17 feet in 12MWT44 (Figure 4-6). Elsewhere, the residual soil was generally less than 10 feet thick. While drilling through the overburden on top of the ridge, no saturated conditions or flowing water was observed in the soil, which is the most common condition. Therefore, it is concluded that very little if any groundwater is stored at the interface between bedrock and overburden. Surface water located in drainage gullies is not hydraulically connected to the bedrock groundwater; therefore, water elevations measured at staff gauges on top of the ridgetop (12SG01 through 12SG07, Figure 2-3) are not considered during preparation of the potentiometric surface maps for the Upper Pennsylvanian water-bearing zone. The surface water at these locations is believed to be perched on top of the clayey residual soils overlying the bedrock surface.

In general, the ridgetop sandstone aquifer (Puz) is recharged by downward infiltration through the residual soil, and recharge occurs more readily where the soil is thin or disturbed and supplanted with fill material.

Depth to groundwater and groundwater elevations were measured on three different occasions, and data are listed in Table 2-2. The first set of water levels were measured in October 2004 before all of the 51 RFI monitoring wells were installed. The second set of water levels was collected in December 2004 after the 51 wells were installed. The third set of water levels were measured in January 2005; this data set included the measurement of water levels in all accessible wells at SWMU 9 (Pesticide Control Area) and SWMU 25 (Dump Site A) which lie to the west and southwest of SWMU 12. The third set of water levels is the most comprehensive and includes wells from a much wider area. The third data set (i.e., January 18, 2005) was used to prepare potentiometric surface maps that are discussed below. Notice in Table 2-2 that the water levels measured in specific wells generally did not vary by more than a foot or two over the three rounds of measurements. Hence, it is felt that the third round of measurements is representative for the time period in which the measurements were made (i.e., late fall and winter months).

Figure 4-10 presents the potentiometric surface for the uppermost sandstone unit (Puz) measured in January 2005. The highest elevations (731 to 733 feet amsl) were measured in six monitoring wells at the far northwest end of SWMU 12. Two ridges of higher groundwater elevations extend from the groundwater high at the north end of Figure 4-10. The larger more pronounced ridge runs southeast along the centerline of the SWMU 12 ridgetop through wells 12MWT16, 12MWT17, AND 12MWT23. The groundwater elevations decrease gradually from 733 down to 711 along this groundwater ridge. To the northeast and southwest of this groundwater ridge, the groundwater elevations decrease rather rapidly to

the sides of the ridge. Shallow groundwater on the northeastern side of this groundwater ridge flows to the northeast and shallow groundwater on the southwestern side of the ridge flows southwest. A line representing the approximate crop line of the upper sandstone unit (i.e., the Puz) is shown on Figure 4-10 and indicates the area within which the Puz is found. The Puz is absent at elevations below this line (i.e., less than 695 feet amsl). All shallow groundwater in the Puz is presumably flowing toward the crop line and discharging to the gullies that are incised on the northwestern and southeastern sides of the ridge or discharging to the soils and gradually evaporating. The hydraulic gradients in the Puz steepen as the sideslopes of the ridge are approached.

A second ridge extends from the northern high area toward the southwest through SWMU 9. The centerline of this ridge passes near wells 09T01, 09-01, 09WTP6, and 09-10. The groundwater elevations decrease gradually along the crest of the groundwater ridge from a high of 732.75 feet amsl at well 12MWT28 down to 723.27 feet amsl at well 09-10. The groundwater elevations decrease more rapidly toward the sides of the topographic ridge to the northwest and east of SWMU 9. In other words, the shallow groundwater potentiometric surface is mimicking topography. Figure 4-10 includes arrows which depict the approximate lateral flow directions in the Puz. Groundwater is flowing toward the cropline on the sides of the ridges. As mentioned above, a line around the ridges has been added to show the approximate base of the Puz where it intersects the ground surface at about 690 to 695 feet amsl. Notice in Figure 4-10 that the groundwater flow arrows on the western side of SWMU 12 ridge and the eastern side of the SWMU 9 ridge are flowing in almost opposite directions toward the same unnamed creek. In general, shallow groundwater throughout NSWC Crane is found to be flowing toward the nearest incised gulley or creek.

Figure 4-11 shows groundwater elevations measured in the 10 monitoring wells screened in the second major sandstone unit (i.e., the Pmz) on January 18, 2005. This map covers only the SWMU 12 area, because no wells at SWMUs 9 or 25 are screened in the Pmz. Like the groundwater in the Puz, the highest groundwater elevation in the Pmz was found at the northwestern end of SWMU 12 (698.69 ft amsl at well 12MWT33). In addition, a groundwater ridge in the Pmz also extends from the northwest end of the SWMU toward the southeast. Groundwater elevations decrease toward the southeast and toward the southwest from the groundwater ridge. The lowest groundwater elevations in the Pmz were measured in wells 12MWT30 (634.90 ft amsl) on the southwest side of SWMU 12 and 12MWT48 (619.64 ft amsl) on the southeast side of SWMU 12. These groundwater elevations are approaching the base of the second sandstone unit (i.e., Pmz) which lies at approximately 610 to 615 feet amsl. Groundwater in the Pmz, like the Puz, should be discharging to the hillside but at a lower elevation. Groundwater discharge around the hillsides has not been verified yet in the field. Arrows on Figure 4-11 show the approximate flow direction for groundwater in the Pmz.

Only two wells were screened in the lower Pennsylvanian rock strata. However, a total of eight wells at SWMUs 9 and 12 are screened in the Glen Dean Limestone or immediately above or below the Glen Dean Limestone, which is the Mississippian formation lying directly below the Pennsylvanian rocks. These wells have been grouped together and are used to represent the flow system within the Glen Dean Limestone (i.e., Mgd). Water levels measured in these eight wells are presented in Figure 4-12 and are contoured to show the approximate flow groundwater flow direction in this limestone. Groundwater flow in the Mississippian limestone is moving toward the south and southeast toward Turkey Creek and the lowest reaches of the two unnamed tributaries. Note that the limestone crops out above the creek level, so the groundwater is discharging either to the ground surface along the creeks or into the alluvium which blankets the valley bottom. This suggests that Turkey Creek and perhaps the lower reaches of the two unnamed tributaries might have perennial flow in them or at least flow most of the year.

During the RFI, slug tests were performed on 14 monitoring wells screened in the Puz and five monitoring wells screened in the Pmz. In many cases, a rising head and falling head test were performed on each well. In six of the wells, only a falling head test was performed (usually because the well was very slow to recover). In four of the wells, only a rising head test was performed because the water levels in the wells were below the top of the screens (which introduces error in evaluating a falling head test). The raw data, data analysis procedures, graphs of the data, and analytical results for each test are presented in Appendix E.1. A summary of the results of slug tests performed on select monitoring wells are presented in Table 4-2. The hydraulic conductivities (K) for the Puz monitoring wells ranged from 0.0037 to 3.7 feet per day (1.3E-06 to 1.3E-03 centimeters per second [cm/s]). The median hydraulic conductivity for the shallow bedrock was approximately 0.34 foot per day (1.2E-04 cm/s). The large variation in hydraulic conductivities determined for the Puz was not surprising because the sandstone and siltstone unit ranges from partially weathered to highly weathered, and from massive (with little fracturing) to highly fractured.

Horizontal hydraulic gradients were calculated graphically at several locations for the Puz (see numbered flow arrows on Figure 4-10). The gradients were very steep (0.08 to 0.1) in the northeast portion of SWMU 12 represented by flow arrows 1 and 2, steep (0.05) along the northwest side of SWMU 12 represented by flow arrow 4, and moderately steep (0.044) on the southeast and southwest sides of SWMU 12 as represented by flow arrow 3 (Figure 4-10). Using the median hydraulic conductivity value for the Puz of 0.34 foot per day and an estimated porosity of 0.10 for the weathered sandstone, values of linear groundwater velocity were estimated for the Puz. These values ranged from 0.15 to 0.34 foot per day. Along the centerline of the ridge, the hydraulic gradients are relatively low and linear groundwater velocities are therefore much less. The gradients become steepest near the outer edges of the ridge where the Puz approaches its crop line. The groundwater velocities therefore increase as the

groundwater approaches the outer edge of the ridge (i.e., its discharge zone). All assumptions, data, and calculations for linear groundwater velocities are presented in Appendix E.2.

The K values for the Pmz monitoring wells (Table 4-2) ranged from 0.01 to 0.37 feet per day (3.7E-06 to 2.0E-05 cm/s) in four of the five wells tested. A very large hydraulic conductivity was calculated for the slug tests performed on the fifth Pmz well, 12MWT47 (62.4 feet per day, 0.022 cm/s). The well log indicates that sandstone is present in the screened interval and it is extensively fractured. This likely explains the unusually high hydraulic conductivity value calculated for this well. The median K value for the Pmz was actually about 50 percent of the median value determined for the Puz monitoring wells.

Horizontal hydraulic gradients were calculated graphically at several locations for the Pmz (see numbered flow arrows on Figure 4-11). The gradients are very steep (0.266) to the east of SWMU 12 as represented by flow arrow 1, steep (0.09) to the east and southeast of SWMU 12 represented by flow arrow 2, and moderately steep (0.066) on the southwest side of SWMU 12 as represented by flow arrow 3 (Figure 4-11). Using the median hydraulic conductivity value for the Pmz of 0.17 foot per day and an estimated porosity of 0.05 for the unweathered sandstone, values of linear groundwater velocity were estimated for the Pmz. These values ranged from 0.22 to 0.90 foot per day. Along the centerline of the ridge and on the south side of SWMU 12, the hydraulic gradients are relatively low and linear groundwater velocities are therefore much less. The gradients become steepest near the outer edges of the ridge where the Pmz approaches its crop line. The groundwater velocities therefore increase as the groundwater approaches the outer edge of the ridge (i.e., its discharge zone). All assumptions, data, and calculations for linear groundwater velocities are presented in Appendix E.2.

Horizontal hydraulic gradients were calculated graphically at several locations for the Mgd (see numbered flow arrows on Figure 4-12). The gradients are very steep (0.16) to the east and southeast of SWMU 12 (as represented by flow arrow 1) and near Dump Site A, and steep (0.064) to the southwest of SWMU 12 as represented by flow arrow 2 (Figure 4-12). Hydraulic conductivity values have not been measured for the Glen Dean Limestone or for the strata at the base of the Pennsylvanian. A K value of 1.0 foot per day and a porosity of 0.02 were used to estimate linear groundwater flow velocities at select locations in the Mgd. These values ranged from 3.2 to 8.0 feet per day. Along the centerline of the ridge and SWMU 12 and on the south side of SWMU 12, the hydraulic gradients are relatively low and linear groundwater velocities are therefore much less. The gradients become steepest near the outer edges of the ridge where the Mgd approaches its crop line. The groundwater velocities therefore increase as the groundwater approaches the outer edge of the ridge (i.e., its discharge zone). All assumptions, data, and calculations for linear groundwater velocities are presented in Appendix E.2.

Most of the groundwater within the ridge is flowing laterally eastward, southward, and westward from the centerline of the ridge. Some groundwater is likely flowing from the upper sandstone unit (Puz) downward to the second sandstone unit (Pmz) and finally down to the lowermost Pennsylvanian strata (Plz) and the Glen Dean Limestone (Mgd). The hydraulic heads measured in monitoring wells at SWMU 12 consistently drop in elevation as the elevations of the well screens decrease (Figure 4-13). This indicates that recharge occurs along the crest and along the upper slopes of the ridge; groundwater flow is mostly lateral with a small vertical component downward. The flow rates downward through the ridge are very low based on the following evidence:

- Much of the upper portion of the Pmz is dry; hence the groundwater in the Puz is perched and cannot move down to the Pmz very quickly. This strongly suggests that the aquitard between the Puz and Pmz is an effective barrier to downward groundwater flow.

- The fact that groundwater elevations decrease dramatically from top to bottom in the ridge (see Figure 4-13) indicates a large vertical hydraulic gradient exists, which reflects the low permeabilities of aquitard materials (i.e., shales and siltstones) that lie in between the Puz, Pmz, and Plz.

- Six different pairs of wells also indicate that a very large hydraulic head difference exists between the Puz and Pmz (see Figure 4-14). The average head difference between the wells in the Puz and the wells in the Pmz in January 2005 was 53 feet. The same approximate drop in hydraulic head occurs between the Pmz and the Mgd.

In section 5.0, the results of groundwater sampling will be presented. Most contaminants in groundwater in the Puz were not detected or were detected in very low concentrations in the Pmz. This information further corroborates the conceptual flow model for groundwater at this site; i.e., that groundwater within the ridge is mostly perched and flows laterally toward the outside edges of the ridge. Very little groundwater is moving downward through the core of the ridge beneath MFA.

4.7 DEMOGRAPHY AND LAND USE

The economic base of communities surrounding NSWC Crane is in transition from agriculture, mining, and quarrying to manufacturing and service industries. The patterns of settlement, population statistics, and median income are similar throughout the region. Because most of the region is covered by vegetation, the area is classified as rural.

There is no state or local planning within the vicinity of NSWC Crane. The only zoning and land use regulations are in the municipalities in the region. None of the municipalities are close enough to impact NSWC Crane. None of the areas adjacent to NSWC Crane are zoned, and zoning is not anticipated in the near future. No known land use or community actions are being considered or proposed at this time.

4.8 ECOLOGY

NSWC Crane is a heavily forested facility situated within the Western Mesophytic Forest Region, Hill Section, and Beech-Maple Forest Region (Braun, 1950). Lindsey et al. (1970) further subdivided the area of the installation into the south-central Oak and Mixed Woods Division, including the Beech-Maple and the Beech-Oak-Maple-Hickory sub-elements. Deam (1940) classified the portion of Martin County in which the facility is located as consisting of the Chestnut Oak Upland based on the dominant floral components at that time. More recently, Kuchler (1964) mapped this portion of Indiana and classified it as belonging to two distinct vegetation classes, the Oak-Hickory and the Beech-Maple forest components of the Broadleaf Forest Classification. This latter classification most closely resembles the current floristic components observed at the facility.

NSWC Crane contains old agricultural fields in various stages of biological succession. Openings on dry upland sites contain almost pure stands of grasses with some clumps of woody plants such as persimmon, sassafras, and sumac. Areas that tend to be wetter have river birch, willow, sycamore, and cottonwood. Hillside communities include hickory, white and black oak, red maple, sugar maple, tulip poplar, ash, and beech (NEESA, 1983). Cleared areas at the facility have various stages of grassland, old field, and scrub/shrub vegetational forms present. Dominant tree species include black oak, white oak, pignut hickory, and yellow poplar. These stands are relatively young, with the average tree diameter ranging from 6 to 12 inches. Shrubs are present in these areas, and leaf litter, limbs, and saplings cover the understory.

The wildlife habitats and vegetation types present at NSWC Crane (including many stages of forest succession, streams, ponds, Greenwood Lake, and grassy open spaces) support a diverse terrestrial and aquatic fauna. The abundance of wildlife is mainly due to the mixture of landforms and vegetation types that occur over the installation. In addition, the lack of agricultural pressures has enhanced wildlife abundance and served to provide an installation-wide "wildlife enclosure" condition. There is an adequate amount of forage materials, concealment opportunities, and shelter locations to support a highly diverse wildlife community at the site.

Terrestrial habitats (i.e., wooded and grassy areas) near the sites may provide shelter and food sources for various species of mammals such as white-tailed deer, coyote, red fox, rabbits, raccoons, and mice and for birds such as ducks, geese, wild turkey, bobwhite quail, red-tailed hawks, and American robins.

The white-tailed deer is the most conspicuous large, wild mammal at the installation. Other mammals include opossum, raccoon, rabbits, mice, bats, chipmunks, squirrels, beaver, groundhogs, gray fox, coyotes, and long-tailed weasel. Fox, coyotes, and hawks are carnivores whose presence indicates a healthy ecosystem with smaller mammals present to provide a food source (NEESA, 1983).

The birds at NSWC Crane are diverse. Previous studies identified over 100 species present at the facility during breeding seasons (Hengeveld, 1987). Because the facility is largely forested, the species found consist predominantly of those that frequent wooded habitat types. Species of waterfowl also use the facility, especially in the vicinity of Greenwood Lake (Figure 1-2). A large number of bird species frequent the non-forested grassland, old field, and scrub/shrub vegetation present over portions of NSWC Crane. The bird population includes a number of threatened, endangered, or species of special concern that use NSWC Crane as their home range. These species include the bald eagle, osprey, sharp-shinned hawk, red-shouldered hawk, broad-winged hawk, black and white warbler, hooded warbler, and worm-eating warbler [Brown & Root Environmental, 1997].

Previous studies conducted at NSWC Crane (Nelson et al., 1987) identified 21 amphibian species and 22 reptilian species including skinks, lizards, snakes, and turtles.

A total of 46 distinct fish species were collected from the installation during a 1987 inventory of fish fauna at NSWC Crane. Other than Greenwood Lake, the 1987 study observed that the greatest number of individual fish species were recorded from the largest stream, Boggs Creek, and that the smallest number of species were recorded from Turkey Creek. Boggs Creek contained 29 species, including eight species of fish characteristic of large river-type systems. This included long-nose gar, paddlefish, bowfin, gizzard shad, ribbon shiner, big mouth buffalo, channel catfish, and flathead catfish. By contrast, the Turkey Creek survey yielded 16 species of fish, none of which were unusual to the area.

TABLE 4-1

ESTIMATED FLOW RATES AT SURFACE WATER SAMPLING LOCATIONS AND STAFF GAUGES
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Location	Estimated Flow Rate (gpm)			
	Round 1		Round 2	
	10/04 - 11/04		3/05	
Surface Water Sampling Station[1]				
12SW/SD01	0		3-5	
12SW/SD02	5-10		1-3	
12SW/SD03	1.4		0	ponded
12SW/SD04	0	ponded	5-10	
12SW/SD05	10-15		3-5	
12SW/SD06	5		< 1	
12SW/SD07	10-20	raining	Dry	
12SW/SD08	6		1-3	
12SW/SD09	70		101	
12SW/SD10	144		81	
12SW/SD11	0	ponded	90	
12SW/SD12	0	ponded	5-10	
12SW/SD13	NE		27	
12SW/SD14	NE		0	ponded
12SW/SD15	5-10	raining	Dry	
12SW/SD16	NE		485	
12SW/SD17	9		1-3	
12SW/SD18	5-10	raining	0	ponded
12SW/SD19	0	ponded	Dry	
12SW/SD20	1-5		1-2	
12SW/SD21	0	ponded	Dry	
12SW/SD22	< 1		Dry	
12SW/SD23	NE		180	
12SW/SD24	269		286	
12SW/SD25	NE		5,334	
12SW/SD26	76		3.4	
12SW/SD27	NE		3,817	
12SW/SD28	1-5	from pool	1.5	
12SW/SD29	1-5	raining	Dry	
12SW/SD30	12	raining	Dry	
12SW/SD31	NA		1-5	
12SW/SD32	NA		3-5	
12SW/SD33	NA		5-10	
12SW/SD34	NA		1	
12SW/SD35	NA		0	
12SW/SD36	NA		1-2	
Staff Gauge	12/15/04		1/18/05	
12SG01	0	Stagnant	0	Dry
12SG02	0	Dry	0	Dry
12SG03	0	Stagnant	0	Dry
12SG04	0	Stagnant	0	Dry
12SG05	0	Dry	0	Dry
12SG06	224		1	
12SG07	15		3-5	
12SG08	44		116	
12SG09	295		225	
12SG10	6,265		8,960	
12SG11	4,704		6,048	
12SG12	73		215	

1 - See surface water sample log sheets for flow calculations or estimates; locations shown on Figure 2-3.
NE = flow rate not estimated or recorded.
NA = not applicable
gpm = gallons per minute.

TABLE 4-2

HYDRAULIC CONDUCTIVITIES OF GEOLOGIC MATERIALS BASED ON SLUG TESTS
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Monitoring Zone / Well No.	Screened Material	Horizontal Hydraulic Conductivity (K_h) (rising head, ft/day)	Horizontal Hydraulic Conductivity (K_h) (falling head, ft/day)	Average Horizontal Hydraulic Conductivity (Kh) (ft/day)	(cm/s)
Upper Pennsylvanian Water-Bearing Zone (Puz)					
12MWT01	coal, shale, and sandstone	3.767	3.611	3.6890	1.30E-03
12MWT03	sandstone, coal, and shaly sandstone	NA	0.0396	0.0396	1.40E-05
12MWT06	sandstone	NA	1.5120	1.5120	5.33E-04
12MWT08	sandstone	0.3363	0.5167	0.4265	1.50E-04
12MWT10	sandstone with shaley interbeds	0.509	0.0487	0.2789	9.84E-05
12MWT13	sandstone, coal, and silty sandstone	0.8206	0.7497	0.7852	2.77E-04
12MWT15	sandstone and silty shale	0.545	NA	0.5450	1.92E-04
12MWT17	sandstone	0.6003	NA	0.6003	2.12E-04
12MWT21	shaly sandstone, coal, and sandstone	0.3555	NA	0.3555	1.25E-04
12MWT23	sandstone with interbedded siltstone and shale	0.3237	NA	0.3237	1.14E-04
12MWT25	shaley sandstone	NA	0.0037	0.0037	1.32E-06
12MWT28	sandstone with some interbedded shale	NA	0.0135	0.0135	4.75E-06
12MWT36	sandstone	0.05023	0.1362	0.0932	3.29E-05
12MWT38	sandstone	0.02275	0.0515	0.0371	1.31E-05
			Median Value	0.3396	1.20E-04
Middle Pennsylvanian Water-Bearing Zone (Pmz)					
12MWT29	sandstone with minor shale interbeds	NA	0.0105	0.0105	3.69E-06
12MWT33	sandstone with interbedded siltstone	0.1653	0.1771	0.1712	6.04E-05
12MWT45	sandstone and siltstone	0.3137	0.4308	0.3723	1.31E-04
12MWT46	sandstone with weathered shale partings	NA	0.0568	0.0568	2.00E-05
12MWT47	sandstone	74.44	50.36	62.40	2.20E-02
			Median Value	0.1712	6.04E-05

NA = Not analyzed

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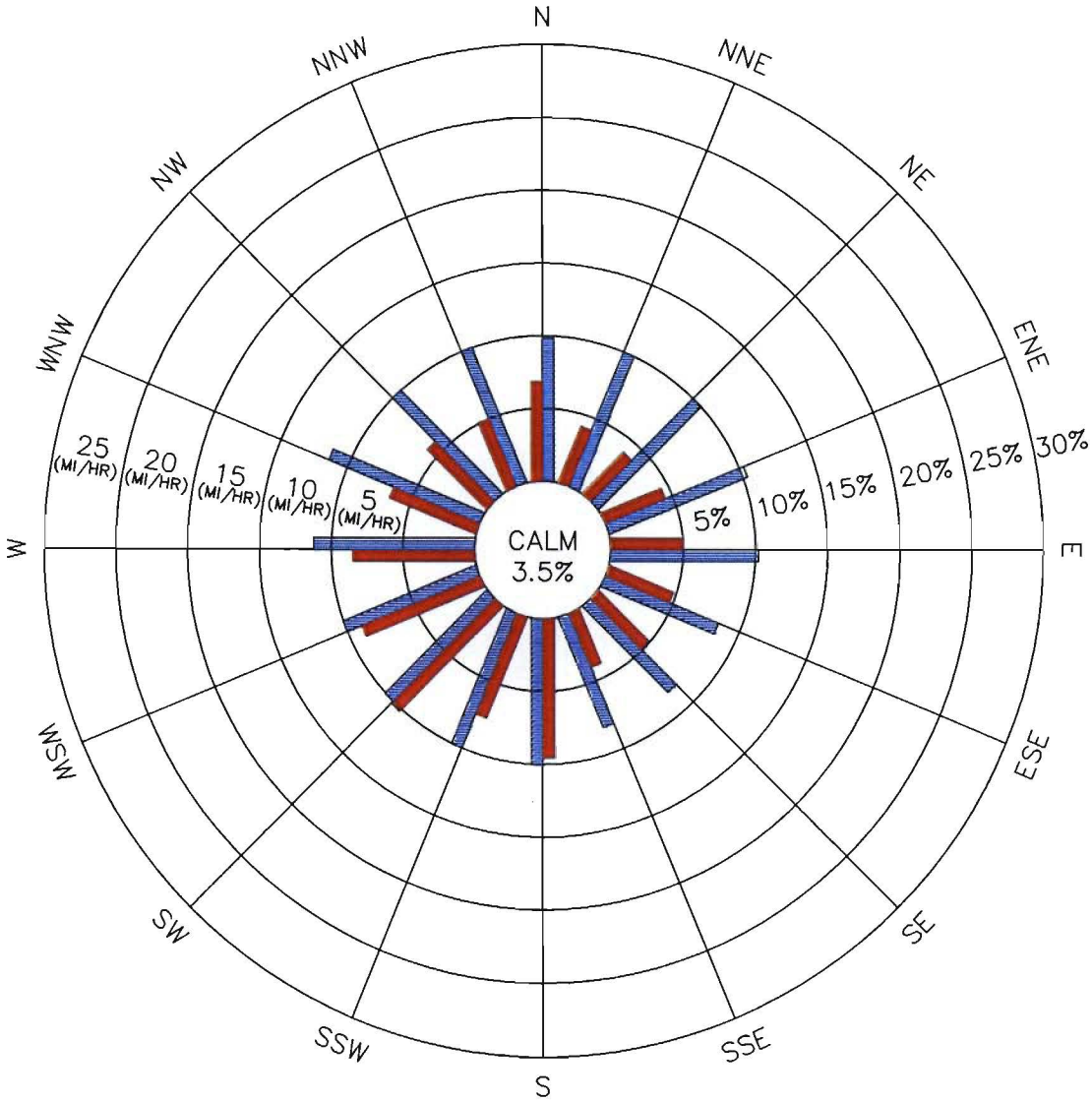

LEGEND:

WIND DIRECTION FREQUENCY (PERCENT)
(DIRECTION FROM WHICH THE WIND IS BLOWING)

MEAN WIND SPEED (MI/HR)

DATA SOURCE: INDIANAPOLIS, INDIANA AIRPORT

PERIOD OF RECORD: 1985–1989
43,824 OBSERVATIONS

DRAWN BY DM	DATE 6/1/05	FIVE-YEAR WIND ROSE SUMMARY FOR INDIANAPOLIS, INDIANA SWMU 12 MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NO. 6878
CHECKED BY	DATE		OWNER NO. 0000
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 4-1 / REV. 0

FORM CADD NO. SDIV-AV.DWG - REV 1 - 9/10/98

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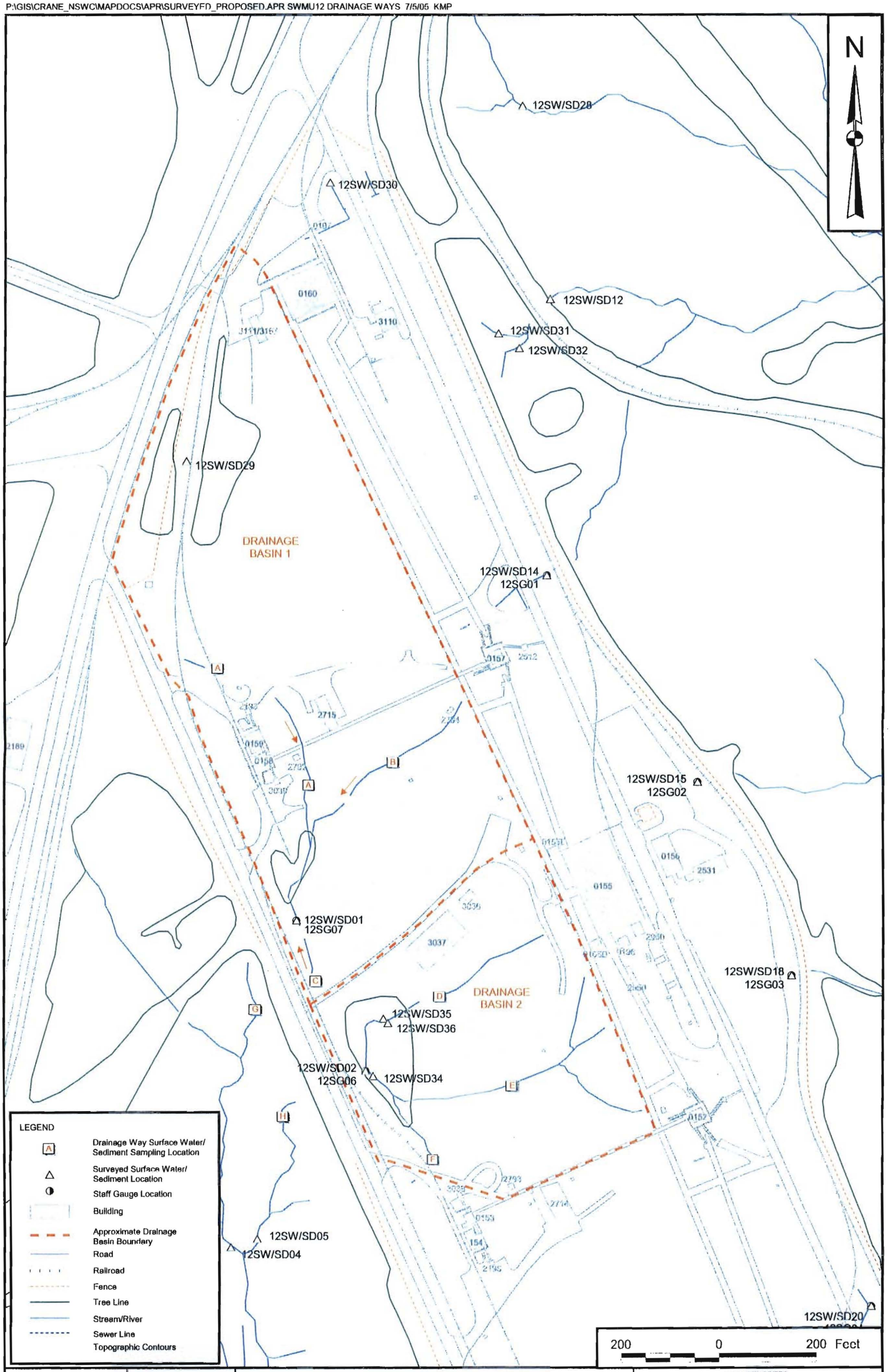

DRAWN BY	DATE
K. PEILA	7/5/05
CHECKED BY	DATE
J. SCHUBERT	7/5/05
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

NAVFAC

SMALL DRAINAGE WAYS AND DRAINAGE BASINS ON WEST SIDE OF MINE FILL A

SWMU 12 - MINE FILL A

NSWC CRANE

CRANE, INDIANA

CONTRACT NUMBER	
6878	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	
DRAWING NO.	REV
FIGURE 4-2	0

PERIOD	EPOCH	THICKNESS (FEET)	LITHOLOGY	FORMATION	GROUP
PENN-SYL-VANIAN	POTTS-VILLE	150–300		MANSFIELD FM.	"RACCOON CREEK"
MISSISSIPPIAN	CHESTER	20–30		GLEN DEAN LS	STEPHENS-PORT
		30–40		HARDINSBURG SS.	
		40–50		GOLCONDA LS.	
		25–40		BIG CLIFTY FM.	
		15–25		BEECH CREEK LS.	
		20–40		ELWREN FM.	WEST BADEN
		0–5		REELSVILLE LS.	
		20–40		SAMPLE FM.	
		10–20		BEAVER BEND LS.	
		12–30		BETHEL FM.	
	MERAMEC	15–20		PAOLI LS.	BLUE RIVER
		100–120		STE. GENEVIEVE LS.	
		100–120		ST. LOUIS LS.	
		90–100		SALEM LS.	SANDERS
		50–80		HARRODSBURG LS.	
	OSAGE	600–800		MULDRAUGH FM.	BORDEN

Source: Draft Report, RCRA Facility Investigation
Phase II Groundwater Release Assessment, SWMU 06/09
Demolition Area and Phase III Release
Characterization SWMU 07/09 Old Rifle Range
November 1995 - Figure 13
by William L. Murphy and Roy Wade

DRAWN BY K. PEILA	DATE 5/31/05	GENERALIZED STRATIGRAPHIC COLUMN SWMU 12 MINE FILL A AND SWMU 25 HIGHWAY 58 DUMP SITE A NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	CONTRACT NUMBER 6878 / OWNER NO. —
CHECKED BY J. LUCAS	DATE 5/31/05		APPROVED BY — / DATE —
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 4 - 3 / REV 0

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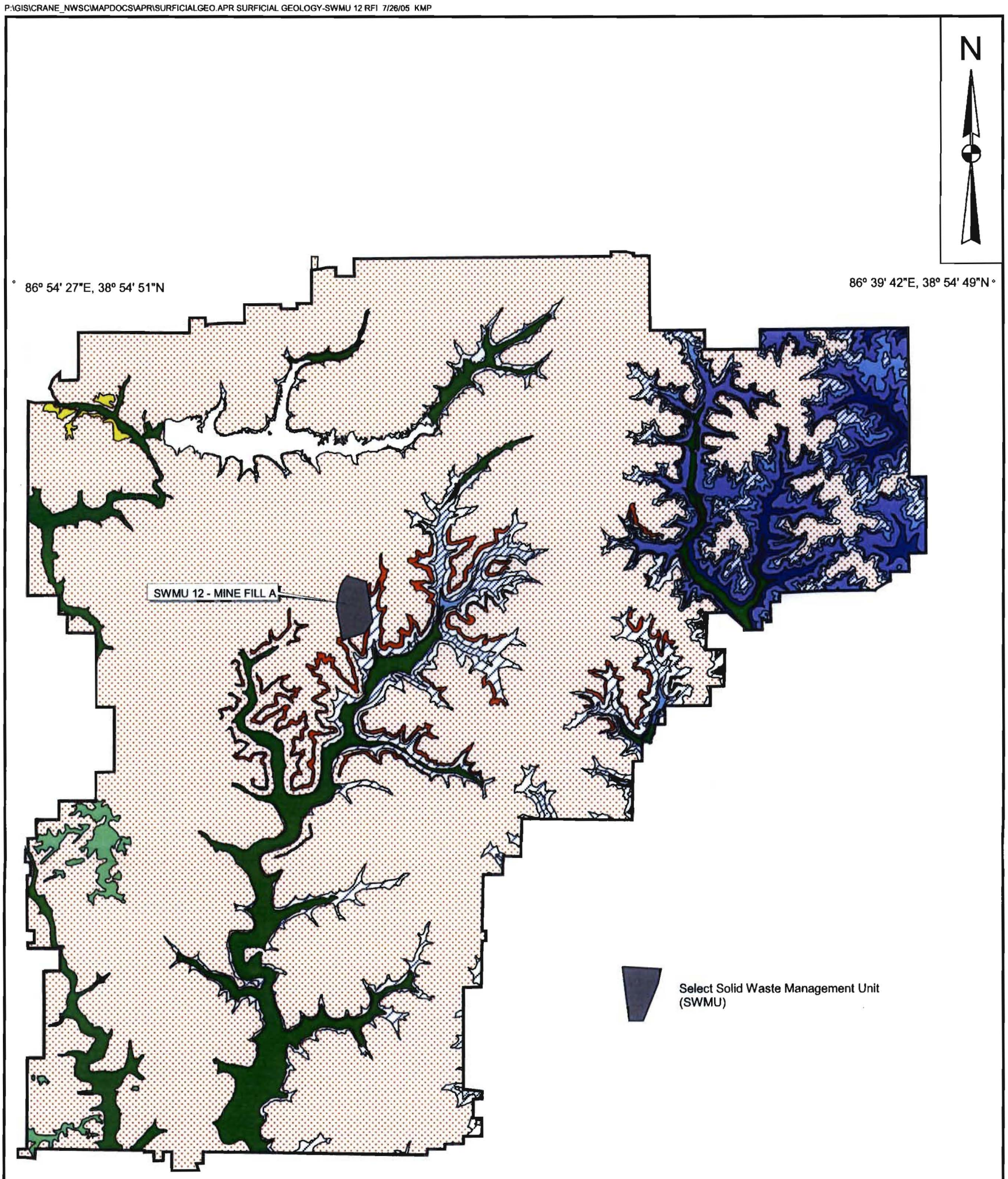

Inferred Depositional Environment	Explanation of Geology
Alluvium	*Alluvium*
Loess/Glacial Outwash	*Loess*
	Glacial Outwash
Residual Soil derived from Pennsylvanian bedrock/colluvium	*Raccoon Creek Group and undifferentiated*
	Sandstone-dominated horizon of Lower Pennsylvanian
Residual soil derived from Mississippian bedrock/colluvium	*Glenn Dean Ls, Hardinsburg Fm, Haney Ls, Indian Springs Shale Mbr, and undifferentiated*
	Sandstone member of the Big Clifty Fm
	Beech Creek Ls
	Elwren Fm, Reelsville Ls, upper Sample Fm, and undifferentiated
	Lower part of Sample Fm, Beaver Bend Ls, Bethel Fm, and undifferentiated
	Paoli Ls, Ste Genevieve Ls, and undifferentiated

Source: Background Soils Report. TtNUS 2001. (Modified from Blunck, 1995).

1.5 0 1.5 Miles

DRAWN BY	DATE
A. JANOCHA	7/09/03
CHECKED BY	DATE
J. LUCAS	4/20/04
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

NAVFAC

SURFICIAL GEOLOGY MAP
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER	CONTRACT NUMBER
6878	CTO 0357
APPROVED BY	DATE
—	—
APPROVED BY	DATE
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DRAWING NO.	REV
FIGURE 4 - 4	0

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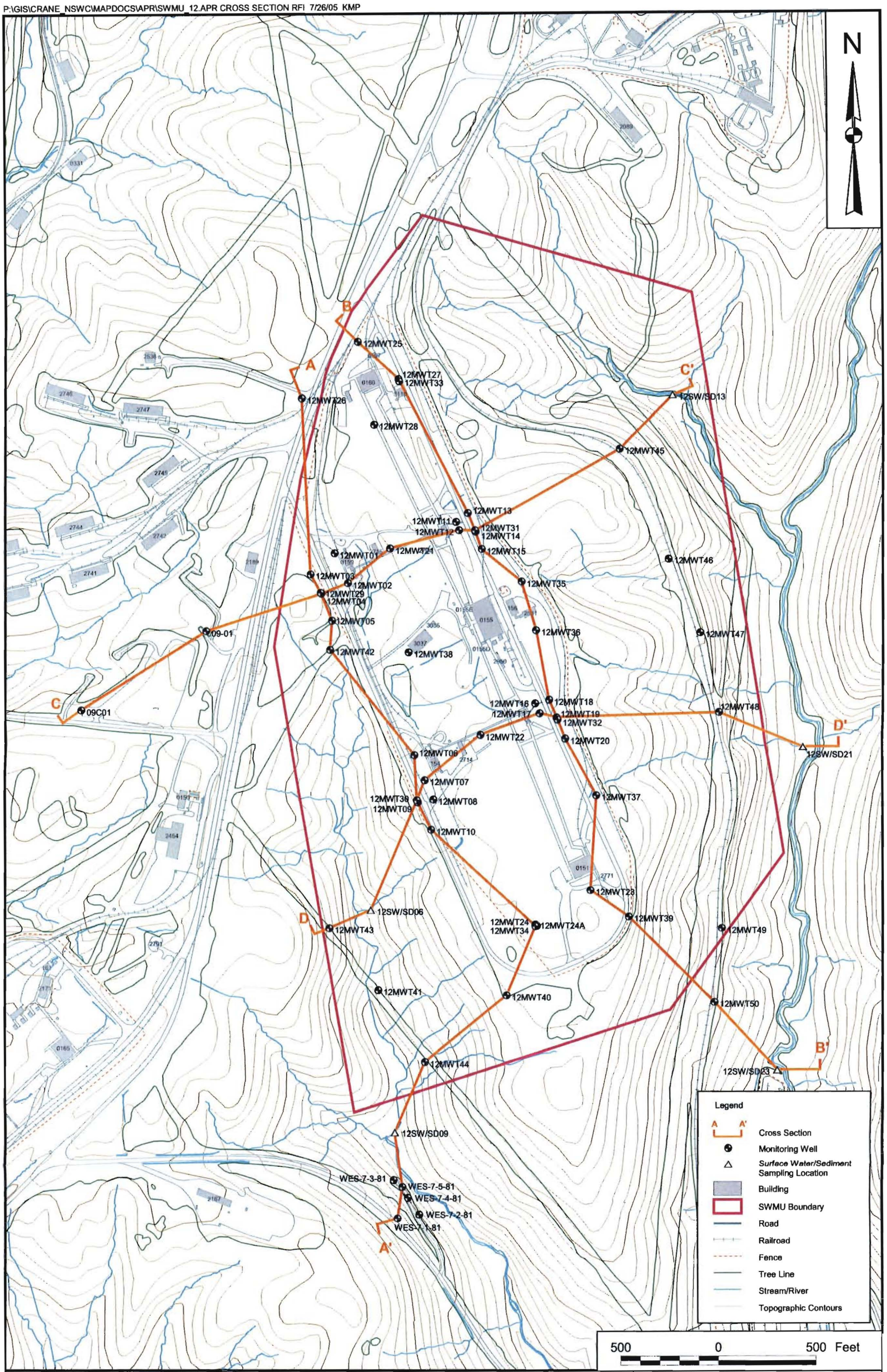
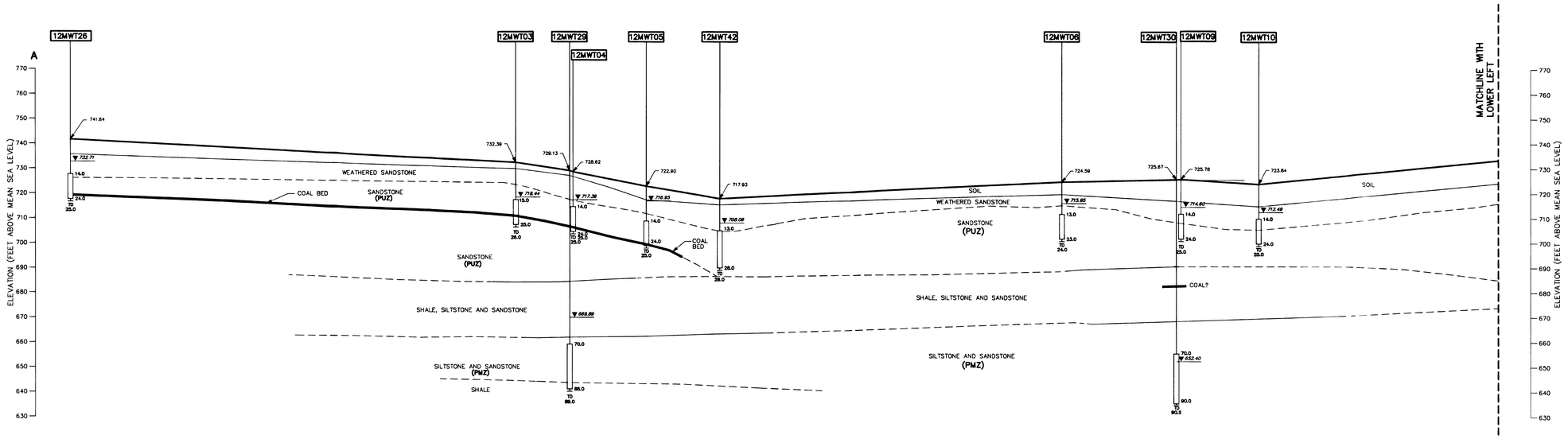
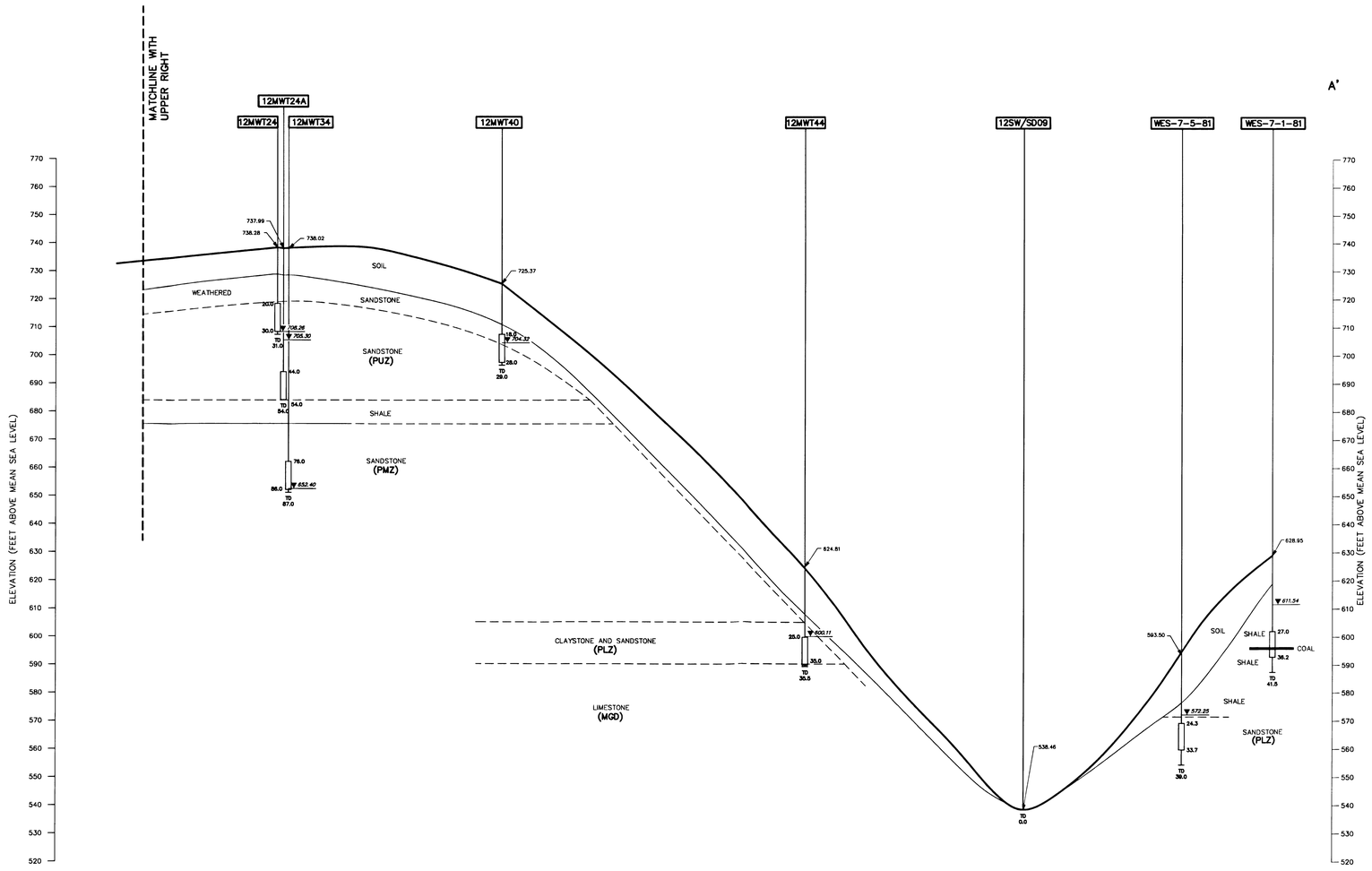


DRAWN BY C. FOSTER	DATE 04/25/05	CROSS SECTION MAP SWMU 12 - MINE FILL A NWSC CRANE CRANE, INDIANA	CONTRACT NUMBER 6878
CHECKED BY J. SCHUBERT	DATE 04/25/05		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 4 - 5 / REV 0





LEGEND:

MONITORING WELL OR BORING NUMBER — 12MWT26
GROUND SURFACE ELEVATION — 741.64
GROUND SURFACE
GROUNDWATER ELEVATION
TOP OF SCREEN INTERVAL (FT BGS) — 14.0
LITHOLOGIC CONTACT (INFERRED BETWEEN BORINGS)
BOTTOM OF SCREEN INTERVAL (FT BGS) — 24.0
TOTAL DEPTH OF WELL OR BORING (FT BGS) — TD 25.0

0 100 200 HORIZONTAL SCALE IN FEET
0 20 40 VERTICAL SCALE IN FEET

(PUZ) = UPPER PENNSYLVANIAN WATER-BEARING ZONE
(PMZ) = MIDDLE PENNSYLVANIAN WATER-BEARING ZONE
(PLZ) = LOWER PENNSYLVANIAN WATER-BEARING ZONE
(MGD) = MISSISSIPPIAN GLEN DEAN LIMESTONE

DRAWN BY DM	DATE 5/2/05	
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SCALE AS NOTED		

NAVFAC

GEOLOGICAL CROSS SECTION A-A'
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

CONTRACT NO. 6878	
OWNER NO. 0000	
APPROVED BY	DATE
DRAWING NO. FIGURE 4-6	REV. 0

FSRK CADD NO. 5SIV-E-STS.DWG - REV 0 - 9/4/98

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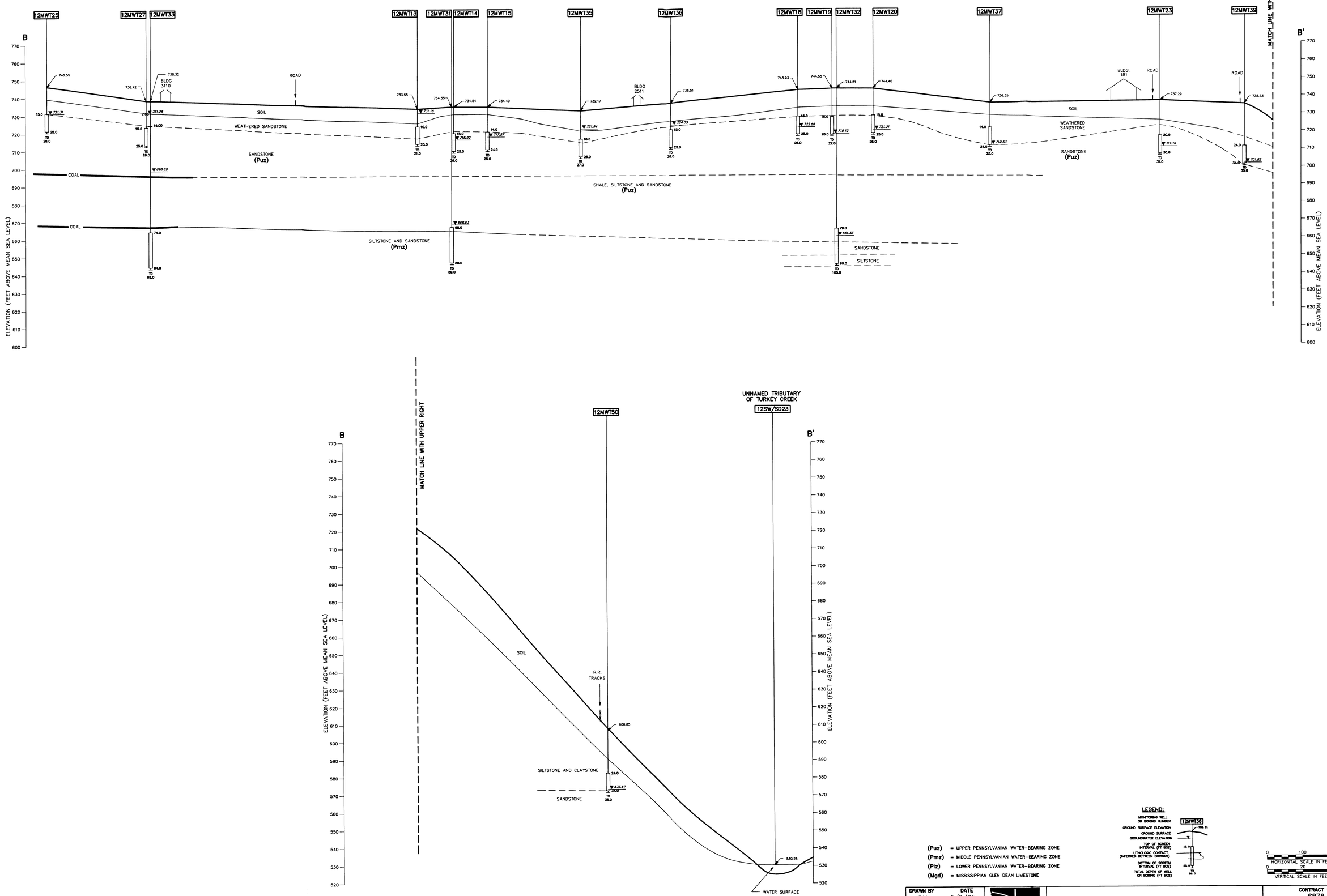


(Puz) = UPPER PENNSYLVANIAN WATER-BEARING ZONE
(Pmz) = MIDDLE PENNSYLVANIAN WATER-BEARING ZONE
(Plz) = LOWER PENNSYLVANIAN WATER-BEARING ZONE
(Mgd) = MISSISSIPPIAN GLEN DEAN LIMESTONE

LEGEND:

MONITORING WELL OR BORING NUMBER — 12MWT36
GROUND SURFACE ELEVATION — 736.91
GROUND SURFACE
GROUNDWATER ELEVATION
TOP OF SCREEN INTERVAL (FT BGS) — 15.0 ft
LITHOLOGIC CONTACT (INFERRED BETWEEN BORINGS)
BOTTOM OF SCREEN INTERVAL (FT BGS) — 25.5 ft
TOTAL DEPTH OF WELL OR BORING (FT BGS) — TD 26.0

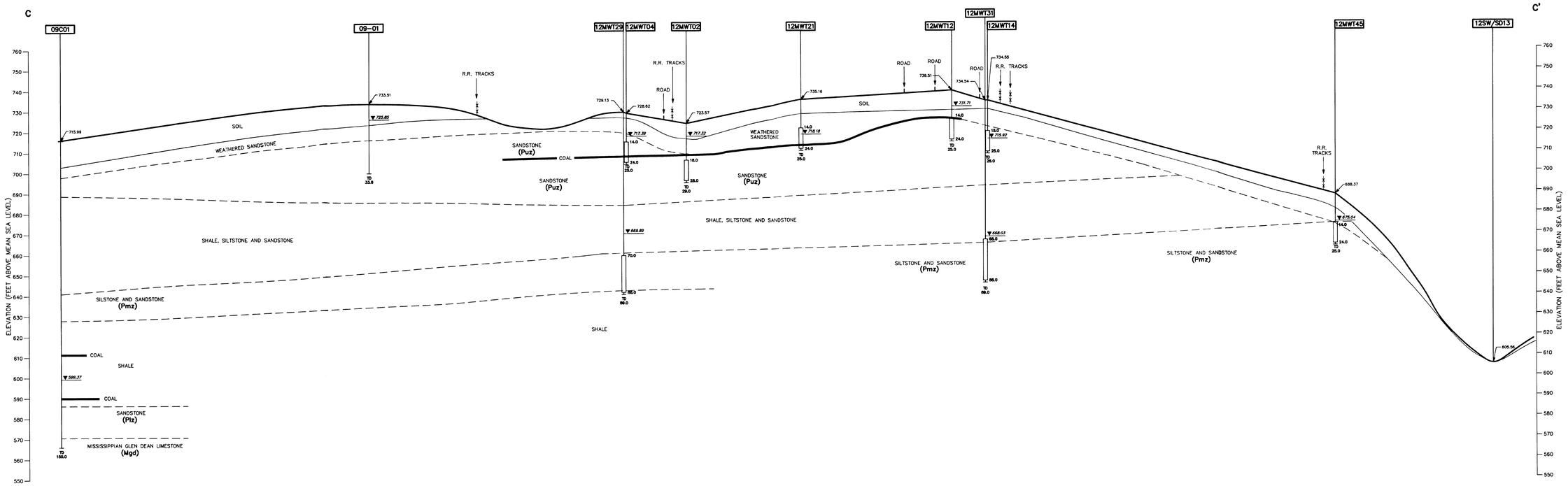
HORIZONTAL SCALE IN FEET: 0 100 200
VERTICAL SCALE IN FEET: 0 20 40

DRAWN BY DM	DATE 5/6/05	GEOLOGIC CROSS SECTION B-B' SWMU 12 MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NO. 6878
CHECKED BY	DATE		OWNER NO. 0000
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 4-7 / REV. 0

ACAD: 6878b2007.dwg 07/13/05 DM PIT

FIGURE 4-7 | REV. 0

FORM CADD NO. EEEV-C-STD.DWG - REV 0 - 9/4/98



(Puz) = UPPER PENNSYLVANIAN WATER-BEARING ZONE
(Pmz) = MIDDLE PENNSYLVANIAN WATER-BEARING ZONE
(Plz) = LOWER PENNSYLVANIAN WATER-BEARING ZONE
(Mgd) = MISSISSIPPIAN GLEN DEAN LIMESTONE

LEGEND:

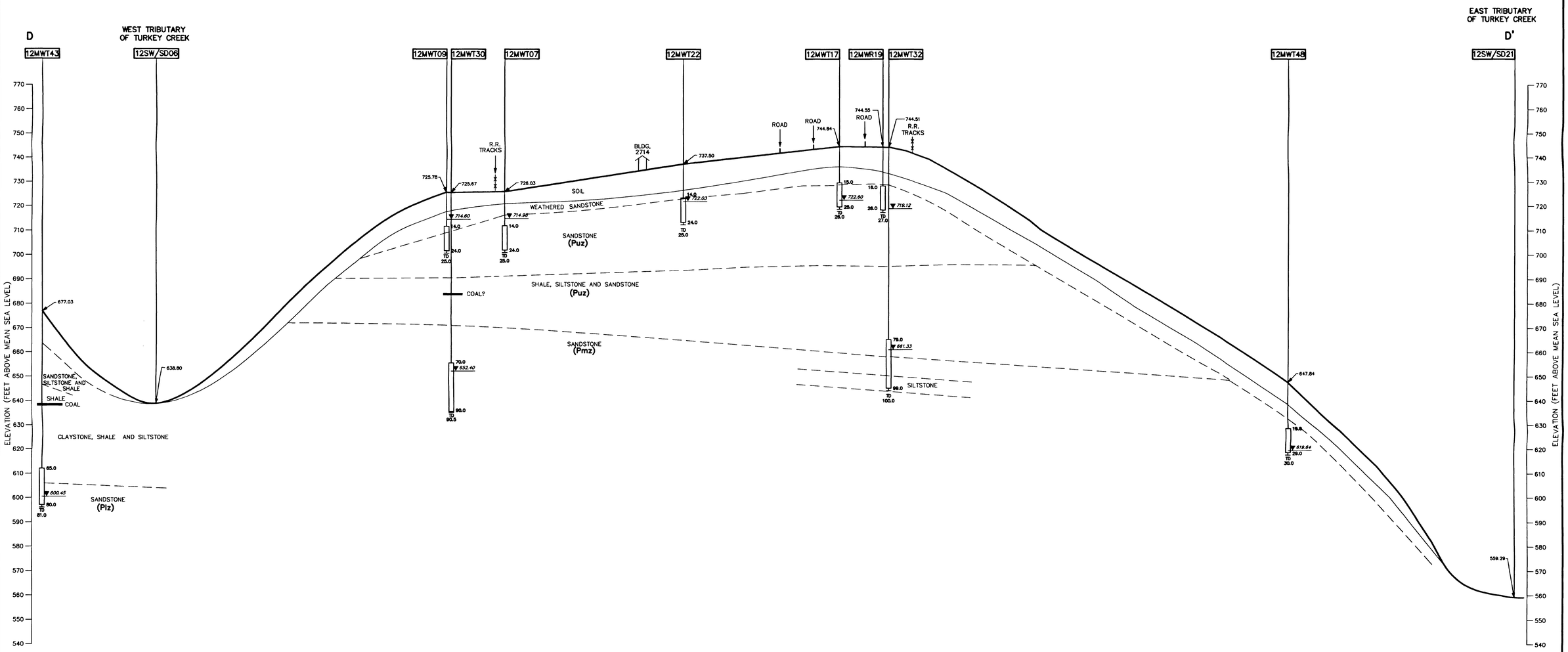
MONITORING WELL OR BORING NUMBER — 12MWT21
GROUND SURFACE ELEVATION — 735.16
GROUND SURFACE
GROUNDWATER ELEVATION
TOP OF SCREEN INTERVAL (FT BGS) — 14.00
LITHOLOGIC CONTACT (INFERRED BETWEEN BORINGS)
BOTTOM OF SCREEN INTERVAL (FT BGS) — 24.5
TOTAL DEPTH OF WELL OR BORING (FT BGS) — TD=25.0

HORIZONTAL SCALE IN FEET: 0 100 200
VERTICAL SCALE IN FEET: 0 20 40

DRAWN BY DM	DATE 5/6/05	GEOLOGIC CROSS SECTION C-C' SWMU 12 MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NO. 6878
CHECKED BY	DATE		OWNER NO. CTO
REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED		NAVFAC	DRAWING NO. FIGURE 4-8 / REV. 0

ACAD: 6878GX05.dwg 07/13/05 DM PIT

FIGURE 4-8 — REV. 0



LEGEND:

- MONITORING WELL OR BORING NUMBER — 24MWT5S
- GROUND SURFACE ELEVATION — 35.86
- GROUND SURFACE
- GROUNDWATER ELEVATION
- TOP OF SCREEN INTERVAL (FT BGS) — 4.00
- LITHOLOGIC CONTACT (INFERRED BETWEEN BORINGS)
- BOTTOM OF SCREEN INTERVAL (FT BGS) — 14.0
- TOTAL DEPTH OF WELL OR BORING (FT BGS) — TD=14.0

(Puz) = UPPER PENNSYLVANIAN WATER-BEARING ZONE
(Pmz) = MIDDLE PENNSYLVANIAN WATER-BEARING ZONE
(Plz) = LOWER PENNSYLVANIAN WATER-BEARING ZONE
(Mgd) = MISSISSIPPIAN GLEN DEAN LIMESTONE

0 100 200 HORIZONTAL SCALE IN FEET
0 20 40 VERTICAL SCALE IN FEET

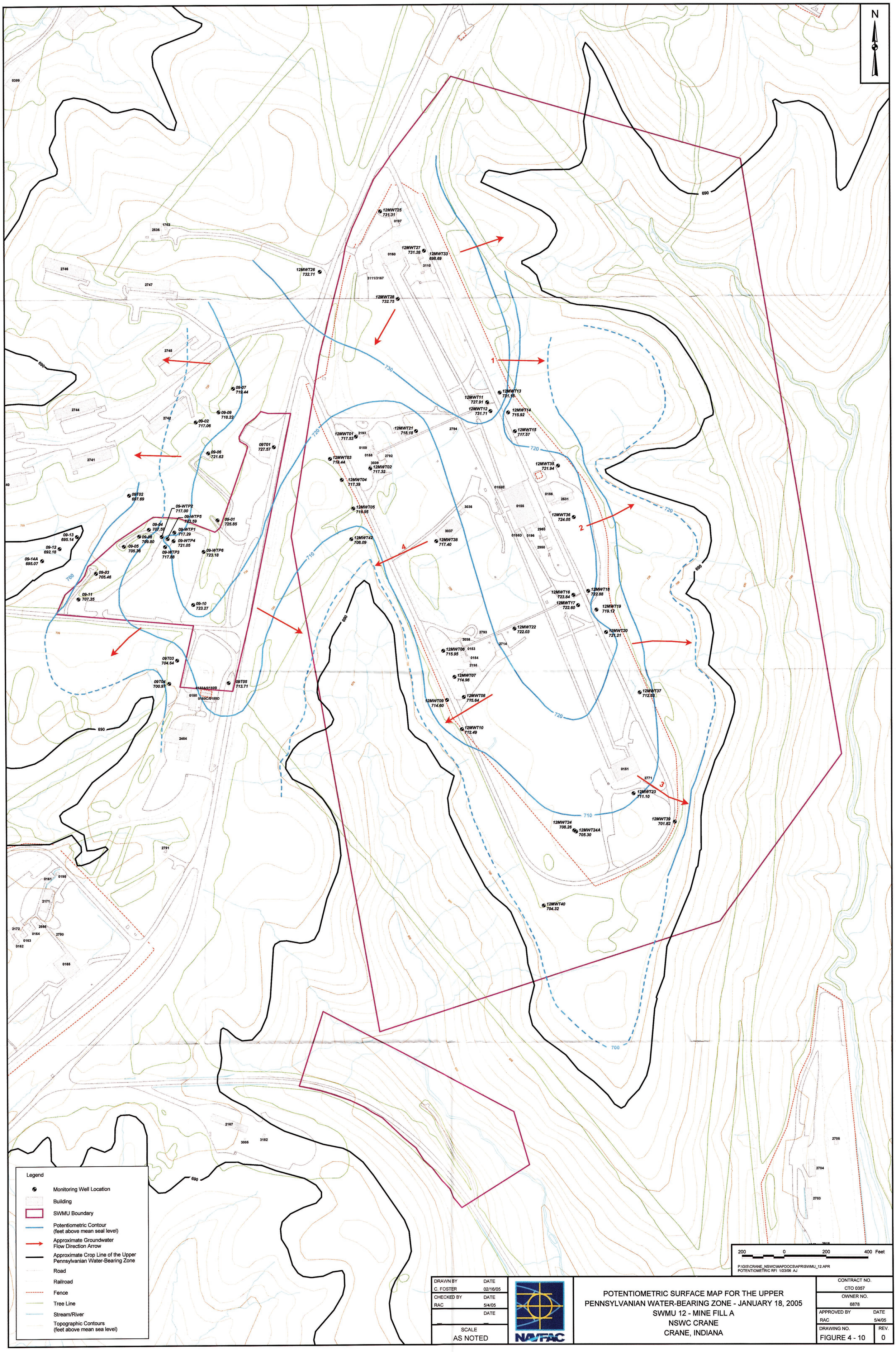
DRAWN BY DM	DATE 5/6/05	NAVFAC	GEOLOGIC CROSS SECTION D-D' SWMU 12 MINE FILL A NSWC CRANE CRANE, INDIANA
CHECKED BY	DATE		
REVISED BY	DATE		
SCALE AS NOTED			

CONTRACT NO. 6878
OWNER NO. CTO
APPROVED BY DATE
DRAWING NO. FIGURE 4-9
REV. 0

DRAWING NO. FIGURE 4-9
REV. 0

FORM CADD NO. SDIV-D-STD.DWG - REV 1 - 9/24/98

ACAD: 6878GX09.dwg 07/13/05 DM PIT



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C. FOSTER	02/16/05
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RAC	5/4/05
	DATE
SCALE	
AS NOTED	

NAVFAC

POTENTIOMETRIC SURFACE MAP FOR THE UPPER PENNSYLVANIAN WATER-BEARING ZONE - JANUARY 18, 2005
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

CONTRACT NO.	
CTO 0357	
OWNER NO.	
6878	
APPROVED BY	DATE
RAC	5/4/05
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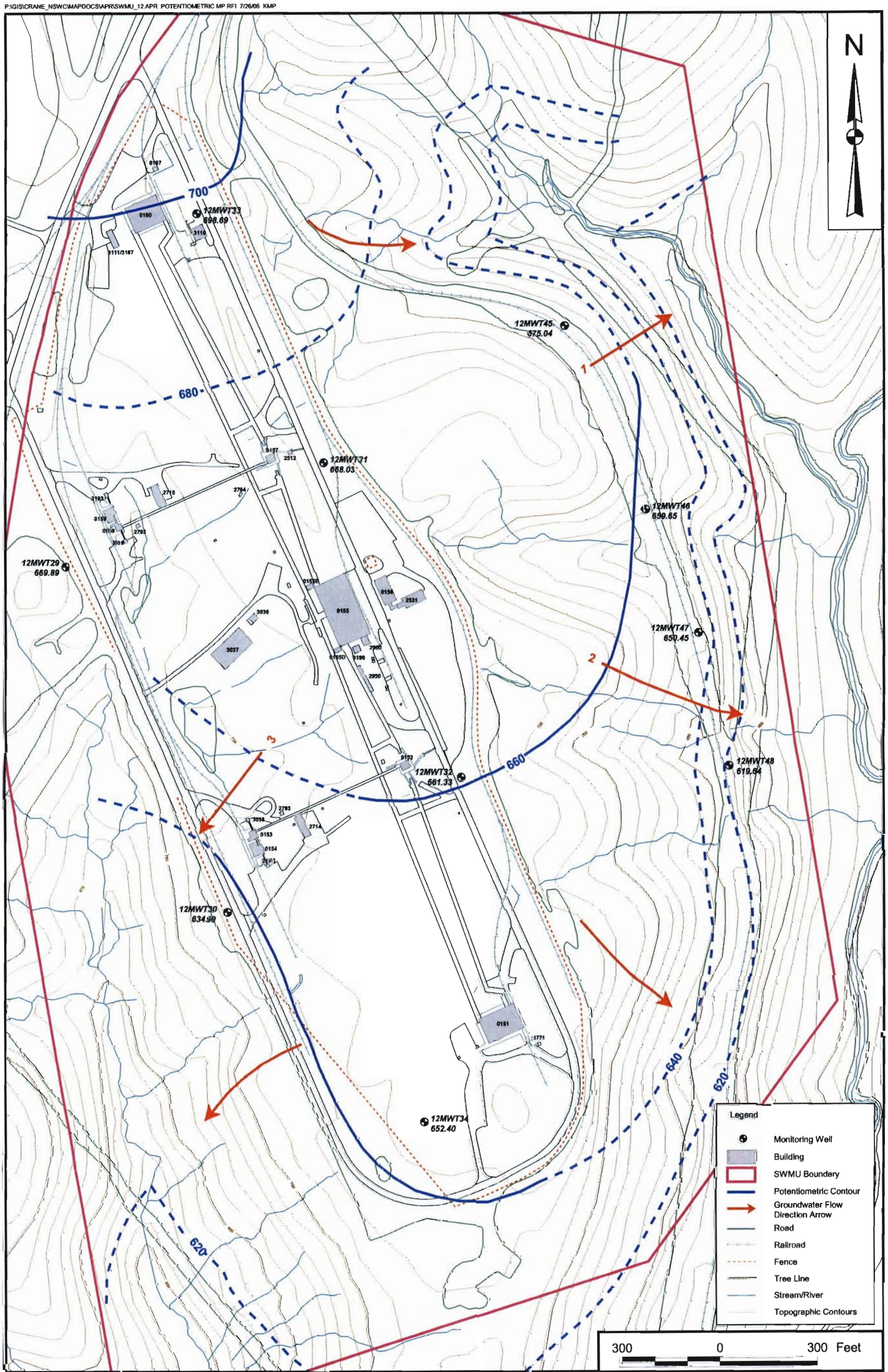
FIGURE 4 - 10	0

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU_12.APR POTENTIOMETRIC MP RFI 7/26/05 KMP



DRAWN BY	DATE
C. FOSTER	4/28/05
CHECKED BY	DATE
J. SCHUBERT	4/28/05
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

NAVFAC

POTENTIOMETRIC SURFACE MAP FOR THE MIDDLE PENNSYLVANIAN WATER-BEARING ZONE - JANUARY 18, 2005
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER	
6878	
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FIGURE 4 - 11	0

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CONTRACT NO. 6878

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DRAWING NO. FIGURE 4 - 12

REV 0

POTENTIOMETRIC SURFACE MAP FOR THE GLEN DEAN LIMESTONE (MISSISSIPPIAN) AQUIFER
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

NAVFAC

DRAWN BY C. FOSTER DATE 4/28/05

CHECKED BY J. SCHUBERT DATE 4/28/05

COST/SCHED-AREA

SCALE AS NOTED

FIGURE 4-13. GROUNDWATER ELEVATIONS IN MONITORING WELLS VERSUS WELL SCREEN DEPTH AT SWMU 12

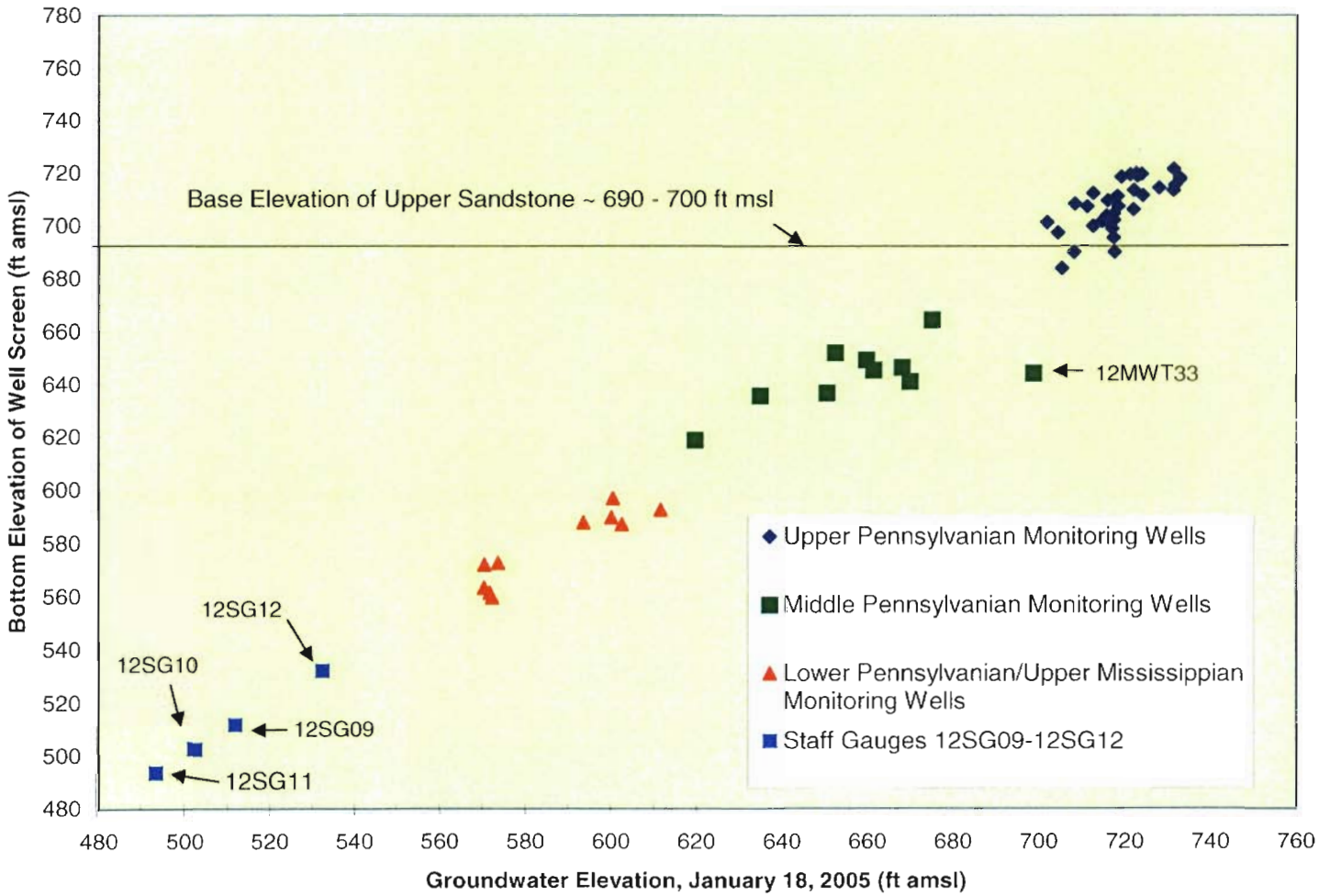
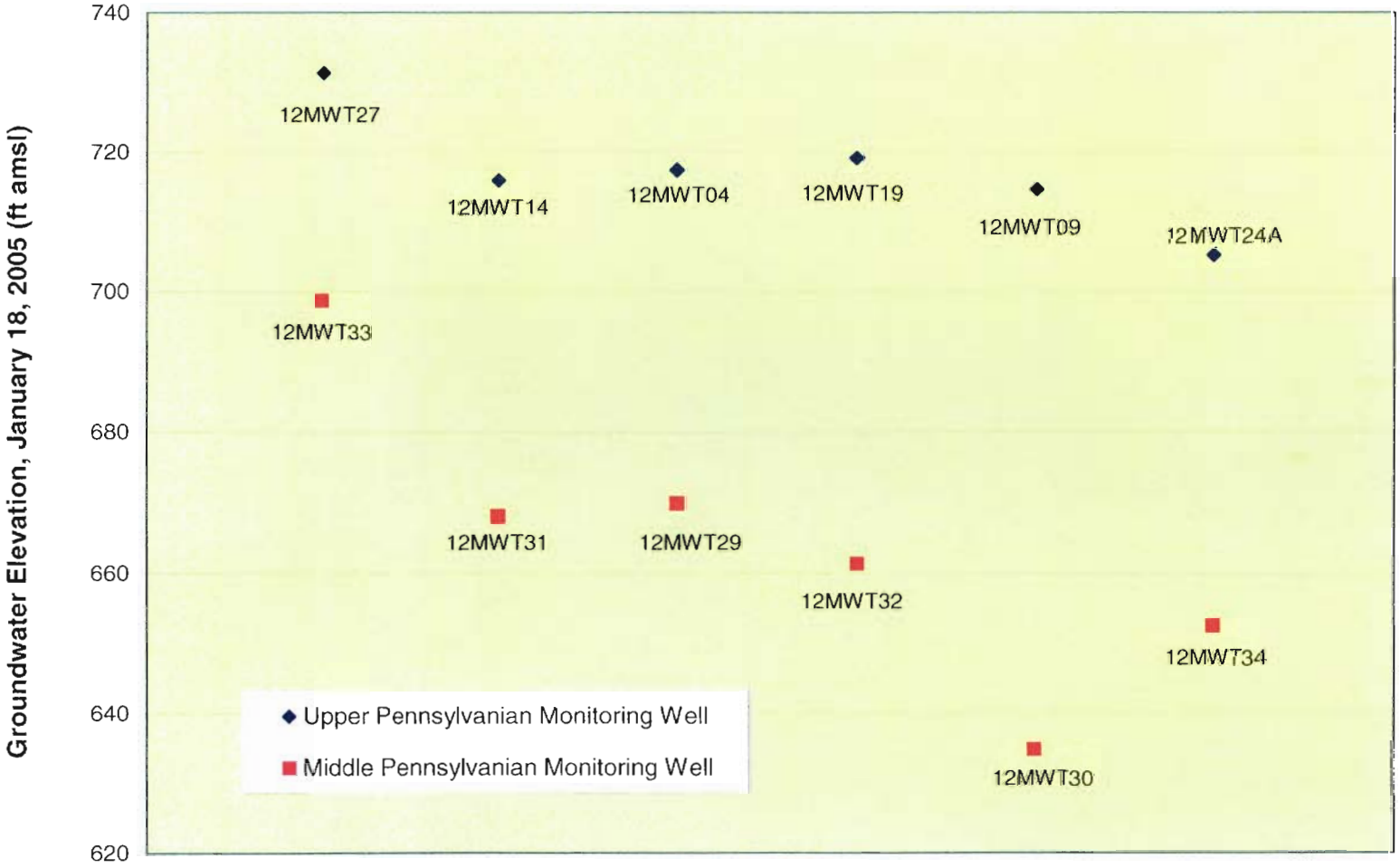


FIGURE 4-14. COMPARISON OF GROUNDWATER ELEVATIONS IN WELL PAIRS AT SWMU 12



5.0 NATURE AND EXTENT OF CONTAMINATION

This section describes the locations, spatial patterns, chemical forms, and concentrations of organic and inorganic chemical contaminants at SWMU 12. When feasible to do so, an attempt was made to identify which chemicals appear to be site-related contaminants and which do not. No evidence was found for the presence of pure phase organic liquids in any medium. One soil sampling location in the Battery Site exhibited a very high lead concentration (429,000 mg/kg) indicative of the presence of a metal salt or metal particle. Except for this one location, all references to chemical contamination in the following text are to contaminants that are dissolved in surface water or groundwater or that are most likely adsorbed to soil or sediment particulates.

The analyses conducted during this RFI are documented in Section 2.0 and summarized in Table 2-3. Data summary tables are presented in Sections 1.0 and 3.0 of this report. The Section 1.0 tables include data from the bioremediation effort; Section 3.0 Tables 3-1 through 3-73 include data from the RFI effort. The RFI effort included collection of samples for the ES/DI and delineation of metals contamination at the Battery Site. Complete results for all samples collected and analyzed for the bioremediation effort are available in the IMRs (MK, 1999 and TolTest, 2002). Complete data set for the RFI are presented in Appendix G tables (G-1 through G-8).

SWMU 12 RFI data sets were subdivided into groups that reflect areas of similar characteristics for particular environmental media. These groupings are described below and are identified in data tables where appropriate.

Organic chemical contamination is defined for this RFI as chemical concentrations that exceed human health or ecological screening values (SVs) and therefore are considered to potentially result in unacceptable human health or ecological risks. Exceedances of SVs are highlighted in the data tables (Tables 3-8 through 3-73, as applicable). Because organic chemicals were assumed not to occur naturally, detections of organic compounds at SWMU 12 were generally considered to be site related unless the site history and observed concentrations or concentration patterns indicated that the contaminants are from non-site-related sources. For example, chemicals such as methylene chloride or acetone are often detected and attributed to laboratory contamination. Other lesser used chemicals such as freons (chlorofluorocarbons), chloroform, and xylenes may also fit this description, depending on the laboratory and time period in which samples were analyzed. Laboratory contamination is often indicated by low concentrations of a chemical in field blanks or laboratory blanks and in multiple samples,

regardless of the origin of the samples. When present as a laboratory contaminant, the concentrations of the contaminating chemical appear to be relatively uniform in magnitude.

Metals contamination is tentatively defined as an exceedance of SVs; however, consideration is given to the natural occurrence of metals in environmental media. Concentrations of metals that are within normal background or upgradient levels are not considered to represent site-related contamination. Background and upgradient data sets used for these evaluations are described in Section 5.1.

Multiple chemicals of environmental interest were detected in multiple areas of SWMU 12 at concentrations greater than SVs. A discussion of all detected chemicals, however, is unnecessary when describing the nature and extent of contamination. Instead, the extent of contamination is best described using representative chemicals whose extent encompasses the extent of other chemicals. This reduces the complications associated with trying to track multiple chemicals when all chemicals have similar distribution patterns. Therefore, emphasis was given to chemicals that:

- Exceed chemical of potential concern (COPC) SVs (described and evaluated further in Sections 7.0 and 8.0).
- Are representative (based on chemical and physical properties) of a particular group of chemicals (e.g., explosives).
- Were detected multiple times and generally pervasive, thus representing the greatest extent of contamination for similar chemicals.
- Were detected infrequently but at environmentally significant concentrations. This may occur, for example, when multiple analytes of similar behavior or origin are detected at a small number of locations but at elevated concentrations that are indicative of a chemical release or contamination pattern.
- May be used to show a connection or no connection among various environmental media.
- May be significant daughter products that demonstrate changes in contaminant concentrations over time due to chemical or biochemical degradation.

- Ultimately were judged to adequately represent contaminants at SWMU 12 in terms of nature and extent.

Comparisons to SVs are tabulated in Sections 7.0 and 8.0 with indications as to whether individual chemicals exceeded the SVs in particular environmental media. The chemicals that exceed SVs are carried forward for further evaluation in the risk assessments of Sections 7.0 and 8.0. Concentrations of representative chemicals are plotted in this section to depict the spatial extent of contamination; however, if the nature and extent of contamination can be easily described, figures were typically omitted and the contamination described in the text.

Section 3.0 includes descriptions of various data quality characteristics of SWMU 12 data for all media and shows that sampling and analysis completeness goals for the project were generally met. Where they were not met, it was because representative samples could not be obtained. This typically occurred when refusal was encountered during advancement of soil borings or where surface or sump water was not available at planned sampling locations and times. In each of these cases, a data gap exists where the samples could not be collected; however, these data gaps have not impaired the evaluation of the nature and extent of contamination. Table 2-3 lists the various samples and the analyses conducted on the samples. Table 2-3 also indicates reasons why proposed samples were not collected and why extra samples were collected or extra analyses were performed. The remainder of this section is a discussion of the various contaminants found at SWMU 12, the nature of the contamination, and a description of the extent of contamination. Where applicable, consideration is given to the following:

- Upgradient or background concentrations as compared to SWMU 12 concentrations.
- Potential migration pathways of contaminants that may have led to current SMWU 12 conditions.
- Whether or not observed contamination is related to site operations.
- Whether or not observed contamination is adequately bounded to support further assessments such as risk assessments.

5.1 BACKGROUND AND UPGRADIENT LOCATIONS

Each background data set and how it was established is described below.

5.1.1 NSWC Crane Soil Background

Tables 3-1 through 3-3 present summary statistics for metals concentrations in the following soil categories:

- All Crane soils (a composite of nine different soil groups)
- Soil Group 3 – Alluvial, Mississippian, and Pennsylvanian surface soil
- Soil Group 8 – Pennsylvanian Subsurface Clay and Silt

These groups represent all soils sampled during the SWMU 12 RFI. The background data were generated during the NSWC Crane basewide background soil investigation. Derivation of the soil groups is described in detail in the report for that investigation (TtNUS, 2001). Section 3.0 of this report also provides some detail regarding the soil groups and the soils they represent.

The background soil groups were used to estimate whether SWMU 12 surface or subsurface soil data represent background concentrations. To accomplish this, the Battery Site data were separated from the rest of the SWMU 12 soil data because the history of the Battery Site is significantly different than the rest of SWMU 12. Samples collected from locations 12SB01 through 12SB11 were placed into the MFA group; samples from locations 12SB12 through 12SB24 and locations 12SB25 through 12SB39 were placed into the Battery Site group. Surface and subsurface soil samples from locations 12SB021 through 12SB24 and all soil samples from locations 12SB25 through 12SB39 were collected during the first round of Battery Site metals contamination delineation. Both the MFA and Battery Site areas include soils from background Soil Groups 3 and 8. Samples collected for the ES/DI (from locations 12SB40 through 12SB71) were analyzed for explosives only, and all explosives detections were assumed to represent site-related contamination. Soil samples were collected from borings 12SB72 through 12SB85 in October 2006 to supplement the original metals delineation at the Battery Site.

Statistical comparisons between background and SWMU 12 RFI metals concentrations were generally not conducted for this investigation, but simple comparisons were made between background soil upper tolerance limits (UTLs) and site concentrations (see Section 5.2.4). References are made in the following text to maximum concentrations, and in certain cases average concentrations, for particular metals in soil samples. These concentrations are used as points of comparison to demonstrate that one soil data set is similar to another. However, the entire background data set should be reviewed when comparing the background data to site data because random fluctuations can cause isolated high or low values in one data set and may cause the data sets to appear different when they are not. In general, the median, average, and maximum values will be similar when the number of data values per data set is the same or similar.

Complications in data interpretation may arise when one data set appears to be a subset of another. For example, a background data set may have a smaller data spread than the site data set when there are fewer background values than site values. This could be an indication that the background data set is a subset of a larger set of background data that was not included in the background study. The background study included soil samples from a large areal coverage of NSWC Crane so the chance of this occurring is small. More likely is the case where a site data set that is comparable to background concentrations is a subset of the overall Crane data set background. This could occur because the site samples are collected from a relatively small area when compared to the breadth of spatial coverage of the background data. The background data set may therefore be a combination of smaller, more localized data subsets, each with its own median and data spread, and these could cause a SWMU data set to appear to have a higher or lower median or average concentration than the NSWC Crane background data. A statistical comparison in such cases may indicate that the two data sets are different. Therefore, it is useful to compare the maximum values of the data sets to determine whether the SWMU maximum value appears to represent a value that is significantly greater than the maximum background value or within the range of background values. Even in this regard, care is required because the data set that has the greater number of values will tend to have the higher individual concentrations even though the median value may be less than the median value of the data set that has fewer values. What is considered to be a significant difference between data sets or maximum values and UTLs, for example, is subjective and requires professional judgment. These issues are described on a case-by-case basis as necessary in the following text.

5.1.2 Surface Water, Seep, and Sediment Upgradient Concentrations

Natural surface water and sediment upgradient samples were grouped into three categories: Gullies, east tributary (to Turkey Creek), and Turkey Creek Main Stream (TCMS). Limiting the number of data groups to three allows each generally distinct site data population to be represented with a maximum of data points. The gullies represent channels that are generally dry except during and immediately after rain storms. This group includes samples collected from the western tributary to Turkey Creek, although the western tributary samples may be expected to show some characteristics that are intermediate between eastern tributary and gully samples. During heavy rains, the water in these channels flows swiftly. Some reaches of these channels may hold water for a time after a rain event, but only in small areas. The east tributary channels are more likely to contain water throughout the year. The TCMS channel contains water year round (or nearly so) and carries a larger volume of water than the other categories.

Of all drainage channels, the gullies are expected to exhibit the most direct influence from site operations. The sampled gullies generally drain only SWMU 12 or locations upgradient of SWMU 12. These channels drain away from SWMU 12, primarily toward the east, west, and northeast. Six upgradient locations representing conditions unaffected by SWMU operations were sampled from the gully system, 12SW/SD08, 12SW/SD22, 12SW/SD26, 12SW/SD28, 12SW/SD29, and 12SW/SD30. All other gully sampling locations are considered to be downgradient of SWMU 12.

The east tributary is a primary tributary to Turkey Creek but does not carry the volume of water that Turkey Creek does. Hence, samples from this area represent intermediate conditions between gully and TCMS conditions. The east tributary receives overland flow from the eastern side of SWMU 12, and it discharges into Turkey Creek. One location, 12SW/SD16, was sampled to represent conditions upgradient of the east tributary.

Turkey Creek integrates flow (and contamination, if present) from all sides of the peninsular SWMU 12. Turkey Creek also receives flow from nearby ridges. This causes TCMS to convey the greatest amount of water and to have the most frequent flow of all channels sampled at SWMU 12. One location (12SW/SD25) was sampled to represent conditions upgradient of Turkey Creek; one location (12SW/SD27) was sampled within Turkey Creek. The integration of flow from ridges other than SWMU 12 also tends to dilute contamination from SWMU 12 and may also contribute some contamination.

Although groundwater discharges at seeps, seep discharges were regarded as surface water for this study. It is believed that seeps exist at SWMU 12, but no seeps could be found at the time of sample collection; therefore, no seep data exist for Rounds 1 and 2 of the RFI.

Comparisons of site data to data from these upgradient locations are discussed in Section 5.3, as applicable.

5.1.3 Sump Water and Sediment Locations

Sumps and catch basins are included in this category. Sumps and catch basins are man made structures. No upgradient material was available for sampling because these structures were on the ridge top and may have represented processing streams related to site operations. Furthermore, the only analyses conducted on sump water and sump sediment were explosives. These chemicals are not naturally occurring, and all detections of explosives were considered to be related to site operations. The analytical database for sump water and sediment are presented in Tables G-7 and G-8.

5.1.4 Groundwater Upgradient Locations

Groundwater monitoring wells were classified into three groups to represent various groundwater conditions at SWMU 12: the Puz, the Pmz, and the PlzMgd zones. Section 4.0 describes in detail the significance of these classifications from a geological perspective.

For the Puz, three wells upgradient of SWMU 12 were sampled: 12MWT25, 12MWT26, and 12MWT28. Based on groundwater flow directions and site history, these wells should be unaffected by site operations. Similarly, well 12MWT33 was selected to represent upgradient conditions for the Pmz, and well 12MWT43 was selected to represent upgradient conditions for the PlzMgd. Well WES-7-1-81 was also selected to represent conditions in the PlzMgd that are unaffected by SWMU 12 operations, but the well was dry and no sample could be collected. WES-7-1-81 is actually located at SWMU 25, across the valley from SWMU 12, but is screened in the PlzMgd geologic formation and is clearly unaffected by SWMU 12 operations.

An attempt was made to sample four other WES wells: WES-7-2-81, WES-7-3-81, WES-7-4-81, and WES-7-5-81. These wells are located at SWMU 25 and are also identified as 25MW02, 25MW03, 25MW04, and 25MW025, respectively. Well WES-4-81 was dry, similar to well WES-7-1-81. Water level measurements were taken in the three remaining WES wells to establish groundwater elevations and flow directions, but the water from the WES wells does not represent SWMU 12 conditions. Therefore, although concentrations were measured in these wells and are presented in this report for completeness, they represent conditions unaffected by SWMU 12. SWMU 25 groundwater may however be influenced by SWMU 9, which is upgradient of these wells.

During the ES/DI, groundwater was collected from temporary wells installed in soil borings where water was available at the overburden-bedrock interface. The locations of these wells were biased toward sumps or similar potential contaminant sources; therefore, no upgradient data set exists for this perched water.

5.2 SOIL CONTAMINATION

Soils were analyzed during the bioremediation effort in RFI Round 1, during the ES/DI throughout the Mine Fill A proper, and during the metals contamination delineation efforts in 2005 and 2006 at the Battery Site. Figures 1-4 through 1-11 depict the extent of explosives contamination in soil at the conclusion of the bioremediation effort. No organic chemical detections in RFI surface and subsurface

soil have been plotted because the frequencies of detection were generally low or the detected concentrations were generally low in all soil samples. Soil data are presented in several tables, and those tables are called out as appropriate in the text below. ES/DI soil data are plotted on Figure 5-1. Figures 5-2 and 5-3 present select soil data for the Mine Fill A proper. Figures 5-4 through 5-12 present select metal concentrations for the Battery Site through the last round of Battery Site metals delineation in 2006.

5.2.1 Explosives

Some bioremediation windrows (see Section 1.2.3.2) were allowed to stand beyond the normal remediation time because concentrations were still too high at the completion of bioremediation to return the soil to excavations. It was evident at the completion of the bioremediation effort that soil explosives concentrations continued to decrease after soils were removed from the bioremediation windrows. The most recent average concentrations provided in Table 1-2 represent concentrations of explosives immediately prior to backfilling in the excavations. They are considered to be the maximum concentrations that could exist today because continued degradation and leaching in the excavations is expected to cause concentrations to decrease. The explosives included in the table are RDX, HMX, and TNT, although additional explosives were analyzed. These three representative explosives were used most often or in the greatest quantities at SWMU 12; therefore, their concentrations represent the worst case for explosives contamination at SWMU 12.

RDX was the second most frequently detected explosive next to HMX. RDX, however, has much lower risk-based SVs in soil than HMX, so it is more important than HMX from a risk perspective.

In Figures 1-4, 1-6, 1-8, and 1-10, the concentrations of RDX in the excavation sidewalls and floors are depicted as they existed immediately after soil was removed from the excavations. The northward orientation is not the same for all figures and is not generally oriented upward. Pink areas indicate that explosives concentrations exceeded industrial clean-up levels. Blue areas indicate areas of explosives concentration that were less than industrial clean-up levels; green areas represent explosives concentrations less than both industrial and more conservative residential clean-up levels. White areas were not excavated because they were not contaminated. Reasons for not being able to completely excavate all grid cell soils that had concentrations in excess of clean-up target levels are provided in Table 1-1. Although an entire grid cell may be colored pink or blue, the amount of material that could not be excavated was typically small when compared to the volume of the entire grid cell. Consequently, the

figures tend to exaggerate the extent of excavation sidewall and floor concentrations exceeding clean-up levels that were not removed.

In Figures 1-5, 1-7, 1-9, and 1-11, average soil explosives concentrations are depicted for soil that was composted to remove explosives contamination and was then replaced in the excavations. The averages are for replaced soil in the individual grids. The color scheme for replaced soil is identical to the previously described pink/blue/green/white scheme. Unlike the excavation floor and sidewall figures described above, the average concentrations were calculated from multiple layers of soil replaced in the excavations. They do not necessarily reflect a homogeneous mixture of soil with a single average concentration throughout the soil column.

Figures 1-4 through 1-11 show that, with few exceptions, the average concentrations of explosives in the excavated grid cells no longer exceeded industrial clean-up values at the completion of the bioremediation effort. In many cases, the final explosives concentrations were less than residential clean-up levels. The general contamination pattern is that areas with greater explosives concentrations are surrounded by areas of lesser concentration. The perimeter areas around each building are generally the areas with the lowest concentrations. Exceptions are described below.

Part or all of the sidewalls and floor of grid 72 (Figure 1-4) exceeded industrial clean-up goals at the completion of bioremediation. However, the volume of soil associated with this level of contamination is assumed to be very small compared to the volume of the entire grid cell. A discussion is presented later concerning this topic. The grid 72 excavation reached a total depth of 19 feet before termination due to a building footer. Total volume of soil that could not be excavated is conservatively estimated to be less than 100 cubic yards (assuming a 3-foot depth of contaminated material remaining in excess of residential clean-up goals). The actual volume is probably much less than this; volume estimates depend on the fraction of sidewalls and floor that are assumed to remain contaminated. Most of the remaining areas around Building 152 met industrial clean-up goals, and approximately 30 to 50 percent of the area met residential clean-up goals.

Around Buildings 153 and 154, excavation depths in the immediate vicinity of the buildings and southeast of the buildings was limited because bedrock was encountered (compare Figures 1-4 and 1-5 to Table 1-2). As shown on Figures 1-4 and 1-5, the average windrow concentrations for replaced soils were generally less than residential clean-up goals over most of the excavated area. The small amount of contaminated volume associated with soil that could not be excavated because of encountering bedrock and utility lines, footers, etc. is assumed to be negligible. Most of the pink areas on Figure 1-6 (grids 2, 5,

200, 203, 203) represent a very small amount of material because bedrock was encountered at 2 feet bgs. Therefore, Figure 1-6 is an exaggeration of high explosives concentrations remaining in soil at the completion of the excavation around Buildings 153 and 154. Furthermore, because clean soil was added to existing soil to a depth of 2 feet near Buildings 153 and 154, the surface soil in the area around Buildings 153 and 154 meets residential or industrial clean-up objectives. When evaluated in conjunction with Figure 1-7, a more accurate representation of site conditions at the completion of bioremediation is obtained.

The excavated areas around Building 157 (Figures 1-8 and 1-9) and Building 158/159 are similar to the conditions described for Buildings 152. A portion of the area near the buildings was most contaminated with respect to excavation sidewalls and floor; perimeter areas were the generally the least contaminated. At the completion of bioremediation, the volume of contaminated material that exceeded residential clean-up levels was small compared to the size of the excavated area and especially in comparison to the entire SMWU 12 area.

The concentrations represented by pink areas in these figures are relatively high. Consequently, a significant mass of explosives contamination could remain at the site even though the volume of residual contaminated soil is relatively small. The U.S. EPA risk range that is commonly accepted as tolerable spans two orders of magnitude ($1x10^{-6}$ to $1x10^{-4}$). The residential and industrial clean-up levels represent a similar span. Using this as a guide and making some simple assumptions, the relative mass of remaining explosives can be estimated. Assuming, for example, that the residual concentration (C_r) averages 100 times the final bioremediated concentration (C_c), that the volume of remaining contamination (V_r) is one hundredth (0.01) the volume of material that was removed and composted (V_c), and that assuming the soil density is identical for these two compartments, the ratio of mass contamination is:

$$(V_r{*}C_r)/(V_c{*}C_c)$$

Using mathematical substitutions for V_r (=0.01 * V_c) and C_r (=100*C_c), this ratio is:

$$[(0.01{*}V_c){*}(100{*}C_c)]/(V_c{*}C_c){*}100\% = 100\%$$

The soil density of replaced material was about 30 percent less than for unexcavated soil, increasing the ratio above to about 130 percent. Regardless of this however, this simple computation indicates that it is within reason to expect the mass of explosives contamination remaining in soil to approximate the mass

replaced to the excavations. The uncertainty of these calculations is estimated to be plus or minus two orders of magnitude. Therefore, a reasonable relative range for mass of explosives remaining compared to mass removed would be 1 percent to 10,000 percent. More accurate measurements of grid areas may reduce the uncertainty to plus or minus one order of magnitude or less. Because the horizontal cross-sectional area is much less than the cross-sectional area of soil removed, the potential for leaching from precipitation infiltration is much less than this calculation would indicate. When the additional detections of explosives in soil and perched groundwater near sumps is considered, it is understandable that the SMWU 12 ridge top could be considered a continuing explosives contamination source for groundwater. Based on available data, the explosives of most significance would be RDX, HMX, 2,4,6-trinitrotoluene, and the primary degradation products of these chemicals (MNX, DMX, TNX, 2-amino-4,6-dinitrotoluene, and 4-amino-2,6-dinitrotioluene). More discussion on soil explosives contamination identified during the ES/DI is provided in later subsections. The ES/DI data indicate that relatively high explosives concentrations are present near certain ES/DI sampling locations on the eastern side of the SWMU (see Figure 5-1). Based on these recent data, the extent of contamination, though not bounded in all directions, appears to represent small quantities of contaminated soil compared to the previous excavations. With the additional detections of explosives, it is evident that the excavations did not address all contaminant sources. Finding all contaminant sources may not be possible, but it is believed based on site history and available data that most significant sources have been identified. Therefore, it is reasonable to consider the SMWU 12 ridge to be a mosaic of sparsely distributed areas of residual explosives contamination in soil, most of which has been delineated on a relatively large scale. The explosive-related chemicals detected most frequently and in the highest concentrations were RDX, HMX, 2,4,6-dinitrotoluene, and the degradation products of these chemicals (MNX, DNX, TNX, 2-amino-4,6-dinitrotoluene, and 4-amino-2,6-dinitrotoluene). More discussion on soil explosives contamination identified during the ES/DI is provided in later subsections.

Section 1.0 describes how explosives were released to surface soil at SWMU 12 proper during site operations. The bioremediation excavations, which targeted concentrations greater than industrial clean-up levels, were generally not very deep, perhaps 3 or 4 feet bgs, on average. This indicates that after decades of precipitation infiltration, the contaminants, which began their migration on the ground surface, have, with few exceptions, not moved very rapidly to deep soils (i.e., deeper than 5 feet) at concentrations greater than industrial and residential clean-up levels. Therefore, the depth of residual explosives contamination that exceeds residential clean-up levels in the excavation floors is not expected to be more than 2 feet below floor depth, on average. However, some areas could not be excavated to achieve explosives concentrations less than industrial clean-up values (see Table 1-1). Because bedrock is shallow in several places, contaminants may have moved directly to bedrock as adsorbed or dissolved

species. In addition, infiltration of precipitation along vertical walls of structures (e.g., exterior building walls) may have facilitated vertical movement to greater depths. More discussion is presented in Section 6.0 concerning fate and transport of contaminants at SWMU 12.

Based on Figures 1-4, 1-6, 1-8, and 1-10, approximately 50 percent of the area covered by excavation sidewalls and floors was left in place with explosives concentrations in excess of residential clean-up levels but less than industrial clean-up levels. These representations, however, are assumed to be an exaggeration because only a small portion of each grid sidewall or floor actually exceeded the clean-up goals. The fraction that remained contaminated was not estimated. Figures 1-5, 1-7, 1-9, and 1-11 show that all soil replaced in excavations had explosives concentrations less than industrial clean-up values and most had concentrations less than the more conservative residential clean-up values. The figures, in total, demonstrate that residual contamination greater than residential clean-up levels after bioremediation is generally well bounded (perimeter grids are colored green or white) in all directions by concentrations that are less than residential clean-up levels. Where this is not the case, the perimeter grids almost always exhibit explosives concentrations less than industrial clean-up values. Therefore, the bounding of explosives contamination in soils is virtually complete relative to industrial clean-up values. The bounding of explosives contamination is also fairly complete relative to residential clean-up levels (see Figures 1-4 through 1-11).

Tables 3-4 through 3-19 present descriptive statistics and soil concentrations for chemicals detected in soils at least once during the SWMU 12 RFI, Round 1, the ES/DI, and the Battery Site metals contamination delineation. Appendix Tables G-1 through G-3 are the entire RFI analytical database for SWMU 12 surface and subsurface soil samples. RDX is the most prevalent explosive chemical at SWMU 12 in terms of number of detections and magnitude of concentrations for all locations. During RFI Round 1, no explosives contamination was detected in soil samples collected at locations biased toward potential contaminant sources. One surface soil sample, 12SB210002 in the Battery Site, had low levels of 1,3,5-trinitrobenzene (0.84 mg/kg), HMX (1.7 mg/kg), and RDX (6.1 mg/kg), but this sample was not biased toward potential explosives contamination sources. A detailed description of the Battery Site is provided in Section 1.0 along with descriptions of previous sampling and excavations conducted there. The detected chemicals in sample 12SS210002 were 1,3,5-trinitrobenzene and RDX. The 1,3,5-trinitrobenzene concentration exceeded its human health SV (0.25 mg/kg) and ecological risk SV (0.376 mg/kg), and the RDX concentration exceeded its human health SV (4.4 µg/kg). There is no ecological risk SV for RDX.

Multiple explosives related chemicals were detected in multiple samples collected near sumps or catch basins during the ES/DI conducted after RFI Round 1 (see Tables 3-7, 3-11, and 3-19). ES/DI samples were located near sumps or catch basins. This sampling revealed that some soil contamination exists outside the bioremediated areas in the Mine Fill A proper. For example, 9 of 32 ES/DI surface soil samples contained detectable concentrations of RDX (see Table 3-7). The maximum RDX concentration (4,800 mg/kg) was found in sample 12SS500002, located about 60 feet southwest of Building 157 (see Figure 5-1). That sample also contained high levels of HMX (800 mg/kg), 2,4,6-trinitrotoluene (65 mg/kg). and 4-amino-2,6-dinitrotoluene (32 µg/kg). Other examples are samples 12SWS570002 (120 mg/kg RDX), 12SB620002 (390 mg/kg RDX), and 12SB610002 (1,100 mg/kg RDX), all of which are located near Building 151. Otherwise, the ES/DI sampling showed that surface and subsurface soils were generally not contaminated or had low levels of contamination even in low lying areas near catch basins.

Of particular interest is that the surface soils in contaminated ES/DI soil borings had much greater concentrations of RDX and other explosives than subsurface soils. This type of spatial distribution suggests that surficial contamination resulted from overflow of the sumps or catch basins or from overland runoff from other areas. Because of the relatively high concentrations in some locations, it is clear that a significant mass of explosives contamination remains in soils, especially surface soils. Based on the physicochemical properties of the explosives, this mass is likely to be distributed between soil particles and the dissolved phase. The extent of explosives contamination in directions away from the sumps and catch basins has not been delineated.

Although explosives contamination evidently remains in SMWU 12 soils, contamination levels are low compared to concentrations present in soils at the start of bioremediation. The mass of explosives contamination remaining in place in the bioremediated areas may be comparable to the mass of contamination replaced to the excavations, but it is concentrated in a relatively small volume of soil with little cross-sectional area exposed to recharge from precipitation. If surface soil, and to a much more limited extent subsurface soil, of the entire SWMU ridge top is viewed as an explosives contamination source, the source is well bounded relative to non-detect values and human health screening values. Site process knowledge suggests that the bulk of soil contamination would be in areas where explosives were most heavily used. Consistent with this, the explosives contamination appears to be limited to the middle one-third of the ridge top between Buildings 158/159, 157, 151, and 154. Bounding is nearly complete in the vertical direction, with the vast majority of explosives contamination residing in surface soils. Any exceptions are very minor. The remaining soil contamination is likely to represent a continuing source of contamination to groundwater and other media. The leaching rate, however, is probably much less than before bioremediation because the surface area in contact with groundwater or precipitation

recharge is now smaller. More details on the fate and transport of SWMU 12 contaminants is provided in Section 6.0.

5.2.2 Semivolatile Organic Compounds

Several SVOCs were detected in surface and subsurface soils during the RFI. Table 2-3 indicates which samples were collected and analyzed for SVOCs. Data quality was compromised for several SVOC compounds (see Section 3.0), but polycyclic aromatic hydrocarbons (PAHs) in soil were not affected significantly. One surface soil sample, 12SS150002, located in MFA Battery Site, had the greatest PAH concentrations and the greatest number of SVOCs detected. All SWMU 12 soil PAH concentration were less than their human health and ecological SVs except for benzo(a)pyrene in sample 12SS150002. The SV exceedance in sample 12SS150002, however, was less than two times the SV (110 µg/kg in the sample versus a 62 µg/kg human health SV). SVs are provided in Sections 7.0 and 8.0. The single SV exceedance was detected in surface soil; therefore, all of the PAH concentrations in excess of SVs are bounded vertically. Laterally, the PAH SV exceedance at location 12SB15 is bounded within approximately 25 feet to the north, west, and south and within approximately 80 feet to the east by concentrations less than SVs. It does not appear the PAH or other SVOC contamination discussed below is widespread in this area, and PAH contamination exceeding SVs is confined to surface soils.

In addition to benzo(a)pyrene exceeding its human health SV, bis(2-ethylhexyl) phthalate (1,300 µg/kg) exceeded its ecological SV of 925 µg/kg at location 12SB15 for surface soil only. Hexachlorophene and pentachlorophenol, commonly regarded as SVOCs, were analyzed using an herbicide analysis method to achieve lower than normal detection limits because they have relatively high toxicities. The hexachlorophene and pentachlorophenol results exhibited a severe low bias [approximately 10 to 90 percent recoveries in matrix spike (MS) and matrix spike duplicate (MSD) samples in solid samples] and a moderate to severe low bias (approximately 20 to 107 percent recoveries in individual MS/MSD samples) in surface water samples. Herbicides were not analyzed in any matrix during Round 2. Precision for pentachlorophenol was erratic in solid samples, with laboratory RPDs ranging from 0 to 122 for individual duplicate pairs. The mean laboratory RPD value (29.8) was just slightly less than the maximum of the 0 to 30 percent reference range that is considered to represent typical performance. Generally, the analytical performance for this compound was poor with erratic precision and moderate to severe low bias. Therefore, it is possible that these compounds could not have been detected at concentrations that were greater than, but within a factor of three to five, of their respective detection limits. Despite this limitation, lack of any detections of these compounds indicates that they are not significant site-related contaminants.

In summary, there was little soil SVOC chemical contamination detected, and the detected contamination appears to be well bounded. Although soil locations 12SB02 through 12SB11 were not analyzed for SVOCs, it is apparent that SVOC contamination is not significant at SWMU 12, except perhaps at the Battery Site. Furthermore, the infrequent exceedances of applicable SVs and the sparse distribution of human health and ecological SV exceedances suggest that these chemicals either are not site related or that they are of little significance as contaminants.

5.2.3 Volatile Organic Chemicals

Several VOC results during the RFI were rejected because of poor analytical performance, but the rejections have no significant effect on the usability of the data. The rejections were generally for chemicals that are part of the analytical VOC fraction but are not of particular interest for SWMU 12 (see Section 3.0 and Table H-2).

Despite the rejected VOC results, it is clear that organic solvents are not significant site-related contaminants. The most frequently detected VOC (9 of 11 samples) was the relatively non-toxic dichlorodifluoromethane (SVs of 9,400 µg/kg for human health risk and 39,500 µg/kg for ecological risk). Methylene chloride was the only other VOC detected in soil samples. The detected concentrations of dichlorodifluoromethane ranged from 2 to 15 µg/kg; methylene chloride concentrations ranged from 1 to 2 µg/kg in three samples. These concentrations are significantly less than human health and ecological SVs; therefore, VOC contamination at SWMU 12 is not significant. Furthermore, the levels of dichlorodifluoromethane (a common refrigerant) and methylene chloride observed may reflect laboratory contamination (e.g., from a leaking laboratory refrigerator or freezer or from use of these chemicals as laboratory solvents). This is corroborated by the observation that all dichlorodifluoromethane concentrations were similar regardless of sample depth and that most of the dichlorodifluoromethane detections and all three methylene chloride detections were in surface soil samples. Surface soil is less likely to contain detectable VOCs because these chemicals readily evaporate into the atmosphere and tend to migrate deeper into soils because of their density. Although these chemicals were not detected in method blanks, this is not unusual if the laboratory contamination is sporadic. The available evidence does not allow a definitive conclusion as to whether the detections represent site contamination or laboratory contamination.

5.2.4 Metals and Miscellaneous Parameters

Soil samples were analyzed for metals as part the bioremediation effort. Additional soil samples were collected across SWMU 12 proper and at the Battery Site in 2004, and in 2005 and 2006 during the RFI metals contamination delineation efforts at the Battery Site.

Soil background data are described in Section 5.1.1. Tables 3-1 through 3-3 present summary statistics for background data, including 95 percent UTLs. These 95 percent UTLs represents the concentration below which 95 percent of a data set is expected to lie with 95 percent confidence. Site metals data were compared to these UTLs to help gage whether site concentrations represent contamination. Organic chemicals were assumed not to occur naturally, hence they have no UTLs. When comparing site surface soil data to background UTLs, data in Table 3-2 was used; when comparing site subsurface soil data to subsurface soil UTLs, data in Table 3-3 was used. UTLs have an inherent degree of certainty so they are not used as absolute limits. Furthermore there is a 5 percent chance that samples collected from background areas will exceed the background UTL. Nevertheless, site concentrations will generally not exceed background UTLs unless the site is contaminated, the UTL is in error, or the site background population is a subpopulation that falls in the upper portion of the overall background concentration distribution.

In the descriptions below, the degree of background concentration exceedances are estimated to emphasize the significance of the exceedances. Several of the ecological or human health SVs are less than background concentrations so the data are compared to the background UTLs to provide perspective on the significance of the contamination. The chance of observing values greater than the UTLs decreases with increasing concentration. Therefore, knowing, for example, that a metal concentration exceeds the background UTL by 30 percent represents a significantly different situation than a metal which exceeds the background UTL by 5 times. In general, concentrations that are less than two times the UTL are considered to be of little significance if they are spatially isolated or are if the metal fairly concentrations are consistent throughout the site. Concentrations that exceed background levels by a small amount and are uniformly distributed laterally and vertically across the site are generally interpreted to represent local variations in background concentrations. If contamination were released, it is not likely to be uniformly distributed. Instead, the metal concentrations would typically be greatest near the point of release and less at more distant locations. These assessments incorporate professional judgment and two different data reviewers may come to different conclusions regarding the significance of the exceedances but the differences are expected to be slight.

Metals Data from the Bioremediation Effort

Metals did not appear to be leachable soil contaminants during the bioremediation effort. The bioremediation program at SWMU 12 focused on the eight RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) plus aluminum. These metals were analyzed in Initial Characterization and Post-Excavation samples. They were not analyzed in the bioremediated compost that was backfilled into the excavated areas of SWMU 12. The data presented in the IMRs indicated that only concentrations of arsenic exceeded residential and/or industrial criteria for the protection of human health (TolTest, 2001, 2002, 2005). An analysis of potential risks for the pre-RFI metals concentrations is presented in the HHRA and ERA sections (Sections 7 and 8, respectively). The HHRA for example, indicated that risks from exposure to arsenic and aluminum in the historical soil samples were acceptable. An important uncertainty factor regarding the pre-RFI metals data is that the concentrations of metals in the bioremediated compost are not known. This is mitigated by the fact that the greatest observed concentrations of aluminum and arsenic detected in the pre-RFI samples were used to determine the exposure concentrations used in the risk assessments.

Metals Data from SWMU 12 Proper

Data for aluminum and nickel are presented on Figures 5-2 and 5-3, respectively, to show the greatest SV exceedances in MFA proper. A more detailed examination of these metals and others is possible using select tables. Examination of SWMU 12 RFI soil data (Tables 3-4 through 3-11 for surface soil, Soil Group 3; Tables 3-12 through 3-19 for subsurface soil, Soil Group 8) indicates that metals concentrations in soil samples from SWMU 12 proper are generally similar to background soil concentrations (compared with Tables 3-2 and 3-3). Several minor exceptions can be found, and two exceptions are more noteworthy as described next. The first noteworthy exception is the 2- to 6-foot bgs depth interval at location 12SB07 which had concentrations of aluminum, barium, chromium, iron, and nickel that exceeded their maximum background values by about 1.5 to 3 times. The second noteworthy exception existed for elevated concentrations of aluminum, barium, chromium, iron, and nickel concentrations in the 2- to 5-foot bgs depth interval at location 12SB11.

The significance of these elevated concentrations at locations 12SB05 and 12SB11 is minor for the reasons described here. The elevated concentrations, in the intermediate sampling depth intervals are bounded by deeper and/or shallower concentrations that are more consistent with background concentrations; therefore, the elevated concentrations are well bounded vertically. In addition, the elevated concentrations are generally less than or not much greater than the soil UTLs (Tables 3-2 and 3-

3). Furthermore, aluminum and nickel concentrations are fairly uniform throughout the soil column. Such uniform concentrations are inconsistent with many contaminant release scenarios. Finally, the concentrations shown in Figures 5-2 and 5-3 indicate that the apparent SV exceedances for aluminum and nickel are quite consistent with concentrations from surface soil to the deepest sampled interval. Because of this and the fact that the concentrations at isolated locations were not much greater than background concentrations, the observed concentrations are interpreted to represent background levels or insignificant levels of contamination. In summary, exceedances of SVs and background UTLs in MFA proper exist but the overall spatial pattern and degree of exceedances indicate, as shown in Figures 5-2 and 5-3 and Tables 3-4 through 3-11, that the exceedances are minor and may represent local variations in background concentrations relative to the basewide background concentrations.

Metals Data from the Battery Site

Metal concentrations were much higher in certain portions of the Battery Site than at SWMU 12 proper, especially in the center of the sampling pattern shown on Figures 5-4 through 5-12. In some locations (e.g., locations 12SB16 and 12SB17), bedrock was outcropping over a fairly wide area and no soil was available for collection near the designated locations. These locations are not shown on Figures 5-4 through 5-12, but they are shown on Figure 2-1 in Section 2.0. The metal concentrations presented on these figures represent metals with a wide range of chemical properties, hence their spatial distributions are considered to be representative of metals that were not depicted in figures.

Soil borings 12SB21 through 12SB24 are located in the central area of the Battery Site. Although the sample numbers (12SB210002 through 12SB240002) indicate that the samples were collected from 0 to 2 feet bgs, they were actually collected to a depth of 6 inches bgs. These samples were used to confirm conditions in and near an excavation soil pile in the Soil Area and were collected at a shallower depth than originally proposed. During excavation, the soil depths within the 0- to 2- foot surface interval were mixed. Consequently, the soils in the 0- to 6-inch interval were judged to be as equally representative of the 0- to 2- foot interval as an actual 0- to 2-foot sample.

In the initial Battery Site sampling, surface soil at location 12SB21 had the greatest number of elevated metals concentrations (compared to background levels in Table 3-2) and the greatest number of SV exceedances (see Table 3-9). The 12SB21 metals with concentrations greater than maximum background concentrations were antimony, arsenic, barium, cadmium, chromium, copper, lead, mercury, silver, tin, and zinc (see Table 3-2). All of these metals are expected components of one type of battery or another. For example, common dry cells contain zinc and manganese, mercury cells contain mercury,

nickel-cadmium cells contain nickel and cadmium, and silver oxide batteries contain silver. In addition, some of the detected metals may be chemical contaminants of other metals. It is possible that electrical wiring containing metals such as copper also may have been discarded with the batteries or that the batteries contained copper components.

Several macronutrients (calcium, magnesium, potassium, and sodium), which were widely detected, are of little environmental significance and are not discussed further. Cobalt, selenium, and vanadium were not detected in surface soil at concentrations in excess of their background surface soil concentration 95 percent UTLs. The maximum subsurface concentrations of these metals were within approximately two times their subsurface soil UTLs. In the 50 surface soil samples, iron concentrations (ranging from 37,900 to 66,700 mg/kg) exceeded the 37,400 mg/kg surface soil UTL by less than a factor of two at 11 fairly widely scattered locations. In the 54 subsurface iron samples, six iron concentrations (ranging from 67,600 to 125,00 mg/kg) exceeded the subsurface soil iron background UTL of 60,200 mg/kg at locations 12SB13, 12SB15, 12SB22, 12SB28, and 12SAB31 by about 2 times or less. Therefore, cobalt, iron, selenium, and vanadium are considered either to be minor contaminants or insignificant contaminants and are not discussed further. There is no background UTL for beryllium or titanium, but beryllium and titanium concentrations at all sampled locations, including SMWU 12 proper, are similar without regard to depth. This spatial distribution indicates that beryllium and titanium are not likely to be a site-related contaminants and therefore beryllium and titanium are not discussed further. Five additional metals not listed here were not plotted on figures. They are silver, mercury, manganese, tin, and thallium. These metals are not discussed in detail below because the extent of contamination described for the plotted metal concentrations encompasses all areas contaminated with these metals.

Figures 5-4 through 5-6 present data for aluminum, antimony, and arsenic, respectively. Aluminum is known to have been used at SWMU 12, and antimony and arsenic could have been present in metallic lead components of batteries. The dot patterns in these three figures reveal a distinct contamination pattern wherein the center of the site has a relatively large number of black dots, but the perimeter of the sampling pattern includes almost all open circles. This indicates that the metals contamination at the site center is well bounded relative to screening levels and background UTLs. Furthermore, the concentrations on the perimeter of the sampling pattern that exceed an SV and the UTLs are within 40 percent of the UTL. By contrast, the locations with black dots in the center of the sampling pattern are considerably greater than the background UTL, sometimes by a factor of 10 or more. Based on this observation and the knowledge that the background UTL will occasionally be exceeded by chance alone, these three figures show that the aluminum, antimony, and arsenic contamination in the site center is well bounded on the perimeter of the sampling pattern. Hence, these metals are not discussed further.

Figure 5-7 (barium) is similar to Figures 5-4 through 5-6. With one exception, the barium concentrations range from equal to the background UTL to two times the UTL value at all perimeter locations. The exception is location 12SB20 in the southeast where the 2- to 4-foot subsurface soil interval had a concentration of 792 mg/kg. This value is about 7.5 times the UTL. The next highest barium concentrations are found in the center of the sampling pattern. Location 12SB21 in the Soil Area, 12SB22 between the Soil and Battery Areas, and 12SB25 located northeast of 12SB22 exhibited the next three highest barium concentrations. The high barium concentration at location 12SB20 is well bounded vertically relative to the applicable screening value of 82 mg/kg and the 115 mg/kg UTL. In general, barium contamination is well bounded in all lateral and vertical directions relative to the background UTLs with this one exception that appears to represent an isolated area of contamination. Most perimeter locations exhibit exceedances of the 82 mg/kg human health SV for surface and subsurface soil, but not the 330 mg/kg ecological SV (applies to surface soil only).

Figures 5-8 (chromium) and 5-11 (nickel) are similar to Figure 5-7 in that there are exceedances of chromium and nickel SVs and UTLs at the sampling pattern perimeter. In these cases, however, the exceedances are within three times the applicable background UTLs. Furthermore, the vertical concentration profiles are remarkably consistent from location to location. This is an indication that the elevated concentrations are not site-related contamination, especially when contaminant releases of metals are known to have occurred to surface soils. Therefore, with the possible exception of locations 12SB72 (49.6 mg/kg) and 12SB81 (69.5 mg/kg) in the northwestern corner of the site (for chromium) and location 12SB82 (38.3 mg/kg) in the northeastern corner of the site (for chromium and nickel), the chromium and nickel contamination appears to be well bounded by samples representing background concentrations along the entire site perimeter. Of these three exceptions, all the nickel exceedances are minor exceedances within 50 percent of the 22.1 mg/kg nickel UTL, two chromium exceedances are minor exceedances within 72 percent of the 28.7 mg/kg background UTL, and one chromium exceedance (69.5 mg/kg at location 12SB81) is more significant (about 2.5 times the UTL). This last location, however, is at a higher elevation than the site center near and is adjacent to the site access road. Based on site history, this location is more likely to have been contaminated by vehicular traffic than by battery disposal because it is near the site access path. The nickel contamination at this location is within the background range of concentrations. Nickel concentrations at all but two widely separated locations (i.e., 12SB33 on the western edge of the Soil Area and 12SB80 on the southern perimeter) are within three times the background UTLs of 22.1 mg/kg (surface soil) and 29.6 mg/kg (subsurface soil). Chromium concentrations at all but two locations (12SB25 located slightly north of the Battery Area northern boundary and 12SB33 located on the western edge of the Soil Area) are within three times the background UTLs of 28.7 mg/kg (surface soil) and 33.0 mg/kg (subsurface soil). Consequently, these

two metals are considered to be minor site contaminants. With the exception of chromium at location 12SB81, chromium and nickel contamination is considered to be well bounded in all lateral and vertical directions. The highest chromium concentrations (122 mg/kg in surface soil at location 12SB25 is the highest) are found in the center of the sampling pattern and are within about five times the background surface soil UTL (28.7 mg/kg). The highest nickel concentrations (63.2 mg/kg in surface soil at location 12SB36) are similar, with the highest concentration being less than 3 times the background UTL (22.1 mg/kg). Chromium and nickel SVs are less than the UTLs so every sample has a concentration of one or both of these naturally occurring metals that exceed an SV.

The contamination pattern on Figure 5-12 is similar to that of Figures 5-8 and 5-11. On Figure 5-12, however, the northeastern most sampling location (12SB82) exhibits a zinc concentration significantly greater than the background UTL, and so do the northernmost locations (12SB27 and 12SB81). Surface soil samples at all three of these locations also exceed the human health and ecological SVs of 65.6 and 83.3 mg/kg. Because zinc is a known component of the types of batteries known to have been discarded at this site, the elevated zinc concentrations are interpreted to represent site-related contamination. The zinc contamination is not completely bounded in the northeasterly and northerly directions, but it is well bounded vertically by concentrations less than the 83.3 mg/kg subsurface background UTL in nearly all of the deepest subsurface soil samples throughout the site. The highest level of zinc contamination is 23,600 mg/kg at location 12SB25 in the northeast center of the site. The ecological SV is less than one-tenth of the background UTL so every location exhibits a surface soil exceedance of the ecological SV. All human health SV exceedances are limited to the interior of the sampling pattern except for location 12SB82 where the surface soil zinc concentration (761 mg/kg) exceeds the 680 mg/kg human health SV.

Figures 5-9 and 5-10 display a slightly more extensive pattern of contamination than the previous figures. On these latter figures there are more black dots and the dots extend more consistently toward the perimeter of the sampling pattern than in the previous figures. The highest concentrations of each of the metals represented in these figures are in the center of the sampling pattern. For example, the highest copper concentration (Figure 5-9) was 1,460 mg/kg at location 12SB26 (just north of the northern edge the Battery Area). The next three highest concentrations occur at locations 12SB33 (1,100 mg/kg) on the eastern edge of the Soil Area, 12SB25 (903 mg/kg) northwest of 12SB26, and 12SB35 (402 mg/kg) in the center of the Soil Area. The background UTLs for copper are.8 mg/kg (surface) and 33.3 mg/kg (subsurface). On the perimeter of the sampling pattern, the exceedances of copper background concentrations are consistently within about five times the background concentration. All are less than the human health SV of 310 mg/kg, but greater than the ecological SV of 5.4 mg/kg. Subsurface soil concentrations were consistently in the range of about 5 to 24 mg/kg. Elevated concentrations are

generally found in the surface soil interval, even in the center of the site. This is consistent with site history, which indicates that the contaminant releases were to surface soil. All locations in Figure 5-9 exhibit an ecological SV exceedance because the SV (5.4 mg/kg) is less than the background UTLs (17.6 mg/kg for surface soil and 33.3 mg/kg for subsurface soil). All human health SV exceedances are limited to the interior of the sampling pattern, with the exceptions of locations 12SB72 (143 mg/kg lead in surface soil), 12SB81 (165 mg/kg lead in surface soil) and 12SB27 (132 mg/kg lead in surface soil), the same is true for Figure 5-10.

Figure 5-9 shows that all lead concentrations along the sampling pattern perimeter are less than the commonly used 400 mg/kg cleanup value. Several of them (locations 12SB79, 12SB77, 12SB74, 12SB72, 12SB165, and 12SB132) exceed background lead concentrations and the human health SV (81 mg/kg) but the highest of these concentrations (165 mg/kg) is about two times this SV. Exceedances of the ecological SV are more significant because the SV is 11 mg/kg. The surface soil lead concentration (Figure 5-10) was particularly high at 12SB21 (429,000 mg/kg in sample 12SS210002) and significantly exceeds the human health (81 mg/kg) and ecological (11 mg/kg) surface soil SVs. Such a high concentration is indicative of a metal particle or a small amount of metal salt being included in the subsample taken for analysis.

Figures 5-8 through 5-12, show that there is a decreasing concentration trend from the site center toward the southwest. This is consistent with the site topography. The western central portion of the Battery Site, which is also known as the Battery Area, is about 10 feet higher in elevation than the central portion of the site. Samples 12SB21, 12SB23, were collected on the steep slope separating the Battery Area from the lower elevation Soil Area. This disparity in elevation and the local topography toward the south cause surface runoff from the site center to flow south then turn southwestward to lower elevations. This provides a driving force for the metal contaminants from the site center to migrate via overland flow in the southwesterly direction. Hence, some of the slightly elevated metals concentrations in the southwestern region of the sampled area could be due to such a migration.

Taken together, Figures 5-4 through 5-12 consistently show that the site center is the most contaminated portion of the Battery Site. Metal concentrations consistently decrease from the site center toward the outer edges of the sampling pattern. There are isolated cases where individual metal concentrations are significantly greater than background concentrations (e.g., five times the background UTL), but the exceedances of background concentrations along the site perimeter are generally slight. Most perimeter metal concentrations are less than human health SVs but many exceed ecological SVs, which are frequently less than naturally occurring metal concentrations.

5.3 SURFACE WATER, SEEP, AND SEDIMENT CONTAMINATION

Surface water and sediment samples were not collected from SWMU 12 during the bioremediation effort, but they were collected during the RFI. During the RFI, seeps, which are considered to represent surface water, were not found and therefore could not be sampled as proposed in the QAPP. Table 2-3 presents a summary of surface and sediment samples collected and the analyses conducted on the samples. Surface water samples were generally analyzed for explosives, metals, nitrate, and nitrite in both sampling rounds. Location 12SW/SD03 was also analyzed for SVOCs in both sampling rounds. Appendix G, Tables G-4 and G-5 present all drainage channel surface water and sediment data, respectively, from RFI Rounds 1 and 2. Comparisons of chemical concentrations to SVs and selection of COPCs for risk assessment are made in Sections 7.0 and 8.0.

Tables 3-20 through 3-49 present summary statistics and results for all chemicals detected at least once in surface water and sediment samples. The matrix below identifies which tables have data for various combinations of environmental media and creek sections (i.e., gully, east tributary, and TCMS).

Table Numbers for Various Surface Water and Sediment Data Sets

Data Sets	Gully	East Tributary	TCMS
Upgradient Surface Water	3-20, 3-23	3-21, 3-24	3-22, 3-25
Downgradient Surface Water	3-26 to 3-28, 3-35	3-29 to 3-31, 3-36	3-32 to 3-34, 3-37
Upgradient Sediment	3-38, 3-41	3-39, 3-42	3-40, 3-43
Downgradient Sediment	3-44, 3-47	3-45, 3-48	3-46, 3-49

Several surface water samples exhibited detectable concentrations of explosives (see Figures 5-13 and 5-14). The chemical concentrations in Figures 5-13 and 5-14 represent those explosives detected most frequently and at the greatest concentrations. Metals concentrations are also shown because they were elevated in a few surface water samples (see Figures 5-15 through 5-22).

Surface water and sediment sampling locations represent the overall surface drainage system of SWMU 12. Seeps, which are included in this system, are groundwater discharge prints that contribute to subsequent surface drainage. Surface drainage at elevations lower than active seeps is therefore a composite of groundwater discharge and surface water runoff. Many seeps are active (i.e., flowing) only at certain times of the year (e.g., during a wet season). As yet unidentified seeps are expected to exist based on geology and hydrology; therefore, the detected surface water and sediment concentrations are most likely representative of groundwater discharge as well as surface runoff.

5.3.1 Explosives

Consistent with expectations, the upgradient gully, east tributary, and TCMS samples did not contain detectable levels of explosives. RDX, HMX, TNT, and the TNT degradation products 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene were detected in downgradient surface water samples at concentrations high enough to cause them to be selected as COPCs for human health risk. Several other explosives were detected much less frequently in surface water. COPC selection tables are presented in Sections 7.0 and 8.0.

HMX and RDX were the most widely detected explosive compounds in SMWU 12 surface water. Detectable HMX concentrations in downgradient surface water samples ranged from 0.28 to 98 µg/L; RDX concentrations ranged from 0.36 to 140 µg/L for all stream data sets. Concentrations of these chemicals and select additional explosives or related compounds are presented on Figures 5-13 and 5-14. The top line at each sampling location is the surface water data; the bottom line is the sediment data. At each location where these explosives were detected, they were generally detected in both rounds of surface water sampling. Locations 12SW/SD31 through 12SW/SD36 were sampled only in Round 2; locations 12SW/SD37 through 12SW/SD40 were not sampled in either round. For locations sampled in Rounds 1 and 2, concentrations in both rounds were fairly consistent, although some exceptions occurred. For example, RDX concentrations at location 12SW12 were 52 and 9 µg/L during Rounds 1 and 2, respectively.

There were four detections of TNT in gully sediments during Round 1; sediments were not sampled in Round 2. No other explosives were detected in sediments. The maximum TNT detection was 2.4 mg/kg, which is less than the 16 mg/kg human health SV (there is no ecological SV).

Explosives concentrations were greater in surface water and sediment samples located close to the top of the SWMU 12 ridge top, whereas the more downgradient locations had lower concentrations or did not have explosives contamination. For example, locations 12SW/SD01, 12SW/SD02, and 12SW/SD35 (located on the western edge of the ridge) had relatively high concentrations in the tens to hundreds of µg/L RDX in surface water. In general, progressively downgradient locations 12SW/SD05, 12SW/SD04, 12SW/SD06, and 12SW/SD07 showed decreases in surface water RDX concentrations as distance from the ridge top increased. Minor exceptions exist to this decreasing trend with downgradient location. For example, location 12SW/SD09 is further downgradient than 12SW/SD07 in the same drainage system, yet RDX concentrations at 12SW/SD09 were 19 µg/L (Round 1) and 8.3 µg/L (Round 2). Nevertheless, the most downgradient sampling location (12SW/SD27, not shown on Figure 5-14) exhibited no

detectable concentrations of any explosive in either Round 1 or Round 2 and the overall trend is decreasing toward downgradient locations. Similar decreasing RDX concentration trends from ridge top to downgradient locations are even more pronounced on the eastern side of the ridge. In all cases, the most downgradient location had no detectable RDX. Therefore, all explosives contamination in surface water and sediment is well bounded in the downgradient direction by concentrations less than detection limits.

5.3.2 Semivolatile Organic Compounds

SVOCs were analyzed in Round 1 and Round 2 surface water samples collected from location 12SW/SD03; no other surface water samples were collected. Sediment samples were collected from each of three locations (12SW/SD03, 12SW/SD07, and 12SW/SD09) for SVOC analyses. Upgradient locations were not analyzed for SVOCs. The SVOC concentrations in these media were low compared to human health and ecological SVs. There were no SVOC detections in SWMU 12 (i.e., downgradient) surface water samples. Kepone and 4-nitroquinoline-1-oxide results were rejected in some sediment samples (see Section 3.0), but based on the low SVOC detections in general, these rejections are of little consequence. PAHs and bis(2-ethylehexyl) phthalate were the only SVOCs detected in SWMU 12 sediments. The concentration of bis(2-ethylhexyl) phthalate (340 µg/kg) exceeded its 35 µg/kg human health SV by an order of magnitude at 12SW/SD07; there is no ecological SV. COPC screening tables are provided in Sections 7.0 and 8.0. Because SVOC detections were so infrequent and of such low concentrations, these chemicals do not appear to be site-related contaminants in surface water and sediment and are not discussed further.

5.3.3 Metals and Miscellaneous Parameters

Surface water and sediment samples were not analyzed for metals during the bioremediation effort, but surface water samples were analyzed for metals during RFI Rounds 1 and 2, and sediment samples were analyzed for metals during RFI Round 1. Surface water sampling locations 12SW/SD01 through 12SW/SD30 were sampled in both rounds if water was available for collection (see Tables 2-3 and 2-4). Locations 12SW/SD31 through 12SW/SD36 were sampled only in Round 2 if water was available. Water was not available at locations 12SW/SD37 through 12SW/SD40 during either round.

The data sets for these locations are divided into gully, east tributary, and TCMS groups representing drainage channels of significantly different characteristics. Surface water and sediment upgradient data are described in Section 5.1.2, and data for these locations are presented in Tables 3-20 through 3-25 and 3-38 through 3-43. Data from drainage channel locations potentially affected by SWMU 12

operations (i.e., downgradient locations) are described below and presented in Tables 3-26 through 3-37 and 3-44 through 3-49.

Figures 5-15 through 5-23 show the concentrations of representative metals and nitrate plus nitrite in surface water and sediment samples from SWMU 12. The tags on the figures display all rounds of data with (usually) two lines of values per tag. The top line of values is surface water data; the lower line is sediment data. If only one line of data is present, the data correspond to the type of sampling location (either surface water or sediment). Each round of data is separated with a slash, and the rounds are presented in sequential order from left to right. Exceedances of SVs are indicated by a filled black dot; the dot is filled if any one of the applicable SVs was exceeded in either round of RFI sampling. For example, a filled dot at location 12SW/SD03 (center of Figure 5-15) indicates that the aluminum concentration in surface water (17,900 µg/L) exceeded the human health surface water SV of 3,600 µg/L and the ecological SV of 87 µg/L. The SVs are listed on the figures.

Total and dissolved metals concentrations were measured in several surface water samples (see Table 2-2). The dissolved concentrations were generally less than half of the total concentrations for: aluminum, cobalt, iron, lead, manganese, and zinc. This indicates that filtration through a 0.45-micron filter removed the majority of these metals from the surface water samples. For the other metals, the dissolved and total metal concentrations were comparable or the metal was essentially all dissolved.

5.3.3.1 Gully Surface Water and Sediment

Ranked data sets may be used to estimate whether measured chemical concentrations are similar to naturally occurring concentrations. This is done by combining upgradient and downgradient data sets and ranking the results from highest to lowest concentration. If the upgradient data appear to cluster toward the low end of the ranking, this is an indication that downgradient sampling locations are contaminated. If both sets of concentrations appear to be evenly distributed across the spectrum of concentrations, the downgradient concentrations are interpreted to be similar to the upgradient concentrations – with one exception. If any downgradient concentrations are significantly greater than the maximum upgradient concentration, this could be an indication of contamination. What is significantly greater is subject to interpretation and depends on the appearance of the distribution. If the distribution of upgradient concentrations appears to be skewed (e.g., lognormal) toward higher concentrations, a greater difference between the highest upgradient concentration and the higher downgradient concentrations is tolerated. The ranking of a particular sampling location at the high end of the concentration spectrum for multiple parameters may also be an indication of contamination.

Table 5-1 presents ranked concentrations for several inorganic parameters in gully surface water samples. Results for upgradient locations are in bold white text with black backgrounds in Table 5-1. Metals that had only a few detections are not included nor are the macronutrients (calcium, magnesium, potassium, and sodium). With this table and Figures 5-15 through 5-23, some significant patterns can be seen as described below. Surface water at location 12SW/SD35 appears at the top of the concentrations rankings for several metals (see Table 5-1), and the metals concentrations are consistently greater than the applicable SVs. Thus, surface water location 12SW/SD35 is contaminated with metals. Surface water location 12SW/SD03 also consistently appears near the top of the concentrations rankings, but several metals concentrations are less than maximum upgradient concentrations. Except for aluminum, barium, beryllium, and manganese, downgradient concentrations that exceed upgradient concentrations are no more than two times the maximum upgradient concentration for location 12SW/SD03. Therefore, surface water at location 12SW/SD03 is considered not to be contaminated except perhaps with aluminum, barium, beryllium, and manganese.

Similar logic applied to other locations and parameters yields the following conclusions. Surface water at sampling location 12SW/SD35 is contaminated with metals relative to any measure (e.g., upgradient concentrations or SVs). This is evident because this location appears at the top of the rankings in Table 5-1 for every metal except manganese. In several cases, the concentrations of metals at this location were orders of magnitude greater than the next highest concentrations. This location, sampled only in Round 2, appears to be an outfall from the settling basin numbered 3037 in Figure 5-2, but multiple conversations with NSWC Crane facilities managers could not confirm this. By one account, the basin may never have been used. It is currently empty and does not show staining from a water level as might be expected if it had once contained water The outfall was sampled directly, before any dilution of the effluent took place. Locations downgradient of this location also would be expected to exhibit elevated metals concentrations. Location 12SW/SD02, which is within 100 feet of location 12SW/SD35, consistently appeared in the upper half and even the upper fourth of the concentration distributions in Table 5-1. If location 12SW/SD02 represented only background concentrations, some of the results would be expected to fall in the lower half of the concentrations distributions by chance alone. The distribution of 12SWSD02 data indicates that concentrations at this location are comparable to upgradient concentrations even though they are in the upper half of upgradient concentrations. If location 12SW/SD35 is ignored, nearby locations 12SW/SD34 and 12SW/SD36 were frequently the locations of the highest or nearly highest concentrations. Because these locations are near 12SW/SD35, if they are contaminated, they should exhibit contaminants similar to those detected at 121SW/SD35. Instead, where as they generally fall in the top fourth of the metals concentrations rankings, the metals concentrations at these two locations are generally within the range of upgradient metals concentrations

and are much more consistent with metal concentrations in other SWMU 12 samples. Based on these observations, it is reasonable to conclude that contamination at 12SW/SD35 is bounded in the downgradient direction by metals concentrations representing the upper end of the upgradient concentration distributions. If any metals contamination is present at locations near 12SW/SD35, it is not clearly discernible based on the available data.

Ignoring location 12SW/SD35, surface water metals concentrations appear to be relatively homogeneous regardless of whether a particular sample represents an upgradient or downgradient location and regardless of the sampling round (see Table 5-1). The bold values (upgradient values) are distributed fairly evenly throughout the sorted data sets in this table. The number of downgradient samples is about four times the number of upgradient samples. This uneven sample distribution between upgradient and downgradient sample numbers favors obtaining the maximum observed concentration in the downgradient sample set. When this is taken into account along with the relatively slight exceedances of SVs or upgradient concentrations for these few exceptional metals, it becomes evident that the observed exceedances of upgradient concentrations in downgradient samples is at least partly an artifact of the sampling design. A factor that supports this assertion is the lack of physical connection between sediment samples with the greatest metals concentration and the lack of spatial patterns to suggest that observed SV or upgradient concentration exceedances are the result of site operations. This is an indication that the only significant area of surface water contamination in gullies is at and near location 12SW/SD35. In Table 5-1, this is evident in that the concentration difference between the locations with the highest and second highest rankings is consistently much greater than between the second, third, and lower ranked locations. The upper range of upgradient concentrations is also similar to the second and lower ranked locations. Although the surface water data generally represent natural conditions, several surface water concentrations exceed SVs. Figures 5-15 through 5-23 identify where the most frequent or significant exceedances of SVs occurred. Screening values are discussed in more detail in Sections 7.0 and 8.0, and risks from exposure to metals at the observed concentrations are evaluated in those sections.

With the exceptions of antimony, cadmium, chromium, lead, and tin, SWMU 12 sediment metals concentrations are similar to upgradient concentrations (see Table 5-2). These exceptional metals concentrations, however, are typically within two times the SV and/or the maximum upgradient sediment concentration. The overall patterns of relative rankings in Table 5-2 are similar to the rankings for surface water locations. The top two locations for each metal generally are the most different with regard to concentration, and concentrations of lower ranked locations are comparable to upgradient metals concentrations. Therefore, the extent of sediment contamination near and downgradient of the outfall,

location 12SW/SD35, has been determined not to extend as far as location 12SW/SD02. This is consistent with the surface water data that indicate delineation of contamination at 12SW/SD35 with a possible trace effect as far away as 12SW/SD02. Although sediment contamination was not measured directly at 12SW/SD35, any sediment contamination that exists at this locale does not extend beyond 12SW/SD02.

Nitrate plus nitrite measured in surface water but not in sediment, was detected at several locations and at slightly elevated concentrations over the two sampling rounds (see Tables 5-3). Table 5-3 is a presentation of ammonia and nitrate plus nitrite data sorted from highest to lowest. Nitrate plus nitrite concentrations exceeded the 1 mg/L human health SV for nitrate at nine locations over the two sampling rounds. The detection of elevated nitrate concentrations is consistent with explosives in surface water and is consistent with SWMU 12 history.

Maximum concentrations of ammonia were observed at locations 12SW1101 (4.2 mg/L in Round 1) and 12SW3501 (1.20 mg/L in Round 2). Location 12SW/SD35 was only sampled in Round 2. This location also had very elevated metals concentrations. Location 12SW/SD11 had no detectable ammonia in Round 2. This location is one of the most downgradient of gully sampling locations. Section 5.3.3.2 describes complete bounding of ammonia concentrations by non-detectable results at the most downgradient surface water sampling locations, including TCMS locations. Ammonia most likely originated in the soil compost, which contained large quantities of chicken manure.

5.3.3.2 East Tributary and Turkey Creek Main Stream Surface Water and Sediment

The data for these drainage channels are indicative of natural conditions. The upgradient locations are very similar in metals concentration very similar to downgradient locations throughout the sampled area. Therefore, it does not appear that any significant metals contamination is present in these channels. Nevertheless, some metals concentrations exceeded SVs (see Tables 3-48 and 3-49). Risks from exposure to surface waters are evaluated in Sections 7.0 and 8.0. Figures 5-15 through 5-23 identify where exceedances of SVs occurred. Because the metals concentrations are indicative of natural conditions, there is no contamination to delineate.

Similar to surface water, sediment data for the east tributary and TCMS samples are comparable to upgradient data (compare Tables 3-29 and 3-32 to Tables 3-21 and 3-22, compare Tables 3-36 and 3-37 to Tables 3-24 and 3-25, compare Tables 3-44 and 3-45 to Tables 3-39 and 3-40, and compare Tables 3-48 and 3-49 to Tables 3-42 and 3-43). There does not appear to be any contamination in these

sediments, although some exceedances of SVs occurred. Figures 5-15 through 5-23 identify where significant exceedances of SVs occurred. Because the metals concentrations are indicative of natural conditions, there is no significant contamination to bound.

In summary, site-related surface water and sediment contamination is limited to explosives and related analytes except at location 12SW/SD35 and its vicinity. Surface water and sediment metals contamination is concentrated at and near location 12SW/SD35. At this outfall, at which sediment was sampled only in Round 2, every environmentally significant metal that was analyzed in surface water (Rounds 1 and 2) had an elevated concentration. The contamination from this outfall is well bounded for metals and is estimated to extend no further than about 150 feet downstream of the outfall. This estimate is based on surface water concentrations and knowledge of contaminant flow patterns. Explosives surface water contamination (5.1 µg/L HMX and 2.1 µg/L RDX) was relatively minor, and no explosives were detected in sediments at this outfall.

Overall, surface water and sediment contamination throughout the investigated area is well bounded by concentrations that are less than human health or ecological SVs, or is comparable to upgradient concentrations. The most downgradient location, 12SW/SD27, was free of contamination in both surface water and sediment.

Nitrate and nitrite are presumed to have been derived from the explosives used at SWMU 12. They may be breakdown products from the degradation of explosives or a result of the use of nitrate salts. Ammonia concentrations were detectable at several locations and may indicate that reduction of nitrates has occurred.

5.4 SUMP WATER AND SEDIMENT CONTAMINATION

Tables 3-50 through 3-53 present descriptive statistics and detailed lists of chemicals detected in at least one sample of sump water and sediment. The entire analytical database for sump water and sediment is provided in Tables G-7 and G-8. Figures 5-24 and 5-25 show RDX concentrations in sump water and sump sediment, respectively. Because the chemicals of concern for the ES/DI were explosives, these samples were analyzed only for explosives. Five compounds were detected in multiple sump water samples (see Table 3-50). The same five compounds were detected in multiple sump sediment samples (see Table 3-52), and 1,3-dinitrobenzene was also detected in one of these sediment samples. These results are an indication that the sumps may have been sources of contamination, especially if they leaked and the sump water mixed with groundwater. Any continued leakage would lead to a continuing source of groundwater contamination. If the sump overflowed, the sump water and perhaps even

sediment may have spilled onto surrounding soils. Some of the soil samples collected near sumps were contaminated with explosives (see Section 5.2.1). The fact that surface soils at some locations near sumps were more contaminated with explosives than subsurface soils is an indication that the sumps may have overflowed to release their contaminants to the soils. However, Figures 5-24 and 5-25 show that the level of contamination remaining in sumps is low compared to the level of contamination in surface soils near select sumps.

5.5 GROUNDWATER CONTAMINATION

Groundwater upgradient data are described in Section 5.1.3. These data apply only to groundwater collected form permanent monitoring wells. No upgradient groundwater samples were collected during the sampling of overburden water during the ES/DI. The subsections below describe the nature and extent of groundwater contamination based on analyses of all groundwater samples.

5.5.1 Overburden Groundwater from Temporary Wells

Several temporary wells were installed through the soil overburden during the ES/DI. This was done in an attempt to collect water that had infiltrated through the overburden and accumulated or migrated along the bedrock surface at the base of the overburden. Such water represents an accumulation of contamination from the soil surface to the bedrock as well as contamination at the overburden-bedrock interface through which the water may move under the influence of gravity.

Multiple overburden wells exhibited detectable concentrations of several explosives (see Table 3-54). The following five chemicals had maximum concentrations in excess of the human health SVs: 2,4,6-trinitrotoluene, 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, HMX, and RDX. The amino compounds are degradation products of 2,4,6-trinitrotoluene, and their presence is an indication that this compound is degrading naturally. All of these chemicals are either adsorbed to soils or present as dissolved species. When in contact with soil, they will tend to establish an equilibrium whereby they partition preferentially into the soil or aqueous phase, depending on their physicochemical properties. More details on the fate and transport of contaminants is presented in Section 6.0.

Of the five chemicals that exceeded human health SVs, the most prevalent was RDX. This is consistent with explosives contamination in other environmental media at SWMU 12. Because this chemical is the most prevalent, its concentrations at temporary well locations were plotted on Figure 5-26. Figure 5-26 shows that all but one water-bearing temporary well had an overburden groundwater RDX concentration in excess of the 0.61 µg/L human health SV. The most contaminated locations were 12TW003 (720 µg/L

RDX), 12TW009 (730 µg/L RDX), and 12TW012 (12,000 µg/L RDX). Location 12TW003 is about 900 feet from the other two locations in the southern half of the SWMU and is located to the west of the ridge. Based on the groundwater potentiometric surfaces for upper and middle bedrock zones (Figures 4-10 and 4-11), this location is influenced by groundwater leaving the ridge top. The two other locations are near Building 152 (see Figure 5-26). Location 12TW009 is within 30 feet of the building and may represent an influence from residual contamination associated with that building. Location 12TW012, however, is about 200 feet from the building and is less likely to represent an influence from soils associated with the building. Post-excavation samples collected from soil immediately southwest of Building 152 had RDX concentrations exceeding industrial SVs (see Figure 1-4), but overburden groundwater closest to this contaminated soil (about 70 feet away) contained just 36 µg/L RDX. Therefore, unless a localized bedrock dip is channeling overburden water toward 12TW012, the high RDX concentrations at that location must be interpreted to be associated with a contaminant source other than Building 152, such as soils near 12TW012.

Three additional temporary well samples that had high levels of RDX contamination were collected from 12TW0002 (170 µg/L), 12TW006 (370 µg/L) and 12TW007 (530 µg/L). Well 12TW002 was near Buildings 158 and 159 in the western central portion of the SWMU. The other two wells were near Building 157 (see Figure 5-26) and were within 15 feet of each other. All three wells were near sumps. The contamination appears to reside in soil in these areas that was not excavated during the bioremediation effort. This is supported by data from temporary well 12TW013, which is about 60 feet downgradient of wells 12TW006 and 12TW007 wells, and had an RDX concentration of 27 µg/L. Groundwater concentrations typically decrease with distance from a contamination source, and the overall groundwater flow is toward the west in the general direction from wells 12TW006 and 12TW007 to well 12TW013. The samples from these wells may also represent contamination form the nearby sumps.

Aside from the wells identified above, temporary wells had RDX concentrations within about an order of magnitude of the human health SV (0.61 µg/L). These wells were located in the northern and southern thirds of the SWMU.

In general, overburden groundwater explosives concentrations are consistent with the knowledge that the highest explosives use appears to have been associated with the central portion of the SMWU. Overburden groundwater in the northern and southern thirds of the SWMU is significantly less contaminated with explosives than the central third.

5.5.2 Pennsylvanian Upper Zone and Middle Zone Wells

One upgradient Puz well (12MWT25) had 0.49 µg/L of RDX in Round 2 but no RDX detection in Round 1. This is significant because RDX is an explosive used extensively at SWMU 12. The metals concentrations in this well, however, appear to be comparable to metals concentrations in other Puz upgradient wells. Furthermore, this well is the most upgradient of all wells and furthest from SWMU operations. Based on these observations, the low detection of RDX may have been a false detection, but this could not be proved. Well 12MWT25I was retained as an upgradient well for the Puz group despite the detection of RDX.

Downgradient groundwater data were not collected from SWMU 12 during the bioremediation effort but were collected during the RFI. Table 2-3 presents a summary of groundwater samples collected and the analyses conducted on the samples. Groundwater samples were generally analyzed for explosives, metals, nitrate, and nitrite in both sampling rounds plus some miscellaneous parameters. Table G-6 of Appendix G presents all groundwater data collected during RFI Rounds 1 and 2 and overburden groundwater collected from temporary wells during the ES/DI. Comparisons of the chemical concentrations to SVs and selection of COPCs for risk assessment are made in Sections 7.0 and 8.0.

The matrix below identifies which tables have data for various groundwater zones.

Table Numbers for Various Data Sets

Data Set	Puz	Pmz	PIzMgd
Upgradient Groundwater	3-56, 3-59	3-57, 3-60	3-58, 3-61
Downgradient Groundwater	3-62 to 3-64, 3-71	3-65 to 3-67, 3-72	3-68 to 3-70, 3-73

Figure 5-27 is a tag map of groundwater concentrations of TNT and two of its degradation products. Figure 5-28 is a tag map of the concentrations of HMX, RDX, and three RDX degradation products (MNX, DNX, and TNX). Well 12MWT24, located adjacent to well 12MWT24A, did not produce enough water for sampling and is not shown on the figures.

RDX and HMX were the first and second most frequently detected explosives, respectively, in groundwater. HMX was detected in many of the same wells as RDX but typically at one-third to one-twentieth of the RDX concentration. Wells 12MWT35 and 12MWT42, where HMX-to-RDX ratios were approximately 1:1 and approximately 1.5:1 for both sampling rounds, were the exceptions. Where RDX concentrations were near detection limits, HMX was not typically detected. RDX has the greater significance because of its greater concentrations and greater toxicity than HMX.

Although RDX concentrations accurately depict the extent of explosives contamination at SWMU 12, the concentrations of explosives that were most frequently detected at the greatest number of locations and at the highest concentrations relative to groundwater SVs are presented in Figures 5-27 and 5-28. The tag maps presented also provide an indication of the degree to which degradation is occurring by including major daughter products of TNT and RDX.

RDX detections were limited to the Puz and Pmz wells with one exception, which is discussed in the next subsection. Wells 12MWT06, 12MWT08, 12MST09, 12MWT11, 12MWT12, 12MWT16, and 12MWT17 had RDX concentrations exceeding 100 µg/L in both rounds of sampling. Several of these RDX concentrations exceeded 1,000 µg/L. These wells form clusters in three different areas of SWMU 12 proper – northeast (wells 12MWT11 through 12MWT14, 12MWT31 and 12MWT46), southwest (wells 12MWT06 through 12MWT10), and east (wells 12MWT16 through 12MWT20 and 12MWT32). The locations of these wells are depicted on Figures 5-27 and 5-28. They reflect the presence of at least three primary explosives contaminant source areas for groundwater contamination at SWMU 12 and are near areas where excavations of explosives-contaminated soil occurred (see Figures 1-4 through 1-11).

Wells 12MWT21 and 12MWT22 had RDX concentrations less than 100 µg/L in one sampling round but greater than 100 µg/L in the other round. The RDX concentrations reported for Rounds 1 (590 µg/L) and 2 (34 µg/L) in well 12MWT22 were different by an order of magnitude, and the second round of data from well 12MWT21 (130 µg/L) was approximately two times the first round concentration (61 µg/L). Similar disparities occurred in well 12MWT22 for all other detected explosives. A laboratory reporting error could not be detected, and the field data do not indicate a reason for the disparity in these results. Therefore, it may be most useful to consider average RDX concentrations from the two sampling rounds when estimating impacts to groundwater at these locations. These wells (12MWT21 and 12MWT22) are located next to conveyors that transferred bulk explosives from shaker houses on the western side to the melt rooms on the eastern side. The conveyors have wood slat floors that would easily allow any spillage to contaminate the ground below. Soils beneath the conveyors are known to be contaminated with explosives.

Ten times an SV is a useful limit for describing contamination by separating data into groups that either clearly exceed the SV or do not as definitively exceed the SV. The maximum detected RDX concentration was 7,400 µg/L in Round 2 at well 12MWT16. This well is located in the eastern portion of the SWMU. Fifteen other Puz wells had RDX concentrations greater than 6.1 µg/L (10 times the human health SV) as shown on Figure 5-28. Pmz wells, which are deeper than the Puz wells, had no detectable

RDX concentrations except at well 12MWT48, which had 1.3 µg/L of RDX in Round 1 and 4.2 µg/L RDX in Round 2. The only other Pmz well explosives detection was 0.52 µg/L of HMX in well 12MWT48 during Round 2. This is an indication that groundwater explosives contamination is confined largely to the shallow zone. More on this topic is presented in the next subsection.

All wells that had concentrations greater than 10 times the RDX SV are located on the SWMU 12 ridge top. From there, concentrations decrease in downgradient directions away from the ridge top and down the hillsides. Figure 4-7 shows the potentiometric surface for Puz and Pmz wells and indicates that groundwater flow is away from the ridge top. Figure 5-28 shows decreasing RDX concentrations with distance from the ridge top. A groundwater divide runs along a northwest-to-southeast line along which is a line of wells bracketed by 12MWT11 and 12MWT23. The predominant groundwater flow direction is from this divide toward the west; however, groundwater also flows toward the east from this divide.

Perimeter well 12MWT48 had 1.3 µg/L RDX in Round 1 and 4.2 µg/L RDX in Round 2, which may represent a random fluctuation caused by sampling or laboratory uncertainty or by natural changes in the groundwater. All other perimeter wells, including Plz/Mgd wells, which are addressed in the next subsection, had RDX concentrations less than SVs. Therefore, the RDX contamination in groundwater is almost, but not completely, bounded laterally by wells that have RDX concentrations less than the 0.61 µg/L human health SV. Furthermore, groundwater flow away from the ridge top is bounded physically by the main drainage channels in the valleys on either side of the peninsular SWMU ridge. These channels are situated between hillsides and receive water flowing from opposite sides of the channels. Therefore, although RDX contamination moves from the ridge top in groundwater toward the streams, it cannot migrate in groundwater beyond the streams from the direction of SWMU 12.

The descriptions of RDX contaminant distributions above would be similar for TNT and other explosives at MFA, although the RDX is the most pervasive of the explosives. In addition, degradation products of TNT and RDX were consistently detected where parent compound concentrations exceeded 50 µg/L. Furthermore, the degradation product concentrations were generally greatest where the parent compound concentrations were greatest. For example, well 12MWT06 had about 7,000 µg/L of RDX and about 170 µg/L of TNT in both rounds of sampling, and this well also had the highest concentrations of degradation products (see Figures 5-27 and 5-28). Degradation products were also detected at moderate concentrations in this well. This demonstrates that explosives degradation is occurring. Degradation of organic compounds, including explosives, is discussed in more detail in Section 6.0.

Groundwater metals data are presented for Puz and Pmz wells in Figures 5-29 through 5-40 for the most significant metals in terms of potential site-related contaminants. An exceedance of the groundwater human health SV in one or more sampling rounds is represented by a filled black dot at the affected sampling location. An open dot indicates that no exceedance occurred in any round. Ecological SVs do not apply to groundwater. Dashes are used to indicate where data are not available for a particular round; the rounds are Round 1 and Round 2 reading from left to right. Each metal is discussed individually in the following text.

Aluminum - Figure 5-29 shows that there were numerous SV exceedances for aluminum in Puz and Pmz wells. The majority of these exeedances were at locations in the northern portion of the site. The greatest exceedances occurred at wells 12MWT07 (southwestern region), wells 12MWT23 and 12MWT24A (southern end of SWMU), and 12MWT48 (southeastern side of SWMU). All of the aluminum concentrations in these wells were significantly greater than the SV and upgradient concentrations. This indicates an influence from the SWMU. Three lines of evidence indicate that the high aluminum concentrations were associated with suspended matter. First, the high aluminum concentrations are generally found in samples that had high turbidities (see Table G-4). Second, high concentrations do not appear to be correlated with low pH values. Low pH values indicate an acidic condition that promotes dissolution of metals from solid matter. When there is no correlation between high metals concentrations and low pH, this is an indication that another factor is causing the high metals concentrations to occur. Third, a comparison of filtered to unfiltered sample results for aluminum indicates that the observed aluminum concentrations, regardless of concentration, are generally attributable to the total metals concentration (unfiltered sample) more so than the dissolved metal concentration (filtered sample). Thus, although aluminum concentrations clearly exceeded upgradient levels and SVs in SWMU 12 site wells, the high concentrations are attributable to high suspended solids content. This could mean that naturally occurring particulate matter such as pulverized rock from drilling is the primary source of aluminum; however, the available data do not provide enough information to definitively determine whether aluminum is a site-related contaminant. Aluminum was used at MFA, but the known areas of use do not correlate to the locations of high aluminum concentrations in groundwater. The Battery Site, where many metals contaminants were detected, is not large enough to have had the effect shown on Figure 5-29. It is also not upgradient of the wells where exceedances of SVs were detected. The outfall at surface water/sediment sampling location 12SW/SD35 may have some effect on nearby wells but could not have had the breadth of effect visible on Figure 5-29. Based on observed concentrations and a known use of aluminum at MFA, aluminum appears to be a site-related contaminant, but the observed concentrations have not been associated with known potential contaminant sources. Figure 5-29 shows that elevated aluminum concentrations are generally well bounded in downgradient directions by wells that have

aluminum concentrations comparable to upgradient concentrations and less than SVs. Exceptions occur in the southern and southeastern portions of the SWMU, with an additional borderline case near well 12MWT05 to the west of the ridge top.

Arsenic - Figure 5-30 shows that groundwater arsenic concentrations exceed the 0.045 µg/L SV in many samples. The arsenic SV is so low that the analytical detection limit exceeds the SV; therefore, every detection of arsenic exceeds the SV, and non-detectable levels of arsenic may also exceed the SV. Wells with undetectable levels of arsenic are not identified as exceedances on Figure 5-30. Many arsenic detections were less than about 3 µg/L, but several were greater than 10 µg/L. For example, the nine highest total arsenic groundwater concentrations in Puz and Pmz wells ranged from 11.6 µg/L (sample 12GWT0701) to 91.2 µg/L (sample 12GWT0501). By contrast, five of eight arsenic concentrations in upgradient Puz and Pmz wells were less than detection limits, and the remaining three results were less than 3 µg/L for Rounds 1 and 2. The number of arsenic detections was greater in Round 1 than in Round 2, and the number of elevated arsenic concentrations was also greater in Round 1. The wells with elevated arsenic concentrations are considerably separated, and the arsenic concentrations in groundwater reveal no pattern that is known to link them to site-related contamination. For example, the wells do not appear to be located where they would be affected by the outfall at surface water sediment/sampling location 12SW/SD35 or the Battery Site. The high concentrations of arsenic suggest that arsenic is a site-related contaminant, but an operationally related source of the arsenic is unknown. The arsenic spatial contamination pattern mimics that of the aluminum contamination pattern.

Beryllium - Figure 5-31 displays beryllium concentrations in groundwater. The greatest concentration of this metal was measured in well 12MWT23 (97.4 µg/L in Round 1). This well had 88.9 µg/L of beryllium in Round 2. Other high beryllium concentrations were detected in well 12MWT07 (28.4 µg/L in Round 1 and 29.4 µg/L in Round 2) and well 12MWT24A (90.3 µg/L in Round 1 and 64.3 µg/L in Round 2). By contrast, there were only three detectable concentrations of beryllium (0.1 to 2.2 µg/L) in the four upgradient Plz and Pmz wells in both sampling rounds. The beryllium concentrations exceeded the 4 µg/L human health risk SV in several wells (see Figure 5-31). This metal appears to be site related, but an operationally related source of beryllium is unknown. The groundwater beryllium concentrations are reasonably well bounded in all downgradient directions by concentrations less than the 4 µg/L SV. The eastern and western tributaries to Turkey Creek also bound the groundwater flow and hence the groundwater beryllium contamination emanating from MFA.

Cadmium - Figure 5-32 displays cadmium concentrations in groundwater. The concentrations were highest in wells 12MWT23 and 12MWT24A (40.7 to 83.4 µg/L) during Rounds 1 and 2. These wells are

located near the southern end of SWMU 12 and are within 500 feet of each other. The next highest cadmium concentrations were detected in well 12MWT07, also in both sampling rounds. This well is approximately 900 feet northwest of wells 12MWT23 and 12MWT24A. The high concentrations of cadmium suggest that cadmium is a site-related groundwater contaminant, but an operationally related source of this contaminant is unknown. The elevated cadmium concentrations are not completely bounded in downgradient directions by wells with concentrations less than SVs; however, the eastern and western tributaries to Turkey Creek prevent groundwater flow and groundwater contamination from moving further away from the SWMU in those directions.

Chromium - Figure 5-33 displays chromium concentrations in groundwater. The concentrations were greatest in well 12MWT48 (ranging from 34.1 to 47.9 µg/L) during Rounds 1 and 2. The maximum upgradient chromium concentration for Puz and Pmz wells was 1.76 µg/L. This metal appears to be site related, but an operationally related source of the chromium is unknown. The chromium spatial concentration pattern mimics that of aluminum and other metals discussed above. Chromium contamination is not bounded in downgradient directions by concentrations that are comparable to upgradient concentrations or less than the SV.

Cobalt - Figure 5-34 displays cobalt concentrations in groundwater. The concentrations were greatest in well 12MWT23 in Rounds 1 (5,460 µg/L) and Round 2 (6,060 µg/L) and represent extremely high concentrations for a metal that is usually found in groundwater at concentrations less than 10 µg/L (Dragun, 1988). The next highest concentrations were observed in wells 12MWT07 (1,680 and 3,160 µg/L in Rounds 1 and 2, respectively) and 12MWT24A (4,640 µg/L in Round 2). In Round 1 however, the concentration in well 12MWT24A was undetectable (at a detection limit of 44 µg/L). Numerous other concentrations exceeded the human health groundwater SV of 73 µg/L (see Figure 5-34). The maximum upgradient cobalt concentration in Puz and Pmz wells was 53.26 µg/L. Because the downgradient concentrations are so much greater than the upgradient concentrations, this metal appears to be site related, but an operationally related source of the cobalt is unknown. The wide variation in cobalt concentrations between Rounds 1 and 2 in well 12MWT24A is unexplained. The cobalt spatial contamination pattern mimics that of aluminum and other metals discussed above. Cobalt contamination is reasonably well bounded in downgradient directions by concentrations that are either comparable to upgradient concentrations or less than the SV.

Iron - Figure 5-35 displays iron concentrations in groundwater. The greatest concentrations detected in wells 12MWT14 (108,000 µg/L) and 12MWT24A (191,000 µg/L) in Round 1 and in wells 12MWT07 (136,000 µg/L) and 12MWT24A (209,000 µg/L) in Round 2. The next highest concentrations were

observed in several different wells (see Figure 5-35). Many of these concentrations exceeded the 1,100 µg/L groundwater SV for human health risk. The maximum upgradient iron concentrations were 41,700 µg/L (Round 1) and 41,800 µg/L (Round 2) in well 12MWT33. The elevated upgradient concentrations indicate that concentrations of this metal are naturally high. Dragun (1988) reports a typical range for iron to be 10 to 10,000 µg/L in groundwater, with extreme values greater than 1,000,000 µg/L. Based on this and associated upgradient concentrations, it does not appear that iron is a site-related or a significant contaminant. Furthermore, iron has a low toxicity compared to other metal toxicities. More detail concerning metals toxicity is provided in Section 8.0. Iron contamination is bounded in downgradient directions by concentrations that are comparable to the upgradient concentrations but not by concentrations less than the SV.

Lead - Figure 5-36 displays lead concentrations in groundwater. The greatest concentration of lead was measured in well 12MWT23 (104 µg/L in Round 2). This well had 31.5 µg/L of lead in Round 1. By contrast, there was only one detectable concentration of lead (0.08 µg/L) in the four upgradient Plz and Pmz wells in both rounds. Lead concentrations exceeded the 15 µg/L human health risk SV in several wells (see Figure 5-36). This metal appears to be site related, but an operationally related source of lead is unknown. The spatial concentrations pattern mimics that of aluminum and other metals described above. Lead contamination is not bounded in downgradient directions by concentrations that are comparable to the upgradient concentrations or by concentrations that are less than the SV.

Manganese - Figure 5-37 displays manganese concentrations in groundwater. The greatest concentrations (65,700 to 138,000 µg/L) were detected in wells 12MWT23 and 12MWT24A in Rounds 1 and 2. The next highest concentrations were observed in several different wells (see Figure 5-37). Many of these concentrations exceeded the 88 µg/L groundwater SV for human health risk (see Figure 5-37). The maximum upgradient manganese concentration was 6,000 µg/L in Round 1 at well 12MWT28. This metal appears to be site related, but an operationally related source of manganese is unknown. The site-related influence appears to be confined to the southern end of the SWMU. Manganese contamination is bounded in downgradient directions by concentrations that are comparable to the upgradient concentrations but not by concentrations less than the SV.

Nickel - Groundwater concentrations of this metal are shown on Figure 5-38. Many of the Puz and Pmz wells had exceedances of the 73 µg/L nickel human health SV. The greatest nickel concentrations were detected in well 12MWT23 (14,000 and 14,600 µg/L for Rounds 1 and 2, respectively). Similar to other metals, nickel concentrations in well 12MWT23 were consistently elevated. The maximum observed upgradient nickel concentration was 131 µg/L in well 12MWT33 (Round 1). This metal appears to be site

related, but an operationally related source of nickel is unknown. Nickel contamination is generally bounded in downgradient directions by concentrations that are comparable to upgradient concentrations, but many of these concentrations exceed the SV of 73 µg/L. An exception occurs to the west in well 12MWT42 where nickel concentrations for Rounds 1 and 2 were 627 and 200 µg/L, respectively, and exceeded the upgradient concentrations and the SV. Nevertheless, all groundwater flow away from MFA is bounded physically by the eastern and western tributaries to Turkey Creek. More on groundwater flow is presented in Section 6.0.

Thallium - There were several detections of thallium at concentrations greater than the human health groundwater SV (0.24 µg/L). Groundwater concentrations of this metal are shown on Figure 5-39. The maximum concentration (6.0 µg/L) was observed in well 12MWT23 in Round 2. In Round 1, the concentration in that well was 1.5 µg/L. In eight upgradient wells, this metal was detected once (0.08 µg/L) in Round 1 at well 12MWT25. That detection may be a false positive. This metal may be site related, but an operationally related source of thallium is unknown. The concentration pattern mimics that of aluminum and other metals described above.

Vanadium - Figure 5-40 displays groundwater vanadium concentrations in Puz and Pmz wells. The highest vanadium concentration (38.0 µg/L) was observed in well 12MWT48 in Round 2. This well was not sampled in Round 1. Vanadium was not detected in upgradient Puz wells in either sampling round. Although multiple vanadium concentrations in groundwater exceed the 3.6 µg/L human health SV, this metal does not appear to be as significant a site-related contaminant as other metals that have exceedances of more than 10 times the SV. The concentration pattern of vanadium however, mimics that of aluminum and other metals described above.

When detected, the majority of the following metals concentrations in groundwater are consistently associated with total metals as opposed to dissolved metals (see Table G-4): aluminum, arsenic, chromium, copper, iron, and lead. This indicates that filtration through a filter with 0.45-micron pore size will generally remove most of these metals from groundwater because they are associated with suspended matter in the water. The suspended matter may be colloidal or particles of larger size. Colloids are generally considered to range in size from 0.001 to 1 micron in size.

The eight greatest nitrate plus nitrite concentrations were observed in wells 12MWT07 (4.1 mg/L) (see Figure 5-41), 12MWT11 (10 mg/L in Round 1 and 4.8 mg/L in Round 2), 12MWT12 (4.7 mg/L in Round 1), 12MWT16 (5.7 mg/L in Round 1 and 4.2 mg/L in Round 2), 12MWT32 (6.1 mg/L in Round 2) and 12MWT36 (5.4 mg/L in Round 1). All other detected nitrate plus nitrite concentrations were less than the

1.0 mg/L nitrate SV. Elevated concentrations were generally detected near the excavations associated with the bioremediation effort. The seven greatest ammonia concentrations were in Puz and Pmz wells 12MWT32 (1.0 µg/L in Round 1 and 1.7 µg/L in Round 2), 12MWT46 (1.8 µg/L in Round 1), 12MWT23 (8.9 µg/L in Round 1 and 4.0 µg/L in Round 2), 12MWT24A (5.9 µg/L in Round 1 and 10 µg/L in Round 2) (see Figure 5-42). The highest observed concentrations of ammonia and nitrate plus nitrite were generally on the ridge top and decreased in directions away from the ridge top. The chicken manure used in the composting operation and which is present in the replaced bioremediated soil contains nitrogen compounds. The nitrogen compounds are the most likely source of NO_3 and NO_2. More on the degradation of chemicals is provided in Section 6.0.

In summary, shallow and intermediate depth wells display a generally consistent concentration pattern, with the most contaminated groundwater near the southern end of the SWMU, and with lesser but still significant contamination toward the southwestern and northwestern regions. Some metals contamination may also exist toward the east, but the levels of contamination in that area are generally not as elevated as in the other areas. Aluminum is known to have been used at MFA, but no history of use for the other metals described above has been identified. Finding low levels of industrial metals such as aluminum, chromium, copper, iron, lead, and zinc as contaminants in groundwater in an industrial area might be expected; detection of elevated concentrations of beryllium, cobalt, mercury, selenium, thallium, and tin is unusual. Therefore, the metals contamination appears to be site related, but sources of the contamination have not been identified. For example, the Battery Site, which exhibits metals contamination in soil, is downgradient of the wells that consistently exhibited high metals concentrations (12MWT23 and 12MWT24A). There are no monitoring wells in the immediate vicinity or downgradient of the Battery Site located at the southern end of SWMU 12. In addition, the high metals concentrations observed in shallow and middle zone wells do not correlate spatially with the 12SW/SD35 outfall. One theory that could explain the observed groundwater metals concentrations is that naturally occurring metals have been mobilized by chemically reducing conditions that resulted from replacing composted soil in the ground. However, it does not appear that this would account for the high levels of metals contamination observed in groundwater at the southern end of the SMWU where composting did not occur.

5.5.3 Pennsylvanian Lower Zone and Mississippian Glen Dean Wells

Four wells in the Plz/Mgd group (12MWT41, 12MWT43, 12MWT44, and 12MWT49) were sampled and analyzed for various combinations of explosives, metals, nitrate plus nitrite, and ammonia (see Table

2-3). Well 12MWT50 belongs to this well group, but it was not sampled because it was dry at the time of sample collection.

One of the five Plz/Mgd wells is the upgradient well (12MWT43). One of the wells (12MWT44) had detectable concentrations of the following compounds during Round 1: TNT (4.2 µg/L), 4-amino-2,6-dinitrotoluene (0.65 µg/L), HMX (0.28 µg/L), and RDX (3.9 µg/L in Round 1). There were no detections of explosives in Plz/Mgd wells during Round 2. The presence of the amino compound is evidence of TNT degradation. The low concentrations of detected explosives and the fact that they were detected only in Round 1 indicate that there is very little explosives contamination reaching the Plz/Mgd groundwater. Metals concentrations in the Plz/Mgd wells were generally greatest in the upgradient well (12MWT43). The only significant exceptions were for macronutrients such as magnesium and calcium, which are not environmentally significant. Therefore, metals are not discussed further for Plz/Mgd wells.

Plz/Mgd upgradient well 12MWT43 had the following chemical concentrations in excess of maximum shallow well (Puz/Pmz) concentrations: antimony (3.5 µg/L and 3.5 µg/L in Rounds 1 and 2, respectively), barium (1360 and 1950 µg/L in Rounds 1 and 2, respectively), chromium (78.9 µg/L in Round 2) and vanadium (58.5 µg/L in Round 2). The chromium (28.4 µg/L in Round 1) and vanadium (39.9 µg/L in Round 1) concentrations were less than the maximum shallow well concentrations. The maximum shallow well concentrations for these four metals were: 3.2 µg/L for antimony (sample 12GWT3101-F), 214 µg/L for barium (sample 12GWT4802), 47.9 µg/L for chromium (sample 12GWT4802), and 49.4 µg/L for vanadium (sample 12GWT4801). In general, metals concentrations in the Plz/Mgd wells were within the range of metal concentrations observed for shallower wells. Consequently, the observed concentrations do not represent any significant site-related contamination, and these analytes are not discussed further for the deep water-bearing zone.

5.5.4 Summary of Upper and Lower Well Contamination

In summary, the primary organic groundwater contaminants are RDX and HMX, with minor contributions from other explosives and explosives degradation products. Explosives contamination is confined almost completely to the shallow and middle zone wells. Concentrations decrease with distance from the ridge top in the downgradient directions. Detection of these explosives is consistent with their use at SWMU 12.

Elevated metals concentrations are evident in shallow and middle zone wells but not in deeper wells. Some metal concentrations are orders of magnitude greater than upgradient concentrations and SVs. An

operationally related source representing the breadth of metallic groundwater contamination is unknown. Metals contamination is not completely bounded in downgradient directions by wells that have concentrations comparable to upgradient concentrations or to SVs.

Despite the presence of groundwater contaminants, the flow of contamination is bounded physically by steams in the valleys on either side of the SWMU 12 ridge. These streams serve as conduits for contaminants that are carried by groundwater and discharge in the valleys to the streams. More on the fate and transport of contaminants and how the streams bound groundwater flow is presented in Section 6.0.

The groundwater concentrations of several metals were not presented. These metals have no human health SVs (calcium, magnesium, potassium, and sodium), the metals concentrations did not exceed the human health SV in any sample (copper, tin), the number of exceedances was small compared to the number of results generated (antimony, barium, mercury, selenium, zinc), all exceedances were within a factor of three of the SV (antimony), or the exceedances were bounded by wells with concentrations less than SVs in the lateral or vertical downgradient direction (antimony in wells 12MWT31 and 12MWT32; mercury in wells 12MWT06, 12MWT11, 12MWT12, and 12MWT17; and zinc in well 12MWT07).

Maximum concentrations of nitrate/nitrite and ammonia in groundwater were observed on the ridge top where explosives concentrations were also generally the highest. These chemicals may be indications of explosives degradation because the greatest concentrations were generally near areas that were filled with composted soil containing high levels of organic matter. This topic is discussed in more detail in Section 6.0.

5.6 SUMMARY OF EXTENT OF CONTAMINATION

At the outset of this investigation, explosives, VOCs, SVOCs, and metals were identified as potential contaminants. After extensive sampling with a focus on areas that should be contaminated if chemical releases had occurred, the following can be said:

- VOCs and SVOCs do not appear to be significant site related contaminants.

- Explosives contamination remains in soil around buildings where excavations were conducted. Very rough calculations indicate that the amount of explosives mass remaining could be approximately equal to the amount removed and thus continue to serve as an explosives source for leaching to

groundwater. Additional areas of explosives contamination were identified during the ES/DI and showed that the bulk of the contamination mass is in the shallow soils.

- Explosives have migrated to groundwater and this groundwater contamination extends to the streams flanking the SMWU 12 ridge. The highest groundwater explosives concentrations appear to be associated with the excavated areas and an area about 200 feet north of Building 151. The explosives concentrations decrease with distance from these areas.

- Evidence of explosives degradation is present.

- The most downgradient surface water and sediment samples collected in the Turkey Creek main stream did not exhibit detectable concentrations of explosives. Therefore, the explosives contamination is well bounded. The streams also serve as a physical barrier to groundwater migration away from the SMWU 12 ridge top. More on the topic of contaminant migration is presented in Section 6.0. Sumps and catch basins that contain explosives contamination represent potential continuing sources of groundwater contamination. Contaminated soils, especially surface soils, near catch basins represent actual continuing groundwater contamination sources.

- Metals appear to be site related contaminants at the outfall near settling basin 3037 but the extent of metals contamination from this point is limited to within about 150 feet down stream. Any evidence of metals contamination in surface water or sediment in the area surrounding the outfall was slight.

- The highest concentrations of metals in groundwater were associated with the southern end of SWMU 12, although areas to the southwest and northwest also showed significantly elevated metals concentrations.

- Because the observed elevated groundwater metals concentrations do not appear to be linked to site use of metals (except perhaps for aluminum), one must consider the possibility that the elevated metals concentrations are an indication of natural conditions or they reflect the mobilization of metals caused by returning composted soils to the excavations. The latter possibility, however, is only likely in those areas downgradient of the composting excavations.

- Some metals (calcium, magnesium, potassium, and sodium) are environmentally benign and are not considered to be site-related contamination. Aluminum, cobalt, iron, selenium, and vanadium, were not detected at concentrations greater than UTLs in surface soil. The concentrations of these metals

in the subsurface were greater than but within two times the 95 percent UTLs in the subsurface. Of these, cobalt, iron, selenium, and vanadium are considered to be insignificant because their concentrations appear to be representative of a local, slightly elevated background population. Aluminum concentrations are also considered to be of little significance for SWMU 12 proper but of greater significance for the Battery Site. Beryllium and titanium do not have background UTLs, but the spatial distributions were fairly uniform throughout the site indicating that beryllium and titanium concentrations probably represent a background population. Manganese, mercury, silver, thallium, and tin have concentrations distributions that are represented by the metals whose concentrations are plotted in Figures 5-2 through 5-12. Based on observed concentrations relative to screening values and background UTLs the most significance contaminants are cadmium (concentrations not plotted) chromium, copper, nickel, lead, silver (concentrations not plotted), tin (concentrations not plotted), and zinc at the Battery Site. The majority of Battery site contamination is located in the center of the sampling pattern.

- Exceedances of SVs on the perimeter of the sampling pattern are generally slight but there is evidence of overland migration of surface contamination toward the southwest of the site. This downgradient contamination is well bounded by concentrations equal to or nearly equal to background UTL values, depending on the metal. In several cases, bedrock was encountered at depths that were shallower than designated sampling intervals, and therefore represents the vertical extent of metal contamination in soils.

TABLE 5-1

TOTAL METALS RANKED DATA SETS FOR GULLY SURFACE WATER
FOR ROUND 1 and ROUND 2 (ug/L[1])
NSWC CRANE
CRANE, INDIANA

SAMPLE	ALUMINUM
12SW3501	67700
12SW0301	17900
12SW3001	**8920**
12SW3601	8360
12SW1802	6240
12SW0202	5550
12SW0101	3970
12SW2002	3320
12SW0701	2680
12SW3401	2550
12SW3101	2190
12SW1501	1810
12SW2901	**1660**
12SW1401	1570
12SW0302	1520
12SW0201	1320
12SW1901	1140
12SW3201	1060
12SW2001	1040
12SW0102	701
12SW1301	616
12SW3301	598
12SW0501	568
12SW1801	557
12SW2601	**424**
12SW1201	417
12SW1701	392
12SW0602	377
12SW0601	346
12SW0901	344
12SW1202	331
12SW0402	283
12SW2101	277
12SW2602	**264**
12SW2201	**260**
12SW0802	**255**
12SW0401	253
12SW1702	218
12SW0801	**181**
12SW1101	128
12SW2801	**102**
12SW1402	90.6
12SW1001	
12SW0502	
12SW0902	
12SW1002	
12SW1102	
12SW1302	
12SW2802	

SAMPLE	ARSENIC
12SW3501	20.3
12SW0201	11.2
12SW0101	11.0
12SW3001	**8.60**
12SW0301	7.30
12SW0501	5.80
12SW3401	5.70
12SW1101	5.10
12SW1401	4.10
12SW0202	3.60
12SW1802	2.90
12SW3601	2.90
12SW2901	**2.00**
12SW0502	1.80
12SW2002	1.80
12SW1501	1.70
12SW3101	1.30
12SW0601	1.20
12SW0701	1.20
12SW2001	1.20
12SW0102	1.10
12SW0901	0.97
12SW0401	0.92
12SW1801	0.91
12SW0602	0.73
12SW1701	0.68
12SW1901	0.68
12SW1201	0.52
12SW0302	0.52
12SW0402	0.47
12SW3201	0.46
12SW0902	0.45
12SW1001	0.41
12SW2601	**0.40**
12SW1301	0.38
12SW1702	0.35
12SW1202	0.32
12SW0801	**0.22**
12SW2801	**0.21**
12SW1402	0.16
12SW2101	
12SW2201	
12SW0802	
12SW1002	
12SW1102	
12SW1302	
12SW2602	
12SW2802	
12SW3301	

SAMPLE	BARIUM
12SW3501	589
12SW0101	428
12SW1101	265
12SW0301	252
12SW1802	124
12SW3001	**112**
12SW3401	109
12SW1901	105
12SW3601	102
12SW1301	91.8
12SW0201	91.5
12SW1701	90.8
12SW2001	89.6
12SW2002	86.0
12SW1401	85.3
12SW0202	81.5
12SW1501	79.0
12SW0501	78.6
12SW2201	**76.9**
12SW0601	73.8
12SW0901	66.7
12SW1001	63.6
12SW0801	**61.8**
12SW2101	58.0
12SW1102	54.6
12SW2901	**53.7**
12SW0302	52.1
12SW2602	**49.1**
12SW0802	**48.8**
12SW1801	47.6
12SW2801	**46.1**
12SW0701	46.0
12SW2601	**45.2**
12SW1002	42.3
12SW0602	40.6
12SW2802	**36.1**
12SW3201	35.8
12SW0502	35.5
12SW0902	35.5
12SW1702	35.4
12SW1302	34.4
12SW3101	34.4
12SW3301	33.9
12SW1202	27.3
12SW0102	26.8
12SW1201	26.5
12SW0402	20.6
12SW0401	17.9
12SW1402	

SAMPLE	BERYLLIUM
12SW3501	5.20
12SW3601	0.68
12SW0301	0.57
12SW0202	0.36
12SW3301	0.31
12SW1802	0.27
12SW0101	0.25
12SW1402	0.25
12SW1301	0.22
12SW2002	0.16
12SW3201	0.16
12SW3401	0.13
12SW1202	0.11
12SW3101	0.11
12SW0302	0.05
12SW0401	0.03
12SW1201	0.03
12SW0102	0.03
12SW2802	**0.03**
12SW0602	0.02
12SW1302	0.02
12SW0201	
12SW0501	
12SW0601	
12SW0701	
12SW0801	
12SW0901	
12SW1001	
12SW1101	
12SW1401	
12SW1501	
12SW1701	
12SW1801	
12SW1901	
12SW2001	
12SW2101	
12SW2201	
12SW2601	
12SW2801	
12SW2901	
12SW3001	
12SW0402	
12SW0502	
12SW0802	
12SW0902	
12SW1002	
12SW1102	
12SW1702	
12SW2602	

TABLE 5-1

TOTAL METALS RANKED DATA SETS FOR GULLY SURFACE WATER
FOR ROUND 1 and ROUND 2 (ug/L[1])
NSWC CRANE
CRANE, INDIANA

SAMPLE	CADMIUM
12SW3501	43.7
12SW1501	3.90
12SW1802	3.10
12SW0301	2.40
12SW1701	2.20
12SW0201	1.60
12SW3001	**1.60**
12SW1801	1.50
12SW1401	0.53
12SW3101	0.37
12SW3601	0.35
12SW0101	0.33
12SW0701	0.21
12SW1702	0.17
12SW3301	0.13
12SW2901	**0.11**
12SW3201	0.11
12SW0602	0.10
12SW2001	0.09
12SW1202	0.07
12SW1102	0.06
12SW0401	
12SW0501	
12SW0601	
12SW0801	
12SW0901	
12SW1001	
12SW1101	
12SW1201	
12SW1301	
12SW1901	
12SW2101	
12SW2201	
12SW2601	
12SW2801	
12SW0102	
12SW0202	
12SW0302	
12SW0402	
12SW0502	
12SW0802	
12SW0902	
12SW1002	
12SW1302	
12SW1402	
12SW2002	
12SW2602	
12SW2802	
12SW3401	

SAMPLE	CHROMIUM
12SW3501	105
12SW0301	14.6
12SW3001	**13.9**
12SW3601	8.40
12SW1802	8.10
12SW0202	6.40
12SW0101	5.00
12SW2002	4.10
12SW3401	3.90
12SW1501	3.60
12SW3101	3.50
12SW1401	3.30
12SW1701	3.20
12SW0701	3.00
12SW2901	**3.00**
12SW0201	2.90
12SW1201	2.60
12SW2001	1.70
12SW1702	1.60
12SW0401	
12SW0501	
12SW0601	
12SW0801	
12SW0901	
12SW1001	
12SW1101	
12SW1301	
12SW1801	
12SW1901	
12SW2101	
12SW2201	
12SW2601	
12SW2801	
12SW0102	
12SW0302	
12SW0402	
12SW0502	
12SW0602	
12SW0802	
12SW0902	
12SW1002	
12SW1102	
12SW1202	
12SW1302	
12SW1402	
12SW2602	
12SW2802	
12SW3201	
12SW3301	

SAMPLE	COBALT
12SW3501	123
12SW0101	21.6
12SW0301	12.5
12SW3601	9.80
12SW3201	9.70
12SW3301	9.20
12SW3001	**9.00**
12SW0202	6.70
12SW1202	6.70
12SW3101	3.60
12SW1802	3.20
12SW1301	3.10
12SW1701	3.10
12SW3401	2.40
12SW1101	2.20
12SW1401	2.10
12SW0102	2.00
12SW2002	1.80
12SW0201	1.70
12SW0701	1.60
12SW1501	1.20
12SW1901	1.20
12SW2901	**1.20**
12SW0501	1.10
12SW1201	0.95
12SW1102	0.75
12SW2802	**0.73**
12SW1702	0.72
12SW0601	0.65
12SW0302	0.61
12SW1402	0.60
12SW2001	0.50
12SW0401	0.49
12SW0901	0.48
12SW1302	0.45
12SW2801	**0.44**
12SW0602	0.43
12SW0402	0.42
12SW1801	0.37
12SW0802	**0.32**
12SW2602	**0.30**
12SW0801	**0.29**
12SW2601	**0.29**
12SW2101	0.28
12SW0502	0.27
12SW1001	0.26
12SW2201	**0.23**
12SW0902	0.18
12SW1002	0.14

SAMPLE	COPPER
12SW3501	1650
12SW0301	32.4
12SW1401	21.6
12SW3001	**20.6**
12SW0201	17.7
12SW0202	12.8
12SW3601	12.4
12SW0501	12.1
12SW3401	11.5
12SW0701	11.5
12SW0101	11.2
12SW3101	9.30
12SW1501	9.10
12SW1802	8.70
12SW2002	6.20
12SW2901	**5.90**
12SW2001	5.70
12SW1801	5.40
12SW0601	5.40
12SW0901	5.30
12SW1701	4.30
12SW1201	4.10
12SW1901	3.30
12SW1001	3.20
12SW0102	3.10
12SW0502	2.80
12SW0401	2.60
12SW1301	2.40
12SW0302	2.10
12SW3201	2.00
12SW2101	1.80
12SW0602	1.60
12SW1202	1.50
12SW1702	1.30
12SW2201	**1.20**
12SW0402	1.20
12SW0902	1.10
12SW1402	1.00
12SW2801	**0.91**
12SW1302	0.84
12SW1102	0.79
12SW0802	**0.79**
12SW3301	0.74
12SW1002	0.74
12SW2802	
12SW2602	
12SW2601	
12SW1101	
12SW0801	

TABLE 5-1

TOTAL METALS RANKED DATA SETS FOR GULLY SURFACE WATER
FOR ROUND 1 and ROUND 2 (ug/L[1])
NSWC CRANE
CRANE, INDIANA

SAMPLE	IRON
12SW3501	95400
12SW0301	23000
12SW3001	**14300**
12SW0101	12600
12SW1101	9390
12SW3601	9080
12SW1802	7380
12SW0202	6580
12SW3201	4270
12SW2002	4080
12SW3401	3010
12SW0701	2830
12SW3101	2650
12SW1501	2430
12SW1401	2160
12SW2901	**1930**
12SW0201	1820
12SW1901	1820
12SW0302	1640
12SW0102	1490
12SW3301	1200
12SW0501	1120
12SW1202	1110
12SW1701	962
12SW2001	925
12SW1801	793
12SW1301	791
12SW2601	**766**
12SW1201	657
12SW0601	612
12SW0901	587
12SW1102	587
12SW0402	559
12SW0401	550
12SW2602	**505**
12SW0801	**461**
12SW0602	459
12SW2101	450
12SW1402	405
12SW1702	401
12SW0502	355
12SW1001	345
12SW2201	**334**
12SW0802	**315**
12SW1302	297
12SW2802	**192**
12SW0902	185
12SW2801	**178**
12SW1002	161

SAMPLE	LEAD
12SW3501	458.0
12SW0301	36.0
12SW3001	**25.3**
12SW1701	16.7
12SW3601	13.0
12SW0202	8.5
12SW1802	6.70
12SW1501	6.10
12SW1401	5.70
12SW0101	5.40
12SW2002	3.80
12SW3101	3.40
12SW1702	3.20
12SW3401	2.70
12SW0701	2.60
12SW2901	**2.00**
12SW1901	1.80
12SW0201	1.70
12SW0302	1.00
12SW3201	0.98
12SW0102	0.94
12SW0501	0.90
12SW2001	0.66
12SW1801	0.56
12SW1202	0.48
12SW1402	0.45
12SW0402	0.35
12SW0802	**0.32**
12SW0602	0.25
12SW1302	0.23
12SW3301	0.21
12SW1102	0.20
12SW2602	**0.20**
12SW0502	0.17
12SW2802	**0.13**
12SW0902	0.10
12SW2801	**0.08**
12SW0401	
12SW0601	
12SW0801	
12SW0901	
12SW1001	
12SW1101	
12SW1201	
12SW1301	
12SW2101	
12SW2201	
12SW2601	
12SW1002	

SAMPLE	MANGANESE
12SW0101	24200
12SW1101	7460
12SW3501	3330
12SW3201	1630
12SW0301	1310
12SW1301	1140
12SW0102	983
12SW1202	974
12SW3601	628
12SW3101	463
12SW3301	347
12SW1701	297
12SW3001	**289**
12SW0202	276
12SW1802	188
12SW1102	161
12SW1901	119
12SW1401	95.3
12SW1201	79.0
12SW3401	72.5
12SW0701	69.9
12SW2002	57.0
12SW2802	**51.5**
12SW2901	**46.3**
12SW2101	38.6
12SW0201	37.2
12SW0401	34.6
12SW1501	33.6
12SW2801	**33.4**
12SW0402	27.7
12SW1402	26.8
12SW1702	25.5
12SW0501	24.6
12SW0302	19.3
12SW1302	17.7
12SW2001	12.9
12SW0802	**12.4**
12SW2201	**12.0**
12SW1801	11.9
12SW2602	**11.2**
12SW0901	10.9
12SW0601	10.0
12SW0801	**10.0**
12SW2601	**8.30**
12SW0602	8.10
12SW1001	5.10
12SW0902	3.60
12SW0502	2.60
12SW1002	1.70

SAMPLE	MERCURY
12SW3501	1.70
12SW0802	**0.66**
12SW1802	0.20
12SW1402	0.11
12SW3401	0.06
12SW0101	
12SW0201	
12SW0301	
12SW0401	
12SW0501	
12SW0601	
12SW0701	
12SW0801	
12SW0901	
12SW1001	
12SW1101	
12SW1201	
12SW1301	
12SW1401	
12SW1501	
12SW1701	
12SW1801	
12SW1901	
12SW2001	
12SW2101	
12SW2201	
12SW2601	
12SW2801	
12SW2901	
12SW3001	
12SW0102	
12SW0202	
12SW0302	
12SW0402	
12SW0502	
12SW0602	
12SW0902	
12SW1002	
12SW1102	
12SW1202	
12SW1302	
12SW1702	
12SW2002	
12SW2602	
12SW2802	
12SW3101	
12SW3201	
12SW3301	
12SW3601	

TABLE 5-1

TOTAL METALS RANKED DATA SETS FOR GULLY SURFACE WATER
FOR ROUND 1 and ROUND 2 (ug/L[1])
NSWC CRANE
CRANE, INDIANA

SAMPLE	NICKEL
12SW3501	140.0
12SW3301	20.5
12SW0301	20.2
12SW3001	**17.6**
12SW3601	16.7
12SW1301	14.1
12SW0202	12.3
12SW3401	9.60
12SW0201	9.20
12SW1401	9.10
12SW0101	9.00
12SW1802	8.90
12SW0501	7.70
12SW3201	7.50
12SW1202	7.00
12SW0701	5.60
12SW2002	5.60
12SW1701	4.80
12SW3101	4.70
12SW0601	4.60
12SW0901	4.20
12SW1501	3.70
12SW1901	3.70
12SW1001	3.60
12SW2001	3.50
12SW2802	**3.50**
12SW0302	3.40
12SW1101	3.30
12SW2901	**3.30**
12SW1801	3.20
12SW0801	**2.90**
12SW2601	**2.70**
12SW0502	2.70
12SW0401	2.60
12SW1201	2.60
12SW2801	**2.60**
12SW0602	2.50
12SW0102	2.40
12SW0402	2.30
12SW1302	2.00
12SW1402	2.00
12SW1102	1.90
12SW1702	1.90
12SW2201	**1.80**
12SW2101	1.70
12SW0902	1.60
12SW1002	1.60
12SW0802	**1.50**
12SW2602	**0.57**

SAMPLE	SELENIUM
12SW3501	9.60
12SW0201	1.20
12SW1401	1.00
12SW3001	**0.73**
12SW0101	
12SW0102	
12SW0202	
12SW0301	
12SW0302	
12SW0401	
12SW0402	
12SW0501	
12SW0502	
12SW0601	
12SW0602	
12SW0701	
12SW0801	
12SW0802	
12SW0901	
12SW0902	
12SW1001	
12SW1002	
12SW1101	
12SW1102	
12SW1201	
12SW1202	
12SW1301	
12SW1302	
12SW1402	
12SW1501	
12SW1701	
12SW1702	
12SW1801	
12SW1802	
12SW1901	
12SW2001	
12SW2002	
12SW2101	
12SW2201	
12SW2601	
12SW2602	
12SW2801	
12SW2802	
12SW2901	
12SW3101	
12SW3201	
12SW3301	
12SW3401	
12SW3601	

SAMPLE	THALLIUM
12SW3501	0.67
12SW1402	0.31
12SW0301	0.21
12SW3001	**0.21**
12SW3601	0.16
12SW1802	0.14
12SW0101	0.12
12SW0202	0.12
12SW3401	0.12
12SW0802	**0.09**
12SW3101	0.09
12SW0502	0.08
12SW2002	0.08
12SW0602	0.07
12SW1002	0.07
12SW1401	0.07
12SW2001	0.07
12SW3201	0.07
12SW3301	0.07
12SW0902	0.06
12SW1102	0.06
12SW1202	0.06
12SW1301	0.06
12SW2602	**0.06**
12SW2801	**0.06**
12SW0201	0.05
12SW1201	0.05
12SW2802	**0.05**
12SW0102	
12SW0302	
12SW0401	
12SW0402	
12SW0501	
12SW0601	
12SW0701	
12SW0801	
12SW0901	
12SW1001	
12SW1101	
12SW1302	
12SW1501	
12SW1701	
12SW1702	
12SW1801	
12SW1901	
12SW2101	
12SW2201	
12SW2601	
12SW2901	

SAMPLE	VANADIUM
12SW3501	138
12SW0301	38.1
12SW3001	**21.6**
12SW3601	14.8
12SW1802	12.1
12SW0202	10.9
12SW0101	9.80
12SW0201	9.20
12SW1401	8.00
12SW3401	8.00
12SW2002	6.00
12SW0701	5.30
12SW0501	4.90
12SW1501	4.70
12SW3101	3.90
12SW2901	**2.90**
12SW0302	2.80
12SW1901	2.60
12SW2001	1.90
12SW0102	1.60
12SW1801	1.50
12SW0502	1.40
12SW0601	1.30
12SW0901	1.30
12SW3201	1.30
12SW0401	
12SW0402	
12SW0602	
12SW0801	
12SW0802	
12SW0902	
12SW1001	
12SW1002	
12SW1101	
12SW1102	
12SW1201	
12SW1202	
12SW1301	
12SW1302	
12SW1402	
12SW1701	
12SW1702	
12SW2101	
12SW2201	
12SW2601	
12SW2602	
12SW2801	
12SW2802	
12SW3301	

TABLE 5-1

TOTAL METALS RANKED DATA SETS FOR GULLY SURFACE WATER
FOR ROUND 1 and ROUND 2 (ug/L[1])
NSWC CRANE
CRANE, INDIANA

SAMPLE	ZINC
12SW3501	5220
12SW3001	**532**
12SW0301	178
12SW1701	103
12SW3601	66.4
12SW1401	56.9
12SW0201	55.7
12SW0202	54.4
12SW1802	47.0
12SW0101	41.8
12SW3301	41.3
12SW2002	38.9
12SW3401	37.0
12SW3101	29.8
12SW1501	29.5
12SW1301	26.9
12SW0701	21.5
12SW1202	21.1
12SW1402	19.4
12SW0501	18.6
12SW1702	16.9
12SW3201	16.3
12SW2901	**11.4**
12SW1901	9.50
12SW2001	8.70
12SW2802	**7.70**
12SW0302	7.60
12SW1302	6.70
12SW1801	6.10
12SW0102	6.10
12SW2801	**5.70**
12SW0802	**5.30**
12SW0402	1.60
12SW0401	
12SW0601	
12SW0801	
12SW0901	
12SW1001	
12SW1101	
12SW1201	
12SW2101	
12SW2201	
12SW2601	
12SW0502	
12SW0602	
12SW0902	
12SW1002	
12SW1102	
12SW2602	

1 Results for each metal are ranked top to bottom from highest to lowest concentration. Bold values are upgradient values.
Blanks represent non-detects.

TABLE 5-2

TOTAL METALS RANKED DATA SETS FOR GULLY SEDIMENT, ROUND 1 ONLY (mg/kg [1])
NSWC CRANE
CRANE, INDIANA

SAMPLE	ALUMINUM		SAMPLE	ANTIMONY		SAMPLE	ARSENIC
12SD120004	25700		12SD130004	4.20		12SD170004	36.0
12SD180004	24700		12SD120004	2.20		12SD090004	32.6
12SD150004	24500		12SD170004	1.60		12SD100004	30.6
12SD140004	23400		12SD180004	0.85		12SD210004	29.3
12SD020004	18200		12SD010004			**12SD280004**	**26.2**
12SD300004	**17800**		12SD020004			12SD130004	25.7
12SD030004	17300		12SD030004			12SD190004	25.6
12SD130004	17200		12SD040004			12SD110004	23.6
12SD210004	17200		12SD050004			**12SD220004**	**21.9**
12SD080004	**17000**		12SD060004			**12SD080004**	**21.6**
12SD220004	**15500**		12SD070004			12SD200004	21.1
12SD070004	15400		12SD080004			12SD120004	16.1
12SD200004	14800		12SD090004			12SD140004	12.2
12SD040004	14600		12SD100004			**12SD300004**	**12.2**
12SD170004	14500		12SD110004			12SD150004	11.1
12SD280004	**14200**		12SD140004			12SD180004	9.30
12SD090004	13700		12SD150004			12SD010004	
12SD110004	13400		12SD190004			12SD020004	
12SD190004	12900		12SD200004			12SD030004	
12SD100004	12800		12SD210004			12SD040004	
12SD060004	12100		12SD220004			12SD050004	
12SD050004	12000		12SD280004			12SD060004	
12SD010004	10300		12SD300004			12SD070004	

TABLE 5-2

TOTAL METALS RANKED DATA SETS FOR GULLY SEDIMENT, ROUND 1 ONLY (mg/kg [1])
NSWC CRANE
CRANE, INDIANA

SAMPLE	BARIUM	SAMPLE	CADMIUM	SAMPLE	CHROMIUM
12SD080004	**196**	12SD150004	7.40	12SD210004	141
12SD090004	182	12SD170004	6.20	12SD100004	84.0
12SD210004	160	12SD010004		12SD170004	83.9
12SD070004	153	12SD020004		12SD090004	82.0
12SD040004	150	12SD030004		**12SD280004**	**64.7**
12SD010004	149	12SD040004		**12SD220004**	**60.3**
12SD110004	143	12SD050004		**12SD080004**	**59.7**
12SD180004	138	12SD060004		12SD190004	45.4
12SD280004	**138**	12SD070004		12SD130004	41.5
12SD020004	108	12SD080004		12SD030004	41.0
12SD060004	103	12SD090004		12SD110004	39.6
12SD140004	88.5	12SD100004		12SD200004	36.7
12SD150004	85.3	12SD110004		12SD140004	35.9
12SD220004	**83.8**	12SD120004		12SD120004	34.4
12SD190004	82.3	12SD130004		12SD150004	29.9
12SD050004	81.0	12SD140004		12SD050004	25.0
12SD100004	73.1	12SD180004		12SD180004	24.5
12SD300004	**70.1**	12SD190004		12SD020004	23.6
12SD030004	69.7	12SD200004		**12SD300004**	**22.1**
12SD200004	64.6	12SD210004		12SD040004	19.1
12SD120004		12SD220004		12SD010004	
12SD130004		12SD280004		12SD060004	
12SD170004		12SD300004		12SD070004	

TABLE 5-2

TOTAL METALS RANKED DATA SETS FOR GULLY SEDIMENT, ROUND 1 ONLY (mg/kg [1])
NSWC CRANE
CRANE, INDIANA

SAMPLE	COBALT		SAMPLE	COPPER		SAMPLE	IRON
12SD130004	108		12SD140004	22.5		12SD100004	217000
12SD120004	98.6		12SD170004	22.5		12SD090004	171000
12SD080004	**65.9**		12SD150004	18.6		12SD210004	163000
12SD210004	35.1		12SD070004	18.3		**12SD280004**	**121000**
12SD090004	32.6		12SD020004	17.7		**12SD220004**	**104000**
12SD040004	32.5		12SD120004	17.1		12SD130004	100000
12SD280004	**31.7**		12SD190004	17.1		12SD110004	95700
12SD170004	29.7		12SD210004	17.1		12SD170004	88700
12SD100004	25.2		12SD090004	16.9		**12SD080004**	**87000**
12SD110004	24.1		12SD130004	16.9		12SD190004	77700
12SD220004	**23.3**		12SD180004	15.9		12SD200004	67300
12SD050004	20.8		12SD110004	15.5		12SD050004	61300
12SD190004	15.9		**12SD220004**	**15.4**		12SD120004	51800
12SD180004	13.6		**12SD280004**	**15.4**		12SD030004	39800
12SD200004	12.2		**12SD300004**	**15.3**		12SD040004	34000
12SD140004	10.2		12SD100004	15.2		12SD140004	30000
12SD300004	**7.9**		**12SD080004**	**14.8**		12SD150004	28700
12SD150004	5.5		12SD200004	10.6		12SD010004	24800
12SD010004			12SD010004			12SD180004	24400
12SD020004			12SD030004			12SD020004	24200
12SD030004			12SD040004			**12SD300004**	**22900**
12SD060004			12SD050004			12SD070004	15700
12SD070004			12SD060004			12SD060004	14100

TABLE 5-2

TOTAL METALS RANKED DATA SETS FOR GULLY SEDIMENT, ROUND 1 ONLY (mg/kg [1])
NSWC CRANE
CRANE, INDIANA

SAMPLE	LEAD		SAMPLE	MANGANESE		SAMPLE	MERCURY
12SD170004	178		12SD130004	6780		12SD140004	0.06
12SD210004	60.3		12SD120004	5730		**12SD220004**	**0.06**
12SD090004	44.7		**12SD080004**	**4430**		12SD120004	0.05
12SD080004	**43.9**		12SD090004	3130		12SD190004	0.05
12SD140004	42.3		12SD040004	3000		12SD130004	0.05
12SD280004	**41.5**		12SD170004	2690		12SD170004	0.05
12SD130004	39.5		12SD210004	2690		12SD090004	0.04
12SD120004	38.4		12SD010004	2610		12SD040004	0.04
12SD100004	36.5		**12SD280004**	**2470**		12SD210004	0.04
12SD220004	**35.7**		12SD100004	2400		12SD070004	0.04
12SD300004	**30.2**		12SD050004	2270		**12SD080004**	**0.04**
12SD190004	26.7		**12SD220004**	**2000**		**12SD280004**	**0.04**
12SD150004	25.9		12SD110004	1620		12SD180004	0.04
12SD200004	25.4		12SD190004	1310		12SD020004	0.04
12SD030004	24.6		12SD070004	1250		12SD060004	0.04
12SD110004	23.8		12SD180004	1200		12SD030004	0.04
12SD050004	22.6		12SD140004	1090		12SD150004	0.03
12SD040004	20.3		12SD060004	972		12SD010004	0.03
12SD180004	19.8		12SD200004	366		12SD100004	0.03
12SD020004	17.3		**12SD300004**	**253**		**12SD300004**	**0.03**
12SD070004	17.3		12SD150004	217		12SD200004	0.02
12SD010004	14.2		12SD020004			12SD110004	0.02
12SD060004	12.6		12SD030004			12SD050004	0.02

TABLE 5-2

TOTAL METALS RANKED DATA SETS FOR GULLY SEDIMENT, ROUND 1 ONLY (mg/kg [1])
NSWC CRANE
CRANE, INDIANA

SAMPLE	NICKEL		SAMPLE	TIN		SAMPLE	VANADIUM
12SD130004	80.9		12SD100004	3.1		12SD090004	71.0
12SD080004	**50.5**		12SD170004	2.7		12SD100004	67.0
12SD280004	**48.1**		12SD120004	2.6		12SD170004	63.2
12SD210004	45.4		12SD010004			12SD030004	55.8
12SD100004	43.1		12SD020004			**12SD080004**	**54.4**
12SD110004	40.3		12SD030004			**12SD220004**	**54.3**
12SD090004	39.7		12SD040004			**12SD280004**	**53.2**
12SD120004	35.6		12SD050004			12SD200004	49.2
12SD220004	**34.1**		12SD060004			12SD120004	48.7
12SD190004	32.9		12SD070004			12SD130004	47.3
12SD170004	32.7		12SD080004			12SD190004	43.8
12SD040004	27.5		12SD090004			12SD140004	42.1
12SD050004	22.9		12SD110004			12SD110004	41.7
12SD200004	17.9		12SD130004			12SD180004	39.6
12SD070004	16.9		12SD140004			12SD150004	38.1
12SD060004	16.6		12SD150004			12SD020004	34.3
12SD300004	**16.1**		12SD180004			12SD050004	33.5
12SD140004	16.0		12SD190004			**12SD300004**	**30.4**
12SD180004	15.9		12SD200004			12SD040004	28.2
12SD150004	14.9		12SD210004			12SD070004	24.3
12SD010004			12SD220004			12SD010004	23.4
12SD020004			12SD280004			12SD060004	
12SD030004			12SD300004			12SD210004	

TABLE 5-2

TOTAL METALS RANKED DATA SETS FOR GULLY SEDIMENT, ROUND 1 ONLY (mg/kg [1])
NSWC CRANE
CRANE, INDIANA

SAMPLE	ZINC
12SD300004	**363**
12SD120004	263.0
12SD140004	261.0
12SD130004	175.0
12SD110004	95.8
12SD150004	87.6
12SD080004	**84.9**
12SD210004	84.1
12SD180004	79.7
12SD200004	78.9
12SD010004	73.8
12SD190004	71.7
12SD020004	70.7
12SD040004	70.5
12SD030004	61.9
12SD050004	61.9
12SD220004	**57.6**
12SD070004	46.6
12SD060004	46.1
12SD090004	
12SD100004	
12SD170004	
12SD280004	

1 Results for each metal are ranked top to bottom from highest to lowest concentration.
Bold values are upgradient values.
Blanks represent non-detects.

TABLE 5-3

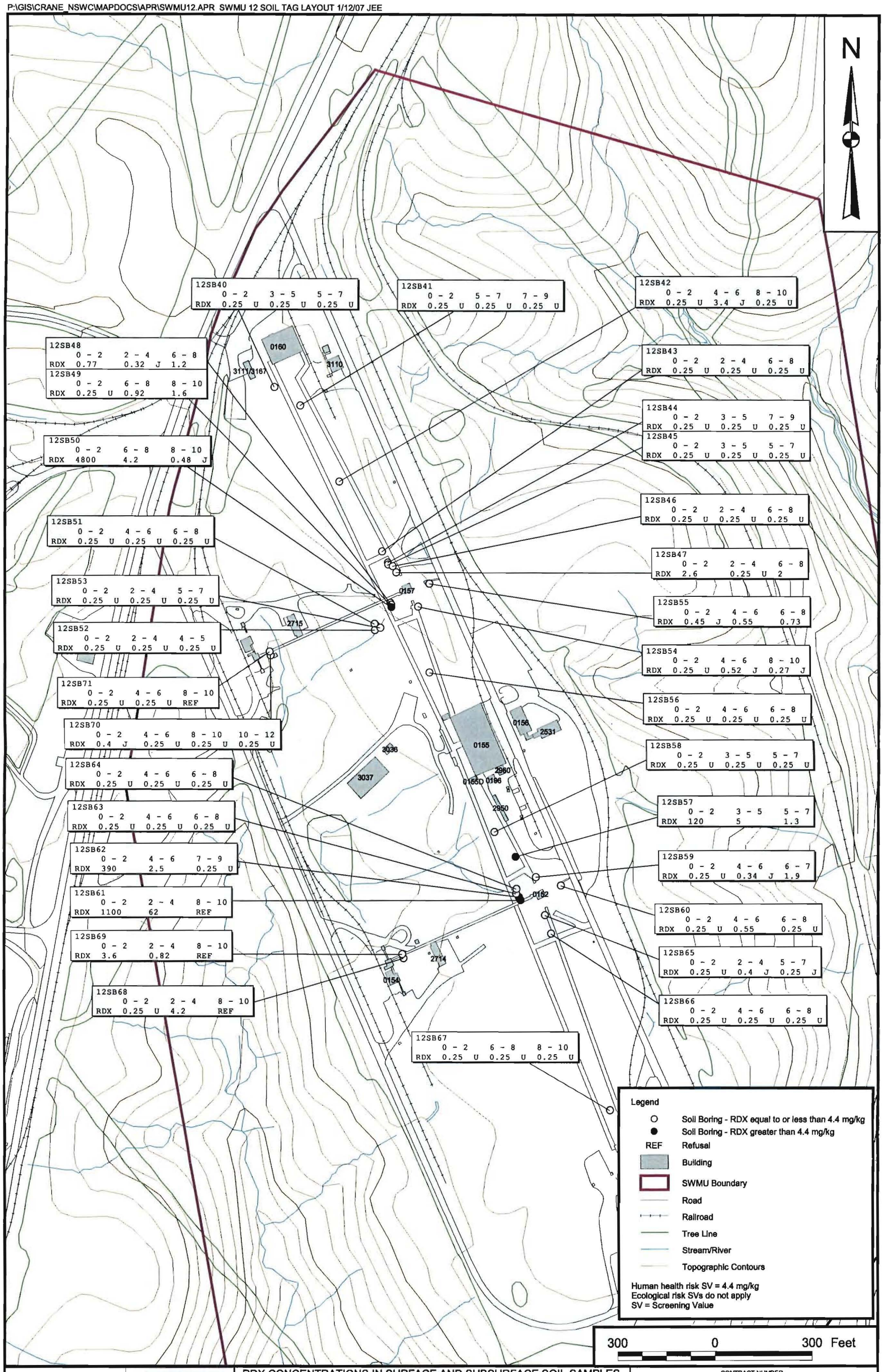
AMMONIA AND NITRATE+NITRITE-N RANKED DATA SETS FOR GULLY SURFACE WATER
ROUND 1 and ROUND 2 (mg/L [1])
NSWC CRANE
CRANE, INDIANA

SAMPLE	AMMONIA-N
12SW1101	4.20
12SW3501	1.20
12SW3201	0.31
12SW1401	0.24
12SW0101	0.22
12SW1202	0.21
12SW1301	0.17
12SW0201	0.16
12SW0401	0.16
12SW1201	0.15
12SW2001	0.15
12SW0601	0.14
12SW3101	0.14
12SW0501	0.12
12SW0301	0.11
12SW0102	0.11
12SW1702	0.09
12SW0202	0.08
12SW2002	0.08
12SW3401	0.08
12SW1402	0.07
12SW3601	0.07
12SW1901	0.06
12SW0402	0.06
12SW1302	0.06
12SW1802	0.06
12SW1701	0.05
12SW0302	0.05
12SW1001	0.04
12SW2201	**0.04**
12SW3001	**0.03**
12SW0701	0.03
12SW0901	0.03
12SW1501	0.03
12SW2101	0.03
12SW2901	**0.02**
12SW0801	**0.02**
12SW1801	0.02
12SW2601	**0.01**
12SW0502	
12SW0602	
12SW0802	
12SW0902	
12SW2602	
12SW3301	

SAMPLE	NITRITE/NITRATE-N
12SW0601	8.20
12SW0201	5.20
12SW0501	4.10
12SW1401	3.80
12SW1201	3.20
12SW0602	2.50
12SW0901	1.90
12SW1402	1.20
12SW1001	1.10
12SW1901	1.00
12SW0401	0.94
12SW3401	0.81
12SW0502	0.70
12SW3001	**0.60**
12SW1202	0.55
12SW1301	0.52
12SW2101	0.51
12SW3101	0.51
12SW0902	0.37
12SW2901	**0.30**
12SW2002	0.30
12SW1302	0.28
12SW2601	**0.26**
12SW0801	**0.20**
12SW1501	0.20
12SW3301	0.20
12SW1702	0.18
12SW1701	0.13
12SW0802	**0.11**
12SW2001	0.08
12SW1801	0.06
12SW2602	**0.05**
12SW0701	0.04
12SW0101	
12SW0301	
12SW1101	
12SW2201	
12SW0102	
12SW0202	
12SW0302	
12SW0402	
12SW1802	
12SW3201	
12SW3501	
12SW3601	

1 Results for each analyte are ranked top to bottom from highest to lowest
Bold values are upgradient values. Blanks represent non-detects.

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU12.APR SWMU 12 SOIL TAG LAYOUT 1/12/07 JEE



DRAWN BY S. STROZ	DATE 7/27/06	RDX CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL SAMPLES (EXTERNAL SUMP/DRAINAGE INVESTIGATION) OF THE MINE FILL A PROPER SWMU 12 MINE FILL A NWSC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS	DATE 1/12/07		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 5 - 1 / REV 0

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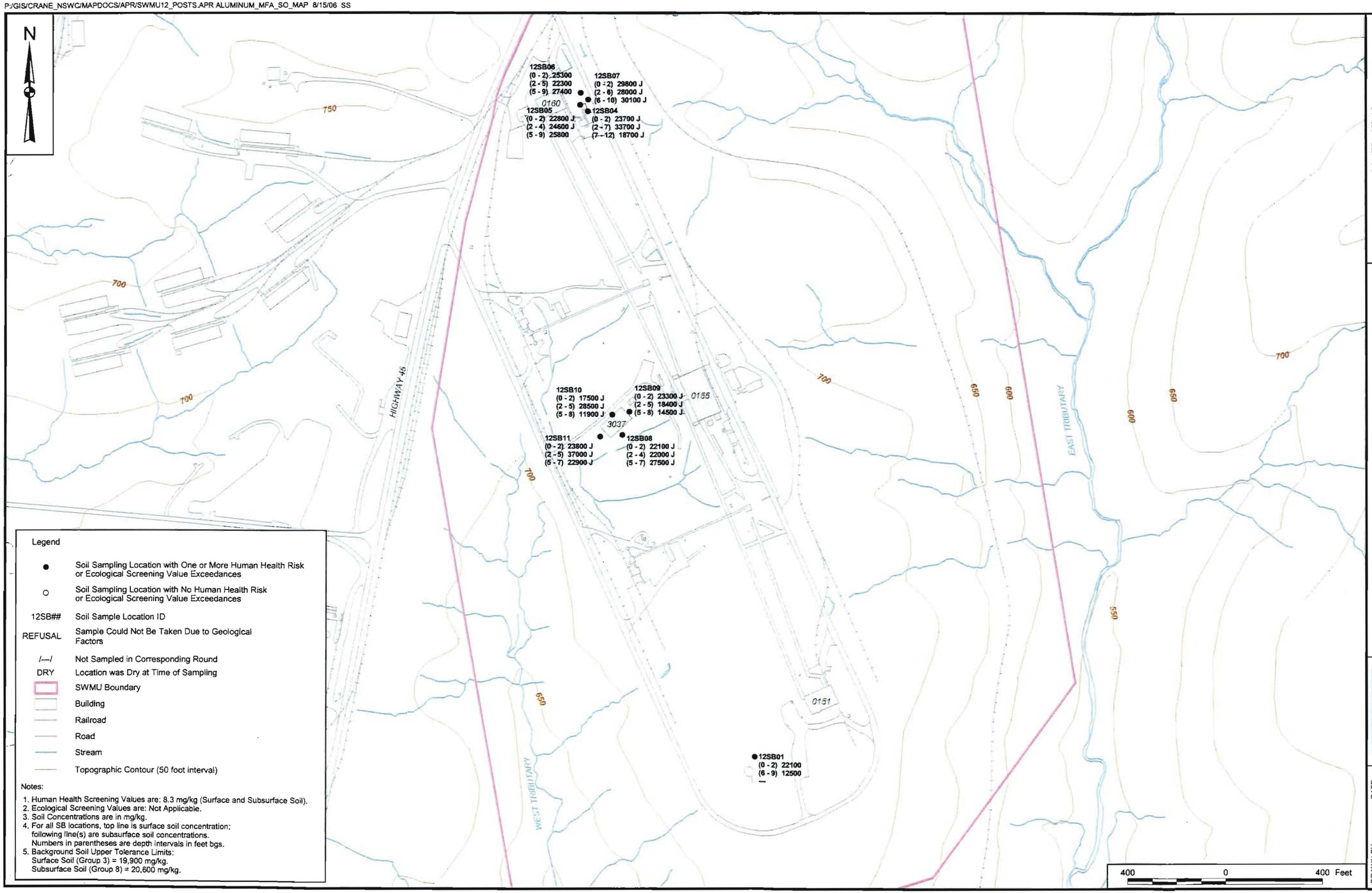


Legend

- ● Soil Sampling Location with One or More Human Health Risk or Ecological Screening Value Exceedances
- ○ Soil Sampling Location with No Human Health Risk or Ecological Screening Value Exceedances
- 12SB## Soil Sample Location ID
- REFUSAL Sample Could Not Be Taken Due to Geological Factors
- /—/ Not Sampled in Corresponding Round
- DRY Location was Dry at Time of Sampling
- SWMU Boundary
- Building
- Railroad
- Road
- Stream
- Topographic Contour (50 foot interval)

Notes:

1. Human Health Screening Values are: 8.3 mg/kg (Surface and Subsurface Soil).
2. Ecological Screening Values are: Not Applicable.
3. Soil Concentrations are in mg/kg.
4. For all SB locations, top line is surface soil concentration; following line(s) are subsurface soil concentrations. Numbers in parentheses are depth intervals in feet bgs.
5. Background Soil Upper Tolerance Limits:
   Surface Soil (Group 3) = 19,900 mg/kg.
   Subsurface Soil (Group 8) = 20,600 mg/kg.

CONTRACT NO. 6878

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 2

REV 0

TOTAL ALUMINUM CONCENTRATIONS (mg/kg)
IN SOIL SAMPLES OF THE MINE FILL A PROPER
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

NAVFAC

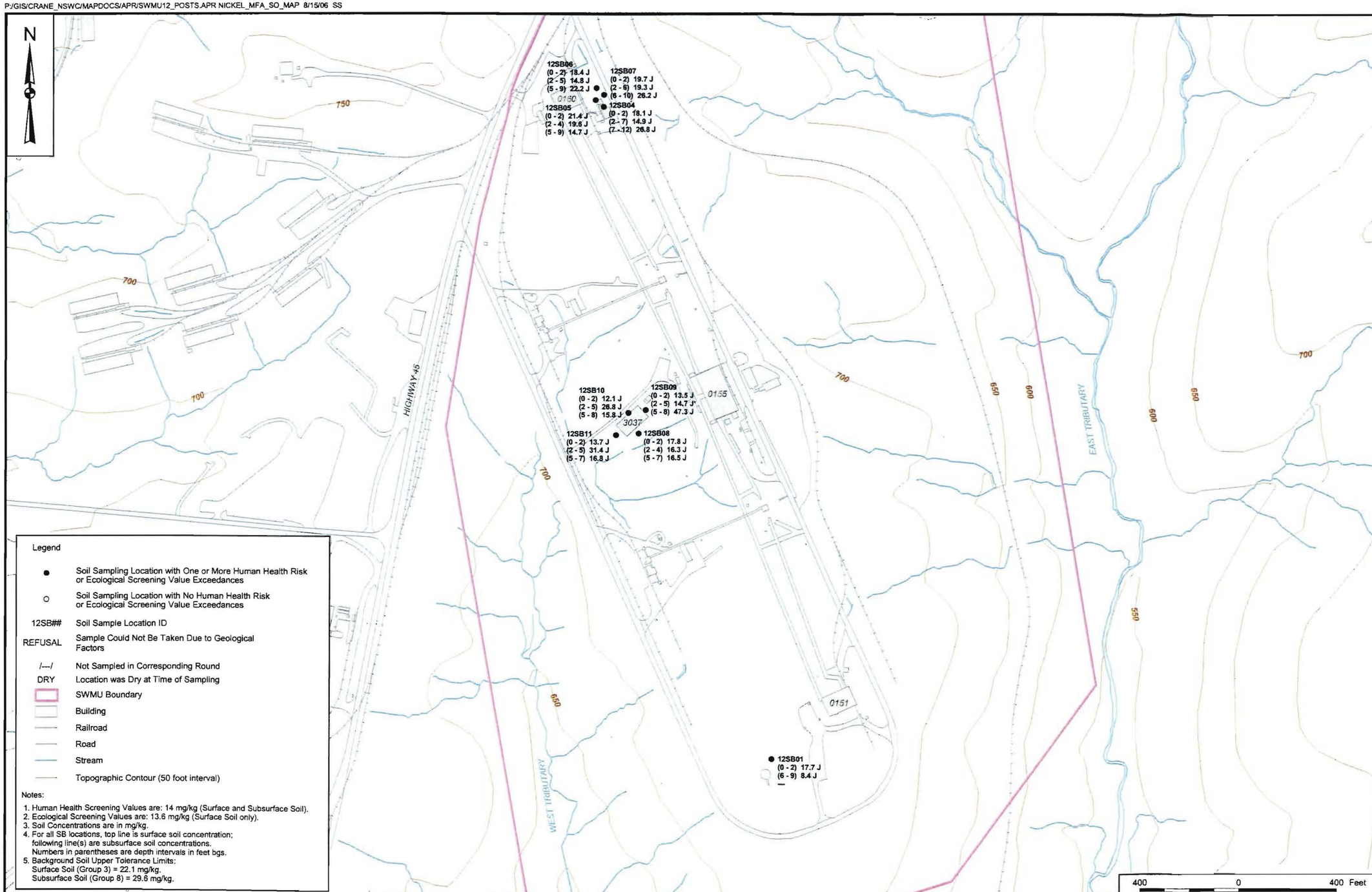
DRAWN BY K. PEILA DATE 7/12/05

CHECKED BY J. LUCAS DATE 8/15/06

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR NICKEL_MFA_SO_MAP 8/15/06 SS



Legend

- ● Soil Sampling Location with One or More Human Health Risk or Ecological Screening Value Exceedances
- ○ Soil Sampling Location with No Human Health Risk or Ecological Screening Value Exceedances
- 12SB## Soil Sample Location ID
- REFUSAL Sample Could Not Be Taken Due to Geological Factors
- /---/ Not Sampled in Corresponding Round
- DRY Location was Dry at Time of Sampling
- SWMU Boundary
- Building
- Railroad
- Road
- Stream
- Topographic Contour (50 foot interval)

Notes:

1. Human Health Screening Values are: 14 mg/kg (Surface and Subsurface Soil).
2. Ecological Screening Values are: 13.6 mg/kg (Surface Soil only).
3. Soil Concentrations are in mg/kg.
4. For all SB locations, top line is surface soil concentration; following line(s) are subsurface soil concentrations. Numbers in parentheses are depth intervals in feet bgs.
5. Background Soil Upper Tolerance Limits:
   Surface Soil (Group 3) = 22.1 mg/kg.
   Subsurface Soil (Group 8) = 29.6 mg/kg.

CONTRACT NO. 6878

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 3

REV 0

TOTAL NICKEL CONCENTRATIONS (mg/kg) IN SOIL SAMPLES OF THE MINE FILL A PROPER SWMU 12 MINE FILL A NSWC CRANE CRANE, INDIANA

NAVFAC

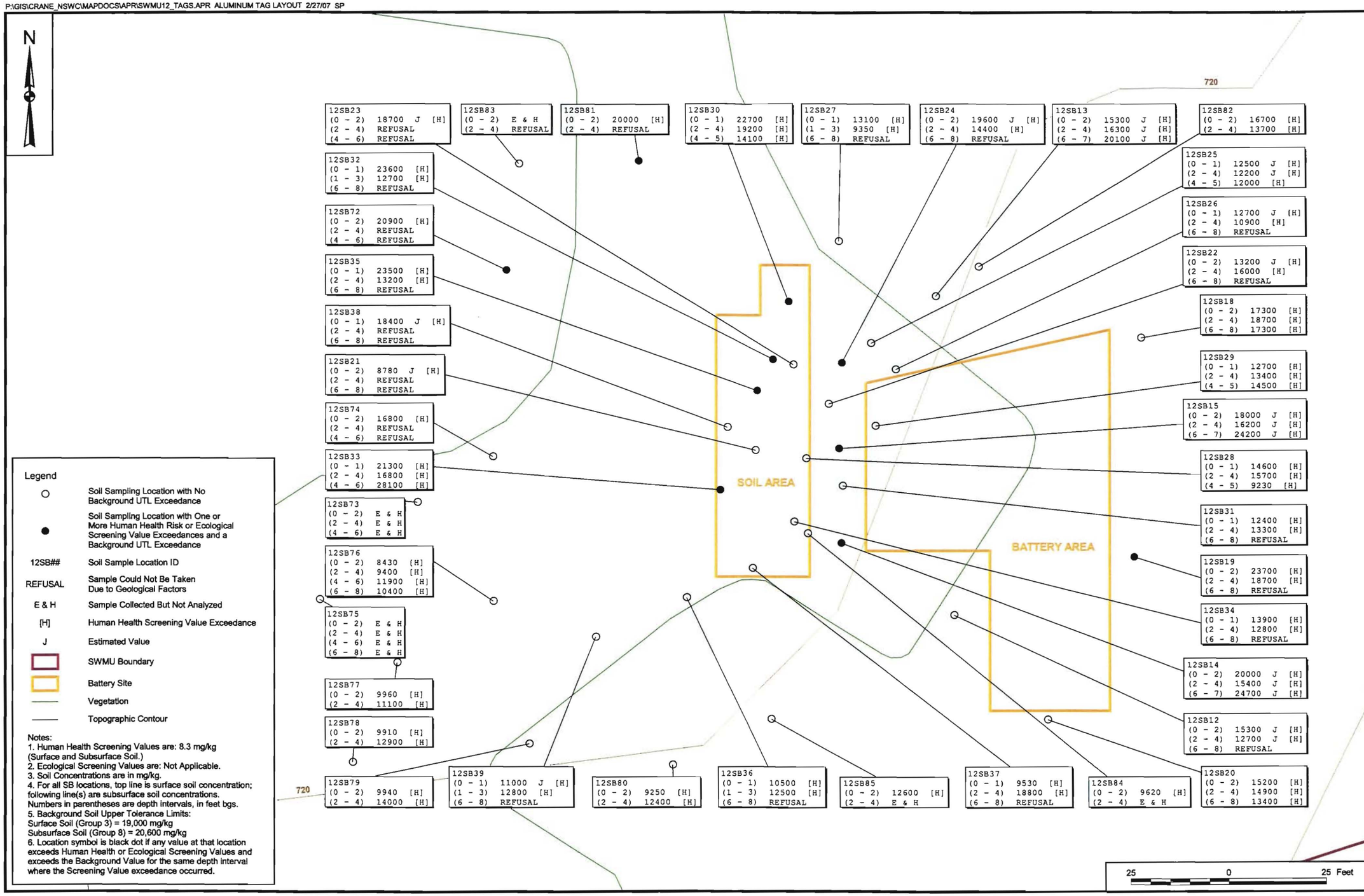
DRAWN BY K. PEILA DATE 7/12/05

CHECKED BY J. LUCAS DATE 8/15/06

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU12_TAGS.APR ALUMINUM TAG LAYOUT 2/27/07 SP



Legend

○	Soil Sampling Location with No Background UTL Exceedance
●	Soil Sampling Location with One or More Human Health Risk or Ecological Screening Value Exceedances and a Background UTL Exceedance
12SB##	Soil Sample Location ID
REFUSAL	Sample Could Not Be Taken Due to Geological Factors
E & H	Sample Collected But Not Analyzed
[H]	Human Health Screening Value Exceedance
J	Estimated Value
	SWMU Boundary
	Battery Site
	Vegetation
	Topographic Contour

Notes:
1. Human Health Screening Values are: 8.3 mg/kg (Surface and Subsurface Soil.)
2. Ecological Screening Values are: Not Applicable.
3. Soil Concentrations are in mg/kg.
4. For all SB locations, top line is surface soil concentration; following line(s) are subsurface soil concentrations. Numbers in parentheses are depth intervals, in feet bgs.
5. Background Soil Upper Tolerance Limits:
Surface Soil (Group 3) = 19,000 mg/kg
Subsurface Soil (Group 8) = 20,600 mg/kg
6. Location symbol is black dot if any value at that location exceeds Human Health or Ecological Screening Values and exceeds the Background Value for the same depth interval where the Screening Value exceedance occurred.

CONTRACT NO. CTO 0357

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 4

REV 0

TOTAL ALUMINUM CONCENTRATIONS (mg/kg) IN SOIL SAMPLES OF THE BATTERY SITE
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

NAVFAC

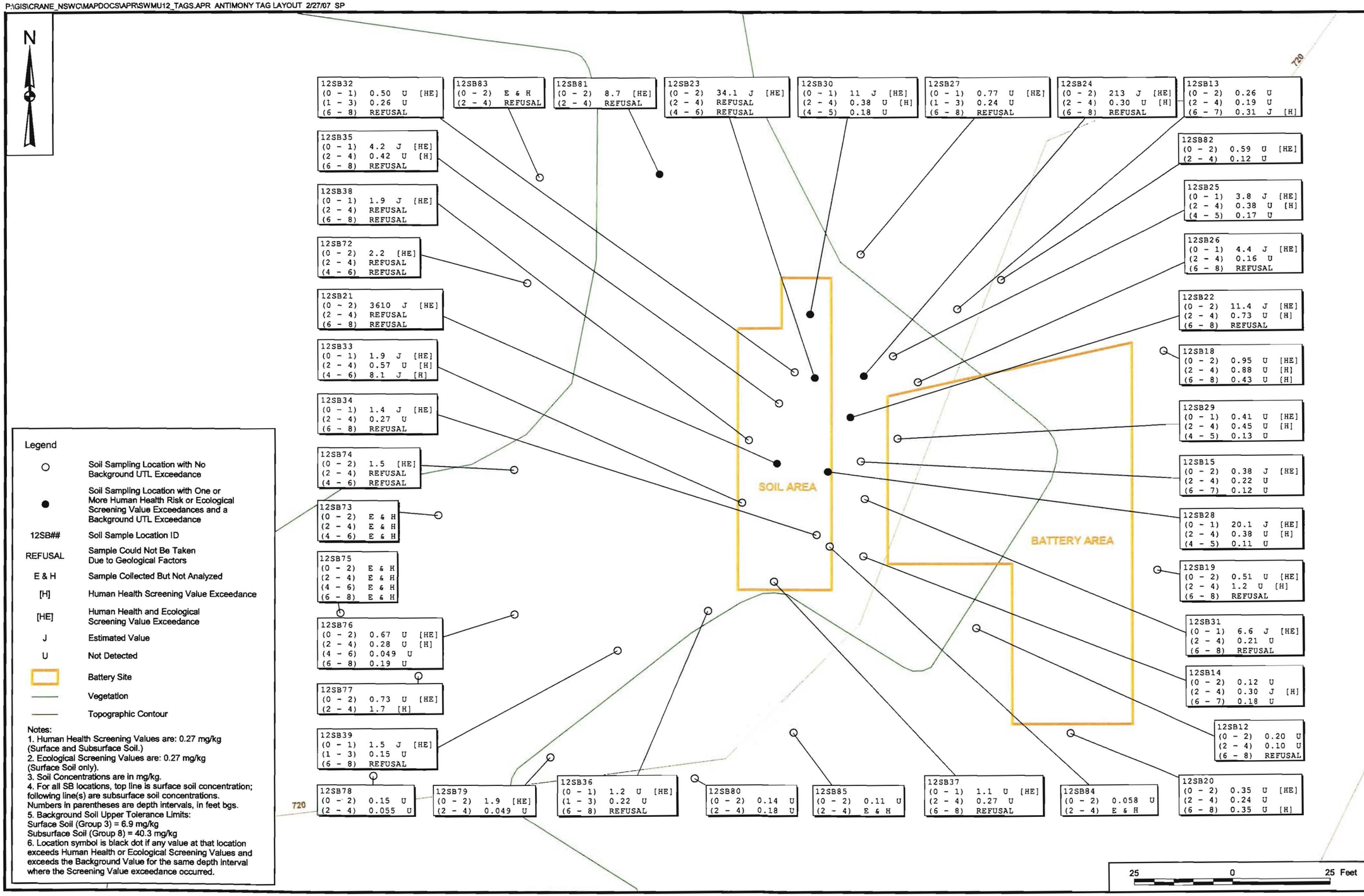
DRAWN BY S. PAXTON DATE 2/27/07

CHECKED BY T. JOHNSTON DATE 2/27/07

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU12_TAGS.APR ANTIMONY TAG LAYOUT 2/27/07 SP



Legend

○	Soil Sampling Location with No Background UTL Exceedance
●	Soil Sampling Location with One or More Human Health Risk or Ecological Screening Value Exceedances and a Background UTL Exceedance
12SB##	Soil Sample Location ID
REFUSAL	Sample Could Not Be Taken Due to Geological Factors
E & H	Sample Collected But Not Analyzed
[H]	Human Health Screening Value Exceedance
[HE]	Human Health and Ecological Screening Value Exceedance
J	Estimated Value
U	Not Detected
▭	Battery Site
——	Vegetation
——	Topographic Contour

Notes:
1. Human Health Screening Values are: 0.27 mg/kg (Surface and Subsurface Soil.)
2. Ecological Screening Values are: 0.27 mg/kg (Surface Soil only).
3. Soil Concentrations are in mg/kg.
4. For all SB locations, top line is surface soil concentration; following line(s) are subsurface soil concentrations. Numbers in parentheses are depth intervals, in feet bgs.
5. Background Soil Upper Tolerance Limits:
Surface Soil (Group 3) = 6.9 mg/kg
Subsurface Soil (Group 8) = 40.3 mg/kg
6. Location symbol is black dot if any value at that location exceeds Human Health or Ecological Screening Values and exceeds the Background Value for the same depth interval where the Screening Value exceedance occurred.

CONTRACT NO. CTO 0357

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 5

REV 0

TOTAL ANTIMONY CONCENTRATIONS (mg/kg) IN SOIL SAMPLES OF THE BATTERY SITE SWMU 12 MINE FILL A NSWC CRANE CRANE, INDIANA

NAVFAC

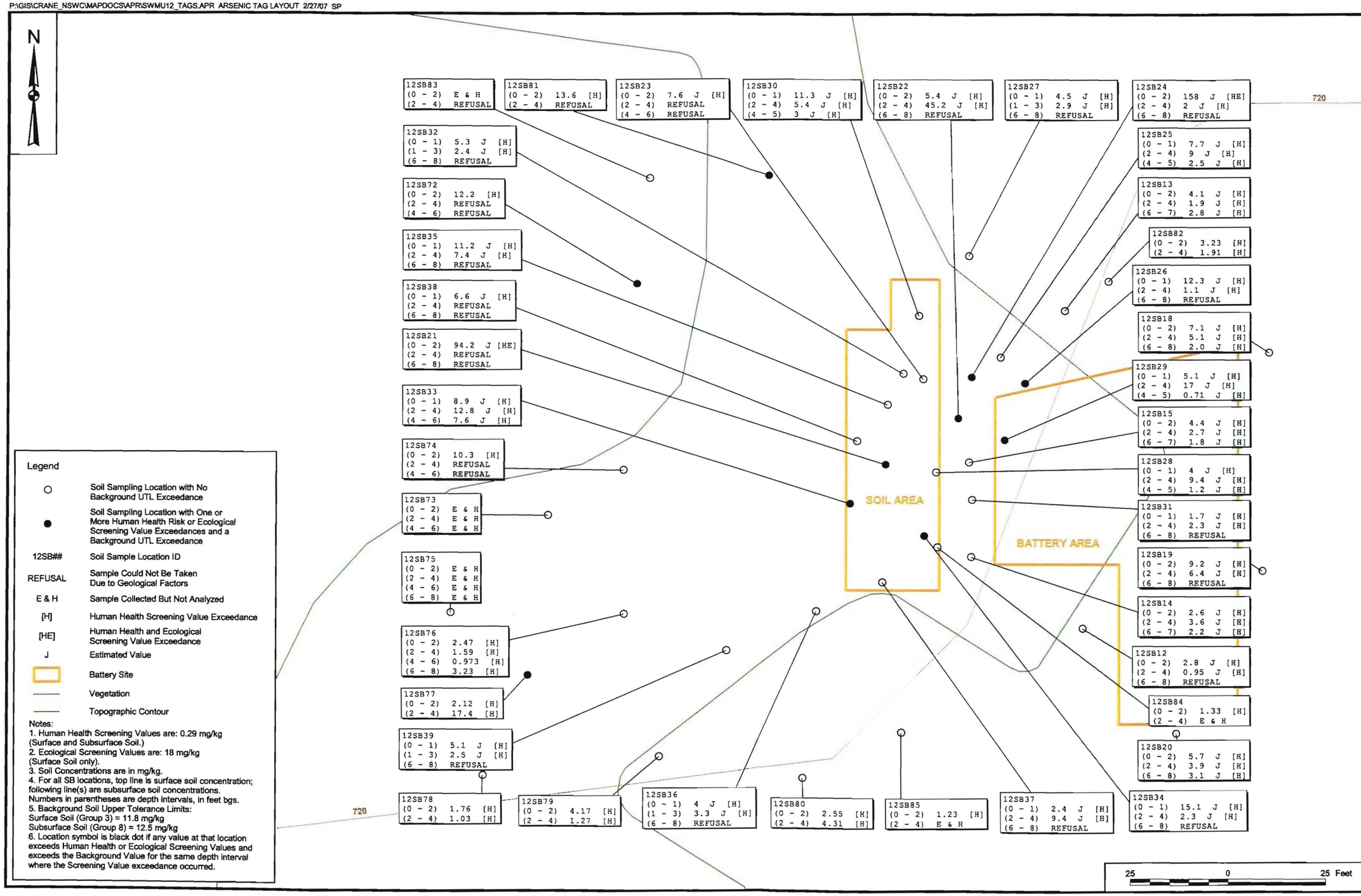
DRAWN BY S. PAXTON DATE 2/27/07

CHECKED BY T. JOHNSTON DATE 2/27/07

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU12_TAGS.APR ARSENIC TAG LAYOUT 2/27/07 SP



Legend

- ○ Soil Sampling Location with No Background UTL Exceedance
- ● Soil Sampling Location with One or More Human Health Risk or Ecological Screening Value Exceedances and a Background UTL Exceedance
- 12SB## Soil Sample Location ID
- REFUSAL Sample Could Not Be Taken Due to Geological Factors
- E & H Sample Collected But Not Analyzed
- [H] Human Health Screening Value Exceedance
- [HE] Human Health and Ecological Screening Value Exceedance
- J Estimated Value
- Battery Site
- Vegetation
- Topographic Contour

Notes:
1. Human Health Screening Values are: 0.29 mg/kg (Surface and Subsurface Soil.)
2. Ecological Screening Values are: 18 mg/kg (Surface Soil only).
3. Soil Concentrations are in mg/kg.
4. For all SB locations, top line is surface soil concentration; following line(s) are subsurface soil concentrations. Numbers in parentheses are depth intervals, in feet bgs.
5. Background Soil Upper Tolerance Limits:
Surface Soil (Group 3) = 11.8 mg/kg
Subsurface Soil (Group 8) = 12.5 mg/kg
6. Location symbol is black dot if any value at that location exceeds Human Health or Ecological Screening Values and exceeds the Background Value for the same depth interval where the Screening Value exceedance occurred.

CONTRACT NO. CTO 0357

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 6

REV 0

TOTAL ARSENIC CONCENTRATIONS (mg/kg) IN SOIL SAMPLES OF THE BATTERY SITE
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

NAVFAC

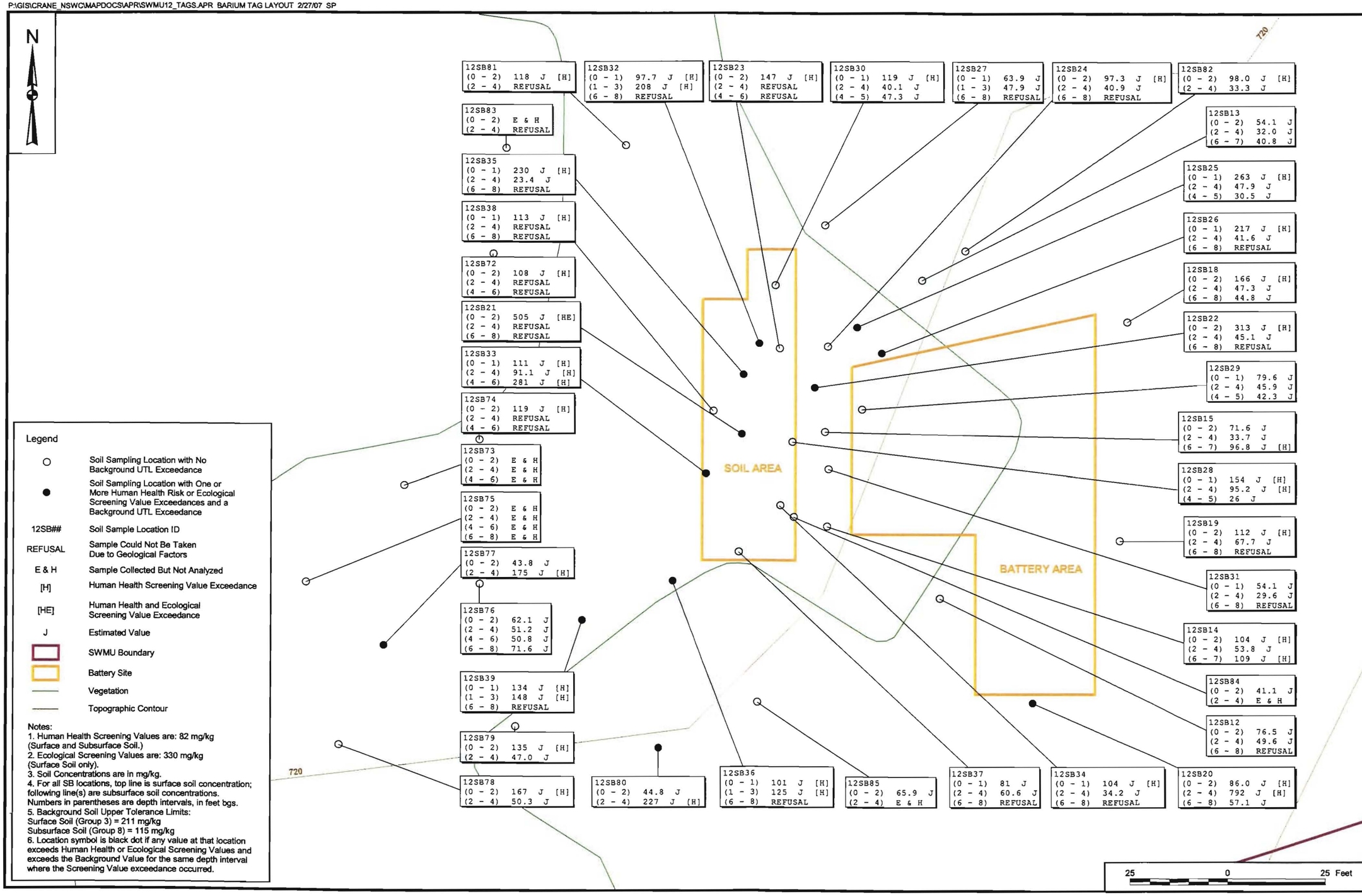
DRAWN BY S. PAXTON DATE 2/27/07

CHECKED BY T. JOHNSTON DATE 2/27/07

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU12_TAGS.APR BARIUM TAG LAYOUT 2/27/07 SP



Legend

○	Soil Sampling Location with No Background UTL Exceedance
●	Soil Sampling Location with One or More Human Health Risk or Ecological Screening Value Exceedances and a Background UTL Exceedance
12SB##	Soil Sample Location ID
REFUSAL	Sample Could Not Be Taken Due to Geological Factors
E & H	Sample Collected But Not Analyzed
[H]	Human Health Screening Value Exceedance
[HE]	Human Health and Ecological Screening Value Exceedance
J	Estimated Value
	SWMU Boundary
	Battery Site
	Vegetation
	Topographic Contour

Notes:
1. Human Health Screening Values are: 82 mg/kg (Surface and Subsurface Soil.)
2. Ecological Screening Values are: 330 mg/kg (Surface Soil only).
3. Soil Concentrations are in mg/kg.
4. For all SB locations, top line is surface soil concentration; following line(s) are subsurface soil concentrations. Numbers in parentheses are depth intervals, in feet bgs.
5. Background Soil Upper Tolerance Limits:
Surface Soil (Group 3) = 211 mg/kg
Subsurface Soil (Group 8) = 115 mg/kg
6. Location symbol is black dot if any value at that location exceeds Human Health or Ecological Screening Values and exceeds the Background Value for the same depth interval where the Screening Value exceedance occurred.

CONTRACT NO. CTO 0357

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 7

REV 0

TOTAL BARIUM CONCENTRATIONS (mg/kg) IN SOIL SAMPLES OF THE BATTERY SITE
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

NAVFAC

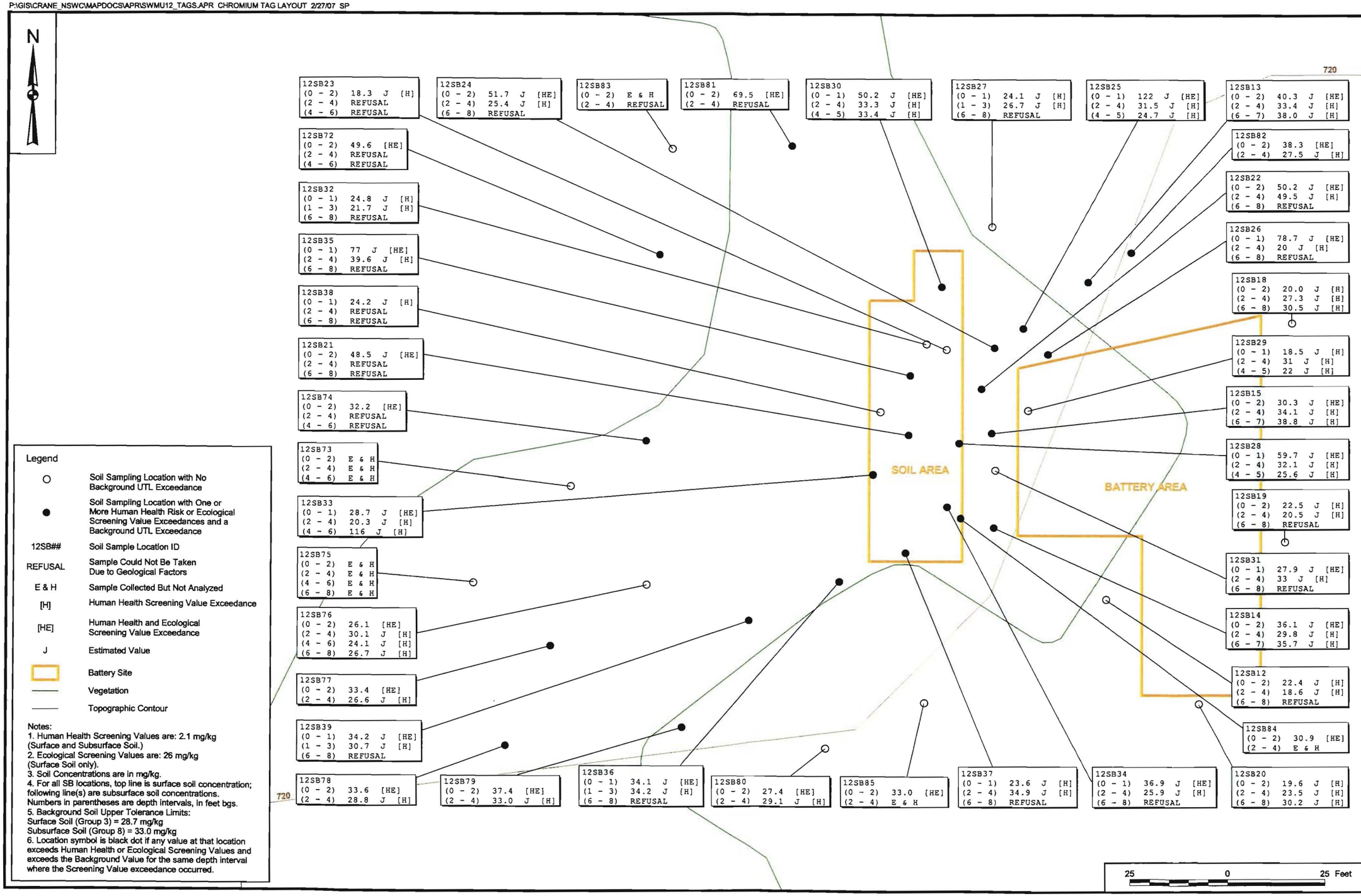
DRAWN BY S. PAXTON DATE 2/27/07

CHECKED BY T. JOHNSTON DATE 2/27/07

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU12_TAGS.APR CHROMIUM TAG LAYOUT 2/27/07 SP



Legend

○	Soil Sampling Location with No Background UTL Exceedance
●	Soil Sampling Location with One or More Human Health Risk or Ecological Screening Value Exceedances and a Background UTL Exceedance
12SB##	Soil Sample Location ID
REFUSAL	Sample Could Not Be Taken Due to Geological Factors
E & H	Sample Collected But Not Analyzed
[H]	Human Health Screening Value Exceedance
[HE]	Human Health and Ecological Screening Value Exceedance
J	Estimated Value
▭	Battery Site
——	Vegetation
——	Topographic Contour

Notes:
1. Human Health Screening Values are: 2.1 mg/kg (Surface and Subsurface Soil.)
2. Ecological Screening Values are: 26 mg/kg (Surface Soil only).
3. Soil Concentrations are in mg/kg.
4. For all SB locations, top line is surface soil concentration; following line(s) are subsurface soil concentrations. Numbers in parentheses are depth intervals, in feet bgs.
5. Background Soil Upper Tolerance Limits:
Surface Soil (Group 3) = 28.7 mg/kg
Subsurface Soil (Group 8) = 33.0 mg/kg
6. Location symbol is black dot if any value at that location exceeds Human Health or Ecological Screening Values and exceeds the Background Value for the same depth interval where the Screening Value exceedance occurred.

CONTRACT NO. CTO 0357

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 8

REV 0

TOTAL CHROMIUM CONCENTRATIONS (mg/kg) IN SOIL SAMPLES OF THE BATTERY SITE
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

NAVFAC

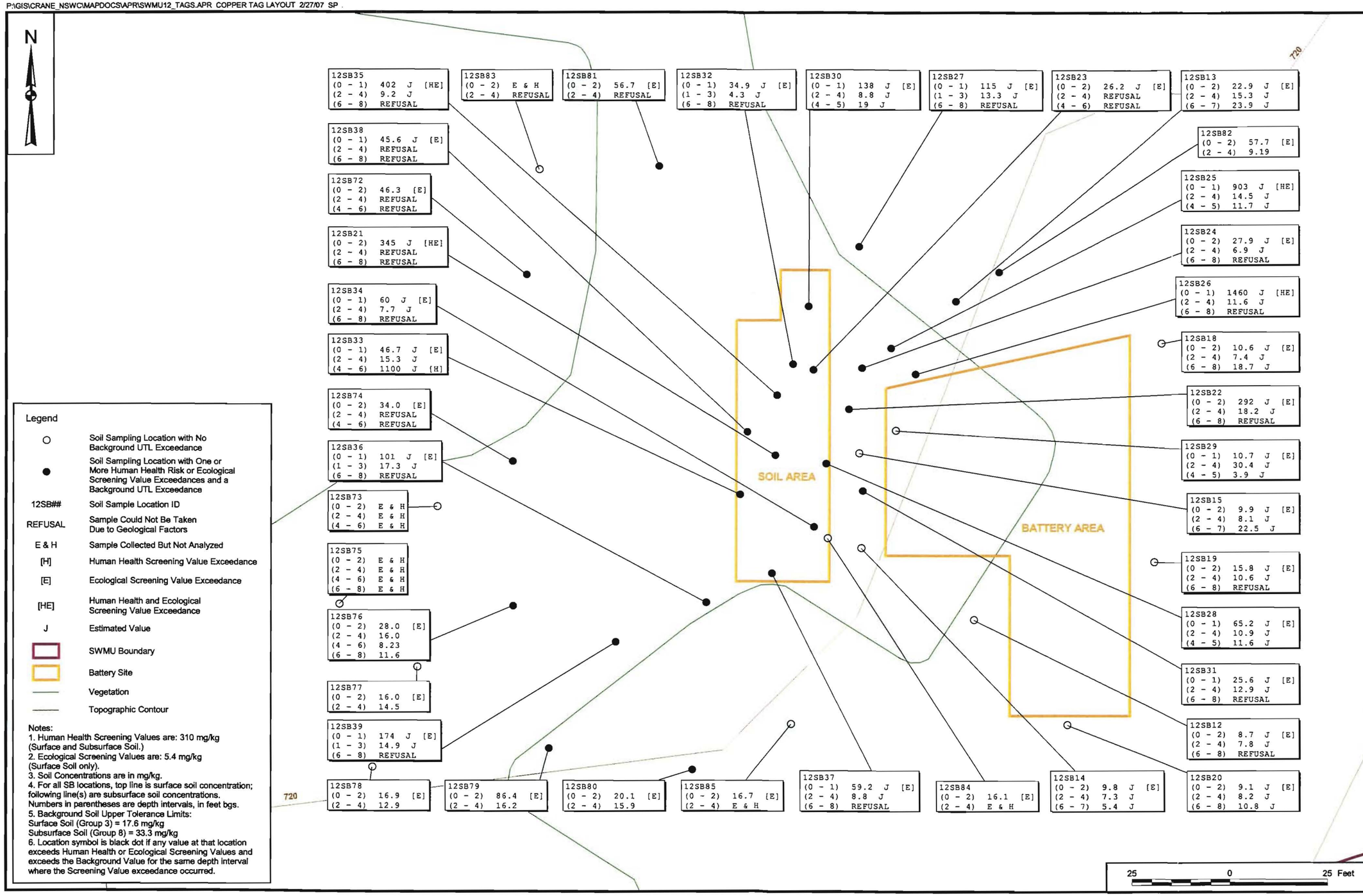
DRAWN BY S. PAXTON DATE 2/27/07

CHECKED BY T. JOHNSTON DATE 2/27/07

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU12_TAGS.APR COPPER TAG LAYOUT 2/27/07 SP



Legend

- Soil Sampling Location with No Background UTL Exceedance
- Soil Sampling Location with One or More Human Health Risk or Ecological Screening Value Exceedances and a Background UTL Exceedance
- 12SB## Soil Sample Location ID
- REFUSAL Sample Could Not Be Taken Due to Geological Factors
- E & H Sample Collected But Not Analyzed
- [H] Human Health Screening Value Exceedance
- [E] Ecological Screening Value Exceedance
- [HE] Human Health and Ecological Screening Value Exceedance
- J Estimated Value
- SWMU Boundary
- Battery Site
- Vegetation
- Topographic Contour

Notes:
1. Human Health Screening Values are: 310 mg/kg (Surface and Subsurface Soil.)
2. Ecological Screening Values are: 5.4 mg/kg (Surface Soil only).
3. Soil Concentrations are in mg/kg.
4. For all SB locations, top line is surface soil concentration; following line(s) are subsurface soil concentrations. Numbers in parentheses are depth intervals, in feet bgs.
5. Background Soil Upper Tolerance Limits:
Surface Soil (Group 3) = 17.6 mg/kg
Subsurface Soil (Group 8) = 33.3 mg/kg
6. Location symbol is black dot if any value at that location exceeds Human Health or Ecological Screening Values and exceeds the Background Value for the same depth interval where the Screening Value exceedance occurred.

CONTRACT NO. CTO 0357

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 9

REV 0

TOTAL COPPER CONCENTRATIONS (mg/kg) IN SOIL SAMPLES OF THE BATTERY SITE
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

NAVFAC

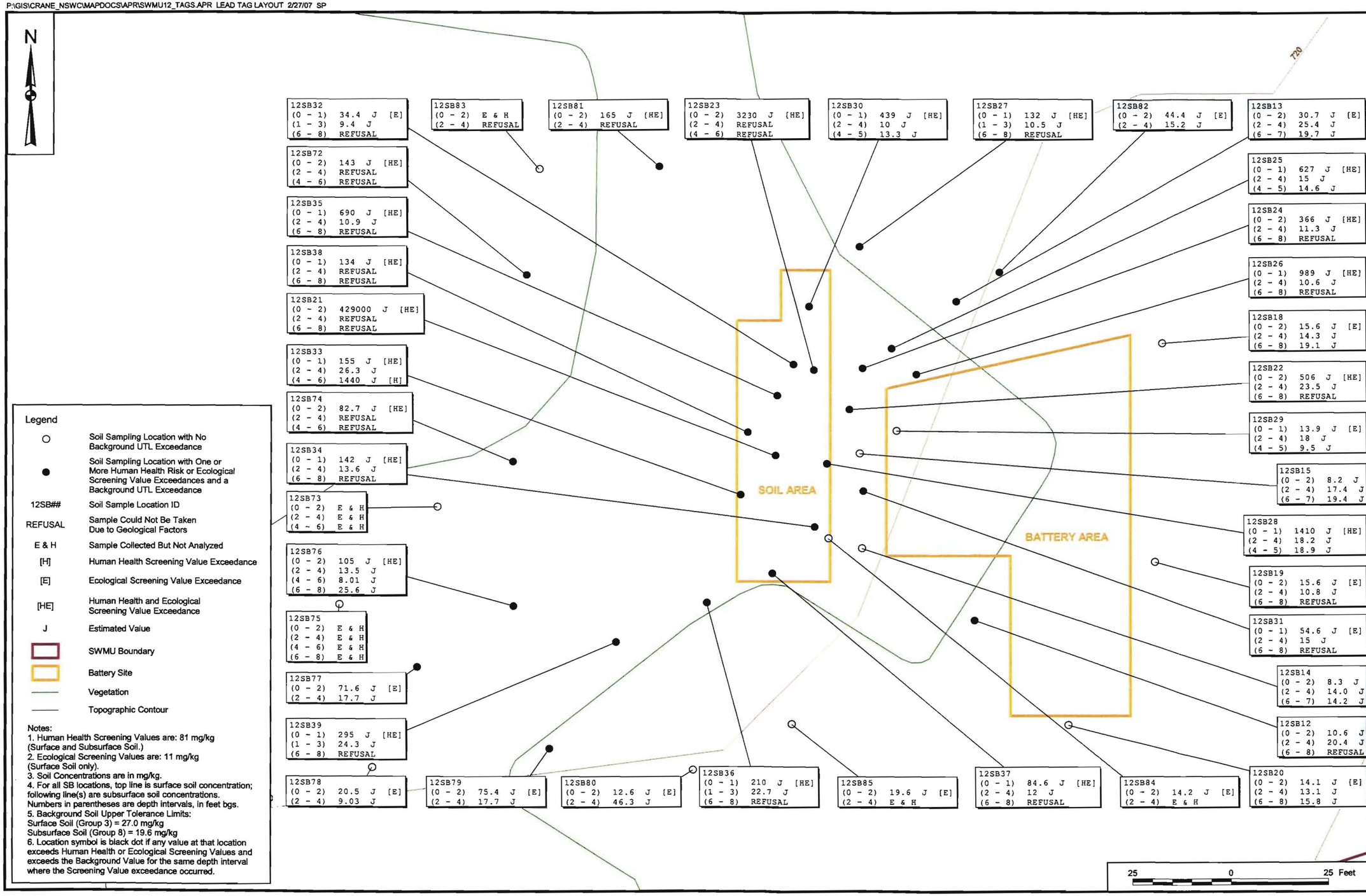
DRAWN BY S. PAXTON DATE 2/27/07

CHECKED BY T. JOHNSTON DATE 2/27/07

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU12_TAGS.APR LEAD TAG LAYOUT 2/27/07 SP



Legend

○	Soil Sampling Location with No Background UTL Exceedance
●	Soil Sampling Location with One or More Human Health Risk or Ecological Screening Value Exceedances and a Background UTL Exceedance
12SB##	Soil Sample Location ID
REFUSAL	Sample Could Not Be Taken Due to Geological Factors
E & H	Sample Collected But Not Analyzed
[H]	Human Health Screening Value Exceedance
[E]	Ecological Screening Value Exceedance
[HE]	Human Health and Ecological Screening Value Exceedance
J	Estimated Value
	SWMU Boundary
	Battery Site
	Vegetation
	Topographic Contour

Notes:
1. Human Health Screening Values are: 81 mg/kg (Surface and Subsurface Soil.)
2. Ecological Screening Values are: 11 mg/kg (Surface Soil only).
3. Soil Concentrations are in mg/kg.
4. For all SB locations, top line is surface soil concentration; following line(s) are subsurface soil concentrations. Numbers in parentheses are depth intervals, in feet bgs.
5. Background Soil Upper Tolerance Limits:
Surface Soil (Group 3) = 27.0 mg/kg
Subsurface Soil (Group 8) = 19.6 mg/kg
6. Location symbol is black dot if any value at that location exceeds Human Health or Ecological Screening Values and exceeds the Background Value for the same depth interval where the Screening Value exceedance occurred.

CONTRACT NO. CTO 0357

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 10

REV 0

TOTAL LEAD CONCENTRATIONS (mg/kg) IN SOIL SAMPLES OF THE BATTERY SITE
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

NAVFAC

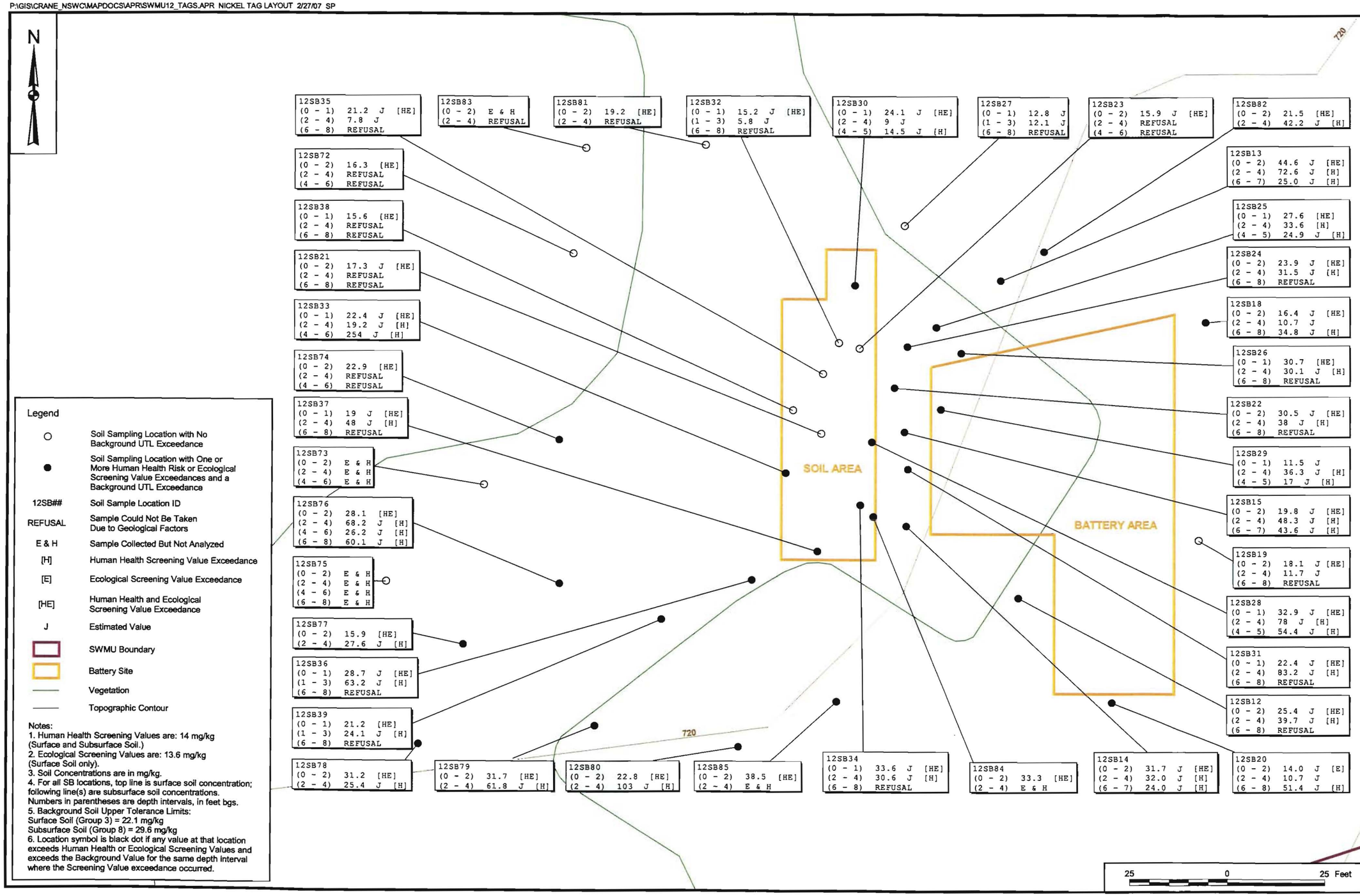
DRAWN BY S. PAXTON DATE 2/27/07

CHECKED BY T. JOHNSTON DATE 2/27/07

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU12_TAGS.APR NICKEL TAG LAYOUT 2/27/07 SP



Legend

- ○ Soil Sampling Location with No Background UTL Exceedance
- ● Soil Sampling Location with One or More Human Health Risk or Ecological Screening Value Exceedances and a Background UTL Exceedance
- 12SB## Soil Sample Location ID
- REFUSAL Sample Could Not Be Taken Due to Geological Factors
- E & H Sample Collected But Not Analyzed
- [H] Human Health Screening Value Exceedance
- [E] Ecological Screening Value Exceedance
- [HE] Human Health and Ecological Screening Value Exceedance
- J Estimated Value
- SWMU Boundary
- Battery Site
- Vegetation
- Topographic Contour

Notes:
1. Human Health Screening Values are: 14 mg/kg (Surface and Subsurface Soil.)
2. Ecological Screening Values are: 13.6 mg/kg (Surface Soil only).
3. Soil Concentrations are in mg/kg.
4. For all SB locations, top line is surface soil concentration; following line(s) are subsurface soil concentrations. Numbers in parentheses are depth intervals, in feet bgs.
5. Background Soil Upper Tolerance Limits:
Surface Soil (Group 3) = 22.1 mg/kg
Subsurface Soil (Group 8) = 29.6 mg/kg
6. Location symbol is black dot if any value at that location exceeds Human Health or Ecological Screening Values and exceeds the Background Value for the same depth interval where the Screening Value exceedance occurred.

CONTRACT NO. CTO 0357

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 11

REV 0

TOTAL NICKEL CONCENTRATIONS (mg/kg) IN SOIL SAMPLES OF THE BATTERY SITE
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

NAVFAC

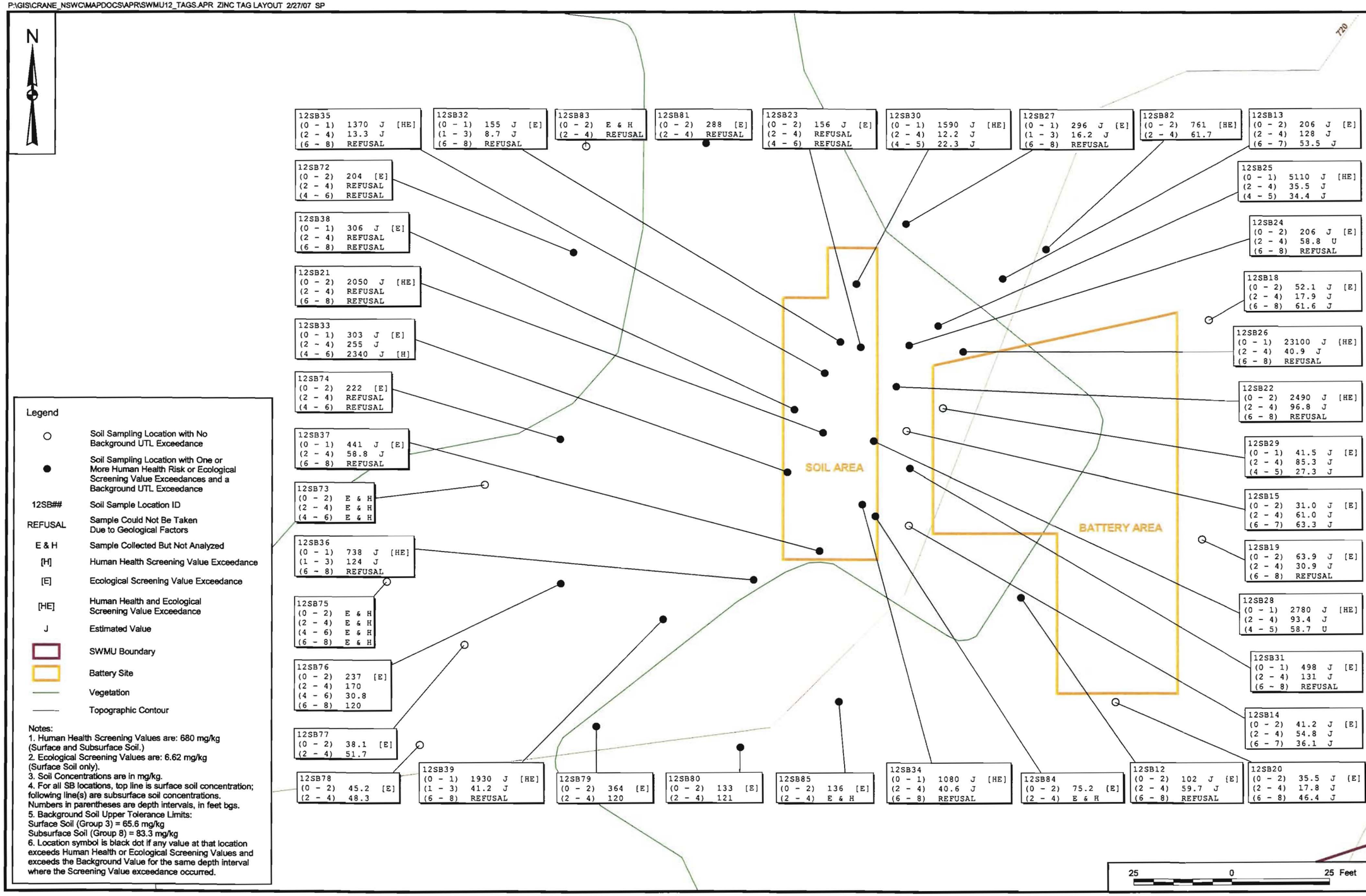
DRAWN BY S. PAXTON DATE 2/27/07

CHECKED BY T. JOHNSTON DATE 2/27/07

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU12_TAGS.APR ZINC TAG LAYOUT 2/27/07 SP



Legend

○	Soil Sampling Location with No Background UTL Exceedance
●	Soil Sampling Location with One or More Human Health Risk or Ecological Screening Value Exceedances and a Background UTL Exceedance
12SB##	Soil Sample Location ID
REFUSAL	Sample Could Not Be Taken Due to Geological Factors
E & H	Sample Collected But Not Analyzed
[H]	Human Health Screening Value Exceedance
[E]	Ecological Screening Value Exceedance
[HE]	Human Health and Ecological Screening Value Exceedance
J	Estimated Value
	SWMU Boundary
	Battery Site
	Vegetation
	Topographic Contour

Notes:
1. Human Health Screening Values are: 680 mg/kg (Surface and Subsurface Soil.)
2. Ecological Screening Values are: 6.62 mg/kg (Surface Soil only).
3. Soil Concentrations are in mg/kg.
4. For all SB locations, top line is surface soil concentration; following line(s) are subsurface soil concentrations. Numbers in parentheses are depth intervals, in feet bgs.
5. Background Soil Upper Tolerance Limits:
Surface Soil (Group 3) = 65.6 mg/kg
Subsurface Soil (Group 8) = 83.3 mg/kg
6. Location symbol is black dot if any value at that location exceeds Human Health or Ecological Screening Values and exceeds the Background Value for the same depth interval where the Screening Value exceedance occurred.

CONTRACT NO. CTO 0357

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 12

REV 0

TOTAL ZINC CONCENTRATIONS (mg/kg) IN SOIL SAMPLES OF THE BATTERY SITE
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

NAVFAC

DRAWN BY S. PAXTON DATE 2/27/07

CHECKED BY T. JOHNSTON DATE 2/27/07

COST/SCHED-AREA

SCALE AS NOTED

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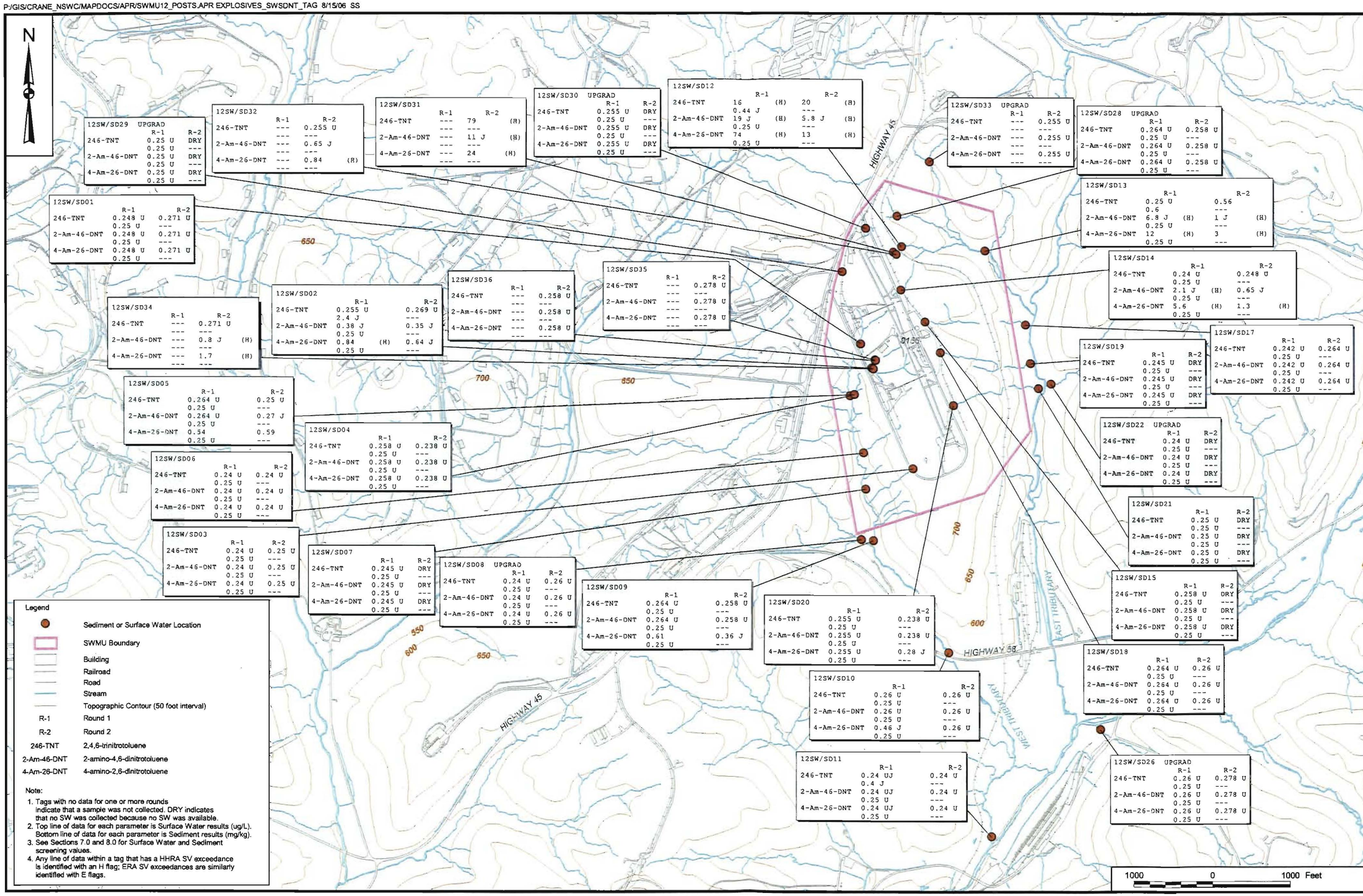


CONTRACT NO. 6878

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 5 - 13

REV 0

SELECT TNT - RELATED EXPLOSIVE CONCENTRATIONS IN GULLY SURFACE WATER (ug/L) AND SEDIMENT (mg/kg)

SWMU 12 MINE FILL A

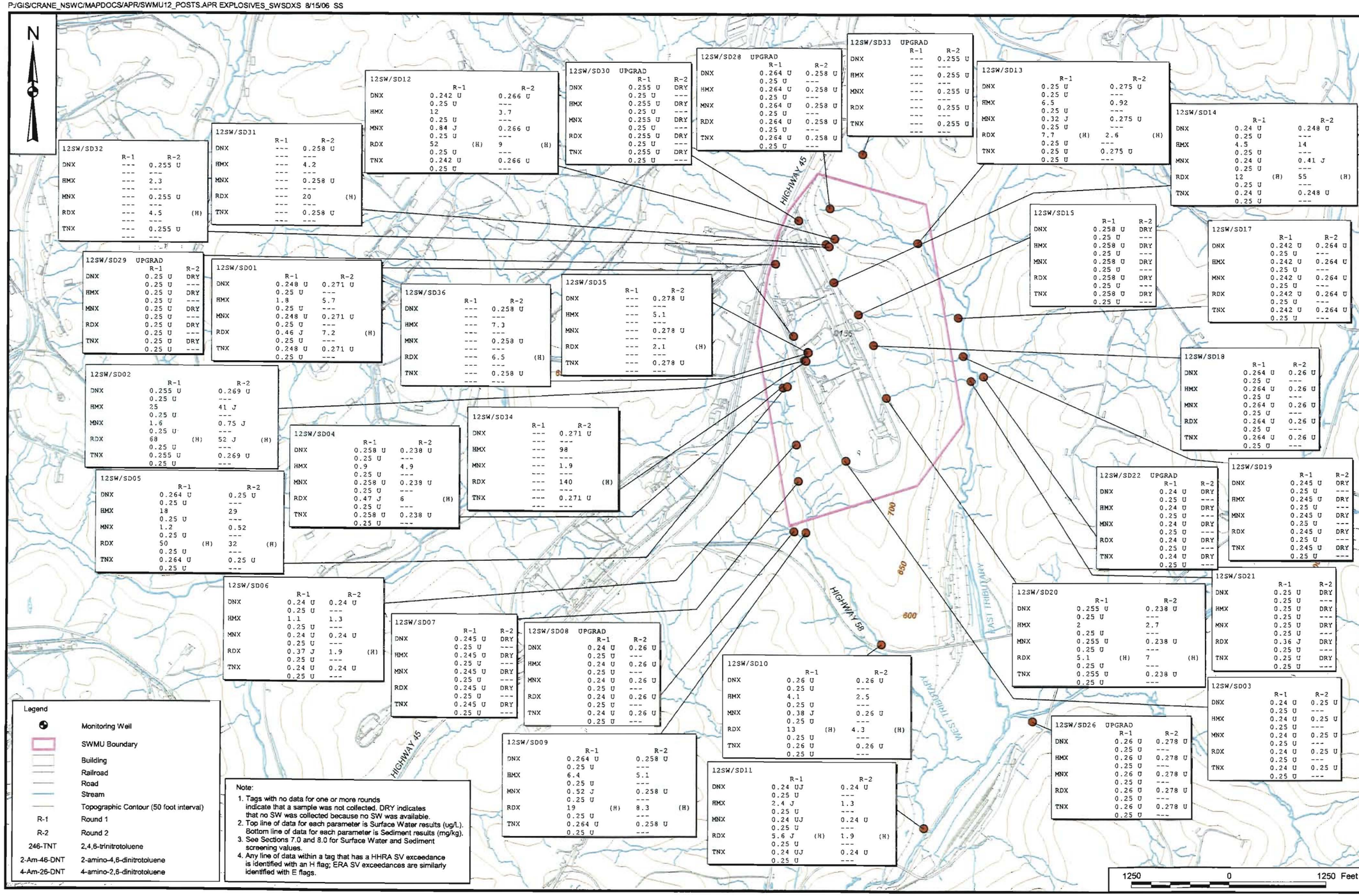
NSWC CRANE

CRANE, INDIANA

NAVFAC

DRAWN BY	DATE	CHECKED BY	DATE	COST/SCHED-AREA	SCALE
K. PEILA	7/12/05	J. LUCAS	8/15/06		AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR EXPLOSIVES_SWSDXS 8/15/06 SS



CONTRACT NO. 6878

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 14

REV 0

HMX AND RDX - RELATED EXPLOSIVE CONCENTRATIONS IN GULLY SURFACE WATER (ug/L) AND SEDIMENT (mg/kg)

SWMU 12 MINE FILL A

NSWC CRANE

CRANE, INDIANA

NAVFAC

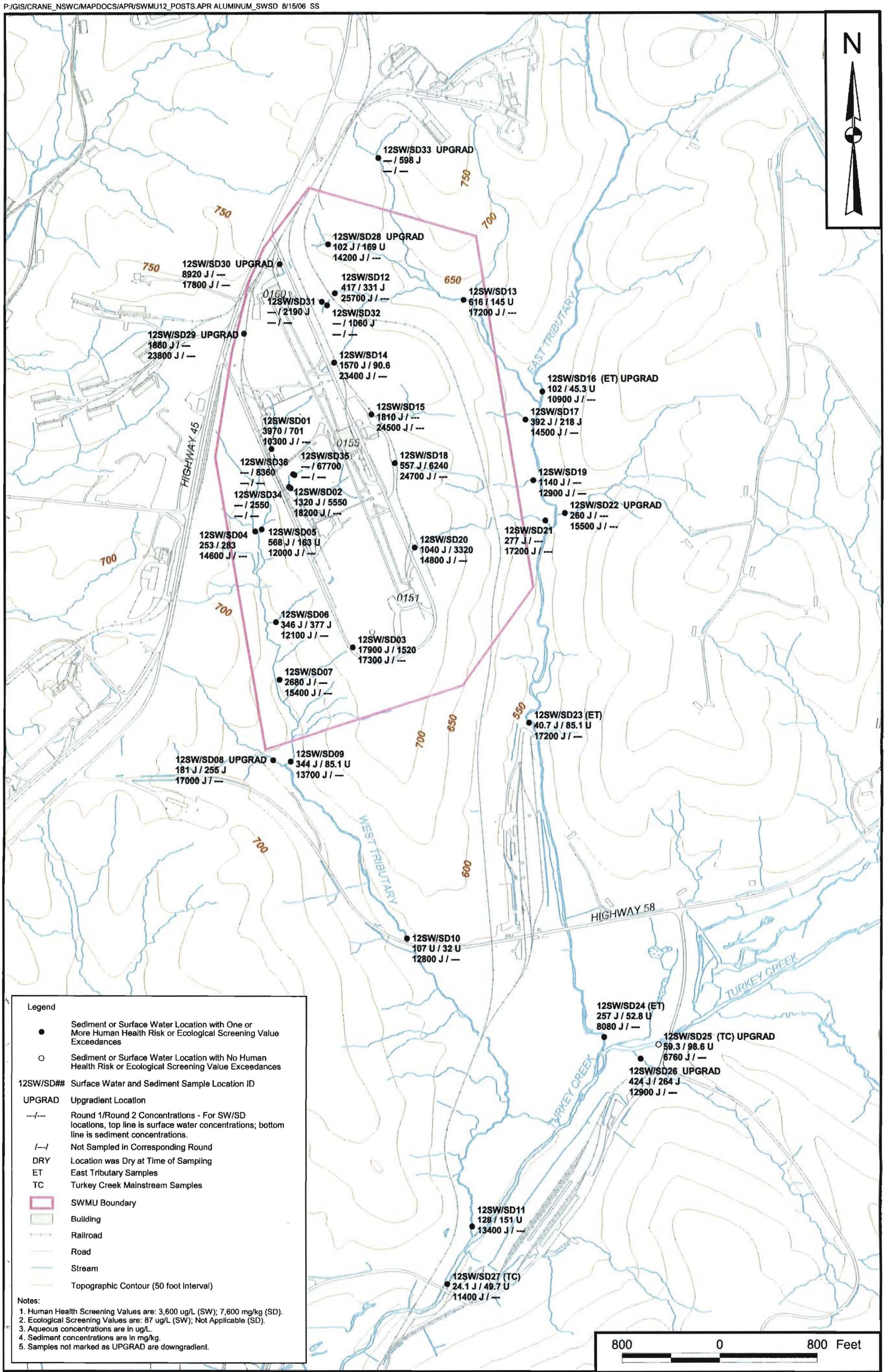
DRAWN BY K. PEILA DATE 7/12/05

CHECKED BY J. LUCAS DATE 8/15/06

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR ALUMINUM_SWSD 8/15/06 SS



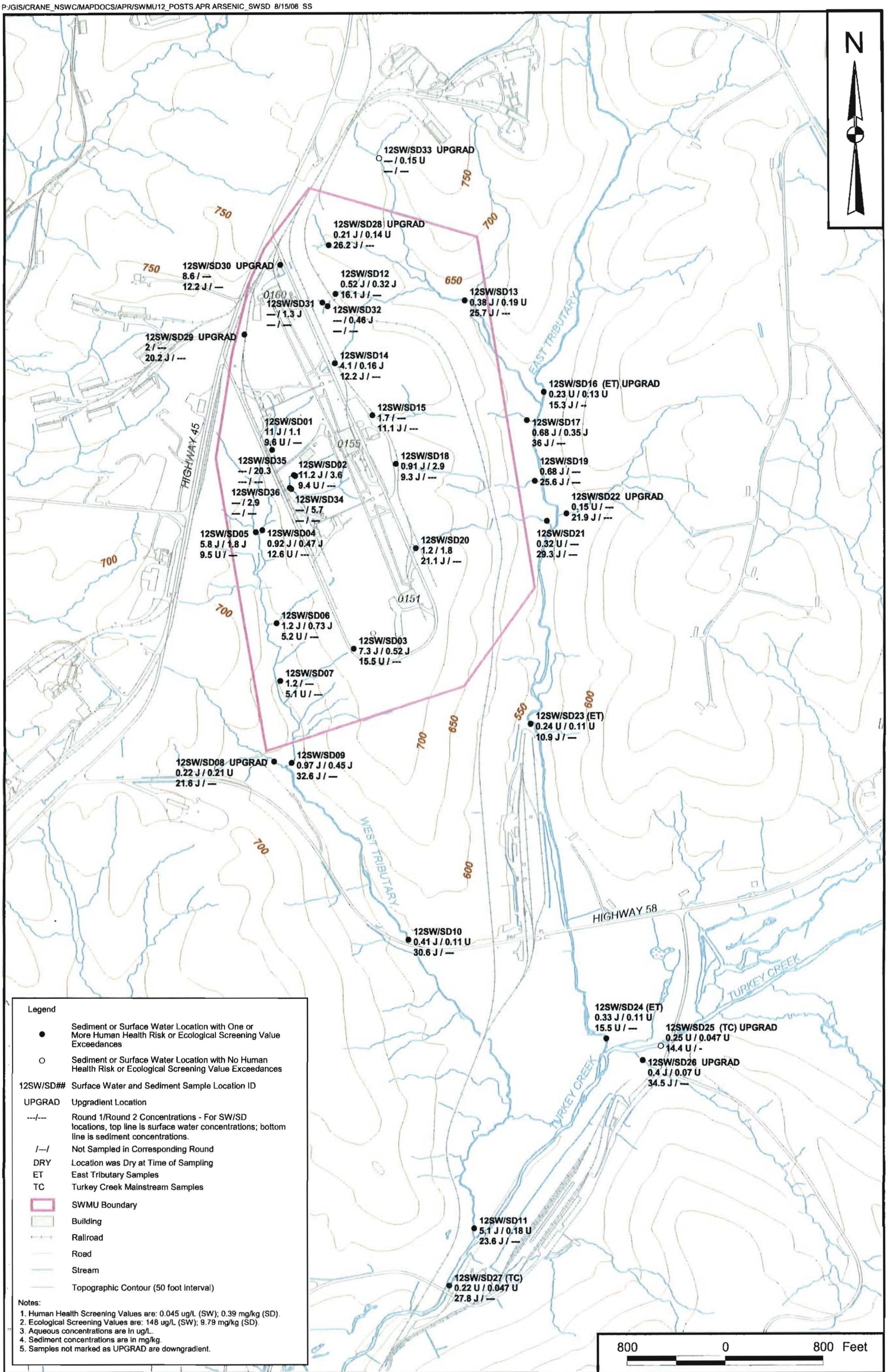
Legend

●	Sediment or Surface Water Location with One or More Human Health Risk or Ecological Screening Value Exceedances
○	Sediment or Surface Water Location with No Human Health Risk or Ecological Screening Value Exceedances
12SW/SD##	Surface Water and Sediment Sample Location ID
UPGRAD	Upgradient Location
---/---	Round 1/Round 2 Concentrations - For SW/SD locations, top line is surface water concentrations; bottom line is sediment concentrations.
/---/	Not Sampled in Corresponding Round
DRY	Location was Dry at Time of Sampling
ET	East Tributary Samples
TC	Turkey Creek Mainstream Samples
	SWMU Boundary
	Building
	Railroad
	Road
	Stream
	Topographic Contour (50 foot interval)

Notes:
1. Human Health Screening Values are: 3,600 ug/L (SW); 7,600 mg/kg (SD).
2. Ecological Screening Values are: 87 ug/L (SW); Not Applicable (SD).
3. Aqueous concentrations are in ug/L.
4. Sediment concentrations are in mg/kg.
5. Samples not marked as UPGRAD are downgradient.

DRAWN BY K. PEILA	DATE 7/12/05	TOTAL ALUMINUM CONCENTRATIONS IN SURFACE WATER (ug/L) AND SEDIMENT (mg/kg) SWMU 12 MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS	DATE 8/15/06		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 5 - 15 REV 0

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR ARSENIC_SWSD 8/15/06 SS



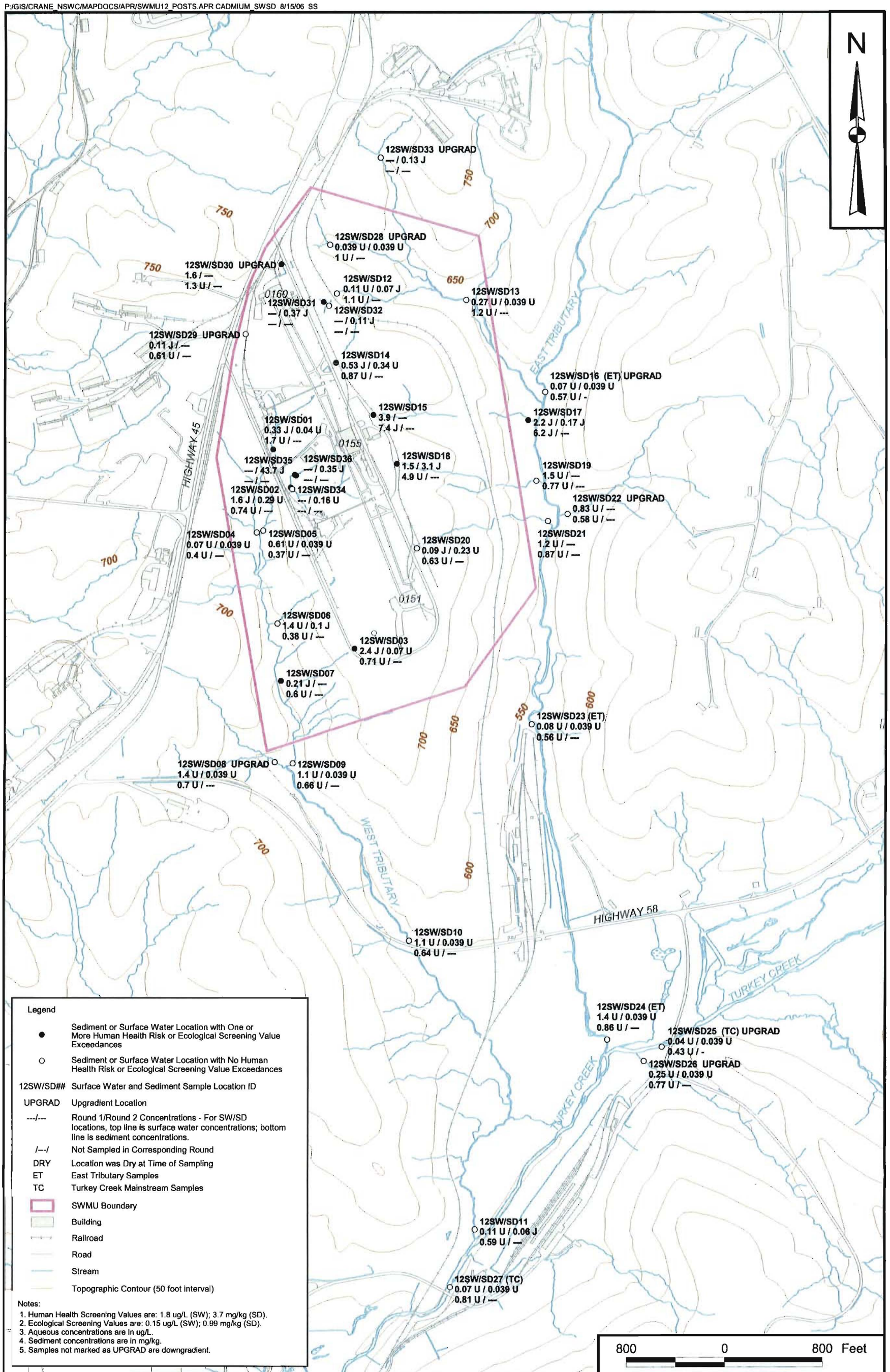
Legend

●	Sediment or Surface Water Location with One or More Human Health Risk or Ecological Screening Value Exceedances
○	Sediment or Surface Water Location with No Human Health Risk or Ecological Screening Value Exceedances
12SW/SD##	Surface Water and Sediment Sample Location ID
UPGRAD	Upgradient Location
---/---	Round 1/Round 2 Concentrations - For SW/SD locations, top line is surface water concentrations; bottom line is sediment concentrations.
/---/	Not Sampled in Corresponding Round
DRY	Location was Dry at Time of Sampling
ET	East Tributary Samples
TC	Turkey Creek Mainstream Samples
	SWMU Boundary
	Building
	Railroad
	Road
	Stream
	Topographic Contour (50 foot interval)

Notes:
1. Human Health Screening Values are: 0.045 ug/L (SW); 0.39 mg/kg (SD).
2. Ecological Screening Values are: 148 ug/L (SW); 9.79 mg/kg (SD).
3. Aqueous concentrations are in ug/L.
4. Sediment concentrations are in mg/kg.
5. Samples not marked as UPGRAD are downgradient.

DRAWN BY K. PEILA	DATE 7/12/05	TOTAL ARSENIC CONCENTRATIONS IN SURFACE WATER (ug/L) AND SEDIMENT (mg/kg) SWMU 12 MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS	DATE 8/15/06		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 5 - 16 REV 0

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR CADMIUM_SWSD 8/15/06 SS



Legend

- ● Sediment or Surface Water Location with One or More Human Health Risk or Ecological Screening Value Exceedances
- ○ Sediment or Surface Water Location with No Human Health Risk or Ecological Screening Value Exceedances
- 12SW/SD## Surface Water and Sediment Sample Location ID
- UPGRAD Upgradient Location
- ---/--- Round 1/Round 2 Concentrations - For SW/SD locations, top line is surface water concentrations; bottom line is sediment concentrations.
- /—/ Not Sampled in Corresponding Round
- DRY Location was Dry at Time of Sampling
- ET East Tributary Samples
- TC Turkey Creek Mainstream Samples
- SWMU Boundary
- Building
- Railroad
- Road
- Stream
- Topographic Contour (50 foot interval)

Notes:
1. Human Health Screening Values are: 1.8 ug/L (SW); 3.7 mg/kg (SD).
2. Ecological Screening Values are: 0.15 ug/L (SW); 0.99 mg/kg (SD).
3. Aqueous concentrations are in ug/L.
4. Sediment concentrations are in mg/kg.
5. Samples not marked as UPGRAD are downgradient.

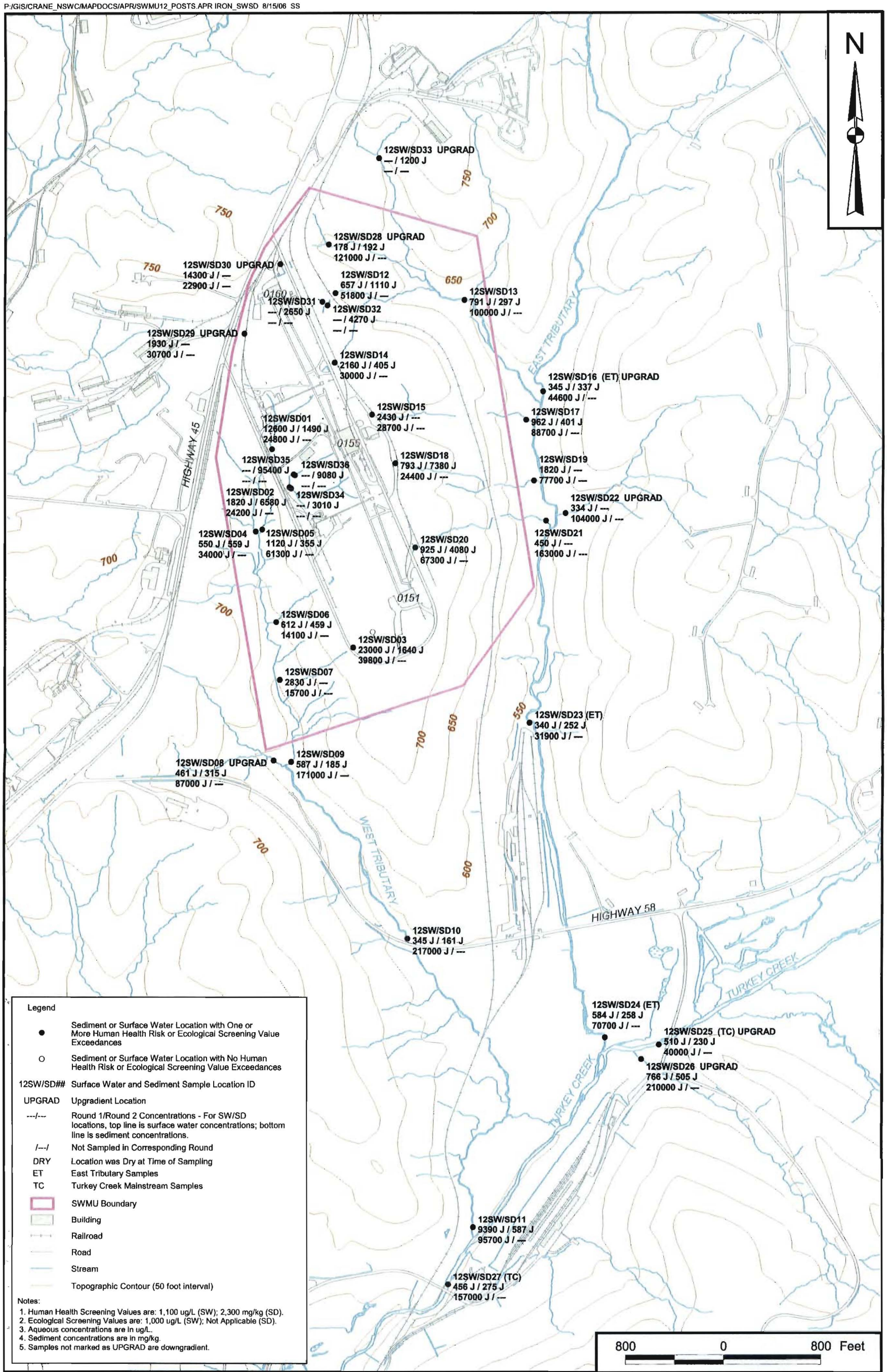
DRAWN BY	DATE
K. PEILA	7/12/05
CHECKED BY	DATE
J. LUCAS	8/15/06
COST/SCHEDULE-AREA	
SCALE	AS NOTED

NAVFAC

TOTAL CADMIUM CONCENTRATIONS IN
SURFACE WATER (ug/L) AND SEDIMENT (mg/kg)
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER	
CTO 0357	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 5 - 17	0

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR IRON_SWSD 8/15/06 SS



Legend

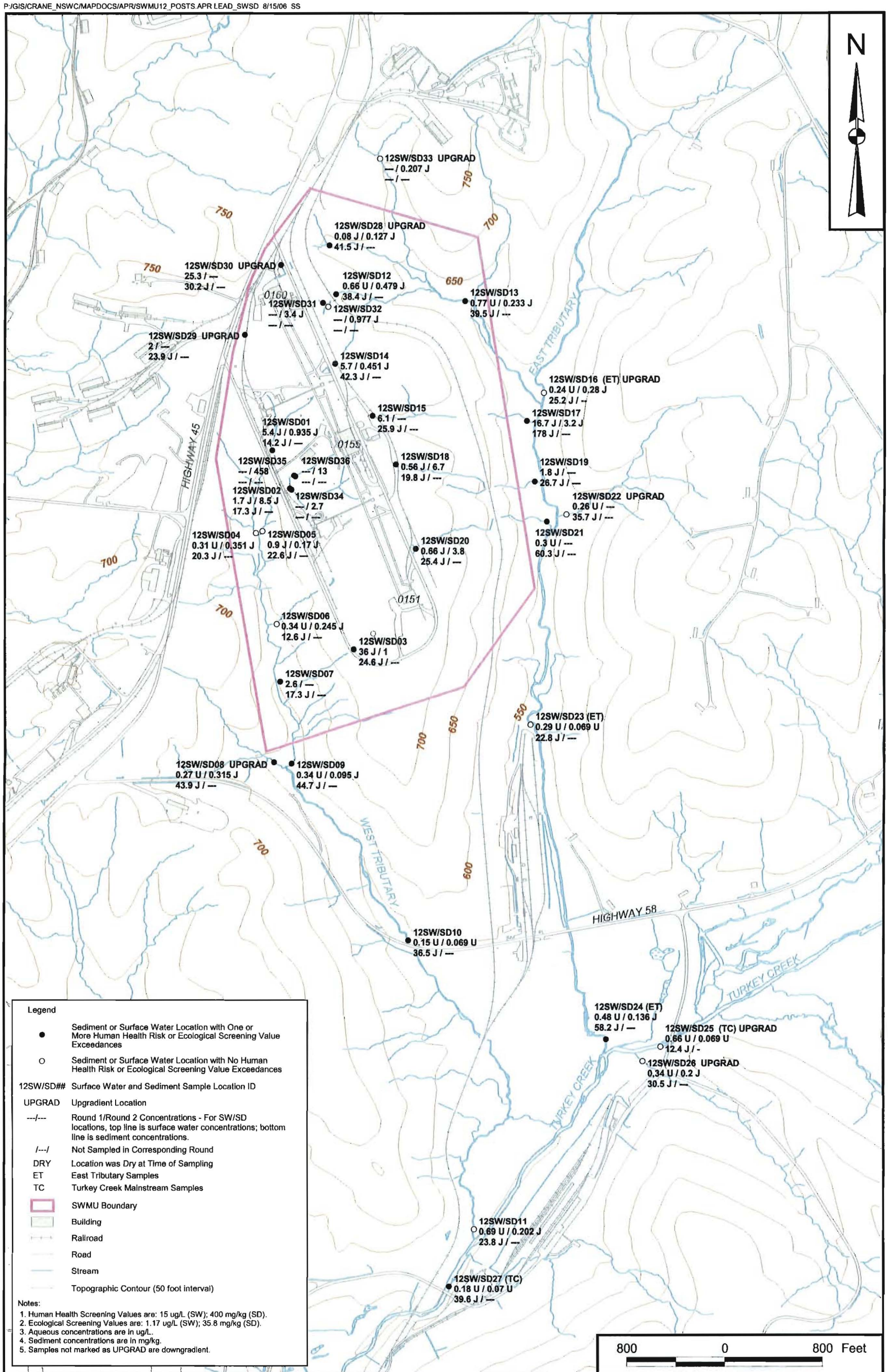
●	Sediment or Surface Water Location with One or More Human Health Risk or Ecological Screening Value Exceedances
O	Sediment or Surface Water Location with No Human Health Risk or Ecological Screening Value Exceedances
12SW/SD##	Surface Water and Sediment Sample Location ID
UPGRAD	Upgradient Location
---/---	Round 1/Round 2 Concentrations - For SW/SD locations, top line is surface water concentrations; bottom line is sediment concentrations.
/---/	Not Sampled in Corresponding Round
DRY	Location was Dry at Time of Sampling
ET	East Tributary Samples
TC	Turkey Creek Mainstream Samples
	SWMU Boundary
	Building
	Railroad
	Road
	Stream
	Topographic Contour (50 foot interval)

Notes:
1. Human Health Screening Values are: 1,100 ug/L (SW); 2,300 mg/kg (SD).
2. Ecological Screening Values are: 1,000 ug/L (SW); Not Applicable (SD).
3. Aqueous concentrations are in ug/L.
4. Sediment concentrations are in mg/kg.
5. Samples not marked as UPGRAD are downgradient.

DRAWN BY K. PEILA	DATE 7/12/05	TOTAL IRON CONCENTRATIONS IN SURFACE WATER (ug/L) AND SEDIMENT (mg/kg) SWMU 12 MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS	DATE 8/15/06		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 5 - 18 REV 0

NAVFAC

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR LEAD_SWSD 8/15/06 SS



Legend

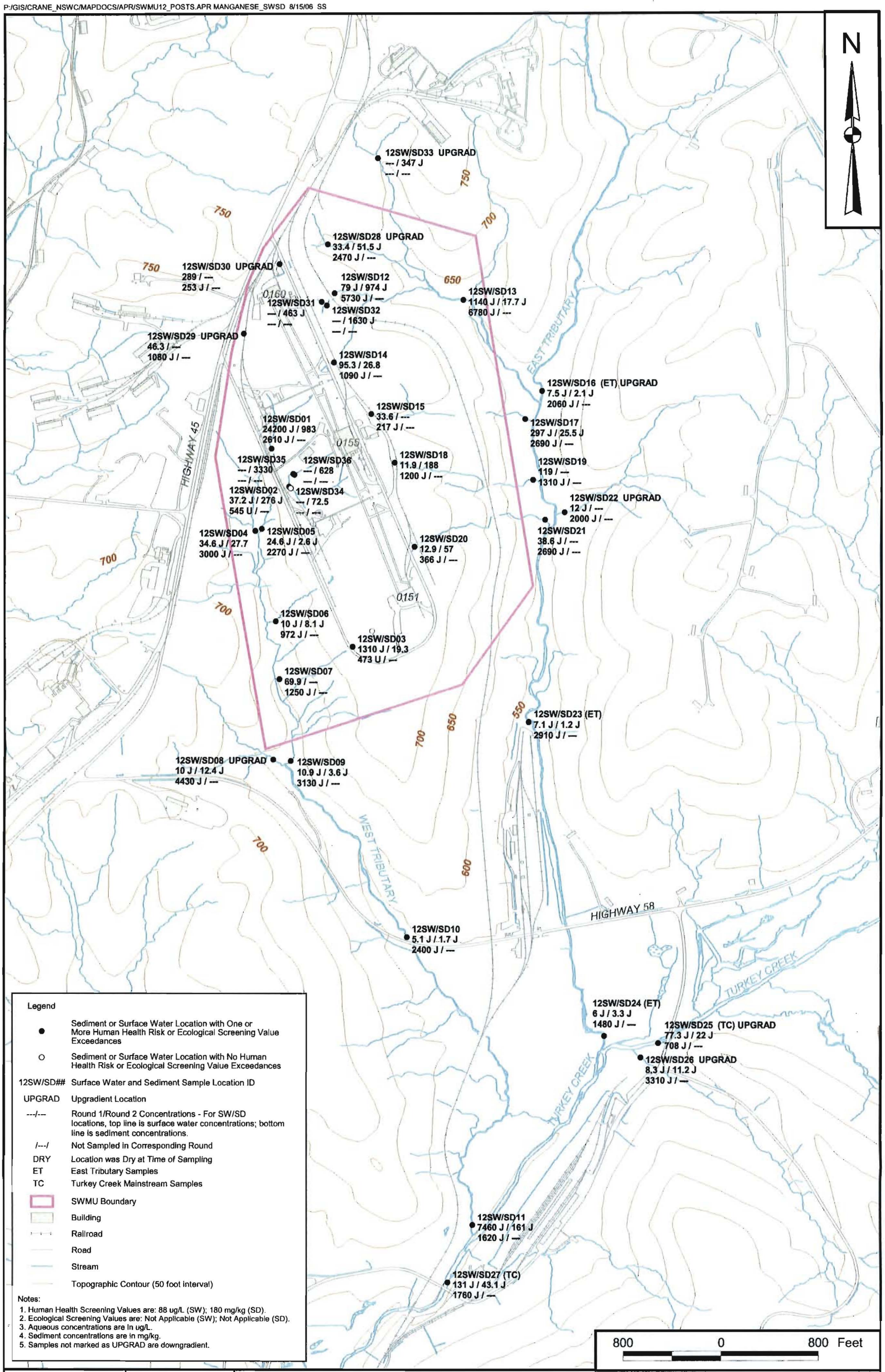
●	Sediment or Surface Water Location with One or More Human Health Risk or Ecological Screening Value Exceedances
○	Sediment or Surface Water Location with No Human Health Risk or Ecological Screening Value Exceedances
12SW/SD##	Surface Water and Sediment Sample Location ID
UPGRAD	Upgradient Location
---/---	Round 1/Round 2 Concentrations - For SW/SD locations, top line is surface water concentrations; bottom line is sediment concentrations.
/---/	Not Sampled in Corresponding Round
DRY	Location was Dry at Time of Sampling
ET	East Tributary Samples
TC	Turkey Creek Mainstream Samples
	SWMU Boundary
	Building
	Railroad
	Road
	Stream
	Topographic Contour (50 foot interval)

Notes:
1. Human Health Screening Values are: 15 ug/L (SW); 400 mg/kg (SD).
2. Ecological Screening Values are: 1.17 ug/L (SW); 35.8 mg/kg (SD).
3. Aqueous concentrations are in ug/L.
4. Sediment concentrations are in mg/kg.
5. Samples not marked as UPGRAD are downgradient.

DRAWN BY K. PEILA	DATE 7/12/05	TOTAL LEAD CONCENTRATIONS IN SURFACE WATER (ug/L) AND SEDIMENT (mg/kg) SWMU 12 MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS	DATE 8/15/06		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 5 - 19 REV 0

NAVFAC

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR MANGANESE_SWSD 8/15/06 SS



Legend

●	Sediment or Surface Water Location with One or More Human Health Risk or Ecological Screening Value Exceedances
○	Sediment or Surface Water Location with No Human Health Risk or Ecological Screening Value Exceedances
12SW/SD##	Surface Water and Sediment Sample Location ID
UPGRAD	Upgradient Location
---/---	Round 1/Round 2 Concentrations - For SW/SD locations, top line is surface water concentrations; bottom line is sediment concentrations.
/---/	Not Sampled in Corresponding Round
DRY	Location was Dry at Time of Sampling
ET	East Tributary Samples
TC	Turkey Creek Mainstream Samples
	SWMU Boundary
	Building
	Railroad
	Road
	Stream
	Topographic Contour (50 foot interval)

Notes:
1. Human Health Screening Values are: 88 ug/L (SW); 180 mg/kg (SD).
2. Ecological Screening Values are: Not Applicable (SW); Not Applicable (SD).
3. Aqueous concentrations are in ug/L.
4. Sediment concentrations are in mg/kg.
5. Samples not marked as UPGRAD are downgradient.

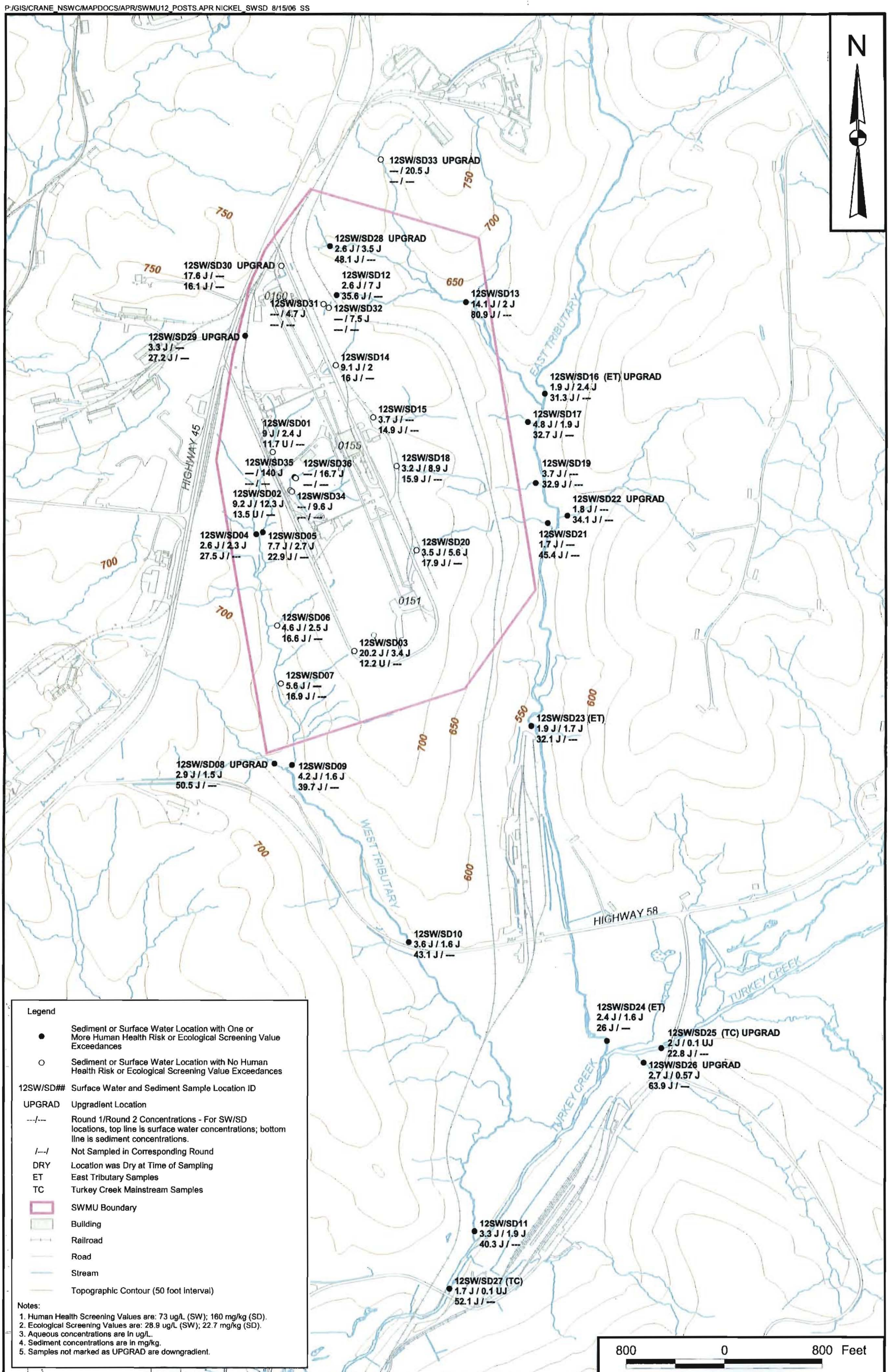
DRAWN BY K. PEILA	DATE 7/12/05
CHECKED BY J. LUCAS	DATE 8/15/06
COST/SCHEDULE-AREA	
SCALE AS NOTED	

NAVFAC

TOTAL MANGANESE CONCENTRATIONS IN SURFACE WATER (ug/L) AND SEDIMENT (mg/kg)
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER CTO 0357	
APPROVED BY —	DATE —
APPROVED BY —	DATE —
DRAWING NO. FIGURE 5 - 20	REV 0

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR NICKEL_SWSD 8/15/06 SS



Legend

●	Sediment or Surface Water Location with One or More Human Health Risk or Ecological Screening Value Exceedances
○	Sediment or Surface Water Location with No Human Health Risk or Ecological Screening Value Exceedances
12SW/SD##	Surface Water and Sediment Sample Location ID
UPGRAD	Upgradient Location
---/---	Round 1/Round 2 Concentrations - For SW/SD locations, top line is surface water concentrations; bottom line is sediment concentrations.
/---/	Not Sampled in Corresponding Round
DRY	Location was Dry at Time of Sampling
ET	East Tributary Samples
TC	Turkey Creek Mainstream Samples
	SWMU Boundary
	Building
	Railroad
	Road
	Stream
	Topographic Contour (50 foot interval)

Notes:
1. Human Health Screening Values are: 73 ug/L (SW); 160 mg/kg (SD).
2. Ecological Screening Values are: 28.9 ug/L (SW); 22.7 mg/kg (SD).
3. Aqueous concentrations are in ug/L.
4. Sediment concentrations are in mg/kg.
5. Samples not marked as UPGRAD are downgradient.

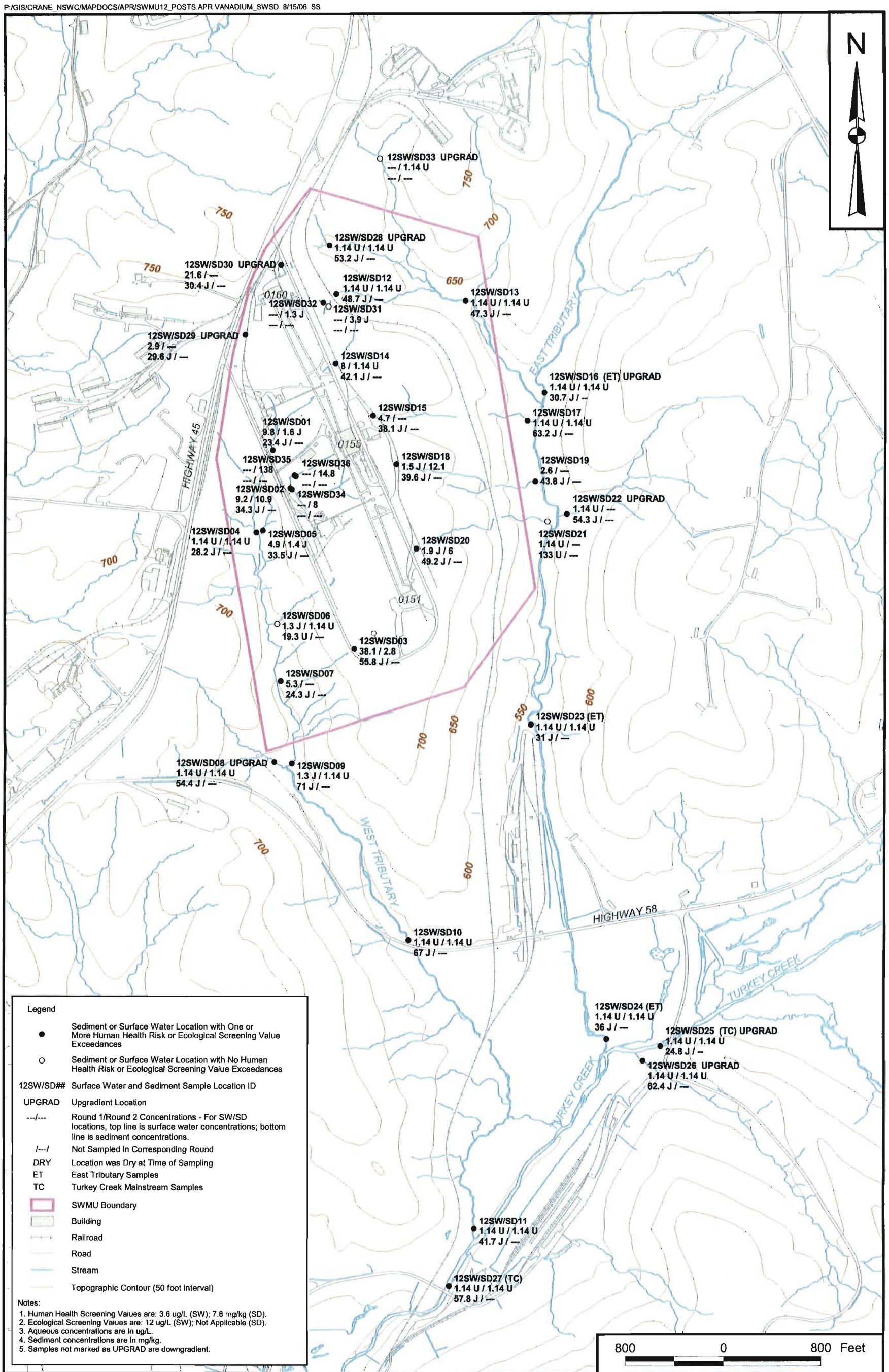
DRAWN BY	DATE
K. PEILA	7/12/05
CHECKED BY	DATE
J. LUCAS	8/15/06
COST/SCHEDULE-AREA	
SCALE	AS NOTED

NAVFAC

TOTAL NICKEL CONCENTRATIONS IN
SURFACE WATER (ug/L) AND SEDIMENT (mg/kg)
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER	
CTO 0357	
APPROVED BY —	DATE —
APPROVED BY —	DATE —
DRAWING NO. FIGURE 5 - 21	REV 0

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR VANADIUM_SWSD 8/15/06 SS



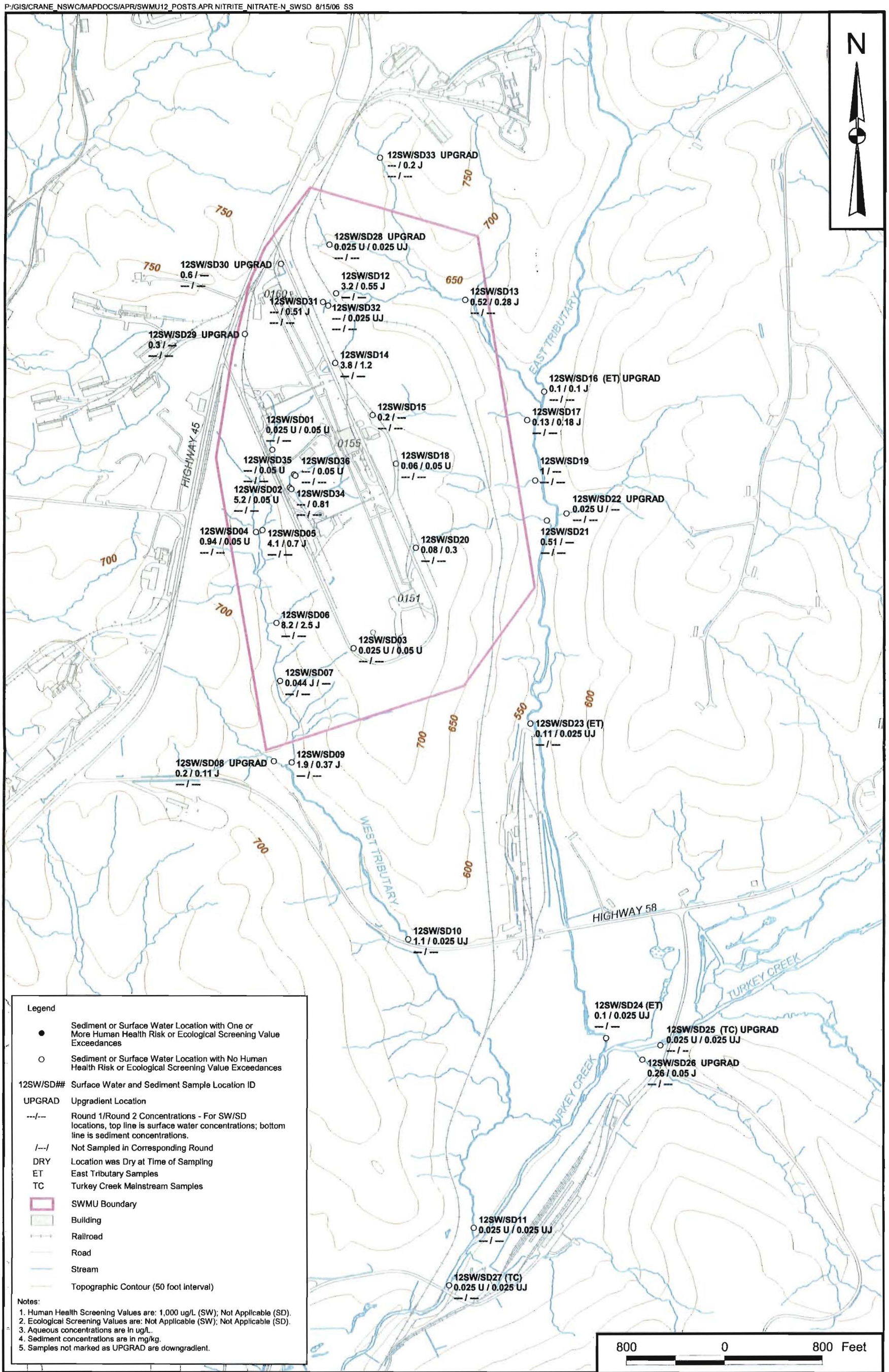
Legend

●	Sediment or Surface Water Location with One or More Human Health Risk or Ecological Screening Value Exceedances
○	Sediment or Surface Water Location with No Human Health Risk or Ecological Screening Value Exceedances
12SW/SD##	Surface Water and Sediment Sample Location ID
UPGRAD	Upgradient Location
---/---	Round 1/Round 2 Concentrations - For SW/SD locations, top line is surface water concentrations; bottom line is sediment concentrations.
/---/	Not Sampled in Corresponding Round
DRY	Location was Dry at Time of Sampling
ET	East Tributary Samples
TC	Turkey Creek Mainstream Samples
	SWMU Boundary
	Building
	Railroad
	Road
	Stream
	Topographic Contour (50 foot interval)

Notes:
1. Human Health Screening Values are: 3.6 ug/L (SW); 7.8 mg/kg (SD).
2. Ecological Screening Values are: 12 ug/L (SW); Not Applicable (SD).
3. Aqueous concentrations are in ug/L.
4. Sediment concentrations are in mg/kg.
5. Samples not marked as UPGRAD are downgradient.

DRAWN BY K. PEILA	DATE 7/12/05	TOTAL VANADIUM CONCENTRATIONS IN SURFACE WATER (ug/L) AND SEDIMENT (mg/kg) SWMU 12 MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS	DATE 8/15/06		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 5 - 22 REV 0

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR NITRITE_NITRATE-N_SWSD 8/15/06 SS



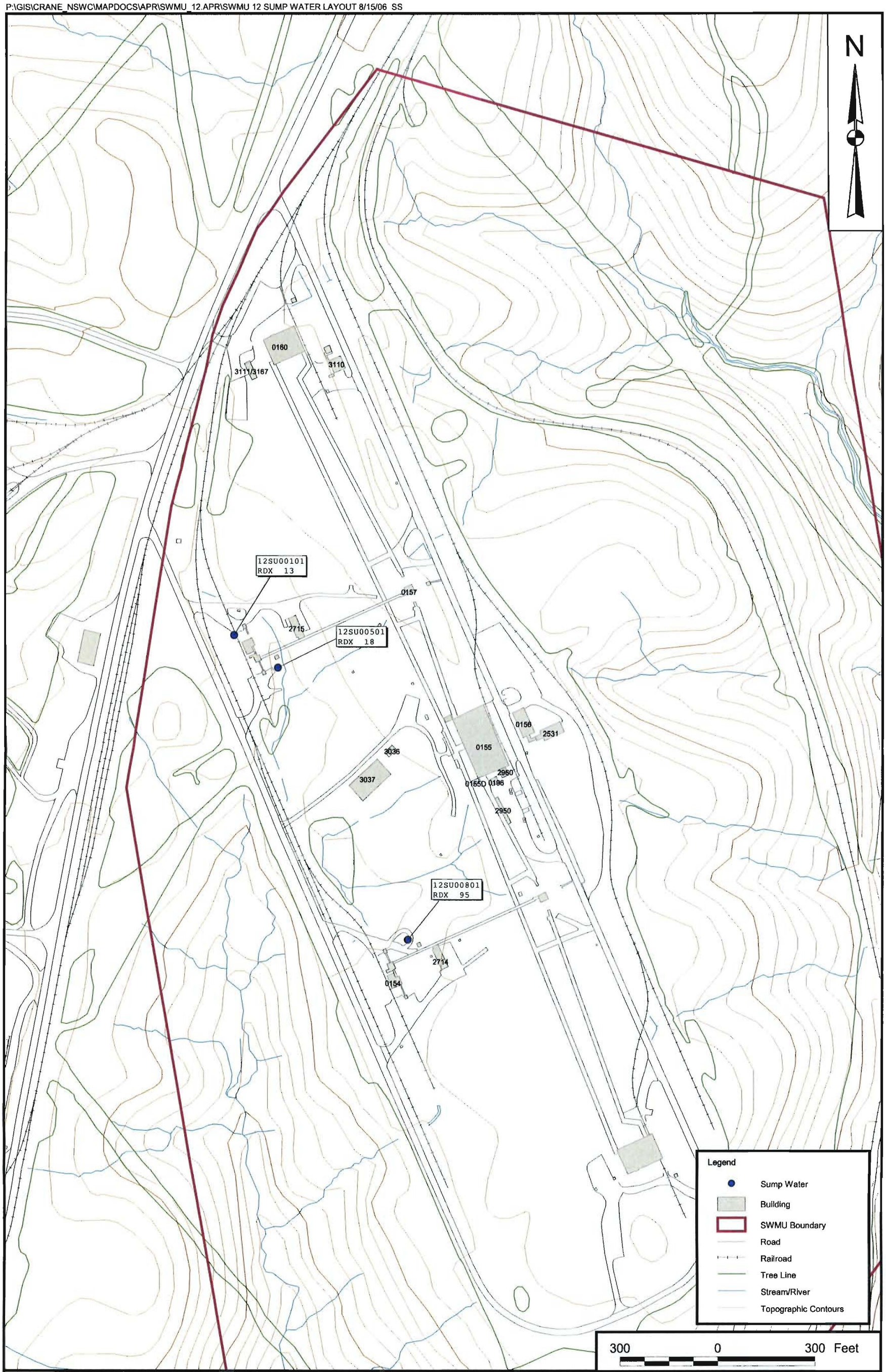
Legend

●	Sediment or Surface Water Location with One or More Human Health Risk or Ecological Screening Value Exceedances
○	Sediment or Surface Water Location with No Human Health Risk or Ecological Screening Value Exceedances
12SW/SD##	Surface Water and Sediment Sample Location ID
UPGRAD	Upgradient Location
---/---	Round 1/Round 2 Concentrations - For SW/SD locations, top line is surface water concentrations; bottom line is sediment concentrations.
/---/	Not Sampled in Corresponding Round
DRY	Location was Dry at Time of Sampling
ET	East Tributary Samples
TC	Turkey Creek Mainstream Samples
	SWMU Boundary
	Building
	Railroad
	Road
	Stream
	Topographic Contour (50 foot interval)

Notes:
1. Human Health Screening Values are: 1,000 ug/L (SW); Not Applicable (SD).
2. Ecological Screening Values are: Not Applicable (SW); Not Applicable (SD).
3. Aqueous concentrations are in ug/L.
4. Sediment concentrations are in mg/kg.
5. Samples not marked as UPGRAD are downgradient.

DRAWN BY K. PEILA	DATE 7/12/05	NITRATE PLUS NITRITE CONCENTRATIONS IN SURFACE WATER (ug/L) AND SEDIMENT (mg/kg) SWMU 12 MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS	DATE 8/15/06		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 5 - 23 REV 0

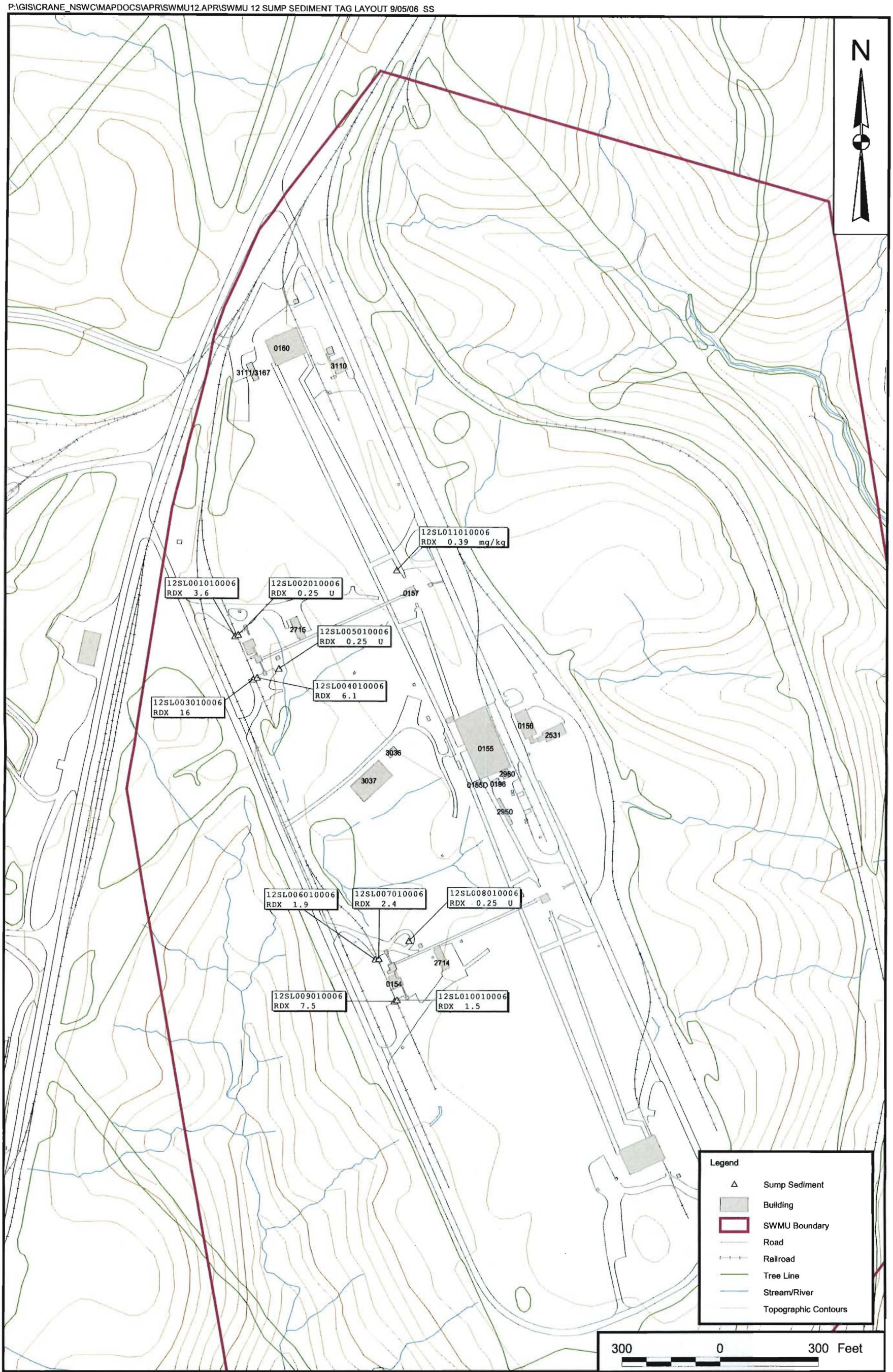
P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU_12.APR\SWMU 12 SUMP WATER LAYOUT 8/15/06 SS



DRAWN BY S. STROZ	DATE 7/28/06	RDX CONCENTRATIONS IN SUMP WATER (ug/L)	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS	DATE 8/15/06	SWMU 12 MINE FILL A	APPROVED BY — / DATE —
COST/SCHEDULE-AREA		NWSC CRANE	APPROVED BY — / DATE —
SCALE AS NOTED		CRANE, INDIANA	DRAWING NO. FIGURE 5 - 24 / REV 0

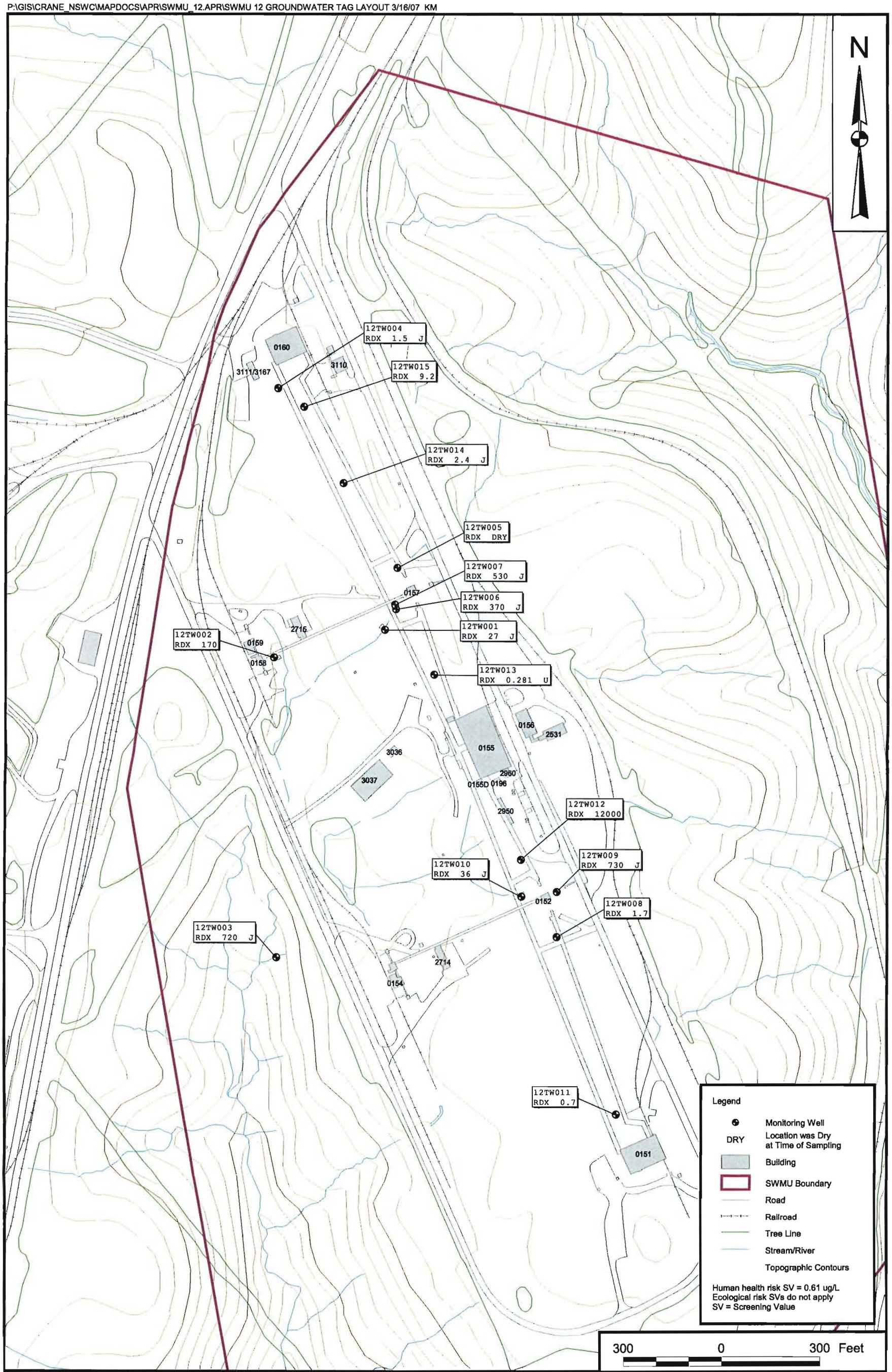
NAVFAC

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU12.APR\SWMU 12 SUMP SEDIMENT TAG LAYOUT 9/05/06 SS



DRAWN BY S. STROZ	DATE 7/28/06	RDX CONCENTRATIONS IN SUMP SEDIMENT (mg/Kg) SWMU 12 MINE FILL A NWSC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS	DATE 9/05/06		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 5 - 25 REV 0

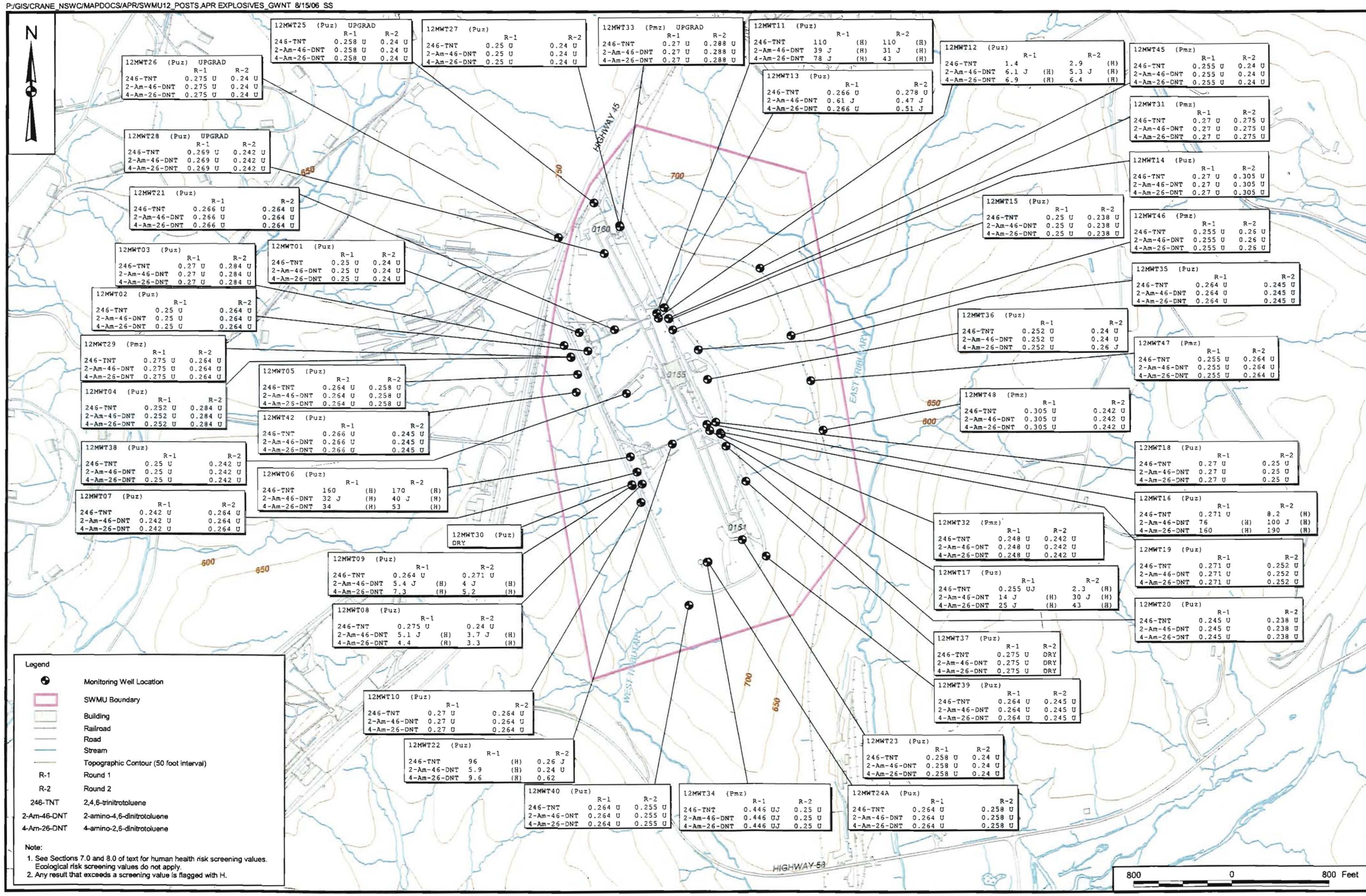
P:\GIS\CRANE_NSWC\MAPDOCS\APR\SWMU_12.APR\SWMU 12 GROUNDWATER TAG LAYOUT 3/16/07 KM



DRAWN BY S. STROZ	DATE 7/28/06	RDX CONCENTRATIONS IN GROUNDWATER FROM SOIL OVERBURDEN TEMPORARY WELLS (ug/L) SWMU 12 MINE FILL A NWSC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0357
CHECKED BY J. LUCAS	DATE 3/16/07		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 5 - 26 / REV 0

NAVFAC

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR EXPLOSIVES_GWNT 8/15/06 SS



CONTRACT NO. CTO 0357

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 5 - 27

REV 0

SELECT TNT - RELATED EXPLOSIVE CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

NSWC CRANE

CRANE, INDIANA

NAVFAC

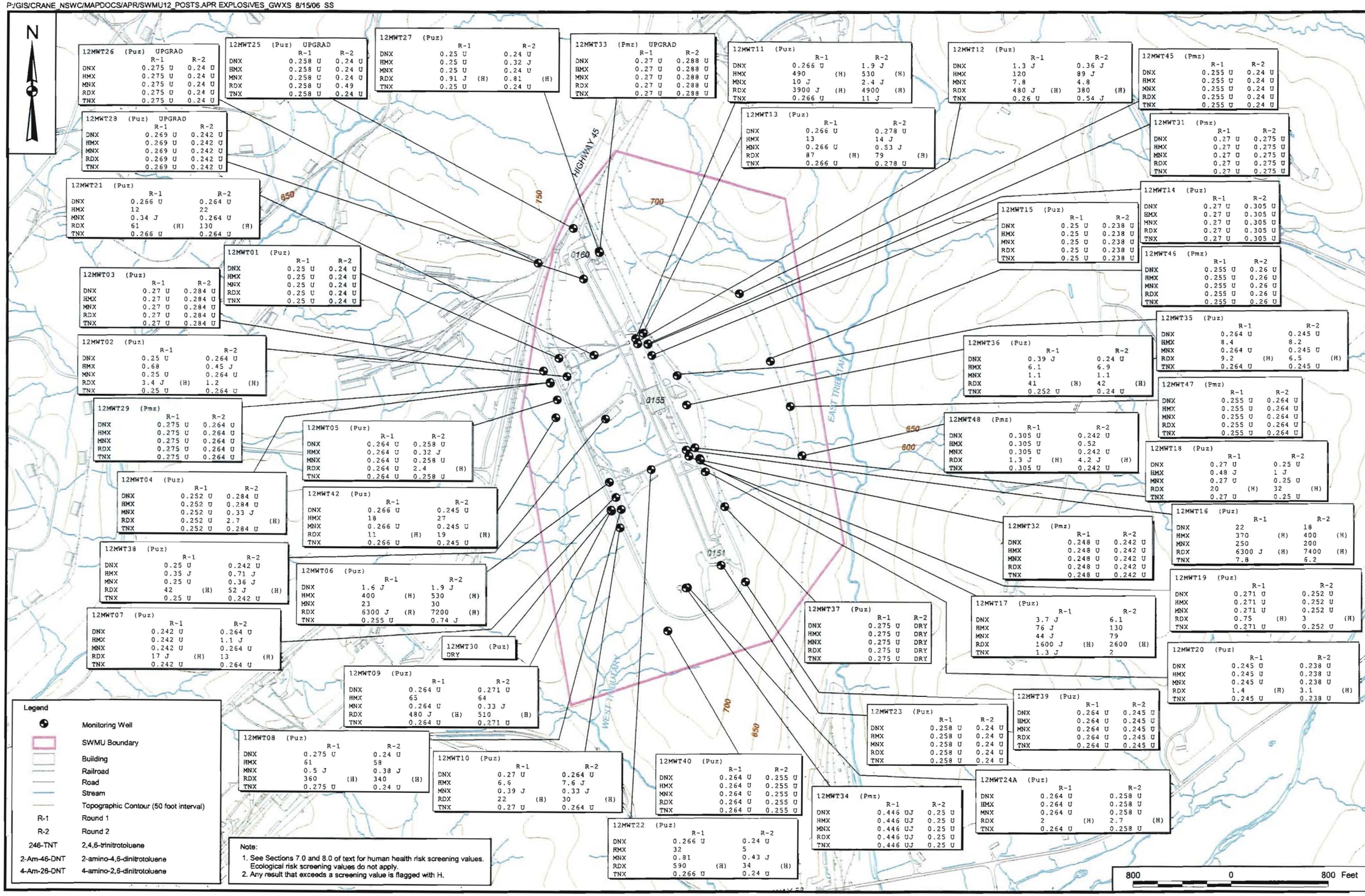
DRAWN BY K. PEILA DATE 7/12/05

CHECKED BY J. LUCAS DATE 8/15/06

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR EXPLOSIVES_GWXS 8/15/06 SS



12MWT26 (Puz) UPGRAD

	R-1	R-2
DNX	0.275 U	0.24 U
HMX	0.275 U	0.24 U
MNX	0.275 U	0.24 U
RDX	0.275 U	0.24 U
TNX	0.275 U	0.24 U

12MWT25 (Puz) UPGRAD

	R-1	R-2
DNX	0.258 U	0.24 U
HMX	0.258 U	0.24 U
MNX	0.258 U	0.24 U
RDX	0.258 U	0.49
TNX	0.258 U	0.24 U

12MWT27 (Puz)

	R-1	R-2
DNX	0.25 U	0.24 U
HMX	0.25 U	0.32 J
MNX	0.25 U	0.24 U
RDX	0.91 J (H)	0.81 (H)
TNX	0.25 U	0.24 U

12MWT33 (Pmz) UPGRAD

	R-1	R-2
DNX	0.27 U	0.288 U
HMX	0.27 U	0.288 U
MNX	0.27 U	0.288 U
RDX	0.27 U	0.288 U
TNX	0.27 U	0.288 U

12MWT11 (Puz)

	R-1	R-2
DNX	0.266 U	1.9 J
HMX	490 (H)	530 (H)
MNX	10 J	2.4 J
RDX	3900 J (H)	4900 (H)
TNX	0.266 U	11 J

12MWT12 (Puz)

	R-1	R-2
DNX	1.3 J	0.36 J
HMX	120	89 J
MNX	7.8	4.8
RDX	480 J (H)	380 (H)
TNX	0.26 U	0.54 J

12MWT45 (Pmz)

	R-1	R-2
DNX	0.255 U	0.24 U
HMX	0.255 U	0.24 U
MNX	0.255 U	0.24 U
RDX	0.255 U	0.24 U
TNX	0.255 U	0.24 U

12MWT28 (Puz) UPGRAD

	R-1	R-2
DNX	0.269 U	0.242 U
HMX	0.269 U	0.242 U
MNX	0.269 U	0.242 U
RDX	0.269 U	0.242 U
TNX	0.269 U	0.242 U

12MWT13 (Puz)

	R-1	R-2
DNX	0.266 U	0.278 U
HMX	13	14 J
MNX	0.266 U	0.53 J
RDX	87 (H)	79 (H)
TNX	0.266 U	0.278 U

12MWT31 (Pmz)

	R-1	R-2
DNX	0.27 U	0.275 U
HMX	0.27 U	0.275 U
MNX	0.27 U	0.275 U
RDX	0.27 U	0.275 U
TNX	0.27 U	0.275 U

12MWT21 (Puz)

	R-1	R-2
DNX	0.266 U	0.264 U
HMX	12	22
MNX	0.34 J	0.264 U
RDX	61 (H)	130 (H)
TNX	0.266 U	0.264 U

12MWT14 (Puz)

	R-1	R-2
DNX	0.27 U	0.305 U
HMX	0.27 U	0.305 U
MNX	0.27 U	0.305 U
RDX	0.27 U	0.305 U
TNX	0.27 U	0.305 U

12MWT15 (Puz)

	R-1	R-2
DNX	0.25 U	0.238 U
HMX	0.25 U	0.238 U
MNX	0.25 U	0.238 U
RDX	0.25 U	0.238 U
TNX	0.25 U	0.238 U

12MWT01 (Puz)

	R-1	R-2
DNX	0.25 U	0.24 U
HMX	0.25 U	0.24 U
MNX	0.25 U	0.24 U
RDX	0.25 U	0.24 U
TNX	0.25 U	0.24 U

12MWT46 (Pmz)

	R-1	R-2
DNX	0.255 U	0.26 U
HMX	0.255 U	0.26 U
MNX	0.255 U	0.26 U
RDX	0.255 U	0.26 U
TNX	0.255 U	0.26 U

12MWT03 (Puz)

	R-1	R-2
DNX	0.27 U	0.284 U
HMX	0.27 U	0.284 U
MNX	0.27 U	0.284 U
RDX	0.27 U	0.284 U
TNX	0.27 U	0.284 U

12MWT35 (Puz)

	R-1	R-2
DNX	0.264 U	0.245 U
HMX	8.4	8.2
MNX	0.264 U	0.245 U
RDX	9.2 (H)	6.5 (H)
TNX	0.264 U	0.245 U

12MWT36 (Puz)

	R-1	R-2
DNX	0.39 J	0.24 U
HMX	6.1	6.9
MNX	1.1	1.1
RDX	41 (H)	42 (H)
TNX	0.252 U	0.24 U

12MWT02 (Puz)

	R-1	R-2
DNX	0.25 U	0.264 U
HMX	0.68	0.45 J
MNX	0.25 U	0.264 U
RDX	3.4 J (H)	1.2 (H)
TNX	0.25 U	0.264 U

12MWT47 (Pmz)

	R-1	R-2
DNX	0.255 U	0.264 U
HMX	0.255 U	0.264 U
MNX	0.255 U	0.264 U
RDX	0.255 U	0.264 U
TNX	0.255 U	0.264 U

12MWT29 (Pmz)

	R-1	R-2
DNX	0.275 U	0.264 U
HMX	0.275 U	0.264 U
MNX	0.275 U	0.264 U
RDX	0.275 U	0.264 U
TNX	0.275 U	0.264 U

12MWT05 (Puz)

	R-1	R-2
DNX	0.264 U	0.258 U
HMX	0.264 U	0.32 J
MNX	0.264 U	0.258 U
RDX	0.264 U	2.4 (H)
TNX	0.264 U	0.258 U

12MWT48 (Pmz)

	R-1	R-2
DNX	0.305 U	0.242 U
HMX	0.305 U	0.52
MNX	0.305 U	0.242 U
RDX	1.3 J (H)	4.2 J (H)
TNX	0.305 U	0.242 U

12MWT18 (Puz)

	R-1	R-2
DNX	0.27 U	0.25 U
HMX	0.48 J	1 J
MNX	0.27 U	0.25 U
RDX	20 (H)	32 (H)
TNX	0.27 U	0.25 U

12MWT04 (Puz)

	R-1	R-2
DNX	0.252 U	0.284 U
HMX	0.252 U	0.284 U
MNX	0.252 U	0.33 J
RDX	0.252 U	2.7 (H)
TNX	0.252 U	0.284 U

12MWT42 (Puz)

	R-1	R-2
DNX	0.266 U	0.245 U
HMX	18	27
MNX	0.266 U	0.245 U
RDX	11 (H)	19 (H)
TNX	0.266 U	0.245 U

12MWT32 (Pmz)

	R-1	R-2
DNX	0.248 U	0.242 U
HMX	0.248 U	0.242 U
MNX	0.248 U	0.242 U
RDX	0.248 U	0.242 U
TNX	0.248 U	0.242 U

12MWT16 (Puz)

	R-1	R-2
DNX	22	18
HMX	370 (H)	400 (H)
MNX	250	200
RDX	6300 J (H)	7400 (H)
TNX	7.8	6.2

12MWT38 (Puz)

	R-1	R-2
DNX	0.25 U	0.242 U
HMX	0.35 J	0.71 J
MNX	0.25 U	0.36 J
RDX	42 (H)	52 J (H)
TNX	0.25 U	0.242 U

12MWT06 (Puz)

	R-1	R-2
DNX	1.6 J	1.9 J
HMX	400 (H)	530 (H)
MNX	23	30
RDX	6300 J (H)	7200 (H)
TNX	0.255 U	0.74 J

12MWT37 (Puz)

	R-1	R-2
DNX	0.275 U	DRY
HMX	0.275 U	DRY
MNX	0.275 U	DRY
RDX	0.275 U	DRY
TNX	0.275 U	DRY

12MWT17 (Puz)

	R-1	R-2
DNX	3.7 J	6.1
HMX	76 J	130
MNX	44 J	79
RDX	1600 J (H)	2600 (H)
TNX	1.3 J	2

12MWT19 (Puz)

	R-1	R-2
DNX	0.271 U	0.252 U
HMX	0.271 U	0.252 U
MNX	0.271 U	0.252 U
RDX	0.75 (H)	3 (H)
TNX	0.271 U	0.252 U

12MWT07 (Puz)

	R-1	R-2
DNX	0.242 U	0.264 U
HMX	0.242 U	1.1 J
MNX	0.242 U	0.264 U
RDX	17 J (H)	13 (H)
TNX	0.242 U	0.264 U

12MWT30 (Puz)
DRY

12MWT20 (Puz)

	R-1	R-2
DNX	0.245 U	0.238 U
HMX	0.245 U	0.238 U
MNX	0.245 U	0.238 U
RDX	1.4 (H)	3.1 (H)
TNX	0.245 U	0.238 U

12MWT09 (Puz)

	R-1	R-2
DNX	0.264 U	0.271 U
HMX	65	64
MNX	0.264 U	0.33 J
RDX	480 J (H)	510 (H)
TNX	0.264 U	0.271 U

12MWT39 (Puz)

	R-1	R-2
DNX	0.264 U	0.245 U
HMX	0.264 U	0.245 U
MNX	0.264 U	0.245 U
RDX	0.264 U	0.245 U
TNX	0.264 U	0.245 U

12MWT23 (Puz)

	R-1	R-2
DNX	0.258 U	0.24 U
HMX	0.258 U	0.24 U
MNX	0.258 U	0.24 U
RDX	0.258 U	0.24 U
TNX	0.258 U	0.24 U

12MWT08 (Puz)

	R-1	R-2
DNX	0.275 U	0.24 U
HMX	61	58
MNX	0.5 J	0.38 J
RDX	360 (H)	340 (H)
TNX	0.275 U	0.24 U

12MWT10 (Puz)

	R-1	R-2
DNX	0.27 U	0.264 U
HMX	6.6	7.6 J
MNX	0.39 J	0.33 J
RDX	22 (H)	30 (H)
TNX	0.27 U	0.264 U

12MWT40 (Puz)

	R-1	R-2
DNX	0.264 U	0.255 U
HMX	0.264 U	0.255 U
MNX	0.264 U	0.255 U
RDX	0.264 U	0.255 U
TNX	0.264 U	0.255 U

12MWT34 (Pmz)

	R-1	R-2
DNX	0.446 UJ	0.25 U
HMX	0.446 UJ	0.25 U
MNX	0.446 UJ	0.25 U
RDX	0.446 UJ	0.25 U
TNX	0.446 UJ	0.25 U

12MWT24A (Puz)

	R-1	R-2
DNX	0.264 U	0.258 U
HMX	0.264 U	0.258 U
MNX	0.264 U	0.258 U
RDX	2 (H)	2.7 (H)
TNX	0.264 U	0.258 U

12MWT22 (Puz)

	R-1	R-2
DNX	0.266 U	0.24 U
HMX	32	5
MNX	0.81	0.43 J
RDX	590 (H)	34 (H)
TNX	0.266 U	0.24 U

Legend

- Monitoring Well
- SWMU Boundary
- Building
- Railroad
- Road
- Stream
- Topographic Contour (50 foot interval)
- R-1 Round 1
- R-2 Round 2
- 246-TNT 2,4,6-trinitrotoluene
- 2-Am-46-DNT 2-amino-4,6-dinitrotoluene
- 4-Am-26-DNT 4-amino-2,6-dinitrotoluene

Note:
1. See Sections 7.0 and 8.0 of text for human health risk screening values. Ecological risk screening values do not apply.
2. Any result that exceeds a screening value is flagged with H.

CONTRACT NO. CTO 0357

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 5 - 28

REV 0

HMX AND RDX - RELATED EXPLOSIVE CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

NSWC CRANE

CRANE, INDIANA

NAVFAC

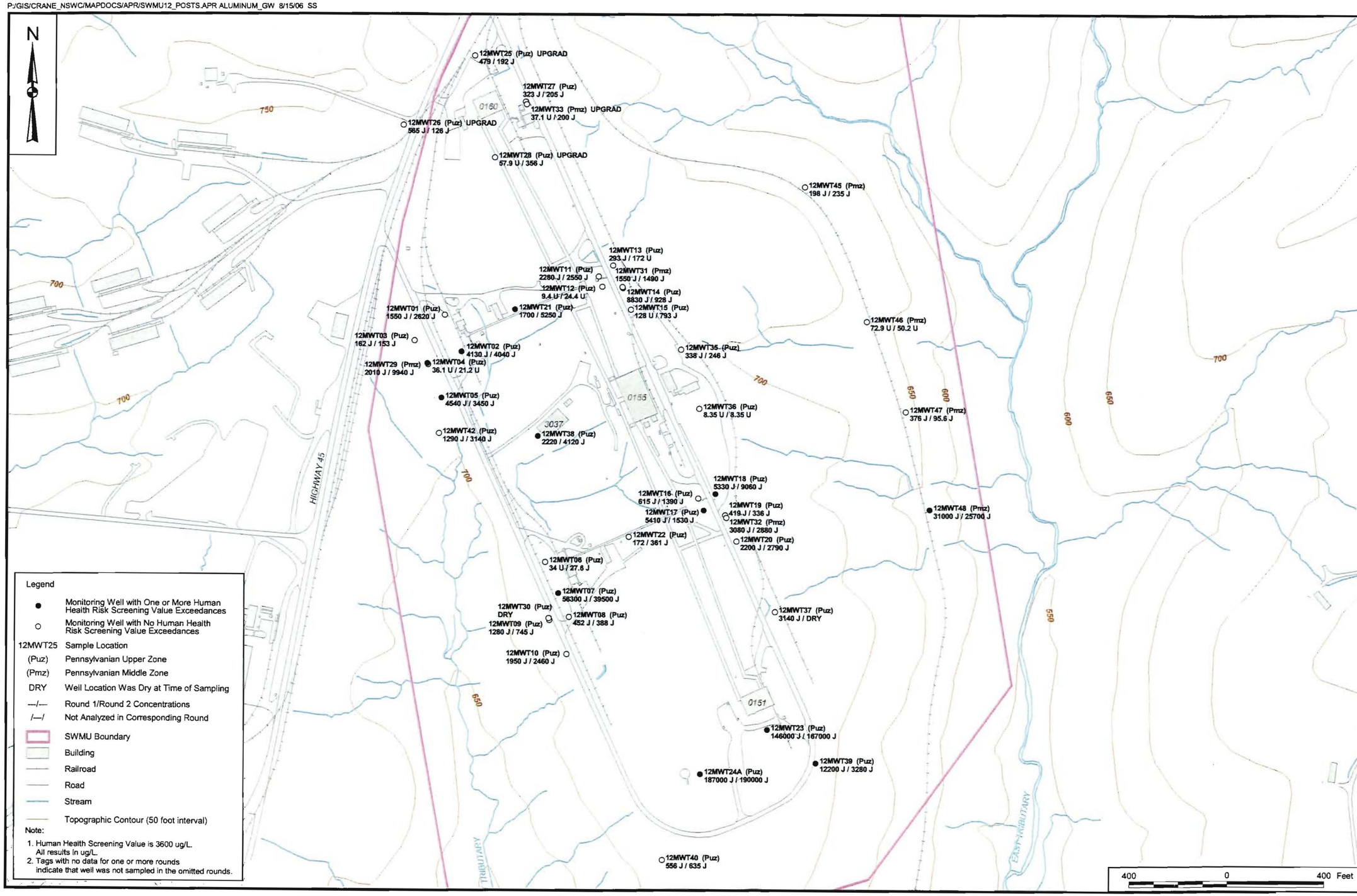
DRAWN BY K. PEILA DATE 7/12/05

CHECKED BY J. LUCAS DATE 8/15/06

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR ALUMINUM_GW 8/15/06 SS



CONTRACT NO. 6878

APPROVED BY — DATE

APPROVED BY — DATE

DRAWING NO. FIGURE 5 - 29

REV 0

TOTAL ALUMINUM CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

NSWC CRANE

CRANE, INDIANA

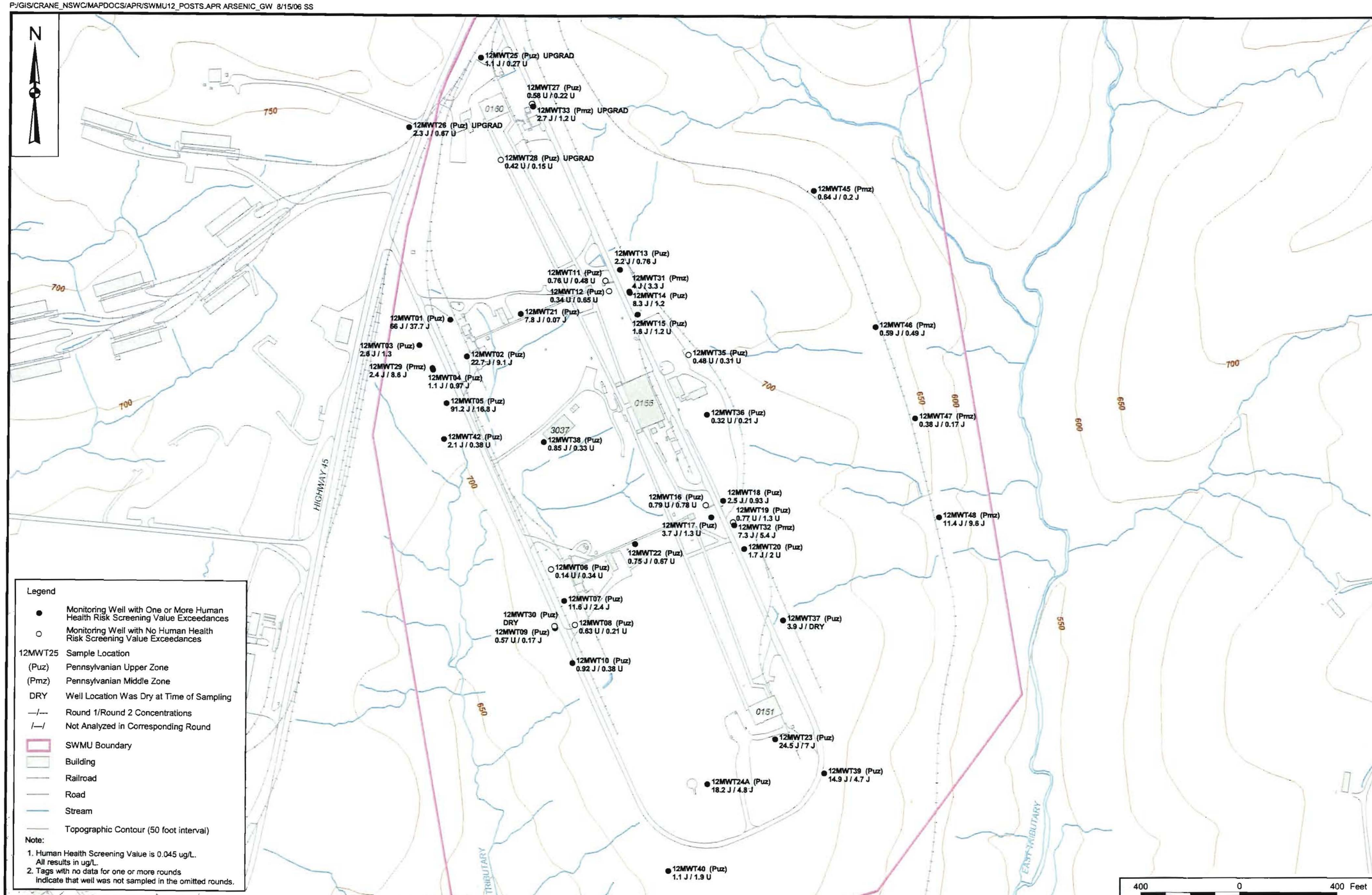
NAVFAC

DRAWN BY	DATE
K. PEILA	7/12/05
CHECKED BY	DATE
J. LUCAS	8/15/06

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR ARSENIC_GW 8/15/06 SS



CONTRACT NO. 6878

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 5 - 30

REV 0

TOTAL ARSENIC CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

NSWC CRANE

CRANE, INDIANA

NAVFAC

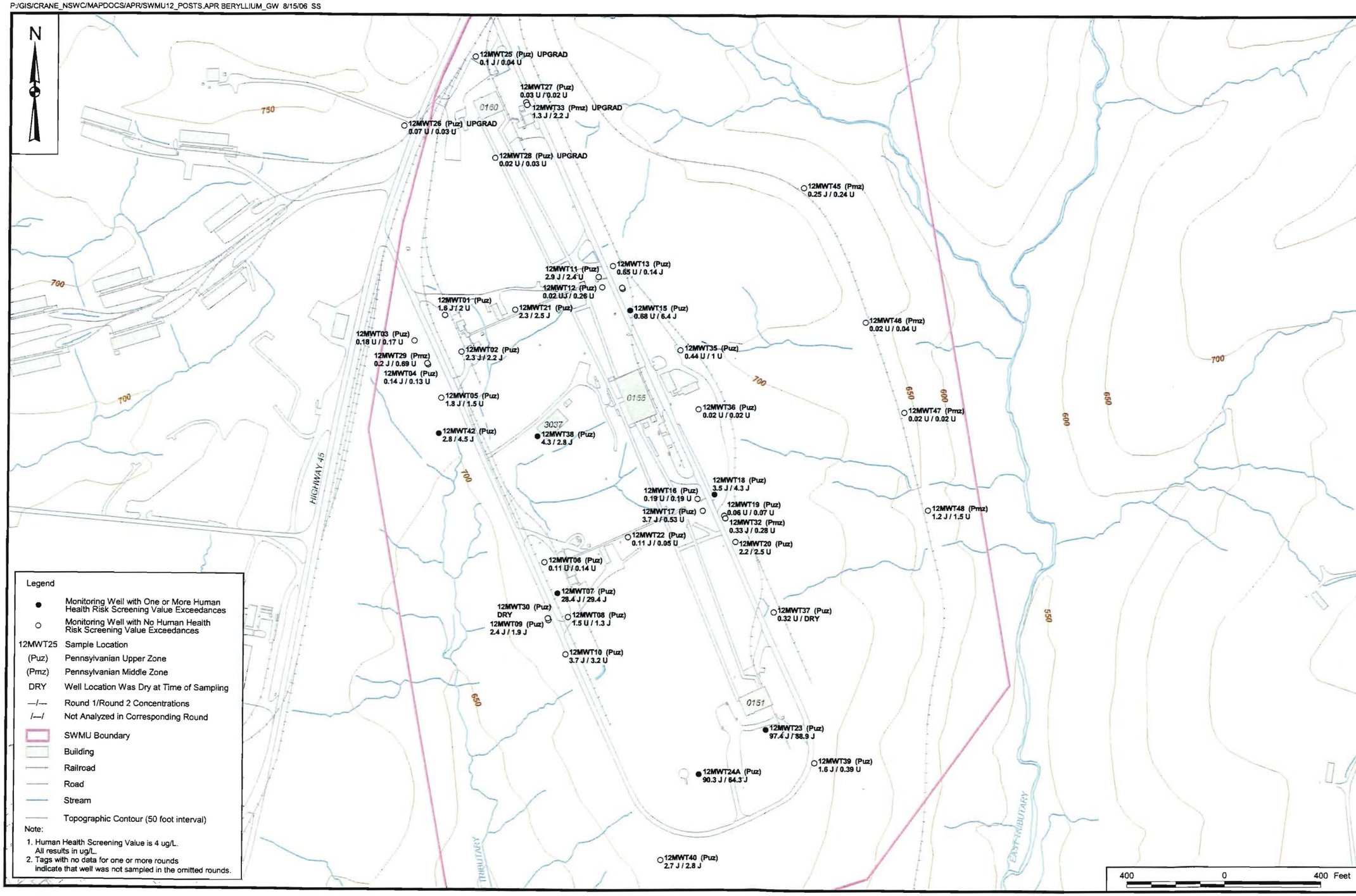
DRAWN BY K. PEILA DATE 7/12/05

CHECKED BY J. LUCAS DATE 8/15/06

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR BERYLLIUM_GW 8/15/06 SS



CONTRACT NO. 6878

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 31

REV 0

TOTAL BERYLLIUM CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

NSWC CRANE

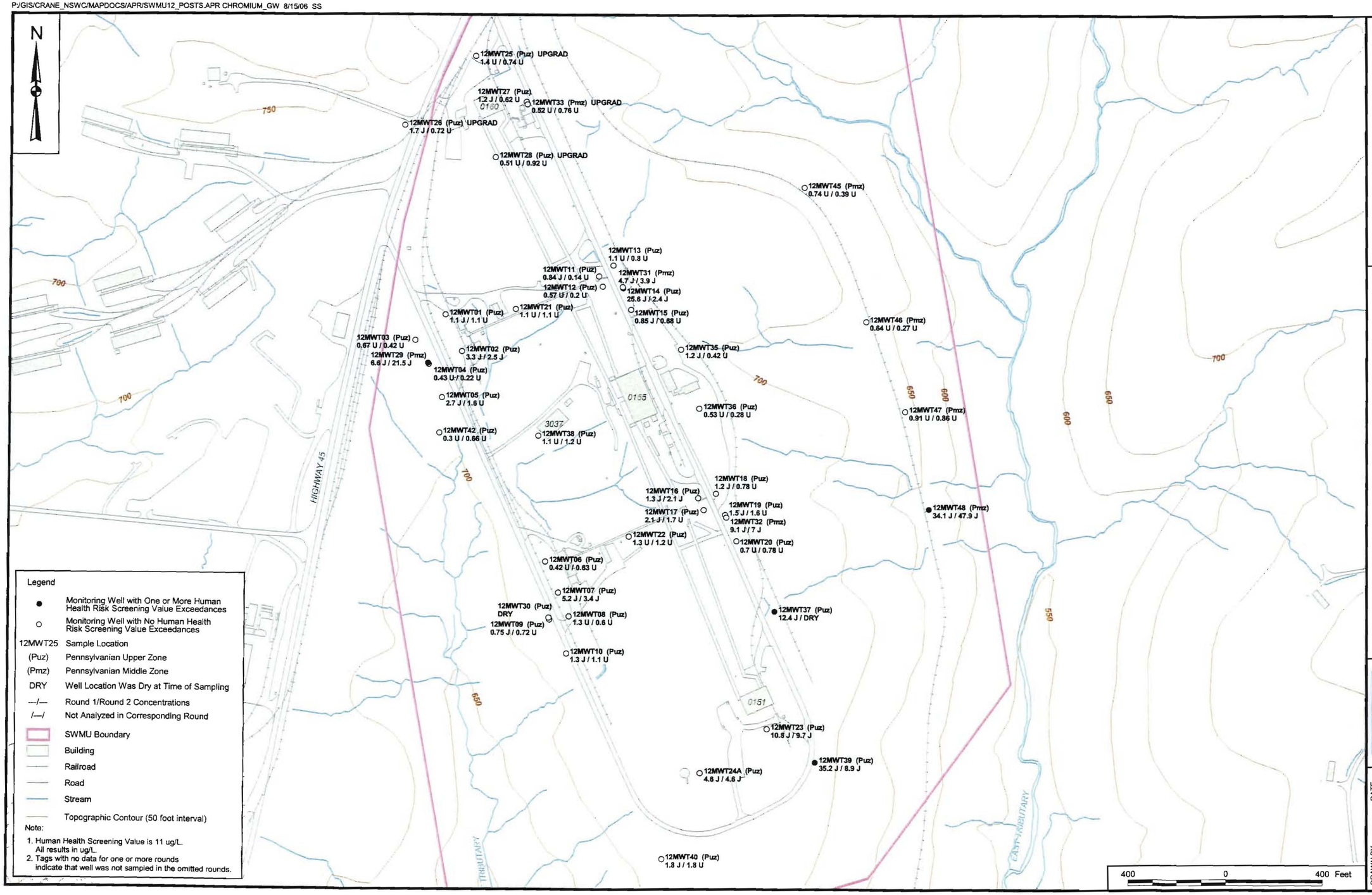
CRANE, INDIANA

NAVFAC

DRAWN BY	DATE
K. PEILA	7/12/05
CHECKED BY	DATE
J. LUCAS	8/15/06
COST/SCHED-AREA	

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR CHROMIUM_GW 8/15/06 SS



CONTRACT NO. 6878

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 33

REV 0

TOTAL CHROMIUM CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

NSWC CRANE

CRANE, INDIANA

NAVFAC

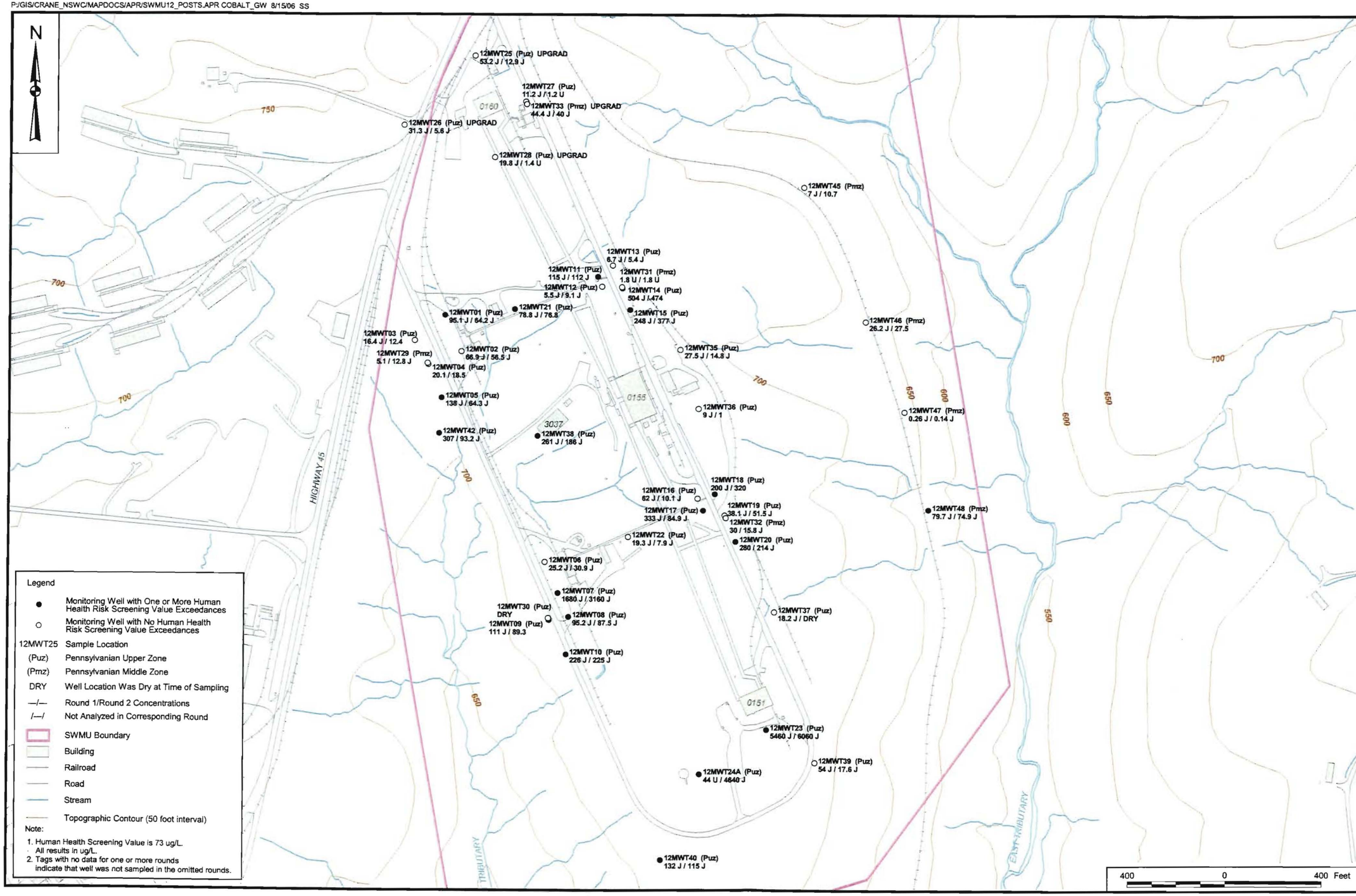
DRAWN BY K. PEILA DATE 7/12/05

CHECKED BY J. LUCAS DATE 8/15/06

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR COBALT_GW 8/15/06 SS



CONTRACT NO. 6878

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 34

REV 0

TOTAL COBALT CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

NSWC CRANE

CRANE, INDIANA

NAVFAC

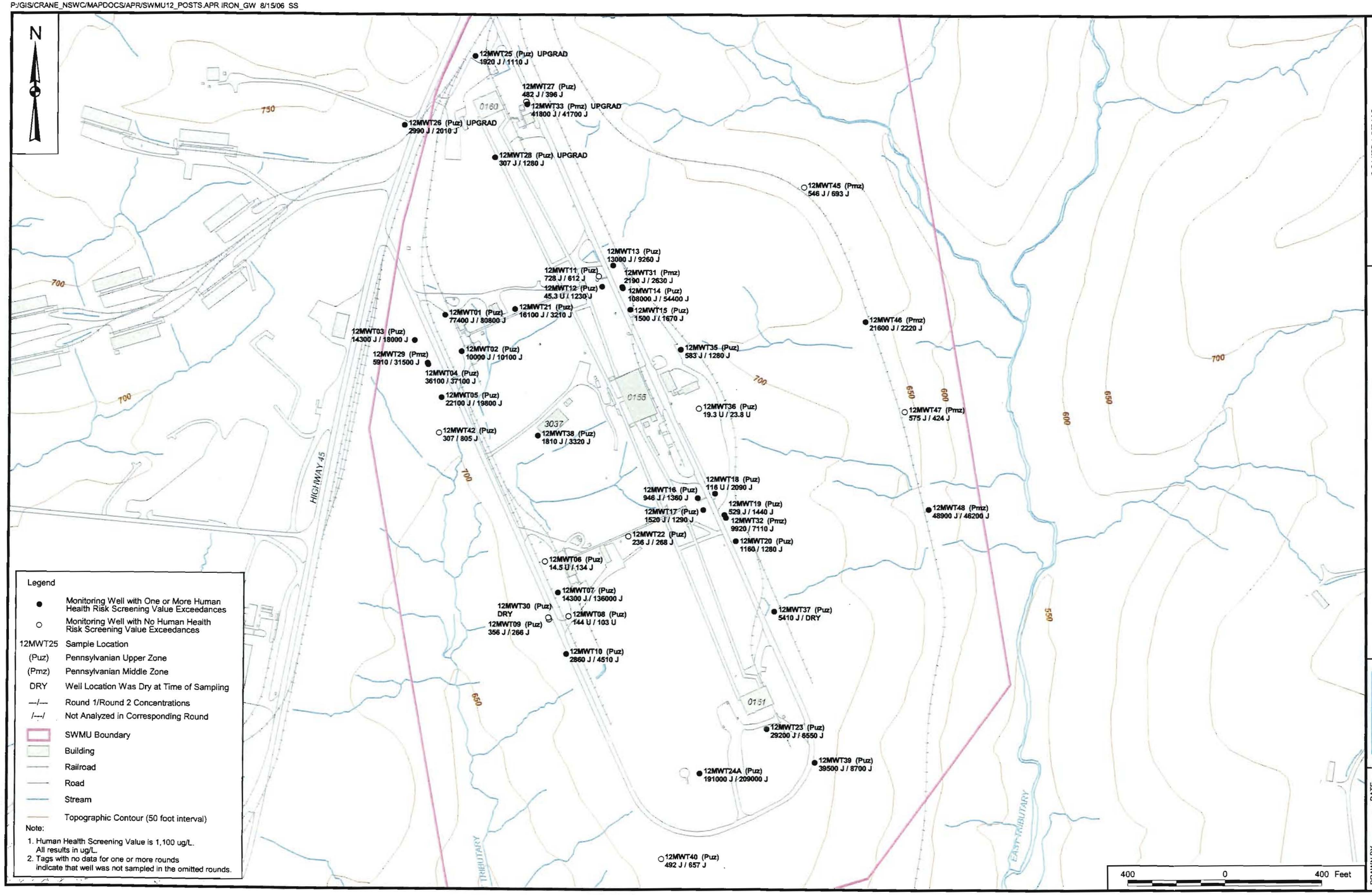
DRAWN BY K. PEILA DATE 7/12/05

CHECKED BY J. LUCAS DATE 8/15/06

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR IRON_GW 8/15/06 SS



CONTRACT NO. 6878

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 35

REV 0

TOTAL IRON CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

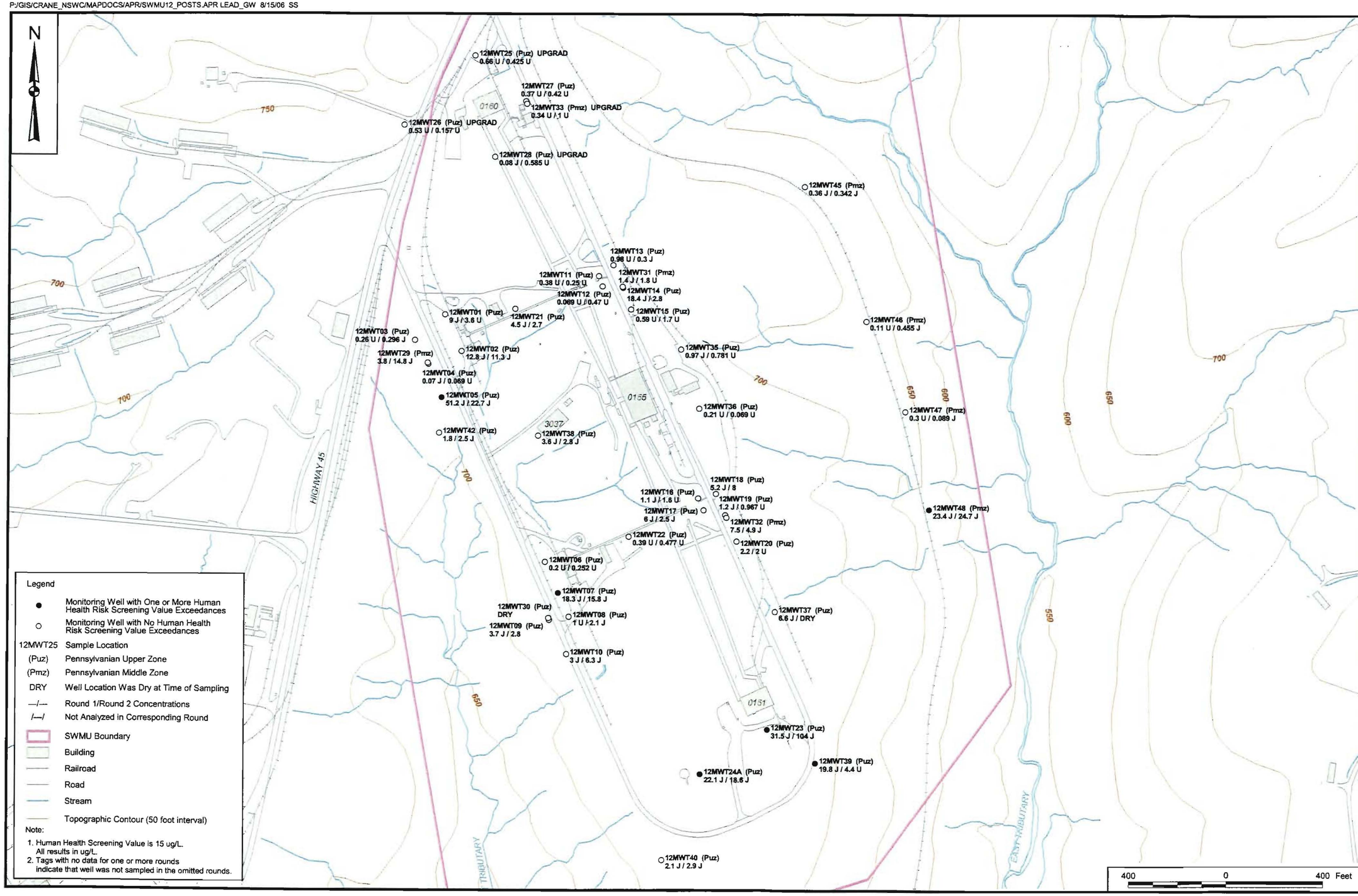
NSWC CRANE

CRANE, INDIANA

NAVFAC

DRAWN BY K. PEILA	DATE 7/12/05
CHECKED BY J. LUCAS	DATE 8/15/06
COST/SCHED-AREA	
SCALE AS NOTED	

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR LEAD_GW 8/15/06 SS



CONTRACT NO. 6878

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 5 - 36

REV 0

TOTAL LEAD CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

NSWC CRANE

CRANE, INDIANA

NAVFAC

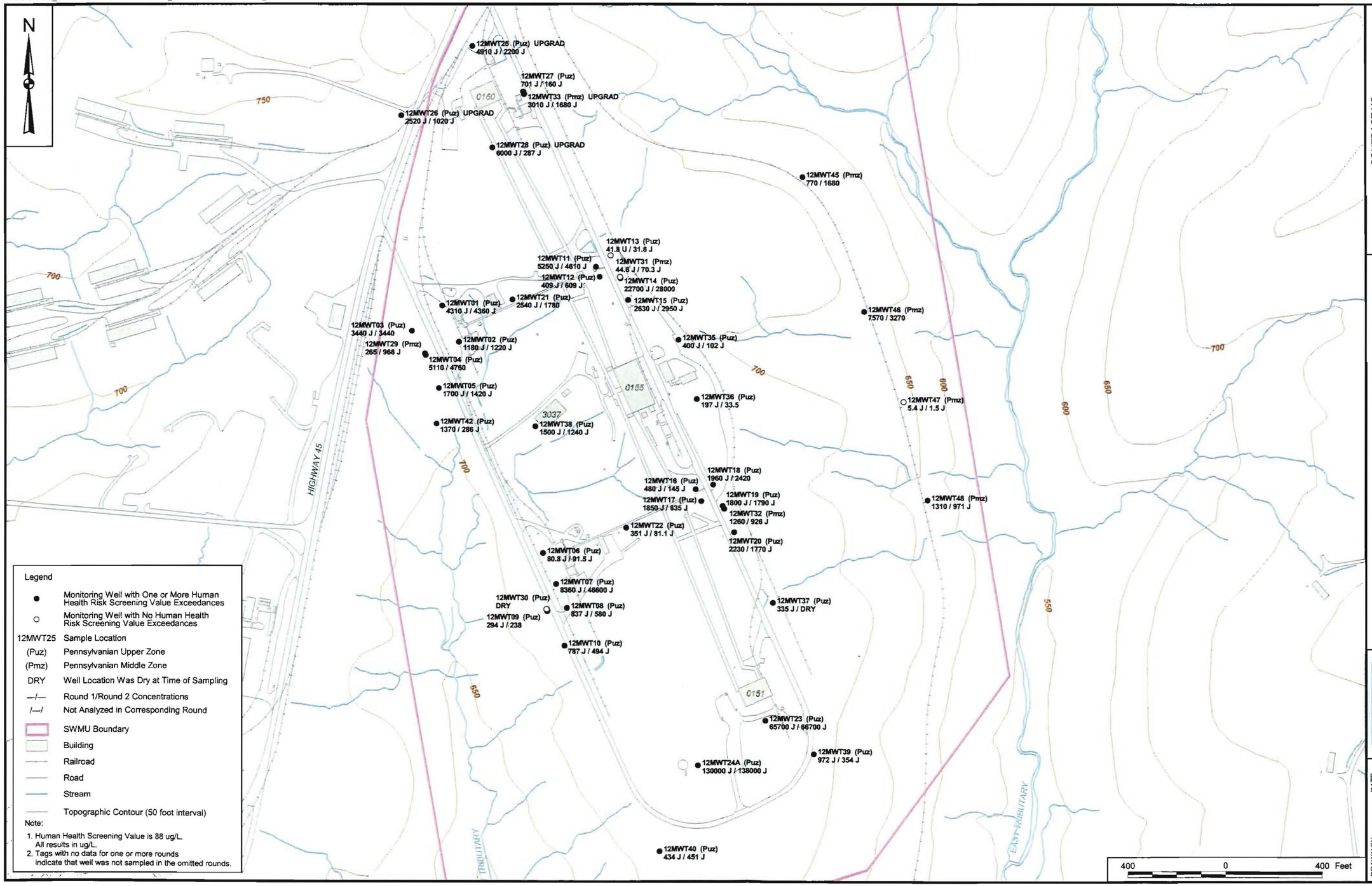
DRAWN BY K. PEILA DATE 7/12/05

CHECKED BY J. LUCAS DATE 8/15/06

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR MANGANESE_GW 8/15/06 SS



CONTRACT NO. 6878

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 37

REV 0

TOTAL MANGANESE CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

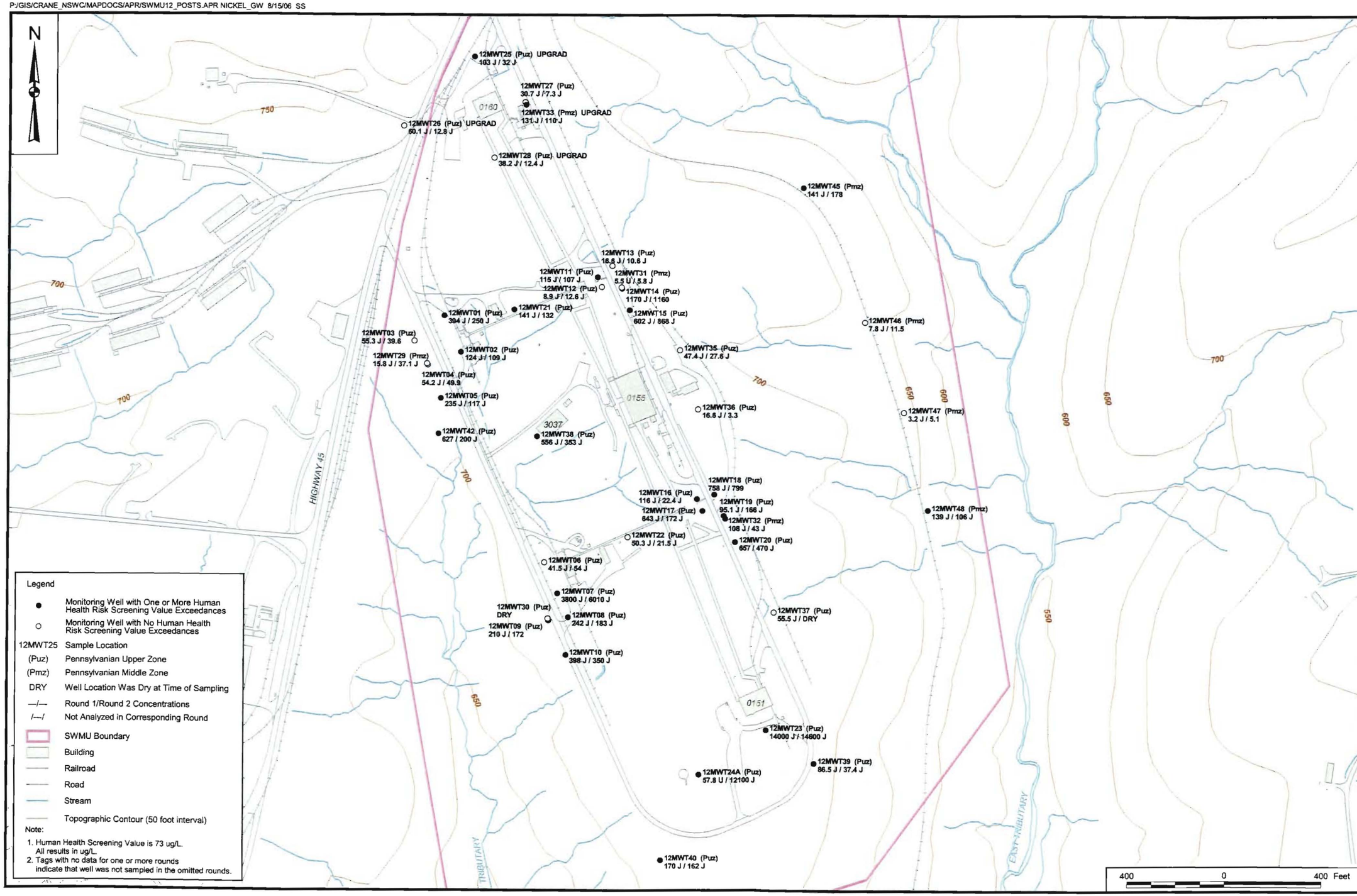
NSWC CRANE

CRANE, INDIANA

NAVFAC

DRAWN BY K. PEILA	DATE 7/12/05
CHECKED BY J. LUCAS	DATE 8/15/06
COST/SCHED-AREA	
SCALE AS NOTED	

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR NICKEL_GW 8/15/06 SS



CONTRACT NO. 6878

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 5 - 38

REV 0

TOTAL NICKEL CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

NSWC CRANE

CRANE, INDIANA

NAVFAC

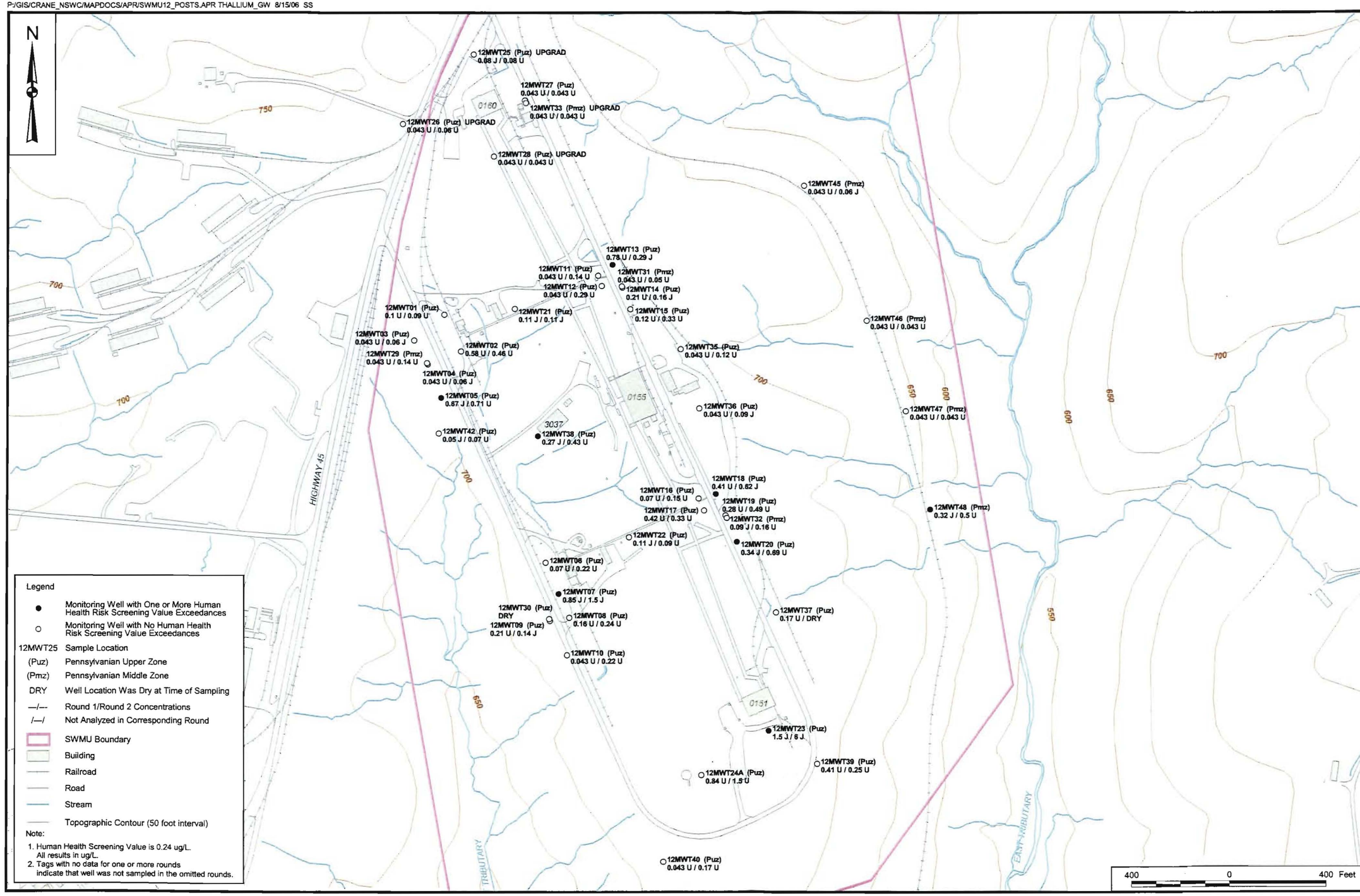
DRAWN BY K. PEILA DATE 7/12/05

CHECKED BY J. LUCAS DATE 8/15/06

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR THALLIUM_GW 8/15/06 SS



CONTRACT NO. 6878

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 5 - 39

REV 0

TOTAL THALLIUM CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

NSWC CRANE

CRANE, INDIANA

NAVFAC

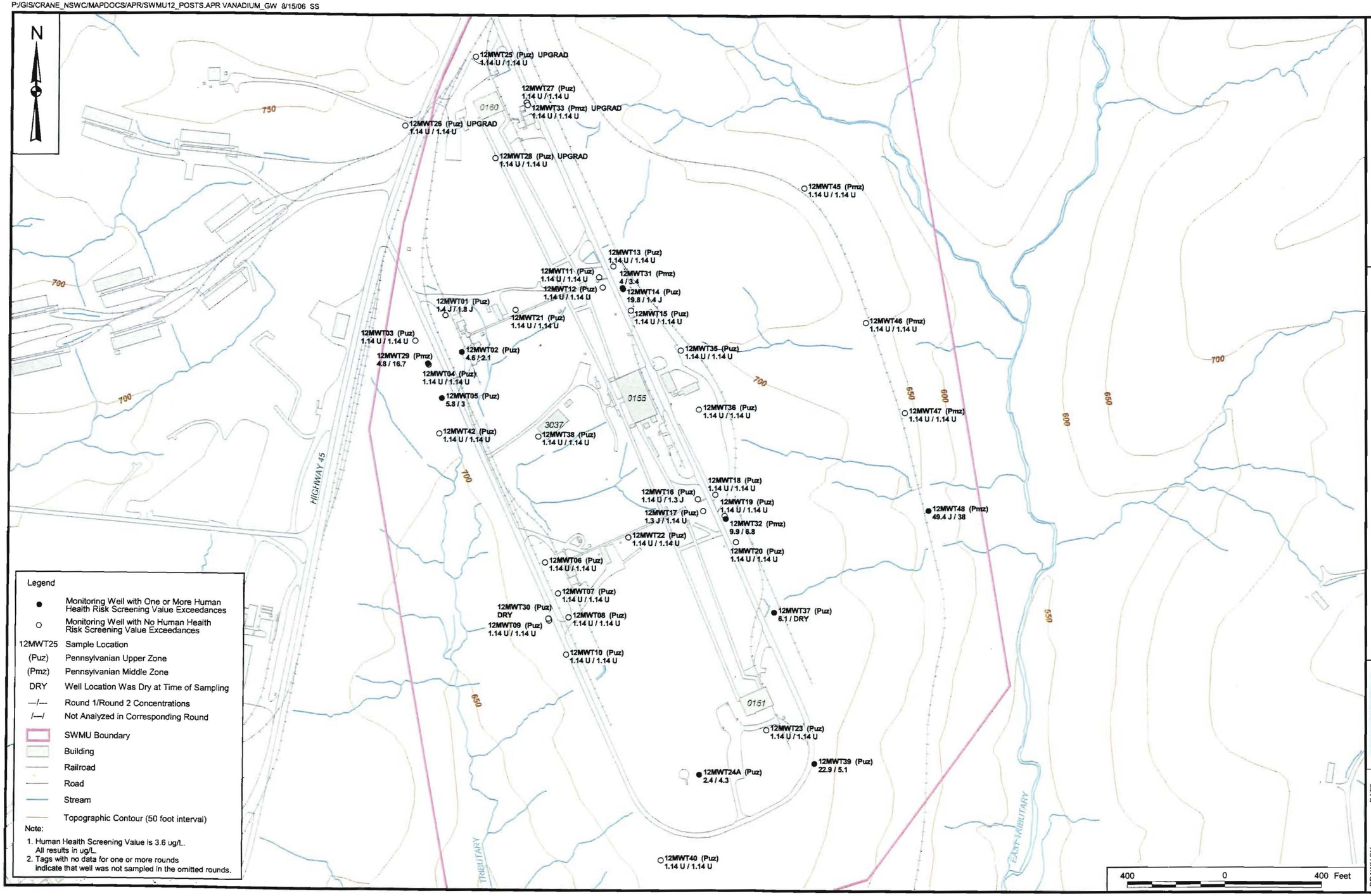
DRAWN BY K. PEILA DATE 7/12/05

CHECKED BY J. LUCAS DATE 8/15/06

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR VANADIUM_GW 8/15/06 SS



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APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5 - 40

REV 0

TOTAL VANADIUM CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

NSWC CRANE

CRANE, INDIANA

NAVFAC

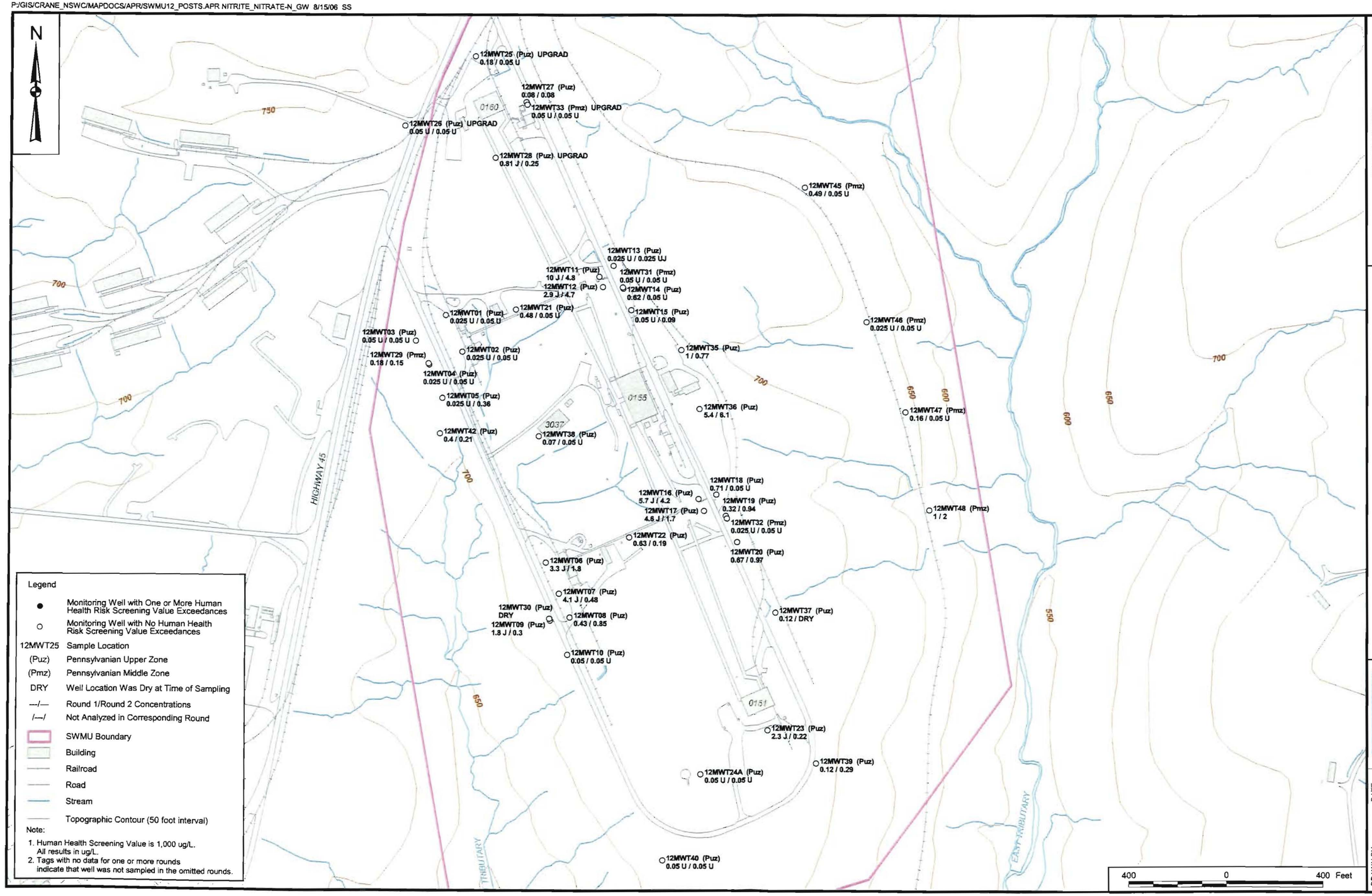
DRAWN BY K. PEILA DATE 7/12/05

CHECKED BY J. LUCAS DATE 8/15/06

COST/SCHED-AREA

SCALE: AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR NITRITE_NITRATE-N_GW 8/15/06 SS



CONTRACT NO. 6878

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 5 - 41

REV 0

NITRATE PLUS NITRITE NITROGEN CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

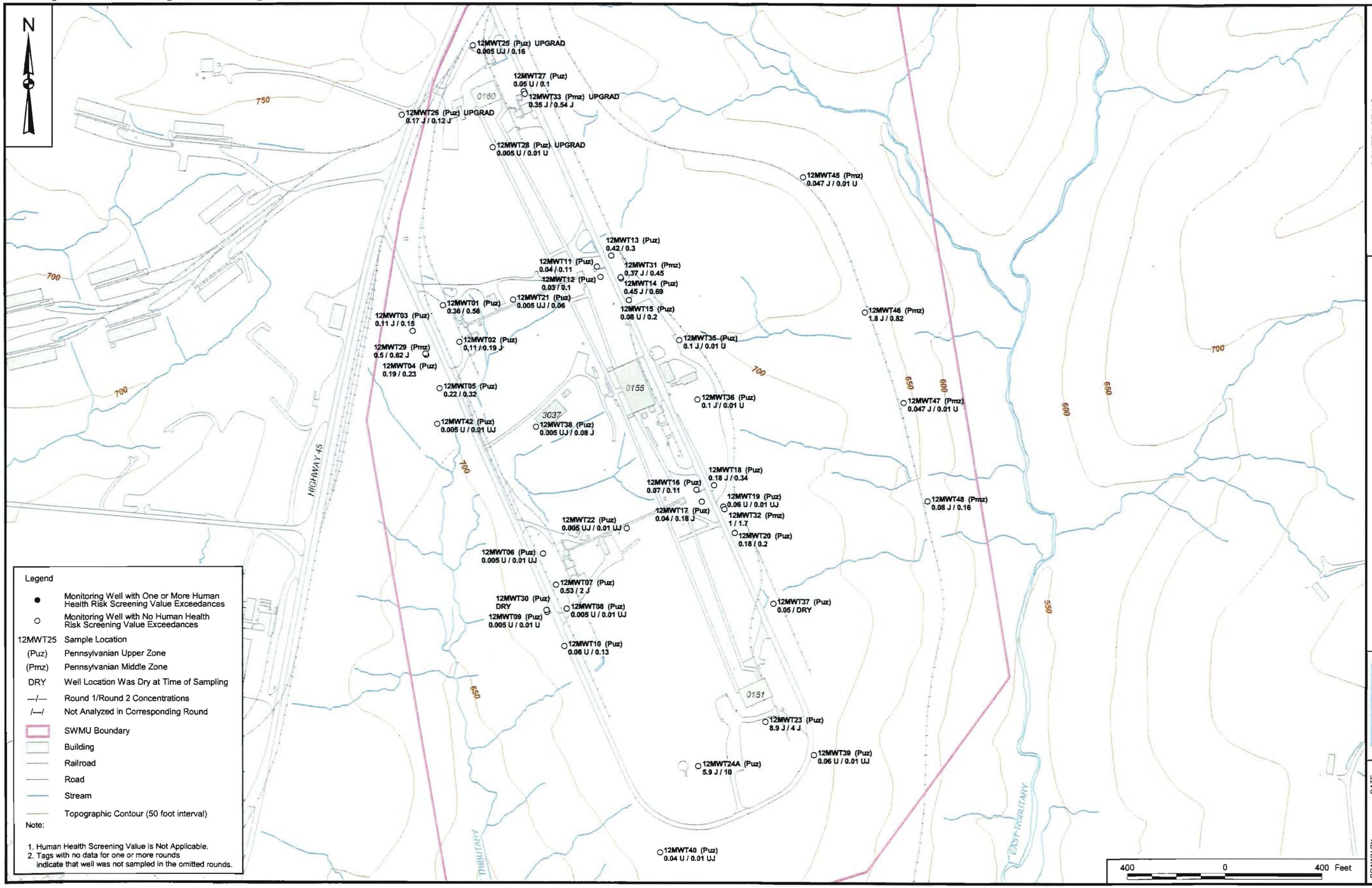
NSWC CRANE

CRANE, INDIANA

NAVFAC

DRAWN BY K. PEILA	DATE 7/12/05	
CHECKED BY J. LUCAS	DATE 8/15/06	
COST/SCHED-AREA		SCALE AS NOTED

P:/GIS/CRANE_NSWC/MAPDOCS/APR/SWMU12_POSTS.APR AMMONIA-N_GW 8/15/06 SS



CONTRACT NO. 6878

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 5 - 42

REV 0

AMMONIA NITROGEN CONCENTRATIONS (ug/L) IN PENNSYLVANIAN UPPER AND MIDDLE ZONE MONITORING WELLS

SWMU 12 MINE FILL A

NSWC CRANE

CRANE, INDIANA

NAVFAC

DRAWN BY K. PEILA DATE 7/12/05

CHECKED BY J. LUCAS DATE 8/15/06

COST/SCHED-AREA

SCALE: AS NOTED

6.0 FATE AND TRANSPORT / CONCEPTUAL MODEL

This section presents an overview of the movement of contaminants at SWMU 12 among the environmental media. The focus is placed on major contaminant groups (explosives, inorganic nitrogen compounds, and metals) that have been detected in environmental media at SWMU 12 and that can be attributed to site operations or remedial actions. The information presented in this section is to be used to:

- Provide information on the chemical and physical properties that affect the mobility, migration, biodegradation, and persistence of the principal COPCs at SWMU 12.
- Assist in human health and ecological risk assessments presented in Sections 7.0 and 8.0, respectively.
- Assist in risk management decisions.
- Assess whether migration of contaminants will result in significant future changes to exposure point concentrations or significant exposure to receptors not currently exposed or at locations not currently exposed.
- Assess whether the potential exists for contaminant concentrations to decrease over time in various media.
- Present a conceptual site model that identifies contamination sources, contaminant migration pathways, and potential receptors.

6.1 PROPERTIES AFFECTING MOBILITY, ATTENUATION, AND PERSISTENCE

COPCs present at SWMU 12 belong to four primary groups: energetic compounds, PAHs, metals, and inorganic nitrogen compounds. VOCs are virtually absent at SWMU 12, so the potential for contaminants to volatilize is very low to non-existent. Not all of the COPCs will be discussed in this section, but the primary contaminants that were detected at the highest concentrations, detected at the highest frequencies, and having the highest potentials to cause human or ecological risk are discussed and evaluated in this section. The primary contaminants are representative of all other site-related contaminants that are not explicitly discussed in this section. The primary physical, chemical, and

biological factors that affect the mobility, migration, biodegradation, and persistence of COPCs at SWMU 12 are solubility, adsorption/desorption, dilution, dispersion, biodegradation, and plant uptake.

6.1.1 Solubilities and Adsorption/Desorption Properties

Literature values and regulatory guidance values for solubilities, organic matter-water partition coefficients (K_{ocs}), soil-water partition coefficients (K_{ds}), and biodegradation rates are summarized in Tables 6-1 through 6-3. These values are based on field investigations, laboratory experiments, and theoretical calculations that are described in scientific literature. In most instances, the values for each parameter have an extremely wide range. Thus, the parameter values listed in Tables 6-1 through 6-3 may not be accurate or entirely applicable to the SWMU 12 setting, but they are useful for comparative purposes to rank COPCs against each other in terms of their relative mobilities and biodegradation potential.

As shown in Table 6-1, PAHs have the lowest solubilities and generally have the highest affinities for sorbing to organic carbon and soil. Like PAHs, many of the metals also have high affinities for sorbing to soil (e.g., aluminum, beryllium, chromium, lead, mercury, and vanadium). For these COPCs, the concentrations dissolved in groundwater should be low and the rates of migration through surface water, soil, and groundwater systems should be very slow or insignificant.

The remaining metals (e.g., antimony, arsenic, cadmium, cobalt, copper, iron, manganese, nickel, and zinc), most of the energetic compounds, nitrate, and ammonia have moderate affinities for sorption to soil and therefore can move through the environment more quickly than the COPCs listed above. However, their mobility and migration rates are still impeded by sorption and in some cases solubility constraints.

The COPCs with the lowest affinities for sorption (i.e., lowest K_{oc} and K_d values) are RDX, 2-amino-4,6-dinitrotoluene (2ADNT), 4-amino-2,6-dinitrotoluene (4ADNT), and nitrate. These compounds have the greatest mobilities and should migrate more quickly through soil, groundwater, and surface water systems. As shown in Section 5.0, RDX has in fact been detected in more media and more samples than any other COPC.

The K_ds of the metals are intermediate to high in value and indicate that the metals should be relatively immobile. However, the natural soils and groundwater associated with the Pennsylvanian age rocks in southern Indiana are slightly to strongly acidic because:

- The Pennsylvanian shales, coals, and sandstone units typically contain pyrite, which forms sulfuric acid when oxidized.

- The near-surface rocks have undergone chemical and physical weathering through a very long period of geologic time, which has allowed the oxidation of pyrite and the leaching and removal of any carbonate minerals that may have once been present in the rocks.

- The residual soils and near-surface rock units have been subjected to acid rain in recent decades.

Because of lower pH values in the soils, bedrock, and groundwater, the solubilities of most metals are generally higher than would be expected at near-neutral pH values. In addition, the K_d values of most of the metals are lower than expected. Therefore, the higher concentrations of metals causing screening level exceedances, as described in Section 5.0, may be due in large part to the lower natural pH values and not reflective of contaminant releases.

Another factor that greatly affects the solubilities and mobilities of iron, manganese, chromium, and arsenic are their valence states. Each of these metals has more than one valence state that is stable in nature. The oxidation-reduction conditions of the soil, bedrock, groundwater, or surface water systems where these metals reside will control their valence states in each specific environment and location. Iron and manganese are much more soluble and mobile under reducing conditions, where the reduced forms of these metals (Fe^{+2}, Mn^{+2}) are most prevalent. Chromium is more soluble and mobile under oxidizing conditions (i.e., surface soils and surface waters), where the oxidized species (Cr^{+6}) should be most prevalent.

Even though the PAHs and many of the metals have high affinities for adsorption to soil and sediment, they can still move through the environment away from a source area via erosion and sediment transport (i.e., surface water pathway) or via wind erosion and subsequent aerial deposition.

6.1.2 Biodegradation

As shown in Table 6-1, the degradation half-lives for the PAHs are on the order of 2 to 10 years. Metals do not degrade at all. Hence, it is probable that the total mass of these COPCs at SWMU 12 will remain relatively stable over time and will not decline as a result of degradation (chemical or biological).

Numerous laboratory studies and past site investigations at Department of Defense facilities have yielded information on the biodegradation of energetic compounds (see Table 6-3). TNT in soils, groundwater, and surface water can degrade biotically or abiotically and can degrade under a fairly wide range of pH and Eh conditions (Price et al., 1997; Brannon et al., 1998; Talmage et al., 1999). The two most common degradation products of TNT found in soils and groundwater are 2ADNT and 4ADNT (Li et al., 1981; Daun et al., 1998; Pennington et al., 1999a,b,c). These compounds subsequently degrade to diaminonitrotoluene compounds and other less reactive compounds. 2ADNT and 4ADNT have been found in numerous surface water and groundwater samples collected at SWMU 12 (see Table 6-4). Thus, there is ample evidence that microbial biodegradation of TNT is occurring and that degradation products of TNT are more mobile than TNT itself.

Scientific studies have shown that HMX and RDX are also biodegraded in soils and groundwater (Tables 6-1 and 6-3). However, the half-lives of HMX and RDX are thought by most researchers to be relatively long (e.g., 20 to 40 years), especially in soils. Hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine (DNX), hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine (MNX), and hexahydro-1,3,5-trinitroso-1,3,5-triazine (TNX) are typically cited as the most prevalent daughter products of RDX biodegradation. Two of these degradation compounds (DNX and MNX) have been detected at SWMU 12 in gully water samples (Tables 3-18) and shallow groundwater samples in the upper monitoring zone (Table 3-48) and are collocated almost everywhere that RDX was detected. Thus, the products of RDX biodegradation appear to be present almost everywhere that RDX is present, albeit in lower concentrations.

HMX is the energetic compound detected at SWMU 12 that is theoretically most resistant to biodegradation. Although HMX degradation is most likely occurring at a slow rate at SWMU 12, there are no known compounds that can be identified at SWMU 12 as explicitly attributable to HMX degradation.

6.1.3 Plant Uptake

Recent research by the USACE (May et al., 2003) suggests that plant uptake and phytoremediation may also be removing, degrading, and volatilizing RDX and TNT from the soils at SWMU 12 at NSWC Crane. Vegetation samples were collected from trees and shrubs located on the northwestern side of the ridge containing SWMU 13. This location was chosen because RDX-contaminated groundwater was considered most likely to be present and being taken up by plants. Results of the leaf analyses showed a relatively high frequency of detections of RDX, HMX, TNT, and degradation products in the 16 vegetation samples that were analyzed (TtNUS, 2005). Thus, the trees and vegetation on the northwestern side of SWMU 13 appear to be taking up groundwater and energetic compounds as groundwater discharges to the hillside. The same process is thought to be occurring along the hillsides on both sides of SWMU 12.

6.2 CONCEPTUAL SITE MODEL

Figure 6-1 presents a schematic diagram of pathways that contaminants may take as migration routes from the site. Table 6-4 presents an overall summary of chemical analyses performed on the samples collected from SWMU 12. For each medium or subset of a medium, the average and maximum COPC concentrations are presented. This summary is intended to present an overall picture of which chemicals are migrating, which ones are the most widespread, and which ones have the potential to migrate further.

6.2.1 Historical Operations and Releases

MFA was used for the preparation of nitrate and the production of large mines, depth charges, rocket heads, aerial bombs, and projectiles. Constituents of these explosives are RDX, TNT, aluminum powder, and wax. Fertilizers (ammonium nitrate) were also melted into bombs. TNT, Composition B, H-6, Tritonal, and Minol were used in mine-filling operations. In the past, explosives powders discharged from roof vents and accumulation on building roofs were washed down to the ground, resulting in the contamination of soils. Large quantities of TNT, Composition B, HBX-1, HBX-3, and H-6 were reportedly collected in sumps at MFA (Halliburton NUS, 1992). In the past, these sumps released explosives-contaminated water directly to surface drainage channels that flow into the Turkey Creek Watershed.

In 1999 and 2000, Toltest performed sampling, excavation, on-site treatment through bioremediation (composting) of explosives-contaminated soil, and on-site backfilling of compost at MFA. The sampling and analysis program consisted of evaluation of ICSs, post-excavation samples, and samples of the bioremediated soil-compost. At SWMU 12, the pre-excavation sampling was conducted around Buildings 151, 152, 153/154, 157, 158/159, and 160. The ICSs were collected from 124 grid sections near these buildings. An additional 82 grid sections were added to the outer limits of the areas being characterized to delineate the horizontal extent of contamination. Samples were then collected at each of the 206 grid sections for site characterization. The analytes selected for analysis included explosives, VOCs, and metals and were based on generator knowledge of process operations and the 1992 RFI (Halliburton NUS, 1992) to ensure that solvent-contaminated soil (or other characteristic wastes) was not transported to the Bioremediation Facility for composting

Based on the results of the initial characterization sampling, individual grids were selected for excavation and remediation. The excavation and remediation program was conducted around Buildings 151, 152, 153/154, 157, 158/159, and 160. During excavation, field screening was used to test for RDX to provide quick field screening results. Following excavation, post-excavation confirmation soil samples were

collected from the bottoms and sidewalls of each grid section and sent to a fixed-base laboratory. RDX and arsenic were the only constituents that exceeded clean-up goals in the post-excavation samples. Grid sections that were excavated were backfilled with the soil-compost. Samples were collected from each windrow of the remediated soil and analyzed for explosives only. Average concentrations of explosives in the remediated soil-compost were less than residential and/or industrial clean-up goals. The IMR for SWMU 12 evaluates the quality of the data for the bioremediation program in regard to analytical parameters such as blank contamination, duplicates, MSs, etc. At least 10 percent of the data were validated. The information on soil conditions at MFA is detailed in the IMR (MK, 2000a) and IMR Addendum #1 (Washington Group International, 2001).

In the early 1990s, a Battery Site was discovered by the NSWC Crane EPD. The Battery Site is located on the southern end of MFA, approximately 140 feet outside the perimeter fence and is accessible through a gate. The Battery Site consists of two areas: (1) Battery Area – where batteries were dumped on the ground surface and (2) Soil Area – an adjacent area where soil and construction debris was dumped in small mounds. The batteries were recognizable as AA household type and their numbers were estimated to be in the thousands. Just prior to MFA Battery Site cleanup (interim measure) operations in June 2002, the batteries were all but unrecognizable and only their inner cores were visible on the ground surface. The size of the Battery Area was approximately 3,500 square feet. The size of the Soil Area was approximately 2,355 square feet consisting of several soil mounds, none exceeding 4 feet in height. At the time of discovery, the potential for the waste from either of these areas to be a listed or characteristic waste was unknown.

6.2.2 Soil Contamination

Explosives: For SWMU 12, the soils within the MFA fenced area are considered to be the source of all site-related energetic contaminants. The soils at SWMU 12 were extensively contaminated with explosives, primarily RDX, around select buildings associated with ordnance manufacturing operations. In the late 1990s, composting and reduction of energetic compounds in the soils located around those buildings was performed in an off-site bioremediation facility as an interim measure. The treated soils were replaced in SWMU 12 excavations around the buildings. See Section 1.2.3 for details concerning the excavation, post-excavation sampling, and backfilling of SWMU 12, and residual contamination left at the conclusion of the remedial activities.

SVOCs: PAHs have been detected at very low concentrations (less than 1.0 mg/kg) in surface soil samples collected from the Battery Site and in gully sediments, but have yet to be detected in Turkey Creek sediment samples. Isosafrole and bis(2-ethylhexyl) phthalate were detected at slightly higher

concentrations in soil but not in drainage channel surface water or sediments. Thus, it appears that some PAHs are migrating via surface water runoff, but at very low concentrations. Based on the very high K_d values of PAHs and the fact that their concentrations declined rapidly with depth in soil, it is very doubtful that PAHs migrated 25 feet downward through soil and rock to enter the upper groundwater system (i.e., Puz, Pathway B, Figure 6-1). In fact, no VOCs or SVOCs have been detected in groundwater samples collected at SWMU 12.

Metals: The only metals detected during interim measures soil composting activities at concentrations significantly greater than background concentrations were arsenic, barium, mercury, and selenium. However, the average concentrations of these metals were within a factor of two of the basewide soil background concentrations, so whether or not these metals are elevated due to site activities is not clear. Lead, chromium, and silver are slightly elevated above basewide background concentrations, but the concentration range is relatively small and the concentrations are evenly distributed across the site, suggesting that the observed concentrations of lead, chromium, and silver are natural. The Battery Site appears to be a source of metals contamination, but this source, located in the Soil Area within the Battery Site, is less than 0.1 acre in size. Furthermore, based on the distribution of metals contaminants within the Battery Site, the elevated metals concentrations are likely to be heterogeneously distributed within the contaminated area. The metals that were elevated in concentrations are likely related to battery disposal; however, the metals of greatest environmental significance are generally known to be relatively immobile in soils.

Contaminant Migration: Metals and residual explosive residues in the composted soils still remain as contaminants at SWMU 12. Thus, there still exists potential for COPCs to leach out of the soils and enter the surface water or groundwater transport systems. There is also potential for the soils to erode and be transported by surface runoff and effect surface water and sediment in drainageways downgradient of SWMU 12. Figure 6-1 presents a schematic diagram of pathways that contaminants may take as migration routes from the site. The contaminants originate in the overburden soil at SWMU 12 (Location A, Figure 6-1). The contaminants that are leached and/or eroded from the soils may enter the gullies that drain the site and transport surface water down the sideslopes of the ridge on which SWMU 12 is located (Pathway D). A discussion of the relative importance for these two migration pathways is provided below.

The soils data show that the detected SVOCs concentrations decrease rapidly with depth throughout SWMU 12. Only surface soils were analyzed for SVOCs at the Battery Site. The steep vertical SVOC concentration gradient at SWMU 12 is consistent with the relatively high affinity of the detected SVOCs for soil and a surface deposition or release mechanism. Based on the relatively low observed PAH

concentrations, it is plausible that the PAHs were deposited as combustion products that were dispersed aerially and settled onto the ground. Because of the steep vertical concentration gradient, SVOCs are not considered likely to migrate into the groundwater either at SWMU 12 or the Battery Site.

The locations where SVOCs were detected in soils are generally grass covered. Therefore, the potential for the continued erosion of SVOC-contaminated soils is low. The locations where bioremediated soil was replaced are covered with grass. All locations where soils were not excavated are underground. Therefore, the potential for erosion of explosive-contaminated soils is considered low.

The residual explosives present in treated and untreated explosive-contaminated soils is expected to continue to migrate into groundwater. However, it is likely that the residuals in the treated soils are continuing to degrade. Several explosives degradation products were observed in groundwater and surface water. Metals contaminants, being chemical elements, do not degrade. Some metals such as mercury and arsenic may be transformed through biological processes into volatile compounds that are more mobile, but this transformation is relatively slow. Metals may also change oxidation state and become mobilized or immobilized depending on the initial and final states. In general, metals are most mobile under acidic, reducing conditions and least mobile under alkaline, oxidizing conditions, but as a group, metals are considered to be relatively immobile.

6.2.3 Groundwater Contamination

Aquifer System: Monitoring wells have been installed and groundwater samples collected from four primary zones in bedrock: the Puz, Pmz, Plz, and the uppermost strata (Glen Dean Formation) of Mgd. Contaminants have probably been migrating downward and entering the shallow groundwater flow system (Pathway B in Figure 6-1) since the beginning of SWMU 12 operations in the 1940s. The majority of groundwater in the shallow sandstone (Puz) is moving southwestward and southeastward toward the unnamed tributaries of Turkey Creek (Figure 4-10). The Puz sandstone intersects the land surface (i.e., crops out) along the upper portions of the ridge. The groundwater in the Puz that reaches the outcrop area will theoretically travel in one of three pathways; taken up by vegetation and transpired (Pathway B1), seep into gullies at the ground surface and join surface water in the gullies traveling downhill (Pathway B2), or migrate down the side of the hill along the bedrock/soil interface that lies 1 to 3 feet bgs (Pathway B3), as diagrammed in Figure 6-1.

A small portion of the groundwater in the Puz is migrating downward through a shale and siltstone aquitard and enters the intermediate groundwater flow system in the Pmz. This groundwater (Pathway C) is flowing primarily south and southeast toward Turkey Creek (Figure 4-11). However, the primary and

secondary permeability of this water-bearing zone is less than the Puz, and the groundwater flow velocities are slower in the deeper groundwater system.

A small portion of the groundwater in the Pmz is migrating farther downward and enters the deeper groundwater flow system in the Pmz and the Mgd. Like the groundwater in the Pmz, this deeper groundwater is flowing primarily south and southeast toward Turkey Creek (Figure 4-12).

During storms and high flow events, most of the surface water from SWMU 12 flows down the hillside (Pathway D) and enters the two unnamed tributaries of Turkey Creek as overland flow in the drainageways (Pathway D1). As the tributaries approach the valley bottom, some of the surface water will infiltrate into the soils and alluvial deposits (Pathway D2) along the tributaries and will continue to flow toward Turkey Creek. This D2 groundwater will mix with the deep groundwater migrating from within the ridge; this mixing will likely occur in the valley bottom alluvium. As a result, the tributary valleys and Turkey Creek contain water from several different sources: surface water from upvalley, surface water discharge from the gullies (D1), and groundwater emanating from the valley floor deposits. The tributary creeks are dry for a good portion of the year, but groundwater may still be traveling through the creek bed sediments as underflow even when the creek bed surface is dry.

Explosives: In groundwater, energetic compounds and degradation products are pervasive in the Puz but are nearly absent in the Pmz (Table 6-4). Low concentrations of HMX and RDX were detected in groundwater from well 12MWT48. The almost complete absence of energetic compounds in the Pmz is very strong evidence that the aquitard separating the Puz from the underlying Pmz is effective, and is causing nearly all of the shallow groundwater in the ridge top to flow laterally to the edge of the hillside. The concentrations of energetic compounds (averages and maximums) found in Puz groundwaters are very similar to the concentrations detected in the gully surface waters, suggesting that the surface waters sampled in gullies between storm events are composed largely of groundwater seepage from the Puz (Pathway B2).

Groundwater collected from one monitoring well (12MWT44) installed near the base of the ridge on the southwestern side of SWMU 12 is also impacted by energetic compounds. Presumably, surface water in the gulley traveling down the hillside past well 12MWT48 contains explosive compounds and is affecting the groundwater quality in the immediate vicinity of the well due to infiltration (Pathway D2, Figure 6-1).

Nitrogen compounds: Soil and sediment samples have generally not been analyzed for nitrate/nitrite and ammonia. These compounds are highly soluble in water (See Table 6-1). Analyses of surface waters

and groundwaters have shown that gully waters and the uppermost (Puz) groundwater samples contain elevated concentrations of nitrate and ammonia (Table 6-4). Even though nitrate and ammonia concentration are moderately high in gully waters, there is no detectable impact to the water in the tributary creeks or Turkey Creek.. Thus, there does not seem to be any significant migration of nitrate or ammonia from SWMU 12 that reaches the mainstream creek or leaves the watershed.

Metals: The average and maximum concentrations of most metals were higher in the upper water-bearing zone (Puz). The exceptions were:

- The average and maximum chromium and tin concentrations were greatest in the Pmz.
- The average and maximum antimony and thallium concentrations were greatest in the Plz and Mgd (combined data).

Based on the information presented in Section 5.0 and Table 6-4, aluminum, arsenic, beryllium, cadmium, cobalt, iron, lead, manganese, mercury, nickel, selenium, and zinc are elevated in the Puz above all other groundwater or surface water groups. However, it is unclear whether SWMU 12 activities were the source of these elevated metal concentrations or whether natural oxidation and leaching of the uppermost Pennsylvanian bedrock is the cause of the elevated concentrations.

The fact that higher concentrations of antimony, chromium, thallium, and tin were found in the deeper groundwaters (Pmz and Plz) is evidence suggesting that these four metals are naturally leached from the rock and not derived from SWMU 12 activities.

6.2.4 Surface Water and Sediment Contamination

Surface water runoff and sediment migrate off of the top of the SWMU 12 ridge along the northeastern and the southwestern sides of the ridge. The runoff flows in gullies down the sides of the ridge. In addition to surface water runoff, contaminated groundwater seeps into a few of the gullies at a slow rate. Therefore, the waters in the gullies flowing down the ridge are a mixture of surface runoff and shallow groundwater seepage. The gullies running down the southwestern side of the ridge enters the west tributary. Ultimately, the unnamed western tributary is the recipient of all surface water runoff, sediment, and groundwater originating from the western side of SWMU 12. Likewise, the unnamed eastern tributary receives all surface water runoff, sediment, and groundwater originating from the eastern side of SWMU 12. Based on the fact that the crest of the SWMU 12 ridge is located closer to the eastern side and most

of the surface area drains west-southwest, it is likely that the west tributary receives a greater proportion of surface water runoff and groundwater from SWMU 12.

Explosives: The maximum concentrations of explosive compounds detected in the gulley samples were relatively high. Most notable were the maximum detections of RDX (140 µg/L), HMX (98 µg/L), TNT (79 µg/L), and 4ADNT (74 µg/L). The highest concentrations of explosives found in gulley samples occurred at sampling location 12SW/SD34 located on the western side of the SWMU and locations 12SW/SD12 and 12SW/SD31 on the northeastern side of the SWMU. These gully waters also contain degradation products of RDX and 2,4,6-TNT (see Table 3-18), which is evidence that explosive compounds are degrading on site. The unnamed tributaries that receives the gully discharges also had detectable concentrations of RDX, HMX, and 4ADNT, but these concentrations were much lower than concentrations detected in the gullies farther up the hillside. Explosive compounds were not detected in any water sample collected from Turkey Creek.

TNT was the only explosive compound detected in gulley sediments, and the concentrations detected were relatively low (less than 3 mg/kg). Explosive compounds have not been detected at all in sediments collected from the tributaries or Turkey Creek.

Nitrogen compounds: Elevated concentrations of nitrate/nitrite and ammonia-N have been detected in the gulley waters on both sides of the ridge and in the western tributary. The highest concentration of nitrate/nitrite (8.2 mg/L) was detected at 12SW/SD06, located on the southwestern side of the ridge. The highest concentration of ammonia (4.2 mg/L) was detected at 12SW/SD11, located at the mouth of the western tributary. The concentration of ammonia was relatively low (0.18 mg/L), and nitrate/nitrite was not detectable in Turkey Creek during two different sampling events. Hence, there is not enough nitrogen leaving SWMU 12 to cause a measurable impact to Turkey Creek.

Metals: The maximum and mean concentrations of metals in gully surface waters were generally lower than the levels of metals concentrations observed in shallow (Puz) groundwater, but were much higher than levels observed in the tributaries or Turkey Creek. The highest average and maximum concentrations of total barium, chromium, copper, lead, and vanadium were detected in gulley water (Table 6-4), and the levels of total aluminum, iron, and zinc were also elevated. This suggests that the water coming down the hillside in the gullies is contributing metals to the creek. Some portion of the water flowing down the gullies is derived from shallow groundwater emanating from the Puz (Pathway C2, Figure 6-1), so the levels of metals detected in the gully waters cannot be attributed solely to runoff from SWMU 12.

Dissolved and particulate metals are moving down the hillside in the gullies and reaching the unnamed tributaries. However, metals in the creek water are either not detectable or were detected at very low concentrations (Table 6-1). Hence, there is no evidence that the gullies or groundwater are having a measurable impact on metals in the creek water.

In Turkey Creek sediments, the metals concentrations are either not detectable or are relatively low. Thus, the discharge of sediment from the gullies does not appear to be having a measurable impact on the creek sediments.

6.2.5 Summary of Conceptual Site Model

Figure 6-1 is a schematic diagram of the conceptual flow and transport model for SWMU 12. Past operations at the site resulted in the release of explosives residue (e.g., TNT, RDX, HMX, ammonium nitrate) to soils surrounding several buildings located within the SWMU fenced area. The following is a summary of the conceptualized aspects of contaminant migration, fate, and persistence at SWMU 12:

- Explosives, primarily RDX, and to lesser extent HMX, TNT degradation products, and ammonium nitrate were released to soils.
- Interim remedial actions have resulted in soils that generally meet residential or industrial standards.
- Residual explosives in soils are degrading.
- The upper zone of groundwater has been contaminated with explosives, primarily RDX, and to a lesser extent HMX, TNT degradation products, and ammonium nitrate.
- Nearly all of the groundwater in the uppermost bedrock (i.e., the Puz) is flowing laterally toward the upper slopes of the ridge. Some of this groundwater seeps into the gullies on the side of the ridge, and some of the contaminated groundwater is taken up by trees and other vegetation and transpired. Thus, natural phytoremediation is playing a part in controlling and reducing the rate of contaminants reaching the base of the ridge.
- Explosives (RDX and TNT) in groundwater are degrading as evidenced by the presence of degradation products.

- Only a trace of contaminants have reached the deeper groundwater monitoring wells (i.e., Pmz or Plz wells). The siltstone and shale layers between the upper and middle water-bearing zones are effective aquitards that prevent shallow groundwater and contaminants from reaching the deeper portion of the ridge.

- One Pmz well (12MWT48) located on the southeastern side of SWMU 12 and one Plz well (12MWT44) located on the southwestern side of SWMU 12 contained relatively low concentrations of explosive compounds. This contamination is derived from contaminated surface water running down the gullies and infiltrating into the groundwater along the valley bottoms.

- No groundwater from SWMU 12 is flowing south or southeast under Turkey Creek. Turkey Creek is the ultimate recipient of all contaminants discharging from SWMU 12.

- Contaminants continue to leach from the surface and near-surface soils and migrate downhill in steep gullies on the sides of the ridge.

- Concentrations of several metals (e.g., aluminum, iron, manganese, cobalt, lead, mercury, nickel, and zinc) are elevated in the uppermost groundwater monitoring zone. The only metal directly attributable to site operations is aluminum; the source(s) of the other metals in the shallow groundwater are unclear. Metals appear to be leaching, in large part, directly from the bedrock (i.e., a natural source).

- PAHs are present in site soils and gully sediments in low concentrations, but have not been detected in any surface water or groundwater samples. It is believed that PAHs are not reaching nor will they reach the tributary streams or shallow groundwater.

- VOCs have not been detected at concentrations greater than screening levels in any sample. Hence, no VOCs were selected as COPCs.

TABLE 6-1

CHEMICAL AND DEGRADATION CHARACTERISTICS OF SITE CONTAMINANTS
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Chemical	Solubility (mg/L)	K_{oc} (L/kg)	K_d (L/kg)	Biodegradation Half-Life (years)
Energetic Compounds				
HMX	5.0[4], 6.6[7], 2,556[1]	631[7], 1,853[1]	0.505 - 14.8[10]	39[6]
RDX	38.4[7], 42.0[4], 59.7[1]	7.6 - 251[7], 195.4[1]	0.1 - 7.8[8]	0.88 - 36[9]
DNX	N/A	N/A	N/A	N/A
MNX	N/A	N/A	N/A	N/A
2,4,6-trinitrotoluene	130[1,4]	1,585[7], 1,834[1]	0.08 - 22.2[8]	0.1 - 10.7[9]
2-amino-4,6-dinitrotoluene	1,223[1], 2,800[4,7]	100.5[1]	4[7]	< 0.05[9]
4-amino-2,6-dinitrotoluene	1,223[1], 2,800[4,7]	100.5[1]	4[7]	< 0.05[9]
2,6-dinitrotoluene	352.4[1]	371.4[1]	0.30[10]	1.0[5]
1,3,5-trinitrobenzene	278[1], 340[7]	1,087[1], 63 - 501[7]	0.05 - 0.87[10]	N/A
1,3-dinitrobenzene	533[1], 500[7]	220.1[1], 63 - 200[7]	0.05 - 0.18[10]	1.0[5]
PAHs				
benzo(a)pyrene	0.00162[1,2]	787,000[1], 1,020,000[2]	630 - 816[10]	2.9[5]
benzo(b)fluoranthene	0.0015[1,2]	803,000[1], 1,230,000[2]	642 - 984[10]	3.34[5]
bis(2-ethylhexyl)phthalate	0.27[1]	165,000[1]	132[10]	1.07[5]
di-N-butyl phthalate	11.2[2]	33,900[2]	27.12[10]	0.063[5]
Metals				
aluminum	59,400[1]	NA	1,500[1]	0
antimony	23,000[1]	NA	45[1,3]	0
arsenic	34,700[1]	NA	29[1,2], 200[3]	0
barium	54,800[1]	NA	41[1]	0
beryllium	149,000[1]	NA	650[3], 790[1,2]	0
cadmium	123,000[1]	NA	6.4[3], 75[1,2]	0
chromium, total	12,000[1]	NA	850[1,3]	0
cobalt	87,500[1]	NA	45[1]	0
copper	421,000[1]	NA	35[1]	0
iron	624,000[1]	NA	25[1]	0
lead	9,581[1]	NA	900[1]	0
manganese	87,200[1]	NA	65[1]	0
mercury	0.06[1]	NA	52[1]	0
nickel	422,000[1]	NA	65[1,2], 150[3]	0
selenium	81,400[1]	NA	5[1]	0
silver	70,500[1]	NA	8.3[1]	0
thallium	26,500[1]	NA	71[1]	0
vanadium	86,400[1]	NA	1,000[1,3]	0
zinc	344,000[1]	NA	38[3], 62[1,2]	0
Nitrogen Compounds				
ammonia-N	3,740[1]	NA	NA	N/A
nitrate/nitrite-N	90,900[1]	NA	NA	N/A

N/A = Not Available
NA = Not Applicable
mg/L - milligrams per liter
L/kg - Liters per kilogram
HMX - Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
RDX - Hexahydro-1,3,5-trinitro-1,3,5-triazine
MNX - hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine
DNX - hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine

References:

1 Oak Ridge National Laboratory (2005)
2 U.S. EPA (2002, Tables C-1 and C-4, pH = 6.8)
3 Baes and Sharp (1983) and Baes et al. (1984)
4 U.S. EPA (2005)
5 Howard et al. (1991)
6 Tomkins (2000)
7 Talmage et al. (1999)
8 Table 6-2
9 Table 6-3
10 K_d calculated by multiplying K_{oc} times f_{oc} value of 0.0008 (average measurement of two SWMU 13 soil samples)

TABLE 6-2

PARTITION COEFFICIENTS OF ENERGETIC COMPOUNDS
SWMU 12 – MINE FILL A
NSWC CRANE
CRANE, INDIANA

Compound	Kd [1] (L/kg)	Reference
RDX	0.21 - 0.33 (0.30)	Pennington et al., 1999c
	0.80 - 4.15 (2.67)	Sikka et al., 1980
	1.4, 4.2 (2.8)	Spanggord et al., 1980b
	0.2 - 7.8 (4.05)	Hale et al., 1979
	(2.17)	Layton et al., 1987
	0.101, 0.284 (0.19)	AMEC, 2001
	1.57, 1.59 (1.58)	Xue, Iskandar, and Selim, 1995
	0.12 - 2.37 (0.89)	Ainsworth et al., 1993
	0.95, 0.97 (0.96)	Singh et al., 1998
	0.2 - 7.8	Townsend and Meyers, 1996
	6.38	Sheremata et al., 2001
	0.29	Price et al., 2000
	0.42	May et al., 2003
TNT	2.0 - 11.0 (4.0)	Pennington and Patrick, 1990
	5.5 - 22.2 (14.6)	Sikka et al., 1980
	5.5 - 19.3	Spanggord et al., 1980a
	1.1, 2.5 (1.8)	AMEC, 2001
	0.08 - 0.33 (0.23)	Pennington et al., 1999c
	2.58	May et al., 2003
2ADNT	3.7, 4.9 (4.3)	Pennington and Patrick, 1990
	2.42	May et al., 2003
4ADNT	2.42	May et al., 2003

1 Individual values or range of values listed in column; average value shown in parentheses.
L/kg - Liters per kilogram
RDX - Hexahydro-1,3,5-trinitro-1,3,5-triazine
TNT - 2,4,6-trinitrotoluene
2ADNT - 2-amino-4,6-dinitrotoluene
4ADNT - 4-amino-2,6-dinitrotoluene

TABLE 6-3

BIODEGRADATION CHARACTERISTICS OF ENERGETIC COMPOUNDS
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Compound	Half-Life[1] (years)	Reference
RDX	36 0.88 - 10.7+ (10.6)	DuBois and Baytos, 1991 Pennington et al., 1999c
TNT	1.0 0.1 0.88 - 10.7+ (4.1) 1.11	DuBois and Baytos, 1991 Cataldo et al., 1989 Pennington et al., 1999c May et al., 2003
2ADNT	< 0.05 < 0.05	Funk et al., 1993 Alvarez et al., 1995
4ADNT	NA	NA

1 Individual values or range of values listed in column; average value shown in parentheses.
RDX - Hexahydro-1,3,5-trinitro-1,3,5-triazine
TNT - 2,4,6-trinitrotoluene
2ADNT - 2-amino-4,6-dinitrotoluene
4ADNT - 4-amino-2,6-dinitrotoluene
NA - Not Available

TABLE 6-4

GENERAL LEVELS OF CONTAMINANT CONCENTRATIONS IN EACH MEDIA
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

Contaminant	SOIL AND SEDIMENT (mg/kg)													
	Surface Soil, MFA		Surface Soil, BDA		Subsurface Soil, MFA		Subsurface Soil, BDA		Gully Sediment		East Tributary Sediment		Turkey Creek Sediment	
	mean	maximum	mean	maximum	mean	maximum	mean	maximum	mean	maximum	mean	maximum	mean	maximum
Explosive Compounds														
HMX			0.268	1.7										
RDX			0.668	6.1										
DNX														
MNX														
2,4,6-trinitrotoluene														
2-amino-4,6-dinitrotoluene														
4-amino-2,6-dinitrotoluene														
2,6-dinitrotoluene														
1,3,5-trinitrobenzene			0.84	0.19					0.301	2.4				
1,3-dinitrobenzene														
SVOCs														
benzo(a)pyrene			0.0151	0.110			0.00236	0.008	0.00466	0.001				
benzo(b)fluoranthene			0.024	0.150			0.00303	0.016	0.00632	0.015				
bis(2-ethylhexyl)phthalate			0.152	1.300			0.07110	0.440	0.140	0.340				
di-N-butyl phthalate			0.0497	0.170										
pyrene			0.0264	0.180					0.00861	0.018				
Metals (total)														
aluminum	23378	29800	16825	23700	23871	37000	17717	24700	16563	25700	12640	17200	11400	11400
antimony	0.448	1.4	352	3610	0.275	0.71	0.214	0.31	0.811	4.2	0.975	1.2		
arsenic	6.76	9	27.4	158	6.30	12.3	3.04	6.4	16.1	36	9.33	10.9	27.8	27.8
barium	90.5	128	158	505	133	568	119	792	111	182	76.8	65	82.4	82.4
beryllium	0.738	0.98	0.818	1.5	1.04	2	1.24	1.7						
cadmium			1.26	6.3					1.17	7.4				
chromium, total	24.0	26.9	32.7	51.7	27.1	38.7	30.0	38.8	42.7	141	29.8	32.8	70.4	70.4
cobalt	8.52	15.7	9.22	13.6	9.31	27	9.80	24.2	26.1	108	29.9	40.4	27.1	27.1
copper	13.1	19	70.7	345	13.4	22.9	12.2	23.9	14.3	22.5	21.2	29.4	19.8	19.8
iron	24389	30600	26705	65900	29481	49600	41098	93300	69958	217000	51300	70700	157000	157000
lead	16.1	31.2	39382	429000	15.4	39.4	17.0	25.4	36.3	178	40.5	58.2	39.6	39.6
manganese	404	1080	566	1400	304	1600	210	796	2097	6780	2195	2910	1760	1760
mercury	0.0250	0.041	0.0519	0.31	0.0242	0.13	0.103	1	0.0386	0.063	0.0250	0.038	0.0100	0.01
nickel	16.9	21.4	23.4	44.6	20.7	47.3	33.7	72.6	27.3	80.9	29.1	32.1	52.1	52.1
selenium			0.244	0.61	0.141	0.38	0.417	2.3						
silver	0.0502	0.21	1.75	18.5										
thallium			0.690	6.4										
tin	0.321	0.61	89.9	838	0.291	0.66			0.643	3.1				
vanadium	39.4	48.6	30.4	42.8	37.3	50.5	27.3	34	43.5	71	33.5	36	57.8	57.8
zinc	53.5	165	494	2490	45.7	99.2	52.6	128	106	263	77.4	75.7		
Miscellaneous														
ammonia-N	0.90	0.98			0.53	0.90								
nitrate/nitrite-N														

TABLE 6-4

GENERAL LEVELS OF CONTAMINANT CONCENTRATIONS IN EACH MEDIA
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA
PAGE 2 OF 2

Contaminant	SURFACE WATER AND GROUNDWATER (ug/L)													
	Gully Surface Water		East Tributary		West Tributary		Turkey Creek		Puz Groundwater		Pmz Groundwater		Plz and Mgd Groundwater	
	mean	maximum	mean	maximum			mean	maximum	mean	maximum	mean	maximum	mean	maximum
Explosive Compounds														
HMX	8.08	98	0.333	0.55	3.6	6.4			56.8	530	0.161	0.52	0.158	0.28
RDX	15.3	140	0.471	0.8	8.7	19			700	7,400	0.462	4.2	0.882	3.9
DNX	ND	ND							1.02	22				
MNX	0.31	1.9			0.20	0.52			10.5	250				
2,4,6-trinitrotoluene	3.08	79							10.6	170			0.942	4.2
2-amino-4,6-dinitrotoluene	1.34	19							6.42	100				
4-amino-2,6-dinitrotoluene	3.65	74	0.339	0.56	0.30	0.61			10.7	190			0.232	0.65
2,6-dinitrotoluene	0.131	0.27							0.536	9.8				
1,3,5-trinitrobenzene	0.148	0.96							4.26	110				
1,3-dinitrobenzene	ND	ND							0.569	8.9				
SVOCs														
benzo(a)pyrene														
benzo(b)fluoranthene														
bis(2-ethylhexyl)phthalate														
di-N-butyl phthalate														
pyrene														
Metals (total)														
aluminum	3491	67700	91.7	257	110	344	24.5	24.1	14252	190000	5615	31000	623	2540
antimony									0.122	1.7	0.552	2.9	0.736	3.1
arsenic	2.58	20.3	0.140	0.33	1.18	5.1			6.15	91.2	3.89	11.4	3.81	9.5
barium	92.9	589	49.1	64.2	88	265	55.4	69.8	35.4	212	67.6	214	42.8	79.3
beryllium	0.231	5.2					0.0150	0.02	7.59	97.4	0.250	1.2		
cadmium	1.67	43.7			0.21	0.06			5.29	83.4	0.502	2.3		
chromium, total	4.90	105							2.59	35.2	9.76	47.9	1.77	6.6
cobalt	5.87	123	0.170	0.26	0.67	2.2	0.188	0.22	434	6060	20.9	79.7	8.28	14.7
copper	48.5	1,650	1.45	3.4	1.9	5.3			10.2	93.3	7.69	24.3	3.24	6.4
iron	5,229	95,400	359	584	1,876	9,390	366	456	19138	209000	12887	48900	3847	7150
lead	15.0	458	0.139	0.136	0.15	0.202			7.05	104	5.92	24.7	2.28	10.5
manganese	1,125	24,200	4.40	7.1	1,274	7,460	87.1	131	9290	138000	1365	7570	1259	2190
mercury	0.0665	1.7							0.437	7.3	0.0183	0.057		
nickel	9.05	140	1.90	2.4	2.7	4.2	0.875	1.7	1021	14600	57.4	178	25.6	44.2
selenium	0.507	9.6							2.50	24.7	1.44	7.7	1.22	2
silver	0.0834	2.6												
thallium	0.0809	0.67	0.0579	0.07	0.04	0.07			0.302	6	0.0747	0.32		
tin	0.142	2.1							0.139	1.4	0.348	1.1	0.985	4.2
vanadium	7.65	138			0.69	1.3			1.76	22.9	9.74	49.4	1.44	4.9
zinc	158	5,220							1364	18000	67.9	262	14.6	40
Miscellaneous														
ammonia-N	0.225	4.2	0.0390	0.13	0.71	4.2	0.0913	0.18	0.608	10	0.543	1.8	0.334	0.5
nitrate/nitrite-N	0.991	8.2	0.0588	0.11	0.57	1.9			1.2	10	0.297	2.0		

HMX - octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
RDX - hexahydro-1,3,5-trinitro-1,3,5-triazine
MNX - hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine
DNX - hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine
A blank space indicates that the analyte was not detected in any sample within the specific sample group.
mg/kg - milligrams per kilogram
µg/L - micrograms per liter

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LEGEND:

PATHWAY DISCRIPTIONS:

A – CONTAMINANT SOURCE AREAS (OVERBURDEN SOIL AND SUMPS)

B – SHALLOW GROUNDWATER FLOW IN PUZ SANDSTONE

B1 – GROUNDWATER TAKEN UP BY VEGETATION AND TRANSPIRED

B2 – GROUNDWATER SEEPS INTO GULLIES AT THE SURFACE AND JOINS SURFACE WATERS

B3 – MIGRATION ALONG BEDROCK/SOIL INTERFACE (1–3' bgs) AND NEAR–SURFACE FRACTURES

C – GROUNDWATER FLOW IN PMZ SANDSTONE

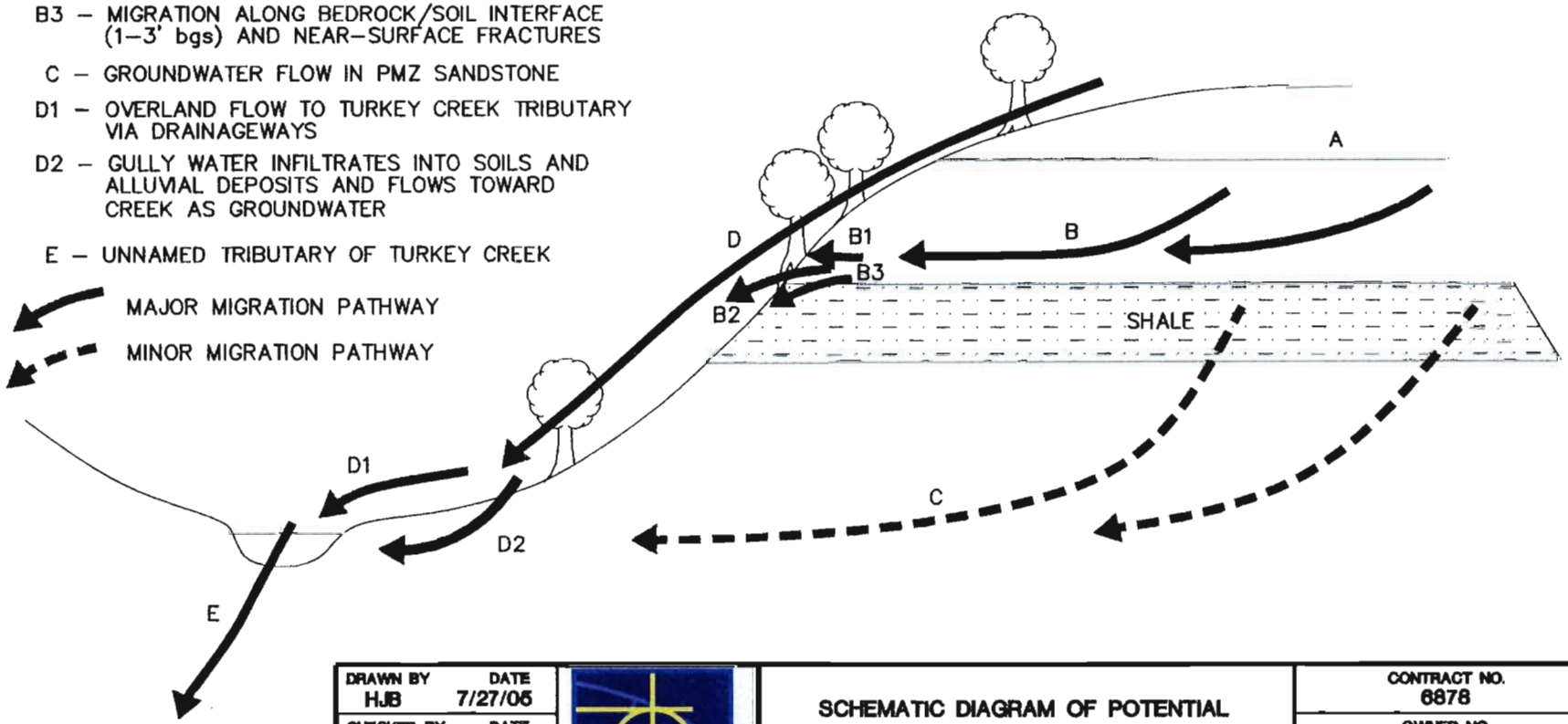
D1 – OVERLAND FLOW TO TURKEY CREEK TRIBUTARY VIA DRAINAGEWAYS

D2 – GULLY WATER INFILTRATES INTO SOILS AND ALLUVIAL DEPOSITS AND FLOWS TOWARD CREEK AS GROUNDWATER

E – UNNAMED TRIBUTARY OF TURKEY CREEK

MAJOR MIGRATION PATHWAY

MINOR MIGRATION PATHWAY



DRAWN BY HJB	DATE 7/27/05	SCHEMATIC DIAGRAM OF POTENTIAL CONTAMINANT MIGRATION PATHWAYS SWMU 12 - MINE FILL A NSWC CRANE CRANE, INDIANA	CONTRACT NO. 6878
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REVISED BY	DATE		APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 6-1 / REV. 0

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7.0 HUMAN HEALTH RISK ASSESSMENT

This section presents the HHRA for MFA (SWMU 12) and the Battery Site at NSWC Crane. The objective of the HHRA is to determine whether detected concentrations of chemicals within the study areas pose a significant threat to potential human receptors under current and/or future land use. The potential risks to human receptors were estimated based on the assumption that no actions are taken to control contaminant releases.

7.1 INTRODUCTION

The following current U.S. EPA, the State of Indiana Department of Environmental Management (IDEM), and United States Navy risk assessment guidance documents were used to develop the framework for the baseline HHRA:

- Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A) (U.S. EPA, 1989).
- Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors (U.S. EPA, 1991).
- Distribution of Preliminary Review Draft: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (U.S. EPA, 1993a).
- Soil Screening Guidance: Technical Background Document (U.S. EPA, 1996).
- Exposure Factors Handbook. Office of Health and Environmental Assessment (U.S. EPA, 1997a).
- Risk Assessment Guidance for Superfund: Volume 1, Human Health Evaluation Manual Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments (U.S. EPA, 2001).
- Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual Part E, Supplemental Guidance for Dermal Risk Assessment, Final Guidance (U.S. EPA, 2004a).
- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. (U.S. EPA 2002a).

- Navy Final Policy on the Use of Background Chemical Levels (Navy, 2004).

- Conducting Human Health Risk Assessments under the Environmental Restoration Program (Navy, 2001).

- Risk Integrated System of Closure. User's Guide and Technical Resource Guidance Document (IDEM, 2004).

This HHRA was prepared using essentially the same methodology used to prepare the HHRAs for SWMUs 4, 5, 9, and 10 (TtNUS, 2003a) and SWMU 13 (TtNUS, 2005).

An HHRA consists of five components: data evaluation, exposure assessment, toxicity assessment, risk characterization, and uncertainty analysis. Sections 7.2 through 7.6 contain detailed discussions of the five components of the HHRA. A schematic diagram of the general risk assessment process is provided as Figure 7-1.

Three major aspects of chemical contamination and environmental fate and transport must be considered to evaluate potential risks: (1) contaminants with toxic characteristics must be found in environmental media and must be released by either natural processes or by human action; (2) potential exposure points must exist; and (3) human receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure. If any one of these factors is absent for a site, the exposure route is regarded as incomplete, and no potential risks are considered to exist for human receptors.

7.2 DATA EVALUATION

Data evaluation, the first component of a baseline HHRA, is a medium-specific task involving the compilation and evaluation of analytical data. The main objective of the data evaluation is to develop a medium-specific list of COPCs that will be used to quantitatively determine potential human health risks for site media.

7.2.1 Data Usability

Data from samples collected during the field investigations were used to assess risks to potential human receptors. A data quality report is included in Section 3.0 that provides information on precision, accuracy, representativeness, completeness, and comparability of the analytical data.

Only fixed-base analytical results for the target analyte lists for the field investigation were used in the quantitative risk evaluation. Typically, unfiltered results for groundwater and surface water were used to assess risks associated with these media. Field measurements and data regarded as unreliable (i.e., qualified as "R" during the data validation process) were not used in the quantitative risk assessment. The elimination of data qualified "R" may result in data gaps that may increase the uncertainty in the risk assessment. However, as discussed in Section 3.2, the chemicals qualified "R" are not constituents of concern at SWMU 12. Therefore, it is unlikely that risks have been underestimated by the removal of the unreliable data from the data sets.

A discussion of the historical data for SWMU 12 is provided in Section 1.3. Historical data from samples collected in 1997, 1998, 1999, and 2000 during the bioremediation program were used in conjunction with the data obtained from the investigation conducted in 2004/2005 in the quantitative risk analysis. The historical data provide a description of post-remediation conditions at SWMU 12 for explosives, metals and VOCs. The historical data were validated and all of the historical data were used in the risk assessment. A data quality discussion of the historical data is provided in Section 6.0 of the IMR (MK, 2000b), and Addendum #1 to the IMR (MK, 2002).

7.2.2 Selection of Chemicals of Potential Concern

The selection of COPCs is a qualitative screening process used to limit the number of chemicals and exposure routes quantitatively evaluated in the baseline HHRA to those site-related constituents that dominate overall potential risks. Screening by risk-based concentrations (RBCs) was used to focus the risk assessment on meaningful chemicals and exposure routes.

In general, a chemical was selected as a COPC and retained for further quantitative risk evaluation if the maximum concentration detected in a sampled medium exceeded a conservative screening level(s). Chemicals eliminated from further evaluation during this evaluation are assumed to present minimal risks to potential human receptors.

7.2.2.1 Derivation of Screening Criteria

Several types of screening levels were used to identify COPCs for SWMU 12. Screening concentrations based on IDEM Risk Integrated System of Closure (RISC) default closure levels (IDEM, 2004) and U.S. EPA Region 9 Preliminary Remediation Goals (PRGs) (U.S. EPA, 2004a) were used, as well as other U.S. EPA criteria. The IDEM default closure levels for soil include risk-based direct contact criteria, soil attenuation capacity, soil saturation concentrations, and migration from soil to groundwater criteria. The

IDEM default closure levels for groundwater are based on U.S. EPA Maximum Contaminant Levels (MCLs), if available. If not, the default closure level is the lesser of the risk-based criteria and solubility limit. The IDEM risk-based default closure levels correspond to a systemic Hazard Quotient (HQ) of 0.1 (for non-carcinogens) or an incremental lifetime cancer risk (ILCR) of 1×10^{-5} (for carcinogens).

The screening levels based on U.S. EPA Region 9 PRGs correspond to HQs of 0.1 (for non-carcinogens) or a ILCR of 1×10^{-6} (for carcinogens). The U.S. EPA Region 9 PRGs for non-carcinogens are based on a Hazard Index (HI) of 1 and were multiplied by 0.1 to account for potential cumulative effects of several chemicals affecting the same target area or producing the same adverse non-carcinogenic health effect. The screening levels to be used for each medium in the risk assessments are briefly discussed below.

Soil

Screening concentrations based on the following criteria were used to select COPCs for surface and subsurface soil:

- IDEM residential default closure levels for direct contact (IDEM, 2004)
- U.S. EPA Region 9 PRGs for residential soil (U.S. EPA, 2004a).
- U.S. EPA generic Soil Screening Levels (SSLs) for the inhalation of volatiles and fugitive dusts calculated online at http://risk.lsd.ornl.gov/calc_start.shtml based on methodology from the U.S. EPA's Soil Screening Guidance (U.S. EPA, 1996).

If the maximum concentration of a constituent exceeded screening levels based on any of these criteria, the chemical was selected as a COPC for soil and carried through to the quantitative risk assessment.

The comparison of site soil data to U.S. EPA generic SSLs for transfers from soil to air was used to identify whether a quantitative analysis of the inhalation of particulates or vapors from the soil exposure pathway was warranted. If the maximum soil concentration of a chemical exceeded the SSL, a quantitative evaluation of potential risks from inhalation was performed. Otherwise, the risks associated with the inhalation pathway are considered insignificant, and this exposure pathway is eliminated from further evaluation.

Soil Screening Levels for the Protection of Groundwater

Comparisons of chemical concentrations in soil with SSLs for the protection of groundwater were used to indicate the potential for a chemical in soil to adversely impact groundwater. The SSL comparisons were

not used to select COPCs for quantitative risk evaluation. Chemicals with maximum concentrations that exceeded the migration to groundwater SSLs are presented and discussed in Sections 7.2.3.1, 7.2.3.2, and 7.2.3.3. The following criteria were used for the SSL comparisons:

- U.S. EPA generic SSLs for migration to groundwater calculated online at http://risk.lsd.ornl.gov/calc_start.shtml based on methodology from the U.S. EPA's Soil Screening Guidance (U.S. EPA, 1996).

- IDEM residential default closure levels for migration of chemicals from soil to groundwater (IDEM, 2004).

Because of the different exposure scenarios for potential human receptors, COPCs were identified for surface and subsurface soil. Surface soil was defined as soil collected from 0 to 2 feet bgs. Subsurface soil was defined as soil collected from depths greater than 2 feet bgs.

Sediment

No specific screening levels exist for human exposure to sediment. COPCs for sediment were selected by comparing detected site concentrations to screening levels based on the following:

- IDEM residential default closure levels for direct contact (IDEM, 2004).
- U.S. EPA Region 9 PRGs for residential soil (U.S. EPA, 2004a).

A chemical detected in sediments was selected as a COPC for sediments if the maximum detected concentration exceeded screening levels based on these criteria. The use of soil screening criteria for sediment COPC identification is regarded as a conservative approach because exposure to sediment is expected to be less than exposure to soil. U.S. EPA generic SSLs for transfers from soil to air and for migration to groundwater are not considered to be appropriate for sediment screening because of the high moisture content associated with sediment matrices.

Groundwater/Surface Water

The same screening levels were used to select COPCs for groundwater and surface water. The following criteria were used as the basis of these screening criteria:

- IDEM residential default closure levels for groundwater (IDEM, 2004)
- U.S. EPA Region 9 PRGs for tap water (U.S. EPA, 2004a)
- U.S. EPA MCLs (U.S. EPA, 2004c)

If the maximum concentration of a constituent exceeded any screening levels based on these criteria, the chemical was selected as a COPC and carried through the quantitative risk assessment.

Risk-based COPC screening levels for tap water ingestion, which are based on daily, residential exposure assumptions, were used to select COPCs for groundwater and surface water. In general, the use of tap water screening levels is regarded as a highly conservative approach to COPC selection at SWMU 12 because groundwater at the site is not used as a potable drinking water source. Potential human exposure to surface water in intermittent ditches, streams, and ponds located within SWMU 12 is expected to be limited to incidental exposures such as that which occurs during trespassing, which is anticipated to be significantly less than the daily exposure assumed for the tap water ingestion scenario.

Federal Ambient Water Quality Criteria (AWQCs) were not used to select COPCs for surface water. AWQCs applicable to the protection of human health assuming routine consumption of water were not used because the more conservative IDEM residential closure levels for groundwater, U.S. EPA Region 9 PRGs for tap water, and U.S. EPA MCLs were used to select COPCs for groundwater and surface water.

Lead as a COPC

Limited criteria are available to evaluate the potential risks associated with lead. There are no RBCs for this chemical because the U.S. EPA has not derived toxicity values [i.e., cancer slope factors (CSFs), reference doses (RfDs)] for lead. However, recommended screening levels are available for lead in soil that are used to indicate the need for response activities.

Guidance from both the Office of Prevention, Pesticides, and Toxic Substances (OPPTS) and the Office of Solid Waste and Emergency Response (OSWER) recommend 400 mg/kg as the lowest screening level for lead-contaminated soil in a residential setting where children are frequently present (U.S. EPA, 1994c). The IDEM default closure level for residential exposures to soil is also 400 mg/kg. OPPTS identifies 2,000 to 5,000 mg/kg as an appropriate range for areas where contact with soil by children in a residential setting is less frequent. A value of 400 mg/kg was used as the screening level for soil and sediment in the HHRA for SWMU 12.

The IDEM default closure level and Safe Drinking Water Act (SDWA) Action Level of 15 µg/L was used as the screening level for lead in groundwater and surface water.

Essential Nutrients and Chemicals without Toxicity Criteria

The essential nutrients calcium, magnesium, potassium, and sodium were not identified as COPCs because these inorganic chemicals are naturally abundant in environmental matrices and are only toxic at high doses. In addition, because of the lack of toxicity criteria, risk-based COPC screening levels are not available for some chemicals [e.g., 2-methylnaphthalene, benzo(g,h,i)perylene, phenanthrene, diamino-nitrotoluenes, DNX, MNX, and TNX]. Appropriate surrogates were selected for some of these chemicals based on similar chemical structure. Pyrene was used as the surrogate for benzo(g,h,i)perylene, and phenanthrene and naphthalene was used as the surrogate for 2-methylnaphthalene Suitable surrogate compounds could not be determined for diamino-nitrotoluenes, DNX, MNX, and TNX. The uncertainty associated with the omission of these chemicals from the quantitative risk assessment is discussed in the uncertainty section of the risk assessment.

Determination of Site-Related Chemicals (Background Evaluation)

The evaluation of chemical concentrations detected in SWMU 12 media in relation to background levels follows guidance presented in U.S. EPA's Role of Background in the CERCLA Clean-up Program (2002b). This guidance document recommends that chemicals exceeding risk-based screening concentrations be evaluated in the quantitative risk assessment. Therefore, if the maximum concentration of any chemical exceeded screening levels, the chemical was selected as a COPC and risks were calculated for that chemical and are presented in Section 7.5. COPCs were not selected on the basis of site data to background data comparisons. However, site-specific background issues are discussed in the Risk Characterization Section (Section 7.5) and Uncertainty Section (Section 7.6).

Frequency of Detection

Chemicals were eliminated from the COPC list if detected at a frequency of less than 5 percent in a medium. A frequency screen was conducted only when there were 20 or more samples from the medium of concern. The decision to eliminate a chemical because of low detection frequency was also based on site history (i.e., whether there a reason to believe that a chemical may be related to past site activities) and the magnitude of the concentration (i.e., whether the concentration of a chemical indicates a potential hot spot area). Only one constituent (antimony in Puz groundwater) was eliminated as a COPC on the basis of frequency of detection. Antimony was detected in 1 of 63 samples, and the maximum concentration (1.7 µg/L) was less than the U.S. EPA MCL (6 µg/L).

7.2.2.2 Decision Rules for Establishing COPCs

The following decision rules were used to select initial lists of COPCs for SWMU 12:

- A chemical detected in groundwater, soil, surface water, or sediment was selected as a COPC if any detected chemical concentration exceeded the screening levels described in Section 7.2.2.1.

- If a chemical was not detected in any of the samples in a particular medium, but detection limits exceeded the risk-based screening levels, the chemical was not selected as a COPC but is qualitatively discussed in the uncertainty analysis section.

- Individual chemicals may be eliminated as COPCs if they are detected at a frequency of less than 5 percent in any given medium but only if there are no other indications the chemical would pose an unacceptable risk to receptors (e.g., there is no evidence of a contaminant hot spot). Chemicals exhibiting unusually high concentrations or that are clearly site related may be retained as COPCs at the discretion of the human health risk assessor.

7.2.3 COPCs Selected for HHRA

COPCs at SWMU 12 were selected for surface soil, subsurface soil, groundwater, surface water, and sediment using the risk-based COPC screening levels described in Section 7.2.2.1. A discussion of the chemicals identified as COPCs and the rationale for COPC selection are provided in the following subsections. COPC selection tables for each medium are presented in Tables 7-1 through 7-19. Chemicals retained as COPCs for SWMU 12 are presented in Table 7-20. The Risk Assessment Guidance for Superfund (RAGS) Part D tables for COPC selection are included in Appendix I.

7.2.3.1 Surface Soil (0 to 2 Feet) - SWMU 12 Proper

This section discusses COPC selection for chemicals detected in surface soil samples collected at SWMU 12 Proper during the field investigation conducted in 2004. Twenty-one metals and ammonia-N were detected in the nine surface soil samples collected at the SWMU 12 Proper area. No organic chemicals were positively detected in the samples (one sample was analyzed for VOCs and SVOCs, and all nine samples were analyzed for explosives). The maximum detected surface soil concentrations were compared to screening levels based on U.S. EPA Region 9 PRGs for residential land use and IDEM residential default closure levels for direct contact. The following chemicals were retained as COPCs for surface soil at SWMU 12 Proper:

- Inorganics - aluminum, arsenic, iron, manganese, and vanadium

COPC selection for direct contact with surface soil is presented in Table 7-1

A comparison of the maximum detected surface soil concentrations to U.S. EPA SSLs for chemical migration from soil to air is presented in Table 7-2. Concentrations of all chemicals were less than U.S. EPA SSLs for soil to air; therefore, exposures through inhalation of fugitive dust emissions from surface soil were not evaluated quantitatively in the HHRA.

The maximum detected surface soil concentrations were also compared to U.S. EPA SSLs for chemical migration from soil to groundwater and IDEM residential default closure levels for migration to groundwater in Table 7-2. The following chemicals were detected in surface soil at maximum concentrations that exceeded the screening levels for migration from soil to groundwater:

- Inorganics - aluminum, antimony, arsenic, barium, chromium, cobalt, manganese, and nickel

The migration to groundwater comparisons presented in Table 7-2 were not used to select COPCs for quantitative risk assessment but to indicate the potential for chemicals in soil to impact groundwater. Because metals are naturally occurring, it is often difficult to assess the impact of metals migration on groundwater. All of the metals exceeding the soil-to-groundwater SSLs were detected in groundwater at SWMU 12 at concentrations exceeding groundwater screening levels and concentrations in upgradient wells. Metals generally are not likely to leach to groundwater under normal environmental conditions (in a dissolved phase) but are more likely to be transported on particulate matter. Of the metals that exceeded the soil-to-groundwater SSLs, only aluminum is known to have been used in processes and operations at SWMU 12. However, barium, chromium, and lead are listed as potential hazardous wastes at SWMU 12 in the Phase I RFI (Halliburton NUS, 1992) because of their presence in grit blast residue (barium and lead) and paint wastes (chromium). Section 5.4.1 of this report discusses in detail the occurrence and distribution of metals in groundwater at MFA. As discussed in Section 5.4.1, the presence of arsenic, barium, chromium, cobalt, manganese, and nickel in groundwater appear to be site related, but an operationally related source of these metals is unknown. Antimony was detected in 1 of 63 groundwater samples (at a concentration less than the MCL) and is not a significant contaminant in groundwater at the site. An additional factor to consider is that turbidity levels exceeding 300 NTU (with some greater than 1,000 NTU) were reported for some samples (see Sections 5.4.1 and 7.2.3.4). Consequently, the elevated metals concentrations reported for some unfiltered samples may be a function, in part, of sample turbidity.

7.2.3.2 Subsurface Soil (Greater than 2 Feet) - SWMU 12 Proper

This section discusses the COPC selection for chemicals detected in subsurface soil samples collected at SWMU 12 Proper during the field investigation conducted in August 2004. Twenty-one metals and ammonia-N were detected in the 17 subsurface soil samples collected at the SWMU 12 Proper area. No organic chemicals were detected in the subsurface soil samples (one sample was analyzed for VOCs and SVOCs and 17 samples were analyzed for explosives). The maximum detected subsurface soil concentrations were compared to screening levels based on U.S. EPA Region 9 PRGs for residential land use and IDEM residential default closure levels for direct contact. The following chemicals were retained as COPCs for subsurface soil at SWMU 12 Proper:

- Inorganics - aluminum, arsenic, barium, iron, manganese, and vanadium.

COPC selection for direct contact with subsurface soil is presented in Table 7-3.

A comparison of the maximum detected subsurface soil concentrations to U.S. EPA SSLs for chemical migration from soil to air is presented in Table 7-4. Concentrations reported for all chemicals were less than U.S. EPA SSLs for soil to air; therefore, exposures through inhalation of fugitive dust emissions from subsurface soil were not evaluated quantitatively in the HHRA.

The maximum detected subsurface soil concentrations were also compared to U.S. EPA SSLs for chemical migration from soil to groundwater and IDEM residential default closure levels for migration to groundwater in Table 7-4. The following chemicals were detected in subsurface soil at maximum concentrations that exceeded the COPC screening levels for migration from soil to groundwater:

- Inorganics - aluminum, antimony, arsenic, barium, chromium, cobalt, manganese, nickel, and selenium.

The site concentrations to criteria comparisons presented in Table 7-4 were not used to select COPCs but to indicate the potential for chemicals in soil to impact groundwater. The metals concentrations detected in the SWMU 12 surface soils are generally similar to those reported for the subsurface soils. Consequently, the preceding discussion regarding the migration of metals from surface soil to groundwater (Section 7.2.3.1) is relevant for the metals concentrations detected in subsurface soils.

7.2.3.3 Historical and Bioremediated Soil (Surface and Subsurface)

Soil data (generally 0 to 3 feet bgs) collected during the SWMU 12 remediation program conducted by MK and TT and reported in the IMR (MK, 2000b) and Addendum #1 to the IMR (TT, 2002) were also used to select COPCs. The COPC selection process for historical data is presented in Table 7-5. The data summarized in Table 7-5 are expected to portray current site conditions (i.e., after remediation) in the six building areas investigated during the remediation program. The IMR indicated that explosives, nine metals (aluminum, arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver), and nine VOCs (1,1-DCA, 1,2-DCA, acetone, chloroform, methyl ethyl ketone, methylene chloride, methyl isobutyl ketone, toluene, and xylenes) were COCs for SWMU 12. Pre-remediation and post-remediation samples were analyzed for these constituents only. IMR Appendix E (ICS analytical results), IMR Appendix H (PES results), IMR Table 4-4 (bioremediated soil analytical results), and Table 4-3 of Addendum #1 to the IMR (bioremediated soil analytical results) were used as the sources of the historical data. Samples from areas known to be excavated were removed from the data set prior to COPC evaluation. The sample frequencies shown in Table 7-5 represent the totals of ICS, PES, and bioremediated samples. A more detailed discussion concerning the use of the historical data in this risk assessment is presented in Section 7.3.3.

The following chemicals were retained as COPCs for quantitative risk assessment of surface and subsurface based on a comparison of historical sample results to the direct contact screening levels:

- Energetics - 2,4,6-trinitrotoluene (TNT), 2-amino-4,6-dinitrotoluene (2-ADNT), 4-amino-2,6-dinitrotoluene (4-ADNT), 2-nitrotoluene, HMX, and RDX.
- Metals - aluminum and arsenic.

Aluminum, 2-ADNT, 4-ADNT, and HMX were selected as COPCs for historical soil samples because the maximum detected concentrations of these non-carcinogens exceeded screening levels (set at an HI of 0.1). However, the maximum concentrations of these chemicals did not exceed U.S. EPA Region 9 PRGs for residential soil.

The comparisons of the maximum detected soil concentrations to U.S. EPA SSLs for chemical migration from soil to air presented in Table 7-6 indicate that concentrations of all chemicals were less than the U.S. EPA SSLs for soil to air. Therefore, exposures through inhalation of fugitive dust emissions from soil in the six building areas investigated in the bioremediation program were not evaluated quantitatively in the HHRA.

The maximum detected surface soil concentrations were also compared to U.S. EPA SSLs for chemical migration from soil to groundwater and IDEM residential default closure levels for migration to groundwater in Table 7-6. The following chemicals were detected in surface soil at maximum concentrations exceeding the COPC screening levels for migration from soil to groundwater:

- Energetics - 1,3,5-trinitrobenzene, TNT, 2,4-dinitrotoluene, 2,6-dinitrotoluene, and 2-nitrotoluene
- VOCs - methylene chloride
- Metals - aluminum, arsenic, barium, cadmium, chromium, and selenium

The site concentrations to criteria comparisons presented in Table 7-6 were not used to select COPCs but were used to indicate the potential for chemicals in soil to impact groundwater. Methylene chloride is considered to be very mobile in soil and may leach to groundwater. However, it is a common laboratory contaminant that was detected in laboratory blanks (MK, 2000) and was not detected in groundwater samples collected at SWMU 12 (or SWMU 13).

Migration to groundwater criteria are currently not available for several of the major explosives site contaminants (i.e., RDX, HMX and the amino-dinitrotoluenes). However, these compounds as well as other explosives were detected in surface soil, subsurface soil, and groundwater at concentrations exceeding screening criteria, indicating that groundwater has been impacted by explosives migrating from soil.

A discussion of the potential for migration of metals from surface soil to groundwater at MFA was presented in Section 7.2.3.1. Additionally, as noted in Section 5.4.1, the high concentrations of cadmium in Puz groundwater suggest that cadmium may be a site-related groundwater contaminant, but an operationally related source of this contaminant is unknown. Section 5.4.1 also states that the elevated cadmium concentrations in groundwater are not completely bounded (i.e., the concentrations reported for the most downgradient well exceeded groundwater screening concentrations). However, the eastern and western tributaries to Turkey Creek prevent groundwater flow and groundwater contamination from moving further away from the SWMU in those downgradient directions.

7.2.3.4 Surface Soil (0 to 2 Feet) - Battery Site

This section discusses COPC selection for chemicals detected in surface soil samples collected at the Battery Site during the field investigation conducted in 2004. Section 5.2 provides a discussion of the nature and extent of soil contamination at the Battery Site. Two VOCs, 19 SVOCs (including 16 PAHs), three energetics, and 24 metals were detected in the 11 surface soil samples collected at the Battery Site.

As stated in Section 5.2, metals concentrations are generally much higher at the Battery Site than at SWMU 12 Proper. For example, the maximum detected concentration of lead in surface soil at the Battery Site (429,000 mg/kg) is several orders of magnitude greater than the lead concentrations in surface soil at SWMU 12 Proper. The maximum detected surface soil concentrations were compared to screening levels based on U.S. EPA Region 9 PRGs for residential land use and IDEM residential default closure levels for direct contact. The following chemicals were retained as COPCs for surface soil at the Battery Site:

- PAHs - benzo(a)pyrene.
- Energetics - RDX.
- Inorganics - aluminum, antimony, arsenic, cadmium, copper, iron, lead, manganese, thallium, vanadium, and zinc.

COPC selection for direct contact with surface soil is presented in Table 7-7.

A comparison of the maximum detected surface soil concentrations to U.S. EPA SSLs for chemical migration from soil to air is presented in Table 7-8. Concentrations reported for all chemicals were less than U.S. EPA SSLs for soil to air; therefore, exposures through inhalation of fugitive dust emissions from surface soil were not evaluated quantitatively in the HHRA.

The maximum detected surface soil concentrations were also compared to U.S. EPA SSLs for chemical migration from soil to groundwater and IDEM residential default closure levels for migration to groundwater in Table 7-8. The following chemicals were detected in surface soil at maximum concentrations that exceeded screening levels for migration from soil to groundwater:

- VOC - methylene chloride.
- Energetic - 1,3,5-trinitrobenzene.
- Inorganics - aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, manganese, nickel, selenium, silver, thallium, and zinc.

The site concentrations to criteria comparisons presented in Table 7-8 were not used to select COPCs but to indicate the potential for chemicals in soil to impact groundwater. All of the metals exceeding soil-to-groundwater SSLs at the Battery Site were detected in groundwater at SWMU 12 at concentrations exceeding groundwater screening levels and concentrations in upgradient wells. Of the metals exceeding the soil-to-groundwater SSLs, only aluminum is known to have been used in processes and operations at SWMU 12. However, barium, chromium, and lead are listed as potential hazardous wastes at SWMU 12

in the Phase I RFI (Halliburton NUS, 1992) because of their presence in grit blast residue (barium and lead) and paint wastes (chromium). Section 5.4.1 of this report discusses in detail the occurrence and distribution of metals in groundwater at MFA. As discussed in Section 5.4.1, the presence of arsenic, barium, cadmium, chromium, cobalt, lead, manganese, nickel, thallium, and vanadium in groundwater appear to be site related, but an operationally related source of these metals is unknown. Antimony was detected in 1 of 63 groundwater samples (at a concentration less than the MCL) and is not a significant contaminant in groundwater at the site. An additional factor to consider is that turbidity levels exceeding 300 NTU (with some greater than 1,000 NTU) were reported for some samples (see Sections 5.4.1 and 7.2.3.4). Consequently, the elevated metals concentrations reported for some unfiltered samples may be a function, in part, of sample turbidity.

7.2.3.5 Subsurface Soil (Greater than 2 Feet) - Battery Site

This section discusses COPC selection for chemicals detected in subsurface soil samples collected at the Battery Site area during the field investigation conducted in 2004. One VOC, six SVOCs (including four PAHs), and 20 metals were detected in the 12 subsurface soil samples collected at the Battery Site. The maximum detected subsurface soil concentrations were compared to screening levels based on U.S. EPA Region 9 PRGs for residential land use and IDEM residential default closure levels for direct contact. The following chemicals were retained as COPCs for subsurface soil at the Battery Site:

- Inorganics - aluminum, arsenic, barium, iron, manganese, and vanadium

COPC selection for direct contact with subsurface soil is presented in Table 7-9.

A comparison of the maximum detected subsurface soil concentrations to U.S. EPA SSLs for chemical migration from soil to air is presented in Table 7-10. Concentrations reported for all chemicals were less than U.S. EPA SSLs for soil to air; therefore, exposures through inhalation of fugitive dust emissions from subsurface soil were not evaluated quantitatively in the HHRA.

The maximum detected subsurface soil concentrations were also compared to U.S. EPA SSLs for chemical migration from soil to groundwater and IDEM residential default closure levels for migration to groundwater in Table 7-10. The following chemicals were detected in subsurface soil at maximum concentrations exceeding the COPC screening levels for migration from soil to groundwater:

- Inorganics - aluminum, antimony, arsenic, barium, chromium, cobalt, manganese, nickel, and selenium.

The migration to groundwater comparisons presented in Table 7-10 were not used to select COPCs but to indicate the potential for chemicals in soil to impact groundwater. The concentrations of some metals (e.g., antimony and lead) in subsurface soil at the Battery Site were several orders of magnitude less than concentrations is surface soil at the site and are more similar to the levels detected in soil at SWMU 12 Proper. See the discussion regarding the migration of metals from soil to groundwater in Section 7.2.3.1.

7.2.3.6 Groundwater

This section presents the results of the COPC selection process for chemicals detected in groundwater at SWMU 12. The COPCs identified for SWMU 12 groundwater are presented in Table 7-11 (Puz), Table 7-12 (Pmz) and Table 7-13 (PlzMgd).

COPC Selection for Pennsylvanian Upper Zone Groundwater

The Puz groundwater data set consists of analytical results for the Rounds 1 and 2 groundwater samples (14 filtered and 63 unfiltered) collected in 2004 and 2005. Data from the two sampling rounds were combined into one data set because there was not a significant difference in constituent concentrations between the two rounds. Seventeen energetics, 23 total metals, ammonia, and nitrate/nitrite-N were detected in Puz samples. The comparison of the maximum detected groundwater concentrations to screening levels based on U.S. EPA Region 9 PRGs for ingestion of tap water, U.S. EPA MCLs, and IDEM groundwater default closure levels is presented in Table 7-11. The following chemicals were retained as COPCs for Puz groundwater:

- Energetics - 1,3-dinitrobenzene, TNT, 2,6-dinitrotoluene, 2-ADNT, 2-nitrotoluene, 4-ADNT, 4-nitrotoluene, HMX, and RDX.

- Inorganics(unfiltered) - aluminum, arsenic, beryllium, cadmium, chromium, cobalt, iron, lead, manganese, mercury, nickel, selenium, thallium, vanadium, zinc, and nitrite/nitrate-N.

- Inorganics(filtered) - aluminum, antimony, arsenic, beryllium, cadmium, cobalt, iron, manganese, mercury, nickel, thallium, and zinc.

2,6-Dinitrotoluene, HMX, chromium, mercury, selenium, and vanadium were selected as COPCs because the maximum detected concentrations of these non-carcinogens exceeded screening levels (set at an HI of 0.1). However, they do not exceed U.S. EPA Region 9 PRGs for tap water. Elevated concentrations

of some metals in groundwater appear to be the result of particulate matter (turbidity) in the samples. The turbidity readings in some samples were greater than 300 NTU, with the readings in several samples (12MWT14 and 12MWT39) being 1,000 NTU or more. The concentration of aluminum detected in unfiltered sample 12GWT3901 was 12,200 µg/L, but aluminum was not detected in the associated filtered sample (12GWT3901-F) collected at the same time and location. At the same location, arsenic was detected at a concentration of 14.9 µg/L in the unfiltered sample, but the concentration in the filtered sample was 1.9 µg/L. In addition, of the metals selected as COPCs for Puz groundwater, only concentrations of beryllium, cadmium, and mercury exceeded U.S. EPA MCLs in both filtered and unfiltered samples. The impact of turbidity on the unfiltered groundwater sample results and on the calculated risks based on such results is discussed in the risk characterization section (Section 7.5). As stated previously, of the metals identified as COPCs for SWMU 12, only aluminum (as aluminum powder) is known to have used in SWMU 12 operations. However, several other metals (e.g., antimony, arsenic, barium, cadmium, chromium, cobalt, manganese, and zinc) have been detected in SWMU 12 soils at concentrations exceeding both background concentrations and SSLs for the migration of chemicals from soils to groundwater by an order of magnitude.

COPC Selection for Pennsylvanian Middle Zone Groundwater

The Pmz groundwater data set consists of analytical results for the Rounds 1 and 2 groundwater samples (10 filtered and 14 unfiltered) collected in 2004 and 2005. Two energetics (HMX and RDX), 23 total metals, ammonia, and nitrate/nitrite-N were detected in the Pmz samples. The comparison of the maximum detected groundwater concentrations to screening levels based on U.S. EPA Region 9 PRGs for ingestion of tap water, U.S. EPA MCLs, and IDEM groundwater default closure levels is presented in Table 7-12. The following chemicals were retained as COPCs for Pmz groundwater:

- Energetics - RDX.
- Inorganics(unfiltered) - aluminum, antimony, arsenic, cadmium, chromium, cobalt, iron, lead, manganese, nickel, thallium, vanadium, and nitrate/nitrite-N.
- Inorganics(filtered) - antimony, arsenic, iron, manganese, and nickel.

HMX, aluminum, antimony, cadmium, chromium, cobalt, nickel, and thallium were selected as COPCs because the maximum detected concentrations exceeded screening levels (set at an HI of 0.1). However, they do not exceed U.S. EPA Region 9 PRGs or IDEM default closure levels for tap water. As with the Puz samples, elevated concentrations of several metals in some Pmz samples appear to be the result of particulate matter (turbidity) in the samples. The turbidity readings in these samples were also greater than 300 NTU, with the readings in several samples (12MWT29 and 12MWT48) being 1,000 NTU

or more. The concentration of aluminum in unfiltered sample 12GWT4801 was 31,000 µg/L, but aluminum was not detected in the associated filtered sample (12GWT4801-F). In addition, none of the metals in the filtered Pmz samples exceeded primary (health-based) drinking water standards.

COPC Selection for Pennsylvanian Lower Zone and Mississippian Glen-Dean Zone

The PlzMgd groundwater data set consists of analytical results for the Rounds 1 and 2 groundwater samples (two filtered and five unfiltered) collected in 2004 and 2005. Four energetics (TNT, 4-ADNT, HMX, and RDX), 19 total metals, and ammonia were detected in the PlzMgd samples. The comparison of the maximum detected groundwater concentrations to screening levels based on U.S. EPA Region 9 PRGs for ingestion of tap water, U.S. EPA MCLs, and IDEM groundwater default closure levels is presented in Table 7-13. The following chemicals were retained as COPCs for PlzMgd groundwater:

- Energetics - TNT, RDX.
- Inorganics(unfiltered) - antimony, arsenic, iron, manganese, and vanadium.
- Inorganics(filtered) - arsenic, iron, manganese, and nickel.

Antimony, iron, and vanadium were selected as COPCs because the maximum detected concentrations of these non-carcinogens exceeded screening levels (set at an HI of 0.1). However, they did not exceed U.S. EPA Region 9 PRGs. As with the Puz and Pmz samples, elevated concentrations for some metals in PlzMgd samples appear to be the result of particulate matter (turbidity) in the samples. For example, the concentrations of aluminum and iron in unfiltered sample 12GWT4901, which had a turbidity reading of 380 NTU, were 2,450 µg/L and 7,150 µg/L, respectively, but these metals were not detected in the associated filtered sample (12GWT4901-F). In contrast to the metals concentrations reported for the Puz and Pmz, none of the unfiltered or filtered metals concentrations in PlzMgd groundwater exceeded SDWA primary MCLs.

Upgradient groundwater samples were also collected during the RFI for the three groundwater zones. Comparisons of groundwater concentrations with concentrations in upgradient samples are presented in Tables 7-11, 7-12, and 7-13 and discussed in the uncertainty section (Section 7.6).

7.2.3.7 Surface Water

As discussed in Sections 5.1.2, surface water and sediment samples were grouped into three categories: gullies, East Tributary (to Turkey Creek), and TCMS. The gullies represent channels that are generally dry except during and immediately after rain storms. During heavy rains the water in these channels

flows swiftly. Some reaches of these channels may hold water for a time after a rain event, but only in small areas. The East Tributary channels are more likely to contain water throughout the year. The TCMS channel contains water year round (or nearly so) and carries a larger volume of water than water bodies in the other categories. Although groundwater seeps at SWMU 12 may also discharge to these surface water bodies/drainage channels, no seeps could be found at the time of sample collection.

Of the three types of drainage channels, the gullies are expected to be most directly influenced by site operations. The sampled gullies generally drain only SWMU 12 or locations upgradient of SWMU 12. These channels drain away from SWMU 12, primarily toward the east, west, and northeast. Six upgradient/upstream locations representing conditions unaffected by SWMU operations were sampled from the gully system. Those locations were 12SW/SD08, 12SW/SD22, 12SW/SD26, 12SW/SD28, 12SW/SD29, and 12SW/SD30 (see Figure 2-3). All other gully sampling locations are considered to be downgradient/downstream of SWMU 12.

The East Tributary is a primary tributary to Turkey Creek but carries a lesser volume of water than typically observed in Turkey Creek. Hence, samples from this area represent intermediate conditions between gully and TCMS conditions. The East Tributary receives overland flow from the eastern side of SWMU 12, and it discharges into Turkey Creek. One location, 12SW/SD16, was sampled to represent conditions upgradient of the East Tributary.

Turkey Creek integrates flow (and contamination, if present) from all sides of the peninsular SWMU 12. Turkey Creek also receives flow from nearby ridges. As noted above, the volume of water conveyed by the TCMS greatly exceeds the volume conveyed by the gullies or the East Tributary and, in contrast to these other channels, the TCMS flows most of the year. One location (12SW/SD25) was sampled to represent conditions upgradient/upstream of Turkey Creek; three locations were sampled for surface water and sediments in Turkey Creek. The integration of flow from ridges other than SWMU 12 also tends to dilute contamination from SWMU 12 with water (and possibly contaminants) from other ridges.

Because of the differences in environmental conditions and analytical results for samples from the gully, East Tributary, and Turkey Creek, these surface water bodies were evaluated separately in the HHRA for SWMU 12. Therefore, COPCs for gully surface water/sediment, East Tributary surface water/sediment, and Turkey Creek surface water/sediment were determined separately in Tables 7-14 through 7-19.

Unfiltered and filtered samples were collected from the surface water locations. In many cases, metals concentrations reported for the unfiltered samples were noticeably greater than metals concentrations reported for the filtered samples (e.g., aluminum and lead). A review of turbidity readings for the

unfiltered samples indicates that the concentrations reported for some of the unfiltered samples may be a consequence of elevated particulate levels (i.e., turbidity) in the samples.

COPC Selection for Gully Surface Water

Thirteen energetics, 23 metals, ammonia, and nitrate/nitrite-N were detected in gully surface water samples. The following chemicals were retained as COPCs for gully surface water:

- Energetics - TNT, 2-ADNT, 4-ADNT, and RDX.
- Inorganics(unfiltered) - aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, thallium, vanadium, zinc, and nitrite/nitrate-N.
- Inorganics(filtered) - arsenic, iron, manganese, and vanadium.

Most metals were selected as COPCs for gully surface water on the basis of maximum concentrations detected in unfiltered sample 12SW3501. The turbidity in this sample was greater than 1,000 NTU, and a comparison of the filtered (12SW3501-F) and unfiltered sample for location 12SW35 shows significant differences in some metal concentrations. For example, the concentration of aluminum detected in the unfiltered sample was 67,700 µg/L, and the concentration in the filtered sample was 77.4 µg/L. Likewise, the concentration of lead detected in the unfiltered sample was 458 µg/L, and the lead concentration in the filtered sample was 0.856 µg/L. Concentrations of lead in all other gully surface water samples were less than COPC screening criteria. Therefore, if this sample was not included in the data set, lead would not have been selected as a COPC for gully surface water. At the same location, arsenic was detected at a concentration of 20.3 µg/L in the unfiltered sample, but the concentration in the filtered sample was 0.46 µg/L. Also, vanadium was detected in the unfiltered sample (138 µg/L) but was not detected in the filtered sample. Consequently, it appears that the elevated concentrations for some metals in surface water are the result of particulate matter (turbidity) in the samples, and this has significantly increased the number of metals selected as COPCs. Arsenic (at a maximum concentration of 16.2 µg/L) was the only metal detected in filtered samples at concentrations exceeding primary SDWA MCLs.

COPC Selection for East Tributary Surface Water

Three energetics, 14 total metals, ammonia, and nitrate/nitrite-N were detected in East Tributary surface water samples. The following chemicals were retained as COPCs:

- Energetics - RDX
- Inorganic - arsenic (filtered and unfiltered)

Chemicals were not detected in the East Tributary surface water samples at concentrations exceeding SDWA MCLs.

COPC Selection for Turkey Creek Surface Water

Eleven metals and ammonia-N were detected in the two surface water samples collected in Turkey Creek.

The following chemicals were retained as COPCs for surface water in Turkey Creek:

- Inorganics - manganese (filtered and unfiltered)

Chemicals were selected as COPCs for the surface waters of the gullies, the East Tributary, and Turkey Creek based on a comparison of maximum concentrations to one or more of the human health screening levels [i.e., screening concentrations based on U.S. EPA Region 9 PRGs, federal MCLs or secondary MCLs (SMCLs), and IDEM residential default closure levels for groundwater] and concentrations in upgradient samples. Barium, chromium, cobalt, mercury, nickel, thallium, vanadium, and zinc were selected as COPCs in gully surface water because the maximum detected concentrations of these non-carcinogens exceeded screening levels (set at an HI of 0.1). However, the maximum concentrations did not exceed U.S. EPA Region 9 PRGs, IDEM default closure levels for tap water, or U.S. EPA MCLs. Likewise, manganese was selected as a COPC for surface water in Turkey Creek because the maximum detected concentration exceeded the screening level set at an HI of 0.1. However, the concentration did not exceed the U.S. EPA Region 9 PRG for residential tap water use. In addition, of the metals identified as COPCs, only aluminum (as aluminum powder) is known to have been used in SWMU 12 operations.

The use of the aforementioned screening levels for COPC selection for surface water assumes that surface water is used as a drinking source (i.e., potential receptors ingest 2 liters of water per day for 350 days per year). Drinking water criteria were used because surface water criteria for human health are currently not available. The use of these criteria for screening and risk assessment is conservative because it is unlikely that surface water at SWMU 12 would ever be used as a source of drinking water. Upgradient surface water samples were also collected during the RFI. Comparisons of surface water concentrations to concentrations in upgradient samples are presented in Tables 7-14, 7-15, and 7-16 and discussed in the uncertainty section (Section 7.6).

7.2.3.8 Sediment

As with surface water, COPCs for sediment were selected separately for gullies, East Tributary, and Turkey Creek. Tables 7-17, 7-18, and 7-19 summarize the COPC selection process for gully, East Tributary, and Turkey Creek sediment, respectively.

COPC Selection for Gully Sediment

Gully sediment samples were analyzed for semivolatiles, energetics, and metals. Ten SVOCs including nine PAHs, one energetic (TNT), and 20 metals were detected in gully sediment samples. The following chemicals were retained as COPCs for gully sediment:

- Inorganics - aluminum, antimony, arsenic, cadmium, iron, manganese, and vanadium

COPC Selection for East Tributary Sediment

Seventeen metals were detected in two East Tributary sediment samples analyzed for energetics and inorganics. The following chemicals were retained as COPCs for sediment in the East Tributary:

- Inorganics - aluminum, arsenic, iron, manganese, and vanadium

COPC Selection for Turkey Creek Sediment

Nineteen metals were detected in three Turkey Creek sediment samples analyzed for energetics and inorganics. The following chemicals were retained as COPCs for Turkey Creek sediment:

- Inorganics - aluminum, arsenic, iron, manganese, and vanadium

These constituents were identified as COPCs in sediment because maximum concentrations exceeded screening levels based on U.S. EPA Region 9 risk-based screening levels for residential soil and IDEM residential default closure levels for direct contact. Aluminum, antimony, cadmium, and vanadium were selected as COPCs in gully sediment because the maximum detected concentrations of these non-carcinogens exceeded screening levels (set at an HI of 0.1). However, they did not exceed U.S. EPA Region 9 PRGs for soil. Likewise, aluminum and vanadium in the East Tributary, and aluminum, manganese, and vanadium in Turkey Creek were selected as COPCs for sediment because the maximum detected concentrations exceeded screening levels (set at an HI of 0.1). However, they did not exceed U.S. EPA Region 9 PRGs for soil.

The use of U.S. EPA Region 9 and IDEM RBCs for soil to evaluate chemical concentrations in sediment is conservative because these criteria were established assuming residential land use scenarios (e.g., routine daily contact with soils). However, it is anticipated that a human receptor would be exposed to the sediments in gullies and streams at the site on a less frequent basis than is assumed for a typical residential exposure to soil. Consequently, the use of soil criteria for COPC screening is likely to overestimate potential risks from exposure to sediment. Comparisons of gully East Tributary and Turkey Creek sediment concentrations with concentrations in the upgradient/upstream samples are presented Tables 7-17 through 7-19.

7.2.4 Summary

Table 7-20 summarizes the chemicals retained as COPCs for soil, groundwater, surface water, and sediment at the SWMU 12 and shows the exposure point concentration (EPC) for each COPC used in the risk assessment. RAGS Part D tables for COPC selection are included in Appendix I.

7.3 EXPOSURE ASSESSMENT

This portion of the risk assessment defines and evaluates, quantitatively or qualitatively, the type and magnitude of human exposure to the chemicals present at or migrating from a site. The exposure assessment is designed to depict the physical setting of the site, to identify potentially exposed populations and applicable exposure pathways, to calculate concentrations of COPCs to which receptors might be exposed, and to estimate chemical intakes under the identified exposure scenarios.

Actual or potential exposures at SWMU 12 were determined based on the most likely pathways of contaminant release and transport, as well as human activity patterns. A complete exposure pathway has three components: a source of chemicals that can be released to the environment, a route of contaminant transport through an environmental medium, and an exposure or contact point for a human receptor.

7.3.1 Conceptual Site Model

This section discusses the conceptual site model (CSM) for SWMU 12. A CSM facilitates consistent and comprehensive evaluation of the potential risks to human health by creating a framework for identifying the pathways by which human receptors may come in contact with environmental media contaminated by site activities. A CSM depicts the relationships among the following elements, which are necessary for defining complete exposure pathways:

- Site sources of contamination
- Contaminant release mechanisms and transport/migration pathways
- Exposure routes
- Potential receptors

Section 6.2 presented a detailed CSM for SWMU 12. This section summarizes the CSM as it applies to the HHRA. Figure 7-2 illustrates the human health CSM for SWMU 12.

The elements of the CSM (contaminant source, release mechanisms, transport/migration pathways, exposure routes, and potential receptors) establish the manner and degree to which a potential receptor may be exposed to chemicals present at the site. The degree of risk incurred by a potential receptor varies according to the means of exposure, the duration of exposure, and the specific chemical to which the receptor is exposed. An exposure, however long in duration, does not necessarily result in an "unacceptable" health or environmental risk, although risks generally increase with increased frequency and/or duration of exposure.

The elements of the CSM, including how they pertain to SWMU 12, are discussed below. Sources of contamination, contaminant release mechanisms, transport and migration pathways, exposure routes, and potential receptors are defined. Table 7-21 provides a site-specific summary of the potential receptors evaluated for SWMU 12. A summary of the exposure routes addressed quantitatively for each human receptor is also provided in Table 7-21.

Site Sources of Environmental Contamination

MFA began operations when NSWC Crane was commissioned in December 1941 and was used for the production of large mines, depth charges, rocket heads, aerial bombs, and projectiles in buildings. The area was also used during the Korean and Vietnam Wars. MFA continued to produce ordnance until 1975, when production was suspended. Production was resumed in 1980 for a short period of time. Most recently, MFA has been used in the production of 2,000-pound aerial bombs. In addition to production, demilitarization activities take place at Buildings 151, 155, and 160. Past history at MFA indicates that demilitarization activities and documented contaminant releases also occurred at Buildings 152, 153, and 3110.

Prior to 1980, a variety of liquid wastes were disposed on site without treatment. Explosives-contaminated wastewater was discharged into unlined ponds or into storm drains and ditches.

Wastewater generated from cleaning operations was discharged into an unlined pond. Oily waters, battery acids, paint thinner, acetone, boiler blowdown, and solvents were dumped behind buildings or into ravines. Waste hydraulic oil was spread on dirt roads. Since the early 1980s, treatment plants have been built, wastewater streams have been connected to the sanitary sewer, and oils and solvents have been collected, segregated, and either recycled, sold, or properly disposed. The major sources of contamination are considered to be from washdown operations prior to 1980 and from the exhaust ventilation system.

Additional details concerning contaminants known or potentially released at MFA can be found in the RCRA Facility Investigation Phase I Environmental Monitoring Report (Halliburton NUS, 1992). Most documented contaminant releases that occurred involved TNT only (near Buildings 151, 152, 153, 160, and 3110) or TNT plus HMX and RDX near Buildings 160 and 3110, or an unspecified explosive powder (in the tunnel area of Building 152) (Halliburton NUS, 1992).

On March 4, 2002, there was a 72,000-gallon release of wastewater from the scrubber building (Building 3111). The building had not been in operation for up to a year, and all of the pumps were shut off as is normal procedure when the building is not in operation. The backflow prevention device failed, which allowed potable water to flood the building to the height of the 6-inch curb. The water then flowed out of the building, across the pavement, and into a ditch along the railroad tracks. Residual TNT from within Building 3111 resulted in a small amount of TNT contamination in the water. The spilled water was sampled, and the total quantity of TNT released was significantly less than the reportable quantity of 10 pounds in any 24-hour period. The contaminated water contained in the building was transferred to Building 3110 for treatment.

Battery Site

The Battery Site is located on the southern end of MFA, approximately 140 feet outside the perimeter fence, and is accessed through a gate. The site consists of two areas: (1) Battery Area - where batteries were dumped on the ground surface and (2) Soil Area - an adjacent area where soil and construction debris were dumped in small mounds. The origin of the debris and the dates of disposal are unknown. A reasonable assumption was made by personnel from the NSWC Crane Environmental Protection Department (EPD) that the mounded soil in the Soil Area originated from within MFA, possibly from the installation of road culverts.

The Battery Site was discovered early in the 1990s when a representative of EPD noticed the gate and trail area leading away from the site. Further investigation revealed the presence of a separate Battery

Area. At that time, the batteries were recognizable as AA household type, and their numbers were estimated to be in the thousands. Just prior to MFA Battery Site cleanup operations, the batteries were all but unrecognizable and only their inner cores were visible on the ground surface. The size of the Battery Area was approximately 3,500 square feet.

The Soil Area had no apparent unusual characteristics: no staining was present and no odor was detectable. The size of the Soil Area was approximately 2,355 square feet consisting of several soil mounds, none exceeding 4 feet in height. The potential for the waste from either of these areas to be a listed or characteristic waste was unknown.

The NSWC Crane Environmental Contracting Officer Technical Representative (ECOTR) made the reasonable assumption that the mounded soil in the Soil Area originated from within MFA. Soil samples obtained from the Soil Area were therefore analyzed for the MFA constituents list generated for bioremediation activities. Based on the unknown origins of the soil mounds, the U.S. EPA Region 5 requested that at least one soil sample from the Soil Area be analyzed for Appendix IX constituents. Soil samples from the Battery Area were analyzed for toxic characteristics and metals. The additional metals chosen for analysis were based on constituents listed in several Material Safety Data Sheets (MSDSs) for batteries, as well as Appendix IX metals.

In October 2001 and June 2002, an interim measure action was conducted for the identification, removal, treatment, and/or disposal of contaminated soil from the SWMU 12 Battery Site. The work was performed in conjunction with the requirements of the approved Final Interim Measures Work Plan for MFA Battery Site (Toltest, 2001). Prior to implementation of the interim measure action, pre-excavation soil samples were collected in February 2001. A report on the interim measure action was completed in December 2002 (Toltest, 2002).

Pre-excavation sampling and analysis of soil samples from the Soil Area and Battery Area indicated that contamination was present in each area at concentrations greater than the industrial cleanup goals. Explosives contamination was present in the Soil Area, and metals contamination was present in the Battery Area.

Remedial actions in the Soil Area included the excavation and treatment of the explosives-contaminated soil in compost windrow N-214 at the NSWC Crane Bioremediation Facility to achieve residential cleanup levels. The treated soils were used as backfill at MFB. Post-excavation sampling and analysis of the Soil Area indicated that the remaining contamination was less than U.S. EPA Region 9 PRGs and IDEM

benchmarks for industrial worker exposure to soils. Based on post-excavation analytical results, no further action was recommended for the Soil Area.

In 2004, a follow-up interim measure action was performed at the Soil Area. The action was performed pursuant to the requirements of the approved Final Interim Measures Work Plan for MFA Battery Site (Toltest, 2001). In September 2004, excavation activities commenced by removing small trees and boulders. Overburden soil and rock were removed from above the seam of contamination and placed to the side; excavation of the vein of contamination followed. Excavation of the vein was started at the northern end of the slope and proceeded to the south. The vein of contaminated soil was still visible in a trench on the southern end of the slope. The aerial extent of this contamination was not determined.

Four post-excavation soil samples were collected at depths of 0 to 2 feet bgs and analyzed for metals, VOCs, SVOCs, herbicides, and explosive compounds. One sample was obtained from the vein of contamination in the trench that was dug at the southern end of the area of excavation. The analytical results (TtNUS, 2004c) indicated that the southernmost soil sample (12SS210002) had the highest concentrations of most energetic and inorganic contaminants. Soil sample 12SS21000 was the only sample of the four that had detectable concentrations of the energetics RDX (6.1 mg/kg), HMX (1.7 mg/kg), and 1,3,5-trinitrobenzene (0.84 mg/kg). This same sample had a lead result of 429,000 mg/kg. Lead concentrations in the other three soil samples ranged from 366 to 3,230 mg/kg. The antimony concentration was notably higher (3,610 mg/kg) at sample 12SS210002 in comparison to concentrations in the other three samples, which ranged from 11.4 to 213 mg/kg. The mercury concentration of 0.31 mg/kg at 12SS210002 was higher in comparison to the other three locations, which had concentrations ranging from 0.034 to 0.069 mg/kg. The tin concentration at 12SS210002 was 838 mg/kg, while concentrations at the other three locations ranged from 12.4 to 90.7 mg/kg.

Post-excavation sampling confirmed that contaminated soil is still present at the site. Results indicated that concentrations of antimony and lead in two samples, 12SB21 and 12SB23, exceeded industrial cleanup goals. The levels of arsenic in all four samples exceeded the industrial cleanup goal. Toltest recommended that additional exploration trenches be dug in an attempt to determine the horizontal extent of the vein.

Based on historical site information and sampling, the following parameters are among the site-related chemical contaminants known to be present or potentially present in environmental media at SWMU 12:

- Explosives (e.g., TNT, HMX, and RDX) and their degradation products (e.g., 2-ADNT)
- VOCs

- SVOCs
- Inorganics (i.e., metals, nitrate/nitrite-N)

The summary of analytical data presented in COPC selection Tables 7-1 through 7-19 indicate that explosives compounds (e.g., TNT) and metals are the primary contaminants remaining in the environmental media at SWMU 12.

Potential Contaminant Release Mechanisms and Transport/Migration Pathways

Based on available historical information for SWMU 12, releases of potentially hazardous constituents to environmental media have occurred as a result of historical site operations in the MFA area. Media of concern at MFA have historically included soil, air, surface water, and groundwater (Halliburton NUS, 1992). Soil was considered a major pathway because explosive powders and particulates were washed from the rooftops of the process buildings onto nearby soil. Air was considered a migration pathway because particulates had been released from building ventilation systems. However, air is no longer considered a major pathway because a particulate abatement system was installed in 1973. Surface water was considered a migration pathway because explosive powders and particulates from the rooftops of the process buildings were deposited onto nearby drainageways and because of past surface water runoff and contaminant releases from the site. A detailed discussion of contaminant transport and migration at SWMU 12 and the Battery Site is presented in Section 6.2.2.

Based on the historical information, plausible contaminant release and migration mechanisms for SWMU 12 include the following:

- Transport of surface soil contaminants to subsurface soils and groundwater (and from one aquifer to another) via infiltration, percolation, and migration within the groundwater aquifer.

- Overland runoff of surface waters, sediments, and surface soil from SWMU 12 via ditches and culverts to intermittent drainageways on the borders of the MFA, eventually flowing into Turkey Creek.

- Migration of contaminants in groundwater (i.e., lateral migration) to potential receptor locations downgradient of SWMU 12 source areas and beyond the NSWC Crane boundary.

- Migration of fugitive dusts and VOCs from surface soils and subsurface soils (e.g., if construction and excavation activities occur).

A more detailed CSM analysis is presented in Section 6.0.

Potential Current and Future Receptors of Concern and Exposure Pathways

NSWC Crane is an active naval base and will remain active for the foreseeable future. SWMU 12 is an active facility, and operations at this facility are expected to continue for the foreseeable future. However, for purposes of completeness, the baseline risk assessment considered receptor exposure under residential, industrial, and recreational land use scenarios. Based on current and potential future land use, the following potential receptors may be exposed to contaminated environmental media within the study area:

- **Maintenance Workers** - A plausible receptor under current and future land use. This includes adult military or civilian personnel assigned duties on an infrequent basis within the study area (e.g., groundskeeping activities and storm sewer and drainage maintenance). This receptor could be exposed to soils (incidental ingestion and dermal contact), surface water (dermal contact), sediments (incidental ingestion and dermal contact), and air (inhalation). Direct contact with groundwater or subsurface soils is not anticipated for this receptor.

- **Occupational Worker** - A plausible receptor under current and future land use. This includes adult military or civilian personnel assigned to routine daily work tasks. This receptor could be exposed to soil (incidental ingestion and dermal contact) and air (inhalation). In addition, it was conservatively assumed that the occupational worker may be exposed to groundwater (ingestion and dermal contact). (A public water supply is not currently available within the study area.) It is anticipated that this receptor would not be routinely exposed to subsurface soils, surface waters, or sediments. This receptor is expected to be exposed to soils on a more frequent basis than the maintenance or construction worker.

- **Trespassers** - A plausible receptor under current or future land use. Although access to the base is controlled, once inside the base, access to the study area is not limited by any physical constraints. In addition, hunting activities are permitted at the base. Because the study area is relatively remote and surrounded by forested areas, hunters (particularly adolescents) may trespass within the study area. This receptor may be exposed to potentially contaminated soil (incidental ingestion and dermal contact), air (inhalation), and surface water (incidental ingestion and dermal contact) and sediments (incidental ingestion and dermal contact) in the intermittent streams. However, exposure to surface water is likely to be limited in some areas because of the intermittent nature of the surface water in

swales and drainage ditches. Also potential exposures to surface water will be limited to wading because the streams at the sites are not deep enough for swimming. Direct contact with groundwater or subsurface soils is not anticipated for this receptor.

- **Construction Workers** - A plausible receptor under future land use. Construction/excavation workers are evaluated in the risk assessment to account for the possibility that excavation and construction could occur in the study area in the future. This receptor could be exposed to surface and subsurface soils (incidental ingestion and dermal contact), groundwater (dermal contact), and air (inhalation). Routine exposure to surface water and sediments is not expected for the construction worker. Significant exposures by a construction worker to groundwater are unlikely because if a construction worker was to have prolonged contact with groundwater, he/she would most likely wear protective clothing such as rubber boots and/or hip waders, which would limit receptor exposure. In addition, most excavation activities would utilize construction equipment such as a backhoe, which would limit a construction worker's exposure. Also, if significant groundwater was encountered during the excavation of a trench or foundation, groundwater would most likely be pumped out of the excavation so that the construction activities could be completed.

- **Recreational Users** - A plausible receptor under future land use. If NSWC Crane closed, the most likely scenario is that the property would be converted to a park. A recreational user may be exposed to potentially contaminated soil (incidental ingestion and dermal contact), air (inhalation), surface water (incidental ingestion and dermal contact), and sediments (incidental ingestion and dermal contact). Exposures to surface water will be limited to wading because the streams at the site are not deep enough for swimming. In addition, it was conservatively assumed that the recreational user may be exposed to groundwater (ingestion and dermal contact) while cleaning up (e.g., washing hands, face, and legs) after visiting the hypothetical park. (A public water supply is not currently available within the study area.) NSWC Crane is not expected to close because principal base operations, the demilitarization of munitions, are critical to the support of the United States Naval fleet.

- **On-Base Residents** - An unlikely receptor under future land use. Although this scenario is highly unlikely, a future residential scenario is typically evaluated in a risk assessment for decision-making purposes. For example, the need for deed restrictions at a site may be eliminated prior to site closure if minimal risks are estimated for residential receptors. It is assumed that a hypothetical resident may be exposed to soils (incidental ingestion and dermal contract), groundwater (ingestion and dermal contact), surface water (ingestion and dermal contact), air (inhalation), and sediment (incidental

ingestion and dermal contact). Potential exposures to surface water will be limited to wading because the streams at the sites are not deep enough for swimming.

Details regarding the assumed receptor characteristics (e.g., intake rate, frequency, duration of exposure) are defined in Section 7.3.4.

7.3.2 Central Tendency Exposure Versus Reasonable Maximum Exposure

Traditionally, exposures evaluated in the HHRA were based on the concept of a reasonable maximum exposure (RME) only, which is defined as "the maximum exposure that is reasonably expected to occur at a site" (U.S. EPA, 1989). However, subsequent risk assessment guidance (U.S. EPA, 1992a) indicates the need to address an average case or central tendency exposure (CTE).

To provide a full characterization of potential exposure, both RME and CTE scenarios were evaluated in the HHRA for SWMU 12. The available guidance (U.S. EPA, 1993a) concerning the evaluation of CTE is limited and at times vague. Therefore, professional judgment was exercised when defining CTE conditions for a particular receptor at a site.

7.3.3 Exposure Point Concentrations

The EPC, which is calculated for COPCs only, is an estimate of the chemical concentration within an exposure unit (EU) likely to be contacted over time by a receptor and is used to estimate exposure intakes. An EU is defined as the area typically encountered/traversed by a receptor under a particular land use scenario. For example, a residential lot size of ¼ acre to 2 acres is often used for the evaluation of a hypothetical future resident. However, the size of an EU is typically based on the distribution of chemical concentrations in a medium as well as on presumed receptor activity patterns.

The following EUs were considered in the risk assessment for SWMU 12:

- Historical Soil Areas - The IMR (MK, 2000) designated six areas as potentially impacted by historical operations at SWMU 12. These included the areas around Buildings 151, 152, 153/154, 157, 158/159, and 160. As indicated in the IMR, ICSs were collected in 1997 and 1998 and analyzed for explosives, the eight RCRA metals plus aluminum, and nine VOCs. Based on the result from the ICSs, the areas around Building 152, 153/154, 157, and 158/159 were excavated because of elevated concentrations of explosives, mainly RDX. The excavated areas were subsequently backfilled with bioremediated soil that met either residential or industrial cleanup goals. The areas

around Buildings 151 and 160 did not require remediation because explosives concentrations were less than cleanup goals. The six areas listed above were designated as EUs for SWMU 12 and were considered in the quantitative risk evaluation. However, as explained in Section 7.6.2, risks were not quantitatively evaluated for Buildings 151 and 160 because soil in these areas did not require remediation and because a preliminary risk evaluation indicated that risks for explosives in these areas were less than U.S. EPA goals.

- Soil samples collected within SWMU 12 Proper in 2004/2005 to evaluate the nature and extent of explosives and metals contamination, as described in Section 3.4.1.1 of QAPP Addendum No. 1 (TtNUS, 2003b). These samples were collected along the edges of settling basins at Structure 3110 located in the center of the site and at Structure 3037 located in the northern portion of MFA (Figure 2-1). The 2004/2005 samples were not collected in the same locations as the historical samples.

- Soil samples collected at the Battery Site in August and September 2004.

In summary, the following six EUs were evaluated for exposure to soil in this HHRA:

- SWMU 12 Proper (2004/2005 data)
- Building 152 (historical and bioremediation data)
- Building 153/154 (historical and bioremediation data)
- Building 157 (historical and bioremediation data)
- Building 158/159 (historical and bioremediation data)
- The Battery Site (2004 data)

- Surface water and sediment - As described in Sections 5.1.2 and 7.2.3.7, three EUs were defined for evaluating risks from surface water and sediment: the gullies, the East Tributary, and Turkey Creek. These were evaluated as distinct EUs because they are separate geographic areas and because of differences noted in the analytical results reported for these areas.

Groundwater - As described previously, three EUs are evaluated for groundwater: Puz, Pmz, and PlzMgd. These three groundwater zones were evaluated as distinct EUs because they are separate aquifers and because of differences in the analytical results reported for each zone.

The following guidelines were used to calculate the EPCs for the EUs defined above:

- If a soil, surface water, or sediment data set for an EU contained fewer than 10 samples, the EPC for the RME and CTE cases was defined as the maximum detected concentration.

- If a surface water or sediment data set for an EU contained 10 or more samples, the 95-percent upper confidence limit (UCL) on the arithmetic mean, which was based on the distribution of the data set, was selected as the EPC for the RME and CTE cases. EPCs were calculated following U.S. EPA's Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (2002c) using the U.S. EPA's ProUCL guidance (Singh, A. et al., 2004).

- The EPCs for groundwater were the arithmetic averages of concentrations in wells in the highly concentrated area of the plume. For explosives, this area was determined to be the area on the ridge encompassing Buildings 152, 153/154, 157, and 158/159, and was defined based on RDX concentrations. For most metals, the highly concentrated area of the Puz plume was the area in the southern portion of the site that included locations 12MWT23, -24, -24A, and -39. For arsenic in the Puz, the highest concentrations were detected in the western portion of the site, and the EPC for arsenic was the average of concentrations at locations 12MWT01, -02, -03, -04, and -05. For Pmz groundwater, the most highly concentrated area of the plume for RDX and metals was the area on the eastern side of the site that included locations 12MWT45, -46, 47, and -48. The maximum concentration was used as the EPC for PlzMgd groundwater because the data set contained less than 10 samples.

- EPCs for soil data sets containing more than 10 samples were calculated using several different approaches. Different methods were used to calculate the EPCs because the soil conditions and data sets in areas where remediation had occurred (represented by historical data) are different from areas investigated in SWMU 12 Proper. The methodologies used to calculate soil EPCs are as follows:

  - For samples collected in SWMU 12 Proper and the Battery Site, the EPCs for surface and subsurface soil were the 95-percent UCLs calculated as described above.

  - For historical soil samples reported in the IMR, EPCs were calculated using a weighted average approach. A weighted average approach was used for the historical data because the concentrations reported for the historical samples represent different volumes of material left in place after remediation. The weighted average approach was also selected because the concentrations of the bioremediated soil, which constitutes a large portion of the soil volume, are averages of windrow data calculated in the IMR. Often materials from different windrows were

placed in the same excavated grid area. Therefore, windrow data represented by average concentrations were mixed with other windrows in the same excavated grid. The materials in the remediated areas consist of the following:

1. Soil in areas (grids) that did not need to be excavated because ICS concentrations were less than residential or industrial cleanup goals (The residential and industrial cleanup goals for RDX used in the IMR were 4 mg/kg and 17 mg/kg, respectively).

2. Bioremediated soil used as backfill for excavated areas. The bioremediated soil was placed in the excavated areas only if explosives concentrations in the bioremediated soil met cleanup goals. Because the grids were usually excavated to a depth of 3 feet, the backfilled bioremediated soil could be classified as either surface or subsurface soil. The concentrations of explosives in the bioremediated soil presented in the IMR and used in the EPC calculations are <u>averages</u> of samples collected in the compost windrows where the soils were treated.

3. Soil remaining in areas that were excavated, which are represented by PES results. PESs were collected from the sidewalls and bottoms of the excavated grid areas. The IMR does not specify the depth of the sidewall samples and therefore the sidewall samples could be interpreted as either surface or subsurface soil.

4. Soil in a few grids that could not be completely excavated because of obstructions such as utility lines, because the bottom of the grid was on rock, because the soil provided structural support for steam lines, or because blast wall footers were encountered. The concentrations of explosives in these soils exceeded cleanup goals. Data from the IMR indicates that these areas were excavated as much as possible and backfilled with bioremediated soil. The residual contaminant concentrations in these grids are represented by a mixture of ICSs, PESs, and bioremediated soil analytical results.

Discussions with TT (by E-mail) and an examination of the grid information presented in Figures 1-4 through 1-11 indicated that the volume of soil left in place (because the soil concentrations did not exceed remediation goals) and the volume of backfilled bioremediated soil constitute most of the soil volume in the six building areas evaluated in the IMR (Items 1 and 2 listed above). The amount of soil in the sides and bottoms of the excavated grids (Item 3) constitute a smaller volume of material, and the amount of soil in the few grid areas that could not be completely excavated (Item 4) constitute a very small amount of material.

Based on this analysis, the following weighting scheme was devised to estimate EPCs for soil in the remediated building areas: concentrations in non-excavated areas and backfilled areas (Items 1 and 2) are assumed to represent 90 percent of the soil volume, PES concentrations in the excavated areas (Item 3) were assumed to constitute 9 percent of the total soil volume, and residual concentrations in the grids that could not be excavated (Item 4) were assumed to constitute 1 percent of the total soil volume. The assumption of 1 percent is considered conservative because the volume of soil that could not be excavated is likely to be much less than the total soil volume.

The following example demonstrates the EPC calculation using weighted averages.

Example Calculation - RDX at Building 153/154

- Average of RDX concentrations in unexcavated and backfilled grids = 3.2 mg/kg (90 percent of volume)

- Average of RDX concentrations remaining in excavated grids = 73.8 mg/kg (9 percent of volume)

- Average of RDX concentrations in grids that could not be completely excavated = 1,563 mg/kg (1 percent of volume)

$$\text{Weighted average} = (0.9 \times 3.2) + (0.09 \times 73.8) + (0.01 \times 1563) = 25 \text{ mg/kg}$$

This value was used as the EPC for calculating risks from RDX in surface/subsurface soil at Building 153/154. Note that EPCs (and risks) were calculated for Buildings 152, 153/154, 157, and 158/159 but not for Buildings 151 and 160. Risks were not quantitatively evaluated for Buildings 151 and 160 because explosives concentrations in the ICSs were less than cleanup goals (and remediation was not required) and because a preliminary risk evaluation indicated that risks for explosives from these areas would meet U.S. EPA benchmarks.

Analytical results less than sample-specific detection limits were substituted with one-half the detection limit prior to the calculation of EPCs.

Table 7-20 summarizes the EPCs used in this HHRA. RAGS Part D Tables for the EPCs are presented in Appendix I.

7.3.4 Chemical Intake Estimation

The methodologies and techniques used to estimate exposure intakes are presented in this section. Intakes for the identified potential receptor groups were calculated using current U.S. EPA risk assessment guidance (e.g., 1991, 1997a, and 2004a) and presented in the risk assessment spreadsheets. All quantitative risk assessment results are presented in RAGS Part D format tables (Appendix I).

Non-carcinogenic intakes were estimated using the concept of an average annual exposure. Carcinogenic intakes were calculated as an incremental lifetime exposure, which assumed a life expectancy of 70 years. Assumptions regarding exposure are presented in Tables 7-22 and 7-23 for the RME and CTE scenarios, respectively. The majority of the exposure assumptions that were used to estimate chemical intakes were based on default assumptions described in the standard U.S. EPA guidance and are summarized in Tables 7-22 and 7-23. The following paragraphs discuss the non-default receptor-specific exposure assumptions that were used in the risk assessment.

7.3.4.1 Dermal Contact with Soil/Sediment

Direct physical contact with soil and sediment may result in the dermal absorption of chemicals. Exposures associated with the dermal route were estimated in the following manner (U.S. EPA, 2004a):

$$\text{Intake}_{si} = \frac{(C_{si})(SA)(AF)(ABS)(CF)(EF)(ED)}{(BW)(AT)}$$

where:

Intake_{si}	=	amount of chemical "i" absorbed during contact with soil/sediment (mg/kg/day)
C_{si}	=	concentration of chemical "i" in soil/sediment (mg/kg)
SA	=	skin surface area available for contact (cm^2/day)
AF	=	skin adherence factor (mg/cm^2)
ABS	=	absorption factor (dimensionless)
CF	=	conversion factor (1×10^{-6} kg/mg)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (year)
BW	=	body weight (kg)

AT = averaging time (days);
for non-carcinogens, AT = ED x 365 days/year;
for carcinogens, AT = 70 years x 365 days/year

Exposed surface areas of the body available for dermal contact were determined on a receptor-specific basis because they correspond with assumed human activities and clothing worn during exposure events. Current guidance documents (U.S. EPA, 1997a and 2004b) were used to develop the default assumptions concerning the amount of skin surface area available for contact for a receptor. To maintain consistency from project to project, input parameters previously used for other NSWC Crane risk assessments (e.g., TtNUS, 2003a and 2003b) were reviewed when developing the exposed surface areas. The rationales used to select the skin areas were as follows:

- For construction workers, maintenance workers, and occupational workers exposed to surface soil or sediment, the surface area available for soil contact was assumed to be the head, hands, and forearms. The skin surface area is 3,300 square centimeters (cm^2) for the CTE and RME scenarios. These values represent the 50th-percentile areas for the head, hands, and forearms (U.S. EPA, 2004a).

- For adolescent trespassers, 25 percent of the total body surface area for an adolescent (aged 6 to 16) was assumed to be available for surface soil and/or sediment contact. The RME value (3,820 cm^2) was derived from the 95th-percentile surface area data, and the CTE value (3,100 cm^2) was derived from the 50th-percentile data, as provided in Table 6-6 of the Exposure Factors Handbook (U.S. EPA, 1997a).

- For adult recreational users exposed to soil/sediment, the exposed surface area available for contact was the sum of the head, arms, hands, lower legs, and feet of an adult male. This skin surface area is 9,070 cm^2 for the RME and CTE scenarios. This value represents the 50th-percentile areas for the arms, hands, lower legs, and feet (U.S. EPA, 1997a). For a small child recreational user (0 to 6 years old), it was assumed that 50 percent of the body surface area was exposed to surface soil and sediment (i.e., 3,300 cm^2). This value represents the 50th-percentile areas presented in Table 6-6 of the Exposure Factors Handbook (U.S. EPA, 1997a).

- For adult residents exposed to surface soil/sediment, the exposed surface area available for contact was the U.S. EPA recommended value of 5,700 cm^2 for the RME and CTE scenarios (U.S. EPA 2004b). This value assumes that the adult resident is wearing a short-sleeved shirt, shorts, and shoes; therefore, the exposed skin surface is limited to the head, hands, forearms, and lower legs.

For a child resident, the recommended value of 2,800 cm^2 was used as the exposed skin surface area for the RME and CTE scenarios (U.S. EPA, 2004b). This value assumes that the child resident is wearing a short-sleeved shirt, shorts, and no shoes; therefore, the exposed skin surface area is limited to the head, hands, forearms, lower legs, and feet.

The following values of soil adherence factors provided in RAGS Part E (U.S. EPA, 2004b) were used to evaluate risks from exposure to soil and sediment:

- Construction workers - 0.3 mg/cm^2 for the RME and 0.1 mg/cm^2 for the CTE. These values are the 95th-percentile and geometric mean values for construction workers, respectively (U.S. EPA, 2004b and 2002a).

- Maintenance workers and occupational workers - 0.2 mg/cm^2 for the RME and 0.02 mg/cm^2 for the CTE (U.S. EPA, 2004b).

- Adolescent trespassers, child recreational users, and child residents - 0.2 mg/cm^2 for the RME and 0.04 mg/cm^2 for the CTE. These values are the 95th-percentile and geometric mean values presented for soccer players (teens) playing in moist conditions (U.S. EPA, 2004b).

- Adult recreational users and adult residents - 0.07 mg/cm^2 for the RME and 0.01 mg/cm^2 for the CTE (U.S. EPA, 2004b).

For the constituents identified as COPCs in soil, the following absorption factors were used (U.S. EPA, 2004b):

- Semivolatile organics - 0.1
- PAHs - 0.13
- Arsenic - 0.03
- Cadmium - 0.001
- Energetics
  TNT - 0.032
  2-ADNT - 0.006
  4-ADNT - 0.009
  HMX - 0.006
  RDX - 0.015

As indicated in RAGS Part E, absorption factors for other metals have not been developed due to insufficient data to support a default value. Therefore, risks from dermal absorption of metals (other than arsenic and cadmium) from soil were not quantified in this risk assessment. The uncertainty associated with the omission of these constituents is discussed in the uncertainty analysis.

7.3.4.2 Incidental Ingestion of Soil and Sediment

Incidental ingestion of soil (and sediment) by potential receptors coincides with dermal exposure. Exposures associated with incidental ingestion were estimated in the following manner (U.S. EPA, 1989):

$$Intake_{si} = \frac{(C_{si})(IR_s)(FI)(EF)(ED)(CF)}{(BW)(AT)}$$

where:

$Intake_{si}$	=	intake of contaminant "i" from soil or sediment (mg/kg/day)
C_{si}	=	concentration of contaminant "i" in soil or sediment (mg/kg)
IR_s	=	ingestion rate (mg/day)
FI	=	fraction ingested from contaminated source (dimensionless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (year)
CF	=	conversion factor (1×10^{-6} kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for non-carcinogens, AT = ED x 365 days/year;
		for carcinogens, AT = 70 years x 365 days/year

The same exposure frequencies and durations used in the estimation of dermal intakes were used to estimate exposure via incidental ingestion. Default values of 1.0 were used for the fraction of soil ingested from the source for both the RME and CTE scenarios. Sediment ingestion rates were the same as those assumed for soil ingestion except that, for recreational users, the fraction ingested was assumed to be 0.5 for both the RME and CTE scenarios.

7.3.4.3 Dermal Contact with Groundwater and Surface Water

The same equation was used to estimate intakes for dermal contact with groundwater and surface water. Direct contact with groundwater at SWMU 12 is limited to exposure that would occur under residential, recreational, typical industrial (occupational), and construction scenarios. Hypothetical future on-base residential receptors were assumed to use groundwater for domestic purposes (i.e., bathing, showering, dish washing) that can result in dermal exposure. Short-term dermal exposure was assumed to occur for the construction worker during excavation activities and for the hypothetical recreational user or occupational worker receptors that may occasionally use restroom facilities (supplied by groundwater pumped from the underlying aquifer) while working or recreating. (Neither restroom facilities nor groundwater supply wells exist at SWMU 12 at this time). Dermal contact with surface water may also occur while receptors are involved in certain activities such as landscaping (maintenance worker), trespassing, or recreational sports (e.g., hiking, wading, etc.).

The following equation was used to assess exposures resulting from dermal contact with water (U.S. EPA, 2004b):

$$DAD_{wi} = \frac{(DA_{event})(EV)(ED)(EF)(A)}{(BW)(AT)}$$

where:

DAD_{wi}	=	dermally absorbed dose of chemical "i" from water (mg/kg/day)
DA_{event}	=	absorbed dose per event (mg/cm^2-event)
EV	=	event frequency (events/day)
ED	=	exposure duration (year)
EF	=	exposure frequency (days/year)
A	=	skin surface area available for contact (cm^2)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/year;
		for carcinogens, AT = 70 years x 365 days/year

Groundwater exposure for hypothetical future on-base residential receptors using groundwater at the site as a domestic water supply was assumed to occur on a daily basis. Exposure to groundwater for construction workers, recreational users, or typical occupational workers and exposure to surface water for maintenance workers, trespassers, and recreational users were also assumed to occur each day the receptor visits the study area. Dermal intakes for residents while showering or bathing assumed total body exposure. For construction workers, trespassers, occupational workers, maintenance workers, and

recreational users, the exposed surface area of the body available for contact was based on assumed activities and was similar to the assumptions outlined for dermal contact with soil and sediment.

The absorbed dose per event (DA_{event}) was estimated using a non-steady-state approach for organic compounds and a traditional steady-state approach for inorganics. For organics, the following equations apply:

$$If\ t_{event} < t^{*},\ then:\ DA_{event} = (2)(K_p)(FA)(C_{wi})(CF)\left(\sqrt{\frac{6\,\tau\, t_{event}}{\pi}}\right)$$

$$If\ t_{event} > t^{*},\ then:\ DA_{event} = (K_p)(FA)(C_{wi})(CF)\left(\frac{t_{event}}{1+B} + 2\,\tau\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right)$$

where:

t_{event}	=	duration of event (hour/event)
t^{*}	=	time it takes to reach steady-state conditions (hour)
K_p	=	permeability coefficient from water through skin (cm/hour)
FA	=	chemical-specific fraction absorbed (dimensionless)
C_{wi}	=	concentration of chemical "i" in water (mg/L)
CF	=	conversion factor (0.001 L/cm^3)
B	=	dimensionless ratio of the permeability of the stratum corneum relative to the permeability across the viable epidermis
τ	=	lag time (hour)
π	=	pi (dimensionless; equal to 3.1416)

Values for the chemical-specific parameters (t^{*}, K_p, τ, FA, and B) were obtained from RAGS Part E, the current dermal guidance (U.S. EPA, 2004b) and are presented in the risk calculation tables in Appendix I. If no published values were available for a particular compound, they were calculated using equations provided in the cited guidance.

The following non-steady-state equation was used to estimate DA_{event} for inorganics:

$$DA_{event} = (K_p)(C_{wi})(t_{event})$$

In general, the recommended default value of 0.001 was used for the dermal permeability of inorganic constituents. For most metals, dermal absorption is not a significant pathway because penetration through the skin is minimal.

7.3.4.4 Direct Ingestion of Groundwater and Incidental Ingestion of Surface Water

Residents may be exposed to groundwater via direct ingestion. In addition, maintenance workers, trespassers, recreational users, and residents may incidentally ingest surface water while at the site. Intakes associated with ingestion of water were evaluated using the following general equation (U.S. EPA, 1989a):

$$\text{Intake}_{wi} = \frac{(C_{wi})(IR_w)(EF)(ED)}{(BW)(AT)}$$

where:

Intake_{wi}	=	intake of chemical "i" from water (mg/kg/day)
C_{wi}	=	concentration of chemical "i" in water (mg/L)
IR_w	=	ingestion rate for groundwater (L/day) or
		ingestion rate for surface water (L/day) = (CR)(ET)
		CR = contact rate for surface water (L/hour)
		ET = exposure time for surface water (hour/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (year)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for non-carcinogens, AT = ED x 365 days/year;
		for carcinogens, AT = 70 years x 365 days/year

The same exposure times, frequencies, and durations used to assess dermal exposure to water were used to estimate intakes for ingestion of water.

7.3.4.5 Summary of Exposure Parameters

A summary of the exposure input parameters for all exposure pathways are presented in Tables 7-22 and 7-23 for the identified potential receptor groups at SWMU 12. In general, standard default parameters (e.g., U.S. EPA, 1991 and 1997a), which combine mid-range and upper-end exposure factors, were used

to assess RME conditions. CTE was assessed primarily by the use of mid-range exposure factors presented in current risk assessment guidance (U.S. EPA, 1989 and 1993a).

7.3.5 Exposure to Lead

Lead was selected as a COPC for soil, groundwater, and surface water. The equations and methodology presented in the previous section cannot be used to evaluate exposure to lead because of the absence of published dose-response parameters. Exposure to lead was assessed using the following models:

- The latest version of U.S. EPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model for lead (U.S. EPA, 2002d). This model is typically used to evaluate lead exposure assuming a residential land use scenario.

- The U.S. EPA's Technical Review Workgroup (TRW) Model for Lead (U.S. EPA, 2003a). This model is typically used to evaluate lead exposure assuming a non-residential land use scenario.

The IEUBK Model for lead (U.S. EPA, 2002d) is designed to estimate blood levels of lead in children (under 7 years of age) based on either default or site-specific input values for air, drinking water, diet, dust, and soil exposure. Studies indicate that infants and young children are extremely susceptible to adverse effects from exposure to lead. Considerable behavioral and developmental impairments have been noted in children with elevated blood-lead levels. The threshold for toxic effects from this chemical is believed to be in the range of 10 to 15 micrograms per deciliter (µg/dL). Blood-lead levels greater than 10 µg/dL are considered to be a "concern."

For SWMU 12, the IEUBK Model was used to address exposure to lead in children when detected groundwater or surface water concentrations exceeded the 15 µg/L federal Action Level promulgated under the SDWA and when detected soil or sediment concentrations exceeded the OSWER soil screening level of 400 mg/kg for residential land use (U.S. EPA, 1994b). Average chemical concentrations, as well as default parameters for some input parameters, were used in the evaluation. Estimated blood-lead levels and probability density histograms are presented as support documentation for this analysis in Appendix I.

Non-residential adult exposure to lead in soil was evaluated using U.S. EPA's TRW Model for lead (U.S. EPA, 2003a). In this model, adult exposure to lead in soil is addressed by an evaluation of the relationship between the site soil lead concentration and the blood-lead concentration in the developing fetuses of adult women. The adult lead model generates a spreadsheet for each exposure scenario

evaluated (i.e., industrial, recreational). The output of the spreadsheet is the probability that the blood-lead concentrations in the fetus exceeds 10 µg/L. The probability that the fetal blood-lead level will exceed 10 µg/L was calculated in accordance with the following U.S. EPA guidelines:

- Use of the TRW Interim Adult Lead Methodology in Risk Assessment (U.S. EPA, 1999)
- Frequently Asked Questions (FAQs) on the Adult Lead Model (U.S. EPA, 2004d)

No models are currently available to evaluate the periodic exposure of adolescent trespassers to lead. Therefore, the results of the IEUBK Model for children were used to qualitatively assess exposure of this receptor because the potential adverse effects from exposure to lead are expected to be of a lesser magnitude for adolescent trespassers than for children.

7.4 TOXICITY ASSESSMENT

The objective of the toxicity assessment is to identify the potential health hazards and adverse effects in exposed populations. Quantitative estimates of the relationship between the magnitude and type of exposures and the severity or probability of human health effects are defined for the identified COPCs. Quantitative toxicity values determined during this component of the risk assessment were integrated with outputs of the exposure assessment to characterize the potential for the occurrence of adverse health effects for each receptor group.

The toxicity value used to evaluate non-carcinogenic health effects is the RfD; carcinogenic effects are quantified using the CSF.

7.4.1 Toxicity Criteria

RfDs and CSFs used in the HHRA for SWMU 12 were obtained from the following primary literature sources (U.S. EPA 2003b):

- Integrated Risk Information System (IRIS) (U.S. EPA, 2005a).

- U.S. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs) - The Office of Research and Development/National Center for Environmental Assessment (NCEA) Superfund Health Risk Technical Support Center develops PPRTVs on a chemical-specific basis when requested by U.S. EPA's Superfund program.

- Other Toxicity Values - These sources include but are not limited to California Environmental Protection Agency (Cal EPA) toxicity values, the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs), and the Annual Health Effects Assessment Summary Tables (HEAST) (U.S. EPA, 1997b).

Although RfDs and CSFs can be found in several toxicological sources, U.S. EPA's IRIS on-line database is the preferred source of toxicity values. This database is continuously updated and values presented have been verified by U.S. EPA. The U.S. EPA Region 9 PRG Tables and Region 3 RBC Tables were also used as a source of toxicity criteria when these criteria were not available from the aforementioned references. The RfDs and CSFs for the constituents selected as COPCs for SWMU 12 are presented in Tables 7-24 and 7-25, respectively.

7.4.1.1 Toxicity Criteria for Dermal Exposure

RfDs and CSFs found in literature are typically expressed as administered doses; therefore, these values are considered inappropriate for estimating the risks associated with dermal routes of exposure. Oral dose-response parameters based on administered doses must be adjusted to absorbed doses before the evaluation of estimated dermal exposure intakes is made.

The adjustment from administered to absorbed dose was made using chemical-specific absorption efficiencies published in available guidance [i.e., U.S. EPA, 2004b (the primary reference), IRIS, ATSDR toxicological profiles, etc.] and the following equations:

$$RfD_{dermal} = (RfD_{oral})(ABS_{GI})$$

$$CSF_{dermal} = (CSF_{oral}) / (ABS_{GI})$$

where: ABS_{GI} = absorption efficiency in the gastrointestinal tract

Absorption efficiencies used in the risk assessment reflect U.S. EPA's current dermal assessment guidance (U.S. EPA, 2004b). The RfDs and CSFs used to evaluate dermal exposure are presented in Tables 7-24 and 7-25, respectively.

7.4.1.2 Toxicity Criteria for Carcinogenic Effects of PAHs

Limited toxicity values are available to evaluate the carcinogenic effects from exposure to PAHs. The most extensively studied PAH is benzo(a)pyrene, which is classified by U.S. EPA as a probable human

carcinogen. Although a CSF is available for benzo(a)pyrene, insufficient data are available to calculate CSFs for other carcinogenic PAHs. Toxic effects for these chemicals were evaluated using the concept of estimated orders of potential potency, which relates the potency of the other potentially carcinogenic PAHs to the potency of benzo(a)pyrene, as presented in current U.S. EPA guidance (U.S. EPA, 1993b). The equivalent oral and inhalation CSFs for these chemicals were derived by multiplying the CSFs for benzo(a)pyrene by the orders of potential potency.

7.4.1.3 Toxicity Criteria for Chromium

Toxicity criteria are available for different forms of chromium, which is considered to be more toxic in the hexavalent state. Because there is no evidence to support the conclusion that hexavalent chromium is present at the sites, speciation analyses was not completed for SWMU 12. However, risks associated with this chemical were assessed by conservatively assuming that 100 percent of the reported total chromium result is attributable to hexavalent chromium.

7.4.1.4 Toxicity Criteria for Nitrate/Nitrite

Results for nitrate and nitrite in groundwater and surface water were reported as nitrate/nitrite-N by the laboratory. However the RfDs for these two species are considerably different. The RfD for nitrate is 1.6 mg/kg/day and the RfD for nitrite is 0.1 mg/kg/day (U.S. EPA, 2005a). Therefore, nitrite is considered to be approximately 15 times more toxic than nitrate. The RfD values used in the risk assessment calculations were based on the expected water chemistry of the two species. Surface water is exposed to the air, is generally well mixed, and is more likely to be an oxidizing environment. This environment favors the predominance of nitrate. Therefore, nitrate/nitrite-N in surface water was evaluated in the risk assessment as if it were nitrate. Groundwater could be an oxidizing or reducing environment depending on conditions in the aquifer. Because nitrate/nitrite-N in groundwater might exist as either species, it is conservatively assumed to be predominantly nitrite for risk assessment purposes.

7.5 RISK CHARACTERIZATION

This section provides a characterization of the potential human health risks associated with the potential exposures to COPCs at SWMU 12. Section 7.5.1 outlines the methods used to quantitatively estimate the type and magnitude of potential risks for human receptors. A summary of the risk characterization for the SWMU 12 is provided in Section 7.5.2.

7.5.1 Quantitative Analysis

Quantitative estimates of risk were calculated according to risk assessment methods outlined in U.S. EPA guidance (U.S. EPA, 1989). Lifetime cancer risks are expressed in the form of dimensionless probabilities, referred to as incremental lifetime cancer risk (ILCRs), based on CSFs. Non-carcinogenic risk estimates are presented in the form of HQs determined through a comparison of intakes with published RfDs.

ILCR estimates were generated for each carcinogenic COPC using estimated exposure intakes and published CSFs, as follows:

$$ILCR = (\text{Estimated Exposure Intake})(CSF)$$

If the above equation resulted in an ILCR greater than 0.01, the following equation was used:

$$ILCR = 1\text{-}[\exp(\text{-Estimated Exposure Intake})(CSF)]$$

An ILCR of 1×10^{-6} indicates that the exposed receptor has a one-in-one-million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons.

As mentioned previously, non-carcinogenic risks were assessed using the concepts of HQs and HIs. The HQ for a non-carcinogenic COPC is the ratio of the estimated intake to the RfD, as follows:

$$HQ = (\text{Estimated Exposure Intake}) / (RfD)$$

An HI was generated by summing the individual HQs for all COPCs. The HI is not a mathematical prediction of the severity of toxic effects and therefore is not a true "risk"; it is simply a numerical indicator of the possibility of the occurrence of non-carcinogenic (threshold) effects.

7.5.1.1 Comparison of Quantitative Risk Estimates to Benchmarks

To interpret the quantitative risks and to aid risk managers in determining the need for remediation at a site, quantitative risk estimates were compared to typical benchmarks. Calculated ILCRs were interpreted using the U.S. EPA's "target range" (1×10^{-6} to 1×10^{-4}), and HIs were evaluated using a value of 1.0.

U.S. EPA has defined the range of 1×10^{-6} to 1×10^{-4} as the ILCR "target range" for most hazardous waste facilities addressed under CERCLA and RCRA. IDEM has defined the same range for the non-default evaluation under their RISC program. Individual or cumulative ILCRs greater than 1×10^{-4} will typically not be considered as protective of human health, and ILCRs less than 1×10^{-6} will typically be regarded as protective. Risk management decisions are necessary when the ILCR is within the 1×10^{-4} to 1×10^{-6} cancer risk range.

An HI exceeding unity (1.0) indicates that there may be potential non-carcinogenic health risks associated with exposure. If an HI exceeded unity, a segregation of target organ effects associated with exposure to COPCs was performed. Only those chemicals that affect the same target organ(s) or exhibit similar critical effect(s) were regarded as truly additive. Consequently, it may be possible for a cumulative HI to exceed 1.0, but no adverse health effects are anticipated if the COPCs do not affect the same target organ or exhibit the same critical effect.

7.5.2 Results of the Risk Characterization

This section contains a summary of the results of the risk characterization for SWMU 12. Quantitative risk estimates for potential human receptors were developed for those chemicals identified as COPCs. Uncertainties associated with the risk estimates are discussed in Section 7.6. The methodology used to calculate the risks presented in this section is provided in Sections 7.3 and 7.4. Potential cancer risks and HIs were calculated for current/future maintenance workers, occupational workers, adolescent trespassers and future construction workers, child recreational users, adult recreational users, and on-site residents under the RME and CTE scenarios and are summarized in Tables 7-26 and 7-27, respectively. Risks were calculated for SWMU 12 Proper, the areas around Buildings 152, 153/154, 157, 159/159, and the Battery Site. Whenever possible, risks for surface soil are presented separately from risks for subsurface soil because exposure to surface soil is the most likely soil exposure route for most receptors. Risks for subsurface soil are also presented in Tables 7-26 and 7-27 to account for the fact that subsurface soil might be brought to the surface at the result of a future excavation project. Sample calculations are presented in Appendix I, and the results of the risk assessment in RAGS Part D format are also included in Appendix I.

7.5.2.1 Non-Carcinogenic Risks - RME

Non-Carcinogenic Risks for Exposure to MFA Proper Soil (Including Bioremediated Soil) - RME

Target organ-specific HIs for all receptors potentially exposed to surface and subsurface soils at SWMU 12 Proper and around Buildings 152, 153/154, 157, and 159/159 were less than unity (1.0), indicating that adverse non-carcinogenic health effects are not anticipated for these receptors under the defined RME exposure conditions.

Non-Carcinogenic Risks for Exposure to Battery Site Soil - RME

Surface Soil – Battery Site

Target organ-specific HIs for maintenance workers, adult recreational users, and adolescent trespassers were less than unity (1.0) for exposure to surface soil, indicating that adverse non-carcinogenic health effects are not anticipated for these receptors under the defined RME exposure conditions. Cumulative HIs for construction workers, occupational workers, child recreational users, future adult residents, and future child residents exceeded unity. The elevated risks for these receptors were primarily due to the ingestion of antimony (detected at a maximum concentration of 3,610 mg/kg) in surface soil. Antimony accounted for more than 90 percent of the total HI for these receptors. For example, the cumulative HI for the future child resident exposure to Battery Site surface soil was 125, and the HQ for antimony was 115. The other primary contributors (i.e., risk drivers) to the child resident HI for surface soil were arsenic (HQ = 6) and iron (HQ = 2).

Subsurface Soil – Battery Site

Target organ-specific HIs for all potential receptors except the future child resident were less than unity (1.0) for exposure to subsurface soil at the Battery Site, indicating that adverse non-carcinogenic health effects no toxic effects are not anticipated for these receptors under the defined RME exposure conditions. The cumulative HI for the future child resident exceeded unity. The elevated HI for this receptor was primarily due to the ingestion of iron (HQ = 2).

Non-Carcinogenic Risks for Exposure to Surface Water and Sediment - RME

Target organ-specific HIs for all potential receptors were less than unity (1.0) indicating that adverse non-carcinogenic health effects are not anticipated for these receptors under the defined RME exposure conditions. Conservatively, the total surface water and sediment HI presented in Table 7-26 represents

the summation of risk estimates developed for COPCs selected for the gullies, the East Tributary, and Turkey Creek.

Non-Carcinogenic Risks for Exposure to Groundwater - RME

In the evaluation of groundwater, the Puz, Pmz, and PlzMgd groundwater zones were treated as distinct exposure units and are discussed separately in the following narrative. Risk estimates presented are based on data reported for unfiltered groundwater samples.

Puz Groundwater - RME

Cumulative HIs for all receptors evaluated for exposure to COPCs in the Puz groundwater (construction workers, occupational workers, child and adult recreational users, and future child and adult residents) exceeded unity (1.0), indicating the potential for adverse non-carcinogenic health effects under the defined exposure conditions. As discussed in Section 7.3.3, the area encompassing Buildings 152, 153/154, 157, and 158/159 was defined as the plume area for evaluating RDX, and the southern portion of the site, including locations 12MWT23, -24, -24A, and -39, was defined as the plume for evaluating most metals. For arsenic in the Puz, the highest concentrations were detected in the western portion of the site; therefore, the EPC for arsenic was the average of concentrations at locations 12MWT01, -02, -03, -04, and -05.

The cumulative HI for the construction worker assumed to be exposed to Puz groundwater by dermal contact was 4. The major contributor to the HI was manganese (HQ = 3). However, risk estimates calculated for filtered manganese concentrations would not exceed 1.

The cumulative HI for the occupational worker assumed to be exposed to Puz groundwater (ingestion of 1 liter of groundwater per work day) was 51. The major contributors to the HI were RDX (HQ = 4), cobalt (HQ = 2), iron (HQ = 3), manganese (HQ = 30), and nickel (HQ = 4).

The cumulative HIs for child and adult recreational users assumed to be exposed to Puz groundwater were 51 and 12, respectively. The child and adult recreational users were assumed to ingest 1 liter of groundwater 52 days per year. The major contributors (HIs greater than 1) to the recreational user HIs were RDX, cobalt, iron, manganese, and nickel.

The cumulative HIs for future child and adult residents assumed to be exposed to Puz groundwater were 511 and 149, respectively. Manganese was the greatest contributor to the cumulative HIs (e.g., the HI for

the child receptor exposed to manganese was 330). Other major contributors to the child HI were RDX (HI = 40), TNT (HI = 3), 2-ADNT (HI = 5), 4-ADNT (HI = 8), aluminum (HI = 10), arsenic (HI = 8), beryllium (HI = 4), cadmium (HI = 10), cobalt (HI = 20), iron (HI = 30), nickel (HI = 40), thallium (HI = 2), zinc (HI = 3), and nitrate/nitrite-N (HI = 2).

Pmz Groundwater - RME

Target organ-specific HIs calculated for construction workers, occupational workers, and child and adult recreational users were less than 1. However, HIs for future child and adult residents exceeded 1 indicating a potential for adverse non-carcinogenic health effects. As discussed in Section 7.3.3, the eastern side of the site, including locations 12MWT45, -46, -47, and -48, is the most highly concentrated area of the plume for explosives and metals in the Pmz groundwater. Consequently, EPCs were based on data from monitoring wells in this area.

The cumulative HIs for future child and adult residents assumed to be exposed to Pmz groundwater were 16 and 5, respectively. Manganese was the greatest contributor to the cumulative HIs (child HI = 7, adult HI = 2). The other major contributor to the child HI was iron (HI = 4).

PlzMgd Groundwater- RME

Target organ-specific HIs for construction workers, occupational workers, and child and adult recreational users were less than 1. However, the HIs for future child and adult residents exceeded 1. The maximum concentration was used as the EPC for PlzMgd groundwater because the data set contained less than 10 samples.

The cumulative HIs for future child and adult residents assumed to be exposed to PlzMgd groundwater were 16 and 5, respectively. Manganese was the greatest contributor to the cumulative HIs (child HI = 9, adult HI = 3). The other major contributors to the child HI were arsenic (HI = 3) and iron (HI = 2).

7.5.2.2 Carcinogenic Risks - RME

Carcinogenic Risks for Exposure to MFA Proper Soil (Including Bioremediated Soil) - RME

Cumulative ILCRs for all potential receptors were less than or within the U.S. EPA target risk range, $1x10^{-6}$ to $1x10^{-4}$ for SWMU 12 Proper and Buildings 152, 153/154, 157, and 158/159.

Carcinogenic Risks for Exposure to Battery Site Soil - RME

Cumulative ILCRs for the construction worker, maintenance worker, occupational worker, adolescent trespasser, and total recreational user (child + adult) exposed to COPCs in surface or subsurface soils were less than or within the U.S. EPA target risk range, $1x10^{-6}$ to $1x10^{-4}$. The total ILCR for future residents (child + adult) exceeded the target risk range.

The primary contributor to the Battery Site ILCR (i.e., greater than 10^{-4}) for the future residents was arsenic (ILCR = $3x10^{-4}$). This risk is mainly due to concentrations of arsenic in surface soil at locations 12SB21 (94.2 mg/kg) and 12SB24 (158 mg/kg). Concentrations of arsenic in the other soil samples (surface and subsurface) collected in the Battery Area were less than 10 mg/kg.

Carcinogenic Risks for Exposure to Surface Water and Sediment - RME

Cumulative ILCRs for all potential receptors were within the U.S. EPA target risk range, $1x10^{-6}$ to $1x10^{-4}$. The cumulative ILCRs are the sums of exposure to COPCs in surface water and sediment in gullies, the East Tributary, and Turkey Creek.

Carcinogenic Risks for Exposure to Groundwater - RME

Puz Groundwater - RME

The cumulative ILCR for the construction worker was less than $1x10^{-6}$. Total ILCRs for the occupational worker (ILCR = $6x10^{-4}$), total recreational user (child + adult ILCR = $2x10^{-4}$), and total residential ILCR (child + adult ILCR = $3x10^{-3}$) exceeded the target risk range.

The primary contributors to the elevated ILCRs for COPCs in the Puz groundwater (i.e., ILCRs greater than 10^{-4}) are RDX and arsenic. RDX (residential receptor ILCR = $2x10^{-3}$) accounted for approximately 75 percent of the total residential ILCR, and arsenic (ILCR = $7x10^{-4}$) accounted for 23 percent of the total residential receptor ILCR. TNT (ILCR = $9x10^{-6}$) was a minor contributor to the residential receptor risk. As noted previously, the risks for RDX are based on the average concentration for the area encompassing Buildings 152, 153/154, 157, and 158/159, and the EPC for arsenic in the Puz is the average concentration for locations 12MWT01, -02, -03, -04, and -05.

Pmz Groundwater - RME

The cumulative ILCR for the construction worker was less than $1x10^{-6}$. Total ILCRs for other potential receptors (occupational workers, recreational users, and future residents) were within U.S. EPA's target risk range ($1x10^{-6}$ to $1x10^{-4}$). The primary contributor to the ILCRs for Pmz groundwater was arsenic, which accounted for 98 percent of the total ILCR (the ILCR for future residential exposure to arsenic in Pmz groundwater was $7x10^{-5}$). The risks for arsenic were based on a concentration of 2.6 µg/L in the unfiltered samples. The average concentration of arsenic in the corresponding filtered samples was 0.2 µg/L, which corresponds to a residential ILCR of $7x10^{-6}$.

PlzMgd Groundwater - RME

The cumulative ILCR for the construction worker was less than $1x10^{-6}$. Total ILCRs for occupational workers and recreational users were within the U.S. EPA target risk range. The total residential receptor ILCR (child + adult ILCR = $3x10^{-4}$) for PlzMgd groundwater exceeded the target risk range.

The primary contributor to the residential receptor ILCR for PlzMgd groundwater was arsenic (ILCR = $3x10^{-4}$). The ILCR for arsenic was based on the maximum detected concentration (9.5 µg/L) in sample 12GWT4102 located in the southwestern portion of MFA. The maximum concentration of arsenic is less than the concentrations in the upgradient wells (17.6 to 19.7 µg/L) and the U.S. EPA MCL for arsenic (10 µg/L). In addition, the maximum detected concentration of arsenic in filtered samples was 1.8 µg/L, which corresponds to a total residential ILCR of $1x10^{-5}$. Minor contributors to the PlzMgd risks were RDX (ILCR = $8x10^{-6}$) and TNT (ILCR = $2x10^{-6}$).

The HIs and ILCRs calculated for exposure to environmental media at SWMU 12 are subject to the following significant sources of uncertainty:

1) The HIs and ILCRs for groundwater were based on exposure to average concentrations of COPCs in the most highly contaminated area of the plume. The use of the arithmetic average for the EPC is recommended by U.S. EPA Regions 1 and 4 (U.S. EPA, 2000a) (See Section 7.3.3). Using the most contaminated part of the plume and maximum concentrations as EPCs (in some cases) may result in overestimation of risks for explosives and metals. There was also uncertainty in assuming that current groundwater concentrations will not change in the future, and this introduced additional uncertainty in the EPC and risks estimated for any groundwater or surface water COPC. Concentrations in groundwater may diminish over time due to natural attenuation processes involving source depletion and dilution. This is an important consideration

for SWMU 12 because extensive remediation has already occurred at the facility, and the elevated concentrations of explosives in groundwater are most likely due to pre-remediation soil contamination.

2) Based on an examination of analytical results and turbidity levels for filtered and unfiltered groundwater and surface water samples, the elevated concentrations of some metals (e.g., aluminum, arsenic, lead, iron, and vanadium) are likely due, in part, to suspended particulates in the samples. As discussed in preceding sections, cancer risk estimates based on unfiltered arsenic concentrations are almost an order magnitude greater than risk estimates based on filtered arsenic concentrations.

3) No constituents were eliminated as COPCs on the basis of background (although background or upgradient data are available for all media at MFA). Therefore, risks from exposure to metals in site media may be overestimated. A cursory examination of the background and upgradient concentrations and site concentrations presented in the COPC selection tables (Tables 7-1 to 7-19) indicates that in most cases (except for PlzMgd groundwater), the calculated risks would not be greatly affected by not eliminating metals on the basis of background. Arsenic was the primary risk driver for PlzMgd groundwater (residential ILCR = $3x10^{-4}$). The data in Table 7-13 indicate that the maximum concentration of arsenic in PlzMgd groundwater was within the range of concentrations in the upgradient wells and therefore arsenic would not have been selected as a COPC if background were used for screening. Aluminum (as aluminum powder) is the only metal known to have been used in SWMU 12 operations.

4) As discussed in Section 7.4.1.5, the reported nitrate/nitrite concentrations in groundwater were evaluated as if nitrites were the predominant nitrogen compound present. The RfD for nitrite is approximately 15 times lower than the RfD for nitrate, indicating that nitrite is the more toxic chemical. The HI calculated for ingestion of nitrate/nitrite in Puz groundwater based on the RfD for nitrite was 2 for the future child resident. However, if the RfD for nitrate had been used, the HI would be less than unity. Therefore, the risks from exposure to nitrate/nitrite in groundwater may be overestimated if nitrite is not the predominant nitrogen compound in the groundwater.

5) Groundwater is not currently used at the site nor is it expected to be used in the future.

7.5.2.3 Non-Carcinogenic Risks - CTE

Non-Carcinogenic Risks for Exposure to SWMU 12 Proper Soil (Including Bioremediated Soil) - CTE

Target organ-specific HIs for all receptors potentially exposed to surface and subsurface soils in SWMU 12 Proper and around Buildings 152, 153/154, 157, and 159/159 were less than unity (1.0), indicating that adverse non-carcinogenic health effects are not anticipated for these receptors under the defined CTE conditions.

Non-Carcinogenic Risks for Exposure to Battery Site Soil - CTE

Surface Soil – Battery Site

Target organ-specific HIs for maintenance workers, adult recreational users, and adolescent trespassers were less than unity (1.0) for exposure to surface soil, indicating that adverse non-carcinogenic health effects are not anticipated for these receptors under the defined RME conditions. Cumulative HIs for construction workers, occupational workers, child recreational users, future adult residents, and future child residents exceeded unity. The elevated risks for these receptors were primarily due to the ingestion of antimony in surface soil. Antimony accounted for more than 90 percent of the total HI for these receptors; the cumulative HI for the future child resident for Battery Site surface soil was 42, and the HQ for antimony was 38.

Subsurface Soil – Battery Site

Target organ-specific HIs for all potential receptors were less than unity (1.0) for exposure to subsurface soil at the Battery Site, indicating that adverse non-carcinogenic health effects are not anticipated for these receptors under the defined RME conditions.

Non-Carcinogenic Risks for Exposure to Surface Water and Sediment - CTE

Target organ-specific HIs for all potential receptors were less than unity (1.0) indicating that adverse non-carcinogenic health effects are not anticipated for these receptors under the defined CTE conditions.

Non-Carcinogenic Risks for Exposure to Groundwater - CTE

Puz Groundwater- CTE

Cumulative HIs (CTE case) for all receptors evaluated for exposure to Puz groundwater (construction workers, occupational workers, child and adult recreational users, and future child and adult residents) exceeded unity (1.0), indicating the potential for adverse non-carcinogenic effects under the defined exposure conditions.

The cumulative HI for the construction worker assumed to be exposed to Puz groundwater by dermal contact was 3. The major contributor to the HI was manganese (HQ = 2). However, risk estimates calculated for filtered manganese concentrations would not exceed 1.

The cumulative HI for the occupational worker assumed to ingest 1 liter of groundwater per work day was 45. The major contributors to the HI were RDX (HQ = 3), iron (HQ = 3) manganese (HQ = 30), and nickel (HQ = 4).

The cumulative HIs for the child and adult recreational users assumed to be exposed to Puz groundwater were 25 and 5, respectively. The major contributors (HIs greater than 1) to the recreational user HIs for the CTE case were RDX, iron, manganese, and nickel.

The cumulative HIs for future child and adult residents assumed to be exposed to Puz groundwater were 152 and 70, respectively. Manganese was the greatest contributor to the cumulative HIs (e.g., the child HI for manganese was 98). Other major contributors to the child HI (HIs greater than 1) were RDX, 4-ADNT, aluminum, arsenic, cadmium, cobalt, iron, and nickel.

Pmz Groundwater - CTE

Target organ-specific HIs (CTE case) for construction workers, occupational workers, child and adult recreational users, and future adult residents were less than 1. The HI for the future child resident exceeded unity.

The cumulative CTE HI for the future child resident assumed to be exposed to Pmz groundwater was 5. Manganese was the primary contributor to the cumulative HI (HI = 2).

PlzMgd Groundwater - CTE

Cumulative HIs (CTE case) for construction workers, occupational workers, child and adult recreational users, and future adult residents were less than unity when evaluated on a target organ basis. The HI for the future child resident exceeded unity.

The cumulative CTE HI for the future child resident assumed to be exposed to PlzMgd groundwater was 5. Manganese was the primary contributor to the cumulative HI (HI = 3).

7.5.2.4 Carcinogenic Risks - CTE

Carcinogenic Risks for Exposure to MFA Proper Soil (Including Bioremediated Soil) - CTE

Cumulative ILCRs for all potential receptors were less than or within the U.S. EPA target risk range, $1x10^{-6}$ to $1x10^{-4}$, for SWMU 12 Proper and Buildings 152, 153/154, 157, and 158/159.

Carcinogenic Risks for Exposure to Battery Site Soil - CTE

Cumulative ILCRs for all potential receptors for the CTE scenarios were less than or within the U.S. EPA target risk range, $1x10^{-6}$ to $1x10^{-4}$.

Carcinogenic Risks for Exposure to Surface Water and Sediment - CTE

Cumulative ILCRs for all potential receptors (CTE case) were within the U.S. EPA target risk range, $1x10^{-6}$ to $1x10^{-4}$. The cumulative ILCRs are the sums of exposure to COPCs in surface water and sediment in gullies, the East Tributary, and Turkey Creek.

Carcinogenic Risks for Exposure to Groundwater - CTE

Puz Groundwater - CTE

The cumulative ILCR for the construction worker was less than $1x10^{-6}$. The ILCR for the recreational user (child + adult) was within the U.S. EPA's target risk range. Total ILCRs for the occupational worker (ILCR = $2x10^{-4}$) and total residential (child + adult ILCR = $3x10^{-4}$) exceeded the target risk range.

The primary contributors to the elevated ILCRs for Puz groundwater (i.e., ILCRs greater than 10^{-4}) are RDX and arsenic. RDX accounts for approximately 75 percent of the total residential ILCR, and arsenic accounts for approximately 20 percent of the total residential ILCR.

Pmz Groundwater - CTE

The cumulative ILCR for the construction worker was less than $1x10^{-6}$. Total ILCRs for other potential receptors (occupational workers, recreational users, and future residents) were within U.S. EPA's target risk range ($1x10^{-6}$ to $1x10^{-4}$). The primary contributor to the ILCRs for Pmz groundwater was arsenic, which accounted for 98 percent of the total ILCR (the ILCR for future residential exposure to arsenic in Pmz groundwater was $8x10^{-6}$). The risks for arsenic were based on a concentration of 2.6 µg/L in the unfiltered samples. The average concentration of arsenic in the corresponding filtered samples was 0.2 µg/L, which corresponds to a residential ILCR of $8x10^{-7}$.

PlzMgd Groundwater - CTE

The cumulative ILCR for the construction worker was less than $1x10^{-6}$. Total ILCRs for occupational workers, recreational users and future residents were within U.S. EPA's target risk range. The primary contributor to the ILCRs for PlzMgd groundwater was arsenic (total residential ILCR = $3x10^{-5}$). The ILCR for arsenic was based on the maximum detected concentration (9.5 µg/L) in sample 12GWT4102 located in the southwestern portion of MFA. The maximum concentration of arsenic is less than the concentrations in upgradient wells (17.6 to 19.7 µg/L) and the U.S. EPA MCL for arsenic (10 µg/L). In addition, the maximum detected concentration of arsenic in filtered samples was 1.8 µg/L, which corresponds to a total residential ILCR of $5x10^{-6}$.

7.5.2.5 Risks from Lead

Lead was identified as a COPC for surface soil in the Battery Area because the maximum detected concentration (429,000 mg/kg) exceeded the 400 mg/kg OSWER SSL for residential land use. Lead was selected as a COPC for Puz and Pmz groundwater because the maximum detected concentrations (104 and 24.7 µg/L, respectively) exceeded the U.S. EPA SDWA Action Level (15 µg/L). Lead was also identified as a COPC for gully surface water because the maximum detected concentration (458 µg/L) exceeded the U.S. EPA SDWA Action Level.

As discussed in Section 7.3.5, the methodology used to calculate the risks presented in Sections 7.5.2.1 through 7.5.2.4 cannot be used to evaluate exposure to lead because of the absence of published dose-response parameters. Exposure to lead was assessed using the U.S. EPA's IEUBK Model for lead (U.S. EPA, 2002d) and the U.S. EPA's TRW Model for lead (U.S. EPA, 2003a). The IEUBK model is typically used to evaluate lead exposure assuming a residential land use scenario, and the TRW model is used to evaluate lead exposure for non-residential land use scenarios.

The blood-lead concentration of a receptor is considered a key indicator of the potential for adverse health effects. The IEUBK and TRW models calculate the probability of a receptor's blood-lead level exceeding 10 µg/dL. The U.S. EPA goal is to limit the childhood risk of exceeding a 10 µg/dL blood-lead concentration to 5 percent.

Child Lead Model (IEUBK) Results

Current U.S. EPA guidance recommends using the average concentration to evaluate exposure to lead. Therefore, the average lead concentration in Battery Area surface soil (39,400 mg/kg), the average concentrations in Puz and Pmz groundwater (39.2 and 7.2 µg/L, respectively), the average concentration in gully surface water (15 µg/L), and model default values for other model parameters were used in the IEUBK and TRW model analyses. The results of the IEUBK model evaluation are presented in the following narrative.

IEUBK Results for Battery Area Surface Soil

The results of the IEUBK Model evaluation for exposure to lead in Battery Area surface soil using an average concentration of 38,500 mg/kg indicate that the estimated geometric mean blood-lead level for a child resident is 87.2 µg/dL. This blood-lead level exceeds the established level of concern (10 µg/dL). Almost 100 percent of children are expected to experience blood-lead levels greater than 10 µg/dL. This estimate exceeds the U.S. EPA's goal of limiting exposure to lead so that no more than 5 percent of the exposed children have an estimated blood-lead level greater than the established level of concern. The average site concentration of lead was actually 39,400 mg/kg. However, a soil lead concentration of 38,500 was used as the EPC because this was the highest concentration the model would accept as an input soil concentration for the default parameters used.

IEUBK Results for Puz Groundwater

The results of the IEUBK Model evaluation for exposure to lead in Puz groundwater using an average concentration of 39.2 µg/L indicate that the estimated geometric mean blood-lead level for a child resident is 5.87 µg/dL. This blood-lead level is less than the established level of concern (10 µg/dL). However, approximately 12.8 percent of children assumed to ingest this concentration of lead in drinking water are expected to experience blood-lead levels greater than 10 µg/dL. This estimate exceeds the U.S. EPA's goal of limiting exposure to lead so that no more than 5 percent of exposed children have an estimated blood-lead level greater than the established level of concern. The lead exposure concentration used for Puz groundwater (39.2 µg/L) is the average concentration in the most highly contaminated area of the

plume at SWMU 12. The average lead concentration in Puz groundwater across the entire site is 7.1 µg/L. Approximately 1.57 percent of children assumed to ingest this concentration of lead in drinking water are expected to experience blood-lead levels greater than 10 µg/dL. This probability is less than the U.S. EPA goal of 5 percent.

IEUBK Results for Pmz Groundwater

The results of the IEUBK Model evaluation for exposure to lead in Pmz groundwater using an average concentration of 7.2 µg/L indicate that the estimated geometric mean blood-lead level for a child resident is 3.6 µg/dL. This blood-lead level is less than the established level of concern (10 µg/dL). Approximately 1.6 percent of children are expected to experience blood-lead levels greater than 10 µg/dL. This estimate is less than U.S. EPA's goal of limiting exposure to lead so that no more than 5 percent of exposed children have an estimated blood-lead level greater than the established level of concern.

IEUBK Results for Gully Surface Water

The results of the IEUBK Model evaluation for exposure to lead in gully surface water using an average concentration of 15 µg/L indicate that the estimated geometric mean blood-lead level for a child resident is 4.2 µg/dL. This blood-lead level is less than the established level of concern (10 µg/dL). Approximately 3.3 percent of children are expected to experience blood-lead levels greater than 10 µg/dL. This estimate is less than U.S. EPA's goal of limiting exposure to lead so that no more than 5 percent of exposed children have an estimated blood-lead level greater than the established level of concern.

No models are currently available to evaluate the periodic exposure of adolescent trespassers to lead in environmental media or to lead in surface water. Therefore, the results of the IEUBK Model for residential children were used to qualitatively assess exposure of this receptor. Based on the results of the IEUBK Model results presented above, it appears that risks for the adolescent trespasser exposed to surface soil in the Battery Site would be unacceptable and that risks for exposure to gully surface water would be acceptable. Evaluating trespasser exposure to surface water using the IEUBK Model is considered to be a conservative approach because potential adverse effects from exposure to lead are expected to be of a lesser magnitude for adolescent trespassers than for residential children.

Adult Lead Model Results

This section summarizes the results of the risk analysis using the Adult Lead Model (ALM) for exposure of construction workers, maintenance workers, and adult recreational users to lead in surface soil in the Battery Area. These receptors were assumed be exposed to the average lead concentration in surface

soil, 39,400 mg/kg. The ALM results indicate that the central estimate blood-lead levels for these receptors and their fetuses greatly exceed the established level of concern (10 µg/dL), and the probabilities that receptor blood-lead levels would be greater than 10 µg/dL exceed the U.S. EPA's goal of limiting exposure to lead so that no more than 5 percent of the exposed receptors have an estimated blood-lead level greater than the established level of concern. These elevated risks are due to exposure to surface soil concentrations at locations 12SB21 (429,000 mg/kg) and 12SB23 (3,230 mg/kg). If Sample 12SB21 was removed from the data set, the average concentration would be 420 mg/kg, and the ALM results would be acceptable (but IEUBK results would still be unacceptable). If samples 12SB21 and 12SB23 were removed from the data set, the average concentration would be 108 mg/kg, and both the ALM and IEUBK results would be acceptable. The surface soil sample at location 12SB21 also contained elevated concentrations of several other metals (e.g., antimony and arsenic) and may constitute a hot spot at the Battery Site.

Summary

In summary, the results of the IEUBK Model analysis indicate that predicted blood-lead levels of children (and adolescent trespassers by inference) exposed to lead in surface soil in the Battery Area and the probabilities that receptor blood-lead levels would be greater than 10 µg/dL would exceed U.S. EPA benchmarks. The IEUBK Model results indicate that results for children exposed to lead in Puz groundwater are unacceptable. The IEUBK Model results indicate that predicted blood-lead levels of children exposed to lead in Pmz groundwater are acceptable. The results of the IEUBK Model analysis indicate that predicted blood-lead levels of children (and adolescent trespassers by inference) exposed to lead in gully surface water are acceptable. The results of the IEUBK Model are presented in Appendix I.

The results of the TRW ALM indicate that predicted blood levels for potential construction workers, maintenance workers, and adult recreational users and their fetuses exposed to lead in surface soil in the Battery Area exceed U.S. EPA's goals, and the probabilities of exceeding these goals as a result of exposure to lead in soil are also unacceptable. The results of the TRW modeling are presented in Appendix I.

7.6 UNCERTAINTY ANALYSIS

This section presents a summary of uncertainties inherent in the risk assessment and includes a discussion of how they may affect the quantitative risk estimates and conclusions of the risk analysis. The baseline HHRA for SWMU 12 was performed in accordance with current U.S. EPA and IDEM guidance. However,

there are varying degrees of uncertainty associated with the baseline HHRA. The following sections discuss general uncertainties in risk assessment and uncertainties specific to the risk assessment for SWMU 12.

Uncertainty in the selection of COPCs was related to the current status of the predictive databases, the grouping of samples, the numbers, types and distributions of samples, data quality, and the procedures used to include or exclude constituents as COPCs. Uncertainty associated with the exposure assessment included the values used as input variables for a given intake route or scenario, the assumptions made to determine EPCs, and the predictions regarding future land use and population characteristics. Uncertainty in the toxicity assessment included the quality of the existing toxicity data needed to support dose-response relationships and the weight of evidence used to determine the carcinogenicity of COPCs. Uncertainty in risk characterization was associated with exposure to multiple chemicals and the cumulative uncertainty from combining conservative assumptions made in earlier steps of the risk assessment process.

Whereas there were various sources of random uncertainty and bias, the magnitude of bias and uncertainty and the direction of bias was influenced by the assumptions made throughout the risk assessment including selection of COPCs and selection of values for dose-response relationships. Throughout the entire risk assessment, assumptions that considered safety factors were made so that the final calculated risks were overestimated.

Generally, risk assessments carry two types of uncertainty, measurement and informational uncertainty. Measurement uncertainty refers to the usual variance that accompanies scientific measurements. For example, this type of uncertainty is associated with analytical data collected for each site. The risk assessment reflects the accumulated variances of the individual values used. Informational uncertainty stems from inadequate availability of information needed to complete the toxicity and exposure assessments. Often, this gap is significant, such as the absence of information on the effects of human exposure to low doses of a chemical, the biological mechanism of action of a chemical, or the behavior of a chemical in soil.

After the risk assessment is complete, the results must be reviewed and evaluated to identify the types and magnitude of uncertainty involved. Reliance on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. For example, to account for uncertainties in the development of exposure assumptions, conservative estimates were made to ensure that the particular assumptions were protective of sensitive subpopulations or the maximum exposed individuals. If a number of conservative assumptions are combined in an exposure model, the resulting calculations can propagate the uncertainties associated with those assumptions,

thereby producing a much larger uncertainty for the final results. This uncertainty is biased toward overpredicting both carcinogenic and non-carcinogenic risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered when making risk management decisions.

This interpretation of uncertainty is especially relevant when the risks exceed the point of departure for defining "acceptable" risk. For example, when risks calculated using a high degree of uncertainty are less than an acceptable risk level (i.e., 10^{-6}), the interpretation of no significant risk is typically straightforward. However, when risks calculated using a high degree of uncertainty exceed an acceptable risk level (i.e., 10^{-4}), a conclusion can be difficult unless uncertainty is considered.

7.6.1 Uncertainty in Selection of COPCs

The most significant issues related to uncertainty in COPC selection were the usability of existing databases [i.e., the use of validated and unvalidated sample results (only validated data were used in this risk assessment)], the completeness, precision, and accuracy of the data set, the inclusion of chemicals potentially attributable to background in the quantitative risk assessment, the screening levels used, and the absence of screening levels for a few chemicals detected in site media. A brief discussion of each of these issues is provided in the remainder of this section.

Usability and Completeness of Existing Databases

Data from samples collected for the RFI and historical data from the bioremediation program (reported in the IMR) were used to assess risks to potential human receptors. RFI data, bioremediation program data, and Battery Site data were biased because samples were collected in areas of known or suspected contamination. For example, the soil samples collected during the RFI were obtained near SWMU 12 buildings. The RFI data were primarily designed to evaluate the nature and extent of contamination, but also to verify that concentrations of other contaminants were not significant. Samples collected during the bioremediation program were obtained from areas where soil was impacted by waste discharges, (i.e., areas around Buildings 152, 153/154, 157, and 158). Samples were also collected around Buildings 151 and 160 but, as stated in the IMR, no exceedances of cleanup objectives were identified.

The soil and groundwater contamination detected during the RFI and historical sampling are well bounded. In the bioremediation program, samples were collected around each building area until concentrations in the grids around each building met residential or industrial cleanup goals. No historical samples were collected in the areas between buildings, and this may be a source of some uncertainty in

the risk assessment. However, soil samples were collected in the RFI to fill data gaps (the samples designated as SWMU 12 Proper in this report). Because the sampling was biased and contamination well bounded and because these areas were not known to be impacted by site activities, the uncertainty is expected to be minimal and risks are not likely to be underestimated.

The historical samples were analyzed for a limited number of analytes [i.e., explosives, nine metals (aluminum, arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver), and nine VOCs (1,1-DCA, 1,2-DCA, acetone, chloroform, methyl ethyl ketone, methylene chloride, methyl isobutyl ketone, toluene, and xylenes)]. These chemicals were identified as COCs for SWMU 12 in the RFI Phase I Environmental Monitoring (Halliburton NUS, 1992a) because, according to the Phase I report, they are "RCRA classified wastes which may have been, or are currently, generated in Mine Fill A." Use of this limited list may underestimate risks, but as previously stated, sampling at SWMU 12 was biased towards known or suspected contaminants and contaminated areas. In addition, the list of chemicals analyzed for during the 2004/2005 RFI was expanded to fill data gaps and included Target Compound List (TCL) VOCs and SVOCs. Therefore, the sampling and analytical program should be adequate for characterizing site-related risks.

Both the RFI and historical data were validated. A data quality report is included in Section 3.0 of this report. Fixed-base analytical results only for the target analyte lists for the field investigations were used in the quantitative risk evaluation. Filtered and unfiltered samples were collected for groundwater and surface water, but only unfiltered results are used to assess risks. Data regarded as unreliable (i.e., qualified as "R" during the data validation process) were not used in the quantitative risk assessment. The elimination of data qualified "R" may increase the uncertainty in the risk assessment. However, as shown in Section 3.0, the chemicals qualified "R" are not typical COCs at SWMU 12.

As discussed in Section 7.2.1, historical data from samples collected during the bioremediation program in 1997 and 1998 were used in conjunction with the data obtained from the investigation conducted in 2004/2005 in the quantitative risk analysis. The historical data were validated, and all of the historical data representing post-remediation conditions at SWMU 12 were used in the risk assessment. Uncertainty associated with the use of the historical data is expected to be negligible.

Chemicals Potentially Attributable to Background

Background concentrations were not a consideration in the COPC selection process. If the maximum concentration of a chemical exceeded its respective screening level, that chemical was selected as a COPC and evaluated in the quantitative risk assessment. However, background soil concentrations have

been characterized for the facility, and upgradient groundwater, surface water, and sediment samples were collected at SWMU 12. The implications of not including background screening in the COPC selection process are discussed in the following paragraphs.

Surface Water and Sediment

Upgradient samples were collected for the gully, East Tributary, and Turkey Creek surface waters and sediments and are presented in Tables 7-14 through 7-19. A comparison of maximum concentrations detected in samples from upgradient locations versus those reported for site-related surface water and sediment sampling locations indicates that the concentrations of most metals at the site-related sampling locations were significantly greater than concentrations in the upgradient samples. However, if exceedance of background had been a COPC selection criterion based on a maximum-site-concentration to maximum-background-concentration comparisons, only arsenic in Turkey Creek sediment would not have been selected as a COPC. However, in some cases, the maximum site concentrations were only slightly greater than the concentrations reported for upgradient locations (in gully sediment, for example). If statistical dataset-to-dataset comparisons had been used (instead of maximum-site-concentration to maximum-background-concentration comparisons), it is likely that more constituents would have been eliminated as COPCs. The HIs calculated for surface water and sediment were less than the U.S. EPA goal of 1, and the ILCRs were less than or within U.S. EPA's target risk range for carcinogens; therefore, the results and conclusions of the risk assessment for surface water and sediment are not significantly affected by not eliminating COPCs from the quantitative risk assessment on the basis of background.

Groundwater

Fifteen metals were selected as COPCs for Puz groundwater zone, 12 metals for the Pmz groundwater zone, and five metals for PlzMgd groundwater zone. As described in Section 7.5.2.1, a number of the metals selected as COPCs were identified as risk drivers for groundwater (e.g., arsenic and manganese in the Puz and arsenic in the Pmz). A comparison of maximum detected concentrations in site wells to metals concentrations in upgradient wells as presented in Tables 7-11, 7-12, and 7-13 indicates that, in most cases, the number of metals selected as COPCs would not change and results of the risk assessment for the Puz and Pmz groundwater zones would not be significantly affected if background comparisons were used to identify COPCs. However, based on the background data presented in Table 7-13, only antimony would have been selected as a COPC for the PlzMgd if background values were used for COPC screening, and the cancer and non-cancer risks calculated for PlzMgd groundwater would be acceptable (The ILCR calculated for future residents exceeded $1x10^{-4}$ because of exposure to arsenic in PlzMgd groundwater). Consequently, risks for exposure to PlzMgd groundwater are likely

overestimated as a result of the inclusion of metals with concentrations within background levels in the quantitative risk assessment.

SWMU 12 Proper Soil

Surface and subsurface soils were analyzed for metals during the bioremediation effort and during RFI Round 1. A discussion of metals concentrations detected in SWMU 12 Proper soil relative to facility background concentrations is presented in Section 5.2.4. Section 5.2.4 states that metals concentrations in soil samples from SWMU 12 Proper are generally similar to background soil concentrations, with the exception of aluminum, barium, chromium, iron, and nickel at a few locations. Of these metals, only aluminum and iron were identified as COPCs for surface or subsurface soil. Metals analyses (for nine metals) were performed on ICSs and PESs during the bioremediation program. No metals analyses were conducted on the bioremediated soil that was later returned to the excavations. Two metals in the historical data (aluminum and arsenic) were selected as COPCs for the risk assessment, yet the average metals concentrations are similar to those calculated for background soil concentrations or only slightly elevated relative to background concentrations reported in the Basewide Background Investigation Report (TtNUS, 2001). For example, the average SWMU 12 concentration of aluminum was 12,750 mg/kg and the average background levels ranged from 5,430 to 13,019 mg/kg. Also, the average SWMU 12 concentration of arsenic was 8.7 mg/kg and the average basewide background levels for arsenic ranged from 4.15 to 7.72 mg/kg.

In addition, the results of the risk assessment indicate the non-cancer HIs calculated for the metals selected as COPCs for SWMU 12 Proper did not exceed U.S. EPA goals, and the ILCRs calculated for exposure to arsenic in soil were within U.S. EPA's risk management range. Furthermore, the concentrations (and risks) for arsenic are relatively uniform across the site, indicating that the levels of arsenic in soil are naturally occurring. Based on the above analysis, the inclusion of metals in the quantitative risk assessment for SWMU 12 Proper may result in a slight overestimation of risks but does not affect the results and conclusions of the risk assessment.

Battery Site Soil

Eleven metals were selected as COPCs in Battery Site surface soil and six metals in subsurface soil. As stated in Section 5.2.4, metals concentrations at the Battery Site were generally much higher than concentrations in SWMU 12 Proper, especially in surface soil. Battery Site locations 12SB21 through 12SB24 exhibited elevated concentrations of one or more metals. Metals concentrations for locations 12SB12 through 12SB20 were comparable to soil samples from the SWMU 12 Proper. The 12SB21

metals with concentrations greater than maximum background concentrations were antimony, arsenic, barium, cadmium, chromium, copper, lead, mercury, silver, tin, and zinc. Most of these metals are expected components of various types of batteries. For example, common dry cells contain zinc and manganese, mercury cells contain mercury, nickel-cadmium cells contain nickel and cadmium, and silver oxide batteries contain silver. In addition, some of the detected metals may be chemical contaminants of other metals. For example, antimony, arsenic, and thallium may be contaminants of lead or may be used in lead alloys. It is plausible that electrical wiring containing metals such as copper also may have been discarded with the batteries.

The discussions in Section 5.2.4 concluded that metals in Battery Area samples having concentrations greater than background levels were undoubtedly site-related contaminants, and these metals would have been selected as COPCs regardless of whether background screening was performed.

In summary, inclusion of metals in the quantitative risk assessment for soil, sediment, surface water, and the Puz and Pmz groundwater zones without considering background does not appear to greatly affect the calculated risks. Risk estimates for the PlzMgd groundwater zone may be over stated as a result of the inclusion of some metals as COPCs because these metals may reflect background conditions.

Uncertainty Associated with Elevated Turbidity in Groundwater and Surface Water Samples

Another significant source of uncertainty for the risk estimates developed for groundwater and surface water exposure is the fact that elevated concentrations of some metals (e.g., aluminum, arsenic, lead, iron, and vanadium) selected as COPCs appear to be, in part, the result of particulate matter in unfiltered samples. As stated previously, this was evident in Puz groundwater samples and gully surface water samples (especially for lead). Elevated turbidity readings were reported for unfiltered samples, and metals concentrations reported for unfiltered samples significantly exceeded concentrations reported for filtered samples. Risks based on the samples with high turbidity readings might be greatly overestimated because groundwater is typically filtered before being used for drinking and other residential uses.

COPC Screening Levels

The use of risk-based screening values based on conservative land use scenarios (i.e., residential land use for soil and sediment and ingestion of tap water for groundwater and surface water) and corresponding to an ILCR of 10^{-6} and HI of 0.1 ensured that all the significant contributors to risk from a site were evaluated. The elimination of chemicals present at concentrations that correspond to ILCRs less than 10^{-6} and HIs less than 0.1 should not have affected the final conclusions of the risk assessment

because those chemicals were not expected to cause a potential health concern at the detected concentrations.

Chemicals without Established Screening Levels

Risk-based screening levels (RBSLs) are currently not available for some constituents [e.g., benzo(g,h,i)perylene and phenanthrene is soil and diamino-nitrotoluenes, DNX, MNX, and TNX in groundwater and surface water]. Appropriate surrogates were selected for these chemicals based on similar chemical structures, if available. For example, pyrene was selected as a surrogate for benzo(g,h,i)perylene and phenanthrene. Applying toxicity values for one compound to another increases the uncertainty in the risk assessment both in regard to the selection of COPCs and the calculated risks. Suitable surrogates could not be found for 2,4-ADNT, 2,6-ADNT, DNX, MNX, and TNX. The omission of these energetics from the quantitative risk assessment may result in an underestimation of risks. However, the risks calculated for explosives in the risk assessment, primarily RDX, were greater than $1x10^{-3}$, and it is unlikely that omission of these compounds would greatly affect the risk assessment results or remedial decisions.

7.6.2 Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arose because of the methods used to calculate EPCs, the determination of land use conditions, the selection of receptors and scenarios, the estimation of EPCs, and the selection of exposure parameters. Each of these is discussed below.

Land Use

The current land use patterns at NSWC Crane are well established, thereby limiting the uncertainty associated with land use assumptions. Land use at SWMU 12 is currently limited and is expected to be limited in the future, as long as NSWC remains open (potential and infrequent trespassers are the only current and likely future receptors). To be conservative, risks to potential and future construction workers, maintenance workers, occupational workers, recreational users, and on-site residents were estimated for the site.

Exposure Point Concentrations

Uncertainty was associated with the use of the 95-percent UCL on the mean concentration as the EPC. As a result of using the 95-percent UCL, the estimations of potential risk for the RME scenario were most likely overstated because this is a representation of the upper limit that potential receptors would be

exposed to over the entire exposure period. In some cases (because data sets contained fewer than 10 samples or because the UCL was greater than the maximum concentration), the maximum concentration was used as the EPC. Use of the maximum concentration as the EPC tends to overestimate potential risks because receptors are assumed to be exposed continuously to the maximum concentration for the entire exposure period. Uncertainty was also introduced when the non-detect results were assigned a value of one-half the non-detect quantitation limit in the calculation of the EPC. This may have either overstated or understated the risks to the receptors.

As discussed in Sections 7.3.3 and 7.5.2.2, risks for groundwater were based on the assumption that EPCs for groundwater were the concentrations in the most highly contaminated areas the plume. The use of these averages is recommended by U.S. EPA Regions 1 and 4 (U.S. EPA, 2000a). The plume areas used for averaging were selected based on areas that contained the higher concentrations of explosives and metals, as explained in Section 7.3.3. Three different areas were selected for the evaluation of the Puz groundwater zone: one for explosives, one for most metals, and a third area for arsenic. Using the most contaminated part of the plume may result in overestimation of risks for explosives and metals.

There was also uncertainty in assuming that current groundwater concentrations will not change in the future, and this introduced additional uncertainty in the EPC and risks for any groundwater or surface water COPC. Concentrations in groundwater may diminish over time due to natural attenuation processes involving source depletion and dilution. This is an important consideration for SWMU 12 because extensive remediation has already occurred at the facility, and the elevated groundwater RDX concentrations are most likely due to pre-remediation soil contamination.

As explained in Section 7.3.3, the EPCs for the historical soil data in the remediated areas of SWMU 12 were weighted averages based on assumed volumes of residual soil and bioremediated soil. Averages were selected to represent the historical data because the concentrations of the bioremediated soil compost, which constitutes a large portion of the soil volume, are averages of windrow data calculated in the IMR. Often bioremediated soil from different windrows was mixed in the same excavated grid, thereby combining average concentrations from various windrows and further averaging concentrations that had already been averaged. Furthermore, much of the data from grids that were not excavated (because concentrations were less than cleanup goals) were from composited samples and are therefore average concentrations. Because much of the historical data consisted mainly of average concentrations, averages were used as EPCs rather than UCLs. An additional consideration is the fact that, with a few exceptions, concentrations in residual soil and bioremediated compost samples were less than residential or industrial cleanup goals (with more than 80 percent of the samples having

concentrations less than residential goals). Based on this analysis, the uncertainty in using weighted averages is minimal, and risks have not been underestimated by use of the weighted averages.

It should be noted that, although the lifetime risks calculated using these weighted averages were acceptable, isolated hot spots (and associated acute risks) may remain in the remediated areas that could be a concern for some potential receptors, especially the excavation/construction worker. For example, the IMR indicates that elevated concentrations of RDX remain in Grid 17 (1,120 mg/kg), Grid 27 (3,780 mg/kg), and Grid 28 (5,940 mg/kg) near Buildings 153/154. Soils with concentrations of RDX that exceeded industrial cleanup goals were also left in place in several grid areas around Buildings 157 and 158/159.

As described in Section 7.3.3, the following weighting scheme was used to estimate the soil EPCs: concentrations in non-excavated areas and backfilled areas were assumed to represent 90 percent of the soil volume, concentrations in the excavated areas were assumed to constitute 9 percent of the total soil volume, and concentrations in the grids that could not be excavated were assumed to constitute 1 percent of the total soil volume. These assumptions were based on an examination of the remediated and unremediated grids areas, discussions with TtNUS personnel, and professional judgment. There is some uncertainty in the weighted averages because they are based on several "unknowns," such as the actual soil volumes. It was also necessary to use some professional judgment when interpreting and applying data from the IMR to determine contaminant concentrations in some grids. The degree and direction of the uncertainty is not known. However, an attempt was made to be conservative when making the assumptions, especially in regard to the assumption that one percent for the volume of soil in the EU could not be excavated. This was an important assumption because these areas contained the highest residual concentrations of RDX. The 1 percent assumption affects the calculation of representative concentrations for only 11 grid areas (i.e., sidewalls or bottoms) associated with the six building areas. In this regard, it should also be noted that, based on information in the IMR, as much soil volume as possible in the affected grid areas was excavated. Therefore, the assumption of 1 percent should be sufficiently conservative.

EPCs were calculated for each of the six building areas investigated in the IMR. However, risks were only quantified for Buildings 152, 153/154, 157, and 158/159 because weighted averages for explosives and metals were highest in these areas and because concentrations of explosives were less than facility cleanup goals in the other two building areas (Buildings 151 and 160). Also, the areas around Buildings 151 and 160 did not require remediation in the bioremediation program. A cursory evaluation of risks for exposure to RDX at Buildings 151 and 160 indicated that ILCRs were less 1×10^{-7} for potential future residents, thereby justifying the omission of these areas from the quantitative risk assessment.

The weighted averages for COPCs in the six areas are presented in Table I-1 in Appendix I.

Another factor to be considered regarding the bioremediated backfilled soil is the fact that the explosives in the compost will continue to biodegrade over time. Evidence of this was shown in the IMR for SWMU 13 data for re-sampled windrows in which bioremediation was allowed to continue for more than 400 days. In these cases, the concentrations of RDX decreased from greater than the facility cleanup goal (17 mg/kg) to about 2 mg/kg or less, and concentrations of HMX and TNT decreased to less than 1 mg/kg. No other explosives (i.e., other than RDX, HMX, and TNT) were detected in the bioremediated soil.

Exposure Routes and Receptor Identification

The determination of various receptor groups and exposure routes of potential concern was based on current land use observed at the site and the anticipated future land use. Therefore, the uncertainty associated with the selection of exposure routes and potential receptors was minimal because they were considered to be well defined. Although residential use of groundwater was evaluated as an exposure scenario, groundwater is not currently used at the site nor is it expected to be used in the future. Therefore, the evaluation of direct exposure to groundwater that was performed in this baseline HHRA was included primarily to aid in risk management decision making.

Exposure Parameters

Each exposure factor (for RME and CTE scenarios) selected for use in the risk assessment had some associated uncertainty. Generally, exposure factors were based on surveys of physiological and lifestyle profiles across the United States. The attributes and activities studied in these surveys generally had a broad distribution. To avoid underestimation of exposure, in most cases, the U.S. EPA guidelines (U.S. EPA, 1991) for the RME receptor were used, which generally specify the use of the 95th-percentile value for most parameters. Therefore, the selected values for the RME receptor represented an upper bound of the observed or expected habits of the majority of the population.

Generally, the uncertainty can be assessed quantitatively for many assumptions made in determining factors for calculating exposures and intakes. Many of these parameters were determined from statistical analyses on human population characteristics. Often, the database used to summarize a particular exposure parameter (i.e., body weight) is quite large. Consequently, the values chosen for such variables in the RME scenario have low uncertainty.

For many parameters for which limited information exists (i.e., dermal absorption of chemicals from soil), greater uncertainty exists. For example, current U.S. EPA guidance (U.S. EPA, 2004b) does not provide dermal absorption factors for exposure to most metals (except arsenic and cadmium) in soil. Therefore, risks for dermal contact from soil were not evaluated for most metals in this risk assessment. Consequently, risks from exposure to soil may have been underestimated.

Many of the exposure parameters used to calculate exposures and risks in this report were selected from a distribution of possible values including U.S. EPA guidance (U.S. EPA, 1991 and 1993a) and dermal guidance (U.S. EPA, 1997b and 2004b). For the RME scenario, the value representing the 95th percentile was generally selected for each parameter to ensure that the assessment bounded the majority of actual risks from a postulated exposure. This risk number is used in risk management decisions but does not indicate what a more average or typical exposure might be or what risk range might be expected for individuals in the exposed population.

To address these issues, U.S. EPA (1992a) suggested the use of the CTE receptor, whose intake variables are often set at approximately the 50th percentile of the distribution. The risks for this receptor seek to incorporate the range of uncertainty associated with various intake assumptions. Some of the parameters presented in this risk assessment were estimated using professional judgment, although U.S. EPA does provide limited guidance for the CTE evaluation (U.S. EPA, 1993a).

7.6.3 Uncertainty in the Toxicological Evaluation

Uncertainties associated with the toxicity assessment (determination of RfDs and CSFs and use of available criteria) are presented in this section.

Derivation of Toxicity Criteria

Uncertainty associated with the toxicity assessment was associated with hazard assessment and dose-response evaluations for the COPCs. The hazard assessment dealt with characterizing the nature and strength of the evidence of causation or the likelihood that a chemical that induces adverse effects in animals will also induce adverse effects in humans. Hazard assessment of carcinogenicity was evaluated as a weight-of-evidence determination using U.S. EPA methods. Positive animal cancer test data suggest that humans contain tissue(s) that may manifest a carcinogenic response; however, the animal data cannot necessarily be used to predict the target tissue in humans. In the hazard assessment of non-

cancer effects however, positive animal data often suggest the nature of the effects (i.e., the target tissues and type of effects) anticipated in humans.

Uncertainty in hazard assessment arose from the nature and quality of the animal and human data. Uncertainty was reduced when similar effects were observed across species, strain, sex, and exposure route; when the magnitude of the response was clearly dose related; when pharmacokinetic data indicated a similar fate in humans and animals; when postulated mechanisms of toxicity were similar for humans and animals; and when the COC was structurally similar to other chemicals for which the toxicity is more completely characterized.

Uncertainty in the dose-response evaluation included the determination of a CSF for the carcinogenic assessment and derivation of an RfD for the non-carcinogenic assessment. Uncertainty was introduced from interspecies (animal to human) extrapolation, which, in the absence of quantitative pharmacokinetic or mechanistic data, is usually based on consideration of interspecies differences in basal metabolic rate. Uncertainty also resulted from intraspecies variation. Most toxicity experiments are performed with animals that are very similar in age and genotype, so intragroup biological variation is minimal, but the human population of concern may reflect a great deal of heterogeneity, including unusual sensitivity or tolerance to the COPC. Even toxicity data from human occupational exposure reflect a bias because only those individuals sufficiently healthy to attend work regularly (the "healthy worker effect") and those not unusually sensitive to the chemical are likely to be occupationally exposed. Finally, uncertainty arises from the quality of the key study from which the quantitative estimate was derived and the database used. For cancer effects, the uncertainty associated with dose-response factors was mitigated by assuming the 95-percent upper bound for the slope factor. Another source of uncertainty in carcinogenic assessment is the method by which data from high doses in animal studies are extrapolated to the dose range expected for environmentally exposed humans. The linearized multistage model, which is used in nearly all quantitative estimations of human risk from animal data, is based on a non-threshold assumption of carcinogenesis. Evidence suggests however that epigenetic carcinogens, as well as many genotoxic carcinogens, have a threshold below which they are non-carcinogenic. Therefore, the use of the linearized multistage model was conservative for chemicals that exhibited a threshold for carcinogenicity.

For non-cancer effects, additional uncertainty factors may have been applied in the derivation of the RfD to mitigate poor quality of the key study or gaps in the database. Additional uncertainty for non-cancer effects arose from the use of an effect level in the estimation of an RfD because this estimation was predicated on the assumption of a threshold less than which adverse effects were not expected. Therefore, an uncertainty factor is usually applied to estimate a no-effect level. Additional uncertainty arose in estimation of an RfD for chronic exposure from subchronic data. Unless empirical data indicated

that effects did not worsen with increasing duration of exposure, an additional uncertainty factor was applied to the no-effect level in the subchronic study. Uncertainty in the derivation of RfDs was mitigated by the use of uncertainty and modifying factors that normally ranged between 3 and 10. The resulting combination of uncertainty and modifying factors may have reached 1,000 or more.

The derivation of dermal RfDs and CSFs from oral values may have caused uncertainty. This was particularly the case when no gastrointestinal absorption rates were available in the literature or when only qualitative statements regarding absorption were available.

Uncertainty Associated with Evaluation of the Dermal Exposure Pathway

According to RAGS Part E (U.S. EPA, 2004b), risks for dermal absorption of chemicals in soil are quantitatively evaluated for arsenic, cadmium, chlordane, 2,4-dichlorophenoxyacetic acid, dichloro-diphenyl-trichloroethane (DDT), TCDD (and other dioxins), PAHs, PCBs, pentachlorophenol, and SVOCs only because of the limited guidance available to evaluate dermal exposure to other constituents. Therefore, risks from dermal exposure to metals in soil and sediment (except for arsenic and cadmium) were not quantified in the risk assessment. Consequently, potential risks may have been underestimated by excluding these constituents from the dermal risk assessment calculations.

Use of Aluminum and Iron Toxicity Criteria

NCEA provisional RfDs were used to evaluate non-carcinogenic effects from exposure to aluminum and iron, which were identified as risk drivers, especially in Puz groundwater. The provisional RfDs for these chemicals are based on allowable intakes rather than adverse effect levels. Therefore, there was some degree of uncertainty associated with the use of the RfDs. Some U.S. EPA regions (e.g., Region 1) consider the use of the oral RfD for aluminum and iron inappropriate and recommend that these metals not be evaluated quantitatively in risk assessments.

Alternate RfD for Iron

As previously discussed, there is uncertainty associated with the toxicity data for iron. The RfD for iron is based on the recommended daily allowance (RDA) for adult human nutrition. Children and adolescents require more iron in their diets than adults do; consequently, using an RfD based on the adult RDA for iron to evaluate exposures to children results in an overestimation of the risks for children. When the HI for exposures to iron by children exceed unity, U.S. EPA Region 3 recommends recalculating the HI using an RfD of 1.1 mg/kg/day (instead of 0.3 mg/kg/day as provided in IRIS). If this value was used to estimate risks for children, the HQs calculated for iron would decrease by a factor of approximately 3.7

(1.1 divided by 0.3). Therefore, the risk estimates calculated for iron may be overestimated. The HI for the child resident assumed to be exposed to Puz groundwater was 30. If the alternate RfD was used, the HI would be 8 and would still exceed the goal of unity for the RME. The CTE HI for the Puz would also still exceed unity if the alternate RfD was used. However, use of the alternate RfD would be significant for exposure to iron in Battery Site surface soil. At the Battery Site, the calculated HQ for iron for the child resident was 2. If the alternate RfD were used, the HQ for iron would be less than unity. The risks for child exposure to iron in other media were less than unity and therefore the overestimation is not significant.

Alternate RfD for Manganese

The oral RfD for manganese listed in the Region 9 PRG table (0.024 mg/kg/day) was used to calculate risks for ingestion of groundwater. This value includes a modification factor of 3 and an adjustment factor for the dietary contribution, which is applied to the non-dietary RfD (0.14 mg/kg/day) presented in IRIS. IRIS indicates that an adjustment for the dietary contribution should be subtracted from this allowable intake. Using the modified and adjusted RfD results in risk estimates six times higher than if the non-dietary RfD were used. If the non-dietary RfD was used for Puz and PlzMgd groundwater, the HQs for manganese for the future child resident would still exceed the goal of unity. However, the HQ for manganese would be less than unity for Pmz groundwater if the non-dietary RfD were used.

Uncertainty in the Toxicity Criteria for Chromium

Toxicity criteria are available for different forms of chromium, which is considered to be more toxic in the hexavalent state. Because there is no evidence to support the conclusion that hexavalent chromium is present at the SWMU 12, speciation analyses were not completed for SWMU 12. However, risks associated with this chemical were assessed by conservatively assuming that 100 percent of the reported total chromium result is attributable to hexavalent chromium. Therefore, the risks calculated for chromium in groundwater, surface water, and sediment are likely overestimated. However, because the HQs calculated for chromium in these media were less than unity by an order or magnitude or more, the uncertainty introduced into the risk assessment is minimal.

Uncertainty in the Toxicity of Nitrate and Nitrite

Results for nitrate and nitrite in groundwater and surface water were reported as nitrate/nitrite-N by the laboratory. However the RfDs for these two species are considerably different. The RfD for nitrate is 1.6 mg/kg/day and the RfD for nitrite is 0.1 mg/kg/day (IRIS, 2005). Therefore, nitrite is considered approximately 15 times more toxic than nitrate. The RfD values used in the risk assessment calculations

were based on the expected water chemistry of the two species. Surface water is exposed to the air, is generally well mixed, and is more likely to be an oxidizing environment. This environment favors the predominance of nitrate. Therefore, nitrate/nitrite-N in surface water was evaluated in the risk assessment as if it was nitrate. Groundwater could be an oxidizing or reducing environment depending on conditions in the aquifer. Because nitrate/nitrite-N in groundwater might equally exist as either species, it was conservatively assumed to be predominantly nitrite for risk assessment purposes. In the risk assessment, the HI calculated for ingestion of nitrate/nitrite in Puz groundwater based on the RfD for nitrite was 2 for the future child resident. If the RfD for nitrate had been used, the HI would be 0.1. Thus, the risks from exposure to nitrate/nitrite in Puz groundwater may be overestimated by using the RfD for nitrite. The risks for exposure to nitrate/nitrite in Pmz groundwater and gully surface water would be less than unity regardless of whether nitrate or nitrite was assumed present.

7.6.4 Uncertainty in the Risk Characterization

Uncertainty in risk characterization resulted from assumptions made regarding additivity of effects from exposure to multiple COPCs from various exposure routes. High uncertainty existed when summing non-cancer risks for several substances across different exposure pathways. This assumed that each substance has a similar effect and/or mode of action. Even when compounds affect the same target organs, they may have different mechanisms of action or differ in their fate in the body, so additivity may not have been an appropriate assumption. However, the assumption of additivity was considered appropriate because in most cases it represented a conservative estimate of risk.

Risks to any individual may also have been overestimated by summing multiple assumed exposure pathway risks for any single receptor. Although every effort was made to develop reasonable scenarios, not all individual receptors may be exposed via all pathways considered.

Finally, the risk characterization did not consider antagonistic or synergistic effects. Little or no information was available to determine the potential for antagonism or synergism for the COPCs. Because chemical-specific interactions could not be predicted, the likelihood for risks to be overpredicted or underpredicted could not be defined, but the methodology used was based on current U.S. EPA guidance.

7.7 SUMMARY AND CONCLUSIONS

This section briefly summarizes the results of the HHRA performed for SWMU 12 (MFA) and the Battery Site.

The baseline HHRA for SWMU 12 was performed to characterize the potential risks to likely human receptors under current and potential future land use. Potential receptors under current and future land use are adolescent trespassers, maintenance workers, and occupational workers. Potential receptors under future land use are construction workers, recreational users (children and adults), and hypothetical residents (children and adults). Although future land use is likely to be the same as current land use, the potential future receptors were evaluated in the baseline HHRA primarily for decision-making purposes.

Potential risks associated with inhalation exposures were considered to be minimal for soil, sediment, surface water, and groundwater. Inhalation of volatile emissions and fugitive dust from soils was evaluated qualitatively via a comparison of site data with U.S. EPA generic SSLs for transfers from soil to air. Inhalation exposure was considered to be relatively insignificant because all detected soil concentrations were less than the SSLs. Few VOCs were detected in site media, and no VOCs were identified as COPCs.

The list of COPCs for SWMU 12 included the following:

- Surface Soil (SWMU 12 Proper) - aluminum, arsenic, iron, manganese, and vanadium.
- Subsurface Soil (SWMU 12 Proper) - aluminum, arsenic, barium, iron, manganese, and vanadium.
- Surface/Subsurface Soil (historical samples) - TNT, 2-ADNT, 4-ADNT, 2-nitrotoluene, HMX, RDX, aluminum, and arsenic.
- Surface Soil (Battery Site) - benzo(a)pyrene, RDX, aluminum, antimony, arsenic, cadmium, copper, iron, lead, manganese, thallium, vanadium, and zinc.
- Subsurface Soil (Battery Site) - aluminum, arsenic, barium, iron, manganese, and vanadium.
- Puz Groundwater - 1,3-dinitrobenzene, TNT, 2,6-dinitrotoluene, 2-ADNT, 2-nitrotoluene, 4-ADNT, 4-nitrotoluene, HMX, RDX, aluminum, arsenic, beryllium, cadmium, chromium, cobalt, iron, lead, manganese, mercury, nickel, selenium, thallium, vanadium, zinc, and nitrite/nitrate-N.
- Pmz Groundwater - RDX, aluminum, antimony, arsenic, cadmium, chromium, cobalt, iron, lead, manganese, nickel, thallium, and vanadium.

- PlzMgd Groundwater - TNT, RDX, antimony, arsenic, iron, manganese, and vanadium.

- Gully Surface Water - TNT, 2-ADNT, 4-ADNT, RDX, aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, thallium, vanadium, zinc, and nitrite/nitrate-N.

- Gully Sediment - aluminum, antimony, arsenic, cadmium, iron, manganese, and vanadium.

- East Tributary Surface Water - RDX and arsenic.

- East Tributary Sediment - aluminum, arsenic, iron, manganese, and vanadium.

- Turkey Creek Surface Water - manganese.

- Turkey Creek Sediment - aluminum, arsenic, iron, manganese, and vanadium.

Quantitative estimates of non-carcinogenic and carcinogenic risks (HIs and ILCRs, respectively) were developed for potential human receptors and are summarized below.

Risk Assessment Results for Exposure to Soil - SWMU 12 Proper

Risks from exposure to COPCs in soil were evaluated for surface and subsurface soil samples collected during the RFI and for historical samples collected from areas near Buildings 152, 153/154, 157, and 158/159. Risks for Buildings 151 and 160 were not quantitatively evaluated because concentrations of explosives were less than facility cleanup goals specified for the bioremediation program, and a semi-quantitative evaluation of these areas showed risks to be negligible. Cumulative HIs for current and future receptors exposed to surface and/or subsurface soil were less than unity (1.0) on a target organ basis, indicating that adverse non-carcinogenic effects are not anticipated for these receptors under the defined exposure conditions. Cumulative ILCRs for all potential receptors were less than or within the U.S. EPA target risk range of $1x10^{-6}$ to $1x10^{-4}$.

Risk Assessment Results for Exposure to COPCs (Except Lead) in Battery Site Soil

Cumulative HIs for maintenance workers, adult recreational users, and adolescent trespassers were less than unity, indicating that no toxic effects are anticipated for these receptors under the defined exposure conditions. However, cumulative HIs for construction workers, occupational workers, child recreational

users, future adult residents, and future child residents exceeded unity. The elevated risks for these receptors were primarily due to the ingestion of antimony in surface soil. Antimony accounted for more than 90 percent of the total HI for these receptors. Other major contributors to the child resident HI were arsenic and iron.

Cumulative ILCRs for the construction worker, maintenance worker, occupational worker, adolescent trespasser, and total recreational user (child + adult) were within the U.S. EPA target risk range of $1x10^{-6}$ to $1x10^{-4}$. The total ILCR for future residents (child + adult) exceeded the target risk range. The primary contributor to the Battery Site ILCR (i.e., ILCR greater than 10^{-4}) for future residents (ILCR = $3x10^{-4}$) was arsenic. This risk is mainly due to concentrations of arsenic in surface soil at locations 12SB21 (94.2 mg/kg) and 12SB24 (158 mg/kg). Concentrations of arsenic in the other soil samples (surface and subsurface) collected in the Battery Area were less than 10 mg/kg and may reflect background conditions.

Risk Assessment Results for Exposure to COPCs (Except Lead) in Groundwater

Maintenance workers and adolescent trespassers were not evaluated for exposure to groundwater.

Results for Puz Groundwater

Cumulative HIs for all receptors evaluated for exposure to the Puz groundwater zone (construction workers, occupational workers, child and adult recreational users, and future child and adult residents) exceeded unity (1.0), indicating the potential for adverse effects under the defined exposure conditions. Manganese was the greatest contributor to the cumulative HIs. Other major contributors to the child HI were RDX, TNT, 2-ADNT, 4-ADNT, aluminum, arsenic, beryllium, cadmium, cobalt, iron, nickel, thallium, zinc, and nitrate/nitrite-N.

The cumulative ILCR for construction workers was less than $1x10^{-6}$. Total ILCRs for occupational workers, recreational users (child + adult), and hypothetical future residents (child + adult) exceeded U.S. EPA's target risk range. The primary contributors to the elevated ILCRs for the Puz groundwater zone (i.e., ILCRs greater than 10^{-4}) were RDX and arsenic. RDX (ILCR = $2x10^{-3}$) accounted for approximately 75 percent of the total residential ILCR, and arsenic (ILCR = $7x10^{-4}$) accounted for approximately 23 percent of the total residential ILCR. TNT was a minor contributor to the cancer risk estimate for the hypothetical future resident.

Results for Pmz Groundwater

Cumulative HIs for construction workers, occupational workers, and child and adult recreational users were less than unity when evaluated on a target organ basis. The HIs for future child and adult residents exceeded unity. Manganese and iron were the major contributors to the cumulative HIs.

The cumulative ILCR for the construction worker was less than $1x10^{-6}$. Total ILCRs for other potential receptors (occupational workers, recreational users, and future residents) were within U.S. EPA's target risk range ($1x10^{-6}$ to $1x10^{-4}$).

Results for PlzMgd Groundwater

Cumulative HIs for construction workers, occupational workers, and child and adult recreational users were less than unity when evaluated on a target organ basis. The HIs for future child and adult residents exceeded unity. Manganese, arsenic, and iron were the major contributors to the cumulative HIs. The maximum concentration was used as the EPC for PlzMgd groundwater because the data set contained less than 10 samples.

The cumulative ILCR for the construction worker was less than $1x10^{-6}$. Total ILCRs for occupational workers and recreational users were within the U.S. EPA target risk range. The total residential ILCR (child + adult) exceeded the target risk range. The primary contributor to the residential ILCR for PlzMgd groundwater was arsenic. The ILCR for arsenic was based on the maximum detected concentration (9.5 µg/L) in sample 12GWT4102 located in the southwestern portion of MFA. The maximum concentration of arsenic was less than concentrations in upgradient wells (17.6 to 19.7 µg/L) and the U.S. EPA MCL for arsenic (10 µg/L). As stated previously, no constituents were eliminated as COPCs on the basis of comparisons to background concentrations. Minor contributors to the PlzMgd risks were RDX (ILCR = $8x10^{-6}$) and TNT (ILCR = $2x10^{-6}$).

As discussed in Sections 7.5 and 7.6, the following important uncertainties are associated the groundwater risks:

- The calculated groundwater risks were based on average concentrations of COPCs in the most highly contaminated area of the plume.

- Comparisons to background values were not used in the COPC selection process and therefore risks for metals may be overestimated.

- The risk estimates developed for groundwater (and surface water) were based concentrations of some metals (e.g., aluminum, arsenic, lead, iron, and vanadium) that appear to be elevated, in part, because of particulate matter in unfiltered samples. This was evident in Puz groundwater samples and gully surface water samples (especially for lead). Elevated turbidity readings were reported for unfiltered samples, and metals concentrations reported for unfiltered samples significantly exceeded concentrations reported for filtered samples. Risks based on the samples with high turbidity readings might be greatly overestimated because groundwater is typically filtered before being used for drinking and other residential uses.

- Even though arsenic was a risk driver for Pmz groundwater, the maximum concentration of arsenic was less than U.S. EPA and IDEM MCLs and less than concentrations reported for samples collected at upgradient locations.

- The risks for nitrate/nitrite may be overestimated by using the RfD for nitrite to estimate risks.

- Groundwater is not currently used at SWMU 12 nor is it expected to be used in the future.

Risk Assessment Results for Exposure to COPCs (Except Lead) in Surface Water and Sediment

Risks for surface water and sediment were evaluated for exposures in gullies, the East Tributary, and Turkey Creek. Construction workers and occupational workers were not evaluated for exposure to surface water and sediment.

The cumulative HIs for surface water and sediment (i.e., the sum of risks for gullies, East Tributary, and Turkey Creek) were less than unity for all potential receptors on a target organ basis.

The cumulative ILCRs for surface water and sediment (i.e., the sum of risks for gullies, East Tributary, and Turkey Creek) were within U.S. EPA's target risk range for all potential receptors.

Risk Assessment Results for Exposure to Lead

Lead was identified as a COPC for surface soil at the Battery Site, for Puz and Pmz groundwater, and for gully surface water. Exposure to lead was evaluated for future child residents (and adolescent trespassers by inference from the child resident results) by using the IEUBK Model and for workers and adult recreational users by the TRW ALM.

Results of the lead evaluation indicated that predicted blood-lead levels for exposure to surface soil in the Battery Area and Puz groundwater exceeded the U.S. EPA level of concern (10 µg/dL) for all potential receptors evaluated (i.e., future child residents, construction workers, maintenance workers, and adult recreational users), and the probabilities of these receptors having blood-lead levels greater than 10 µg/dL exceeded U.S. EPA's goal of 5 percent. The elevated risks for the Battery Area were due to exposure to surface soil concentrations at locations 12SB21 (429,000 mg/kg) and 12SB23 (3,230 mg/kg). If sample 12SB21 was removed from the data set, the average concentration would be 420 mg/kg, and results for the IEUBK Model would still be unacceptable, but ALM results would be acceptable. If samples 12SB21 and 12SB23 were removed from the data set, the average concentration would be 108 mg/kg, and the IEUBK and ALM results would be acceptable. The surface soil sample at location 12SB21 also contained elevated concentrations of several other metals (e.g., antimony and arsenic) and may constitute a hot spot at the Battery Site. The risk for exposure to lead in Puz groundwater was based on the average concentration in the most highly contaminated area of the plume at SWMU 12. This area is the area in the southern portion of the site and includes locations 12MWT23, -24, -24A, and -39.

Results of the lead evaluation for Pmz groundwater and gully surface water indicated that predicted blood-lead levels were less than the U.S. EPA level of concern (10 µg/dL) for all potential receptors, and the probabilities of the receptors having blood-lead levels greater than 10 µg/dL were less than U.S. EPA's goal of 5 percent.

Summary

In summary for SWMU 12, no significant potential human health risks are expected for exposures to soil at SWMU 12 Proper, surface water, or sediment for all potential receptors. Non-carcinogenic and carcinogenic risk estimates exceeding U.S. EPA benchmarks were estimated for exposure to surface and subsurface soil at the Battery Site and for Puz, Pmz, and PlzMgd groundwater. The elevated risk estimates for the Battery Site were due to exposure to lead, antimony, arsenic, and iron in surface soil. The elevated risk estimates for Puz groundwater were due to exposure to explosives, 11 metals (including lead), and nitrate/nitrite-N. The elevated risk estimates for Pmz groundwater were due to exposure to iron and manganese for hypothetical future residents. The elevated risk estimates for PlzMgd groundwater were due to exposure to arsenic, iron, and manganese for hypothetical future residents. As discussed in the risk assessment, the risk estimates were subject to a number of significant uncertainties. Among these are the fact that comparisons to background levels were not used in the COPC screening process, the concentrations of metals in some groundwater samples appear to be

elevated because of turbidity in the samples, and the concentrations of some metals (e.g., arsenic in the PlzMgd) appear to be within background levels.

TABLE 7-1

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SURFACE SOIL - DIRECT CONTACT
SWMU 12 (MINE FIELD A) - PROPER
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-detections[2]	Concentration Used for Screening[3]	Concentration Greater Than Background ?[4]	U.S. EPA Region 9 PRG (Residential)[5]		Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Inorganics (mg/kg)															
7429-90-5	ALUMINUM	17500 J	29800 J	mg/kg	12SS070002	9/9	---	29800	NA	7600	N	NA	IDEM	Yes	ASL
7440-36-0	ANTIMONY	0.35 J	1.4 J	mg/kg	12SS070002	5/9	0.29 - 0.49	1.4	NA	3.1	N	140	IDEM	No	BSL
7440-38-2	ARSENIC	4 J	9 J	mg/kg	12SS010002	9/9	---	9	NA	0.39	C	3.9	IDEM	Yes	ASL
7440-39-3	BARIUM	50.2 J	128 J	mg/kg	12SS010002	9/9	---	128	NA	540	N	23000	IDEM	No	BSL
7440-41-7	BERYLLIUM	0.53 J	0.98 J	mg/kg	12SS080002	8/9	0.5	0.98	NA	15	N	680	IDEM	No	BSL
7440-70-2	CALCIUM	285 J	26000 J	mg/kg	12SS060002	9/9	---	26000	NA	NA	N	NA	IDEM	No	NUT
7440-47-3	CHROMIUM	18.1 J	26.9 J	mg/kg	12SS050002	9/9	---	26.9	NA	210	C	430	IDEM	No	BSL
7440-48-4	COBALT	4.6 J	15.7 J	mg/kg	12SS010002	9/9	---	15.7	NA	140	N	NA	IDEM	No	BSL
7440-50-8	COPPER	8.1 J	19 J	mg/kg	12SS070002	9/9	---	19	NA	310	N	13000	IDEM	No	BSL
7439-89-6	IRON	18800 J	30600 J	mg/kg	12SS050002	9/9	---	30600	NA	2300	N	NA	IDEM	Yes	ASL
7439-92-1	LEAD	10.7 J	31.2 J	mg/kg	12SS070002	9/9	---	31.2	NA	400		400	IDEM	No	BSL
7439-95-4	MAGNESIUM	1360 J	3050 J	mg/kg	12SS060002	9/9	---	3050	NA	NA	N	NA	IDEM	No	NUT
7439-96-5	MANGANESE	140 J	1080 J	mg/kg	12SS010002	9/9	---	1080	NA	180	N	NA	IDEM	Yes	ASL
7439-97-6	MERCURY	0.009 J	0.041 J	mg/kg	12SS040002	9/9	---	0.041	NA	2.3	N	100	IDEM	No	BSL
7440-02-0	NICKEL	12.1 J	21.4 J	mg/kg	12SS050002	9/9	---	21.4	NA	160	N	6900	IDEM	No	BSL
7440-09-7	POTASSIUM	1130 J	2120 J	mg/kg	12SS070002	9/9	---	2120	NA	NA	N	NA	IDEM	No	NUT
7440-22-4	SILVER	0.21 J	0.21 J	mg/kg	12SS080002	1/9	0.042 - 0.14	0.21	NA	39	N	1700	IDEM	No	BSL
7440-23-5	SODIUM	59.8 J	59.8 J	mg/kg	12SS060002	1/9	26.9 - 62.6	59.8	NA	NA	N	NA	IDEM	No	NUT
7440-31-5	TIN	0.58 J	0.61 J	mg/kg	12SS080002	2/9	0.38 - 0.6	0.61	NA	4700	N	NA	IDEM	No	BSL
7440-62-2	VANADIUM	28.4 J	48.6 J	mg/kg	12SS070002	9/9	---	48.6	NA	7.8	N	NA	IDEM	Yes	ASL
7440-66-6	ZINC	23.3 J	165 J	mg/kg	12SS070002	9/9	---	165	NA	2300	N	100000	IDEM	No	BSL

Shaded cell indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 -The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in soil relative to NSWC Crane background levels is presented in Section 5.0.
5 - U.S. EPA Region 9 Preliminary Remediation Goal (PRG). The noncarcinogenic values (denoted with a "N" flag) are the PRG divided by 10 to correspond to a target Hazard Quotient of 0.1. Carcinogenic values represent an incremental lifetime cancer risk of $1X10^{-6}$ (carcinogens denoted with a "C" flag) (U.S. EPA Region 9, October 2004, Updated December 28, 2004).
6 - Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for soil (IDEM, 2004).
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level .

Associated Samples

13SS010002	12SS060002
12SS010002	12SS070002
12SS020002	12SS080002
12SS030002	12SS090002
12SS040002	12SS100002
12SS050002	12SS110002

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Non-carcinogen
NA = Not applicable/not available
CAS = Chemical Abstracts Service

Rationale Codes:
For selection as a COPC:
ASL = Above screening level

For Elimination as a COPC:
BSL = Below COPC screening level/ARAR/TBC
NUT = Essential nutrient

TABLE 7-2

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SURFACE SOIL - MIGRATION PATHWAYS
SWMU 12 (MINE FIELD A) - PROPER
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections[2]	Concentration Used for Screening[3]	Concentration Greater Than Background ?[4]	U.S. EPA Generic SSL for Soil to Air[5]		U.S. EPA Generic SSL for Migration to Groundwater[5]	IDEM Closure Level for Migration to Groundwater[6]
Inorganics (mg/kg)													
7429-90-5	ALUMINUM	17500 J	29800 J	mg/kg	12SS070002	9/9	---	29800	NA	686000	N	8.3	NA
7440-36-0	ANTIMONY	0.35 J	1.4 J	mg/kg	12SS070002	5/9	0.29 - 0.49	1.4	NA	NA	N	0.27	5.4
7440-38-2	ARSENIC	4 J	9 J	mg/kg	12SS010002	9/9	---	9	NA	745	C	0.29	29
7440-39-3	BARIUM	50.2 J	128 J	mg/kg	12SS010002	9/9	---	128	NA	68600	N	82	1600
7440-41-7	BERYLLIUM	0.53 J	0.98 J	mg/kg	12SS080002	8/9	0.5	0.98	NA	1330	C	3.2	63
7440-70-2	CALCIUM	285 J	26000 J	mg/kg	12SS060002	9/9	---	26000	NA	NA		NA	NA
7440-47-3	CHROMIUM	18.1 J	26.9 J	mg/kg	12SS050002	9/9	---	26.9	NA	267	C	2.1	38
7440-48-4	COBALT	4.6 J	15.7 J	mg/kg	12SS010002	9/9	---	15.7	NA	1140	C	0.17	NA
7440-50-8	COPPER	8.1 J	19 J	mg/kg	12SS070002	9/9	---	19	NA	NA	N	560	920
7439-89-6	IRON	18800 J	30600 J	mg/kg	12SS050002	9/9	---	30600	NA	NA	N	NA	NA
7439-92-1	LEAD	10.7 J	31.2 J	mg/kg	12SS070002	9/9	---	31.2	NA	NA	N	NA	81
7439-95-4	MAGNESIUM	1360 J	3050 J	mg/kg	12SS060002	9/9	---	3050	NA	NA		NA	NA
7439-96-5	MANGANESE	140 J	1080 J	mg/kg	12SS010002	9/9	---	1080	NA	6860	N	110	NA
7439-97-6	MERCURY	0.009 J	0.041 J	mg/kg	12SS040002	9/9	---	0.041	NA	NA	N	NA	2.1
7440-02-0	NICKEL	12.1 J	21.4 J	mg/kg	12SS050002	9/9	---	21.4	NA	13300	C	14	950
7440-09-7	POTASSIUM	1130 J	2120 J	mg/kg	12SS070002	9/9	---	2120	NA	NA		NA	NA
7440-22-4	SILVER	0.21 J	0.21 J	mg/kg	12SS080002	1/9	0.042 - 0.14	0.21	NA	NA	N	1.6	31
7440-23-5	SODIUM	59.8 J	59.8 J	mg/kg	12SS060002	1/9	26.9 - 62.6	59.8	NA	NA		NA	NA
7440-31-5	TIN	0.58 J	0.61 J	mg/kg	12SS080002	2/9	0.38 - 0.6	0.61	NA	NA	N	NA	NA
7440-62-2	VANADIUM	28.4 J	48.6 J	mg/kg	12SS070002	9/9	---	48.6	NA	NA	N	260	NA
7440-66-6	ZINC	23.3 J	165 J	mg/kg	12SS070002	9/9	---	165	NA	NA	N	680	14000

Shaded cell indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 -The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in soil relative to NSWC Crane background levels is presented in Section 5.0.
5 - U.S. EPA Soil Screening Levels (SSLs) calculated on the U.S. EPA Internet Site at http://risk.lsd.ornl.gov/calc_start.htm. The soil-to-air SSLs for non-carcinogens are divided by 10. The migration-to-groundwater value represents a dilution attenuation factor (DAF) of 1.
6 - Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for soil (IDEM, 2004).

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Non-carcinogen
NA = Not applicable/not available
CAS = Chemical Abstracts Service

Associated Samples

13SS010002	12SS060002
12SS010002	12SS070002
12SS020002	12SS080002
12SS030002	12SS090002
12SS040002	12SS100002
12SS050002	12SS110002

TABLE 7-3

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SUBSURFACE SOIL - DIRECT CONTACT
SWMU 12 (MINE FIELD A) - PROPER
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Subsurface Soil

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections[2]	Concentration Used for Screening[3]	Concentration Greater Than Background ?[4]	U.S. EPA Region 9 PRG (Residential)[5]		Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Inorganics (mg/kg)															
7429-90-5	ALUMINUM	11900 J	37000 J	mg/kg	12SB110205	17/17	---	37000	NA	7600	N	NA	IDEM	Yes	ASL
7440-36-0	ANTIMONY	0.38 J	0.71 J	mg/kg	12SB070206	6/17	0.13 - 0.87	0.71	NA	3.1	N	140	IDEM	No	BSL
7440-38-2	ARSENIC	2.5 J	12.3 J	mg/kg	12SB080507	17/17	---	12.3	NA	0.39	C	3.9	IDEM	Yes	ASL
7440-39-3	BARIUM	45.2 J	568 J	mg/kg	12SB070610	17/17	---	568	NA	540	N	23000	IDEM	Yes	ASL
7440-41-7	BERYLLIUM	0.47 J	2 J	mg/kg	12SB090508	17/17	---	2	NA	15	N	680	IDEM	No	BSL
7440-70-2	CALCIUM	357 J	8100 J	mg/kg	12SB050204	17/17	---	8100	NA	NA		NA	IDEM	No	NUT
7440-47-3	CHROMIUM	21.2 J	38.7 J	mg/kg	12SB110205	17/17	---	38.7	NA	210	C	430	IDEM	No	BSL
7440-48-4	COBALT	2.2 J	27 J	mg/kg	12SB070610	17/17	---	27	NA	140	N	NA	IDEM	No	BSL
7440-50-8	COPPER	4 J	22.9 J	mg/kg	12SB090508	17/17	---	22.9	NA	310	N	13000	IDEM	No	BSL
7439-89-6	IRON	8380 J	49600 J	mg/kg	12SB060509	17/17	---	49600	NA	2300	N	NA	IDEM	Yes	ASL
7439-92-1	LEAD	8.8 J	39.4 J	mg/kg	12SB080507	17/17	---	39.4	NA	400		400	IDEM	No	BSL
7439-95-4	MAGNESIUM	911 J	4560 J	mg/kg	12SB040712	17/17	---	4560	NA	NA		NA	IDEM	No	NUT
7439-96-5	MANGANESE	12.5 J	1600 J	mg/kg	12SB050204	17/17	---	1600	NA	180	N	NA	IDEM	Yes	ASL
7439-97-6	MERCURY	0.007 J	0.13	mg/kg	12SB040207	12/15	0.007	0.13	NA	2.3	N	100	IDEM	No	BSL
7440-02-0	NICKEL	8.4 J	47.3 J	mg/kg	12SB090508	17/17	---	47.3	NA	160	N	6900	IDEM	No	BSL
7440-09-7	POTASSIUM	894 J	2490 J	mg/kg	12SB100508	17/17	---	2490	NA	NA		NA	IDEM	No	NUT
7782-49-2	SELENIUM	0.21 J	0.38 J	mg/kg	12SB080507	3/17	0.04 - 0.6	0.38	NA	39	N	1700	IDEM	No	BSL
7440-23-5	SODIUM	62.1 J	179 J	mg/kg	12SB040712	5/17	53.3 - 101	179	NA	NA		NA	IDEM	No	NUT
7440-31-5	TIN	0.49 J	0.66 J	mg/kg	12SB110205	3/17	0.27 - 0.7	0.66	NA	4700	N	NA	IDEM	No	BSL
7440-62-2	VANADIUM	17.4 J	50.5 J	mg/kg	12SB080507	17/17	---	50.5	NA	7.8	N	NA	IDEM	Yes	ASL
7440-66-6	ZINC	9.8 J	99.2 J	mg/kg	12SB090508	17/17	---	99.2	NA	2300	N	100000	IDEM	No	BSL
Miscellaneous Parameters (mg/kg)															
NA	AMMONIA-N	0.16 J	0.9 J	mg/kg	12SB020608	2/2	---	0.9	NA	NA		NA	NA	No	NTX
NA	CATION EXCHANGE CAPACITY (MEQ/1)	9.2	16	mg/kg	12SB020608	2/2	---	16	NA	NA		NA	NA	No	NTX
NA	PH (S.U.)	6.05	6.1	mg/kg	12SB030608	2/2	---	6.1	NA	NA		NA	NA	No	NTX

Shaded cell indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in soil relative to NSWC Crane background levels is presented in Section 5.0.
5 - U.S. EPA Region 9 Preliminary Remediation Goal (PRG). The non-carcinogenic values (denoted with a "N" flag) are the PRG divided by 10 to correspond to a target Hazard Quotient of 0.1. Carcinogenic values represent an incremental lifetime cancer risk of $1x10^{-6}$ (carcinogens denoted with a "C" flag) (U.S. EPA Region 9, October 2004, Updated December 28, 2004).
6 - Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for soil (IDEM, 2004).
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level .

Associated Samples

12SB120204	12SB150204	12SB180204
12SB120608	12SB150607	12SB180608
12SB130204	12SB160204	12SB190204
12SB130607	12SB160608	12SB190608
12SB140204	12SB170204	12SB200204
12SB140607	12SB170608	12SB200608

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Non-carcinogen
NA = Not applicable/not available
CAS = Chemical Abstracts Service

Rationale Codes:
For selection as a COPC:
ASL = Above screening level

For Elimination as a COPC:
BSL = Below COPC screening level/ARAR/TBC
NTX = No Toxicity Information
NUT = Essential nutrient

TABLE 7-4

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SUBSURFACE SOIL - MIGRATION PATHWAYS
SWMU 12 (MINE FIELD A) - PROPER
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Subsurface Soil

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Ddetections[2]	Concentration Used for Screening[3]	Concentration Greater Than Background ?[4]	U.S. EPA Generic SSL for Soil to Air[5]		U.S. EPA Generic SSL for Migration to Groundwater[5]	IDEM Closure Level for Migration to Groundwater[6]
Inorganics (mg/kg)													
7429-90-5	ALUMINUM	11900 J	37000 J	mg/kg	12SB110205	17/17	---	37000	NA	686000	N	8.3	NA
7440-36-0	ANTIMONY	0.38 J	0.71 J	mg/kg	12SB070206	6/17	0.13 - 0.87	0.71	NA	NA	N	0.27	5.4
7440-38-2	ARSENIC	2.5 J	12.3 J	mg/kg	12SB080507	17/17	---	12.3	NA	745	C	0.29	29
7440-39-3	BARIUM	45.2 J	568 J	mg/kg	12SB070610	17/17	---	568	NA	68600	N	82	1600
7440-41-7	BERYLLIUM	0.47 J	2 J	mg/kg	12SB090508	17/17	---	2	NA	1330	C	3.2	63
7440-70-2	CALCIUM	357 J	8100 J	mg/kg	12SB050204	17/17	---	8100	NA	NA		NA	NA
7440-47-3	CHROMIUM	21.2 J	38.7 J	mg/kg	12SB110205	17/17	---	38.7	NA	267	C	2.1	38
7440-48-4	COBALT	2.2 J	27 J	mg/kg	12SB070610	17/17	---	27	NA	1140	C	0.17	NA
7440-50-8	COPPER	4 J	22.9 J	mg/kg	12SB090508	17/17	---	22.9	NA	NA	N	560	920
7439-89-6	IRON	8380 J	49600 J	mg/kg	12SB060509	17/17	---	49600	NA	NA	N	NA	NA
7439-92-1	LEAD	8.8 J	39.4 J	mg/kg	12SB080507	17/17	---	39.4	NA	NA		NA	81
7439-95-4	MAGNESIUM	911 J	4560 J	mg/kg	12SB040712	17/17	---	4560	NA	NA		NA	NA
7439-96-5	MANGANESE	12.5 J	1600 J	mg/kg	12SB050204	17/17	---	1600	NA	6860	N	110	NA
7439-97-6	MERCURY	0.007 J	0.13	mg/kg	12SB040207	12/15	0.007	0.13	NA	NA	N	NA	2.1
7440-02-0	NICKEL	8.4 J	47.3 J	mg/kg	12SB090508	17/17	---	47.3	NA	13300	N	14	950
7440-09-7	POTASSIUM	894 J	2490 J	mg/kg	12SB100508	17/17	---	2490	NA	NA		NA	NA
7782-49-2	SELENIUM	0.21 J	0.38 J	mg/kg	12SB080507	3/17	0.04 - 0.6	0.38	NA	NA	N	0.26	5.2
7440-23-5	SODIUM	62.1 J	179 J	mg/kg	12SB040712	5/17	53.3 - 101	179	NA	NA		NA	NA
7440-31-5	TIN	0.49 J	0.66 J	mg/kg	12SB110205	3/17	0.27 - 0.7	0.66	NA	NA	N	NA	NA
7440-62-2	VANADIUM	17.4 J	50.5 J	mg/kg	12SB080507	17/17	---	50.5	NA	NA	N	260	NA
7440-66-6	ZINC	9.8 J	99.2 J	mg/kg	12SB090508	17/17	---	99.2	NA	NA	N	680	14000
Miscellaneous Parameters (mg/kg)													
NA	AMMONIA-N	0.16 J	0.9 J	mg/kg	12SB020608	2/2	---	0.9	NA	NA		1.37×10^8	NA
NA	CATION EXCHANGE CAPACITY (MEQ/1)	9.2	16	mg/kg	12SB020608	2/2	---	16	NA	NA		NA	NA
NA	PH (S.U.)	6.05	6.1	mg/kg	12SB030608	2/2	---	6.1	NA	NA		NA	NA

Shaded cell indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 -The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in soil relative to NSWC Crane background levels is presented in Section 5.0.
5 - U.S. EPA Soil Screening Levels (SSLs) calculated on the U.S. EPA Internet Site at http://risk.lsd.ornl.gov/calc_start.htm. The soil-to-air SSLs for non-carcinogens are divided by 10. The migration-to-groundwater value represents a dilution attenuation factor (DAF) of 1.
6 - Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for soil (IDEM, 2004).

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Non-carcinogen
NA = Not applicable/not available
CAS = Chemical Abstracts Service

Associated Samples

12SB120204	12SB150204	12SB180204
12SB120608	12SB150607	12SB180608
12SB130204	12SB160204	12SB190204
12SB130607	12SB160608	12SB190608
12SB140204	12SB170204	12SB200204
12SB140607	12SB170608	12SB200608

TABLE 7-5

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SURFACE / SUBSURFACE SOIL - DIRECT CONTACT - HISTORICAL DATA
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface / Subsurface Soil

CAS Number	Chemical	Minimum Concentration[1]		Maximum Concentration[1]		Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections[2]	Concentration Used for Screening[3]	Concentration Greater Than Background ?[4]	U.S. EPA Region 9 PRG (Residential)[5]		Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Energetics (mg/kg)																	
99-35-4	1,3,5-TRINITROBENZENE	0.135	J	5.26		mg/kg	Bldg 157, Grid 112	14/442	0.192 - 31.2	5.26	NA	180	N	NA	IDEM	No	BSL
118-96-7	2,4,6-TRINITROTOLUENE	0.06	J	793		mg/kg	Bldg 153, Grid 27	246/442	0.2 - 12.5	793	NA	3.1	N	NA	IDEM	Yes	ASL
121-14-2	2,4-DINITROTOLUENE	0.242	J	0.242	J	mg/kg	Bldg 158, Grid 58	1/442	0.192 - 312	0.242	NA	12	N	6.3	IDEM	No	BSL
606-20-2	2,6-DINITROTOLUENE	0.178	J	1.41		mg/kg	Bldg 158, Grid 58	3/442	0.2 - 32.5	1.41	NA	6.1	N	6.3	IDEM	No	BSL
1321-12-6	2-AMINO-4,6-DINITROTOLUENE	0.0524	J	2.33		mg/kg	Bldg 153, Grid 4	65/442	0.192 - 312	2.33	NA	1.2	N	NA	IDEM	Yes	ASL
88-72-2	2-NITROTOLUENE	0.074	J	0.939		mg/kg	Bldg 158, Grid 58	3/442	0.192 - 31.2	0.939	NA	0.88	C	NA	IDEM	Yes	ASL
1321-12-6	4-AMINO-2,6-DINITROTOLUENE	0.0664	J	5.8		mg/kg	Bldg 153, Grid 4	88/442	0.192 - 312	5.8	NA	1.2	N	NA	IDEM	Yes	ASL
2691-41-0	HMX	0.191	J	752		mg/kg	Bldg 153, Grid 28	348/442	1 - 2.2	752	NA	310	N	NA	IDEM	Yes	ASL
121-82-4	RDX	0.0849	J	5940		mg/kg	Bldg 153, Grid 28	332/442	0.5 - 1	5940	NA	4.4	C	NA	IDEM	Yes	ASL
Inorganics (mg/kg)																	
7429-90-5	ALUMINUM	3310		35200		mg/kg	Bldg 153, Grid 173	210/210	---	35200	NA	7600	N	NA	NA	Yes	ASL
7440-38-2	ARSENIC	2.9		57.3		mg/kg	Bldg 158, Grid 196	107/110	11.5 - 12.2	57.3	NA	0.39	C	3.9	IDEM	Yes	ASL
7440-39-3	BARIUM	14.4		351		mg/kg	Bldg 153, Grid 205	337/337	---	351	NA	540	N	23000	IDEM	No	BSL
7440-43-9	CADMIUM	0.03		2.4		mg/kg	Bldg 153, Grid 170	143/337	0.03 - 0.95	2.4	NA	3.7	N	12	IDEM	No	BSL
18540-29-9	CHROMIUM	4.4		60.4		mg/kg	Bldg 153, Grid 37	337/337	---	60.4	NA	210	C	430	IDEM	No	BSL
7439-92-1	LEAD	3.7	B	71		mg/kg	Bldg 158, Grid 44	337/337	---	71	NA	400	N	400	IDEM	No	BSL
7487-94-7	MERCURY	0.0073	J	1.6		mg/kg	Bldg 158, Grid 12	120/210	0.02 - 0.14	1.6	NA	2.3	N	100	IDEM	No	BSL
7782-49-2	SELENIUM	0.5	B	1.4		mg/kg	Bldg 153, Grid 179	21/110	0.36 - 46.9	1.4	NA	39	N	1700	IDEM	No	BSL
7440-22-4	SILVER	0.14	B	0.14	B	mg/kg	Bldg 160, Grid 186	1/110	0.13 - 1.4	0.14	NA	39	N	1700	IDEM	No	BSL
Volatile Organics (ug/kg)																	
67-64-1	ACETONE	2	J	200	B	ug/kg	Bldg 158, Grid 148	129/247	4 - 29	200	NA	1400000	N	4800000	IDEM	No	BSL
67-66-3	CHLOROFORM	2	JB	2	JB	ug/kg	Bldg 157, Grid 110	1/76	5 - 6	2	NA	220	C	910	IDEM	No	BSL
78-93-3	2-BUTANONE	3	J	12	J	ug/kg	Bldg 153, Grid 173	7/247	4 - 15	12	NA	2200000	N	44000000	IDEM	No	BSL
75-09-2	METHYLENE CHLORIDE	1	J	75		ug/kg	Bldg 158, Grid 56	112/247	4 - 10	75	NA	9100	C	120000	IDEM	No	BSL
108-88-3	TOLUENE	1	J	7		ug/kg	Bldg 158, Grid 183	13/247	4 - 10	7	NA	520000	sat	1700000	IDEM	No	BSL
1330-20-7	XYLENES	2	J	13	B	ug/kg	Bldg 153, Grid 135	15/247	4 - 10	13	NA	27000	N	690000	IDEM	No	BSL

Shaded cell indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes

1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 -The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in historical samples relative to NSWC Crane background levels is presented in Section 5.0.
5 - U.S. EPA Region 9 Preliminary Remediation Goal (PRG). The non-carcinogenic values (denoted with a "N" flag) are the PRG divided by 10 to correspond to a target Hazard Quotient of 0.1. Carcinogenic values represent an incremental lifetime cancer risk of $1x10^{-6}$ (carcinogens denoted with a "C" flag) (U.S. EPA Region 9, October 2004, Updated December 28, 2004).
6 - Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for soil (IDEM, 2004).
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level.

Definitions:

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
B = Compound was found in the associated blank
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Noncarcinogen
NA = Not applicable/not available
sat = Soil saturation concentration
CAS = Chemical Abstracts Service

Rationale Codes:

For selection as a COPC:
ASL = Above screening level

For Elimination as a COPC:
BSL = Below COPC screening level/ARAR/TBC

TABLE 7-6

COMPARISON OF SOIL CONCENTRATIONS TO CRITERIA FOR MIGRATION FROM SOIL TO AIR AND SOIL TO GROUNDWATER - HISTORICAL SURFACE / SUBSURFACE SOIL DATA
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface / Subsurface Soil

CAS Number	Chemical	Minimum Concentration[1]		Maximum Concentration[1]		Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections[2]	Concentration Used for Screening[3]	Concentration Greater Than Background ?[4]	U.S. EPA Generic SSL for Soil to Air[5]		U.S. EPA Generic SSL for Migration to Groundwater[5]	IDEM Closure Level for Migration to Groundwater[6]
Explosives (mg/kg)															
99-35-4	1,3,5-TRINITROBENZENE	0.135	J	5.26		mg/kg	Bldg 157, Grid 112	14/442	0.192 - 31.2	5.26	NA	NA	N	0.25	NA
118-96-7	2,4,6-TRINITROTOLUENE	0.06	J	793		mg/kg	Bldg 153, Grid 27	246/442	0.2 - 12.5	793	NA	NA	N	0.00057	NA
121-14-2	2,4-DINITROTOLUENE	0.242	J	0.242	J	mg/kg	Bldg 158, Grid 58	1/442	0.192 - 312	0.242	NA	NA	N	0.000049	0.0091
606-20-2	2,6-DINITROTOLUENE	0.178	J	1.41		mg/kg	Bldg 158, Grid 58	3/442	0.2 - 32.5	1.41	NA	NA	N	0.000042	0.0091
1321-12-6	2-AMINO-4,6-DINITROTOLUENE	0.0524	J	2.33		mg/kg	Bldg 153, Grid 4	65/442	0.192 - 312	2.33	NA	NA	N	NA	NA
88-72-2	2-NITROTOLUENE	0.074	J	0.939		mg/kg	Bldg 158, Grid 58	3/442	0.192 - 31.2	0.939	NA	NA	C	0.00015	NA
1321-12-6	4-AMINO-2,6-DINITROTOLUENE	0.0664	J	5.8		mg/kg	Bldg 153, Grid 4	88/442	0.192 - 312	5.8	NA	NA	N	NA	NA
2691-41-0	HMX	0.191	J	752		mg/kg	Bldg 153, Grid 28	348/442	1 - 2.2	752	NA	NA	N	NA	NA
121-82-4	RDX	0.0849	J	5940		mg/kg	Bldg 153, Grid 28	332/442	0.5 - 1	5940	NA	NA	C	NA	NA
Inorganics (mg/kg)															
7429-90-5	ALUMINUM	3310		35200		mg/kg	Bldg 153, Grid 173	210/210	---	35200	NA	686000	N	8.3	NA
7440-38-2	ARSENIC	2.9		57.3		mg/kg	Bldg 158, Grid 196	107/110	11.5 - 12.2	57.3	NA	745	C	0.29	3.9
7440-39-3	BARIUM	14.4		351		mg/kg	Bldg 153, Grid 205	337/337	---	351	NA	68600	N	82	1600
7440-43-9	CADMIUM	0.03		2.4		mg/kg	Bldg 153, Grid 170	143/337	0.03 - 0.95	2.4	NA	1780	C	0.38	7.5
18540-29-9	CHROMIUM	4.4		60.4		mg/kg	Bldg 153, Grid 37	337/337	---	60.4	NA	267	C	2.1	38
7439-92-1	LEAD	3.7	B	71		mg/kg	Bldg 158, Grid 44	337/337	---	71	NA	NA	N	NA	81
7487-94-7	MERCURY	0.0073	J	1.6		mg/kg	Bldg 158, Grid 12	120/210	0.02 - 0.14	1.6	NA	NA	N	NA	2.1
7782-49-2	SELENIUM	0.5	B	1.4		mg/kg	Bldg 153, Grid 179	21/110	0.36 - 46.9	1.4	NA	NA	N	0.26	5.2
7440-22-4	SILVER	0.14	B	0.14	B	mg/kg	Bldg 160, Grid 186	1/110	0.13 - 1.4	0.14	NA	NA	N	1.6	31
Volatile Organics (ug/kg)															
67-64-1	ACETONE	2	J	200	B	ug/kg	Bldg 158, Grid 148	129/247	4 - 29	200	NA	NA	N	6600	3800
67-66-3	CHLOROFORM	2	JB	2	JB	ug/kg	Bldg 157, Grid 110	1/76	5- 6	2	NA	280	C	29	470
78-93-3	2-BUTANONE	3	J	12	J	ug/kg	Bldg 153, Grid 173	7/247	4 - 15	12	NA	24000000	sat	4400	35000
75-09-2	METHYLENE CHLORIDE	1	J	75		ug/kg	Bldg 158, Grid 56	112/247	4 - 10	75	NA	13000	C	1.2	23
108-88-3	TOLUENE	1	J	7		ug/kg	Bldg 158, Grid 183	13/247	4 - 10	7	NA	650000	sat	590	12000
1330-20-7	XYLENES	2	J	13	B	ug/kg	Bldg 153, Grid 135	15/247	4 - 10	13	NA	71000	N	7100	170000

Shaded cell indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in historical samples relative to Crane background levels is presented in Section 5.0.
5 - U.S. EPA Soil Screening Levels (SSLs) calculated on the U.S. EPA Internet Site at http://risk.lsd.ornl.gov/calc_start.htm. The soil-to-air SSLs for non-carcinogens are divided by 10. The migration-to-groundwater value represents a dilution attenuation factor (DAF) of 1.
6 - Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for soil (IDEM, 2004).

Definitions:
B = Compound was found in the associated blank
C = Carcinogen
J = Estimated value
N = Non-carcinogen
NA = Not applicable/not available
sat = Soil saturation concentration
CAS = Chemical Abstracts Service

TABLE 7-7

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN -SURFACE SOIL - DIRECT CONTACT
SWMU12 (MINE FIELD A) - BATTERY AREA
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections[2]	Concentration Used for Screening[3]	Concentration Greater Than Background ?[4]	U.S. EPA Region 9 PRG (Residential)[5]		Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Volatile Organics (ug/kg)															
75-71-8	DICHLORODIFLUOROMETHANE	2 J	15	ug/kg	12SS210002	9/11	1.14 - 1.25	15	NA	9400	N	NA	IDEM	No	BSL
75-09-2	METHYLENE CHLORIDE	1 J	2 J	ug/kg	12SS220002, 12SS230002	3/11	0.921 - 1.6	2	NA	9100	C	120000	IDEM	No	BSL
Semivolatile Organics (ug/kg)															
83-32-9	ACENAPHTHENE	4 J	4 J	ug/kg	12SS150002	1/11	3.47 - 3.82	4	NA	370000	N	9500000	IDEM	No	BSL
208-96-8	ACENAPHTHYLENE	19	19	ug/kg	12SS150002	1/11	3.47 - 3.82	19	NA	370000	N	1100000	IDEM	No	BSL
120-12-7	ANTHRACENE	21	21	ug/kg	12SS150002	1/11	3.47 - 3.82	21	NA	2200000	N	47000000	IDEM	No	BSL
56-55-3	BENZO(A)ANTHRACENE	5 J	98	ug/kg	12SS150002	5/11	3.63 - 3.82	98	NA	620	C	5000	IDEM	No	BSL
50-32-8	BENZO(A)PYRENE	12	110	ug/kg	12SS150002	4/11	3.47 - 3.82	110	NA	62	C	500	IDEM	Yes	ASL
205-99-2	BENZO(B)FLUORANTHENE	13	150	ug/kg	12SS150002	5/11	3.63 - 3.82	150	NA	620	C	5000	IDEM	No	BSL
191-24-2	BENZO(G,H,I)PERYLENE	13	93	ug/kg	12SS150002	5/11	3.63 - 3.82	93	NA	230000	N	50000	IDEM	No	BSL
207-08-9	BENZO(K)FLUORANTHENE	4 J	90	ug/kg	12SS150002	5/11	3.63 - 3.82	90	NA	6200	C	50000	IDEM	No	BSL
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	1300	1300	ug/kg	12SS150002	1/11	70.4 - 77.5	1300	NA	35000	C	300000	IDEM	No	BSL
218-01-9	CHRYSENE	12	110	ug/kg	12SS210002	5/11	3.63 - 3.82	110	NA	62000	C	500000	IDEM	No	BSL
84-74-2	DI-N-BUTYL PHTHALATE	170 J	170 J	ug/kg	12SS210002	1/11	73.6 - 77.5	170	NA	610000	N	18000000	IDEM	No	BSL
53-70-3	DIBENZO(A,H)ANTHRACENE	21	21	ug/kg	12SS150002	1/11	3.47 - 3.82	21	NA	62	C	500	IDEM	No	BSL
206-44-0	FLUORANTHENE	11	140	ug/kg	12SS150002	5/11	3.63 - 3.82	140	NA	230000	N	6300000	IDEM	No	BSL
86-73-7	FLUORENE	4 J	4 J	ug/kg	12SS150002	1/11	3.47 - 3.82	4	NA	270000	N	6300000	IDEM	No	BSL
193-39-5	INDENO(1,2,3-CD)PYRENE	11	80	ug/kg	12SS150002	5/11	3.63 - 3.82	80	NA	620	C	5000	IDEM	No	BSL
120-58-1	ISOSAFROLE	2300	8400	ug/kg	12SS180002	2/11	70.4 - 77.5	8400	NA	NA		NA	IDEM	No	NTX
91-20-3	NAPHTHALENE	4 J	38	ug/kg	12SS210002	3/11	3.63 - 3.82	38	NA	5600	N	3200000	IDEM	No	BSL
85-01-8	PHENANTHRENE	9 J	140 J	ug/kg	12SS210002	5/11	3.63 - 3.82	140	NA	230000	N	470000	IDEM	No	BSL
129-00-0	PYRENE	19	180	ug/kg	12SS150002	5/11	3.63 - 3.82	180	NA	230000	N	4700000	IDEM	No	BSL
Energetics (mg/kg)															
99-35-4	1,3,5-TRINITROBENZENE	0.84	0.84	mg/kg	12SS210002	1/11	0.25	0.84	NA	180	N	NA	IDEM	No	BSL
2691-41-0	HMX	1.7	1.7	mg/kg	12SS210002	1/11	0.25	1.7	NA	310	N	NA	IDEM	No	BSL
121-82-4	RDX	6.1	6.1	mg/kg	12SS210002	1/11	0.25	6.1	NA	4.4	C	NA	IDEM	Yes	ASL
Inorganics (mg/kg)															
7429-90-5	ALUMINUM	8780 J	23700	mg/kg	12SS190002	11/11	---	23700	NA	7600	N	NA	IDEM	Yes	ASL
7440-36-0	ANTIMONY	0.38 J	3610 J	mg/kg	12SS210002	5/11	0.12 - 0.95	3610	NA	3.1	N	140	IDEM	Yes	ASL
7440-38-2	ARSENIC	2.6 J	158 J	mg/kg	12SS240002	11/11	---	158	NA	0.39	C	3.9	IDEM	Yes	ASL
7440-39-3	BARIUM	54.1 J	505 J	mg/kg	12SS210002	11/11	---	505	NA	540	N	23000	IDEM	No	BSL
7440-41-7	BERYLLIUM	0.72 J	1.5 J	mg/kg	12SS130002, 12SS140002	7/11	0.35 - 1	1.5	NA	15	N	680	IDEM	No	BSL
7440-43-9	CADMIUM	5.8 J	6.3 J	mg/kg	12SS220002	2/11	0.2 - 0.81	6.3	NA	3.7	N	12	IDEM	Yes	ASL
7440-70-2	CALCIUM	299 J	17800 J	mg/kg	12SS150002	11/11	---	17800	NA	NA		NA	IDEM	No	NUT
7440-47-3	CHROMIUM	18.3 J	51.7 J	mg/kg	12SS240002	11/11	---	51.7	NA	210	C	430	IDEM	No	BSL
7440-48-4	COBALT	5 J	13.6 J	mg/kg	12SS220002	11/11	---	13.6	NA	140	N	NA	IDEM	No	BSL
7440-50-8	COPPER	8.7 J	345 J	mg/kg	12SS210002	11/11	---	345	NA	310	N	13000	IDEM	Yes	ASL
7439-89-6	IRON	7160 J	65900 J	mg/kg	12SS130002	11/11	---	65900	NA	2300	N	NA	IDEM	Yes	ASL
7439-92-1	LEAD	8.2 J	429000 J	mg/kg	12SS210002	11/11	---	429000	NA	400		400	IDEM	Yes	ASL
7439-95-4	MAGNESIUM	940 J	2750 J	mg/kg	12SS220002	11/11	---	2750	NA	NA		NA	IDEM	No	NUT
7439-96-5	MANGANESE	68.7 J	1400	mg/kg	12SS230002	11/11	---	1400	NA	180	N	NA	IDEM	Yes	ASL
7439-97-6	MERCURY	0.009 J	0.31	mg/kg	12SS210002	9/11	0.007	0.31	NA	2.3	N	100	IDEM	No	BSL
7440-02-0	NICKEL	14 J	44.6 J	mg/kg	12SS130002	11/11	---	44.6	NA	160	N	6900	IDEM	No	BSL
7440-09-7	POTASSIUM	558 J	4370 J	mg/kg	12SS140002	11/11	---	4370	NA	NA		NA	IDEM	No	NUT
7782-49-2	SELENIUM	0.49 J	0.61 J	mg/kg	12SS240002	2/11	0.13 - 0.56	0.61	NA	39	N	1700	IDEM	No	BSL
7440-22-4	SILVER	18.5 J	18.5 J	mg/kg	12SS210002	1/11	0.042 - 0.72	18.5	NA	39	N	1700	IDEM	No	BSL
7440-23-5	SODIUM	78.2 J	370 J	mg/kg	12SS220002	3/11	20.5 - 153	370	NA	NA		NA	IDEM	No	NUT
7440-28-0	THALLIUM	6.4 J	6.4 J	mg/kg	12SS210002	1/11	0.15 - 0.34	6.4	NA	0.52	N	24	IDEM	Yes	ASL
7440-31-5	TIN	12.4 J	838 J	mg/kg	12SS210002	4/11	0.46 - 2.3	838	NA	4700	N	NA	IDEM	No	BSL
7440-62-2	VANADIUM	16.8 J	42.8 J	mg/kg	12SS190002	11/11	---	42.8	NA	7.8	N	NA	IDEM	Yes	ASL
7440-66-6	ZINC	31 J	2490 J	mg/kg	12SS220002	11/11	---	2490	NA	2300	N	100000	IDEM	Yes	ASL

TABLE 7-7

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN -SURFACE SOIL - DIRECT CONTACT
SWMU12 (MINE FIELD A) - BATTERY AREA
NSWC CRANE
CRANE, INDIANA

Shaded cell indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 -The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in soil relative to NSWC Crane background levels is presented in Section 5.0.
5 - U.S. EPA Region 9 Preliminary Remediation Goal (PRG). The non-carcinogenic values (denoted with a "N" flag) are the PRG divided by 10 to correspond to a target Hazard Quotient of 0.1. Carcinogenic values represent an incremental lifetime cancer risk of $1x10^{-6}$ (carcinogens denoted with a "C" flag) (U.S. EPA Region 9, October 2004, Updated December 28, 2004).
6 - Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for soil (IDEM, 2004).
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level.

Associated Samples

12SS120002	12SS190002
12SS130002	12SS200002
12SS140002	12SS210002
12SS160002	12SS220002
12SS170002	12SS230002
12SS180002	12SS240002

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Non-carcinogen
NA = Not applicable/not available
CAS = Chemical Abstracts Service

Rationale Codes:
For selection as a COPC:
ASL = Above screening level

For Elimination as a COPC:
BSL = Below COPC screening level/ARAR/TBC
NTX = No toxicity information
NUT = Essential nutrient

TABLE 7-8

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SURFACE SOIL - MIGRATION PATHWAYS
SWMU 12 (MINE FIELD A) - BATTERY AREA
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections[2]	Concentration Used for Screening[3]	Concentration Greater Than Background ?[4]	U.S. EPA Generic SSL for Soil to Air[5]		U.S. EPA Generic SSL for Migration to Groundwater[5]	IDEM Closure Level for Migration to Groundwater[6]
Volatile Organics (ug/kg)													
75-71-8	DICHLORODIFLUOROMETHANE	2 J	15	ug/kg	12SS210002	9/11	1.14 - 1.25	15	NA	25000	N	28000	NA
75-09-2	METHYLENE CHLORIDE	1 J	2 J	ug/kg	12SS220002, 12SS230002	3/11	0.921 - 1.6	2	NA	13000	C	1.2	23
Semivolatile Organics (ug/kg)													
83-32-9	ACENAPHTHENE	4 J	4 J	ug/kg	12SS150002	1/11	3.47 - 3.82	4	NA	NA	N	31000	130000
208-96-8	ACENAPHTHYLENE	19	19	ug/kg	12SS150002	1/11	3.47 - 3.82	19	NA	NA	N	NA	18000
120-12-7	ANTHRACENE	21	21	ug/kg	12SS150002	1/11	3.47 - 3.82	21	NA	NA	N	650000	51000
56-55-3	BENZO(A)ANTHRACENE	5 J	98	ug/kg	12SS150002	5/11	3.63 - 3.82	98	NA	NA	C	160	19000
50-32-8	BENZO(A)PYRENE	12	110	ug/kg	12SS150002	4/11	3.47 - 3.82	110	NA	NA	C	410	8200
205-99-2	BENZO(B)FLUORANTHENE	13	150	ug/kg	12SS150002	5/11	3.63 - 3.82	150	NA	NA	C	490	57000
191-24-2	BENZO(G,H,I)PERYLENE	13	93	ug/kg	12SS150002	5/11	3.63 - 3.82	93	NA	NA	N	NA	16000
207-08-9	BENZO(K)FLUORANTHENE	4 J	90	ug/kg	12SS150002	5/11	3.63 - 3.82	90	NA	NA	C	490	39000
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	1300	1300	ug/kg	12SS150002	1/11	70.4 - 77.5	1300	NA	NA	C	180000	3600000
218-01-9	CHRYSENE	12	110	ug/kg	12SS210002	5/11	3.63 - 3.82	110	NA	7500000	C	160	25000
84-74-2	DI-N-BUTYL PHTHALATE	170 J	170 J	ug/kg	12SS210002	1/11	73.6 - 77.5	170	NA	NA	N	250000	5000000
53-70-3	DIBENZO(A,H)ANTHRACENE	21	21	ug/kg	12SS150002	1/11	3.47 - 3.82	21	NA	NA	C	1500	18000
206-44-0	FLUORANTHENE	11	140	ug/kg	12SS150002	5/11	3.63 - 3.82	140	NA	NA	N	310000	880000
86-73-7	FLUORENE	4 J	4 J	ug/kg	12SS150002	1/11	3.47 - 3.82	4	NA	NA	N	41000	170000
193-39-5	INDENO(1,2,3-CD)PYRENE	11	80	ug/kg	12SS150002	5/11	3.63 - 3.82	80	NA	NA	C	1400	3100
120-58-1	ISOSAFROLE	2300	8400	ug/kg	12SS180002	2/11	70.4 - 77.5	8400	NA	NA		NA	NA
91-20-3	NAPHTHALENE	4 J	38	ug/kg	12SS210002	3/11	3.63 - 3.82	38	NA	17000	N	3100	700
85-01-8	PHENANTHRENE	9 J	140 J	ug/kg	12SS210002	5/11	3.63 - 3.82	140	NA	NA	N	NA	13000
129-00-0	PYRENE	19	180	ug/kg	12SS150002	5/11	3.63 - 3.82	180	NA	NA	N	230000	570000
Energetics (mg/kg)													
99-35-4	1,3,5-TRINITROBENZENE	0.84	0.84	mg/kg	12SS210002	1/11	0.25	0.84	NA	NA	N	0.25	NA
2691-41-0	HMX	1.7	1.7	mg/kg	12SS210002	1/11	0.25	1.7	NA	NA	N	NA	NA
121-82-4	RDX	6.1	6.1	mg/kg	12SS210002	1/11	0.25	6.1	NA	NA	C	NA	NA
Inorganics (mg/kg)													
7429-90-5	ALUMINUM	8780 J	23700	mg/kg	12SS190002	11/11	---	23700	NA	686000	N	8.3	NA
7440-36-0	ANTIMONY	0.38 J	3610 J	mg/kg	12SS210002	5/11	0.12 - 0.95	3610	NA	NA	N	0.27	5.4
7440-38-2	ARSENIC	2.6 J	158 J	mg/kg	12SS240002	11/11	---	158	NA	745	C	0.29	29
7440-39-3	BARIUM	54.1 J	505 J	mg/kg	12SS210002	11/11	---	505	NA	68600	N	82	1600
7440-41-7	BERYLLIUM	0.72 J	1.5 J	mg/kg	12SS130002, 12SS140002	7/11	0.35 - 1	1.5	NA	1330	C	3.2	63
7440-43-9	CADMIUM	5.8 J	6.3 J	mg/kg	12SS220002	2/11	0.2 - 0.81	6.3	NA	1780	C	0.38	7.5
7440-70-2	CALCIUM	299 J	17800 J	mg/kg	12SS150002	11/11	---	17800	NA	NA		NA	NA
7440-47-3	CHROMIUM	18.3 J	51.7 J	mg/kg	12SS240002	11/11	---	51.7	NA	267	C	2.1	38
7440-48-4	COBALT	5 J	13.6 J	mg/kg	12SS220002	11/11	---	13.6	NA	1140	C	0.17	NA
7440-50-8	COPPER	8.7 J	345 J	mg/kg	12SS210002	11/11	---	345	NA	NA	N	560	920
7439-89-6	IRON	7160 J	65900 J	mg/kg	12SS130002	11/11	---	65900	NA	NA	N	NA	NA
7439-92-1	LEAD	8.2 J	429000 J	mg/kg	12SS210002	11/11	---	429000	NA	NA		NA	81
7439-95-4	MAGNESIUM	940 J	2750 J	mg/kg	12SS220002	11/11	---	2750	NA	NA		NA	NA
7439-96-5	MANGANESE	68.7 J	1400	mg/kg	12SS230002	11/11	---	1400	NA	68600	N	110	NA
7439-97-6	MERCURY	0.009 J	0.31	mg/kg	12SS210002	9/11	0.007	0.31	NA	NA	N	NA	2.1
7440-02-0	NICKEL	14 J	44.6 J	mg/kg	12SS130002	11/11	---	44.6	NA	13300	C	14	950
7440-09-7	POTASSIUM	558 J	4370 J	mg/kg	12SS140002	11/11	---	4370	NA	NA		NA	NA
7782-49-2	SELENIUM	0.49 J	0.61 J	mg/kg	12SS240002	2/11	0.13 - 0.56	0.61	NA	NA	N	0.26	5.2
7440-22-4	SILVER	18.5 J	18.5 J	mg/kg	12SS210002	1/11	0.042 - 0.72	18.5	NA	NA	N	1.6	31
7440-23-5	SODIUM	78.2 J	370 J	mg/kg	12SS220002	3/11	20.5 - 153	370	NA	NA		NA	NA
7440-28-0	THALLIUM	6.4 J	6.4 J	mg/kg	12SS210002	1/11	0.15 - 0.34	6.4	NA	NA	N	0.056	2.8
7440-31-5	TIN	12.4 J	838 J	mg/kg	12SS210002	4/11	0.46 - 2.3	838	NA	NA	N	NA	NA
7440-62-2	VANADIUM	16.8 J	42.8 J	mg/kg	12SS190002	11/11	---	42.8	NA	NA	N	260	NA
7440-66-6	ZINC	31 J	2490 J	mg/kg	12SS220002	11/11	---	2490	NA	NA	N	680	14000

TABLE 7-8

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SURFACE SOIL - MIGRATION PATHWAYS
SWMU 12 (MINE FIELD A) - BATTERY AREA
NSWC CRANE
CRANE, INDIANA

Shaded cell indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in soil relative to NSWC Crane background levels is presented in Section 5.0.
5 - U.S. EPA Soil Screening Levels (SSLs) calculated on the U.S. EPA Internet Site at http://risk.lsd.ornl.gov/calc_start.htm. The soil-to-air SSLs for non-carcinogens are divided by 10. The migration-to-groundwater value represents a dilution attenuation factor (DAF) of 1.
6 - Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for soil (IDEM, 2004).

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirements/To Be Considered
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Non-carcinogen
NA = Not applicable/not available
CAS = Chemical Abstracts Service

Associated Samples

12SS120002	12SS190002
12SS130002	12SS200002
12SS140002	12SS210002
12SS160002	12SS220002
12SS170002	12SS230002
12SS180002	12SS240002

TABLE 7-9

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SUBSURFACE SOIL - DIRECT CONTACT
SWMU 12 (MINE FIELD A) - BATTERY AREA
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Subsurface Soil

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections[2]	Concentration Used for Screening[3]	Concentration Greater Than Background ?[4]	U.S. EPA Region 9 PRG (Residential)[5]		Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Volatile Organics (ug/kg)															
75-71-8	DICHLORODIFLUOROMETHANE	3 J	6 J	ug/kg	12SB150204, 12SB130607	9/12	0.865 - 1.13	6	NA	9400	N	NA	IDEM	No	BSL
Semivolatile Organics (ug/kg)															
56-55-3	BENZO(A)ANTHRACENE	8	8	ug/kg	12SB140607	1/12	3.56 - 3.88	8	NA	620	C	5000	IDEM	No	BSL
205-99-2	BENZO(B)FLUORANTHENE	16	16	ug/kg	12SB140607	1/12	3.56 - 3.88	16	NA	620	C	5000	IDEM	No	BSL
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	440 J	440 J	ug/kg	12SB140607	1/12	72.4 - 78.8	440	NA	35000	C	300000	IDEM	No	BSL
218-01-9	CHRYSENE	14	14	ug/kg	12SB140607	1/12	3.56 - 3.88	14	NA	62000	C	500000	IDEM	No	BSL
206-44-0	FLUORANTHENE	11	11	ug/kg	12SB140607	1/12	3.56 - 3.88	11	NA	230000	N	6300000	IDEM	No	BSL
120-58-1	ISOSAFROLE	260 J	690	ug/kg	12SB180204	2/12	73.4 - 78.8	690	NA	NA		NA	IDEM	No	NTX
Inorganics (mg/kg)															
7429-90-5	ALUMINUM	12700 J	24700 J	mg/kg	12SB140607	12/12	---	24700	NA	7600	N	NA	IDEM	Yes	ASL
7440-36-0	ANTIMONY	0.3 J	0.31 J	mg/kg	12SB130607	2/12	0.1 - 1.2	0.31	NA	3.1	N	140	IDEM	No	BSL
7440-38-2	ARSENIC	0.95 J	6.4 J	mg/kg	12SB190204	12/12	---	6.4	NA	0.39	C	3.9	IDEM	Yes	ASL
7440-39-3	BARIUM	32 J	792 J	mg/kg	12SB200204	12/12	---	792	NA	540	N	23000	IDEM	Yes	ASL
7440-41-7	BERYLLIUM	0.51 J	1.7 J	mg/kg	12SB140204	12/12	---	1.7	NA	15	N	680	IDEM	No	BSL
7440-70-2	CALCIUM	287 J	1160 J	mg/kg	12SB180608	12/12	---	1160	NA	NA		NA	IDEM	No	NUT
7440-47-3	CHROMIUM	18.6 J	38.8 J	mg/kg	12SB150607	12/12	---	38.8	NA	210	C	430	IDEM	No	BSL
7440-48-4	COBALT	3.3 J	24.2 J	mg/kg	12SB130204	12/12	---	24.2	NA	140	N	NA	IDEM	No	BSL
7440-50-8	COPPER	5.4 J	23.9 J	mg/kg	12SB130607	12/12	---	23.9	NA	310	N	13000	IDEM	No	BSL
7439-89-6	IRON	6580 J	93300 J	mg/kg	12SB130204	12/12	---	93300	NA	2300	N	NA	IDEM	Yes	ASL
7439-92-1	LEAD	10.8 J	25.4 J	mg/kg	12SB130204	12/12	---	25.4	NA	400	N	400	IDEM	No	BSL
7439-95-4	MAGNESIUM	824 J	1910 J	mg/kg	12SB190204	12/12	---	1910	NA	NA		NA	IDEM	No	NUT
7439-96-5	MANGANESE	22.6 J	796 J	mg/kg	12SB130204	12/12	---	796	NA	180	N	NA	IDEM	Yes	ASL
7439-97-6	MERCURY	0.008 J	1 J	mg/kg	12SB190204	7/11	0.007	1	NA	2.3	N	100	IDEM	No	BSL
7440-02-0	NICKEL	10.7 J	72.6 J	mg/kg	12SB130204	12/12	---	72.6	NA	160	N	6900	IDEM	No	BSL
7440-09-7	POTASSIUM	1010 J	5130 J	mg/kg	12SB140607	12/12	---	5130	NA	NA		NA	IDEM	No	NUT
7782-49-2	SELENIUM	0.67 J	2.3 J	mg/kg	12SB130607	2/12	0.13 - 0.88	2.3	NA	39	N	1700	IDEM	No	BSL
7440-23-5	SODIUM	56.8 J	505 J	mg/kg	12SB200608	4/12	37.4 - 246	505	NA	NA		NA	IDEM	No	NUT
7440-62-2	VANADIUM	20.6 J	34 J	mg/kg	12SB190204	12/12	---	34	NA	7.8	N	NA	IDEM	Yes	ASL
7440-66-6	ZINC	17.8 J	128 J	mg/kg	12SB130204	12/12	---	128	NA	2300	N	100000	IDEM	No	BSL

Shaded cell indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in soil relative to NSWC Crane background levels is presented in Section 5.0.
5 - U.S. EPA Region 9 Preliminary Remediation Goal (PRG). The non-carcinogenic values (denoted with a "N" flag) are the PRG divided by 10 to correspond to a target Hazard Quotient of 0.1. Carcinogenic values represent an incremental lifetime cancer risk of 1×10^{-6} (carcinogens denoted with a "C" flag) (USEPA Region 9, October 2004, Updated December 28, 2004).
6 - Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for soil (IDEM, 2004).
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level.

Associated Samples

13SS010002	12SB160608
12SB120204	12SB170204
12SB120608	12SB170608
12SB130204	12SB180204
12SB130607	12SB180608
12SB140204	12SB190204
12SB140607	12SB190608
12SB150204	12SB200204
12SB150607	12SB200608
12SB160204	

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Non-carcinogen
NA = Not applicable/not available
CAS = Chemical Abstracts Service

Rationale Codes:
For selection as a COPC:
ASL = Above screening level

For Elimination as a COPC:
BSL = Below COPC screening level/ARAR/TBC
NTX = No toxicity information
NUT = Essential nutrient

TABLE 7-10

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - SUBSURFACE SOIL - MIGRATION PATHWAYS
SWMU 12 (MINE FIELD A) - BATTERY AREA
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Subsurface Soil

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections[2]	Concentration Used for Screening[3]	Concentration Greater Than Background ?[4]	U.S. EPA Generic SSL for Soil to Air[5]		U.S. EPA Generic SSL for Migration to Groundwater[5]	IDEM Closure Level for Migration to Groundwater[6]
Volatile Organics (ug/kg)													
75-71-8	DICHLORODIFLUOROMETHANE	3 J	6 J	ug/kg	12SB150204, 12SB130607	9/12	0.865 - 1.13	6	NA	25000	N	28000	NA
Semivolatile Organics (ug/kg)													
56-55-3	BENZO(A)ANTHRACENE	8	8	ug/kg	12SB140607	1/12	3.56 - 3.88	8	NA	NA	C	160	19000
205-99-2	BENZO(B)FLUORANTHENE	16	16	ug/kg	12SB140607	1/12	3.56 - 3.88	16	NA	NA	C	490	57000
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	440 J	440 J	ug/kg	12SB140607	1/12	72.4 - 78.8	440	NA	NA	C	180000	3600000
218-01-9	CHRYSENE	14	14	ug/kg	12SB140607	1/12	3.56 - 3.88	14	NA	7500000	C	160	25000
206-44-0	FLUORANTHENE	11	11	ug/kg	12SB140607	1/12	3.56 - 3.88	11	NA	NA	N	310000	880000
120-58-1	ISOSAFROLE	260 J	690	ug/kg	12SB180204	2/12	73.4 - 78.8	690	NA	NA		NA	NA
Inorganics (mg/kg)													
7429-90-5	ALUMINUM	12700 J	24700 J	mg/kg	12SB140607	12/12	---	24700	NA	686000	N	8.3	NA
7440-36-0	ANTIMONY	0.3 J	0.31 J	mg/kg	12SB130607	2/12	0.1 - 1.2	0.31	NA	NA	N	0.27	5.4
7440-38-2	ARSENIC	0.95 J	6.4 J	mg/kg	12SB190204	12/12	---	6.4	NA	745	C	0.29	29
7440-39-3	BARIUM	32 J	792 J	mg/kg	12SB200204	12/12	---	792	NA	68600	N	82	1600
7440-41-7	BERYLLIUM	0.51 J	1.7 J	mg/kg	12SB140204	12/12	---	1.7	NA	1330	C	3.2	63
7440-70-2	CALCIUM	287 J	1160 J	mg/kg	12SB180608	12/12	---	1160	NA	NA		NA	NA
7440-47-3	CHROMIUM	18.6 J	38.8 J	mg/kg	12SB150607	12/12	---	38.8	NA	267	C	2.1	38
7440-48-4	COBALT	3.3 J	24.2 J	mg/kg	12SB130204	12/12	---	24.2	NA	1140	C	0.17	NA
7440-50-8	COPPER	5.4 J	23.9 J	mg/kg	12SB130607	12/12	---	23.9	NA	NA	N	560	920
7439-89-6	IRON	6580 J	93300 J	mg/kg	12SB130204	12/12	---	93300	NA	NA	N	NA	NA
7439-92-1	LEAD	10.8 J	25.4 J	mg/kg	12SB130204	12/12	---	25.4	NA	NA	N	NA	81
7439-95-4	MAGNESIUM	824 J	1910 J	mg/kg	12SB190204	12/12	---	1910	NA	NA		NA	NA
7439-96-5	MANGANESE	22.6 J	796 J	mg/kg	12SB130204	12/12	---	796	NA	6860	N	110	NA
7439-97-6	MERCURY	0.008 J	1 J	mg/kg	12SB190204	7/11	0.007	1	NA	NA	N	NA	2.1
7440-02-0	NICKEL	10.7 J	72.6 J	mg/kg	12SB130204	12/12	---	72.6	NA	13300	C	14	950
7440-09-7	POTASSIUM	1010 J	5130 J	mg/kg	12SB140607	12/12	---	5130	NA	NA		NA	NA
7782-49-2	SELENIUM	0.67 J	2.3 J	mg/kg	12SB130607	2/12	0.13 - 0.88	2.3	NA	NA	N	0.26	5.2
7440-23-5	SODIUM	56.8 J	505 J	mg/kg	12SB200608	4/12	37.4 - 246	505	NA	NA		NA	NA
7440-62-2	VANADIUM	20.6 J	34 J	mg/kg	12SB190204	12/12	---	34	NA	NA	N	260	NA
7440-66-6	ZINC	17.8 J	128 J	mg/kg	12SB130204	12/12	---	128	NA	NA	N	680	14000

Shaded cell indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in soil relative to NSWC Crane background levels is presented in Section 5.0.
5 - U.S. EPA Soil Screening Levels (SSLs) calculated on the U.S. EPA Internet Site at http://risk.lsd.ornl.gov/calc_start.htm. The soil-to-air SSLs for non-carcinogens are divided by 10. The migration-to-groundwater value represents a dilution attenuation factor (DAF) of 1.
6 - Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for soil (IDEM, 2004).

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Non-carcinogen
NA = Not applicable/not available
CAS = Chemical Abstracts Service

Associated Samples

13SS010002	12SB160608
12SB120204	12SB170204
12SB120608	12SB170608
12SB130204	12SB180204
12SB130607	12SB180608
12SB140204	12SB190204
12SB140607	12SB190608
12SB150204	12SB200204
12SB150607	12SB200608
12SB160204	

TABLE 7-11

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER - PENNSYLVANIA UPPER ZONE
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections[2]	Concentration Used for Screening[3]	Concentrations in Upgradient Samples [4]	Screening Toxicity Value[5]	Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Energetics														
99-35-4	1,3,5-Trinitrobenzene	0.66 J	110	ug/L	12GWT1101, 12GWT1102	9/63	0.238 - 0.305	110	NA	110 N	NA NA	NA NA	No	BSL
99-65-0	1,3-Dinitrobenzene	0.28 J	8.9	ug/L	12GWT0602	8/63	0.238 - 0.305	8.9	NA	0.36 N	NA NA	NA NA	Yes	ASL
118-96-7	2,4,6-Trinitrotoluene	0.26 J	170	ug/L	12GWT0602	10/63	0.238 - 0.305	170	NA	1.8 N	NA NA	NA NA	Yes	ASL
6629-29-4	2,4-Diamino-6-Nitrotoluene	0.42 J	75 J	ug/L	12GWT1102	12/63	0.238 - 0.305	75	NA	NA	NA NA	NA NA	No	NTX
121-14-2	2,4-Dinitrotoluene	0.3 J	2.8 J	ug/L	12GWT1101	4/63	0.238 - 0.305	2.8	NA	7.3 N	NA NA	NA NA	No	BSL
606-20-2	2,6-Dinitrotoluene	0.27 J	9.8 J	ug/L	12GWT0601	11/63	0.238 - 0.305	9.8	NA	3.6 N	NA NA	NA NA	Yes	ASL
35572-78-2	2-Amino-4,6-Dinitrotoluene	0.47 J	100 J	ug/L	12GWT1602	17/63	0.238 - 0.305	100	NA	0.73 N[8]	NA NA	NA NA	Yes	ASL
88-72-2	2-Nitrotoluene	0.3 J	0.45 J	ug/L	12GWT1101	2/63	0.238 - 0.305	0.45	NA	0.049 C	NA NA	NA NA	Yes	ASL
618-87-1	3,5-Dinitroaniline	0.63 J	12 J	ug/L	12GWT1102	10/63	0.238 - 0.305	12	NA	NA	NA NA	NA NA	No	NTX
99-08-1	3-Nitrotoluene	0.68 J	1.7 J	ug/L	12GWT1301	4/63	0.238 - 0.305	1.7	NA	12 N	NA NA	NA NA	No	BSL
19406-51-0	4-Amino-2,6-Dinitrotoluene	0.26 J	190	ug/L	12GWT1602	18/63	0.238 - 0.305	190	NA	0.73 N[8]	NA NA	NA NA	Yes	ASL
99-99-0	4-Nitrotoluene	5.8 J	5.8 J	ug/L	12GWT0602	1/63	0.238 - 0.305	5.8	NA	0.66 C	NA NA	NA NA	Yes	ASL
NA	DNX	0.36 J	22	ug/L	12GWT1601	10/63	0.238 - 0.305	22	NA	NA	NA NA	NA NA	No	NTX
2691-41-0	HMX	0.32 J	530	ug/L	12GWT0602, 12GWT1102	37/63	0.238 - 0.305	530	NA	180 N	NA NA	NA NA	Yes	ASL
NA	MNX	0.33 J	250	ug/L	12GWT1601	23/63	0.238 - 0.305	250	NA	NA	NA NA	NA NA	No	NTX
121-82-4	RDX	0.75	7400	ug/L	12GWT1602	46/63	0.238 - 0.305	7400	NA	0.61 C	NA NA	NA NA	Yes	ASL
NA	TNX	0.54 J	11 J	ug/L	12GWT1102	7/63	0.238 - 0.305	11	NA	NA	NA NA	NA NA	No	NTX
Total Metals														
7429-90-5	Aluminum	27.6 J	190000 J	ug/L	12GWT24A02	54/63	8.35 - 172	190000	126 - 565	3600 N	NA NA	NA NA	Yes	ASL
7440-36-0	Antimony	1.7 J	1.7 J	ug/L	12GWT24A01	1/63	0.085 - 2.7	1.7	ND	1.5 N	6 6	FED-MCL IDEM	No	FREQ
7440-38-2	Arsenic	0.07 J	91.2 J	ug/L	12GWT0501	37/63	0.14 - 2	91.2	1.1 - 2.3	0.045 C	10 50	FED-MCL IDEM	Yes	ASL
7440-39-3	Barium	7.9 J	212 J	ug/L	12GWT3901	56/63	9 - 18.8	212	17.5 - 38.4	260 N	2000 2000	FED-MCL IDEM	No	BSL

TABLE 7-11

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER - PENNSYLVANIA UPPER ZONE
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections[2]	Concentration Used for Screening[3]	Concentrations in Upgradient Samples [4]	Screening Toxicity Value[5]	Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Total Metals (Continued)														
7440-41-7	Beryllium	0.11 J	97.4 J	ug/L	12GWT2301	34/63	0.02 - 3.2	97.4	0.1	7.3 N	4 4	FED-MCL IDEM	Yes	ASL
7440-43-9	Cadmium	0.04 J	83.4 J	ug/L	12GWT2302	30/63	0.039 - 3.4	83.4	ND	1.8 N	5 5	FED-MCL IDEM	Yes	ASL
7440-70-2	Calcium	2100 J	589000 J	ug/L	12GWT0702	62/63	25300	589000	77900 - 216000	NA	NA NA	NA NA	No	NUT
7440-47-3	Chromium	0.75 J	35.2 J	ug/L	12GWT3901	27/63	0.14 - 1.8	35.2	1.7	11 N[9]	100 100	FED-MCL IDEM[9]	Yes	ASL
7440-48-4	Cobalt	1	6060 J	ug/L	12GWT2302	61/63	1.2 - 44	6060	5.6 - 53.2	73 N	NA NA	NA NA	Yes	ASL
7440-50-8	Copper	0.67 J	93.3 J	ug/L	12GWT2302	57/63	0.17 - 1.1	93.3	0.84 - 4	150 N	1300 1300	FED-MCL[10] IDEM	No	BSL
7439-89-6	Iron	134 J	209000 J	ug/L	12GWT24A02	56/63	14.5 - 144	209000	307 - 2990	1100 N	NA NA	NA NA	Yes	ASL
7439-92-1	Lead	0.07 J	104 J	ug/L	12GWT2302	39/63	0.069 - 4.4	104	0.08	NA	15 15	FED-MCL[10] IDEM	Yes	ASL
7439-95-4	Magnesium	2530 J	1160000 J	ug/L	12GWT0702	63/63	---	1160000	50000 - 233000	NA	NA NA	NA NA	No	NUT
7439-96-5	Manganese	31.6 J	138000 J	ug/L	12GWT24A02	62/63	41.8	138000	287 - 6000	88 N	NA NA	NA NA	Yes	ASL
7439-97-6	Mercury	0.03 J	7.3	ug/L	12GWT0602	21/63	0.03 - 0.094	7.3	ND	1.1 N	2 2	FED-MCL IDEM	Yes	ASL
7440-02-0	Nickel	3.3	14600 J	ug/L	12GWT2302	62/63	57.8	14600	12.4 - 103	73 N	NA 730	NA IDEM	Yes	ASL
7440-09-7	Potassium	352 J	17800 J	ug/L	12GWT3901	63/63	---	17800	1630 -5320	NA	NA NA	NA NA	No	NUT
7782-49-2	Selenium	0.62 J	24.7 J	ug/L	12GWT2302	32/63	0.094 - 3	24.7	0.99 - 3.4	18 N	50 50	FED-MCL IDEM	Yes	ASL
7440-23-5	Sodium	11300 J	789000 J	ug/L	12GWT0702	61/63	6.79 - 307	789000	116000 - 167000	NA	NA NA	NA NA	No	NUT
7440-28-0	Thallium	0.05 J	6 J	ug/L	12GWT2302	18/63	0.043 - 1.5	6	0.08	0.24 N	2 2	FED-MCL IDEM	Yes	ASL
7440-31-5	Tin	0.08 J	1.4 J	ug/L	12GWT3901	6/63	0.048 - 1.1	1.4	NA	2200 N	NA NA	NA NA	No	BSL
7440-62-2	Vanadium	1.3 J	22.9	ug/L	12GWT3901	15/63	1.14	22.9	ND	3.6 N	NA NA	NA NA	Yes	ASL
7440-66-6	Zinc	2.8 J	18000	ug/L	12GWT2302	57/63	3.1 - 357	18000	8 - 26.1	1100 N	NA 11000	NA IDEM	Yes	ASL
Dissolved Metals														
7429-90-5	Aluminum, Filtered	42.8 J	8580 J	ug/L	12GWT1802	10/14	10.6 - 105	8580	ND	3600 N	NA NA	NA NA	Yes	ASL
7440-36-0	Antimony, Filtered	1.9 J	1.9 J	ug/L	12GWT3901	1/14	0.085 - 1.1	1.9	ND	1.5 N	6 6	FED-MCL IDEM	Yes	ASL

TABLE 7-11

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER - PENNSYLVANIA UPPER ZONE
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections[2]	Concentration Used for Screening[3]	Concentrations in Upgradient Samples [4]	Screening Toxicity Value[5]	Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Dissolved Metals (Continued)														
7440-38-2	Arsenic, Filtered	0.87 J	1.5 J	ug/L	12GWT1401	5/14	0.28 - 1.1	1.5	2.5	0.045 C	10 50	FED-MCL IDEM	Yes	ASL
7440-39-3	Barium, Filtered	8.2 J	79.5 J	ug/L	12GWT3901	14/14	---	79.5	38.8	260 N	2000 2000	FED-MCL IDEM	No	BSL
7440-41-7	Beryllium, Filtered	0.09 J	5.1 J	ug/L	12GWT1802	4/14	0.04 - 1.1	5.1	ND	7.3 N	4 4	FED-MCL IDEM	Yes	ASL
7440-43-9	Cadmium, Filtered	0.43 J	6.6	ug/L	12GWT1802	5/14	0.06 - 0.96	6.6	ND	1.8 N	5 5	FED-MCL IDEM	Yes	ASL
7440-70-2	Calcium, Filtered	8590 J	303000 J	ug/L	12GWT1401	14/14	---	303000	107000	NA	NA NA	NA NA	No	NUT
7440-47-3	Chromium, Filtered	0.88 J	2.6 J	ug/L	12GWT3902	7/14	0.2 - 1.7	2.6	ND	11 N[9]	100 100	FED-MCL IDEM[9]	No	BSL
7440-48-4	Cobalt, Filtered	7 J	563 J	ug/L	12GWT1401	14/14	---	563	41.4	73 N	NA NA	NA NA	Yes	ASL
7440-50-8	Copper, Filtered	1.3 J	8.6	ug/L	12GWT3701	11/14	0.59 - 1	8.6	1.3	150 N	1300 1300	FED-MCL[10] IDEM	No	BSL
7439-89-6	Iron, Filtered	282 J	99700 J	ug/L	12GWT1401	7/14	6.15 - 99.3	99700	2830	1100 N	NA NA	NA NA	Yes	ASL
7439-92-1	Lead, Filtered	1	8.5	ug/L	12GWT1802	8/14	0.2 - 0.75	8.5	ND	NA	15 15	FED-MCL[10] IDEM	No	BSL
7439-95-4	Magnesium, Filtered	5290 J	281000 J	ug/L	12GWT1902	14/14	---	281000	80600	NA	NA NA	NA NA	No	NUT
7439-96-5	Manganese, Filtered	84.9 J	29700	ug/L	12GWT1402	14/14	---	29700	3350	88 N	NA NA	NA NA	Yes	ASL
7439-97-6	Mercury, Filtered	0.04 J	2.9 J	ug/L	12GWT3901	3/14	0.03 - 0.13	2.9	ND	1.1 N	2 2	FED-MCL IDEM	Yes	ASL
7440-02-0	Nickel, Filtered	14.1 J	1320 J	ug/L	12GWT1401	14/14	---	1320	76.1	73 N	NA 730	NA IDEM	Yes	ASL
7440-09-7	Potassium, Filtered	1080 J	18300 J	ug/L	12GWT3901	14/14	---	18300	4130	NA	NA NA	NA NA	No	NUT
7782-49-2	Selenium, Filtered	1.2 J	6.2 J	ug/L	12GWT1802	4/14	0.24 - 2.6	6.2	ND	18 N	NA 50	NA IDEM	No	BSL
7440-23-5	Sodium, Filtered	34000 J	220000 J	ug/L	12GWT1902	14/14	---	220000	170000	NA	NA NA	NA NA	No	NUT
7440-28-0	Thallium, Filtered	0.1 J	0.63 J	ug/L	12GWT1802	3/14	0.043 - 0.46	0.63	ND	0.24 N	2 2	FED-MCL IDEM	Yes	ASL
7440-31-5	Tin, Filtered	0.1 J	0.21 J	ug/L	12GWT3701	2/14	0.048 - 0.37	0.21	NA	2200 N	NA NA	NA NA	No	BSL
7440-62-2	Vanadium, Filtered	1.2 J	1.2 J	ug/L	12GWT1402	1/14	1.14	1.2	ND	3.6 N	NA NA	NA NA	No	BSL
7440-66-6	Zinc, Filtered	11.4 J	1180	ug/L	12GWT1802	14/14	---	1180	12.9	1100 N	NA 11000	NA IDEM	Yes	ASL

TABLE 7-11

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER - PENNSYLVANIA UPPER ZONE
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

CAS Number	Chemical	Minimum Concentration(1)	Maximum Concentration(1)	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections(2)	Concentration Used for Screening(3)	Concentrations in Upgradient Samples (4)	Screening Toxicity Value(5)	Potential ARAR/TBC(6)	Potential ARAR/TBC Source(6)	COPC Flag	Rationale for Contaminant Deletion or Selection(7)
Miscellaneous Parameters (mg/L)														
NA	Ammonia-N	0.03	10	mg/L	12GWT24A02	40/63	0.005 - 0.08	10	0.12 - 0.17	NA	NA NA	NA NA	No	NTX
NA	Nitrite/Nitrate-N	0.05	10 J	mg/L	12GWT1101	42/63	0.025 - 0.05	10	0.18 - 0.81	1 N	1 NA	FED-MCL(9) NA	Yes	ASL
NA	Total Organic Carbon	1	1	mg/L	12GWT0201	1/2	1	1	1.7 - 1.8	NA	NA NA	NA NA	No	NTX

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in groundwater relative to upgradient well concentrations is presented in Section 5.0.
5 - The U.S. EPA Region 9 tap water screening level is presented. Value represents the risk-based tap water screening level divided by 10 to correspond to a target Hazard Quotient of 0.1 for non-carcinogens (denoted with a "N" flag), or an incremental lifetime cancer risk of $1x10^{-6}$ for carcinogens (denoted with a "C" flag) (U.S. EPA Region 9, October 2004).
6 - U.S. EPA Primary Drinking Water Standard (U.S. EPA, 2004b).
Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for groundwater (IDEM, 2004).
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level.
8 - Value is for aminodinitrotoluene.
9 - Value is for hexavalent chromium.
10 - The MCL for this parameter is actually a treatment technique. The Safe Water Drainking Act (SDWA) action level (at the tap) has been presented.

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
MCL = Maximum Contaminant Level
N = Non-carcinogen
NA = Not applicable/not available
ND = Not detected
CAS = Chemical Abstracts Service

Rationale Codes:
For selection as a COPC:
ASL = Above screening level.

For elimination as a COPC:
BSL = Below screening level
FREQ = Frequency of occurrence less than 5 percent (1 of 20 samples)
NUT = Essential nutrient
NTX = No toxicity data

Associated Samples

12GWT0101	12GWT0901	12GWT1601	12GWT2101	12GWT3602
12GWT0102	12GWT0902	12GWT1601-F	12GWT2102	12GWT3701
12GWT0201	12GWT1001	12GWT1602	12GWT2201	12GWT3701-F
12GWT0202	12GWT1002	12GWT1602-F	12GWT2202	12GWT3702
12GWT0301	12GWT1101	12GWT1701	12GWT2301	12GWT3801
12GWT0302	12GWT1102	12GWT1701-F	12GWT2302	12GWT3802
12GWT0401	12GWT1201	12GWT1702	12GWT2401	12GWT3901
12GWT0402	12GWT1202	12GWT1702-F	12GWT2402	12GWT3901-F
12GWT0501	12GWT1301	12GWT1801	12GWT24A01	12GWT3902
12GWT0502	12GWT1302	12GWT1802	12GWT24A02	12GWT3902-F
12GWT0601	12GWT1401	12GWT1802-F	12GWT2701	12GWT4001
12GWT0602	12GWT1401-F	12GWT1901	12GWT2702	12GWT4001-F
12GWT0701	12GWT1402	12GWT1902	12GWT3501	12GWT4002
12GWT0702	12GWT1402-F	12GWT1902-F	12GWT3501-F	12GWT4002-F
12GWT0801	12GWT1501	12GWT2001	12GWT3502	12GWT4201
12GWT0802	12GWT1502	12GWT2002	12GWT3601	12GWT4202

TABLE 7-12

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER - PENNSYLVANIAN MIDDLE ZONE
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections[2]	Concentration Used for Screening[3]	Concentrations in Upgradient Samples [4]	Screening Toxicity Value[5]	Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Energetics														
2691-41-0	HMX	0.52	0.52	ug/L	12GWT4802	1/16	0.24 - 0.446	0.52	NA	180 N	NA NA	NA NA	No	BSL
121-82-4	RDX	1.3 J	4.2 J	ug/L	12GWT4802	2/16	0.24 - 0.446	4.2	NA	0.61 C	NA NA	NA NA	Yes	ASL
Total Metals														
7429-90-5	Aluminum	95.6 J	31000 J	ug/L	12GWT4801	12/14	50.2 - 72.9	31000	200	3600 N	NA NA	NA NA	Yes	ASL
7440-36-0	Antimony	2 J	2.9 J	ug/L	12GWT3101	3/14	0.085 - 0.41	2.9	ND	1.5 N	6 6	FED-MCL IDEM	Yes	ASL
7440-38-2	Arsenic	0.17 J	11.4 J	ug/L	12GWT4801	14/14	---	11.4	2.7	0.045 C	10 50	FED-MCL IDEM	Yes	ASL
7440-39-3	Barium	10.6 J	214 J	ug/L	12GWT4802	14/14	---	214	13.2	260 N	2000 2000	FED-MCL IDEM	No	BSL
7440-41-7	Beryllium	0.2 J	1.2 J	ug/L	12GWT4801	4/14	0.02 - 1.5	1.2	1.3 - 2.2	7.3 N	4 4	FED-MCL IDEM	No	BSL
7440-43-9	Cadmium	0.07 J	2.3 J	ug/L	12GWT4801	5/14	0.039 - 1.3	2.3	ND	1.8 N	5 5	FED-MCL IDEM	Yes	ASL
7440-70-2	Calcium	12300 J	194000 J	ug/L	12GWT3202	14/14	---	194000	56400 - 61100	NA	NA NA	NA NA	No	NUT
7440-47-3	Chromium	3.9 J	47.9 J	ug/L	12GWT4802	8/14	0.27 - 0.91	47.9	ND	11 N[8]	100 100	FED-MCL IDEM[8]	Yes	ASL
7440-48-4	Cobalt	0.14 J	79.7 J	ug/L	12GWT4801	12/14	1.8	79.7	40 - 44.4	73 N	NA NA	NA NA	Yes	ASL
7440-50-8	Copper	0.68 J	24.3 J	ug/L	12GWT4801	14/14	---	24.3	0.7 - 2.5	150 N	1300 1300	FED-MCL[9] IDEM	No	BSL
7439-89-6	Iron	424 J	48900 J	ug/L	12GWT4801	14/14	---	48900	41700 - 41800	1100 N	NA NA	NA NA	Yes	ASL
7439-92-1	Lead	0.089 J	24.7 J	ug/L	12GWT4802	11/14	0.11 - 1.8	24.7	ND	NA	15 15	FED-MCL[9] IDEM	Yes	ASL
7439-95-4	Magnesium	4080 J	121000 J	ug/L	12GWT3202	14/14	---	121000	27200 - 33500	NA	NA NA	NA NA	No	NUT
7439-96-5	Manganese	1.5 J	7570	ug/L	12GWT4601	14/14	---	7570	1680 - 3010	88 N	NA NA	NA NA	Yes	ASL
7439-97-6	Mercury	0.057 J	0.057 J	ug/L	12GWT4802	1/14	0.03 - 0.034	0.057	ND	1.1 N	2 2	FED-MCL IDEM	No	BSL
7440-02-0	Nickel	3.2 J	178	ug/L	12GWT4502	13/14	5.5	178	110 - 131	73 N	NA 730	NA IDEM	Yes	ASL
7440-09-7	Potassium	1380 J	11200 J	ug/L	12GWT3202	14/14	---	11200	4520 - 4770	NA	NA NA	NA NA	No	NUT
7782-49-2	Selenium	0.98 J	7.7 J	ug/L	12GWT3201	9/14	0.54 - 2.1	7.7	ND	18 N	50 50	FED-MCL IDEM	No	BSL
7440-23-5	Sodium	10000 J	161000 J	ug/L	12GWT2901	14/14	---	161000	32200 - 40300	NA	NA NA	NA NA	No	NUT

TABLE 7-12

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER - PENNSYLVANIAN MIDDLE ZONE
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections[2]	Concentration Used for Screening[3]	Concentrations in Upgradient Samples [4]	Screening Toxicity Value[5]	Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Total Metals (Continued)														
7440-28-0	Thallium	0.06 J	0.32 J	ug/L	12GWT4801	3/14	0.043 - 0.5	0.32	ND	0.24 N	2 2	FED-MCL IDEM	Yes	ASL
7440-31-5	Tin	0.08 J	1.1 J	ug/L	12GWT4801	4/14	0.048 - 1.6	1.1	ND	2200 N	NA NA	NA NA	No	BSL
7440-62-2	Vanadium	3.4	49.4 J	ug/L	12GWT4801	8/14	1.14	49.4	ND	3.6 N	NA NA	NA NA	Yes	ASL
7440-66-6	Zinc	2.5 J	262	ug/L	12GWT4502	12/14	3.4 - 4.8	262	96 - 128	1100 N	NA 11000	NA IDEM	No	BSL
Dissolved Metals														
7429-90-5	Aluminum, Filtered	9.1 J	210 J	ug/L	12GWT4502	2/10	9.1 - 140	210	NA	3600 N	NA NA	NA NA	No	BSL
7440-36-0	Antimony, Filtered	2.3 J	3.2 J	ug/L	12GWT3101	2/10	0.085 - 1.6	3.2	NA	1.5 N	6 6	FED-MCL IDEM	Yes	ASL
7440-38-2	Arsenic, Filtered	0.15 J	3.7 J	ug/L	12GWT3101	8/10	0.28 - 1.6	3.7	NA	0.045 C	10 50	FED-MCL IDEM	Yes	ASL
7440-39-3	Barium, Filtered	11.2 J	68 J	ug/L	12GWT3201	10/10	---	68	NA	260 N	2000 2000	FED-MCL IDEM	No	BSL
7440-43-9	Cadmium, Filtered	0.06 J	1.7 J	ug/L	12GWT4801	5/10	0.039 - 0.17	1.7	NA	1.8 N	5 5	FED-MCL IDEM	No	BSL
7440-70-2	Calcium, Filtered	12600 J	237000	ug/L	12GWT3201	10/10	---	237000	NA	NA	NA NA	NA NA	No	NUT
7440-47-3	Chromium, Filtered	0.81 J	0.81 J	ug/L	12GWT3101	1/10	0.14 - 0.78	0.81	NA	11 N[8]	100 100	FED-MCL IDEM[8]	No	BSL
7440-48-4	Cobalt, Filtered	1.9	29.2	ug/L	12GWT3201	6/10	0.13 - 0.98	29.2	NA	73 N	NA NA	NA NA	No	BSL
7440-50-8	Copper, Filtered	0.99 J	3.5	ug/L	12GWT2901	6/10	0.16 - 0.33	3.5	NA	150 N	1300 1300	FED-MCL[9] IDEM	No	BSL
7439-89-6	Iron, Filtered	295 J	1250	ug/L	12GWT3201	5/10	6.2 - 120	1250	NA	1100 N	NA NA	NA NA	Yes	ASL
7439-92-1	Lead, Filtered	0.12 J	0.315 J	ug/L	12GWT4502	3/10	0.069 - 0.45	0.315	NA	NA	15 15	FED-MCL[9] IDEM	No	BSL
7439-95-4	Magnesium, Filtered	3650 J	139000 J	ug/L	12GWT3201	10/10	---	139000	NA	NA	NA NA	NA NA	No	NUT
7439-96-5	Manganese, Filtered	27.2 J	3300	ug/L	12GWT4602	9/10	25.4	3300	NA	88 N	NA NA	NA NA	Yes	ASL
7440-02-0	Nickel, Filtered	6.8 J	178	ug/L	12GWT4502	7/10	0.68 - 2.1	178	NA	73 N	NA 730	NA IDEM	Yes	ASL
7440-09-7	Potassium, Filtered	908 J	11900 J	ug/L	12GWT3201	10/10	---	11900	NA	NA	NA NA	NA NA	No	NUT
7782-49-2	Selenium, Filtered	0.99 J	7.6 J	ug/L	12GWT3201	3/10	0.17 - 2.4	7.6	NA	18 N	NA 50	NA IDEM	No	BSL
7440-23-5	Sodium, Filtered	12600 J	171000 J	ug/L	12GWT2901	10/10	---	171000	NA	NA	NA NA	NA NA	No	NUT

TABLE 7-12

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER - PENNSYLVANIAN MIDDLE ZONE
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

CAS Number	Chemical	Minimum Concentration(1)	Maximum Concentration(1)	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections(2)	Concentration Used for Screening(3)	Concentrations in Upgradient Samples (4)	Screening Toxicity Value(5)	Potential ARAR/TBC(6)	Potential ARAR/TBC Source(6)	COPC Flag	Rationale for Contaminant Deletion or Selection(7)
Dissolved Metals (Continued)														
7440-28-0	Thallium, Filtered	0.06 J	0.06 J	ug/L	12GWT4502	1/10	0.043 - 0.13	0.06	NA	0.24 N	2 2	FED-MCL IDEM	No	BSL
7440-66-6	Zinc, Filtered	4.2 J	234	ug/L	12GWT4502	6/10	1.7 - 6.4	234	NA	1100 N	NA 11000	NA IDEM	No	BSL
Miscellaneous Parameters (mg/L)														
NA	Ammonia-N	0.047 J	1.8 J	mg/L	12GWT4601	12/14	0.01	1.8	0.35 - 0.54	NA	NA NA	NA NA	No	NTX
NA	Nitrite/Nitrate-N	0.15	2	mg/L	12GWT4802	6/14	0.025 - 0.05	2	ND	1 N	1 NA	FED-MCL(9) NA	Yes	ASL

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in groundwater relative to upgradient well concentrations is presented in Section 5.0.
5 - The U.S. EPA Region 9 tap water screening level is presented. Value represents the risk-based tap water screening level divided by 10 to correspond to a target Hazard Quotient of 0.1 for non-carcinogens (denoted with a "N" flag), or an incremental lifetime cancer risk of $1x10^{-6}$ for carcinogens (denoted with a "C" flag) (U.S. EPA Region 9, October 2004).
6 - U.S. EPA Primary Drinking Water Standard (U.S. EPA, 2004b).
Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for groundwater (IDEM, 2004).
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level.
8 - Value is for hexavalent chromium.
9 - The MCL for this parameter is actually a treatment technique. The Safe Drinking Water Act (SDWA) action level (at the tap) has been presented.

Associated Samples

12GWT2901	12GWT3101-F	12GWT3401	12GWT4602-F
12GWT2901-F	12GWT3102	12GWT3402	12GWT4701
12GWT2902	12GWT3102-F	12GWT4501	12GWT4702
12GWT2902-F	12GWT3201	12GWT4502	12GWT4801
12GWT3001	12GWT3201-F	12GWT4502-F	12GWT4801-F
12GWT3002	12GWT3202	12GWT4601	12GWT4802
12GWT3101	12GWT3202-F	12GWT4602	12GWT4802-F

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
MCL = Maximum Contaminant Level
N = Non-carcinogen
NA = Not applicable/not available
ND = Not detected.
CAS = Chemical Abstracts Service

Rationale Codes:
For selection as a COPC:
ASL = Above screening level

For elimination as a COPC:
BSL = Below screening level
NUT = Essential nutrient
NTX = No toxicity data

TABLE 7-13

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER - PENNSYLVANIAN LOWER AND MISSISSIPPIAN GLEN DEAN ZONE
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections[2]	Concentration Used for Screening[3]	Concentrations in Upgradient Samples [4]	Screening Toxicity Value[5]	Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Energetics														
118-96-7	2,4,6-Trinitrotoluene	4.2	4.2	ug/L	12GWT4401	1/5	0.24 - 0.266	4.2	NA	1.8 N	NA NA	NA NA	Yes	ASL
19406-51-0	4-Amino-2,6-Dinitrotoluene	0.65	0.65	ug/L	12GWT4401	1/5	0.24 - 0.266	0.65	NA	0.73 N[8]	NA NA	NA NA	No	BSL
2691-41-0	HMX	0.28 J	0.28 J	ug/L	12GWT4401	1/5	0.24 - 0.266	0.28	NA	180 N	NA NA	NA NA	No	BSL
121-82-4	RDX	3.9	3.9	ug/L	12GWT4401	1/5	0.24 - 0.266	3.9	NA	0.61 C	NA NA	NA NA	Yes	ASL
Total Metals														
7429-90-5	Aluminum	165 J	2540 J	ug/L	12GWT4901	3/5	8.35 - 55.4	2540	18000 - 31600	3600 N	NA NA	NA NA	No	BSL
7440-36-0	Antimony	3.1 J	3.1 J	ug/L	12GWT4101	1/5	0.085 - 0.9	3.1	ND	1.5 N	6 6	FED-MCL IDEM	Yes	ASL
7440-38-2	Arsenic	1.7 J	9.5 J	ug/L	12GWT4102	4/5	2.1	9.5	17.6 - 19.7	0.045 C	10 50	FED-MCL IDEM	Yes	ASL
7440-39-3	Barium	24.8 J	79.3 J	ug/L	12GWT4901	4/5	20.5	79.3	1360 - 1950	260 N	2000 2000	FED-MCL IDEM	No	BSL
7440-70-2	Calcium	106000 J	201000 J	ug/L	12GWT4402	5/5	---	201000	27200 - 33100	NA	NA NA	NA NA	No	NUT
7440-47-3	Chromium	6.6 J	6.6 J	ug/L	12GWT4901	1/5	0.58 - 2	6.6	28.4 - 78.9	11 N[9]	100 100	FED-MCL IDEM[9]	No	BSL
7440-48-4	Cobalt	5.3 J	14.7 J	ug/L	12GWT4402	4/5	1.2	14.7	39.1 - 54.3	73 N	NA NA	NA NA	No	BSL
7440-50-8	Copper	1.2 J	6.4 J	ug/L	12GWT4901	4/5	1.4	6.4	45.1 - 58.5	150 N	1300 1300	FED-MCL[10] IDEM	No	BSL
7439-89-6	Iron	914 J	7150 J	ug/L	12GWT4901	5/5	---	7150	46100 - 84200	1100 N	NA NA	NA NA	Yes	ASL
7439-92-1	Lead	0.53 J	10.5 J	ug/L	12GWT4901	2/5	0.069 - 0.35	10.5	35.6 - 39.5	NA	15 15	FED-MCL[10] IDEM	No	BSL
7439-95-4	Magnesium	13000 J	171000 J	ug/L	12GWT4402	5/5	---	171000	7580 - 17300	NA	NA NA	NA NA	No	NUT
7439-96-5	Manganese	531	2190 J	ug/L	12GWT4402	5/5	---	2190	1340 - 1790	88 N	NA NA	NA NA	Yes	ASL
7440-02-0	Nickel	6.3 J	44.2 J	ug/L	12GWT4401	5/5	---	44.2	92.1 - 132	73 N	NA 730	NA IDEM	No	BSL
7440-09-7	Potassium	2550 J	9660 J	ug/L	12GWT4402	5/5	---	9660	6290 - 10800	NA	NA NA	NA NA	No	NUT
7782-49-2	Selenium	1.2 J	2 J	ug/L	12GWT4401	4/5	0.77	2	1.5 - 2.2	18 N	50 50	FED-MCL IDEM	No	BSL
7440-23-5	Sodium	6380 J	158000 J	ug/L	12GWT4401	5/5	---	158000	152000 - 208000	NA	NA NA	NA NA	No	NUT
7440-31-5	Tin	4.2 J	4.2 J	ug/L	12GWT4901	1/5	0.1 - 0.73	4.2	1.9 - 2.4	2200 N	NA NA	NA NA	No	BSL
7440-62-2	Vanadium	4.9	4.9	ug/L	12GWT4901	1/5	1.14	4.9	39.9 - 58.5	3.6 N	NA NA	NA NA	Yes	ASL

TABLE 7-13

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER - PENNSYLVANIAN LOWER AND MISSISSIPPIAN GLEN DEAN ZONE
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

CAS Number	Chemical	Minimum Concentration(1)	Maximum Concentration(1)	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections(2)	Concentration Used for Screening(3)	Concentrations in Upgradient Samples (4)	Screening Toxicity Value(5)	Potential ARAR/TBC(6)	Potential ARAR/TBC Source(6)	COPC Flag	Rationale for Contaminant Deletion or Selection(7)
Total Metals (Continued)														
7440-66-6	Zinc	9.1 J	40 J	ug/L	12GWT4901	4/5	7.5	40	158 - 244	1100 N	NA 11000	NA IDEM	No	BSL
Dissolved Metals														
7440-38-2	Arsenic, Filtered	1.8 J	1.8 J	ug/L	12GWT4401	1/2	0.6	1.8	3.4 - 5.3	0.045 C	10 50	FED-MCL IDEM	Yes	ASL
7440-39-3	Barium, Filtered	56.4 J	65 J	ug/L	12GWT4901	2/2	---	65	552 - 735	260 N	2000 2000	FED-MCL IDEM	No	BSL
7440-70-2	Calcium, Filtered	150000 J	168000 J	ug/L	12GWT4901	2/2	---	168000	8860 - 12600	NA	NA NA	NA NA	No	NUT
7440-48-4	Cobalt, Filtered	5.5 J	15.5	ug/L	12GWT4401	2/2	---	15.5	0.64 - 1.8	73 N	NA NA	NA NA	No	BSL
7440-50-8	Copper, Filtered	3.6 J	3.6 J	ug/L	12GWT4401	1/2	0.3	3.6	2.4 - 5	150 N	1300 1300	FED-MCL(10) IDEM	No	BSL
7439-89-6	Iron, Filtered	1130 J	1130 J	ug/L	12GWT4401	1/2	10.6	1130	1870	1100 N	NA NA	NA NA	Yes	ASL
7439-95-4	Magnesium, Filtered	14600 J	112000 J	ug/L	12GWT4401	2/2	---	112000	3240 - 3960	NA	NA NA	NA NA	No	NUT
7439-96-5	Manganese, Filtered	580 J	1240 J	ug/L	12GWT4901	2/2	---	1240	65.6 - 134	88 N	NA NA	NA NA	Yes	ASL
7440-02-0	Nickel, Filtered	21.8 J	73.9 J	ug/L	12GWT4401	2/2	---	73.9	3.4 - 6	73 N	NA 730	NA IDEM	Yes	ASL
7440-09-7	Potassium, Filtered	2260 J	7940 J	ug/L	12GWT4401	2/2	---	7940	2910 - 3970	NA	NA NA	NA NA	No	NUT
7782-49-2	Selenium, Filtered	1.9 J	1.9 J	ug/L	12GWT4401	1/2	0.45	1.9	0.68 - 0.94	18 N	NA 50	NA IDEM	No	BSL
7440-23-5	Sodium, Filtered	8390 J	172000 J	ug/L	12GWT4401	2/2	---	172000	171000 - 207000	NA	NA NA	NA NA	No	NUT
7440-31-5	Tin, Filtered	1 J	1 J	ug/L	12GWT4401	1/2	1.6	1	1.1	2200 N	NA NA	NA NA	No	BSL
7440-66-6	Zinc, Filtered	8 J	8 J	ug/L	12GWT4401	1/2	7.1	8	3.8 - 29	1100 N	NA 11000	NA IDEM	No	BSL
Miscellaneous Parameters (mg/L)														
NA	Ammonia-N	0.16 J	0.5 J	mg/L	12GWT4402	5/5	---	0.5	0.83 - 0.9	NA	NA NA	NA NA	No	NTX

TABLE 7-13

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUNDWATER - PENNSYLVANIAN LOWER AND MISSISSIPPIAN GLEN DEAN ZONE
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

CAS Number	Chemical	Minimum Concentration(1)	Maximum Concentration(1)	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections(2)	Concentration Used for Screening(3)	Concentrations in Upgradient Samples (4)	Screening Toxicity Value(5)	Potential ARAR/TBC(6)	Potential ARAR/TBC Source(6)	COPC Flag	Rationale for Contaminant Deletion or Selection(7)

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in groundwater relative to upgradient well concentrations is presented in Section 5.0.
5 - The U.S. EPA Region 9 tap water screening level is presented. Value represents the risk-based tap water screening level divided by 10 to correspond to a target Hazard Quotient of 0.1 for non-carcinogens (denoted with a "N" flag), or an incremental lifetime cancer risk of $1x10^{-6}$ for carcinogens (denoted with a "C" flag) (U.S. EPA Region 9, October 2004).
6 - U.S. EPA Primary Drinking Water Standard (U.S. EPA, 2004).
Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for groundwater (IDEM, 2004).
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level.
8 - Value is for aminodinitrotoluene.
9 - Values are for hexavalent chromium.
10 - The MCL for this parameter is actually a treatment technique. The Safe Drinking Water Act (SDWA) action level (at the tap) has been presented.

Associated Samples

12GWT4101	12GWT4402
12GWT4102	12GWT4901
12GWT4401	12GWT4901
12GWT4401-F	12GWT4901-F

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/\To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
MCL = Maximum Contaminant Level
N = Non-carcinogen
NA = Not applicable/not available
ND = Not detected
CAS = Chemical Abstracts Service

Rationale Codes:
For selection as a COPC:
ASL = Above screening level

For elimination as a COPC:
BSL = Below screening level
NUT = Essential nutrient
NTX = No toxicity data

TABLE 7-14

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GULLY SURFACE WATER
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Surface Water
Exposure Medium: Surface Water

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections[2]	Concentration Used for Screening[3]	Concentrations in Upgradient Samples [4]	Screening Toxicity Value[5]	Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Energetics														
99-35-4	1,3,5-Trinitrobenzene	0.96 J	0.96 J	ug/L	12SW3101	1/39	0.238 - 0.278	0.96	NA	110 N	NA NA	NA NA	No	BSL
118-96-7	2,4,6-Trinitrotoluene	0.56	79	ug/L	12SW3101	4/39	0.238 - 0.278	79	NA	1.8 N	NA NA	NA NA	Yes	ASL
6629-29-4	2,4-Diamino-6-Nitrotoluene	0.79 J	1.6 J	ug/L	12SW3101	3/39	0.238 - 0.278	1.6	NA	NA	NA NA	NA NA	No	NTX
121-14-2	2,4-Dinitrotoluene	0.27 J	0.47 J	ug/L	12SW1201	3/39	0.238 - 0.278	0.47	NA	7.3 N	NA NA	NA NA	No	BSL
59229-75-3	2,6-Diamino-4-Nitrotoluene	0.27 J	0.27 J	ug/L	12SW3601	1/39	0.238 - 0.278	0.27	NA	NA	NA NA	NA NA	No	NTX
606-20-2	2,6-Dinitrotoluene	0.27 J	0.27 J	ug/L	12SW1201	1/39	0.238 - 0.278	0.27	NA	3.6 N	NA NA	NA NA	No	BSL
35572-78-2	2-Amino-4,6-Dinitrotoluene	0.27 J	19 J	ug/L	12SW1201	12/39	0.238 - 0.278	19	NA	0.73 N[8]	NA NA	NA NA	Yes	ASL
618-87-1	3,5-Dinitroaniline	0.6	1.9	ug/L	12SW1301	3/39	0.238 - 0.278	1.9	NA	NA	NA NA	NA NA	No	NTX
99-08-1	3-Nitrotoluene	0.71 J	0.71 J	ug/L	12SW1401	1/39	0.238 - 0.278	0.71	NA	12 N	NA NA	NA NA	No	BSL
19406-51-0	4-Amino-2,6-Dinitrotoluene	0.28 J	74	ug/L	12SW1201	17/39	0.238 - 0.278	74	NA	0.73 N[8]	NA NA	NA NA	Yes	ASL
2691-41-0	HMX	0.9	98	ug/L	12SW3401	29/39	0.24 - 0.264	98	NA	180 N	NA NA	NA NA	No	BSL
NA	MNX	0.32 J	1.9	ug/L	12SW3401	10/39	0.238 - 0.278	1.9	NA	NA	NA NA	NA NA	No	NTX
121-82-4	RDX	0.36 J	140	ug/L	12SW3401	30/39	0.24 - 0.264	140	NA	0.61 C	NA NA	NA NA	Yes	ASL
Total Metals														
7429-90-5	Aluminum	90.6	67700	ug/L	12SW3501	33/39	32 - 163	67700	102 - 8920	3600 N	NA NA	NA NA	Yes	ASL
7440-38-2	Arsenic	0.16 J	20.3	ug/L	12SW3501	35/39	0.11 - 0.32	20.3	0.21 - 8.6	0.045 C	10 50	FED-MCL IDEM	Yes	ASL
7440-39-3	Barium	17.9 J	589 J	ug/L	12SW3501	38/39	0.37	589	33.9 - 112	260 N	2000 2000	FED-MCL IDEM	Yes	ASL
7440-41-7	Beryllium	0.02 J	5.2	ug/L	12SW3501	19/39	0.02 - 0.17	5.2	0.03 - 0.31	7.3 N	4 4	FED-MCL IDEM	Yes	ASL
7440-43-9	Cadmium	0.06 J	43.7 J	ug/L	12SW3501	18/39	0.039 - 1.5	43.7	0.11 - 1.6	1.8 N	5 5	FED-MCL IDEM	Yes	ASL
7440-70-2	Calcium	1100 J	119000 J	ug/L	12SW3501	39/39	---	119000	19100 - 75500	NA	NA NA	NA NA	No	NUT
7440-47-3	Chromium	1.6 J	105 J	ug/L	12SW3501	17/39	0.08 - 2	105	3 - 13.9	11 N[9]	100 100	FED-MCL IDEM[9]	Yes	ASL
7440-48-4	Cobalt	0.14 J	123	ug/L	12SW3501	39/39	---	123	0.23 - 9.2	73 N	NA NA	NA NA	Yes	ASL
7440-50-8	Copper	0.74 J	1650 J	ug/L	12SW3501	38/39	0.98	1650	0.74 - 20.6	150 N	1300 1300	FED-MCL[10] IDEM	Yes	ASL

TABLE 7-14

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GULLY SURFACE WATER
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Surface Water
Exposure Medium: Surface Water

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections[2]	Concentration Used for Screening[3]	Concentrations in Upgradient Samples [4]	Screening Toxicity Value[5]	Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Total Metals (Continued)														
7439-89-6	Iron	161 J	95400 J	ug/L	12SW3501	39/39	---	95400	178 - 14300	1100 N	NA NA	NA NA	Yes	ASL
7439-92-1	Lead	0.095 J	458	ug/L	12SW3501	30/39	0.069 - 0.77	458	0.08 - 25.3	NA	15 15	FED-MCL[10] IDEM	Yes	ASL
7439-95-4	Magnesium	315	34500	ug/L	12SW3501	39/39	---	34500	5720 - 11100	NA	NA NA	NA NA	No	NUT
7439-96-5	Manganese	1.7 J	24200 J	ug/L	12SW0101	39/39	---	24200	8.3 - 347	88 N	NA NA	NA NA	Yes	ASL
7439-97-6	Mercury	0.06 J	1.7	ug/L	12SW3501	4/39	0.03	1.7	0.66 - 0.66	1.1 N	2 2	FED-MCL IDEM	Yes	ASL
7440-02-0	Nickel	1.6 J	140 J	ug/L	12SW3501	39/39	---	140	0.57 - 20.5	73 N	NA 730	NA IDEM	Yes	ASL
7440-09-7	Potassium	107 J	167000 J	ug/L	12SW1401	38/39	5.55	167000	551 - 2240	NA	NA NA	NA NA	No	NUT
7782-49-2	Selenium	1 J	9.6 J	ug/L	12SW3501	3/39	0.11 - 0.92	9.6	0.73 - 0.73	18 N	50 50	FED-MCL IDEM	No	BSL
7440-22-4	Silver	2.6 J	2.6 J	ug/L	12SW3501	1/39	0.028 - 0.18	2.6	ND	18 N	NA 180	FED-MCL IDEM	No	BSL
7440-23-5	Sodium	571 J	30900 J	ug/L	12SW1401	36/39	897 - 28100	30900	2260 - 24000	NA	NA NA	NA NA	No	NUT
7440-28-0	Thallium	0.05 J	0.67 J	ug/L	12SW3501	22/39	0.043	0.67	0.05 - 0.21	0.24 N	2 2	FED-MCL IDEM	Yes	ASL
7440-31-5	Tin	2.1 J	2.1 J	ug/L	12SW3501	1/39	0.048 - 0.56	2.1	ND	2200 N	NA NA	NA NA	No	BSL
7440-62-2	Vanadium	1.3 J	138	ug/L	12SW3501	23/39	1.14	138	2.9 - 21.6	3.6 N	NA NA	NA NA	Yes	ASL
7440-66-6	Zinc	1.6 J	5220	ug/L	12SW3501	27/39	1.3 - 8.9	5220	5.3 - 532	1100 N	NA 11000	NA IDEM	Yes	ASL
Dissolved Metals														
7429-90-5	Aluminum, Filtered	9.9 J	966	ug/L	12SW0202	16/39	8.35 - 137	966	24.7 - 138	3600 N	NA NA	NA NA	No	BSL
7440-38-2	Arsenic, Filtered	0.06 J	16.2 J	ug/L	12SW1701	24/39	0.047 - 0.56	16.2	0.11 - 1	0.045 C	10 50	FED-MCL IDEM	Yes	ASL
7440-39-3	Barium, Filtered	17.1 J	227 J	ug/L	12SW1101	39/39	---	227	36.5 - 72	260 N	2000 2000	FED-MCL IDEM	No	BSL
7440-41-7	Beryllium, Filtered	0.03 J	0.14 J	ug/L	12SW1301	3/39	0.02 - 0.09	0.14	0.1 - 0.1	7.3 N	4 4	FED-MCL IDEM	No	BSL
7440-43-9	Cadmium, Filtered	0.07 J	1.2	ug/L	12SW1402	15/39	0.039 - 0.64	1.2	0.06 - 0.16	1.8 N	5 5	FED-MCL IDEM	No	BSL
7440-70-2	Calcium, Filtered	3080 J	103000 J	ug/L	12SW1802	39/39	---	103000	19200 - 57500	NA	NA NA	NA NA	No	NUT
7440-47-3	Chromium, Filtered	0.96 J	1.4 J	ug/L	12SW1702, 12SW3101	9/39	0.33 - 1.9	1.4	0.92 - 0.92	11 N[9]	100 100	FED-MCL IDEM[9]	No	BSL
7440-48-4	Cobalt, Filtered	0.1 J	8.5 J	ug/L	12SW3201	33/39	0.088 - 0.27	8.5	0.12 - 8.9	73 N	NA NA	NA NA	No	BSL

TABLE 7-14

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GULLY SURFACE WATER
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Surface Water
Exposure Medium: Surface Water

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections[2]	Concentration Used for Screening[3]	Concentrations in Upgradient Samples [4]	Screening Toxicity Value[5]	Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Dissolved Metals (Continued)														
7440-50-8	Copper, Filtered	0.57 J	16.5 J	ug/L	12SW1401	34/39	0.6 - 2.3	16.5	0.5 - 3.6	150 N	1300 1300	FED-MCL[10] IDEM	No	BSL
7439-89-6	Iron, Filtered	85 J	1320 J	ug/L	12SW3201	39/39	---	1320	125 - 868	1100 N	NA NA	NA NA	Yes	ASL
7439-92-1	Lead, Filtered	0.125 J	1.8	ug/L	12SW0202	30/39	0.069 - 0.3	1.8	0.12 - 0.28	NA	15 15	FED-MCL[10] IDEM	No	BSL
7439-95-4	Magnesium, Filtered	1480 J	21300	ug/L	12SW3401	39/39	---	21300	5620 - 8490	NA	NA NA	NA NA	No	NUT
7439-96-5	Manganese, Filtered	0.77 J	7170 J	ug/L	12SW1101	33/39	0.752 - 4.6	7170	1 - 235	88 N	NA NA	NA NA	Yes	ASL
7439-97-6	Mercury, Filtered	0.053 J	0.27	ug/L	12SW3401	6/39	0.03	0.27	ND	1.1 N	2 2	FED-MCL IDEM	No	BSL
7440-02-0	Nickel, Filtered	1.5 J	9.9 J	ug/L	12SW1301	39/39	---	9.9	1.7 - 20.6	73 N	NA 730	NA IDEM	No	BSL
7440-09-7	Potassium, Filtered	356 J	168000 J	ug/L	12SW1401	39/39	---	168000	553 - 2270	NA	NA NA	NA NA	No	NUT
7782-49-2	Selenium, Filtered	0.61 J	1.1 J	ug/L	12SW0201	5/39	0.094 - 0.84	1.1	ND	18 N	NA 50	NA IDEM	No	BSL
7440-22-4	Silver, Filtered	0.04 J	0.04 J	ug/L	12SW1802	1/39	0.028 - 0.14	0.04	ND	18 N	NA 180	FED-MCL IDEM	No	BSL
7440-23-5	Sodium, Filtered	1630 J	40100 J	ug/L	12SW1402	36/39	948 - 28400	40100	2100 - 27800	NA	NA NA	NA NA	No	NUT
7440-28-0	Thallium, Filtered	0.05 J	0.06 J	ug/L	12SW1401	4/32	0.043 - 0.09	0.06	0.06 - 0.06	0.24 N	2 2	FED-MCL IDEM	No	BSL
7440-31-5	Tin, Filtered	0.08 J	7.4 J	ug/L	12SW1701	4/39	0.048 - 0.26	7.4	ND	2200 N	NA NA	NA NA	No	BSL
7440-62-2	Vanadium, Filtered	1.6 J	6.3	ug/L	12SW0201	6/39	1.14	6.3	ND	3.6 N	NA NA	NA NA	Yes	ASL
7440-66-6	Zinc, Filtered	1.2 J	34.9 J	ug/L	12SW0202	27/39	2.1 - 16.6	34.9	2.2 - 41.2	1100 N	NA 11000	NA IDEM	No	BSL
Miscellaneous Parameters (mg/L)														
TTNUS493	Ammonia-N	0.019 J	4.2 J	mg/L	12SW1101	34/39	0.005	4.2	0.013 - 0.037	NA	NA NA	NA NA	No	NTX
TTNUS494	Nitrite/Nitrate-N	0.044 J	8.2	mg/L	12SW0601	26/39	0.025 - 0.05	8.2	0.05 - 0.6	1 N	1 NA	FED-MCL[10] NA	Yes	ASL

TABLE 7-14

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GULLY SURFACE WATER
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Surface Water
Exposure Medium: Surface Water

CAS Number	Chemical	Minimum Concentration(1)	Maximum Concentration(1)	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections(2)	Concentration Used for Screening(3)	Concentrations in Upgradient Samples (4)	Screening Toxicity Value(5)	Potential ARAR/TBC(6)	Potential ARAR/TBC Source(6)	COPC Flag	Rationale for Contaminant Deletion or Selection(7)

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in surface water relative to upgradient locations is presented in Section 5.0.
5 - The U.S. EPA Region 9 tap water screening level is presented. Value represents the risk-based tap water screening level divided by 10 to correspond to a target Hazard Quotient of 0.1 for non-carcinogens (denoted with a "N" flag), or an incremental lifetime cancer risk of $1x10^{-6}$ for carcinogens (denoted with a "C" flag) (U.S. EPA Region 9, 2004).
6 - U.S. EPA Primary Drinking Water Standard (U.S. EPA, 2004b).
Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for groundwater (IDEM, 2004).
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level.
8 - Value is for aminodinitrotoluene.
9 - Values are for hexavalent chromium.
10 - The MCL for this parameter is actually a treatment technique. The Safe Drinking Water Act (SDWA) action level (at the tap) has been presented.

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
MCL = Maximum Contaminant Level
N = Non-carcinogen
NA = Not applicable/not available
ND = Not detected
CAS = Chemical Abstracts Service

Rationale Codes:
For selection as a COPC:
ASL = Above screening level

For elimination as a COPC:
BSL = Below screening level
NUT = Essential nutrient
NTX = No toxicity data

Associated Samples

12SW0101	12SW0402-F	12SW0902-F	12SW1302	12SW1802	12SW3201-F
12SW0101-F	12SW0501	12SW1001	12SW1302-F	12SW1802-F	12SW3401
12SW0102	12SW0501-F	12SW1001-F	12SW1401	12SW1901	12SW3401-F
12SW0102-F	12SW0502	12SW1002	12SW1401-F	12SW1901-F	12SW3501
12SW0201	12SW0502-F	12SW1002-F	12SW1402	12SW1902	12SW3501-F
12SW0201-F	12SW0601	12SW1101	12SW1402-F	12SW2001	12SW3601
12SW0202	12SW0601-F	12SW1101-F	12SW1501	12SW2001-F	12SW3601-F
12SW0202-F	12SW0602	12SW1102	12SW1501-F	12SW2002	
12SW0301	12SW0602-F	12SW1102-F	12SW1502	12SW2002-F	
12SW0301-F	12SW0701	12SW1201	12SW1701	12SW2101	
12SW0302	12SW0701-F	12SW1201-F	12SW1701-F	12SW2101-F	
12SW0302-F	12SW0702	12SW1202	12SW1702	12SW2102	
12SW0401	12SW0901	12SW1202-F	12SW1702-F	12SW3101	
12SW0401-F	12SW0901-F	12SW1301	12SW1801	12SW3101-F	
12SW0402	12SW0902	12SW1301-F	12SW1801-F	12SW3201	

TABLE 7-15

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - EAST TRIBUTARY SURFACE WATER
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Surface Water
Exposure Medium: Surface Water

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections[2]	Concentration Used for Screening[3]	Concentrations in Upgradient Samples [4]	Screening Toxicity Value[5]	Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Energetics														
19406-51-0	4-Amino-2,6-Dinitrotoluene	0.252 J	0.56	ug/L	12SW2401	3/4	0.245	0.56	NA	0.73 N[8]	NA NA	NA NA	No	BSL
2691-41-0	HMX	0.28 J	0.55	ug/L	12SW2401	3/4	0.245	0.55	NA	180 N	NA NA	NA NA	No	BSL
121-82-4	RDX	0.39 J	0.8	ug/L	12SW2401	3/4	0.245	0.8	NA	0.61 C	NA NA	NA NA	Yes	ASL
Total Metals														
7429-90-5	Aluminum	40.7 J	257 J	ug/L	12SW2401	2/4	52.8 - 85.1	257	102	3600 N	NA NA	NA NA	No	BSL
7440-38-2	Arsenic	0.33 J	0.33 J	ug/L	12SW2401	1/4	0.11 - 0.24	0.33	ND	0.045 C	10 50	FED-MCL IDEM	Yes	ASL
7440-39-3	Barium	38.2 J	64.2 J	ug/L	12SW2301	4/4	---	64.2	39 - 41.8	260 N	2000 2000	FED-MCL IDEM	No	BSL
7440-70-2	Calcium	40400	59300 J	ug/L	12SW2301	4/4	---	59300	47200 - 63500	NA	NA NA	NA NA	No	NUT
7440-48-4	Cobalt	0.15 J	0.26 J	ug/L	12SW2401	3/4	0.2	0.26	0.18	73 N	NA NA	NA NA	No	BSL
7440-50-8	Copper	1.4 J	3.4 J	ug/L	12SW2401	2/4	0.58 - 1.4	3.4	0.89 - 1.5	150 N	1300 1300	FED-MCL[9] IDEM	No	BSL
7439-89-6	Iron	252 J	584 J	ug/L	12SW2401	4/4	---	584	337 - 345	1100 N	NA NA	NA NA	No	BSL
7439-92-1	Lead	0.136 J	0.136 J	ug/L	12SW2402	1/4	0.069 - 0.48	0.136	0.28	NA	15 15	FED-MCL[9] IDEM	No	BSL,BKG
7439-95-4	Magnesium	6740 J	10400 J	ug/L	12SW2301	4/4	---	10400	9130 - 11100	NA	NA NA	NA NA	No	NUT
7439-96-5	Manganese	1.2 J	7.1 J	ug/L	12SW2301	4/4	---	7.1	2.1 - 7.5	88 N	NA NA	NA NA	No	BSL
7440-02-0	Nickel	1.6 J	2.4 J	ug/L	12SW2401	4/4	---	2.4	1.9 - 2.4	73 N	NA 730	NA IDEM	No	BSL
7440-09-7	Potassium	1140 J	2940 J	ug/L	12SW2301	4/4	---	2940	1170 - 2730	NA	NA NA	NA NA	No	NUT
7440-23-5	Sodium	11600 J	25000 J	ug/L	12SW2301	4/4	---	25000	19700 - 28000	NA	NA NA	NA NA	No	NUT
7440-28-0	Thallium	0.07 J	0.07 J	ug/L	12SW2301, 12SW2302, 12SW2402	3/4	0.043	0.07	0.06 - 0.09	0.24 N	2 2	FED-MCL IDEM	No	BSL

TABLE 7-15

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - EAST TRIBUTARY SURFACE WATER
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Surface Water
Exposure Medium: Surface Water

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections[2]	Concentration Used for Screening[3]	Concentrations in Upgradient Samples [4]	Screening Toxicity Value[5]	Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Dissolved Metals														
7429-90-5	Aluminum, Filtered	8.7 J	9.6 J	ug/L	12SW2302	2/4	8.6 - 18.6	9.6	ND	3600 N	NA NA	NA NA	No	BSL
7440-38-2	Arsenic, Filtered	0.21 J	0.21 J	ug/L	12SW2401	1/4	0.1 - 0.16	0.21	ND	0.045 C	10 50	FED-MCL IDEM	Yes	ASL
7440-39-3	Barium, Filtered	44.4 J	66.8 J	ug/L	12SW2301	4/4	---	66.8	43.2 - 44.8	260 N	2000 2000	FED-MCL IDEM	No	BSL
7440-70-2	Calcium, Filtered	36200 J	57500 J	ug/L	12SW2301	4/4	---	57500	49300 - 50700	NA	NA NA	NA NA	No	NUT
7440-47-3	Chromium, Filtered	1.2 J	1.6 J	ug/L	12SW2302	2/4	0.65 - 0.82	1.6	1.4	11 N[10]	100 100	FED-MCL IDEM[10]	No	BSL
7440-48-4	Cobalt, Filtered	0.17 J	0.17 J	ug/L	12SW2302, 12SW2401	2/4	0.14 - 0.17	0.17	0.18	73 N	NA NA	NA NA	No	BSL
7440-50-8	Copper, Filtered	1.3 J	2.8 J	ug/L	12SW2401	3/4	1.3	2.8	0.89	150 N	1300 1300	FED-MCL[9] IDEM	No	BSL
7439-89-6	Iron, Filtered	229 J	305 J	ug/L	12SW2301	4/4	---	305	251 - 321	1100 N	NA NA	NA NA	No	BSL
7439-92-1	Lead, Filtered	0.2 J	0.254 J	ug/L	12SW2302	2/4	0.198 - 0.39	0.254	0.24	NA	15 15	FED-MCL[9] IDEM	No	BSL
7439-95-4	Magnesium, Filtered	6920 J	10600 J	ug/L	12SW2301	4/4	---	10600	9370 - 12300	NA	NA NA	NA NA	No	NUT
7439-96-5	Manganese, Filtered	0.82 J	3.5 J	ug/L	12SW2401	3/4	4.2	3.5	1.2	88 N	NA NA	NA NA	No	BSL
7440-02-0	Nickel, Filtered	2.2 J	2.8 J	ug/L	12SW2302	4/4	---	2.8	2.7 - 3.3	73 N	NA 730	NA IDEM	No	BSL
7440-09-7	Potassium, Filtered	1240 J	3040 J	ug/L	12SW2301	4/4	---	3040	1330 - 2820	NA	NA NA	NA NA	No	NUT
7440-23-5	Sodium, Filtered	12000 J	23800 J	ug/L	12SW2301	4/4	---	23800	21900 - 24100	NA	NA NA	NA NA	No	NUT
7440-28-0	Thallium, Filtered	0.07 J	0.07 J	ug/L	12SW2301	1/4	0.043 - 0.11	0.07	0.07	0.24 N	2 2	FED-MCL IDEM	No	BSL
7440-66-6	Zinc, Filtered	2.1 J	5.2 J	ug/L	12SW2402	2/4	3.3 - 6.5	5.2	1.5	1100 N	NA 11000	NA IDEM	No	BSL

TABLE 7-15

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - EAST TRIBUTARY SURFACE WATER
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Surface Water
Exposure Medium: Surface Water

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections[2]	Concentration Used for Screening[3]	Concentrations in Upgradient Samples [4]	Screening Toxicity Value[5]	Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Miscellaneous Parameters (mg/L)														
NA	Ammonia-N	0.021 J	0.13 J	mg/L	12SW2301	2/4	0.005	0.13	0.12	NA	NA NA	NA NA	No	NTX
NA	Nitrite/Nitrate-N	0.1	0.11	mg/L	12SW2301	2/4	0.025	0.11	0.1	1 N	1 NA	FED-MCL[9] NA	No	BSL

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in surface water relative to upgradient locations is presented in Section 5.0.
5 - The U.S. EPA Region 9 tap water screening level is presented. Value represents the risk-based tap water screening level divided by 10 to correspond to a target Hazard Quotient of 0.1 for non-carcinogens (denoted with a "N" flag), or an incremental lifetime cancer risk of $1x10^{-6}$ for carcinogens (denoted with a "C" flag) (U.S. EPA Region 9, October 2004).
6 - U.S. EPA Primary Drinking Water Standard (U.S. EPA, 2004b).
Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for groundwater (IDEM, 2004).
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level.
8 - Value is for aminodinitrotoluene.
9 - The MCL for this parameter is actually a treatment technique. The Safe Water Drinking Act (SDWA) action level (at the tap) has been presented.
10 - Value is for hexavalent chromium.

Associated Samples

12SW2301	12SW2401
12SW2301-F	12SW2401-F
12SW2302	12SW2402
12SW2302-F	12SW2402-F

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
MCL = Maximum Contaminant Level
N = Non-carcinogen
NA = Not applicable/not available
ND = Not detected
CAS = Chemical Abstracts Service

Rationale Codes:
For selection as a COPC:
ASL = Above screening level

For elimination as a COPC:
BSL = Below screening level
NUT = Essential nutrient
NTX = No toxicity data

TABLE 7-16

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - TURKEY CREEK SURFACE WATER
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Surface Water
Exposure Medium: Surface Water

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections[2]	Concentration Used for Screening[3]	Concentrations in Upgradient Samples [4]	Screening Toxicity Value[5]	Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Total Metals														
7429-90-5	Aluminum	24.1 J	24.1 J	ug/L	12SW2701	1/2	49.7	24.1	59.3	3600 N	NA NA	NA NA	No	BSL,BKG
7440-39-3	Barium	41 J	69.8 J	ug/L	12SW2701	2/2	---	69.8	35.4 - 75	260 N	2000 2000	FED-MCL IDEM	No	BSL
7440-41-7	Beryllium	0.02 J	0.02 J	ug/L	12SW2701	1/2	0.02	0.02	0.04	7.3 N	4 4	FED-MCL IDEM	No	BSL,BKG
7440-70-2	Calcium	34800 J	54500 J	ug/L	12SW2701	2/2	---	54500	31100 - 61000	NA	NA NA	NA NA	No	NUT
7440-48-4	Cobalt	0.22 J	0.22 J	ug/L	12SW2702	1/2	0.31	0.22	0.15	73 N	NA NA	NA NA	No	BSL
7439-89-6	Iron	275 J	456 J	ug/L	12SW2701	2/2	---	456	230 - 510	1100 N	NA NA	NA NA	No	BSL
7439-95-4	Magnesium	5120 J	9220 J	ug/L	12SW2701	2/2	---	9220	4260 - 9410	NA	NA NA	NA NA	No	NUT
7439-96-5	Manganese	43.1 J	131 J	ug/L	12SW2701	2/2	---	131	22 - 77.3	88 N	NA NA	NA NA	Yes	ASL
7440-02-0	Nickel	1.7 J	1.7 J	ug/L	12SW2701	1/2	0.1	1.7	2	73 N	NA 730	NA IDEM	No	BSL,BKG
7440-09-7	Potassium	915 J	1600 J	ug/L	12SW2701	2/2	---	1600	663 - 1670	NA	NA NA	NA NA	No	NUT
7440-23-5	Sodium	4630 J	9630 J	ug/L	12SW2701	2/2	---	9630	3570 - 10300	NA	NA NA	NA NA	No	NUT
Dissolved Metals														
7440-39-3	Barium, Filtered	36.9 J	64.4 J	ug/L	12SW2701-F	2/2	---	64.4	34.7 - 59.5	260 N	2000 2000	FED-MCL IDEM	No	BSL
7440-70-2	Calcium, Filtered	25500 J	53900 J	ug/L	12SW2701-F	2/2	---	53900	23900 - 57700	NA	NA NA	NA NA	No	NUT
7440-48-4	Cobalt, Filtered	0.18 J	0.18 J	ug/L	12SW2702-F	1/2	0.28	0.18	ND	73 N	NA NA	NA NA	No	BSL
7440-50-8	Copper, Filtered	0.41 J	0.41 J	ug/L	12SW2702-F	1/2	0.78	0.41	0.3	150 N	1300 1300	FED-MCL[8] IDEM	No	BSL
7439-89-6	Iron, Filtered	172 J	288 J	ug/L	12SW2701-F	2/2	---	288	149 - 249	1100 N	NA NA	NA NA	No	BSL
7439-95-4	Magnesium, Filtered	5800 J	8900 J	ug/L	12SW2701-F	2/2	---	8900	5250 - 8210	NA	NA NA	NA NA	No	NUT
7439-96-5	Manganese, Filtered	33.5 J	124 J	ug/L	12SW2701-F	2/2	---	124	18 - 49.2	88 N	NA NA	NA NA	Yes	ASL
7440-02-0	Nickel, Filtered	1.7 J	1.8 J	ug/L	12SW2702-F	2/2	---	1.8	1.5	73 N	NA 730	NA IDEM	No	BSL
7440-09-7	Potassium, Filtered	875 J	1600 J	ug/L	12SW2701-F	2/2	---	1600	741 - 1490	NA	NA NA	NA NA	No	NUT
7440-23-5	Sodium, Filtered	5240 J	9440 J	ug/L	12SW2701-F	2/2	---	9440	4640 - 9090	NA	NA NA	NA NA	No	NUT
7440-66-6	Zinc, Filtered	1.9 J	1.9 J	ug/L	12SW2702-F	1/2	2.7	1.9	3.9	1100 N	NA 11000	NA IDEM	No	BSL,BKG

TABLE 7-16

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - TURKEY CREEK SURFACE WATER
SWMU 12 (MINE FIELD A)
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Future
Medium: Surface Water
Exposure Medium: Surface Water

CAS Number	Chemical	Minimum Concentration(1)	Maximum Concentration(1)	Units	Location of Maximum Concentration	Frequency of Detection	Range of Nondetections(2)	Concentration Used for Screening(3)	Concentrations in Upgradient Samples (4)	Screening Toxicity Value(5)	Potential ARAR/TBC(6)	Potential ARAR/TBC Source(6)	COPC Flag	Rationale for Contaminant Deletion or Selection(7)
Miscellaneous Parameters (mg/L)														
NA	Ammonia-N	0.18 J	0.18 J	mg/L	12SW2701	1/2	0.005	0.18	NA	NA	NA NA	NA NA	No	NTX

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in surface water relative to upgradient locations is presented in Section 5.0.
5 - The U.S. EPA Region 9 tap water screening level is presented. Value represents the risk-based tap water screening level divided by 10 to correspond to a target Hazard Quotient of 0.1 for non-carcinogens (denoted with a "N" flag), or an incremental lifetime cancer risk of $1x10^{-6}$ for carcinogens (denoted with a "C" flag) (U.S. EPA Region 9, October 2004).
6 - U.S. EPA Primary Drinking Water Standard (U.S. EPA, 2004b).
Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for groundwater (IDEM, 2004).
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level.
8 - The MCL for this parameter is actually a treatment technique. The Safe Drinking Water Act (SDWA) action level (at the tap) has been presented.

Associated Samples
12SW2701
12SW2701-F
12SW2702
12SW2702-F

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
MCL = Maximum Contaminant Level
N = Non-carcinogen
NA = Not applicable/not available
ND = Not detected
CAS = Chemical Abstracts Service

Rationale Codes:
For selection as a COPC:
ASL = Above screening level.

For elimination as a COPC:
BSL = Below screening level
NUT = Essential nutrient
NTX = No toxicity data

TABLE 7-17

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GULLY SEDIMENT
SWMU 12 (MINE FIELD A) - BATTERY AREA
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections[2]	Concentration Used for Screening[3]	Concentrations in Upgradient Samples[4]	U.S. EPA Region 9 PRG (Residential)[5]		Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Semivolatile Organics (ug/kg)															
56-55-3	BENZO(A)ANTHRACENE	9	9	ug/kg	12SD030004	1/3	3.65 - 4.28	9	NA	620	C	5000	IDEM	No	BSL
50-32-8	BENZO(A)PYRENE	10	10	ug/kg	12SD030004	1/3	3.65 - 4.28	10	NA	62	C	500	IDEM	No	BSL
205-99-2	BENZO(B)FLUORANTHENE	15	15	ug/kg	12SD030004	1/3	3.65 - 4.28	15	NA	620	C	5000	IDEM	No	BSL
207-08-9	BENZO(K)FLUORANTHENE	7 J	7 J	ug/kg	12SD030004	1/3	3.65 - 4.28	7	NA	6200	C	50000	IDEM	No	BSL
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	340 J	340 J	ug/kg	12SD070004	1/3	74.1 - 85.7	340	NA	35000	C	300000	IDEM	No	BSL
218-01-9	CHRYSENE	11	11	ug/kg	12SD030004	1/3	3.65 - 4.28	11	NA	62000	C	500000	IDEM	No	BSL
206-44-0	FLUORANTHENE	4 J	15	ug/kg	12SD030004	3/3	---	15	NA	230000	N	6300000	IDEM	No	BSL
91-20-3	NAPHTHALENE	7 J	7 J	ug/kg	12SD070004	1/3	3.65 - 4.22	7	NA	5600	N	3200000	IDEM	No	BSL
85-01-8	PHENANTHRENE	6 J	10	ug/kg	12SD030004	2/3	3.65	10	NA	230000	N	470000	IDEM	No	BSL
129-00-0	PYRENE	6 J	18	ug/kg	12SD030004	2/3	3.65	18	NA	230000	N	4700000	IDEM	No	BSL
Energetics (mg/kg)															
118-96-7	2,4,6-TRINITROTOLUENE	0.4 J	2.4 J	mg/kg	12SD020004	4/19	0.25	2.4	NA	3.1	N	NA	IDEM	No	BSL
Inorganics (mg/kg)															
7429-90-5	ALUMINUM	10300 J	25700 J	mg/kg	12SD120004	19/19	---	25700	12900 - 23800	7600	N	NA	IDEM	Yes	ASL
7440-36-0	ANTIMONY	0.85 J	4.2 J	mg/kg	12SD130004	4/19	0.24 - 2.3	4.2	ND	3.1	N	140	IDEM	Yes	ASL
7440-38-2	ARSENIC	9.3 J	36 J	mg/kg	12SD170004	12/19	5.1 - 15.5	36	12.2 - 34.5	0.39	C	3.9	IDEM	Yes	ASL
7440-39-3	BARIUM	64.6 J	182 J	mg/kg	12SD090004	16/19	138 - 220	182	70.1 - 196	540	N	23000	IDEM	No	BSL
7440-43-9	CADMIUM	6.2 J	7.4 J	mg/kg	12SD150004	2/19	0.37 - 4.9	7.4	ND	3.7	N	12	IDEM	Yes	ASL
7440-70-2	CALCIUM	893 J	65300 J	mg/kg	12SD030004	19/19	---	65300	1610 - 46900	NA		NA	IDEM	No	NUT
7440-47-3	CHROMIUM	19.1 J	141 J	mg/kg	12SD210004	16/19	14.7 - 17.8	141	22.1 - 72.6	210	C	430	IDEM	No	BSL
7440-48-4	COBALT	5.5 J	108 J	mg/kg	12SD130004	14/19	6.9 - 17.3	108	7.9 - 65.9	140	N	NA	IDEM	No	BSL
7440-50-8	COPPER	10.6 J	22.5 J	mg/kg	12SD140004, 12SD170004	14/19	10.5 - 13.9	22.5	14.8 - 41.9	310	N	13000	IDEM	No	BSL
7439-89-6	IRON	14100 J	217000 J	mg/kg	12SD100004	19/19	---	217000	22900 - 210000	2300	N	NA	IDEM	Yes	ASL
7439-92-1	LEAD	12.6 J	178 J	mg/kg	12SD170004	19/19	---	178	23.9 - 43.9	400		400	IDEM	No	BSL
7439-95-4	MAGNESIUM	670 J	8190 J	mg/kg	12SD140004	19/19	---	8190	1130 - 4670	NA		NA	IDEM	No	NUT
7439-96-5	MANGANESE	217 J	6780 J	mg/kg	12SD130004	17/19	473 - 545	6780	253 - 4430	180	N	NA	IDEM	Yes	ASL
7439-97-6	MERCURY	0.019 J	0.063 J	mg/kg	12SD140004	19/19	---	0.063	0.029 - 0.059	2.3	N	100	IDEM	No	BSL
7440-02-0	NICKEL	14.9 J	80.9 J	mg/kg	12SD130004	16/19	11.7 - 13.5	80.9	16.1 - 63.9	160	N	6900	IDEM	No	BSL
7440-09-7	POTASSIUM	969 J	2440 J	mg/kg	12SD140004	19/19	---	2440	866 - 2200	NA		NA	IDEM	No	NUT
7440-23-5	SODIUM	89.7 J	102 J	mg/kg	12SD020004	2/19	25.5 - 154	102	ND	NA		NA	IDEM	No	NUT
7440-31-5	TIN	2.6 J	3.1 J	mg/kg	12SD100004	3/19	0.33 - 0.63	3.1	ND	4700	N	NA	IDEM	No	BSL
7440-62-2	VANADIUM	23.4 J	71 J	mg/kg	12SD090004	17/19	19.3 - 133	71	29.6 - 62.4	7.8	N	NA	IDEM	Yes	ASL
7440-66-6	ZINC	46.1 J	263 J	mg/kg	12SD120004	16/19	121 - 528	263	57.6 - 363	2300	N	100000	IDEM	No	BSL

Shaded cell indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in sediment relative to upgradient locations is presented in Section 5.0.
5 - U.S. EPA Region 9 Preliminary Remediation Goal (PRG). The non-carcinogenic values (denoted with a "N" flag) are the PRG divided by 10 to correspond to a target Hazard Quotient of 0.1. Carcinogenic values represent an incremental lifetime cancer risk of $1x10^{-6}$ (carcinogens denoted with a "C" flag) (U.S. EPA Region 9, October 2004, Updated December 28, 2004).
6 - Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for soil (IDEM, 2004).
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level.

Associated Samples

12SD010004	12SD060004	12SD120004	12SD180004
12SD020004	12SD070004	12SD130004	12SD190004
12SD030004	12SD090004	12SD140004	12SD200004
12SD040004	12SD100004	12SD150004	12SD210004
12SD050004	12SD110004	12SD170004	

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Non-carcinogen
NA = Not applicable/not available
sat = Soil saturation concentration
CAS = Chemical Abstracts Service

Rationale Codes:
For selection as a COPC:
ASL = Above screening level

For elimination as a COPC:
BSL = Below screening level
NTX = No toxicity data
NUT = Essential nutrient

TABLE 7-18

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - EAST TRIBUTARY SEDIMENT
SWMU 12 (MINE FIELD A) - BATTERY AREA
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections[2]	Concentration Used for Screening[3]	Concentration in Upgradient Sample [4]	EPA Region 9 PRG (Residential)[5]		Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Inorganics (mg/kg)															
7429-90-5	ALUMINUM	8080 J	17200 J	mg/kg	12SD230004	2/2	---	17200	10900	7600	N	NA	IDEM	Yes	ASL
7440-36-0	ANTIMONY	1.2 J	1.2 J	mg/kg	12SD230004	1/2	1.5	1.2	0.81	3.1	N	140	IDEM	No	BSL
7440-38-2	ARSENIC	10.9 J	10.9 J	mg/kg	12SD230004	1/2	15.5	10.9	15.3	0.39	C	3.9	IDEM	Yes	ASL
7440-39-3	BARIUM	65 J	65 J	mg/kg	12SD240004	1/2	177	65	108	540	N	23000	IDEM	No	BSL
7440-70-2	CALCIUM	897 J	1920 J	mg/kg	12SD230004	2/2	---	1920	9270	NA		NA	IDEM	No	NUT
7440-47-3	CHROMIUM	26.8 J	32.8 J	mg/kg	12SD240004	2/2	---	32.8	29	210	C	430	IDEM	No	BSL
7440-48-4	COBALT	19.4 J	40.4 J	mg/kg	12SD230004	2/2	---	40.4	28.3	140	N	NA	IDEM	No	BSL
7440-50-8	COPPER	13 J	29.4 J	mg/kg	12SD240004	2/2	---	29.4	11.5	310	N	13000	IDEM	No	BSL
7439-89-6	IRON	31900 J	70700 J	mg/kg	12SD240004	2/2	---	70700	44600	2300	N	NA	IDEM	Yes	ASL
7439-92-1	LEAD	22.8 J	58.2 J	mg/kg	12SD240004	2/2	---	58.2	25.2	400		400	IDEM	No	BSL
7439-95-4	MAGNESIUM	710 J	1340 J	mg/kg	12SD230004	2/2	---	1340	2090	NA		NA	IDEM	No	NUT
7439-96-5	MANGANESE	1480 J	2910 J	mg/kg	12SD230004	2/2	---	2910	2060	180	N	NA	IDEM	Yes	ASL
7439-97-6	MERCURY	0.012 J	0.038 J	mg/kg	12SD230004	2/2	---	0.038	0.027	2.3	N	100	IDEM	No	BSL
7440-02-0	NICKEL	26 J	32.1 J	mg/kg	12SD230004	2/2	---	32.1	31.3	160	N	6900	IDEM	No	BSL
7440-09-7	POTASSIUM	838 J	1210 J	mg/kg	12SD230004	2/2	---	1210	1200	NA		NA	IDEM	No	NUT
7440-62-2	VANADIUM	31 J	36 J	mg/kg	12SD240004	2/2	---	36	30.7	7.8	N	NA	IDEM	Yes	ASL
7440-66-6	ZINC	75.7 J	75.7 J	mg/kg	12SD230004	1/2	158	75.7	71.2	2300	N	100000	IDEM	No	BSL

Shaded cell indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in sediment relative to upgradient locations is presented in Section 5.0.
5 - U.S. EPA Region 9 Preliminary Remediation Goal (PRG). The non-carcinogenic values (denoted with a "N" flag) are the PRG divided by 10 to correspond to a target Hazard Quotient of 0.1. Carcinogenic values represent an incremental lifetime cancer risk of $1x10^{-6}$ (carcinogens denoted with a "C" flag) (U.S. EPA Region 9, October 2004, Updated December 28, 2004).
6 - Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for soil (IDEM, 2004).
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level .

Associated Samples
12SD230004
12SD240004

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Non-carcinogen
NA = Not applicable/not available
CAS = Chemical Abstracts Service

Rationale Codes:
For selection as a COPC:
ASL = Above screening level

For elimination as a COPC:
BSL = Below screening level
NTX = No toxicity data
NUT = Essential nutrient

TABLE 7-19

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - TURKEY CREEK SEDIMENT
SWMU 12 (MINE FIELD A) - BATTERY AREA
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

CAS Number	Chemical	Minimum Concentration[1]	Maximum Concentration[1]	Units	Location of Maximum Concentration	Frequency of Detection	Range of Non-Detections[2]	Concentration Used for Screening[3]	Concentration in Upgradient Sample [4]	EPA Region 9 PRG (Residential)[5]		Potential ARAR/TBC[6]	Potential ARAR/TBC Source[6]	COPC Flag	Rationale for Contaminant Deletion or Selection[7]
Inorganics (mg/kg)															
7429-90-5	ALUMINUM	5360 J	11400 J	mg/kg	12SD270004	3/3	---	11400	6760	7600	N	NA	IDEM	Yes	ASL
7440-38-2	ARSENIC	4.5 J	27.8 J	mg/kg	12SD270004	3/3	---	27.8	ND	0.39	C	3.9	IDEM	Yes	ASL
7440-39-3	BARIUM	51.6 J	82.4 J	mg/kg	12SD270004	3/3	---	82.4	45.1	540	N	23000	IDEM	No	BSL
7440-41-7	BERYLLIUM	0.43 J	0.49 J	mg/kg	13SD4401	2/3	2.6	0.49	ND	15	N	680	IDEM	No	BSL
7440-43-9	CADMIUM	0.17 J	0.19 J	mg/kg	13SD4401	2/3	0.81	0.19	ND	3.7	N	12	IDEM	No	BSL
7440-70-2	CALCIUM	703 J	1830 J	mg/kg	12SD270004	3/3	---	1830	64000	NA		NA	IDEM	No	NUT
7440-47-3	CHROMIUM	11.8 J	70.4 J	mg/kg	12SD270004	3/3	---	70.4	26.4	210	C	430	IDEM	No	BSL
7440-48-4	COBALT	7 J	27.1 J	mg/kg	12SD270004	3/3	---	27.1	ND	140	N	NA	IDEM	No	BSL
7440-50-8	COPPER	6.3 J	19.8 J	mg/kg	12SD270004	3/3	---	19.8	ND	310	N	13000	IDEM	No	BSL
7439-89-6	IRON	14100 J	157000 J	mg/kg	12SD270004	3/3	---	157000	40000	2300	N	NA	IDEM	Yes	ASL
7439-92-1	LEAD	9.4 J	39.6 J	mg/kg	12SD270004	3/3	---	39.6	12.4	400		400	IDEM	No	BSL
7439-95-4	MAGNESIUM	565 J	748 J	mg/kg	12SD270004	3/3	---	748	6620	NA		NA	IDEM	No	NUT
7439-96-5	MANGANESE	444	1760 J	mg/kg	12SD270004	3/3	---	1760	708	180	N	NA	IDEM	Yes	ASL
7439-97-6	MERCURY	0.01 J	0.01 J	mg/kg	12SD270004	1/1	---	0.01	ND	2.3	N	100	IDEM	No	BSL
7440-02-0	NICKEL	10.7 J	52.1 J	mg/kg	12SD270004	3/3	---	52.1	22.8	160	N	6900	IDEM	No	BSL
7440-09-7	POTASSIUM	748 J	810 J	mg/kg	12SD270004	3/3	---	810	903	NA		NA	IDEM	No	NUT
7782-49-2	SELENIUM	0.13 J	0.16 J	mg/kg	13SD4401	2/3	0.54	0.16	ND	39	N	1700	IDEM	No	BSL
7440-62-2	VANADIUM	14 J	57.8 J	mg/kg	12SD270004	3/3	---	57.8	24.8	7.8	N	NA	IDEM	Yes	ASL
7440-66-6	ZINC	27.2 J	32 J	mg/kg	13SD4401	2/3	204	32	55.6	2300	N	100000	IDEM	No	BSL

Shaded cell indicates that the maximum concentration exceeds the specified criterion and that the chemical is selected as a COPC.

Footnotes
1 - Sample and duplicate are considered as two separate samples when determining the minimum and maximum concentrations.
2 - Values presented are sample-specific quantitation limits.
3 - The maximum detected concentration is used for screening purposes.
4 - Background is not considered for COPC screening. A discussion of metals concentrations in sediment relative to upgradient locations is presented in Section 5.0.
5 - U.S. EPA Region 9 Preliminary Remediation Goal (PRG). The non-carcinogenic values (denoted with a "N" flag) are the PRG divided by 10 to correspond to a target Hazard Quotient of 0.1. Carcinogenic values represent an incremental lifetime cancer risk of $1x10^{-6}$ (carcinogens denoted with a "C" flag) (U.S. EPA Region 9, October 2004, Updated December 28, 2004).
6 - Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential closure levels for soil (IDEM, 2004).
7 - The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level.

Associated Sample
12SD270004

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered Criterion
C = Carcinogen
COPC = Chemical of potential concern
J = Estimated value
N = Non-carcinogen
NA = Not applicable/not available
CAS = Chemical Abstracts Service

Rationale Codes:
For selection as a COPC:
ASL = Above screening level

For elimination as a COPC:
BSL = Below screening level
NTX = No toxicity data
NUT = Essential nutrient

TABLE 7-20

SUMMARY OF COPCs AND EXPOSURE POINT CONCENTRATIONS
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Chemical of Potential Concern	Exposure Point Concentration for Soil							
	Surface Soil MFA Proper[1] (mg/kg)	Suburface Soil MFA Proper[2] (mg/kg)	Surface/ Subsurface Soil - Building 152[3] (mg/kg)	Surface/ Subsurface Soil - Building 153/154[3] (mg/kg)	Surface/ Subsurface Soil - Building 157[3] (mg/kg)	Surface/ Subsurface Soil - Building 158[3] (mg/kg)	Surface Soil Battery Site[2] (mg/kg)	Suburface Soil Battery Site[2] (mg/kg)
2,4,6-Trinitrotoluene			2	2	4	3		
2-Amino-4,6-Dinitrotoluene			0.3	0.6	0.3	0.3		
4-Amino-2,6-Dinitrotoluene			0.3	0.6	0.3	0.3		
2-Nitrotoluene			0	0.4		0.2		
HMX			2	6	2	4		
RDX			3	25	3	15	6	
Benzo(a)pyrene							0.08	
Aluminum	29800	26900	13100	13700	16600	14900	19000	19700
Antimony							3600	3.8
Arsenic	9	7.5	8.9	11.5	8.9	16.2	123	387
Barium		183						
Cadmium							6.3[4]	
Copper							303	
Iron	30600	34200					38400	54400
Lead							39400[5]	
Manganese	1080	542					828	355
Thalium							6.4	
Vanadium	48.6	41.6					34.9	29.5
Zinc							2160	

TABLE 7-20

SUMMARY OF COPCs AND EXPOSURE POINT CONCENTRATIONS
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Chemical of Potential Concern	Exposure Point Concentrations for Soil								
	Groundwater			Surface Water			Sediment		
	Puz[6]	Pmz[6]	PlzMgd[6]	Gully[2]	East Tributary[1]	Turkey Creek[1]	Gully[2]	East Tributary[1]	Turkey Creek[1]
	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(mg/kg)	(mg/kg)	(mg/kg)
1,3-Dinitrobenzene	0.8								
2,4,6-Trinitrotoluene	17		4.2	24					
2,6-Dinitrotoluene	0.8								
2-Amino-4,6-Dinitrotoluene	10			7					
2-Nitrotoluene	0.1								
4-Amino-2,6-Dinitrotoluene	17			23					
4-Nitrotoluene	0.3								
HMX	88								
RDX	1100	0.8	3.9	25	0.8				
Aluminum	140000	6810		7570			18500	17200	11400
Antimony		1.3	3.1				1.2	10.9	27.8
Arsenic	24.9	2.6	9.5	5.3	0.33		22.6		
Beryllium	24.9			273					
Barium	68.5			1.6					
Cadmium	48.5	0.92		2.6			5.9		
Chromium	13	10.5		8					
Cobalt	3250	33.3		7.8					
Copper				468					
Iron	95100	13600	7150	7260			97800	70700	157000
Lead	39.2[5]	7.2[5]		15[5]					
Manganese	80300	1740	2190	3620		131	3070	2910	1760
Mercury	0.53			0.26					
Nickel	8160	73.8		24.4					
Selenium	9.2								
Thallium	1.8	0.11		0.16					
Vanadium	6.1	10.5	4.9	43.4			50.1	36	57.8
Zinc	10700			1480					
Nitrite/Nitrate-N	1.8	0.53		3.8					

BLANK SPACES INDICATE THAT THE CHEMICAL WAS NOT SELECTED AS A COPC FOR THE SPECIFIED MEDIUM.
COPCs - Chemicals of Potential Concern

1 - Data set consists of less than 10 samples; therefore, the maximum concentration was used as the EPC.
2 - UCLs calculated according to the U.S EPA's ProUCL guidance, unless otherwise noted. See RAGS Part D Table 3s in Appendix I for details concerning the UCLs.
3 - The EPCs for explosives and metals obtained during the bioremediation program are weighted averages representing post-remediation conditions at SWMU 12 (See Section 7.3.3).
4 - The maximum concentration was used as the EPC because there were less than 50 percent positive detections in the data set.
5 - The EPC for lead is the arithmetic average, as recommended by U.S. EPA guidance.
6 - The EPC for groundwater is the arithmetic average of samples in the most highly contaminated area of the plume (See Section 7.3.3).

TABLE 7-21

RECEPTORS AND EXPOSURE ROUTES FOR QUANTITATIVE EVALUATION
SWMU 12 MINE FILL A
NSWC CRANE
CRANE, INDIANA

Receptors	Exposure Routes
Maintenance Workers (current/future land use)	• Soil dermal contact (surface/subsurface) • Soil ingestion (surface/subsurface) • Inhalation of air/dust/emissions (surface/subsurface) • Surface water/sediment dermal contact • Sediment (incidental ingestion)
Occupational Workers (current/future land use)	• Soil dermal contact (surface/subsurface) • Soil ingestion (surface/subsurface) • Inhalation of air/dust/emissions (surface/subsurface) • Direct ingestion of groundwater • Groundwater dermal contact
Adolescent Trespassers (6 to 17 years) (current/future land use)	• Soil dermal contact (surface/subsurface) • Soil ingestion (surface/subsurface) • Inhalation of air/dust/emissions (surface/subsurface) • Surface water/sediment dermal contact • Surface water/sediment ingestion
Construction Workers (future land use)	• Soil dermal contact (surface and subsurface) • Soil ingestion (surface and subsurface) • Inhalation of air/dust/emissions (surface and subsurface) • Groundwater dermal contact (during excavation)
Small Child (0 to 6 years) and Adult Recreational Users (future land use)	• Soil dermal contact (surface/subsurface) • Soil ingestion (surface/subsurface) • Inhalation of air/dust/emissions (surface/subsurface) • Surface water/sediment dermal contact • Surface water/sediment ingestion • Groundwater dermal contact • Direct ingestion of groundwater
On-Base Residents (Adult/Children) (future land use)	• Soil dermal contact (surface/subsurface) • Soil ingestion (surface/subsurface) • Inhalation of air/dust/emissions (surface/subsurface) • Direct ingestion of groundwater • Groundwater dermal contact (showering/bathing) • Surface water/sediment dermal contact • Surface water/sediment ingestion

TABLE 7-22

SUMMARY OF EXPOSURE INPUT PARAMETERS
REASONABLE MAXIMUM EXPOSURES
SWMU 12 MINE FILL A
NSWC CRANE
CRANE INDIANA

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Trespasser	Child Recreational User	Adult Recreational User	On-Site Child Resident	On-Site Adult Resident
All Exposures								
C_{soil}/C_{sed} (mg/kg)	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
C_{gw} (µg/L)	Average	NA	Average	NA	Average	Average	Average	Average
C_{sw} (µg/L)	NA	Maximum or 95% UCL[1]	NA	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
ED (years)	1[2]	25[3]	25[3]	11[4]	6[5]	24[5]	6[5]	24[5]
BW (kg)	70[5]	70[5]	70[5]	43[6]	15[5]	70[5]	15[5]	70[5]
AT_n (days)	365[6]	9,125[6]	9,125[6]	4,015[6]	2,190[6]	8,760[6]	2,190[6]	8,760[6]
AT_c (days)	25,550[6]	25,550[6]	25,550[6]	25,550[6]	25,550[6]	25,550[6]	25,550[6]	25,550[6]
Incidental Ingestion/Dermal Contact with Soil								
IR (mg/day)	330[7]	100[5]	100[5]	100[5]	200[5]	100[5]	200[5]	100[5]
EF-Soil (days/year)	150[8]	24[9]	250[5]	26[10]	52[11]	52[11]	350[5]	350[5]
FI (unitless)	1[5]	1[5]	1[5]	1[5]	0.5[2]	0.5[2]	1[5]	1[5]
SA (cm^2/day)	3,300[12]	3,300[12]	3,300[12]	3,280[13]	3,300[14]	9,070[15]	2,800[12]	5,700[12]
AF (mg/cm^2)	0.3[12]	0.2[12]	0.2[12]	0.2[12]	0.2[12]	0.07[12]	0.2[12]	0.07[12]
ABS (unitless)	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]
CF (kg/mg)	$1X10^{-6}$	$1X10^{-6}$	$1X10^{-6}$	$1X10^{-6}$	$1X10^{-6}$	$1X10^{-6}$	$1X10^{-6}$	$1X10^{-6}$
Ingestion/Dermal Contact with Groundwater								
IR_{gw} (L/day)	NA	NA	1[2]	NA	1[2]	1[2]	1.5[16]	2[5]
EF (days/year)	150[8]	NA	250[5]	NA	52[11]	52[11]	350[5]	350[5]
ET (hours/day) and t_{event} (hours/event)	2[2]	NA	0.25[2]	NA	0.25[2]	0.25[2]	0.25[16]	0.25[16]
EV (events/day)	1[2]	NA	1[2]	NA	1[2]	1[2]	1[2]	1[2]
A (cm^2/day)	3,300[12]	NA	3,300[12]	NA	3,300[14]	9,070[15]	6,600[12]	18,000[12]
K_p (cm/hour)	chemical-specific[12]	NA	chemical-specific[12]	NA	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]
t* (hour/event), τ (hour), and B (unitless)	chemical-specific[12]	NA	chemical-specific[12]	NA	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]

TABLE 7-22

SUMMARY OF EXPOSURE INPUT PARAMETERS
REASONABLE MAXIMUM EXPOSURES
SWMU 12 MINE FILL A
NSWC CRANE
CRANE INDIANA

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Trespasser	Child Recreational User	Adult Recreational User	On-Site Child Resident	On-Site Adult Resident
Ingestion/Dermal Contact with Surface Water								
CR_{sw} (ml/hr)	NA	NA	NA	0.05[17]	0.05[17]	0.01[17]	0.05[17]	0.01[17]
EF (days/year)	NA	24[9]	NA			52[11]	52[11]	52[11]
ET (hours/day) and t_{event} (hours/event)	NA	2[2]	NA	4[2]	4[2]	4[2]	4[2]	4[2]
EV (events/day)	NA	1[2]	NA	1[2]	1[2]	1[2]	1[2]	1[2]
A (cm^2/day)	NA	3,300[12]	NA	3,280[13]	3,300[14]	9,070[15]	3,300[14]	9,070[15]
K_p (cm/hour)	NA	chemical-specific[12]	NA	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]
t* (hour/event), τ (hour), and B (unitless)	NA	chemical-specific[12]	NA	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]
CF (L/cm^3)	NA	$1x10^{-3}$	NA	$1x10^{-3}$	$1x10^{-3}$	$1x10^{-3}$	$1x10^{-3}$	$1x10^{-3}$
Incidental Ingestion/Dermal Contact with Sediment								
IR (mg/day)	NA	100[5]	NA	100[5]	200[5]	100[5]	100[2]	50[2]
EF-Sediment (days/year)	NA	24[9]	NA	26[10]	52[11]	52[11]	52[11]	52[11]
FI (unitless)	NA	1[5]	NA	1[5]	0.5[2]	0.5[2]	1[5]	1[5]
SA (cm^2/day)	NA	3,300[12]	NA	3,280[13]	3,300[14]	9,070[15]	2,800[12]	5,700[12]
AF (mg/cm^2)	NA	0.2[12]	NA	0.2[12]	0.2[12]	0.07[12]	0.2[12]	0.07[12]
ABS (unitless)	NA	chemical-specific[12]	NA	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]	chemical-specific[12]
CF (kg/mg)	NA	$1X10^{-6}$	NA	$1X10^{-6}$	$1X10^{-6}$	$1X10^{-6}$	$1X10^{-6}$	$1X10^{-6}$

TABLE 7-22

SUMMARY OF EXPOSURE INPUT PARAMETERS
REASONABLE MAXIMUM EXPOSURES
SWMU 12 MINE FILL A
NSWC CRANE
CRANE INDIANA

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Trespasser	Child Recreational User	Adult Recreational User	On-Site Child Resident	On-Site Adult Resident

Notes:

A	Skin surface area available for contact	EF	Exposure frequency
ABS	Absorption factor	ET	Exposure time
AF	Soil-to-skin adherence factor	EV	Event frequency
AT_c	Averaging time for carcinogenic effects	FI	Fraction ingested from contaminated source
AT_n	Averaging time for non-carcinogenic effects	InhR	Inhalation rate
B	Bunge Model partitioning coefficient	IR	Ingestion rate (soil or groundwater)
BW	Body weight	K_p	Permeability coefficient from water through skin
CF	Conversion factor	SA	Skin surface area available for contact
CR	Contact rate	PEF	Particulate emission factor
$C_{soil/sed}$	Exposure concentration for soil/sediment	τ	Lag time
$C_{gw/sw}$	Exposure concentration for groundwater/surface water	t^*	Time it takes to reach steady-state conditions
C_{air}	Exposure concentration for air	t_{event}	Duration of event
ED	Exposure duration		

1 - U.S. EPA, 2002c.
2 - Professional judgment.
3 - U.S. EPA, 1991.
4 - Adolescents ages 7 to 16 years old.
5 - U.S. EPA, 1993.
6 - U.S. EPA, 1989.
7 - U.S. EPA, 2002a.
8 - Ground is assumed to be frozen or snow covered 22 weeks per year.
9 - Assume 2 days a month for reasonable maximum exposure and 1 day a month for central tendency exposure.
10 - Assume 1 day a week in warm weather months for reasonable maximum exposure and every other week for central tendency exposure.
11 - Assume 2 days a week in warm weather months for reasonable maximum exposure and 1 day a week for central tendency exposure.
12 - U.S. EPA, 2004a.
13 - Assume 25 percent of total body surface area is exposed, U.S. EPA, 1997a.
14 - Assume 50 percent of total body surface area is exposed, U.S. EPA, 2004a.
15 - Assume that head, arms, hands, lower legs, and feet are exposed, U.S. EPA, 1997a.
16 - U.S. EPA, 1997a.
17 - U.S. EPA Region 4, 2000.

TABLE 7-23

SUMMARY OF EXPOSURE INPUT PARAMETERS
CENTRAL TENDENCY EXPOSURES
SWMU 12 MINE FILL A
NSWC CRANE
CRANE INDIANA

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Trespasser	Child Recreational User	Adult Recreational User	On-Site Child Resident	On-Site Adult Resident
All Exposures								
C_{soil}/C_{sed} (mg/kg)	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
C_{gw} (µg/L)	Average	NA	Average	NA	Average	Average	Average	Average
C_{sw} (µg/L)	NA	Maximum or 95% UCL[1]	NA	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]	Maximum or 95% UCL[1]
ED (years)	1[2]	9[3]	9[3]	11[4]	2[3]	7[3]	2[3]	7[3]
BW (kg)	70[3]	70[3]	70[3]	43[5]	15[3]	70[3]	15[3]	70[3]
AT_n (days)	365[5]	3,285[5]	3,285[5]	4,015[5]	730[5]	2,555[5]	730[5]	2,555[5]
AT_c (days)	25,550[5]	25,550[5]	25,550[5]	25,550[5]	25,550[5]	25,550[5]	25,550[5]	25,550[5]
Incidental Ingestion/Dermal Contact with Soil								
IR (mg/day)	165[6]	50[3]	50[3]	50[3]	100[3]	50[3]	100[3]	50[3]
EF-Soil (days/year)	150[7]	12[8]	219[3]	13[9]	26[10]	26[10]	234[3]	234[3]
FI (unitless)	1[3]	1[3]	1[3]	1[3]	0.5[2]	0.5[2]	1[3]	1[3]
SA (cm^2/day)	3,300[11]	3,300[11]	3,300[11]	3,100[12]	3,300[13]	9,070[14]	2,800[11]	5,700[11]
AF (mg/cm^2)	0.1[11]	0.02[11]	0.02[11]	0.04[11]	0.04[11]	0.01[11]	0.04[11]	0.01[11]
ABS (unitless)	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]
CF (kg/mg)	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$
Ingestion/Dermal Contact with Groundwater								
IR_{gw} (L/day)	NA	NA	1[2]	NA	1[2]	1[2]	0.66[15]	1.4[3]
EF (days/year)	150[7]	NA	219[3]	NA	26[10]	26[10]	234[3]	234[3]
ET (hours/day) and t_{event} (hours/event)	1.5[2]	NA	0.167[2]	NA	0.167[2]	0.167[2]	0.167[15]	0.167[15]
EV (events/day)	1[2]	NA	1[2]	NA	1[2]	1[2]	1[2]	1[2]
A (cm^2/day)	3,300[11]	NA	3,300[11]	NA	3,300[13]	9,070[14]	6,600[11]	18,000[11]
K_p (cm/hour)	chemical-specific[11]	NA	chemical-specific[11]	NA	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]
t* (hour/event), τ (hour), and B (unitless)	chemical-specific[11]	NA	chemical-specific[11]	NA	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]

TABLE 7-23

SUMMARY OF EXPOSURE INPUT PARAMETERS
CENTRAL TENDENCY EXPOSURES
SWMU 12 MINE FILL A
NSWC CRANE
CRANE INDIANA

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Trespasser	Child Recreational User	Adult Recreational User	On-Site Child Resident	On-Site Adult Resident
Ingestion/Dermal Contact with Surface Water								
CR_{sw} (ml/hr)	NA	NA	NA	0.05[16]	0.05[16]	0.01[16]	0.05[16]	0.01[16]
EF (days/year)	NA	12[8]	NA		26[10]	26[10]	26[10]	26[10]
ET (hours/day) and t_{event} (hours/event)	NA	1.5[2]	NA	2[2]	2[2]	2[2]	2[2]	2[2]
EV (events/day)	NA	1[2]	NA	1[2]	1[2]	1[2]	1[2]	1[2]
A (cm^2/day)	NA	3,300[11]	NA	3,100[12]	3,300[13]	9,070[14]	3,300[13]	9,070[14]
K_p (cm/hour)	NA	chemical-specific[11]	NA	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]
t* (hour/event), τ (hour), and B (unitless)	NA	chemical-specific[11]	NA	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]
CF (L/cm^3)	NA	$1x10^{-3}$	NA	$1x10^{-3}$	$1x10^{-3}$	$1x10^{-3}$	$1x10^{-3}$	$1x10^{-3}$
Incidental Ingestion/Dermal Contact with Sediment								
IR (mg/day)	NA	50[3]	NA	50[3]	100[3]	50[3]	50[2]	25[2]
EF-Sediment (days/year)	NA	12[8]	NA	13[9]	26[10]	26[10]	26[10]	26[10]
FI (unitless)	NA	1[3]	NA	1[3]	0.5[2]	0.5[2]	1[3]	1[3]
SA (cm^2/day)	NA	3,300[11]	NA	3,100[12]	3,300[13]	9,070[14]	2,800[11]	5,700[11]
AF (mg/cm^2)	NA	0.02[11]	NA	0.04[11]	0.04[11]	0.01[11]	0.04[11]	0.01[11]
ABS (unitless)	NA	chemical-specific[11]	NA	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]	chemical-specific[11]
CF (kg/mg)	NA	$1x10^{-6}$	NA	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$

TABLE 7-23

SUMMARY OF EXPOSURE INPUT PARAMETERS
CENTRAL TENDENCY EXPOSURES
SWMU 12 MINE FILL A
NSWC CRANE
CRANE INDIANA

Exposure Parameter	Construction Worker	Maintenance Worker	Occupational Worker	Adolescent Trespasser	Child Recreational User	Adult Recreational User	On-Site Child Resident	On-Site Adult Resident

Notes:

A	Skin surface area available for contact	EF	Exposure frequency
ABS	Absorption factor	ET	Exposure time
AF	Soil-to-skin adherence factor	EV	Event frequency
AT_c	Averaging time for carcinogenic effects	FI	Fraction ingested from contaminated source
AT_n	Averaging time for non-carcinogenic effects	InhR	Inhalation rate
B	Bunge Model partitioning coefficient	IR	Ingestion rate (soil or groundwater)
BW	Body weight	K_p	Permeability coefficient from water through skin
CF	Conversion factor	NA	Not applicable
CR	Contact rate	SA	Skin surface area available for contact
$C_{soil/sed}$	Exposure concentration for soil/sediment	PEF	Particulate emission factor
$C_{gw/sw}$	Exposure concentration for groundwater/surface water	τ	Lag time
C_{air}	Exposure concentration for air	t^*	Time it takes to reach steady-state conditions
ED	Exposure duration	t_{event}	Duration of event
		UCL	Upper confidence limit on arithmetic mean

1 - U.S. EPA, 2002c.
2 - Professional judgment.
3 - U.S. EPA, 1993.
4 - Adolescents ages 7 to 16 years old.
5 - U.S. EPA, 1989.
6 - Central tendency exposure is assumed to be one-half the reasonable maximum exposure value.
7 - Ground is assumed to be frozen or snow covered 22 weeks per year.
8 - Assume 2 days a month for RME and one day a month for CTE.
9 - Assume 1 day a week in warm weather months for RME and every other week for CTE.
10 - Assume 2 days a week in warm weather months for RME and one day a week for CTE.
11 - U.S. EPA, 2004a.
12 - Assume 25 percent of total body surface area is exposed, U.S. EPA, 1997.
13 - Assume 50 percent of total body surface area is exposed, U.S. EPA, 2004a.
14 - Assume that head, arms, hands, lower legs, and feet are exposed (U.S. EPA, 1997a).
15 - U.S. EPA, 1997a.
16 - U.S. EPA Region 4, 2000.

TABLE 7-24

NON-CANCER TOXICITY DATA - ORAL/DERMAL
SWMU 12 MINE FILL A
NSWC CRANE, CRANE, INDIANA

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal[1]	Absorbed RfD for Dermal[2]		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source	Date
Energetics										
1,3-Dinitrobenzene	Chronic	$1x10^{-4}$	mg/kg/day	1	$1x10^{-4}$	mg/kg/day	Spleen	3000/1	IRIS	9/01/2005
2,4,6-Trinitrotoluene	Chronic	5.0E-04	mg/kg/day	1	5.0E-04	mg/kg/day	Liver	1000/1	IRIS	9/01/2005
2,6-Dinitrotoluene	Chronic	1.0E-03	mg/kg/day	1	1.0E-03	mg/kg/day	CNS, Blood, Kidney	3000/1	HEAST	7/1997
2-Amino-4,6-Dinitrotoluene	Chronic	2.00E-04	mg/kg/day	1	2.0E-04	mg/kg/day	Liver	NA	NCEA	10//2004
2-Nitrotoluene	Chronic	1.0E-02	mg/kg/day	1	1.0E-02	mg/kg/day	Spleen	10000/1	HEAST	7/1997
4-Nitrotoluene	Chronic	1.0E-02	mg/kg/day	1	1.0E-02	mg/kg/day	Spleen	10000/1	HEAST	7/1997
4-Amino-2,6-Dinitrotoluene	Chronic	2.00E-04	mg/kg/day	1	2.0E-04	mg/kg/day	Liver	NA	NCEA	10//2004
HMX	Chronic	5.0E-02	mg/kg/day	1	5.0E-02	mg/kg/day	Liver, Blood	1000/1	IRIS	9/01/2005
RDX	Chronic	3.0E-03	mg/kg/day	1	3.0E-03	mg/kg/day	Prostate	100/1	IRIS	9/01/2005
Inorganics										
Aluminum	Chronic	1.0E+00	mg/kg/day	1	1.0E+00	mg/kg/day	CNS	100	NCEA	10/19/2004
Antimony	Chronic	4.0E-04	mg/kg/day	0.15	6.0E-05	mg/kg/day	Blood	1000/1	IRIS	9/01/2005
Arsenic	Chronic	3.0E-04	mg/kg/day	1	3.0E-04	mg/kg/day	Skin, CVS	3/1	IRIS	9/01/2005
Barium	Chronic	7.0E-02	mg/kg/day	0.07	4.9E-03	mg/kg/day	Kidney	3/1	IRIS	9/01/2005
Beryllium	Chronic	2.0E-03	mg/kg/day	0.007	1.4E-05	mg/kg/day	GS	300/1	IRIS	9/01/2005
Cadmium[3]	Chronic	5.0E-04	mg/kg/day	0.05	2.5E-05	mg/kg/day	Kidney	10/1	IRIS	9/01/2005
Chromium III	Chronic	1.5E+00	mg/kg/day	0.013	2.0E-02	mg/kg/day	NOEL	100/10	IRIS	9/01/2005
Chromium VI	Chronic	3.0E-03	mg/kg/day	0.025	7.5E-05	mg/kg/day	Fetotoxicity/GS/Bone	300/3	IRIS	9/01/2005
Cobalt	Chronic	2.0E-02	mg/kg/day	1	2.0E-02	mg/kg/day	NA	NA	EPA 9	10/2004
Copper	Chronic	4.0E-02	mg/kg/day	1	4.0E-02	mg/kg/day	GS	NA	HEAST	7/1997
Iron	Chronic	3.0E-01	mg/kg/day	1	3.0E-01	mg/kg/day	NA	1	NCEA	10//2004
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lithium	Chronic	2.0E-03	mg/kg/day	1	2.0E-03	mg/kg/day	NA	NA	NCEA	10/2004
Manganese (Soil)	Chronic	7.0E-02	mg/kg/day	0.04	2.8E-03	mg/kg/day	CNS	1/1	IRIS	9/01/2005
Manganese (Water)	Chronic	2.4E-02	mg/kg/day	0.04	9.6E-04	mg/kg/day	CNS	3/1	IRIS	9/01/2005
Mercury[4]	Chronic	3.0E-04	mg/kg/day	0.07	2.1E-05	mg/kg/day	CNS	1000/1	IRIS	9/01/2005
Nickel	Chronic	2.0E-02	mg/kg/day	0.04	8.0E-04	mg/kg/day	Body Weight	300/1	IRIS	9/01/2005
Selenium	Chronic	5.0E-03	mg/kg/day	1	5.0E-03	mg/kg/day	NOEL	3/1	IRIS	9/01/2005
Thallium	Chronic	7.0E-05	mg/kg/day	1	7.0E-05	mg/kg/day	Liver	NA	IRIS	9/1/2005
Vanadium	Chronic	1.0E-03	mg/kg/day	0.026	2.6E-05	mg/kg/day	Kidney	300	NCEA	10/19/2004
Zinc	Chronic	3.0E-01	mg/kg/day	1	3.0E-01	mg/kg/day	Blood	3/1	IRIS	9/01/2005
Nitrate	Chronic	1.6E+00	mg/kg/day	1	1.6E+00	mg/kg/day	Blood	1/1	IRIS	9/01/2005
Nitrite	Chronic	1.0E-01	mg/kg/day	1	1.0E-01	mg/kg/day	Blood	1/10	IRIS	9/01/2005

Notes:

1 - U.S. EPA, 2004a.

2 - Adjusted dermal RfD = Oral RfD x Oral absorption efficiency for dermal.

3 - Water value for cadmium is listed.

4 - Values are for mercuric chloride.

Definitions:

CNS = Central nervous system.

CVS = Cardiovascular system.

EPA 9 = U.S. EPA Region 9 PRG Table, October, 2004, updated December 25, 2004.

GS = Gastrointestinal system.

HEAST= Health Effects Assessment Summary Tables.

IRIS = Integrated Risk Information System.

NA = Not applicable.

NOEL = No observed effect level.

TABLE 7-25

CANCER TOXICITY DATA - ORAL/DERMAL
SWMU 12 MINE FILL A
NSWC CRANE, CRANE, INDIANA

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal[1]	Absorbed Cancer Slope Factor for Dermal[2]		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source(s)	Date
Semivolatile Organic Compounds								
Benzo(a)anthracene	7.3E-01	$(mg/kg/day)^{-1}$	1	7.3E-01	$(mg/kg/day)^{-1}$	B2	EPA[1]	7/1993
Benzo(a)pyrene	7.3E+00	$(mg/kg/day)^{-1}$	1	7.3E+00	$(mg/kg/day)^{-1}$	B2	IRIS	9/01/2005
Benzo(b)fluoranthene	7.3E-01	$(mg/kg/day)^{-1}$	1	7.3E-01	$(mg/kg/day)^{-1}$	B2	EPA[1]	7/1993
Dibenzo(a,h)anthracene	7.3E+00	$(mg/kg/day)^{-1}$	1	7.3E+00	$(mg/kg/day)^{-1}$	B2	EPA[1]	7/1993
Indeno(1,2,3-cd)pyrene	7.3E-01	$(mg/kg/day)^{-1}$	1	7.3E-01	$(mg/kg/day)^{-1}$	B2	EPA[1]	7/1993
Dioxins/Furans								
2,3,7,8-TCDD	1.5E+05	$(mg/kg/day)^{-1}$	1	1.5E+05	$(mg/kg/day)^{-1}$	B2	HEAST	7/1997
PCBs								
PCBs	2.0E+00	$(mg/kg/day)^{-1}$	1	2.0E+00	$(mg/kg/day)^{-1}$	B2	IRIS	9/01/2005
Energetics								
2,4,6-Trinitrotoluene	3.0E-02	$(mg/kg/day)^{-1}$	1	3.0E-02	$(mg/kg/day)^{-1}$	C	IRIS	9/01/2005
RDX	1.1E-01	$(mg/kg/day)^{-1}$	1	1.1E-01	$(mg/kg/day)^{-1}$	C	IRIS	9/01/2005
2-Nitrotoluene	2.3E-01	$(mg/kg/day)^{-1}$	1	2.3E-01	$(mg/kg/day)^{-1}$	NA	EPA 9	10/2004
4-Nitrotoluene	7.0E-02	$(mg/kg/day)^{-1}$	1	7.0E-02	$(mg/kg/day)^{-1}$	NA	EPA 9	10/2004
Metals								
Arsenic	1.5E+00	$(mg/kg/day)^{-1}$	1	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	9/01/2005

Notes:
1 - U.S. EPA, 2004a.
2 - Adjusted cancer slope factor for dermal =
Oral cancer slope factor / Oral absorption efficiency for dermal.

IRIS = Integrated Risk Information System.
HEAST= Health Effects Assessment Summary Tables.
EPA[1] = U.S. EPA, 1993b.

EPA 9 = U.S. EPA Region 9 PRG Table, October, 2004, updated December 28, 2004.

NA = Not available.

U.S. EPA Group:
A - Human carcinogen.
B1 - Probable human carcinogen - indicates that limited human data are available.
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans .
C - Possible human carcinogen.
D - Not classifiable as a human carcinogen.
E - Evidence of noncarcinogenicity.

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-5}$ and $\leq 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-6}$ and $\leq 1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Construction Worker	Surface Soil SWMU 12 Proper	Ingestion	4.E-07	- -	- -	- -	0.4	- -
		Dermal Contact	3.E-08	- -	- -	- -	0.005	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-07	- -	- -	- -	0.4	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	3.E-07	- -	- -	- -	0.4	- -
		Dermal Contact	3.E-08	- -	- -	- -	0.004	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-07	- -	- -	- -	0.4	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	4.E-07	- -	- -	- -	0.09	- -
		Dermal Contact	3.E-08	- -	- -	- -	0.006	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-07	- -	- -	- -	0.1	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	6.E-07	- -	- -	- -	0.1	- -
		Dermal Contact	5.E-08	- -	- -	- -	0.008	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-07	- -	- -	- -	0.1	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	4.E-07	- -	- -	- -	0.1	- -
		Dermal Contact	3.E-08	- -	- -	- -	0.007	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-07	- -	- -	- -	0.1	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	7.E-07	- -	- -	- -	0.2	- -
		Dermal Contact	6.E-08	- -	- -	- -	0.01	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-07	- -	- -	- -	0.2	- -
	Surface Soil Battery Site	Ingestion	5.E-06	- -	- -	Arsenic	19	Antimony
		Dermal Contact	5.E-07	- -	- -	- -	0.07	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-06	- -	- -	Arsenic	19	Antimony
	Subsurface Soil Battery Site	Ingestion	2.E-07	- -	- -	- -	0.5	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-07	- -	- -	- -	0.5	- -

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-5}$ and $\leq 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-6}$ and $\leq 1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Construction Worker (continued)	Surface Water Gully	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Sediment Gully	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Surface Water East Tributary	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Sediment East Tributary	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Sediment Turkey Creek	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Groundwater Pennsylvanian Upper Zone	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	8.E-08	- -	- -	- -	4	Manganese
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-08	- -	- -	- -	4	Manganese
	Groundwater Pennsylvanian Middle Zone	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	2.E-09	- -	- -	- -	0.1	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-09	- -	- -	- -	0.1	- -
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	8.E-09	- -	- -	- -	0.1	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-09	- -	- -	- -	0.1	- -
Total MFA Proper Surface Soil			4.E-07				0.4	
Total MFA Proper Subsurface Soil			3.E-07				0.4	
Total Building 152 Surface/subsurface Soil			4.E-07				0.1	
Total Building 153/154 Surface/subsurface Soil			6.E-07				0.1	
Total Building 157 Surface/subsurface Soil			4.E-07				0.1	
Total Building 158/159 Surface/subsurface Soil			8.E-07				0.2	
Total Surface Water and Sediment			NA				NA	
Total PUZ Groundwater			8.E-08				4	
Total PMZ Groundwater			2.E-09				0.1	
Total PlzMgd Groundwater			8.E-09				0.1	
Total Battery Site Surface Soil			6.E-06				19	
Total Battery Site Suburface Soil			2.E-07				0.5	

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Maintenance Worker	Surface Soil SWMU 12 Proper	Ingestion	5.E-07	- -	- -	- -	0.02	- -
		Dermal Contact	9.E-08	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	5.E-07	- -	- -	- -	0.02	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	4.E-07	- -	- -	- -	0.02	- -
		Dermal Contact	7.E-08	- -	- -	- -	0.0005	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	5.E-07	- -	- -	- -	0.02	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	5.E-07	- -	- -	- -	0.005	- -
		Dermal Contact	9.E-08	- -	- -	- -	0.0006	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-07	- -	- -	- -	0.005	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	7.E-07	- -	- -	- -	0.006	- -
		Dermal Contact	1.E-07	- -	- -	- -	0.0009	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-07	- -	- -	- -	0.007	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	5.E-07	- -	- -	- -	0.005	- -
		Dermal Contact	9.E-08	- -	- -	- -	0.0007	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-07	- -	- -	- -	0.006	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	9.E-07	- -	- -	- -	0.008	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-06	- -	- -	- -	0.009	- -
	Surface Soil Battery Site	Ingestion	6.E-06	- -	- -	Arsenic	0.9	- -
		Dermal Contact	1.E-06	- -	- -	- -	0.008	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	7.E-06	- -	- -	Arsenic	0.9	- -
	Subsurface Soil Battery Site	Ingestion	2.E-07	- -	- -	- -	0.02	- -
		Dermal Contact	4.E-08	- -	- -	- -	0.0002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-07	- -	- -	- -	0.02	- -

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Maintenance Worker (continued)	Surface Water Gully	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	3.E-08	- -	- -	- -	0.04	- -
		Total	3.E-08	- -	- -	- -	0.04	- -
	Sediment Gully	Ingestion	1.E-06	- -	- -	- -	0.05	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.002	- -
		Total	1.E-06	- -	- -	- -	0.05	- -
	Surface Water East Tributary	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	2.E-09	- -	- -	- -	0.00002	- -
		Total	2.E-09	- -	- -	- -	0.00002	- -
	Sediment East Tributary	Ingestion	5.E-07	- -	- -	- -	0.03	- -
		Dermal Contact	1.E-07	- -	- -	- -	0.001	- -
		Total	7.E-07	- -	- -	- -	0.04	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	0.002	- -
		Total	NA	- -	- -	- -	0.002	- -
	Sediment Turkey Creek	Ingestion	1.E-06	- -	- -	- -	0.07	- -
		Dermal Contact	3.E-07	- -	- -	- -	0.002	- -
		Total	2.E-06	- -	- -	Arsenic	0.07	- -
	Groundwater Pennsylvanian Upper Zone	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Groundwater Pennsylvanian Middle Zone	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Groundwater Pennsylvanian Lower and Mississipplan Glen Dean Zone	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Total MFA Proper Surface Soil		5.E-07				0.02	
	Total MFA Proper Subsurface Soil		5.E-07				0.02	
	Total Building 152 Surface/subsurface Soil		6.E-07				0.005	
	Total Building 153/154 Surface/subsurface Soil		8.E-07				0.007	
	Total Building 157 Surface/subsurface Soil		6.E-07				0.006	
	Total Building 158/159 Surface/subsurface Soil		1.E-06				0.009	
	Total Surface Water and Sediment		4.E-06				0.2	
	Total PUZ Groundwater		NA				NA	
	Total PMZ Groundwater		NA				NA	
	Total PlzMgd Groundwater		NA				NA	
	Total Battery Site Surface Soil		7.E-06				0.9	
	Total Battery Site Suburface Soil		2.E-07				0.02	

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Occupational Worker	Surface Soil SWMU 12 Proper	Ingestion	5.E-06	- -	- -	Arsenic	0.2	- -
		Dermal Contact	9.E-07	- -	- -	- -	0.006	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-06	- -	- -	Arsenic	0.2	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	4.E-06	- -	- -	Arsenic	0.2	- -
		Dermal Contact	8.E-07	- -	- -	- -	0.005	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	5.E-06	- -	- -	Arsenic	0.2	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	5.E-06	- -	- -	Arsenic	0.05	- -
		Dermal Contact	9.E-07	- -	- -	- -	0.007	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-06	- -	- -	Arsenic	0.05	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	7.E-06	- -	- -	Arsenic	0.06	- -
		Dermal Contact	1.E-06	- -	- -	- -	0.009	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-06	- -	- -	Arsenic	0.1	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	5.E-06	- -	- -	Arsenic	0.05	- -
		Dermal Contact	9.E-07	- -	- -	- -	0.008	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-06	- -	- -	Arsenic	0.1	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	9.E-06	- -	- -	Arsenic	0.1	- -
		Dermal Contact	2.E-06	- -	- -	Arsenic	0.01	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-05	- -	- -	Arsenic	0.1	- -
	Surface Soil Battery Site	Ingestion	6.E-05	- -	Arsenic	- -	10	Antimony
		Dermal Contact	1.E-05	- -	- -	Arsenic	0.08	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-05	- -	Arsenic	- -	10	Antimony
	Subsurface Soil Battery Site	Ingestion	2.E-06	- -	- -	Arsenic	0.2	- -
		Dermal Contact	4.E-07	- -	- -	- -	0.002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-06	- -	- -	Arsenic	0.2	- -

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Occupational Worker (continued)	Surface Water Gully	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Sediment Gully	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Surface Water East Tributary	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Sediment East Tributary	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Sediment Turkey Creek	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Groundwater Pennsylvanian Upper Zone	Ingestion	6.E-04	RDX	Arsenic	2,4,6-Trinitrotoluene	51	RDX, Cobalt, Iron, Manganese, Nickel
		Dermal Contact	1.E-06	- -	- -	- -	0.8	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-04	- -	- -	- -	52	RDX, Cobalt, Iron, Manganese, Nickel
	Groundwater Pennsylvanian Middle Zone	Ingestion	1.E-05	- -	- -	Arsenic	2	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.02	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-05	- -	- -	Arsenic	2	- -
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	5.E-05	- -	Arsenic	- -	2	- -
		Dermal Contact	5.E-08	- -	- -	- -	0.02	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	5.E-05	- -	Arsenic	RDX	2	- -
		Total MFA Proper Surface Soil	6.E-06				0.2	
		Total MFA Proper Subsurface Soil	5.E-06				0.2	
		Total Building 152 Surface/subsurface Soil	6.E-06				0.05	
		Total Building 153/154 Surface/subsurface Soil	8.E-06				0.07	
		Total Building 157 Surface/subsurface Soil	6.E-06				0.06	
		Total Building 158/159 Surface/subsurface Soil	1.E-05				0.09	
		Total Surface Water and Sediment	NA				NA	
		Total PUZ Groundwater	6.E-04				52	
		Total PMZ Groundwater	1.E-05				2	
		Total PlzMgd Groundwater	5.E-05				2	
		Total Battery Site Surface Soil	8.E-05				10	
		Total Battery Site Suburface Soil	2.E-06				0.2	

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-5}$ and $\leq 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-6}$ and $\leq 1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Trespasser	Surface Soil SWMU 12 Proper	Ingestion	4.E-07	- -	- -	- -	0.04	- -
		Dermal Contact	7.E-08	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-07	- -	- -	- -	0.04	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	3.E-07	- -	- -	- -	0.04	- -
		Dermal Contact	6.E-08	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-07	- -	- -	- -	0.04	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	4.E-07	- -	- -	- -	0.008	- -
		Dermal Contact	7.E-08	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-07	- -	- -	- -	0.009	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	5.E-07	- -	- -	- -	0.01	- -
		Dermal Contact	1.E-07	- -	- -	- -	0.002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-07	- -	- -	- -	0.01	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	4.E-07	- -	- -	- -	0.009	- -
		Dermal Contact	7.E-08	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-07	- -	- -	- -	0.01	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	7.E-07	- -	- -	- -	0.01	- -
		Dermal Contact	1.E-07	- -	- -	- -	0.002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-07	- -	- -	- -	0.02	- -
	Surface Soil Battery Site	Ingestion	5.E-06	- -	- -	Arsenic	2	- -
		Dermal Contact	1.E-06	- -	- -	- -	0.01	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-06	- -	- -	Arsenic	2	- -
	Subsurface Soil Battery Site	Ingestion	1.E-07	- -	- -	- -	0.04	- -
		Dermal Contact	3.E-08	- -	- -	- -	0.0004	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-07	- -	- -	- -	0.04	- -

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-5}$ and $\leq 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-6}$ and $\leq 1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Trespasser (continued)	Surface Water Gully	Ingestion	6.E-07	- -	- -	- -	0.1	- -
		Dermal Contact	4.E-08	- -	- -	- -	0.1	- -
		Total	6.E-07	- -	- -	- -	0.2	- -
	Sediment Gully	Ingestion	9.E-07	- -	- -	- -	0.09	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.003	- -
		Total	1.E-06	- -	- -	- -	0.09	- -
	Surface Water East Tributary	Ingestion	3.E-08	- -	- -	- -	0.0005	- -
		Dermal Contact	2.E-09	- -	- -	- -	0.00003	- -
		Total	3.E-08	- -	- -	- -	0.0005	- -
	Sediment East Tributary	Ingestion	4.E-07	- -	- -	- -	0.06	- -
		Dermal Contact	8.E-08	- -	- -	- -	0.001	- -
		Total	5.E-07	- -	- -	- -	0.06	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	0.0018	- -
		Dermal Contact	NA	- -	- -	- -	0.003	- -
		Total	NA	- -	- -	- -	0.005	- -
	Sediment Turkey Creek	Ingestion	1.E-06	- -	- -	- -	0.1	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.003	- -
		Total	1.E-06	- -	- -	- -	0.1	- -
	Groundwater Pennsylvanian Upper Zone	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Groundwater Pennsylvanian Middle Zone	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Total MFA Proper Surface Soil		4.E-07				0.04	
	Total MFA Proper Subsurface Soil		4.E-07				0.04	
	Total Building 152 Surface/subsurface Soil		4.E-07				0.009	
	Total Building 153/154 Surface/subsurface Soil		6.E-07				0.01	
	Total Building 157 Surface/subsurfsce Soil		4.E-07				0.01	
	Total Building 158/159 Surface/subsurface Soil		8.E-07				0.02	
	Total Surface Water and Sediment		4.E-06				0.5	
	Total PUZ Groundwater		NA				NA	
	Total PMZ Groundwater		NA				NA	
	Total PlzMgd Groundwater		NA				NA	
	Total Battery Site Surface Soil		6.E-06				2	
	Total Battery Site Suburface Soil		2.E-07				0.04	

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-5}$ and $\leq 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-6}$ and $\leq 1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Child Recreational User	Surface Soil SWMU 12 Proper	Ingestion	1.E-06	- -	- -	- -	0.2	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.006	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-06	- -	- -	- -	0.2	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	9.E-07	- -	- -	- -	0.2	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.005	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-06	- -	- -	- -	0.2	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	1.E-06	- -	- -	- -	0.05	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.006	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-06	- -	- -	- -	0.05	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	2.E-06	- -	- -	- -	0.06	- -
		Dermal Contact	3.E-07	- -	- -	- -	0.009	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-06	- -	- -	Arsenic	0.07	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	1.E-06	- -	- -	- -	0.05	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.007	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-06	- -	- -	- -	0.06	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	2.E-06	- -	- -	Arsenic	0.08	- -
		Dermal Contact	4.E-07	- -	- -	- -	0.01	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-06	- -	- -	Arsenic	0.09	- -
	Surface Soil Battery Site	Ingestion	2.E-05	- -	Arsenic	- -	9	Antimony
		Dermal Contact	3.E-06	- -	- -	Arsenic	0.08	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-05	- -	Arsenic	- -	9	Antimony
	Subsurface Soil Battery Site	Ingestion	5.E-07	- -	- -	- -	0.2	- -
		Dermal Contact	9.E-08	- -	- -	- -	0.002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-07	- -	- -	- -	0.2	- -

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Child Recreational User (continued)	Surface Water Gully	Ingestion	2.E-06	- -	- -	- -	0.7	- -
		Dermal Contact	1.E-07	- -	- -	- -	0.8	- -
		Total	2.E-06	- -	- -	- -	1	- -
	Sediment Gully	Ingestion	3.E-06	- -	- -	Arsenic	0.5	- -
		Dermal Contact	5.E-07	- -	- -	- -	0.02	- -
		Total	3.E-06	- -	- -	Arsenic	0.5	- -
	Surface Water East Tributary	Ingestion	9.E-08	- -	- -	- -	0.003	- -
		Dermal Contact	6.E-09	- -	- -	- -	0.0002	- -
		Total	1.E-07	- -	- -	- -	0.003	- -
	Sediment East Tributary	Ingestion	1.E-06	- -	- -	- -	0.3	- -
		Dermal Contact	3.E-07	- -	- -	- -	0.007	- -
		Total	2.E-06	- -	- -	Arsenic	0.4	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	0.01	- -
		Dermal Contact	NA	- -	- -	- -	0.02	- -
		Total	NA	- -	- -	- -	0.03	- -
	Sediment Turkey Creek	Ingestion	3.E-06	- -	- -	Arsenic	0.7	- -
		Dermal Contact	7.E-07	- -	- -	- -	0.02	- -
		Total	4.E-06	- -	- -	Arsenic	0.7	- -
	Groundwater Pennsylvanian Upper Zone	Ingestion	1.E-04	- -	RDX, Arsenic	- -	50	RDX, Cobalt, Iron, Manganese, Nickel
		Dermal Contact	5.E-07	- -	- -	- -	2	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-04	- -	RDX, Arsenic	- -	51	RDX, Cobalt, Iron, Manganese, Nickel
	Groundwater Pennsylvanian Middle Zone	Ingestion	3.E-06	- -	- -	Arsenic	2	- -
		Dermal Contact	6.E-09	- -	- -	- -	0.04	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-06	- -	- -	Arsenic	2	- -
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	1.E-05	- -	- -	Arsenic	2	- -
		Dermal Contact	2.E-08	- -	- -	- -	0.04	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-05	- -	- -	Arsenic	2	- -
	Total MFA Proper Surface Soil		1.E-06				0.2	
	Total MFA Proper Subsurface Soil		1.E-06				0.2	
	Total Building 152 Surface/subsurface Soil		1.E-06				0.05	
	Total Building 153/154 Surface/subsurface Soil		2.E-06				0.07	
	Total Building 157 Surface/subsurface Soil		1.E-06				0.06	
	Total Building 158/159 Surface/subsurface Soil		3.E-06				0.09	
	Total Surface Water and Sediment		1.E-05				3	
	Total PUZ Groundwater		1.E-04				51	
	Total PMZ Groundwater		3.E-06				2	
	Total PlzMgd Groundwater		1.E-05				2	
	Total Battery Site Surface Soil		2.E-05				9	
	Total Battery Site Subsurface Soil		6.E-07				0.2	

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Adult Recreational User	Surface Soil SWMU 12 Proper	Ingestion	5.E-07	- -	- -	- -	0.02	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	7.E-07	- -	- -	- -	0.02	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	4.E-07	- -	- -	- -	0.02	- -
		Dermal Contact	1.E-07	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	5.E-07	- -	- -	- -	0.02	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	5.E-07	- -	- -	- -	0.005	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	7.E-07	- -	- -	- -	0.006	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	7.E-07	- -	- -	- -	0.007	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	9.E-07	- -	- -	- -	0.008	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	5.E-07	- -	- -	- -	0.006	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	7.E-07	- -	- -	- -	0.007	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	9.E-07	- -	- -	- -	0.008	- -
		Dermal Contact	3.E-07	- -	- -	- -	0.002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-06	- -	- -	- -	0.01	- -
	Surface Soil Battery Site	Ingestion	6.E-06	- -	- -	Arsenic	1	- -
		Dermal Contact	2.E-06	- -	- -	Arsenic	0.02	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	9.E-06	- -	- -	Arsenic	1	- -
	Subsurface Soil Battery Site	Ingestion	2.E-07	- -	- -	- -	0.03	- -
		Dermal Contact	8.E-08	- -	- -	- -	0.0005	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-07	- -	- -	- -	0.03	- -

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Adult Recreational User (continued)	Surface Water Gully	Ingestion	3.E-07	- -	- -	- -	0.03	- -
		Dermal Contact	3.E-07	- -	- -	- -	0.4	- -
		Total	6.E-07	- -	- -	- -	0.5	- -
	Sediment Gully	Ingestion	1.E-06	- -	- -	- -	0.05	- -
		Dermal Contact	5.E-07	- -	- -	- -	0.003	- -
		Total	2.E-06	- -	- -	Arsenic	0.06	- -
	Surface Water East Tributary	Ingestion	2.E-08	- -	- -	- -	0.0001	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.00009	- -
		Total	3.E-08	- -	- -	- -	0.0002	- -
	Sediment East Tributary	Ingestion	6.E-07	- -	- -	- -	0.04	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.001	- -
		Total	8.E-07	- -	- -	- -	0.04	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	0.0004	- -
		Dermal Contact	NA	- -	- -	- -	0.01	- -
		Total	NA	- -	- -	- -	0.01	- -
	Sediment Turkey Creek	Ingestion	1.E-06	- -	- -	- -	0.07	- -
		Dermal Contact	6.E-07	- -	- -	- -	0.004	- -
		Total	2.E-06	- -	- -	Arsenic	0.08	- -
	Groundwater Pennsylvanian Upper Zone	Ingestion	1.E-04	- -	RDX, Arsenic	- -	11	Manganese
		Dermal Contact	1.E-06	- -	- -	- -	0.9	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-04	- -	RDX, Arsenic	- -	12	Manganese, Aluminum
	Groundwater Pennsylvanian Middle Zone	Ingestion	3.E-06	- -	- -	Arsenic	0.3	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.02	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-06	- -	- -	Arsenic	0.4	- -
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	1.E-05	- -	- -	Arsenic	0.3	- -
		Dermal Contact	5.E-08	- -	- -	- -	0.02	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-05	- -	- -	Arsenic	0.4	- -
	Total MFA Proper Surface Soil		7.E-07				0.02	
	Total MFA Proper Subsurface Soil		5.E-07				0.02	
	Total Building 152 Surface/subsurface Soil		7.E-07				0.006	
	Total Building 153/154 Surface/subsurface Soil		9.E-07				0.008	
	Total Building 157 Surface/subsurface Soil		7.E-07				0.007	
	Total Building 158/159 Surface/subsurface Soil		1.E-06				0.01	
	Total Surface Water and Sediment		5.E-06				0.6	
	Total PUZ Groundwater		1.E-04				12	
	Total PMZ Groundwater		3.E-06				0.36	
	Total PlzMgd Groundwater		1.E-05				0.37	
	Total Battery Site Surface Soil		9.E-06				1	
	Total Battery Site Suburface Soil		3.E-07				0.03	

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Total Recreational Risks	Surface Soil SWMU 12 Proper	Ingestion	2.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	4.E-07	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-06	- -	- -	Arsenic	NA	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	1.E-06	- -	- -	- -	NA	- -
		Dermal Contact	3.E-07	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-06	- -	- -	Arsenic	NA	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	2.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	4.E-07	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-06	- -	- -	Arsenic	NA	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	2.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	6.E-07	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-06	- -	- -	Arsenic	NA	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	2.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	4.E-07	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-06	- -	- -	Arsenic	NA	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	3.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	7.E-07	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-06	- -	- -	Arsenic	NA	- -
	Surface Soil Battery Site	Ingestion	2.E-05	- -	Arsenic	- -	NA	- -
		Dermal Contact	6.E-06	- -	- -	Arsenic	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-05	- -	Arsenic	- -	NA	- -
	Subsurface Soil Battery Site	Ingestion	7.E-07	- -	- -	- -	NA	- -
		Dermal Contact	2.E-07	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-07	- -	- -	- -	NA	- -

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Total Recreational Risks (continued)	Surface Water Gully	Ingestion	2.E-06	- -	- -	- -	NA	- -
		Dermal Contact	4.E-07	- -	- -	- -	NA	- -
		Total	3.E-06	- -	- -	- -	NA	- -
	Sediment Gully	Ingestion	4.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	1.E-06	- -	- -	- -	NA	- -
		Total	5.E-06	- -	- -	Arsenic	NA	- -
	Surface Water East Tributary	Ingestion	1.E-07	- -	- -	- -	NA	- -
		Dermal Contact	2.E-08	- -	- -	- -	NA	- -
		Total	1.E-07	- -	- -	- -	NA	- -
	Sediment East Tributary	Ingestion	2.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	5.E-07	- -	- -	- -	NA	- -
		Total	2.E-06	- -	- -	Arsenic	NA	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Sediment Turkey Creek	Ingestion	5.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	1.E-06	- -	- -	- -	NA	- -
		Total	6.E-06	- -	- -	Arsenic	NA	- -
	Groundwater Pennsylvanian Upper Zone	Ingestion	2.E-04	RDX	Arsenic	- -	NA	- -
		Dermal Contact	2.E-06	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-04	RDX	Arsenic	- -	NA	- -
	Groundwater Pennsylvanian Middle Zone	Ingestion	6.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	2.E-08	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-06	- -	- -	Arsenic	NA	- -
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	2.E-05	- -	Arsenic	- -	NA	- -
		Dermal Contact	7.E-08	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-05	- -	Arsenic	- -	NA	- -
Total MFA Proper Surface Soil			2.E-06				NA	
Total MFA Proper Subsurface Soil			2.E-06				NA	
Total Building 152 Surface/subsurface Soil			2.E-06				NA	
Total Building 153/154 Surface/subsurface Soil			3.E-06				NA	
Total Building 157 Surface/subsurface Soil			2.E-06				NA	
Total Building 158/159 Surface/subsurface Soil			4.E-06				NA	
Total Surface Water and Sediment			2.E-05				NA	
Total PUZ Groundwater			2.E-04				NA	
Total PMZ Groundwater			6.E-06				NA	
Total PlzMgd Groundwater			2.E-05				NA	
Total Battery Site Surface Soil			3.E-05				NA	
Total Battery Site Suburface Soil			8.E-07				NA	

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Future Child Resident	Surface Soil SWMU 12 Proper	Ingestion	1.E-05	- -	- -	Arsenic	3	- -
		Dermal Contact	1.E-06	- -	- -	Arsenic	0.03	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-05	- -	Arsenic	- -	3	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	1.E-05	- -	- -	Arsenic	3	- -
		Dermal Contact	1.E-06	- -	- -	- -	0.03	- -
		Inhalation	NA	- -	- -	Arsenic	NA	- -
		Total	1.E-05	- -	- -	Arsenic	3	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	2.E-05	- -	- -	Arsenic	0.6	- -
		Dermal Contact	1.E-06	- -	- -	- -	0.04	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-05	- -	Arsenic	- -	0.7	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	2.E-05	- -	Arsenic	RDX	0.8	- -
		Dermal Contact	2.E-06	- -	- -	- -	0.05	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-05	- -	Arsenic	RDX	0.9	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	2.E-05	- -	- -	Arsenic	0.7	- -
		Dermal Contact	1.E-06	- -	- -	- -	0.04	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-05	- -	Arsenic	- -	0.8	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	3.E-05	- -	Arsenic	RDX	1	- -
		Dermal Contact	2.E-06	- -	- -	Arsenic	0.07	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-05	- -	Arsenic	RDX	1	- -
	Surface Soil Battery Site	Ingestion	2.E-04	Arsenic	- -	- -	124	Antimony, Arsenic, Iron
		Dermal Contact	2.E-05	- -	Arsenic	- -	0.5	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-04	Arsenic	- -	- -	125	Antimony, Arsenic, Iron
	Subsurface Soil Battery Site	Ingestion	6.E-06	- -	- -	Arsenic	3	Iron
		Dermal Contact	5.E-07	- -	- -	- -	0.01	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	7.E-06	- -	- -	Arsenic	3	Iron

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Future Child Resident (continued)	Surface Water Gully	Ingestion	2.E-06	- -	- -	- -	0.7	- -
		Dermal Contact	1.E-07	- -	- -	- -	0.8	- -
		Total	2.E-06	- -	- -	- -	1	- -
	Sediment Gully	Ingestion	3.E-06	- -	- -	Arsenic	0.5	- -
		Dermal Contact	5.E-07	- -	- -	- -	0.01	- -
		Total	3.E-06	- -	- -	Arsenic	0.5	- -
	Surface Water East Tributary	Ingestion	9.E-08	- -	- -	- -	0.003	- -
		Dermal Contact	6.E-09	- -	- -	- -	0.0002	- -
		Total	1.E-07	- -	- -	- -	0.003	- -
	Sediment East Tributary	Ingestion	1.E-06	- -	- -	- -	0.3	- -
		Dermal Contact	2.E-07	- -	- -	- -	0.006	- -
		Total	2.E-06	- -	- -	Arsenic	0.4	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	0.01	- -
		Dermal Contact	NA	- -	- -	- -	0.02	- -
		Total	NA	- -	- -	- -	0.03	- -
	Sediment Turkey Creek	Ingestion	3.E-06	- -	- -	Arsenic	0.7	- -
		Dermal Contact	6.E-07	- -	- -	- -	0.01	- -
		Total	4.E-06	- -	- -	Arsenic	0.7	- -
	Groundwater	Ingestion	1.E-03	RDX, Arsenic	- -	2,4,6-Trinitrotoluene	501	2,4,6-Trinitrotoluene, 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, RDX, Aluminum, Arsenic, Beryllium, Cadmium, Cobalt, Iron, Manganese, Nickel, Thallium, Zinc, Nitrate/Nitrite-N
	Pennsylvanian Upper Zone	Dermal Contact	3.E-06	- -	- -	RDX	10	Manganese
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-03	RDX, Arsenic	- -	2,4,6-Trinitrotoluene	511	2,4,6-Trinitrotoluene, 2-Amino-4,6-dinitrotoluene, 4-Amino-2,6-dinitrotoluene, RDX, Aluminum, Arsenic, Beryllium, Cadmium, Cobalt, Iron, Manganese, Nickel, Thallium, Zinc, Nitrate/Nitrite-N

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-5}$ and $\leq 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-6}$ and $\leq 1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Future Child Resident (continued)	Groundwater Pennsylvanian Middle Zone	Ingestion	3.E-05	- -	Arsenic	- -	16	Iron, Manganese
		Dermal Contact	4.E-08	- -	- -	- -	0.3	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-05	- -	Arsenic	- -	16	Iron, Manganese
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	1.E-04	- -	Arsenic	RDX	16	Arsenic, Iron, Manganese
		Dermal Contact	1.E-07	- -	- -	- -	0.3	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-04	- -	Arsenic	RDX	16	Arsenic, Iron, Manganese
Total MFA Proper Surface Soil			2.E-05				3	
Total MFA Proper Subsurface Soil			1.E-05				3	
Total Building 152 Surface/subsurface Soil			2.E-05				0.7	
Total Building 153/154 Surface/subsurface Soil			2.E-05				0.9	
Total Building 157 Surface/subsurface Soil			2.E-05				0.8	
Total Building 158/159 Surface/subsurface Soil			3.E-05				1	
Total Surface Water and Sediment			1.E-05				3	
Total PUZ Groundwater			1.E-03				511	
Total PMZ Groundwater			3.E-05				16	
Total PlzMgd Groundwater			1.E-04				16	
Total Battery Site Surface Soil			2.E-04				125	
Total Battery Site Suburface Soil			7.E-06				3	

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-5}$ and $\leq 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-6}$ and $\leq 1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Future Adult Resident	Surface Soil SWMU 12 Proper	Ingestion	6.E-06	- -	- -	Arsenic	0.3	- -
		Dermal Contact	8.E-07	- -	- -	- -	0.005	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	7.E-06	- -	- -	Arsenic	0.3	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	5.E-06	- -	- -	Arsenic	0.3	- -
		Dermal Contact	6.E-07	- -	- -	- -	0.004	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-06	- -	- -	Arsenic	0.3	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	6.E-06	- -	- -	Arsenic	0.07	- -
		Dermal Contact	8.E-07	- -	- -	- -	0.006	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	7.E-06	- -	- -	Arsenic	0.07	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	9.E-06	- -	- -	Arsenic	0.09	- -
		Dermal Contact	1.E-06	- -	- -	- -	0.008	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-05	- -	- -	Arsenic	0.1	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	6.E-06	- -	- -	Arsenic	0.08	- -
		Dermal Contact	8.E-07	- -	- -	- -	0.006	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	7.E-06	- -	- -	Arsenic	0.1	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	1.E-05	- -	- -	Arsenic	0.1	- -
		Dermal Contact	1.E-06	- -	- -	- -	0.01	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-05	- -	- -	Arsenic	0.1	- -
	Surface Soil Battery Site	Ingestion	9.E-05	- -	Arsenic	Arsenic	13	Antimony
		Dermal Contact	1.E-05	- -	- -	- -	0.07	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-04	- -	Arsenic	Arsenic	13	Antimony
	Subsurface Soil Battery Site	Ingestion	3.E-06	- -	- -	Arsenic	0.3	- -
		Dermal Contact	3.E-07	- -	- -	- -	0.002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-06	- -	- -	Arsenic	0.3	- -

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Future Adult Resident (continued)	Surface Water Gully	Ingestion	3.E-07	- -	- -	- -	0.03	- -
		Dermal Contact	3.E-07	- -	- -	- -	0.45	- -
		Total	6.E-07	- -	- -	- -	0.5	- -
	Sediment Gully	Ingestion	1.E-06	- -	- -	- -	0.05	- -
		Dermal Contact	3.E-07	- -	- -	- -	0.002	- -
		Total	1.E-06	- -	- -	- -	0.06	- -
	Surface Water East Tributary	Ingestion	2.E-08	- -	- -	- -	0.0001	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.0001	- -
		Total	3.E-08	- -	- -	- -	0.0002	- -
	Sediment East Tributary	Ingestion	6.E-07	- -	- -	- -	0.04	- -
		Dermal Contact	1.E-07	- -	- -	- -	0.001	- -
		Total	7.E-07	- -	- -	- -	0.04	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	0.0004	- -
		Dermal Contact	NA	- -	- -	- -	0.01	- -
		Total	NA	- -	- -	- -	0.01	- -
	Sediment Turkey Creek	Ingestion	1.E-06	- -	- -	- -	0.07	- -
		Dermal Contact	3.E-07	- -	- -	- -	0.002	- -
		Total	2.E-06	- -	- -	Arsenic	0.07	- -
	Groundwater Pennsylvanian Upper Zone	Ingestion	1.E-03	RDX, Arsenic	- -	2,4,6-Trinitrotoluene	143	4-Amino-2,6-dinitrotoluene, RDX, Aluminum, Arsenic, Cadmium, Cobalt, Iron, Manganese, Nickel
		Dermal Contact	7.E-06	- -	- -	RDX	5.9	Manganese
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-03	RDX, Arsenic	- -	2,4,6-Trinitrotoluene	149	4-Amino-2,6-dinitrotoluene, RDX, Aluminum, Arsenic, Cadmium, Cobalt, Iron, Manganese, Nickel
	Groundwater Pennsylvanian Middle Zone	Ingestion	4.E-05	- -	Arsenic	- -	5	Manganese
		Dermal Contact	9.E-08	- -	- -	- -	0.2	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-05	- -	Arsenic	- -	5	Manganese
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	1.E-04	- -	Arsenic	RDX	5	Manganese
		Dermal Contact	3.E-07	- -	- -	- -	0.2	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-04	- -	Arsenic	RDX	5	Manganese
	Total MFA Proper Surface Soil		7.E-06				0.3	
	Total MFA Proper Subsurface Soil		6.E-06				0.3	
	Total Building 152 Surface/subsurface Soil		7.E-06				0.07	
	Total Building 153/154 Surface/subsurface Soil		1.E-05				0.10	
	Total Building 157 Surface/subsurface Soil		7.E-06				0.08	
	Total Building 158/159 Surface/subsurface Soil		1.E-05				0.1	
	Total Surface Water and Sediment		5.E-06				0.6	
	Total PUZ Groundwater		1.E-03				149	
	Total PMZ Groundwater		4.E-05				5	
	Total PlzMgd Groundwater		1.E-04				5	
	Total Battery Site Surface Soil		1.E-04				13	
	Total Battery Site Suburface Soil		3.E-06				0.3	

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-5}$ and $\leq 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-6}$ and $\leq 1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Total Residential Risks	Surface Soil SWMU 12 Proper	Ingestion	2.E-05	- -	Arsenic	- -	NA	- -
		Dermal Contact	2.E-06	- -	- -	Arsenic	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-05	- -	Arsenic	- -	NA	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	2.E-05	- -	Arsenic	- -	NA	- -
		Dermal Contact	2.E-06	- -	- -	Arsenic	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-05	- -	Arsenic	- -	NA	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	2.E-05	- -	Arsenic	- -	NA	- -
		Dermal Contact	2.E-06	- -	- -	Arsenic	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-05	- -	Arsenic	- -	NA	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	3.E-05	- -	Arsenic	RDX	NA	- -
		Dermal Contact	3.E-06	- -	- -	Arsenic	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-05	- -	Arsenic	RDX	NA	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	2.E-05	- -	Arsenic	- -	NA	- -
		Dermal Contact	2.E-06	- -	- -	Arsenic	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-05	- -	Arsenic	- -	NA	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	4.E-05	- -	Arsenic	RDX	NA	- -
		Dermal Contact	4.E-06	- -	- -	Arsenic	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-05	- -	Arsenic	RDX	NA	- -
	Surface Soil Battery Site	Ingestion	3.E-04	Arsenic	- -	- -	NA	- -
		Dermal Contact	3.E-05	- -	Arsenic	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-04	Arsenic	- -	- -	NA	- -
	Subsurface Soil Battery Site	Ingestion	9.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	8.E-07	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-05	- -	- -	Arsenic	NA	- -

TABLE 7-26

SUMMARY OF CANCER RISKS AND HAZARD INDICES - REASONABLE MAXIMUM EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Total Residential Risks (continued)	Surface Water Gully	Ingestion	2.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	4.E-07	- -	- -	- -	NA	- -
		Total	3.E-06	- -	- -	Arsenic	NA	- -
	Sediment Gully	Ingestion	4.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	7.E-07	- -	- -	- -	NA	- -
		Total	5.E-06	- -	- -	Arsenic	NA	- -
	Surface Water East Tributary	Ingestion	1.E-07	- -	- -	- -	NA	- -
		Dermal Contact	2.E-08	- -	- -	- -	NA	- -
		Total	1.E-07	- -	- -	- -	NA	- -
	Sediment East Tributary	Ingestion	2.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	4.E-07	- -	- -	- -	NA	- -
		Total	2.E-06	- -	- -	Arsenic	NA	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Sediment Turkey Creek	Ingestion	5.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	9.E-07	- -	- -	- -	NA	- -
		Total	6.E-06	- -	- -	Arsenic	NA	- -
	Groundwater Pennsylvanian Upper Zone	Ingestion	3.E-03	RDX, Arsenic	- -	2,4,6-Trinitrotoluene	NA	- -
		Dermal Contact	1.E-05	- -	- -	RDX	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-03	RDX, Arsenic	- -	2,4,6-Trinitrotoluene	NA	- -
	Groundwater Pennsylvanian Middle Zone	Ingestion	7.E-05	- -	Arsenic	- -	NA	- -
		Dermal Contact	1.E-07	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	7.E-05	- -	Arsenic	- -	NA	- -
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	3.E-04	Arsenic	- -	2,4,6-Trinitrotoluene, RDX	NA	- -
		Dermal Contact	5.E-07	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-04	Arsenic	- -	2,4,6-Trinitrotoluene, RDX	NA	- -
Total MFA Proper Surface Soil			2.E-05				NA	
Total MFA Proper Subsurface Soil			2.E-05				NA	
Total Building 152 Surface/subsurface Soil			2.E-05				NA	
Total Building 153/154 Surface/subsurface Soil			3.E-05				NA	
Total Building 157 Surface/subsurface Soil			2.E-05				NA	
Total Building 158/159 Surface/subsurface Soil			4.E-05				NA	
Total Surface Water and Sediment			2.E-05				NA	
Total PUZ Groundwater			3.E-03				NA	
Total PMZ Groundwater			7.E-05				NA	
Total PlzMgd Groundwater			3.E-04				NA	
Total Battery Site Surface Soil			3.E-04				NA	
Total Battery Site Suburface Soil			1.E-05				NA	

NA = Not Applicable

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Construction Worker	Surface Soil SWMU 12 Proper	Ingestion	2.E-07	- -	- -	- -	0.2	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-07	- -	- -	- -	0.2	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	2.E-07	- -	- -	- -	0.2	- -
		Dermal Contact	9.E-09	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-07	- -	- -	- -	0.2	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	2.E-07	- -	- -	- -	0.05	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-07	- -	- -	- -	0.05	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	3.E-07	- -	- -	- -	0.06	- -
		Dermal Contact	2.E-08	- -	- -	- -	0.003	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-07	- -	- -	- -	0.07	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	2.E-07	- -	- -	- -	0.05	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-07	- -	- -	- -	0.06	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	4.E-07	- -	- -	- -	0.08	- -
		Dermal Contact	2.E-08	- -	- -	- -	0.004	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-07	- -	- -	- -	0.08	- -
	Surface Soil Battery Site	Ingestion	3.E-06	- -	- -	Arsenic	9	Antimony
		Dermal Contact	2.E-07	- -	- -	- -	0.02	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-06	- -	- -	Arsenic	9	Antimony
	Subsurface Soil Battery Site	Ingestion	8.E-08	- -	- -	- -	0.2	- -
		Dermal Contact	5.E-09	- -	- -	- -	0.0007	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-08	- -	- -	- -	0.2	- -

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Construction Worker (continued)	Surface Water Gully	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	NA	--	--	--	NA	--
		Total	NA	--	--	--	NA	--
	Sediment Gully	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	NA	--	--	--	NA	--
		Total	NA	--	--	--	NA	--
	Surface Water East Tributary	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	NA	--	--	--	NA	--
		Total	NA	--	--	--	NA	--
	Sediment East Tributary	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	NA	--	--	--	NA	--
		Total	NA	--	--	--	NA	--
	Surface Water Turkey Creek	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	NA	--	--	--	NA	--
		Total	NA	--	--	--	NA	--
	Sediment Turkey Creek	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	NA	--	--	--	NA	--
		Total	NA	--	--	--	NA	--
	Groundwater Pennsylvanian Upper Zone	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	7.E-08	--	--	--	3	Manganese
		Inhalation	NA	--	--	--	NA	--
		Total	7.E-08	--	--	--	3	Manganese
	Groundwater Pennsylvanian Middle Zone	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	2.E-09	--	--	--	0.08	--
		Inhalation	NA	--	--	--	NA	--
		Total	2.E-09	--	--	--	0.08	--
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	6.E-09	--	--	--	0.08	--
		Inhalation	NA	--	--	--	NA	--
		Total	6.E-09	--	--	--	0.08	--
Total MFA Proper Surface Soil			2.E-07				0.2	
Total MFA Proper Subsurface Soil			2.E-07				0.2	
Total Building 152 Surface/subsurface Soil			2.E-07				0.05	
Total Building 153/154 Surface/subsurface Soil			3.E-07				0.07	
Total Building 157 Surface/subsurface Soil			2.E-07				0.06	
Total Building 158/159 Surface/subsurface Soil			4.E-07				0.08	
Total Surface Water and Sediment			NA				NA	
Total PUZ Groundwater			7.E-08				3	
Total PMZ Groundwater			2.E-09				0.08	
Total PlzMgd Groundwater			6.E-09				0.08	
Total Battery Site Surface Soil			3.E-06				9	
Total Battery Site Suburface Soil			8.E-08				0.2	

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Maintenance Worker	Surface Soil SWMU 12 Proper	Ingestion	4.E-08	- -	- -	- -	0.005	- -
		Dermal Contact	2.E-09	- -	- -	- -	0.00003	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-08	- -	- -	- -	0.005	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	3.E-08	- -	- -	- -	0.005	- -
		Dermal Contact	1.E-09	- -	- -	- -	0.00002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-08	- -	- -	- -	0.005	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	4.E-08	- -	- -	- -	0.001	- -
		Dermal Contact	2.E-09	- -	- -	- -	0.00003	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-08	- -	- -	- -	0.001	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	6.E-08	- -	- -	- -	0.002	- -
		Dermal Contact	2.E-09	- -	- -	- -	0.00004	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-08	- -	- -	- -	0.002	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	4.E-08	- -	- -	- -	0.001	- -
		Dermal Contact	2.E-09	- -	- -	- -	0.00004	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-08	- -	- -	- -	0.001	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	8.E-08	- -	- -	- -	0.002	- -
		Dermal Contact	3.E-09	- -	- -	- -	0.00006	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-08	- -	- -	- -	0.002	- -
	Surface Soil Battery Site	Ingestion	6.E-07	- -	- -	- -	0.2	- -
		Dermal Contact	2.E-08	- -	- -	- -	0.0004	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-07	- -	- -	- -	0.2	- -
	Subsurface Soil Battery Site	Ingestion	2.E-08	- -	- -	- -	0.006	- -
		Dermal Contact	7.E-10	- -	- -	- -	0.00001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-08	- -	- -	- -	0.006	- -

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Maintenance Worker (continued)	Surface Water Gully	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	3.E-09	--	--	--	0.01	--
		Total	3.E-09	--	--	--	0.01	--
	Sediment Gully	Ingestion	1.E-07	--	--	--	0.01	--
		Dermal Contact	4.E-09	--	--	--	0.00008	--
		Total	1.E-07	--	--	--	0.01	--
	Surface Water East Tributary	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	2.E-10	--	--	--	0.000004	--
		Total	2.E-10	--	--	--	0.000004	--
	Sediment East Tributary	Ingestion	5.E-08	--	--	--	0.009	--
		Dermal Contact	2.E-09	--	--	--	0.00003	--
		Total	5.E-08	--	--	--	0.009	--
	Surface Water Turkey Creek	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	NA	--	--	--	0.0004	--
		Total	NA	--	--	--	0.0004	--
	Sediment Turkey Creek	Ingestion	1.E-07	--	--	--	0.02	--
		Dermal Contact	5.E-09	--	--	--	0.00009	--
		Total	1.E-07	--	--	--	0.02	--
	Groundwater Pennsylvanian Upper Zone	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	NA	--	--	--	NA	--
		Inhalation	NA	--	--	--	NA	--
		Total	NA	--	--	--	NA	--
	Groundwater Pennsylvanian Middle Zone	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	NA	--	--	--	NA	--
		Inhalation	NA	--	--	--	NA	--
		Total	NA	--	--	--	NA	--
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	NA	--	--	--	NA	--
		Inhalation	NA	--	--	--	NA	--
		Total	NA	--	--	--	NA	--
Total MFA Proper Surface Soil			4.E-08				0.005	
Total MFA Proper Subsurface Soil			4.E-08				0.005	
Total Building 152 Surface/subsurface Soil			4.E-08				0.001	
Total Building 153/154 Surface/subsurface Soil			6.E-08				0.002	
Total Building 157 Surface/subsurface Soil			4.E-08				0.001	
Total Building 158/159 Surface/subsurface Soil			8.E-08				0.002	
Total Surface Water and Sediment			3.E-07				0.05	
Total PUZ Groundwater			NA				NA	
Total PMZ Groundwater			NA				NA	
Total PlzMgd Groundwater			NA				NA	
Total Battery Site Surface Soil			6.E-07				0.2	
Total Battery Site Suburface Soil			2.E-08				0.006	

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Occupational Worker	Surface Soil SWMU 12 Proper	Ingestion	7.E-07	- -	- -	- -	0.1	- -
		Dermal Contact	3.E-08	- -	- -	- -	0.0005	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-07	- -	- -	- -	0.1	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	6.E-07	- -	- -	- -	0.09	- -
		Dermal Contact	2.E-08	- -	- -	- -	0.0004	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-07	- -	- -	- -	0.09	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	8.E-07	- -	- -	- -	0.02	- -
		Dermal Contact	3.E-08	- -	- -	- -	0.0006	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-07	- -	- -	- -	0.02	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	1.E-06	- -	- -	- -	0.03	- -
		Dermal Contact	4.E-08	- -	- -	- -	0.0008	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-06	- -	- -	- -	0.03	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	8.E-07	- -	- -	- -	0.02	- -
		Dermal Contact	3.E-08	- -	- -	- -	0.0007	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-07	- -	- -	- -	0.02	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	1.E-06	- -	- -	- -	0.03	- -
		Dermal Contact	6.E-08	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-06	- -	- -	- -	0.04	- -
	Surface Soil Battery Site	Ingestion	1.E-05	- -	- -	Arsenic	4	Antimony
		Dermal Contact	4.E-07	- -	- -	- -	0.007	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-05	- -	- -	Arsenic	4	Antimony
	Subsurface Soil Battery Site	Ingestion	3.E-07	- -	- -	- -	0.1	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.0002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-07	- -	- -	- -	0.1	- -

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Occupational Worker (continued)	Surface Water Gully	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Sediment Gully	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Surface Water East Tributary	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Sediment East Tributary	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Sediment Turkey Creek	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Groundwater Pennsylvanian Upper Zone	Ingestion	2.E-04	- -	RDX, Arsenic	- -	45	RDX, Iron, Manganese, Nickel
		Dermal Contact	3.E-07	- -	- -	- -	0.5	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-04	- -	RDX, Arsenic	- -	45	Iron, Manganese, N
	Groundwater Pennsylvanian Middle Zone	Ingestion	4.E-06	- -	- -	Arsenic	1	- -
		Dermal Contact	3.E-09	- -	- -	- -	0.01	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-06	- -	- -	Arsenic	1	- -
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	2.E-05	- -	Arsenic	- -	1	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.01	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-05	- -	Arsenic	- -	1	- -
		Total MFA Proper Surface Soil	8.E-07				0.1	
		Total MFA Proper Subsurface Soil	6.E-07				0.09	
		Total Building 152 Surface/subsurface Soil	8.E-07				0.02	
		Total Building 153/154 Surface/subaurface Soil	1.E-06				0.03	
		Total Building 157 Surface/subsurface Soil	8.E-07				0.02	
		Total Building 158/159 Surface/subaurface Soil	1.E-06				0.04	
		Total Surface Water and Sediment	NA				NA	
		Total PUZ Groundwater	2.E-04				45	
		Total PMZ Groundwater	4.E-06				1	
		Total PlzMgd Groundwater	2.E-05				1	
		Total Battery Site Surface Soil	1.E-05				4	
		Total Battery Site Suburface Soil	3.E-07				0.1	

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Trespasser	Surface Soil SWMU 12 Proper	Ingestion	9.E-08	- -	- -	- -	0.009	- -
		Dermal Contact	7.E-09	- -	- -	- -	0.00009	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	9.E-08	- -	- -	- -	0.009	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	7.E-08	- -	- -	- -	0.009	- -
		Dermal Contact	5.E-09	- -	- -	- -	0.00008	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-08	- -	- -	- -	0.009	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	9.E-08	- -	- -	- -	0.002	- -
		Dermal Contact	7.E-09	- -	- -	- -	0.0001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-07	- -	- -	- -	0.002	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	1.E-07	- -	- -	- -	0.003	- -
		Dermal Contact	9.E-09	- -	- -	- -	0.0001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-07	- -	- -	- -	0.003	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	9.E-08	- -	- -	- -	0.002	- -
		Dermal Contact	7.E-09	- -	- -	- -	0.0001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-07	- -	- -	- -	0.002	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	2.E-07	- -	- -	- -	0.003	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.0002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-07	- -	- -	- -	0.004	- -
	Surface Soil Battery Site	Ingestion	1.E-06	- -	- -	- -	0.4	- -
		Dermal Contact	9.E-08	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-06	- -	- -	- -	0.4	- -
	Subsurface Soil Battery Site	Ingestion	4.E-08	- -	- -	- -	0.01	- -
		Dermal Contact	3.E-09	- -	- -	- -	0.00004	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-08	- -	- -	- -	0.01	- -

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Trespasser (continued)	Surface Water Gully	Ingestion	1.E-07	--	--	--	0.03	--
		Dermal Contact	1.E-08	--	--	--	0.03	--
		Total	2.E-07	--	--	--	0.06	--
	Sediment Gully	Ingestion	1.E-07	--	--	--	0.01	--
		Dermal Contact	2.E-08	--	--	--	0.0003	--
		Total	1.E-07	--	--	--	0.01	--
	Surface Water East Tributary	Ingestion	8.E-09	--	--	--	0.0001	--
		Dermal Contact	5.E-10	--	--	--	0.000007	--
		Total	8.E-09	--	--	--	0.0001	--
	Sediment East Tributary	Ingestion	5.E-08	--	--	--	0.008	--
		Dermal Contact	8.E-09	--	--	--	0.0001	--
		Total	6.E-08	--	--	--	0.008	--
	Surface Water Turkey Creek	Ingestion	NA	--	--	--	0.0005	--
		Dermal Contact	NA	--	--	--	0.0007	--
		Total	NA	--	--	--	0.001	--
	Sediment Turkey Creek	Ingestion	1.E-07	--	--	--	0.01	--
		Dermal Contact	2.E-08	--	--	--	0.0003	--
		Total	2.E-07	--	--	--	0.01	--
	Groundwater Pennsylvanian Upper Zone	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	NA	--	--	--	NA	--
		Inhalation	NA	--	--	--	NA	--
		Total	NA	--	--	--	NA	--
	Groundwater Pennsylvanian Middle Zone	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	NA	--	--	--	NA	--
		Inhalation	NA	--	--	--	NA	--
		Total	NA	--	--	--	NA	--
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	NA	--	--	--	NA	--
		Dermal Contact	NA	--	--	--	NA	--
		Inhalation	NA	--	--	--	NA	--
		Total	NA	--	--	--	NA	--
Total MFA Proper Surface Soil			9.E-08				0.009	
Total MFA Proper Subsurface Soil			8.E-08				0.009	
Total Building 152 Surface/subsurface Soil			1.E-07				0.002	
Total Building 153/154 Surface/subsurface Soil			1.E-07				0.003	
Total Building 157 Surface/subsurface Soil			1.E-07				0.002	
Total Building 158/159 Surface/subsurface Soil			2.E-07				0.004	
Total Surface Water and Sediment			5.E-07				0.09	
Total PUZ Groundwater			NA				NA	
Total PMZ Groundwater			NA				NA	
Total PlzMgd Groundwater			NA				NA	
Total Battery Site Surface Soil			1.E-06				0.4	
Total Battery Site Suburface Soil			4.E-08				0.01	

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Child Recreational User	Surface Soil SWMU 12 Proper	Ingestion	9.E-08	--	--	--	0.05	--
		Dermal Contact	7.E-09	--	--	--	0.0006	--
		Inhalation	NA	--	--	--	NA	--
		Total	1.E-07	--	--	--	0.05	--
	Subsurface Soil SWMU 12 Proper	Ingestion	8.E-08	--	--	--	0.05	--
		Dermal Contact	6.E-09	--	--	--	0.0005	--
		Inhalation	NA	--	--	--	NA	--
		Total	8.E-08	--	--	--	0.05	--
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	9.E-08	--	--	--	0.01	--
		Dermal Contact	7.E-09	--	--	--	0.0006	--
		Inhalation	NA	--	--	--	NA	--
		Total	1.E-07	--	--	--	0.01	--
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	1.E-07	--	--	--	0.02	--
		Dermal Contact	1.E-08	--	--	--	0.0009	--
		Inhalation	NA	--	--	--	NA	--
		Total	1.E-07	--	--	--	0.02	--
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	9.E-08	--	--	--	0.01	--
		Dermal Contact	7.E-09	--	--	--	0.0007	--
		Inhalation	NA	--	--	--	NA	--
		Total	1.E-07	--	--	--	0.01	--
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	2.E-07	--	--	--	0.02	--
		Dermal Contact	1.E-08	--	--	--	0.001	--
		Inhalation	NA	--	--	--	NA	--
		Total	2.E-07	--	--	--	0.02	--
	Surface Soil Battery Site	Ingestion	1.E-06	--	--	--	2	Antimony
		Dermal Contact	1.E-07	--	--	--	0.008	--
		Inhalation	NA	--	--	--	NA	--
		Total	1.E-06	--	--	--	2	Antimony
	Subsurface Soil Battery Site	Ingestion	4.E-08	--	--	--	0.06	--
		Dermal Contact	3.E-09	--	--	--	0.0002	--
		Inhalation	NA	--	--	--	NA	--
		Total	4.E-08	--	--	--	0.06	--

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Child Recreational User (continued)	Surface Water Gully	Ingestion	2.E-07	--	--	--	0.2	--
		Dermal Contact	1.E-08	--	--	--	0.2	--
		Total	2.E-07	--	--	--	0.4	--
	Sediment Gully	Ingestion	2.E-07	--	--	--	0.1	--
		Dermal Contact	2.E-08	--	--	--	0.002	--
		Total	2.E-07	--	--	--	0.1	--
	Surface Water East Tributary	Ingestion	8.E-09	--	--	--	0.0006	--
		Dermal Contact	5.E-10	--	--	--	0.00004	--
		Total	8.E-09	--	--	--	0.0007	--
	Sediment East Tributary	Ingestion	1.E-07	--	--	--	0.09	--
		Dermal Contact	9.E-09	--	--	--	0.0007	--
		Total	1.E-07	--	--	--	0.09	--
	Surface Water Turkey Creek	Ingestion	NA	--	--	--	0.003	--
		Dermal Contact	NA	--	--	--	0.004	--
		Total	NA	--	--	--	0.007	--
	Sediment Turkey Creek	Ingestion	3.E-07	--	--	--	0.2	--
		Dermal Contact	2.E-08	--	--	--	0.002	--
		Total	3.E-07	--	--	--	0.2	--
	Groundwater Pennsylvanian Upper Zone	Ingestion	2.E-05	--	RDX	Arsenic	25	RDX, Iron, Manganese, Nickel
		Dermal Contact	6.E-08	--	--	--	0.5	--
		Inhalation	NA	--	--	--	NA	--
		Total	2.E-05	--	RDX	Arsenic	25	Iron, Manganese, N
	Groundwater Pennsylvanian Middle Zone	Ingestion	5.E-07	--	--	--	0.8	--
		Dermal Contact	6.E-10	--	--	--	0.01	--
		Inhalation	NA	--	--	--	NA	--
		Total	5.E-07	--	--	--	0.8	--
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	2.E-06	--	--	Arsenic	0.8	--
		Dermal Contact	3.E-09	--	--	--	0.01	--
		Inhalation	NA	--	--	--	NA	--
		Total	2.E-06	--	--	Arsenic	0.8	--
Total MFA Proper Surface Soil			1.E-07				0.05	
Total MFA Proper Subsurface Soil			8.E-08				0.05	
Total Building 152 Surface/subsurface Soil			1.E-07				0.01	
Total Building 153/154 Surface/subsurface Soil			1.E-07				0.02	
Total Building 157 Surface/subsurface Soil			1.E-07				0.01	
Total Building 158/159 Surface/subsurface Soil			2.E-07				0.02	
Total Surface Water and Sediment			8.E-07				0.7	
Total PUZ Groundwater			2.E-05				25	
Total PMZ Groundwater			5.E-07				0.8	
Total PlzMgd Groundwater			2.E-06				0.8	
Total Battery Site Surface Soil			1.E-06				2	
Total Battery Site Suburface Soil			4.E-08				0.06	

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Adult Recreational User	Surface Soil SWMU 12 Proper	Ingestion	3.E-08	--	--	--	0.006	--
		Dermal Contact	4.E-09	--	--	--	0.00008	--
		Inhalation	NA	--	--	--	NA	--
		Total	4.E-08	--	--	--	0.006	--
	Subsurface Soil SWMU 12 Proper	Ingestion	3.E-08	--	--	--	0.005	--
		Dermal Contact	3.E-09	--	--	--	0.00007	--
		Inhalation	NA	--	--	--	NA	--
		Total	3.E-08	--	--	--	0.006	--
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	3.E-08	--	--	--	0.001	--
		Dermal Contact	4.E-09	--	--	--	0.0001	--
		Inhalation	NA	--	--	--	NA	--
		Total	4.E-08	--	--	--	0.001	--
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	5.E-08	--	--	--	0.002	--
		Dermal Contact	5.E-09	--	--	--	0.000	--
		Inhalation	NA	--	--	--	NA	--
		Total	6.E-08	--	--	--	0.002	--
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	4.E-08	--	--	--	0.001	--
		Dermal Contact	4.E-09	--	--	--	0.0001	--
		Inhalation	NA	--	--	--	NA	--
		Total	4.E-08	--	--	--	0.002	--
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	7.E-08	--	--	--	0.002	--
		Dermal Contact	7.E-09	--	--	--	0.0002	--
		Inhalation	NA	--	--	--	NA	--
		Total	7.E-08	--	--	--	0.002	--
	Surface Soil Battery Site	Ingestion	5.E-07	--	--	--	0.2	--
		Dermal Contact	5.E-08	--	--	--	0.001	--
		Inhalation	NA	--	--	--	NA	--
		Total	5.E-07	--	--	--	0.2	--
	Subsurface Soil Battery Site	Ingestion	1.E-08	--	--	--	0.006	--
		Dermal Contact	2.E-09	--	--	--	0.00004	--
		Inhalation	NA	--	--	--	NA	--
		Total	2.E-08	--	--	--	0.006	--

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Adult Recreational User (continued)	Surface Water Gully	Ingestion	2.E-08	--	--	--	0.007	--
		Dermal Contact	2.E-08	--	--	--	0.1	--
		Total	5.E-08	--	--	--	0.1	--
	Sediment Gully	Ingestion	9.E-08	--	--	--	0.01	--
		Dermal Contact	9.E-09	--	--	--	0.0002	--
		Total	1.E-07	--	--	--	0.01	--
	Surface Water East Tributary	Ingestion	1.E-09	--	--	--	0.00003	--
		Dermal Contact	1.E-09	--	--	--	0.00002	--
		Total	2.E-09	--	--	--	0.00005	--
	Sediment East Tributary	Ingestion	4.E-08	--	--	--	0.009	--
		Dermal Contact	5.E-09	--	--	--	0.0001	--
		Total	5.E-08	--	--	--	0.009	--
	Surface Water Turkey Creek	Ingestion	NA	--	--	--	0.0001	--
		Dermal Contact	NA	--	--	--	0.003	--
		Total	NA	--	--	--	0.003	--
	Sediment Turkey Creek	Ingestion	1.E-07	--	--	--	0.02	--
		Dermal Contact	1.E-08	--	--	--	0.0003	--
		Total	1.E-07	--	--	--	0.02	--
	Groundwater Pennsylvanian Upper Zone	Ingestion	2.E-05	--	--	RDX, Arsenic	5	Manganese
		Dermal Contact	1.E-07	--	--	--	0.3	--
		Inhalation	NA	--	--	--	NA	--
		Total	2.E-05	--	--	RDX, Arsenic	6	Manganese
	Groundwater Pennsylvanian Middle Zone	Ingestion	4.E-07	--	--	--	0.2	--
		Dermal Contact	1.E-09	--	--	--	0.008	--
		Inhalation	NA	--	--	--	NA	--
		Total	4.E-07	--	--	--	0.2	--
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	2.E-06	--	--	--	0.2	--
		Dermal Contact	5.E-09	--	--	--	0.008	--
		Inhalation	NA	--	--	--	NA	--
		Total	2.E-06	--	--	--	0.2	--
Total MFA Proper Surface Soil			4.E-08				0.006	
Total MFA Proper Subsurface Soil			3.E-08				0.006	
Total Building 152 Surface/subsurface Soil			4.E-08				0.001	
Total Building 153/154 Surface/subsurface Soil			6.E-08				0.002	
Total Building 157 Surface/subsurface Soil			4.E-08				0.002	
Total Building 158/159 Surface/subsurface Soil			7.E-08				0.002	
Total Surface Water and Sediment			3.E-07				0.2	
Total PUZ Groundwater			2.E-05				6	
Total PMZ Groundwater			4.E-07				0.2	
Total PlzMgd Groundwater			2.E-06				0.2	
Total Battery Site Surface Soil			5.E-07				0.2	
Total Battery Site Suburface Soil			2.E-08				0.006	

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Total Recreational Risks	Surface Soil SWMU 12 Proper	Ingestion	1.E-07	- -	- -	- -	NA	- -
		Dermal Contact	1.E-08	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-07	- -	- -	- -	NA	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	1.E-07	- -	- -	- -	NA	- -
		Dermal Contact	9.E-09	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-07	- -	- -	- -	NA	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	1.E-07	- -	- -	- -	NA	- -
		Dermal Contact	1.E-08	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-07	- -	- -	- -	NA	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	2.E-07	- -	- -	- -	NA	- -
		Dermal Contact	2.E-08	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-07	- -	- -	- -	NA	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	1.E-07	- -	- -	- -	NA	- -
		Dermal Contact	1.E-08	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-07	- -	- -	- -	NA	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	2.E-07	- -	- -	- -	NA	- -
		Dermal Contact	2.E-08	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-07	- -	- -	- -	NA	- -
	Surface Soil Battery Site	Ingestion	2.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	2.E-07	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-06	- -	- -	Arsenic	NA	- -
	Subsurface Soil Battery Site	Ingestion	5.E-08	- -	- -	- -	NA	- -
		Dermal Contact	5.E-09	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-08	- -	- -	- -	NA	- -

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Total Recreational Risks (continued)	Surface Water Gully	Ingestion	2.E-07	- -	- -	- -	NA	- -
		Dermal Contact	3.E-08	- -	- -	- -	NA	- -
		Total	2.E-07	- -	- -	- -	NA	- -
	Sediment Gully	Ingestion	3.E-07	- -	- -	- -	NA	- -
		Dermal Contact	3.E-08	- -	- -	- -	NA	- -
		Total	3.E-07	- -	- -	- -	NA	- -
	Surface Water East Tributary	Ingestion	9.E-09	- -	- -	- -	NA	- -
		Dermal Contact	2.E-09	- -	- -	- -	NA	- -
		Total	1.E-08	- -	- -	- -	NA	- -
	Sediment East Tributary	Ingestion	2.E-07	- -	- -	- -	NA	- -
		Dermal Contact	1.E-08	- -	- -	- -	NA	- -
		Total	2.E-07	- -	- -	- -	NA	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Sediment Turkey Creek	Ingestion	4.E-07	- -	- -	- -	NA	- -
		Dermal Contact	3.E-08	- -	- -	- -	NA	- -
		Total	4.E-07	- -	- -	- -	NA	- -
	Groundwater Pennsylvanian Upper Zone	Ingestion	4.E-05	- -	RDX	Arsenic	NA	- -
		Dermal Contact	2.E-07	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-05	- -	RDX	Arsenic	NA	- -
	Groundwater Pennsylvanian Middle Zone	Ingestion	9.E-07	- -	- -	- -	NA	- -
		Dermal Contact	2.E-09	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	9.E-07	- -	- -	- -	NA	- -
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	4.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	8.E-09	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	4.E-06	- -	- -	Arsenic	NA	- -
Total MFA Proper Surface Soil			1.E-07				NA	
Total MFA Proper Subsurface Soil			1.E-07				NA	
Total Building 152 Surface/subsurface Soil			1.E-07				NA	
Total Building 153/154 Surface/subsurface Soil			2.E-07				NA	
Total Building 157 Surface/subsurface Soil			1.E-07				NA	
Total Building 158/159 Surface/subsurface Soil			3.E-07				NA	
Total Surface Water and Sediment			1.E-06				NA	
Total PUZ Groundwater			4.E-05				NA	
Total PMZ Groundwater			9.E-07				NA	
Total PlzMgd Groundwater			4.E-06				NA	
Total Battery Site Surface Soil			2.E-06				NA	
Total Battery Site Suburface Soil			6.E-08				NA	

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Future Child Resident	Surface Soil SWMU 12 Proper	Ingestion	2.E-06	--	--	Arsenic	1	--
		Dermal Contact	6.E-08	--	--	--	0.004	--
		Inhalation	NA	--	--	--	NA	--
		Total	2.E-06	--	--	Arsenic	1	--
	Subsurface Soil SWMU 12 Proper	Ingestion	1.E-06	--	--	--	0.9	--
		Dermal Contact	5.E-08	--	--	--	0.004	--
		Inhalation	NA	--	--	--	NA	--
		Total	1.E-06	--	--	--	0.9	--
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	2.E-06	--	--	Arsenic	0.2	--
		Dermal Contact	6.E-08	--	--	--	0.005	--
		Inhalation	NA	--	--	--	NA	--
		Total	2.E-06	--	--	Arsenic	0.2	--
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	2.E-06	--	--	Arsenic	0.3	--
		Dermal Contact	8.E-08	--	--	--	0.007	--
		Inhalation	NA	--	--	--	NA	--
		Total	3.E-06	--	--	Arsenic	0.3	--
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	2.E-06	--	--	Arsenic	0.2	--
		Dermal Contact	6.E-08	--	--	--	0.006	--
		Inhalation	NA	--	--	--	NA	--
		Total	2.E-06	--	--	Arsenic	0.2	--
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	3.E-06	--	--	Arsenic	0.3	--
		Dermal Contact	1.E-07	--	--	--	0.009	--
		Inhalation	NA	--	--	--	NA	--
		Total	3.E-06	--	--	Arsenic	0.4	--
	Surface Soil Battery Site	Ingestion	2.E-05	--	Arsenic	--	42	Antimony, Arsenic
		Dermal Contact	8.E-07	--	--	--	0.06	--
		Inhalation	NA	--	--	--	NA	--
		Total	2.E-05	--	Arsenic	--	42	Antimony, Arsenic
	Subsurface Soil Battery Site	Ingestion	7.E-07	--	--	--	1	--
		Dermal Contact	2.E-08	--	--	--	0.002	--
		Inhalation	NA	--	--	--	NA	--
		Total	7.E-07	--	--	--	1	--

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Future Child Resident (continued)	Surface Water Gully	Ingestion	2.E-07	- -	- -	- -	0.2	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.2	- -
		Total	2.E-07	- -	- -	- -	0	- -
	Sediment Gully	Ingestion	2.E-07	- -	- -	- -	0.1	- -
		Dermal Contact	2.E-08	- -	- -	- -	0.001	- -
		Total	2.E-07	- -	- -	- -	0.1	- -
	Surface Water East Tributary	Ingestion	8.E-09	- -	- -	- -	0.0006	- -
		Dermal Contact	5.E-10	- -	- -	- -	0.00004	- -
		Total	8.E-09	- -	- -	- -	0.0007	- -
	Sediment East Tributary	Ingestion	1.E-07	- -	- -	- -	0.09	- -
		Dermal Contact	7.E-09	- -	- -	- -	0.0006	- -
		Total	1.E-07	- -	- -	- -	0.09	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	0.003	- -
		Dermal Contact	NA	- -	- -	- -	0.004	- -
		Total	NA	- -	- -	- -	0.007	- -
	Sediment Turkey Creek	Ingestion	3.E-07	- -	- -	- -	0.2	- -
		Dermal Contact	2.E-08	- -	- -	- -	0.001	- -
		Total	3.E-07	- -	- -	- -	0.2	- -
	Groundwater Pennsylvanian Upper Zone	Ingestion	1.E-04	- -	RDX, Arsenic	- -	147	4-amino-2,6-dinitrotoluene, RDX, Aluminum, Arsenic, Cadmium, Cobalt, Iron, Manganese, Nickel
		Dermal Contact	6.E-07	- -	- -	- -	5	Manganese
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-04	- -	RDX, Arsenic	- -	152	4-amino-2,6-dinitrotoluene, RDX, Aluminum, Arsenic, Cadmium, Cobalt, Iron, Manganese, Nickel
	Groundwater Pennsylvanian Middle Zone	Ingestion	3.E-06	- -	- -	Arsenic	5	Manganese
		Dermal Contact	6.E-09	- -	- -	- -	0.1	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-06	- -	- -	Arsenic	5	Manganese
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	1.E-05	- -	- -	Arsenic	5	Manganese
		Dermal Contact	2.E-08	- -	- -	- -	0.1	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-05	- -	- -	Arsenic	5	Manganese
Total MFA Proper Surface Soil			2.E-06				1	
Total MFA Proper Subsurface Soil			1.E-06				0.9	

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-5}$ and $\leq 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-6}$ and $\leq 1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Total Building 152 Surface/subsurface Soil			2.E-06				0.2	
Total Building 153/154 Surface/subsurface Soil			3.E-06				0.3	
Total Building 157 Surface/subsurface Soil			2.E-06				0.2	
Total Building 158/159 Surface/subsurface Soil			3.E-06				0.4	
Total Surface Water and Sediment			8.E-07				0.7	
Total PUZ Groundwater			1.E-04				152	
Total PMZ Groundwater			3.E-06				5	
Total PlzMgd Groundwater			1.E-05				5	
Total Battery Site Surface Soil			2.E-05				42	
Total Battery Site Suburface Soil			7.E-07				1	

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Future Adult Resident	Surface Soil SWMU 12 Proper	Ingestion	6.E-07	- -	- -	- -	0.1	- -
		Dermal Contact	2.E-08	- -	- -	- -	0.0005	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	6.E-07	- -	- -	- -	0.1	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	5.E-07	- -	- -	- -	0.1	- -
		Dermal Contact	2.E-08	- -	- -	- -	0.0004	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	5.E-07	- -	- -	- -	0.1	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	6.E-07	- -	- -	- -	0.02	- -
		Dermal Contact	2.E-08	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	7.E-07	- -	- -	- -	0.02	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	9.E-07	- -	- -	- -	0.03	- -
		Dermal Contact	3.E-08	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	9.E-07	- -	- -	- -	0.03	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	6.E-07	- -	- -	- -	0.03	- -
		Dermal Contact	2.E-08	- -	- -	- -	0.0006	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	7.E-07	- -	- -	- -	0.03	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	1.E-06	- -	- -	- -	0.04	- -
		Dermal Contact	4.E-08	- -	- -	- -	0.001	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-06	- -	- -	- -	0.04	- -
	Surface Soil Battery Site	Ingestion	9.E-06	- -	- -	Arsenic	4	Antimony
		Dermal Contact	3.E-07	- -	- -	- -	0.007	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	9.E-06	- -	- -	Arsenic	4	Antimony
	Subsurface Soil Battery Site	Ingestion	3.E-07	- -	- -	- -	0.1	- -
		Dermal Contact	9.E-09	- -	- -	- -	0.0002	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-07	- -	- -	- -	0.1	- -

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Future Adult Resident (continued)	Surface Water Gully	Ingestion	2.E-08	- -	- -	- -	0.007	- -
		Dermal Contact	2.E-08	- -	- -	- -	0.1	- -
		Total	5.E-08	- -	- -	- -	0.1	- -
	Sediment Gully	Ingestion	9.E-08	- -	- -	- -	0.01	- -
		Dermal Contact	6.E-09	- -	- -	- -	0.0001	- -
		Total	9.E-08	- -	- -	- -	0.01	- -
	Surface Water East Tributary	Ingestion	1.E-09	- -	- -	- -	0.00003	- -
		Dermal Contact	1.E-09	- -	- -	- -	0.00002	- -
		Total	2.E-09	- -	- -	- -	0.00005	- -
	Sediment East Tributary	Ingestion	4.E-08	- -	- -	- -	0.009	- -
		Dermal Contact	3.E-09	- -	- -	- -	0.00006	- -
		Total	4.E-08	- -	- -	- -	0.009	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	0.0001	- -
		Dermal Contact	NA	- -	- -	- -	0.003	- -
		Total	NA	- -	- -	- -	0.003	- -
	Sediment Turkey Creek	Ingestion	1.E-07	- -	- -	- -	0.02	- -
		Dermal Contact	7.E-09	- -	- -	- -	0.0002	- -
		Total	1.E-07	- -	- -	- -	0.02	- -
	Groundwater Pennsylvanian Upper Zone	Ingestion	2.E-04	RDX	Arsenic	- -	67	RDX, Aluminum, Cobalt, Iron, Manganese, Nickel
		Dermal Contact	1.E-06	- -	- -	RDX	3	Manganese
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-04	RDX	Arsenic	- -	70	RDX, Aluminum, Cobalt, Iron, Manganese, Nickel
	Groundwater Pennsylvanian Middle Zone	Ingestion	5.E-06	- -	- -	Arsenic	2	- -
		Dermal Contact	1.E-08	- -	- -	- -	0.07	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	5.E-06	- -	- -	Arsenic	2	- -
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	2.E-05	- -	Arsenic	- -	2	- -
		Dermal Contact	5.E-08	- -	- -	- -	0.07	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-05	- -	Arsenic	- -	2	- -
	Total MFA Proper Surface Soil		6.E-07				0.1	
	Total MFA Proper Subsurface Soil		5.E-07				0.1	
	Total Building 152 Surface/subsurface Soil		7.E-07				0.02	
	Total Building 153/154 Surface/subsurface Soil		9.E-07				0.03	
	Total Building 157 Surface/subsurface Soil		7.E-07				0.03	
	Total Building 158/159 Surface/subsurface Soil		1.E-06				0.04	
	Total Surface Water and Sediment		3.E-07				0.2	
	Total PUZ Groundwater		2.E-04				70	
	Total PMZ Groundwater		5.E-06				2	
	Total PlzMgd Groundwater		2.E-05				2	

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-5}$ and $\leq 1x10^{-4}$	Chemicals with Cancer Risks $> 1x10^{-6}$ and $\leq 1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Total Battery Site Surface Soil			9.E-06				4	
Total Battery Site Suburface Soil			3.E-07				0.1	

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Total Residential Risks	Surface Soil SWMU 12 Proper	Ingestion	2.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	8.E-08	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-06	- -	- -	Arsenic	NA	- -
	Subsurface Soil SWMU 12 Proper	Ingestion	2.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	6.E-08	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-06	- -	- -	Arsenic	NA	- -
	Surface and Subsurface Soil Bldg 152 Historical Data	Ingestion	2.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	8.E-08	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-06	- -	- -	Arsenic	NA	- -
	Surface and Subsurface Soil Bldg 153/154 Historical Data	Ingestion	3.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	1.E-07	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-06	- -	- -	Arsenic	NA	- -
	Surface and Subsurface Soil Bldg 157 Historical Data	Ingestion	2.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	8.E-08	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	2.E-06	- -	- -	Arsenic	NA	- -
	Surface and Subsurface Soil Bldg 158/159 Historical Data	Ingestion	4.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	1.E-07	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	5.E-06	- -	- -	Arsenic	NA	- -
	Surface Soil Battery Site	Ingestion	3.E-05	- -	Arsenic	- -	NA	- -
		Dermal Contact	1.E-06	- -	- -	Arsenic	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-05	- -	Arsenic	- -	NA	- -
	Subsurface Soil Battery Site	Ingestion	1.E-06	- -	- -	- -	NA	- -
		Dermal Contact	3.E-08	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	1.E-06	- -	- -	- -	NA	- -

TABLE 7-27

SUMMARY OF CANCER RISKS AND HAZRD INDICES - CENTRAL TENDENCY EXPOSURE
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Receptor	Medium	Exposure Route	Cancer Risk	Chemicals with Cancer Risks > $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-5}$ and ≤ $1x10^{-4}$	Chemicals with Cancer Risks > $1x10^{-6}$ and ≤ $1x10^{-5}$	Hazard Index (HI)	Chemicals with HI > 1
Total Residential Risks (continued)	Surface Water Gully	Ingestion	2.E-07	- -	- -	- -	NA	- -
		Dermal Contact	3.E-08	- -	- -	- -	NA	- -
		Total	2.E-07	- -	- -	- -	NA	- -
	Sediment Gully	Ingestion	3.E-07	- -	- -	- -	NA	- -
		Dermal Contact	2.E-08	- -	- -	- -	NA	- -
		Total	3.E-07	- -	- -	- -	NA	- -
	Surface Water East Tributary	Ingestion	9.E-09	- -	- -	- -	NA	- -
		Dermal Contact	2.E-09	- -	- -	- -	NA	- -
		Total	1.E-08	- -	- -	- -	NA	- -
	Sediment East Tributary	Ingestion	2.E-07	- -	- -	- -	NA	- -
		Dermal Contact	1.E-08	- -	- -	- -	NA	- -
		Total	2.E-07	- -	- -	- -	NA	- -
	Surface Water Turkey Creek	Ingestion	NA	- -	- -	- -	NA	- -
		Dermal Contact	NA	- -	- -	- -	NA	- -
		Total	NA	- -	- -	- -	NA	- -
	Sediment Turkey Creek	Ingestion	4.E-07	- -	- -	- -	NA	- -
		Dermal Contact	3.E-08	- -	- -	- -	NA	- -
		Total	4.E-07	- -	- -	- -	NA	- -
	Groundwater Pennsylvanian Upper Zone	Ingestion	3.E-04	RDX	Arsenic	- -	NA	- -
		Dermal Contact	2.E-06	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-04	RDX	Arsenic	- -	NA	- -
	Groundwater Pennsylvanian Middle Zone	Ingestion	8.E-06	- -	- -	Arsenic	NA	- -
		Dermal Contact	2.E-08	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	8.E-06	- -	- -	Arsenic	NA	- -
	Groundwater Pennsylvanian Lower and Mississippian Glen Dean Zone	Ingestion	3.E-05	- -	Arsenic	- -	NA	- -
		Dermal Contact	7.E-08	- -	- -	- -	NA	- -
		Inhalation	NA	- -	- -	- -	NA	- -
		Total	3.E-05	- -	Arsenic	- -	NA	- -
Total MFA Proper Surface Soil			2.E-06				NA	
Total MFA Proper Subsurface Soil			2.E-06				NA	
Total Building 152 Surface/subsurface Soil			2.E-06				NA	
Total Building 153/154 Surface/subsurface Soil			3.E-06				NA	
Total Building 157 Surface/subsurface Soil			2.E-06				NA	
Total Building 158/159 Surface/subsurface Soil			5.E-06				NA	
Total Surface Water and Sediment			1.E-06				NA	
Total PUZ Groundwater			3.E-04				NA	
Total PMZ Groundwater			8.E-06				NA	
Total PlzMgd Groundwater			3.E-05				NA	
Total Battery Site Surface Soil			3.E-05				NA	
Total Battery Site Suburface Soil			1.E-06				NA	

NA = Not Applicable

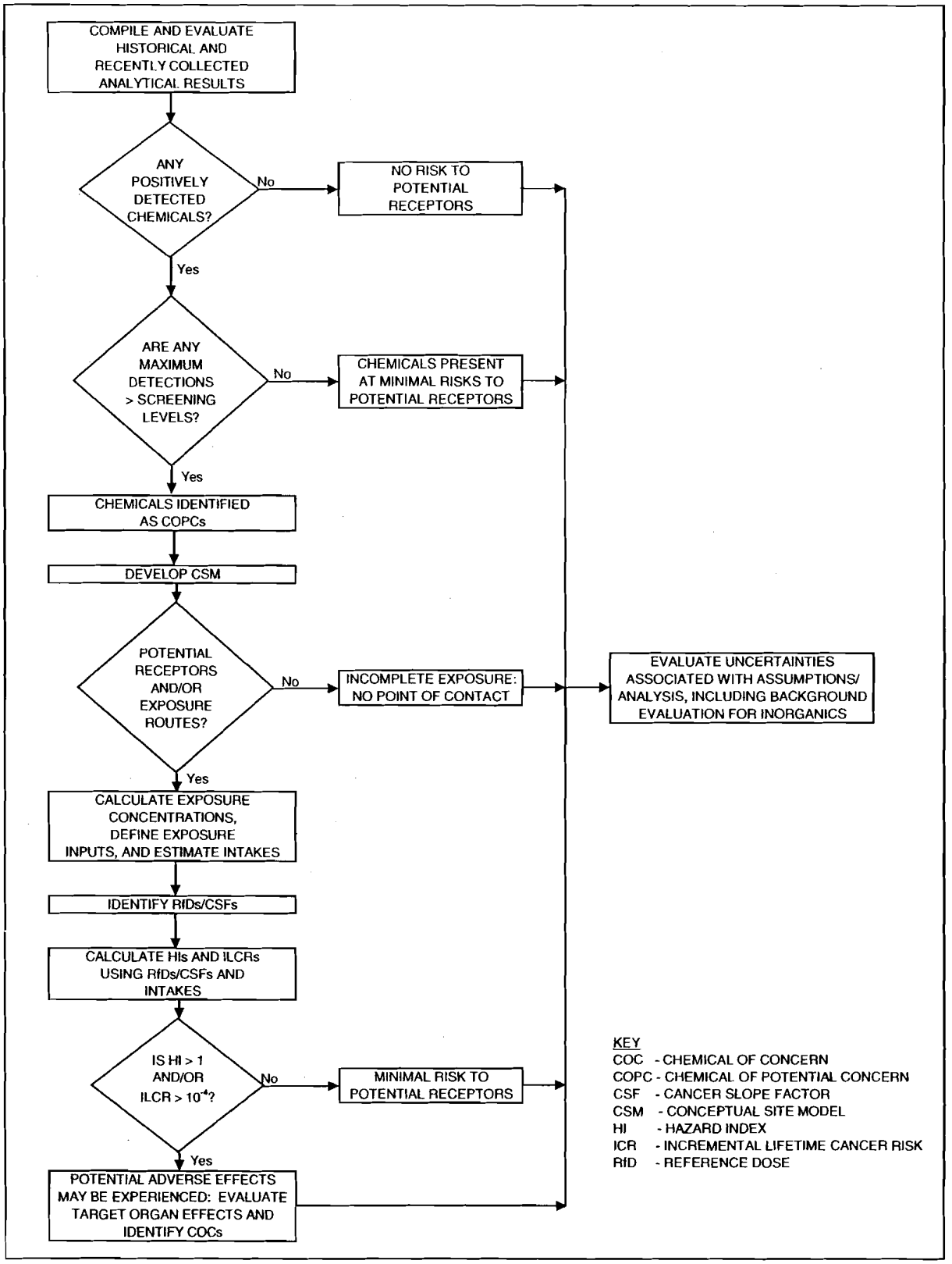
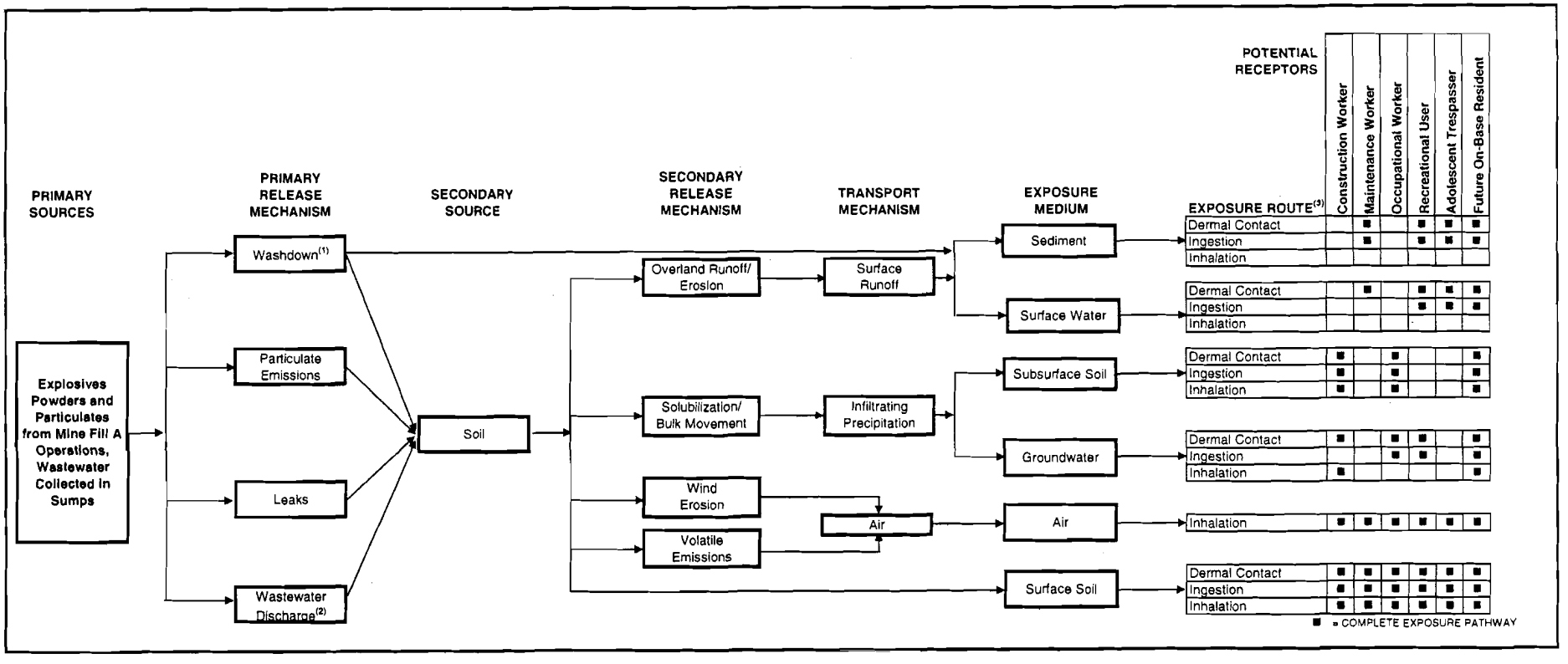


FIGURE 7-1

SUMMARY OF HUMAN HEALTH RISK ASSESSMENT PROCESS
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

FIGURE 7-2

HUMAN HEALTH CONCEPTUAL SITE MODEL
SWMU 12 (MINE FILL A)
NSWC CRANE, INDIANA



1. Washdown of powders and particulates from rooftops.
2. Wastewater containing explosives was collected in sumps that released the wastewater directly to surface drainage that flows into Boggs Creek.
3. Blank space indicates incomplete exposure pathway or relatively insignificant or not applicable potential exposure.

8.0 ECOLOGICAL RISK ASSESSMENT

The goal of this screening-level ecological risk assessment (SERA) for SWMU 12 – MFA is to evaluate the potential for adverse ecological impacts of site-related contamination. The goal of this SERA was accomplished by identifying the contaminants of potential concern (COPCs) detected at concentrations that exceeded screening levels, identifying the locations of these exceedances, and concluding whether or not further investigation and/or remedial action at SWMU 12 at Naval Surface Warfare Center (NSWC) Crane is warranted from an ecological perspective.

8.1 INTRODUCTION

The SERA methodology used at NSWC Crane is in accordance with the following guidance documents:

- Department of Navy Environmental Policy Memorandum 97-04: Use of Ecological Risk Assessments dated May 16, 1997.
- Navy Policy for Conducting Ecological Risk Assessment (Navy, 1999).
- Final Guidelines for Ecological Risk Assessment (U.S. EPA, 1998).
- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (U.S. EPA, 1997a).

This SERA consists of Steps 1, 2, and 3a of the eight ecological risk evaluation steps required by U.S. EPA guidance (1997a and 1998) and the Navy Policy for Conducting Ecological Risk Assessments (ERAs) (Navy, 1999). These eight steps include Steps 1 and 2, which constitute a SERA, followed by four additional steps, which constitute a Baseline ERA (BERA), and conclude with Step 8, a risk management evaluation. Step 3a is technically the first step of the BERA and it consists of a refinement of the conservative exposure assumptions. Steps 3b through 7 are conducted if additional evaluations or investigations are necessary. Aspects of Step 8, risk management, are addressed throughout the ERA process, in cooperation with the Region 5 regulators.

A schematic diagram of the general risk assessment process is provided in Figure 8-1. In addition, Figures 8-2, 8-3, and 8-4 are flow charts that summarize the ERA process used to evaluate risks for ecological receptors exposed to chemicals in surface soil, sediment, and surface water, respectively. These flow charts are discussed later in this ERA.

8.2 SCREENING-LEVEL PROBLEM FORMULATION

The screening-level problem formulation is the first step of a SERA and includes identification of potential receptor groups, COPCs, and the mechanisms for contaminant fate, transport, and toxicity. Determination of the complete exposure pathways that exist at a site is accomplished at this point to facilitate receptor selection. The problem formulation process enables the risk assessor to identify the ecological resources to be protected (known as assessment endpoints); the measurements that will be used to evaluate risks to those resources (known as measures of effects); and the chemicals, geographic areas, and environmental media relevant to the risk assessment.

As part of receptor identification, site habitats and potential ecological receptors are described. These characteristics, as they apply to ecological risk, are described in the following subsections.

8.2.1 Environmental Setting

8.2.1.1 Basewide Environmental Setting

A biological characterization of NSWC Crane, including a list of plants and animals found at the facility, is presented in the Installation Assessment (IA) (Army, 1978) and the Initial Assessment Study (IAS) (NEESA, 1983) and is summarized in the Environmental Monitoring Reports (EMRs) (Halliburton NUS, 1992a and 1992b). A list of the species that may inhabit NSWC Crane and that are protected under the United States Endangered Species Act, Indiana Department of Natural Resources Heritage Data Center, or the United States Fish and Wildlife Service is summarized in the RCRA Facility Permit and below. The following paragraphs briefly summarize the environmental setting at the base.

Eighty percent of NSWC Crane's 63,000 acres is classified as Central Hardwoods Forest of the United States (NEESA, 1983). In addition, some agricultural fields are in various stages of succession. Open spaces on dry upland sites contain almost pure stands of grasses with some clumps of woody plants such as persimmon, sassafras, and sumac. Wetter sites have river birch, willow, sycamore, and cottonwood. Hillside communities have mostly hickory, white and black oak, red maple, sugar maple, tulip poplar, ash, and beech (NEESA, 1983).

The great variety of habitats at NSWC Crane (i.e., many stages of forest succession, streams, ponds, Lake Greenwood, grassy open spaces) lead to great diversity of animal species (NEESA, 1983). Some of these species include but are not limited to mammals such as white-tailed deer, beaver, coyote, hawks, red fox, rabbits, raccoons, and mice; birds such as ducks, geese, wild turkey, bobwhite quail, red-tailed hawks, and American robins; and various amphibians, reptiles, fish, and invertebrates.

Six main creeks receive drainage in five separate drainage basins at NSWC Crane: Furst Creek, Sulphur Creek, Little Sulphur Creek, Boggs Creek, Turkey Creek, and Seed Tick Creek. There also are many smaller streams, creeks, and drainage ditches located at the facility, along with several small man-made ponds and one large lake (Lake Greenwood). Lake Greenwood is the source of potable water for NSWC Crane. Surface water from the facility eventually discharges to the eastern fork of the White River, which is located south of the facility.

The drainage ditches at MFA (which is approximately 63 acres in size) discharge to Turkey Creek, which eventually drain to Boggs Creek. The Boggs Creek-Headwaters and Boggs Creek-Goldsberry Hollow waterbody segments designated State water uses are aquatic life support, fish consumption, and primary contact. These waterbody segments were not assessed as part of the 2004 Indiana Integrated Water Quality Monitoring and Assessment Report to determine if the waterbody was supporting those uses (IDEM, 2004). However, the Boggs Creek-Buzzard Run waterbody segment, located downstream of the Boggs Creek-Goldsberry Hollow waterbody segment, is fully supporting the aquatic life support and primary contact water uses; it was not assessed for the fish consumption water use (IDEM, 2004). The Turkey Creek waterbody segment was included in the IDEM Assessment Report but was not assessed because insufficient data or no data were available to determine designated uses.

Threatened and Endangered Species

The Endangered Species Management Plan for NSWC Crane (Comarco Systems, Inc., 2000) identified the federal and State threatened and endangered species and species of special concern potentially present at NSWC Crane. Information included in the Endangered Species Management Plan was obtained from studies and surveys conducted by the Navy and other agencies and groups such as universities and research institutions. A small subset of these studies include the Inventory of Neotropical Migratory Birds, Mist Net and Radiotelemetry Surveys for the Indiana bat, Bobcat Trapping, Rattlesnake Survey, Purdue University Wildlife Studies, and several fish surveys, and bird counts. These studies and others that were used in compiling the list of endangered species present at NSWC Crane are described in more detail in the Endangered Species Management Plan (Comarco Systems, Inc., 2000) and below.

The Indiana bat and bald eagle are the only federally threatened or endangered species at NSWC Crane. The bald eagle is not likely present at SWMU 12 due to a lack of vast expanses of open water (i.e., the preferred hunting habitat for the bald eagle). No mist nets were located at SWMU 12 during the Mist Net and Radiotelemetry Surveys for the Indiana bat; however, two mist net sites were located in the main stream tributary to Boggs Creek adjacent to SWMU 13, which is the nearest SWMU to SWMU 12. No

Indiana bats were captured at these two locations between May 18 and July 11, 1998. Therefore, although Indiana bats have been captured at NSWC Crane, their presence surrounding SWMU 12 has not been documented.

In addition, a number of State endangered and federal and State species of concern have been listed for NSWC Crane (Comarco Systems, Inc., 2000). The State endangered species list includes two mammals (bobcat and Indiana bat), one reptile (timber rattlesnake), and several birds (bald eagle, osprey, loggerhead shrike, yellow-crowned night-heron, Virginia rail, king rail, and Henslow's sparrow). The Indiana Division of Fish and Wildlife website (http://www.in.gov/dnr/fishwild/endangered/e-list.htm) was reviewed to verify that no changes in the status of these species had occurred since October 2000. This list is much larger than that presented in Comarco Systems, Inc. (2000) and is not reiterated here.

Boggs Creek and Turkey Creek discharge off-site to the East Fork of the White River. River otters, a state endangered species, are being reintroduced to Indiana. The otters are expanding from their original release sites into other watersheds including the East Fork of the White River (IDNR, 2004). Also, the East Fork of the White River is the site for an ongoing study of lake sturgeon populations, another state endangered species (IDNR, 2004). Finally, spotted darters, a state endangered species, have been found in the East Fork of the White River (IDNR, 2000). Other threatened, endangered, or special concern species also may be present in the water bodies just outside the boundaries of NSWC Crane. For example, a survey of the freshwater mussel species present in the East Fork White River was initiated in 2003; however, results are not yet available.

8.2.1.2 Site-Specific Environmental Setting

Figure 8-5 is an aerial photograph of SWMU 12 and indicates the SWMU boundaries. Appendix J.1 presents the ecological assessment checklist.

SWMU 12 consists of buildings, roads, railroad lines, parking lots, grass-covered fields, and adjoining forested areas. The grass fields make up approximately half of the SWMU area, and the other half of the SWMU is represented by heavily forested areas. Most of the surface runoff from SWMU 12 drains south and southeast. Surface drainage at MFA is routed away from buildings and roads via storm sewers, culverts, and ditches located throughout the relatively flat portion of the ridgetop. The ditches and storm sewers lead to larger drainageways and gullies that flow down both sides of the ridge in northeastern and southwestern directions. The main drainageways and gullies at SWMU 12 eventually flow to Turkey Creek or the unnamed tributary (East Tributary) to Turkey Creek. The sides of the ridge consist of steeper slopes that lead down to the adjacent stream valleys. SWMU 12 is located in the central portion

of NSWC Crane within the Boggs and Turkey Creek Drainage Basin, which is one of the five drainage basins that carry surface water off the installation and eventually drain into the East Fork of the White River and then to the Wabash River to the southwest.

8.2.2 Contaminants, Ecotoxicity, and Fate and Transport

Based on historical site data, the following parameters are among the site-related chemical contaminants known to be present or potentially present in environmental media at SWMU 12:

- Explosives (e.g., TNT and HMX) and their degradation products (e.g., 2-amino-4,6-dinitrotoluene).
- Semivolatile organic compounds (SVOCs) (e.g., PAHs).
- Volatile organic compounds (VOCs) (e.g., solvents).
- Metals (e.g., zinc).

8.2.2.1 Physical and Chemical Characteristics

Physical and chemical characteristics of contaminants may affect their mobility, transport, and bioavailability in the environment. These characteristics include bioaccumulation factors (BAFs), organic carbon partition coefficients, and octanol-water partition coefficients. The physical and chemical characteristics of the different chemical classes present in SWMU 12 media are presented in Appendix J.2.

8.2.3 Potential Exposure Pathways

MFA has been used for the production of large mines, depth charges, rocket heads, aerial bombs, and projectiles in buildings. Most recently, MFA has been used in the production of 2,000-pound aerial bombs. In addition to production, demilitarization activities take place at Buildings 151, 155, and 160. Past history at MFA indicates that demilitarization activities and documented contaminant releases also occurred at Buildings 152, 153, and 3110. Most documented contaminant releases that occurred involved TNT only (near Buildings 151, 152, 153, 160, or 3110) or TNT plus HMX and RDX near Buildings 160 and 3110, or an unspecified explosive powder (in the tunnel area of Building 152) (Halliburton NUS, 1992).

Section 1.2.2 of this RFI describes the operational history, deposition mechanisms, and potential contaminant migration patterns for SWMU 12. Section 1.2.3 presents detailed descriptions of previous investigations and the potential sources of contamination for SWMU 12. The contaminants from these

sources may have migrated to soil, sediment, surface water, and/or groundwater via various transport pathways (e.g., runoff, leaks, direct discharge, etc.).

8.2.3.1 Surface Soil

Several groups of terrestrial ecological receptors can be exposed to contaminants in surface soil. Invertebrates such as earthworms are exposed to contaminants as they move through the soil and ingest soil particles while searching for food. Plants are exposed to the contaminants via direct contact as contaminants are absorbed through the roots. Contaminants are then translocated to different parts of the plants (e.g., leaves, seeds). These pathways are evaluated in the SERA.

Small mammals may be exposed to contaminants in soil via several exposure routes. They may be exposed by direct contact as they search for food or burrow into the soil. Exposure of terrestrial wildlife to contaminants in soil via dermal contact is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons are expected to minimize transfer of contaminants across dermal tissue. Therefore, the dermal pathway was not evaluated in the SERA. Small mammals also may be exposed to contaminants in the soil via incidental ingestion of soil and ingestion of plants and/or invertebrates that have accumulated contaminants from the soil. These pathways are evaluated in the SERA.

Larger predatory species such as the red fox and red-tailed hawk can be indirectly exposed to soil contaminants by ingesting small mammals that have accumulated contaminants from soil. This pathway is evaluated in the SERA.

8.2.3.2 Groundwater

Ecological receptors are not directly exposed to contaminants in groundwater at the site. Exposure to groundwater discharging as a seep or directly to a surface water body represents a complete exposure pathway and is evaluated as part of the surface water pathway.

8.2.3.3 Surface Water/Sediment

As mentioned above, contaminants in groundwater may discharge as seeps that flow into surface water or may discharge directly into a surface water body. Contaminants in soil may also enter the intermittent drainage channels at SWMU 12 via overland flow.

The aquatic habitat at SWMU 12 consists of small and intermittent gullies that drain SWMU 12 water run-off to an unnamed tributary of Turkey Creek and eventually to Turkey Creek. Although the small tributaries are typically wet during rain events only, these gullies feed water and sediments to the East Tributary at SWMU 12, which drains to Turkey Creek. Turkey Creek is a perennial stream that supports benthic macroinvertebrates and fish year-round. Therefore, it is likely that populations of benthic macroinvertebrates that inhabit Turkey Creek are able to repopulate portions of the East Tributary and the intermittent drainage channels at SWMU 12 after heavy rain events. It is also possible that fish from Turkey Creek migrate upstream into the East Tributary and the drainageways/gullies at SMWU 12 and are exposed to contaminants in surface water and sediment. Although it is unlikely that enough water is present in the East Tributary and the intermittent drainage channels to sustain benthic macroinvertebrates during all times of the year, it is possible that these receptors are present in the East Tributary and the intermittent gullies at SWMU 12 during wet seasons. The intermittent gullies are typically dry except during heavy rain events; however, during several site visits some water was present. Therefore, the presence of small fish during at least some times of the year is possible. Fish could be exposed to chemical contamination by direct contact with, and ingestion of, contaminated surface water or sediments.

Piscivorous wildlife may consume fish that have accumulated chemicals from surface water and sediment in Turkey Creek. However, it is unlikely that piscivorous wildlife will obtain significant portions of their diet from the East Tributary and the intermittent drainageways/gullies; therefore, this exposure pathway was only evaluated in this SERA for Turkey Creek, where fish are present year round.

8.2.3.4 Air

Although inhalation of particulates by mammals and birds may be a complete pathway, it is expected to be insignificant compared to other pathways such as ingestion of food items that have bioaccumulated contaminants from soil, particularly because exhaust emissions from ventilation systems ceased in 1975 with the discontinuation of ordnance assembly at SWMU 12 (although ordnance assembly was resumed in 1980 but only for a short amount of time). Also, inhalation pathways are not typically evaluated in SERAs because of the uncertainty inherent in estimating exposure levels and toxicological effects. Therefore, the air inhalation pathway is not evaluated in the SERA.

8.2.4 Endpoints

8.2.4.1 Assessment Endpoints

Assessment endpoints are an explicit expression of the environmental value that is to be protected (U.S. EPA, 1997a). The selection of these endpoints is based on the habitats present, the migration pathways of probable contaminants, and the relevant exposure routes for the receptors.

As discussed in 8.2.1.2, the habitat in the central portion of SWMU 12 consists primarily of open areas with grasses and shrubs, surrounded by wooded areas. However, the SWMU is covered to some extent by roads and buildings (see Figure 8-5). The gullies adjacent to the site are intermittent, but they ultimately drain to larger water bodies. Based on the habitats at SWMU 12, the assessment endpoints include protection of the following groups of receptors from adverse effects of contaminants on their growth, survival, and reproduction:

- Soil invertebrates
- Terrestrial vegetation
- Herbivorous birds and mammals
- Soil invertebrate-eating birds and mammals
- Piscivorous birds and mammals
- Benthic macroinvertebrates
- Fish
- Amphibians and reptiles

The following paragraphs discuss the reasons that the above assessment endpoints were selected for evaluation in the SERA.

Soil Invertebrates: Soil invertebrates are expected to be present in the soil at SWMU 12. They aid in the formation of soil and the redistribution and decomposition of organic matter in the soil, and they serve as a food source for higher trophic-level organisms. They also can accumulate bioaccumulative contaminants that can then be transferred to the higher trophic-level organisms that consume soil invertebrates.

Terrestrial Vegetation: Terrestrial vegetation at SWMU 12 (where present) consists of grasses, shrubs, and trees. They serve as a food source and provide shade and cover for many organisms, and they help

to prevent soil erosion, among other important functions. They also can accumulate some contaminants that can then be transferred to the higher trophic-level organisms that consume plants.

Herbivorous Birds and Mammals: Herbivorous birds and mammals (i.e., animals that consume only plant tissue) may be present in vegetative habitats at SWMU 12. Their role in the community is essential because, without them, higher trophic levels could not exist (Smith, 1966). They may be exposed to and accumulate contaminants present in the plants they consume.

Soil Invertebrate-Eating Birds and Mammals: Soil invertebrate-eating birds and mammals are present throughout the base in different terrestrial habitats (i.e., forested, open field) and are likely present at SWMU 12. These are considered first-level carnivores, and they serve as a food source for higher trophic-level carnivores. They may be exposed to and accumulate contaminants present in the food items they consume.

Piscivorous birds and mammals: Piscivorous birds and mammals consist of birds and mammals that eat fish. These are considered first-level carnivores, and they serve as a food source for higher trophic-level carnivores. They may be exposed to and accumulate contaminants present in the food items they consume. Piscivorous birds and mammals are evaluated at SWMU 12 because they are potentially exposed to contaminants that have migrated from SWMU 12 to Turkey Creek and accumulated in fish they consume.

Benthic Macroinvertebrates: Benthic macroinvertebrates are similar to soil invertebrates in that they serve as a food source for higher trophic-level organisms (i.e., fish, amphibians, birds, mammals). Their presence in the intermittent gullies and the East Tributary will be ephemeral because of a lack of suitable habitat and water flow; however, these receptors are present in Turkey Creek year round. Benthic macroinvertebrates can accumulate contaminants that can then be transferred to higher trophic-level organisms such as fish in Turkey Creek that consume them.

Fish: Fish are not present in the gullies leading away from SWMU 12 because the drainageways are usually dry. However, Turkey Creek is a perennial stream that supports fish year round. Fish in Turkey Creek may be exposed to and can accumulate contaminants from the food items they consume or from the surface water in which they live. Additionally, fish in Turkey Creek may swim upstream into the East Tributary and the intermittent drainage channels at SWMU 12 during higher flow periods. Fish in Turkey Creek are evaluated as part of the SERA for the potential migration of SWMU 12 surface water and sediment concentrations and the potential migration of fish into this main waterbody.

Amphibians and Reptiles: Amphibians are expected to inhabit water bodies and the surrounding areas, and reptiles can inhabit both aquatic environments and terrestrial habitats. Amphibians and reptiles feed primarily on invertebrates, plants, fish, and/or small mammals. They are exposed to and can accumulate contaminants from the food items they consume or from the surface water, sediment, or surface soil in which they live.

Not all of the potential assessment endpoints listed above will be evaluated in the SERA. As indicated in U.S. EPA guidance (1997a), "it is not practical or possible to directly evaluate risks to all of the individual components of the ecosystem at a site. Instead, assessment endpoints focus the risk assessment on particular components of the ecosystem that could be adversely affected by contaminants from the site." Therefore, the SERA will focus on the endpoints that will tend to yield the highest risks, which should then account for endpoints that will have lower risks. For example, omnivores were not selected as assessment endpoints because exposure to contaminants in plants is greatest for herbivores and exposure to contaminants in invertebrates is greatest for insectivores. Therefore, omnivores will be protected by protecting herbivores and insectivores.

8.2.4.2 Measurement Endpoints

Measurement endpoints are estimates of measurable biological impacts (e.g., mortality, growth, and reproduction) used to evaluate the assessment endpoints. The following measures of effects were used to evaluate the assessment endpoints in the SERA:

- Soil screening values - Mortality, growth, and reproduction of plants and soil invertebrates will be evaluated by comparing the measured concentrations of chemicals in surface soil to screening values designed to be protective of ecological receptors.

- Wildlife toxicity reference values (TRVs) - Mortality, reproductive, and/or developmental effects of birds and mammals will be evaluated by comparing the estimated dose incurred (based on conservative and average assumptions) from ingestion of contaminants in surface water, sediment, surface soil, plants, invertebrates, and small mammals to wildlife TRVs.

- Sediment screening values - Mortality and other adverse effects (e.g., growth, feeding rates, and behavioral changes) of benthic macroinvertebrates will be evaluated by comparing the measured concentrations of chemicals in sediment to screening values designed to be protective of ecological receptors.

- Surface water screening values - Mortality and other adverse effects (e.g., growth, feeding rates, and behavioral changes) of aquatic organisms will be evaluated by comparing the measured concentrations of chemicals in the surface water to screening values designed to be protective of ecological receptors.

8.2.4.3 Selection of Receptor Species

Many receptors in the soil, sediment, and surface water environments at SWMU 12 are grouped into general categories such as soil, sediment, or aquatic invertebrates and vegetation. This is a reflection of the nature of the threshold values, effects values, or criteria typically used to characterize risk for such organisms. However, for vertebrate receptors, selection of a representative species is required so that risks incurred by intake through eating and drinking can be estimated to these upper-level species.

Ingestion is the primary route of exposure for most mammals and birds. The selection of species used to represent the receptor groups identified in Section 8.2.4.1 was based on considerations of their preferred habitat, body size, sensitivity to contaminants, home range, abundance, commercial or sport utilization, legal status, and functional role (e.g., predators). To be conservative, chosen representative species have small home ranges. The availability of exposure parameters such as body mass, feeding rate, and drinking rate may also be a factor in selecting surrogate species. The following surrogate species are proposed for use in food-chain modeling:

- Herbivorous mammal - meadow vole
- Herbivorous bird - bobwhite quail
- Insectivorous mammal - short tail shrew
- Insectivorous bird - American woodcock
- Piscivorous mammal - mink
- Piscivorous bird - belted kingfisher

Receptor profiles for each of these species above are presented in Appendix J.3.

8.2.4.4 Conceptual Model

A conceptual model in problem formulation is a written description and visual representation of predicted relationships between ecological entities and the stressors to which they may be exposed. The

conceptual model consists of two primary components: predicted relationships among stressor, exposure, and assessment endpoint response and a diagram that illustrates the relationships (U.S. EPA, 1998).

The primary sources of known or potential contamination at SWMU 12 were identified based on past operational practices and the physical characteristics of the sites. As discussed in Section 1.0, the primary sources of contamination have been identified as explosive powders and particulates from MFA operations and wastewater discharged to ditches. These contaminants have been released to environmental media via washdown of explosive powders and particulates from rooftops, particulate emissions, leaks, and wastewater discharge; therefore, the primary stressors to ecological receptors are contaminants in surface soil, surface water, and sediment. The primary receptors for contaminants in surface soil are plants, invertebrates, amphibians, and reptiles, and secondary receptors are birds and mammals. The primary receptors for contaminants in surface water and sediment are fish, if present, amphibians, reptiles, and aquatic/benthic invertebrates, and secondary receptors are birds and mammals. Figure 8-6 presents the conceptual site model for SWMU 12.

8.3 ECOLOGICAL EFFECTS EVALUATION/SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN

8.3.1 Ecological Effects Evaluation

The preliminary ecological effects evaluation is an investigation of the relationship between the magnitude of exposure to a chemical and the nature and magnitude of adverse effects resulting from exposure. In addition to being a toxicological evaluation, it may also include descriptions of apparent effects seen during the site visit (i.e., stressed vegetation). Toxicity thresholds are usually expressed in units of concentration when the medium of concern is in intimate contact with the receptor, such as surface water for aquatic organisms or soil for soil invertebrates. For other receptors, such as terrestrial vertebrates, toxicity data are typically available as doses, with units equal to mass of contaminant per unit of body mass per unit of time (usually mg/kg-day).

As the first step in the ecological effects evaluation, COPCs were selected by comparing contaminant concentrations in surface water, sediment, and surface soil samples to Region 5 ecological screening levels (ESLs) (U.S. EPA, 2003a). U.S. EPA has developed Ecological Soil Screening Levels (Eco-SSLs) for a few chemicals. These values were used in place of the Region 5 ESLs because they are based on more recent data. Also, the Region 5 ESLs for surface water are the lowest water quality criteria for the various states in U.S. EPA Region 5. State of Indiana Water Quality Standards (WQSs) and U.S. EPA Water Quality Criteria (WQC) were considered; however, only WQCs were used in the Step 3a evaluation

because these values have been more recently updated. The following bullets present the rules used in the selection of COPCs:

- A contaminant was retained as a COPC for risks to plants and invertebrates, aquatic organisms, and benthic invertebrates and/or wildlife if the maximum detected concentration exceeded the associated ESL (or substituted screening level as described above) in surface soil, surface water, or sediment, respectively. Contaminants retained as COPCs are further evaluated as part of Step 3a of the eight-step ERA process.

- Calcium, magnesium, potassium, and sodium were not retained as COPCs in any medium because of their relatively low toxicity to ecological receptors and their high natural variability in concentrations. These metals are considered essential nutrients.

- Contaminants without ESLs (or substituted screening levels, as appropriate) were retained as COPCs for further evaluation as part of Step 3a of the eight-step ERA process.

An Ecological Effects Quotient (EEQ) approach was used to characterize the risk to ecological receptors. This approach characterizes potential effects by comparing exposure concentrations with effects data. The EEQs for terrestrial receptors were calculated as follows:

$$EEQ = \frac{C_{ss}}{SSSL}$$

where:

C_{ss} = Contaminant concentration in surface soil (µg/kg or mg/kg)

SSSL = Surface Soil Screening Level (µg/kg or mg/kg), as described above

The EEQs for aquatic receptors were calculated as follows:

$$EEQ = \frac{C_{sw}}{SWSL} \text{ or } \frac{C_{sd}}{SDSL}$$

where:

C_{sw} = Contaminant concentration in surface water (µg/L)

C_{sd} = Contaminant concentration in sediment (µg/kg or mg/kg)

SWSL = Surface Water Screening Level (µg/L)

SDSL = Sediment Screening Level (µg/kg or mg/kg)

An EEQ of greater than 1.0 was considered to indicate potential risk. Such values do not necessarily indicate that an effect will occur but only that a low (i.e., conservative) threshold has been exceeded.

8.3.2 Selection of Contaminants of Potential Concern at SWMU 12

Three surface soil data sets exist for SWMU 12 including: 1) historical surface soil samples collected as a part of the bioremediation program at SWMU 12, 2) SWMU 12 Proper surface soil samples collected during Round 1 of the SWMU 12 RFI, and 3) surface soil samples collected from the BDA during Round 1 of the SWMU 12 RFI. Historical samples collected during the bioremediation program (henceforth called historical surface soil samples) were biased around the buildings in order to evaluate pre-remedial activities and post-remediation conditions associated with the identification, removal, and treatment through bioremediation of explosives-contaminated soils. Historical samples were analyzed for explosives, metals, and VOCs. As discussed in Section 2.5, additional surface soil samples were also collected during one round as part of this SWMU 12 RFI. These samples (henceforth called SWMU 12 Proper and BDA surface soil samples) were analyzed for explosives, SVOCs, VOCs, and inorganics.

Similarly, three sediment and surface water data sets exist for SWMU 12 including: 1) gully sediment and surface water samples, 2) East Tributary sediment and surface water samples, and 3) Turkey Creek sediment and surface water samples. Sediment and surface water samples were collected from intermittent streams, drainageways, and surface runoff locations at SWMU 12 during the two rounds of sampling for the RFI. These data are identified as gully samples. Because SWMU 12 sits atop a ridge, gully samples were collected to evaluate contaminants migrating from the SWMU into the East Tributary of Turkey Creek that is located at the base of the ridge. East Tributary and Turkey Creek surface water and sediment samples were collected in order to evaluate contaminant concentrations that have already migrated from the SWMU and their impacts on aquatic receptors. Additionally, two sediment samples collected as a part of the SWMU 13 (Mine Fill B) RFI in Turkey Creek (13SD4501 and 13SD4401) were included in the Turkey Creek sediment data set because these samples were collected in Turkey Creek downstream of SWMU 12.

8.3.2.1 Surface Soil

Table 8-1 is the ecological screening table for surface soil samples collected as a part of the RFI from SWMU 12 Proper. Table 8-2 is the surface soil ecological screening table for samples collected during

the RFI from the Battery Disposal Area. Locations of surface soil samples collected during the RFI sampling events are illustrated in Figure 2-1. Table 8-3 is the ecological screening table for surface soil samples collected as part of the remedial activities at SWMU 12. As discussed in Section 1.2.3, the surface soil samples collected during remedial activities were located surrounding the buildings at SMWU 12. The maximum concentrations of each data set were used for the initial screenings. Chemicals selected as COPCs for plants/invertebrates and wildlife are highlighted in Tables 8-1, 8-2, and 8-3.

SWMU 12 Proper RFI Samples

Eight metals were selected as COPCs because the maximum detected concentrations exceeded associated ESLs. Additionally, two metals were selected as COPCs for further evaluation in Step 3a because no criteria are available. Five COPCs in surface soil were included in the food-chain model (Section 8.4.2) because they are considered bioaccumulative chemicals (U.S. EPA, 2000) (see Table 8-1).

Battery Disposal Area Samples

Two SVOCs, one energetic, and 16 metals were selected as COPCs because the maximum detected concentrations exceeded associated ESLs. Additionally, two energetics and two metals were selected as COPCs for further evaluation in Step 3a because no criteria are available. Thirteen COPCs were included in the food-chain model (Section 8.4.2) because they are considered bioaccumulative chemicals (U.S. EPA, 2000) (see Table 8-2). Although energetics are not listed in U.S. EPA, 2000 as important bioaccumulative chemicals, they were retained for food-chain modeling as a conservative measure.

Historical Samples

Six metals and one energetic were selected as COPCs because the maximum detected concentrations exceeded associated ESLs. Additionally, five energetics were selected as COPCs for further evaluation in Step 3a because no criteria are available. Twelve COPCs were included in the food-chain model (Section 8.4.2) because they are considered bioaccumulative chemicals (U.S. EPA, 2000) (see Table 8-3). Although energetics are not listed in U.S. EPA, 2000 as important bioaccumulative chemicals, they were retained for food-chain modeling as a conservative measure.

8.3.2.2 Sediment

Gully Samples

Table 8-4 is the ecological sediment screening table for downgradient gully samples collected at SWMU 12. Seven metals were selected as COPCs because the maximum detected concentrations exceeded associated ESLs. Additionally, one SVOC, one energetic, and seven metals were selected as COPCs for further evaluation in Step 3a because no criteria are available.

East Tributary Samples

Table 8-5 is the ecological sediment screening table for the downgradient East Tributary samples collected at SMWU 12. Three metals were selected as COPCs because the maximum detected concentrations exceeded associated ESLs. Additionally, six metals were selected as COPCs for further evaluation in Step 3a because no criteria are available.

Turkey Creek Samples

Table 8-6 is the ecological sediment screening table for the downgradient Turkey Creek sediment samples collected at SWMU 12. Four metals were selected as COPCs because the maximum detected concentrations exceeded associated ESLs. Additionally, seven metals were selected as COPCs for further evaluation in Step 3a because no criteria are available. Five metals COPCs were included in the food-chain model (Section 8.4.2) because they are considered bioaccumulative chemicals (U.S. EPA, 2000) (see Table 8-6).

8.3.2.3 Surface Water

Gully Samples

Table 8-7 is the ecological surface water screening table for the downgradient gully samples collected at SWMU 12. Fifteen total metals and seven dissolved metals were selected as COPCs because the maximum detected concentrations exceeded associated ESLs. Additionally, five energetics, one total metal, one dissolved metal, and nitrite/nitrate-N were selected as COPCs for further evaluation in Step 3a because no criteria are available for comparison to the maximum concentrations. All five energetic COPCs, nine total metals COPCs, and four dissolved metals COPCs were included in the food-chain model (Section 8.4.2) because they are considered bioaccumulative chemicals (U.S. EPA, 2000) (see Table 8-7).

East Tributary Samples

Table 8-8 is the ecological surface water screening table for the downgradient East Tributary samples collected at SWMU 12. Two total metals and one dissolved metal were selected as COPCs because the maximum detected concentrations exceeded associated ESLs. Additionally, one energetic, total and dissolved manganese, and nitrite/nitrate-N were selected as COPCs for further evaluation in Step 3a because no criteria are available.

Turkey Creek Samples

Table 8-9 is the ecological surface water screening table for the downgradient Turkey Creek samples collected at SWMU 12. Manganese (total and dissolved) was selected as a COPC because no criteria is available.

8.3.2.4 Summary

Historical data collected as part of SWMU 12 remedial activities as well as SWMU 12 Proper and BDA surface soil samples were evaluated as part of a conservative ecological screening on surface soils at SWMU 12. Additionally, sediment and surface water data that were collected from the gullies at SWMU 12, the East Tributary, and Turkey Creek were evaluated. Chemicals selected as COPCs were evaluated further in the Step 3a evaluation.

In summary, a SERA was performed for SWMU 12. Adequate information exists to determine that potential risks are possible for receptors exposed to the selected COPCs because concentrations for some chemicals either exceeded the screening values or screening values do not exist for some chemicals. Therefore, the SERA is advancing to the Step 3a of the BERA – the refinement of the site-related COPCs.

8.4 STEP 3A -REFINEMENT OF CONSERVATIVE EXPOSURE ASSUMPTIONS

Step 3a consists of refining the conservative exposure assumptions/concentrations when evaluating potential risks to ecological receptors (i.e., plants, invertebrates, and wildlife receptors) and re-evaluating the analytical data using benchmarks that may be more appropriate for the assessment endpoints. The objective of the Step 3a evaluation is to further reduce the number of chemicals retained as COPCs, if possible, to focus any additional efforts on those chemicals causing ecological concern. The Step 3a evaluation is designed to eliminate chemicals from further evaluation for certain groups of receptors. For

example, a chemical may not be retained as a COPC in soil based on risks to soil invertebrates but may be retained for evaluating risks to plants or wildlife. Therefore, chemicals are evaluated during Step 3a in order of plants/invertebrates, aquatic receptors, and wildlife.

Figures 8-2, 8-3, and 8-4 are flow charts that present the ERA process used to evaluate risks to ecological receptors from chemicals in the surface soil, sediment, and surface water, respectively. The following sections describe the process for further evaluating chemicals initially selected as COPCs in soil, sediment, and surface water.

Surface Soil

Chemicals initially selected as COPCs in surface soil were carried through three independent flow paths: 1) to further evaluate risks to plants, 2) to further evaluate risks to invertebrates, and 3) to further evaluate risks to wildlife (i.e., mammals and birds). This evaluation was conducted to determine whether there are potential risks to all three receptor groups (i.e., plants, invertebrates, and wildlife), or to only one or two of the receptor groups. This is important because if the site proceeds further in a BERA, the studies in the BERA should only focus on the receptors that are at potential risk. Because most of the Region 5 soil screening levels are based on risks to mammals or birds, potential risks to plants and invertebrates are not known. Therefore, the first step in the Step 3a evaluation was to compare the maximum chemical concentrations in soil to "no-effects benchmarks" for plants and invertebrates such as the U.S. EPA Eco SSLs for those receptors. Although some of the alternate benchmarks may be based on effects concentrations such as effects concentration for 20 percent of test population (EC_{20}), samples with chemical concentrations less than the no-effects benchmarks are not expected to have significant effects. The following bullets outline decisions made based on this comparison:

- If the concentration was less than the no-effects benchmark, it was concluded that the chemical is not causing an unacceptable risk to that receptor group, and the chemical was not evaluated further in Step 3a.

- If the chemical concentration was greater than the no-effects benchmark (or the chemical does not have a no-effects benchmark), the chemical was further evaluated in Step 3a to determine if the risks are great enough to warrant additional evaluations [e.g., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS), etc.].

- If the concentration was greater than the no-effects benchmark (or the chemical does not have a no-effects benchmark) but is less than background concentrations, it was concluded that the chemical is

not causing an unacceptable site-related risk to that receptor group, and the chemical was not evaluated further in Step 3a.

Concurrent with the evaluation of risks to plants and invertebrates, bioaccumulative chemicals selected as COPCs were evaluated to determine if there are unacceptable risks to wildlife. Even though the conservative COPC screening level may have been based on risks to wildlife, risks to wildlife were further evaluated in Step 3a to determine potential risks under a less conservative exposure scenario. The first step in the process was to determine whether the COPC is bioaccumulative. A chemical was considered to be bioaccumulative, and thus carried through the food-chain model, if it was included in the list of important bioaccumulative chemicals in U.S. EPA (2000). Also, some chemicals, such as energetics, that are not typically considered to be very bioaccumulative were included in the food-chain models to be conservative. Non-bioaccumulative chemicals were not carried through the food-chain model, and it was concluded that they are not causing an unacceptable risk to wildlife. The following bullets outline decisions made based on the results of the food-chain model:

- If the EEQ (see Section 8.3.1) was less than 1.0 using average contaminant concentrations and exposure factors and the No Observable Adverse Effects Level (NOAEL) as the TRV, it was concluded that the chemical is not causing an unacceptable risk to wildlife, and the chemical was not evaluated further in Step 3a.

- If the EEQ was greater than 1.0 using average contaminant concentrations and exposure factors and the NOAEL as the TRV, the chemical was further evaluated in Step 3a to determine if the risks are great enough to warrant additional evaluations [e.g., proceed to a BERA, develop cleanup levels, proceed to a CMS, etc.].

- If the EEQ was greater than 1.0 using average contaminant concentrations and exposure factors and the NOAEL as the TRV, but the concentration of the chemical was less than background, it was concluded that the chemical is not causing an unacceptable site-related risk to wildlife, and the chemical was not evaluated further in Step 3a.

For chemicals evaluated further in Step 3a, the other Step 3a factors described below were used to determine if the risks are great enough to warrant additional evaluations [e.g., proceed to a BERA, develop cleanup levels, proceed to a CMS, etc.].

Sediment

Chemicals initially selected as COPCs in sediment were carried through two independent flow paths, 1) to further evaluate risks to invertebrates, and 2) to further evaluate risks to terrestrial wildlife (i.e., mammals and birds). This further evaluation was conducted to determine if there are potential risks from that chemical to both receptor groups (i.e., invertebrates and wildlife), or to only one of the receptor groups. This is important because if the site proceeds further in a BERA, the studies in the BERA should only focus on the receptors that are at potential risk. Because many of the Region 5 sediment screening levels are based on equilibrium partitioning, the maximum contaminant concentration was compared to an alternate lower effects level following the order of preference listed below (as applicable):

- Canadian Sediment Guidelines (OMOE, 1993) Lowest Effects Levels
- Long and Morgan (1991) Effects-Range Low
- Long et al. (1995) Effects-Range Low
- Other values, as necessary and available

The following bullets outline decisions made based on this comparison:

- If the concentration was less than the lower-effects benchmark, it was concluded that the chemical is not causing an unacceptable risk to invertebrates, and the chemical was not evaluated further in Step 3a.

- If the concentration was greater than the lower-effects benchmark, the chemical was further evaluated in Step 3a to determine if the risks are great enough to warrant additional evaluations (e.g., proceed to a BERA, develop cleanup levels, proceed to a CMS, etc.).

- If the concentration was greater than the lower-effects benchmark but the chemical concentration was less than upgradient concentrations, it was concluded that the chemical is not causing an unacceptable site-related risk to invertebrates, and the chemical was not evaluated further in Step 3a.

For chemicals evaluated further in Step 3a, the other Step 3a factors described below were used to determine if the risks are great enough to warrant additional evaluations (i.e., proceed to a BERA, develop cleanup levels, proceed to a CMS, etc.).

Surface Water

Chemicals selected as COPCs in surface water were carried through two independent flow paths: 1) to further evaluate risks to aquatic organisms, and 2) to further evaluate risks to terrestrial wildlife (i.e., mammals and birds). As discussed above, this further evaluation was conducted to determine if there are potential risks from that chemical to both receptor groups (i.e., invertebrates and wildlife) or to only one of the receptor groups. This is important because if the site proceeds further in a BERA, the studies in the BERA should only focus on the receptors that are at potential risk. Organic chemicals initially selected as COPCs were evaluated directly in Step 3a. However, for metals, the following decisions were made:

- If the metal was either not detected in the filtered sample or was detected at a concentration less than the screening level in the filtered (i.e., dissolved) sample, it was concluded that the chemical is not causing an unacceptable risk to aquatic organisms, and the chemical was not evaluated further in Step 3a.

- If the metal was detected in the filtered (i.e., dissolved) sample at a concentration greater than the screening level, and the chemical concentration was greater than upgradient concentrations, it was concluded that the chemical may be causing an unacceptable risk to aquatic organisms and the chemical was evaluated further in Step 3a.

- If the metal was detected in the filtered (i.e., dissolved) sample at a concentration greater than the screening level, but the chemical concentration was less than upgradient concentrations, it was concluded that the chemical is not causing an unacceptable risk to aquatic organisms and the chemical was not evaluated further in Step 3a.

Concurrent with the evaluation of risks to aquatic organisms, chemicals retained as site-related COPCs were further evaluated to determine if there are unacceptable risks to terrestrial wildlife. The following bullets outline decisions made based on the results of the food-chain model:

- If the EEQ was less than 1.0 (based on the surface water portion of the food-chain model) using average contaminant concentrations and exposure factors and the NOAEL as the TRV, it was concluded that the chemical is not causing an unacceptable risk to terrestrial wildlife.

- If the EEQ was greater than 1.0 (based on the surface water portion of the food-chain model) using average contaminant concentrations and exposure factors and the NOAEL as the TRV, and the chemical concentration was greater than background (or upgradient concentrations) the chemical

was further evaluated in Step 3a to determine if the risks are great enough to warrant additional evaluations (e.g., proceed to a BERA, develop cleanup levels, proceed to a CMS, etc.).

- If the EEQ was greater than 1.0 using average contaminant concentrations and exposure factors and the NOAEL as the TRV, but the chemical concentration was less than background (or upgradient concentrations), it was concluded that the chemical is not causing an unacceptable site-related risk to terrestrial wildlife.

For chemicals evaluated further in Step 3a, the other Step 3a factors described below were used to determine if the risks are great enough to warrant additional evaluations (e.g., proceed to a BERA, develop cleanup levels, proceed to a CMS, etc.).

Other Step 3a Factors

For chemicals evaluated further in Step 3a, the following factors were evaluated, as appropriate, to determine if the risks are great enough to warrant additional evaluations (e.g., proceed to a BERA, develop cleanup levels, proceed to a CMS). All of these factors may not be discussed for each chemical and/or receptor group.

- Magnitude of criterion exceedance: Although the magnitude of the risks may not relate directly to the magnitude of a criterion exceedance, the magnitude of the criterion exceedance may be one item used in a lines-of-evidence approach to determine the need for further site evaluation. The greater the criterion exceedance, the greater the probability and concern that an unacceptable risk exists.

- Frequency of chemical detection and spatial distribution: A chemical detected at a low frequency typically is of less concern than a chemical detected at higher frequency if toxicity and concentrations and spatial areas represented by the data are similar. All else being equal, chemicals detected frequently were given greater consideration than those detected relatively infrequently. In addition, the spatial distribution of a chemical may be evaluated to determine the area that a sample represents.

- Contaminant bioavailability: Many contaminants (especially metals) are present in the environment in forms that are typically not bioavailable, and limited bioavailability was considered when evaluating the exposures of receptors to site contaminants. Contaminants with generally less bioavailability are considered to be less toxic than the more bioavailable contaminants, all other factors being equal.

- Habitat: Although exceedances of criteria may occur, potential risks to ecological receptors may be minimal if there is little habitat for those receptors. Therefore, the extent of habitat was used qualitatively when considering additional evaluation. Areas with little habitat were less of a concern than areas with suitable habitat to support the receptors of interest.

- Alternate benchmarks: These benchmarks are used to further evaluate risks to specific groups of ecological receptors (e.g., plants, invertebrates) because while ESLs are useful for initial screening, they are the most conservative values available for soil, sediment, and surface water evaluation. For example, the ESLs for soil may be based on risks to small mammals. Therefore, an exceedance of that ESL does not necessarily indicate that potential risks to plants or invertebrates exist, so other more appropriate benchmarks were used to evaluate potential risks to those receptors. Use of these alternate benchmarks was case-specific.

In addition to the general Step 3a factors above, other factors were evaluated in Step 3a for each receptor group. The following sections discuss the other factors that may be used, including the specific alternate benchmarks that may be used in Step 3a.

Terrestrial Plants and Invertebrates: The alternate benchmarks used to further evaluate risks to plants and invertebrates are listed below. The ecological endpoint for each benchmark that was used in this step was provided in the ERA. For example, if a benchmark is based on a 25 percent reduction in growth of a lettuce plant, that information was presented.

- Canadian Soil Quality Guidelines (EC, 1999).

- Oak Ridge National Laboratory (ORNL) Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision (Efroymson, et al., 1997a).

- ORNL Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision (Efroymson, et al., 1997b).

Additional sources of toxicity data from the literature were used to evaluate potential risks to terrestrial vegetation and invertebrates from surface soil contaminants not included in the above documents.

Sediment: In addition to the Step 3a factors presented above, additional evaluations for sediment included comparing chemical concentrations in the sediment to higher effects levels to show the probability of a range of possible effects. The higher effects levels used to further evaluate risks to benthic invertebrates were from the same sources listed in order of preference in the sediment subsection above. A description of what the higher effects levels used in this step represent is provided in the Step 3a. For example, the Consensus-based Probable Effect Concentrations (PECs) were intended to identify contaminant concentrations above which harmful effects on sediment-dwelling organisms were expected to occur frequently (MacDonald et al., 2000).

Also, emphasis was placed on average sediment concentrations because aquatic organisms are exposed to average chemical concentrations as they swim in the water or as the sediment is transported downstream.

Surface Water: In addition to the Step 3a factors presented above, additional evaluations for surface water included comparing chemical concentrations in surface water to acute water quality standards/criteria to show a range of possible effects. Also, emphasis was placed on average surface water concentrations because aquatic organisms are exposed to average chemical concentrations as they swim in the water or as the water flows over them (for organisms that are relatively sessile). More emphasis was placed on dissolved metals concentrations (compared to total metals concentrations) because dissolved metals are a better indicator of potential bioavailability than are total recoverable metals.

8.4.1 Terrestrial Plants, Terrestrial and Aquatic Invertebrates, and Fish

Potential risks to terrestrial plants, terrestrial and aquatic invertebrates, and fish from exposure to chemicals initially selected as COPCs were further evaluated as discussed above. The following subsections discuss whether COPCs are retained for further evaluation for soil invertebrates and terrestrial vegetation (Section 8.4.1.1), benthic invertebrates (Section 8.4.1.2), and aquatic organisms (Section 8.4.1.3). COPCs based on risks to upper-level receptors via the food chain are discussed in Section 8.4.2.

8.4.1.1 Soil Invertebrates and Terrestrial Vegetation – Surface Soil Risk

Risks to terrestrial plants and invertebrates resulting from exposure to the COPCs in surface soil are evaluated using the methodologies described above (Section 8.4). Table 8-10 presents a summary of

some of the common alternate benchmarks available for surface soil COPCs, along with a summary of the Step 3a evaluation. The toxicological basis of the alternate benchmarks is presented below.

8.4.1.1.1 MFA Proper Surface Soil

Antimony

Antimony was initially selected as a COPC because the maximum detected soil concentration of 1.4 mg/kg exceeded the U.S. EPA Eco-SSL of 0.27 mg/kg. However, the Eco-SSL is based on risks to mammals and not risks to plants and invertebrates. Therefore, antimony concentrations were compared to the following alternate benchmarks to evaluate risks to plants and invertebrates:

- Eco-SSL for soil invertebrates - 78 mg/kg (U.S. EPA, 2005a)
- ORNL Plant - 5 mg/kg (Efroymson et al., 1997b)

The Eco-SSL for soil invertebrates is the geometric mean of the EC_{20} values reported for each of three test species (i.e., enchytraeid, springtail, and earthworm) exposed under similar conditions. An Eco-SSL for plants is not available. The ORNL plant value of 5 mg/kg is based on a report of unspecified toxic effects on plants grown in surface soil with the addition of 5 mg/kg antimony.

The maximum detected antimony concentration in MFA proper samples is less than the values for risks to plants and invertebrates. Therefore, risks to plants and invertebrates are acceptable; antimony is not retained as a COPC for further evaluation in this area.

Chromium

Chromium was initially selected as a COPC because the maximum soil concentration of 26.9 mg/kg exceeded the U.S. EPA Eco-SSL of 26 mg/kg. However, the Eco-SSL is based on risks to birds and not plants and invertebrates. Eco-SSLs for plants and invertebrates are not available for chromium; therefore, chromium concentrations were compared to the following alternate benchmark to evaluate risks to plants and soil invertebrates:

- Canadian Soil Quality Guideline (SQG) - 64 mg/kg (EC, 1999a)

As presented in the supporting document for the Canadian SQG for chromium (EC, 1999a), the Canadian guideline for total chromium (64 mg/kg) is the geometric mean of the threshold effects concentration

(TEC) of 78 mg/kg for risks to plants and invertebrates and the nutrient and energy cycling check (NECC) value of 52 mg/kg. The TEC is the sixth of 22 data points associated with the no observable effects and observable effects data for plants and invertebrates and corresponds to the average radish germination EC_{25}. As detailed in the supporting document, no effects concentrations for earthworms (235 mg/kg to 900 mg/kg) were greater than no effects concentrations for plants (10 mg/kg to 230 mg/kg), indicating invertebrates are less sensitive to total chromium than plants. Additionally, the Canadian SQG is based on *total* chromium (for which soil samples at this site were analyzed). Chromium toxicity is due primarily to hexavalent chromium; other forms of chromium are much less toxic (Eisler, 1986). It is unlikely that most, if any, chromium in SWMU 12 soil is hexavalent chromium. Trivalent chromium is the predominant form of this metal in most soils and is not bioavailable (Eisler, 1986).

The maximum concentration of chromium is less than the SQG; therefore, risks to plants and invertebrates are acceptable overall, and chromium is not retained as a COPC for these receptors. However, because chromium is a bioaccumulative chemical, risks to wildlife from chromium are evaluated in Section 8.4.2 of this ERA.

Cobalt

Cobalt was initially selected as a COPC because the maximum concentration of 15.7 mg/kg exceeded the U.S. EPA Eco-SSL for plants of 13 mg/kg. However, the maximum background concentration for Soil Group 3 is 27.1 mg/kg (see Table 3-2); therefore, site-related risks to plants and invertebrates from cobalt are acceptable and cobalt is not retained as a COPC.

Copper

Copper was initially selected as a COPC because the maximum detected soil concentration of 19 mg/kg exceeded the Region 5 ecological screening level (ESL) of 5.4 mg/kg. However, the ESL is based on risks to wildlife (i.e., the masked shrew) and not risks to plants and invertebrates. Therefore, the maximum copper concentration was compared to the SQG and ORNL values to evaluate risks to plants and invertebrates:

- Canadian SQG – 63 mg/kg (CCME, 1997)

The copper Canadian SQG of 63 mg/kg is the 25th percentile of effects and no effects data distribution for plants and invertebrates, which is the seventeenth of 69 data points and corresponds to an effect on radish seedling emergence. Therefore, some studies showed effects at less than 63 mg/kg but many

more studies did not show effects at this concentration. Copper concentrations less than the Canadian SQG of 63 mg/kg are expected to be protective of plants and invertebrates.

The maximum detected copper concentration is less than the SQG. Therefore, risks to plants and invertebrates from copper are acceptable and copper is not retained as a COPC for further evaluation in this area. Because copper is a bioaccumulative chemical, risks to wildlife from copper are evaluated in Section 8.4.2 of this ERA.

Iron

Iron was initially selected as a COPC for soil invertebrates because a Region 5 ESL (and U.S. EPA Eco-SSL) is not available. Iron was detected in all nine SWMU 12 Proper surface soil samples at concentrations ranging from 18,800 mg/kg to 30,600 mg/kg. According to the Ecological SSL for iron (U.S. EPA, 2003b), iron is essential for plant growth and is generally considered to be a micronutrient. Because plants regulate its uptake, iron is not expected to be toxic to plants in well-aerated soils with pH levels between 5 and 8 standard units (S.U.) (U.S. EPA, 2003b). Measured pH levels ranged from 6 to 7.7 S.U. at SWMU 12. For this reason, iron was not selected as a COPC for plants. No toxicity data were located to evaluate risks to invertebrates from iron; however concentrations in SWMU 12 Proper samples are within the range of background concentrations for Soil Group 3 (10,700 mg/kg - 36,200 mg/kg) (see Table 3-2). Additionally, iron is generally considered a non-toxic metal and it is highly unlikely that soil invertebrates are being impacted by iron at the SWMU. For these reasons, any potential site related risks to plants and invertebrates from iron are considered acceptable and iron is not retained as a COPC for risks to these receptors.

Lead

Lead was initially selected as a COPC because the maximum soil concentration of 31.2 mg/kg exceeded the U.S. EPA Eco-SSL for birds of 11 mg/kg. Because the Eco-SSL used in the conservative COPC screening is based on risks to wildlife and not risks to plants and invertebrates, lead concentrations were compared to the following U.S. EPA Eco-SSLs for soil invertebrates and plants to evaluate risks to these receptors:

- Eco-SSL for soil invertebrates – 1,700 mg/kg (U.S. EPA, 2005b)
- Eco-SSL for plants – 120 mg/kg (U.S. EPA, 2005b)

The Eco-SSL for soil invertebrates is the geometric mean of the maximum acceptable toxicant concentrations (MATC) values for one test species (*Folsomia candida*) under three different test conditions (pH of 4.5 to 6.0 S.U.) and is based on a reproductive endpoint. The Eco-SSL for plants is the geometric mean of the MATC values for four test species under three different test conditions (pH of 4.0 to 6.3 S.U.). The ecological endpoint for the derivation of the Eco-SSL for plants was growth.

The maximum concentration is less than the Eco-SSLs for soil invertebrates and plants; therefore, risks to these receptors are acceptable so lead is not retained as a COPC for further evaluation in this area. Because lead is a bioaccumulative chemical, risks to wildlife from lead are evaluated in Section 8.4.2 of this ERA.

Manganese

Manganese was initially selected as a COPC because a Region 5 ESL is not available; therefore, manganese concentrations were compared to the following ORNL values to evaluate risks to plants and invertebrates:

- ORNL Plant – 500 mg/kg
- ORNL Soil Microorganisms and Microbial Processes – 100 mg/kg

An ORNL value for earthworms is not available, so the ORNL soil microorganisms and microbial processes value was used instead. The value is based on a 21-day study in which nitrification by native soil microflora (in a sandy loam soil) was severely inhibited at 100 ppm manganese added as a sulfate salt. The ORNL plant value is based on a 17-day study in which stem weight of bush beans grown in loam soil was reduced by 29 percent at a concentration of 500 ppm manganese sulfate.

Manganese was detected at a maximum concentration of 1,080 mg/kg at location 12SS01. Although the maximum manganese concentration at SWMU 12 is greater than the ORNL values, concentrations of manganese are within the range of background concentrations for Soil Group 3 (268 mg/kg to 3,040 mg/kg) (see Table 3-2). Therefore, manganese in surface soil at SMWU 12 does not appear to be related to historical activities, and site-related risks to plants and soil invertebrates are acceptable. Manganese is not retained as a COPC for risks to these receptors.

Nickel

Nickel was initially selected as a COPC because the maximum concentration of 21.4 mg/kg exceeded the Region 5 ESL of 13.6 mg/kg. However, the ESL is based on risks to wildlife (i.e., the masked shrew) and not risks to plants and invertebrates. Therefore, the maximum nickel concentration was compared to the following Canadian SQG to evaluate risks to plants and invertebrates:

- Canadian SQG – 50 mg/kg (EC, 1999b)

The Canadian SQG (soil contact) is the 25th percentile (eighth datum point of 31) of 50 mg/kg from a study in which unspecified effects on onion growth were noted. The maximum concentration is less than the SQG and so risks to plants and invertebrates at SWMU 12 are acceptable; nickel is not retained as a COPC for risks to plants and invertebrates. However, because nickel is a bioaccumulative chemical, risks to wildlife from nickel are evaluated in Section 8.4.2.

Vanadium

Vanadium was initially selected as a COPC because the maximum concentration of 48.6 mg/kg exceeded the U.S. EPA Eco-SSL of 7.8 mg/kg. However, the Eco-SSL is based on risks to birds and not risks to plants and invertebrates. Therefore, vanadium concentrations at SWMU 12 were compared to the following Canadian SQG to evaluate risks to these receptors:

- Canadian SQG – 130 mg/kg (EC, 1999c)

The Canadian SQG of 130 mg/kg corresponds to the third of 10 data points, which is the 25th percentile based on seedling emergence by lettuce. The maximum vanadium concentration is less than the SQG and so risks to plants and invertebrates from vanadium at SWMU 12 are acceptable; vanadium is not retained as a COPC.

Zinc

Zinc was initially selected as a COPC because the maximum soil concentration of 165 mg/kg exceeded the ESL of 6.62 mg/kg. However, even though the ESL is based on risks to invertebrates, the following alternate benchmark was used to further evaluate risks to plants and soil invertebrates:

- Canadian SQG – 200 mg/kg (EC, 1999d)

The Canadian SQG of 200 mg/kg is the lowest LOEC of the plants and invertebrate data set and is based on an effect on seedling emergence for radish (EC, 1999d). The weight-of-evidence method was not used to develop the SQG because greater than 50 percent of the "effects" data were dominated by median effective or median lethal concentrations (EC, 1999d). As presented in Appendix VI of the Canadian SQG document (EC, 1999d), all of the earthworm effects and no-effects data (with the exception of one test in one study) were equal to or greater than 200 mg/kg, indicating that earthworms appear to be less sensitive to zinc than plants. As indicated in Efroymson et al., (1997a), the ORNL benchmark for invertebrates (100 mg/kg) is lower than concentrations at which effects have been observed. This is further supported by the toxicity test data presented in the Canadian SQG document for earthworms.

The maximum zinc detected concentration of zinc is less than the Canadian SQG. Therefore, risks to plants and invertebrates from zinc are acceptable, and zinc is not retained for further evaluation. Because zinc is a bioaccumulative chemical, risks to wildlife from zinc are evaluated in Section 8.4.2.

Summary of SWMU 12 Proper Surface Soil Risks

In summary, the list of chemicals initially selected as COPCs in SWMU 12 Proper surface soil samples were further evaluated in Step 3a, the first step of the BERA. After a review of alternate toxicity information (based on soil invertebrates and plants) for the initial COPCs was conducted, maximum and average concentrations were compared to the alternate toxicity information, as appropriate.

No chemicals initially selected as COPCs in SWMU 12 Proper surface soil samples were retained as COPCs.

8.4.1.1.2 Battery Disposal Area Surface Soil

As discussed in Section 1.2.3, an interim measure action was conducted at the Battery Disposal Area (BDA) in October 2001 and June 2002. Pre-excavation sampling and analysis of soil samples from the Soil Area and Battery Area indicated that contamination was present in each area at concentrations greater than the industrial clean-up goals. Explosives contamination was present in the Soil Area, and metals contamination was present in the Battery Area. Based on the remedial actions, no further action was recommended for the Soil Area.

In September 2004, excavation activities to address contamination left in place at the Soil Area began by removing small trees and boulders. A vein of contamination was excavated. Four post-excavation soil samples (12SS210002, 12SS220002, 12SS230002, and 12SS240002) were collected. One sample (12SS210002) was obtained from the vein of contamination in the trench that was dug at the southern end of the area of excavation. This sample had the highest concentrations of most energetic and inorganic contaminants. These samples confirmed that contaminated soil is still present at the site.

Phthalates

Bis(2-ethylhexyl) phthalate and di-n-butyl phthalate were initially selected as COPCs because the single detected concentrations of each chemical slightly exceeded the Region 5 ESL. However, the ESLs for these phthalates are based on risks to wildlife (i.e., the masked shrew) and not risks to plants and invertebrates. ORNL benchmarks for plants and invertebrates are available for some phthalates. Therefore, the bis(2-ethylhexyl) phthalate and di-n-butyl phthalate concentrations were compared to the following ORNL values to evaluate risks to plants and invertebrates:

- ORNL Plant (di-n-butyl phthalate)– 200 mg/kg (Efroymson et al., 1997b)
- ORNL Plant [bis (2-ethylhexyl) phthalate] – 100 mg/kg (Efroymson et al., 1997b)
- ORNL Earthworm (dimethyl phthalate) – 200 mg/kg (Efroymson et al., 1997a)

The bis(2-ethylhexyl) phthalate ORNL benchmark for plants is based on an EC_{50} value of 134 mg/kg based on effects on the growth of lettuce from seedling to 14 days in loam soils. Even though the ORNL benchmark is based on an EC_{50} concentration, the maximum detected concentration is much lower than the ORNL plant benchmark, so impacts to plants are not expected. Therefore, risks to plants from bis(2-ethylhexyl) phthalate are acceptable, and bis(2-ethylhexyl) phthalate is not retained as a COPC for risks to plants. The single detected concentration for di-n-butyl phthalate (1.3 mg/kg) is well below the ORNL plant value.

No benchmarks are available for bis(2-ethylhexyl) phthalate and di-n-butyl phthalate to evaluate risks to earthworms; therefore, the ORNL earthworm benchmark for dimethylphthalate (200 mg/kg) was used because the toxicity of these phthalates is anticipated to be generally similar in magnitude. The ORNL earthworm benchmark for dimethylphthalate was developed based on survival of adults of four earthworm species. After 14 days, a three-fold difference in sensitivity of the earthworms was observed. An LC_{50} value of 1,064 mg/kg was the lowest toxic concentration of the three reported. The ORNL earthworm value of 200 mg/kg for dimethylphthalate was obtained by dividing the LC_{50} (1,064 mg/kg) by a safety factor five (Efroymson et al., 1997a). Although there are uncertainties in comparing the maximum

bis(2-ethylhexyl) phthalate and di-n-butylphthalate concentrations to toxicity information available for dimethylphthalate benchmarks, the maximum bis(2-ethylhexyl) phthalate and di-n-butylphthalate concentrations are much less than the ORNL earthworm benchmark for dimethylphthalate, so impacts to invertebrates are not likely.

Phthalates are frequent laboratory contaminants and are used in the production of plastics; therefore, their presence at SWMU 12 is unlikely related to site activities because plastics were never produced at SWMU 12. Additionally, these phthalates were only detected in one of 11 samples collected at concentrations only slightly exceeding the conservative screening value, and were less than the ORNL values for risks to plants and earthworms using other phthalates as surrogates. Therefore, risks to plants and invertebrates from bis(2-ethylhexyl) phthalate and di-n-butyl phthalate are acceptable, and these phthalates are not retained for further evaluation.

Energetics

1,3,5-Trinitirobenzene was initially selected as a COPC because the maximum soil concentration of 0.84 mg/kg was greater than the ESL of 0.376 mg/kg. 1,3,5-Trinitrobenzene was detected in only one of 11 samples collected at the BDA. The ESL is based on exposure to wildlife (meadow vole) and not risks to invertebrates and plants; however, no other alternate toxicity data for plants and invertebrates exposed to 1,3,5-trinitrobenzene are available. Despite the uncertainties that exist in evaluating risks to invertebrates and plants because an alternate benchmark for these receptors could not be located, the one detection at the BDA (out of 11 samples) at a concentration slightly greater than the ESL does not warrant retaining 1,3,5-trinitrobenzene as a COPC. Although 1,3,5-trinitrobenzene is not considered a bioaccumulative chemical, risks to wildlife are evaluated in Section 8.4.2 of this ERA to be conservative.

HMX was initially selected as a COPC because a Region 5 screening level is not available. The only available alternate toxicity information for HMX is a LOEC of 280 mg/kg for earthworm reproduction (Robidoux et al., 2001). The LOEC is based on the number of juveniles hatching per cocoon being significantly reduced by HMX at 280 mg/kg in soil; a NOEC was not generated from the study (Robidoux et al., 2001). LOEC values are the lowest concentrations at which effects have been observed while NOEC values are defined as the highest concentration at which effects are not observed. Typically, concentrations between NOEC and LOEC values represent a range where the actual effects concentration (i.e., the concentration where effects on the test organism are first observed) is uncertain. In cases where only a LOEC is reported, it is common practice to divide the LOEC value by an uncertainty factor of 10 in order to estimate a NOEC value. Also, productivity of cocoons and juveniles as well as total biomass of juveniles were significantly reduced by HMX at >280 mg/kg in soil (Robidoux et

al., 2001). HMX was detected in only one of 11 samples collected at the BDA at a concentration of 1.7 mg/kg, which is less than the LOEC for earthworm reproduction and less than the estimated NOEC of 28 mg/kg (i.e., if the LOEC is divided by an uncertainty factor of 10). Therefore, risks to soil invertebrates are acceptable. No toxicological data for plants could be located. However, contaminated soil was excavated from the BDA in September 2001 and June 2002. After excavation, the BDA was seeded, and grass now covers the remediated area; therefore, plants, at least grasses, do not appear to be impacted by HMX in the soil. The surrounding vegetation and forested area were not affected by the remediation. Therefore, despite uncertainties in evaluating risks to plants at the BDA despite a lack of toxicity information, the potentially impacted area only represents a small percentage of potential habitat at the BDA and risks to the plant community (if any) are not expected to be significant. Although HMX is not considered a bioaccumulative chemical, risks to wildlife are evaluated in Section 8.4.2 of this ERA to be conservative.

RDX was initially selected as a COPC because a Region 5 screening level is not available. Therefore, the RDX concentration was compared to a plant effects concentration of 100 mg/kg (Talmage et al., 1999) and a LOEC of 95 mg/kg for earthworm reproduction (Robidoux et al., 2000). The plant benchmark of 100 mg/kg from Talmage et al. (1999) is from a study in which an RDX concentration of 100 mg/kg significantly reduced the biomass of cucumber plants. The LOEC for earthworm reproduction was based on the productivity of juveniles (total number of juveniles, biomass, and number of juveniles per hatched cocoon) being significantly reduced by RDX at 95 mg/kg in soil; a NOEC was not generated from the study (Robidoux et al., 2000). RDX was detected in only one of 11 samples collected at the BDA at a concentration of 6.1 mg/kg. The RDX concentration is less than the alternate benchmarks for plants and invertebrates and is less than the earthworm estimated NOEC of 9.5 mg/kg (i.e., if the LOEC is divided by an uncertainty factor of 10). Therefore, risks to invertebrates and plants from RDX in the soil are acceptable, and RDX is not retained as a COPC for risks to plants and invertebrates. Although, RDX is not considered a bioaccumulative chemical, risks to wildlife are evaluated in Section 8.4.2 of this ERA to be conservative.

Antimony

Antimony was initially selected as a COPC because the maximum detected soil concentration of 3,610 mg/kg at location 12SS21 exceeded the U.S. EPA Eco-SSL for mammals of 0.27 mg/kg. Because the Eco-SSL is based on risks to mammals and not risks to plants and invertebrates, antimony concentrations were compared to the following alternate benchmarks to evaluate risks to plants and invertebrates:

- Eco-SSL for soil invertebrates - 78 mg/kg (U.S. EPA, 2005a)
- ORNL Plant - 5 mg/kg (Efroymson et al., 1997b)

Antimony was detected at concentrations exceeding the ORNL plant value at four of the locations at the BDA (12SS21 through 12SS24). Two of these locations also had sample concentrations exceeding the Eco-SSL for soil invertebrates (12SS21 and 12SS24). Concentrations of other metals were also elevated with respect to criteria for plants and soil invertebrates at these locations.

In summary, risks to plants from antimony in the surface soil are possible at locations 12SS21 through 12SS24 and to soil invertebrates at locations 12SS21 and 12SS24. Risks to plants and invertebrates are acceptable however at the other sampling locations. Risks to plants and soil invertebrates are unacceptable at the above locations, and antimony is retained as a COPC for further evaluation.

Arsenic

Arsenic was initially selected as a COPC because the maximum surface soil concentration of 158 mg/kg exceeded the U.S. EPA Eco-SSL for plants of 18 mg/kg. An Eco-SSL for soil invertebrates is not available; therefore, arsenic concentrations were compared to the following Canadian SQG for soil invertebrates and plants to further evaluate risks to these receptors.

- Canadian SQG – 17.1 mg/kg (EC, 1999e)

The Canadian SQG for soil contact is the geometric mean of effects concentrations for reduction in spinach yields and is the 25th percentile of 46 data points (EC, 1999e). Concentrations at two locations (12SS21 and 12SS24) exceed the Canadian SQG. These locations are located within the "hot spot" area where concentrations of other metals were elevated with respect to toxicity information. All other locations at the BDA are less than the SQG. therefore, risks to plants and invertebrates are possible at locations 12SS21 and 12SS24 and arsenic is retained as a COPC for further evaluation. Because arsenic is a bioaccumulative chemical, risks to wildlife from arsenic in surface soil are further evaluated in Section 8.4.2.

Barium

Barium was initially selected as a COPC because the maximum soil concentration of 505 mg/kg exceeded the U.S. EPA Eco-SSL for soil invertebrates of 330 mg/kg (U.S. EPA, 2005c). The U.S. EPA Eco-SSL of 330 mg/kg for soil invertebrates was developed after a review of over 152 technical studies.

Of these, three studies were accepted for inclusion in the development of the Eco-SSL based on a ranking that followed U.S. EPA Study Acceptance Criteria. The Eco-SSL is the geometric mean of the EC_{20} values (based on reproduction) reported for each of three test species under three separate test conditions of pH (U.S. EPA, 2005c). The ORNL plant benchmark of 500 mg/kg is based on a study that found a 38 percent reduction in shoot growth of barley 14 days after the addition of 500 mg/kg barium, which was the lowest concentration tested (Efroymson et al., 1997b).

Only the maximum concentration of barium at the BDA exceeded the Eco-SSL for soil invertebrates (330 mg/kg) and the plant benchmark from Efroymson et al. (1997b) (500 mg/kg). Therefore, although potential risks from barium are possible at location 12SS21, the overall risks to plants and invertebrates at the BDA are acceptable, and barium is not retained as a COPC for risks to these receptors.

Cadmium

Cadmium was initially selected as a COPC because the maximum soil concentration of 6.3 mg/kg exceeded the U.S. EPA Eco-SSL for mammals of 0.36 mg/kg. Because the Eco-SSL used in the conservative COPC screening is based on risks to wildlife and not risks to plants and invertebrates, cadmium concentrations were compared to the following U.S. EPA Eco-SSLs for soil invertebrates and plants to evaluate risks to these receptors:

- U.S. EPA Eco-SSL for soil invertebrates – 140 mg/kg (U.S. EPA, 2005d)
- U.S. EPA Eco-SSL for plants – 32 mg/kg (U.S. EPA, 2005d)

The U.S. EPA Eco-SSL for soil invertebrates of 140 mg/kg was developed after a review of over 239 technical studies. Of these, 10 studies were accepted for inclusion in the development of the Eco-SSL. The Eco-SSL is the geometric mean of the MATC or Effects Concentration for 10 percent of the test population (EC_{10}) values (based on growth, population, or reproduction) reported for each of three test species evaluated under six separate test conditions of pH (U.S. EPA, 2005d). The U.S. EPA Eco-SSL for plants (32 mg/kg) was developed after a review of over 716 technical studies. Of these, 14 studies were accepted for inclusion in the development of the Eco-SSL. The Eco-SSL is the geometric mean of the MATC (based on growth) reported for 14 test species under six separate test conditions of pH and percent organic matter (U.S. EPA, 2005d).

The maximum cadmium detection is less than the Eco-SSLs for plants and soil invertebrates. Therefore, risks to plants and invertebrates from cadmium are acceptable, and cadmium is not retained as a COPC

for risks to these receptors. However, because cadmium is a bioaccumulative chemical, risks to wildlife from cadmium are evaluated in Section 8.4.2 of this ERA.

Chromium

Chromium was initially selected as a COPC because the maximum soil concentration of 51.7 mg/kg exceeded the U.S. EPA Eco-SSL for birds of 26 mg/kg. Eco-SSLs based on risks to plants and invertebrates are not available; therefore, the following alternate benchmark was used to further evaluate risks to plants and soil invertebrates:

- Canadian SQG – 64 mg/kg (EC, 1999a)

The maximum concentration of chromium is less than the SQG; therefore, potential risks to plants and invertebrates are acceptable, and chromium is not retained as a COPC for risks to plants and invertebrates. However, because chromium is a bioaccumulative chemical, risks to wildlife from chromium are evaluated in Section 8.4.2 of this ERA.

Cobalt

Cobalt was initially selected as a COPC because the maximum concentration of 13.6 mg/kg at location 12SS22 exceeded the U.S. EPA Eco-SSL for plants of 13 mg/kg. However, cobalt concentrations in BDA samples are within the range of background concentrations for Soil Group 3 (6 mg/kg to 27.1 mg/kg) (see Table 3-2); therefore, site-related risks to plants and invertebrates from cobalt are acceptable, and cobalt is not retained as a COPC.

Copper

Copper was initially selected as a COPC because the maximum detected soil concentration of 345 mg/kg exceeded the Region 5 ESL of 5.4 mg/kg. However, the ESL is based on risks to wildlife (i.e., the masked shrew) and not risks to plants and invertebrates. Therefore, the maximum copper concentration was compared to the following SQG to evaluate risks to plants and invertebrates:

- Canadian SQG – 63 mg/kg (CCME, 1997)

Copper was detected at two locations at concentrations exceeding the SQG. These samples were collected from locations where elevated concentrations of other metals were detected (12SS21 and

12SS22). All other soil concentrations were less than the alternate benchmarks, and copper concentrations in surface soil are not expected to be causing unacceptable risks at other locations at the BDA. Therefore, risks to plants and invertebrates from copper in the surface soil are possible at 12SS21 and 12SS22, and copper is retained as a COPC for further evaluation at these locations. Because copper is a bioaccumulative chemical, risks to wildlife from copper are evaluated in Section 8.4.2 of this ERA.

Iron

Iron was initially selected as a COPC for risks to invertebrates because no Region 5 screening level is available. According to the Ecological SSL for iron (U.S. EPA, 2003a), iron is essential for plant growth and is generally considered to be a micronutrient. Because plants regulate its uptake, iron is not expected to be toxic to plants in well-aerated soils with pH levels between 5 and 8 S.U. (U.S. EPA, 2003a). Because measured pH levels ranged from 6 to 7.7 S.U. at SWMU 12, iron was not initially selected as a COPC for plants.

No toxicity data were located to evaluate risks to invertebrates from iron; however, because iron is generally considered a non-toxic metal, it is highly unlikely that soil invertebrates are being impacted by iron at the BDA. For these reasons, any potential risks to plants and invertebrates from iron are acceptable, and iron is not retained as a COPC for risks to these receptors.

Lead

Lead was initially selected as a COPC because the maximum soil concentration of 429,000 mg/kg exceeded the U.S. EPA Eco-SSL for birds of 11 mg/kg. Because the Eco-SSL used in the conservative COPC screening is based on risks to wildlife and not risks to plants and invertebrates, lead concentrations were compared to the following U.S. EPA Eco-SSLs for soil invertebrates and plants to evaluate risks to these receptors:

- Eco-SSL for plants – 120 mg/kg (U.S. EPA, 2005b)
- Eco-SSL for soil invertebrates – 1,700 mg/kg (U.S. EPA, 2005b)

The maximum lead concentration at the BDA is greater than the U.S. EPA Eco-SSLs for plants and soil invertebrates. Although surrounding locations have samples with concentrations that are significantly less than the maximum concentration, concentrations in surrounding samples are elevated compared to the Eco-SSLs for plants and invertebrates. For example, concentrations at locations 12SS22 (506 mg/kg)

and 12SS24 (366 mg/kg) are less than the Eco-SSL for soil invertebrates but greater than the Eco-SSL for plants. The detected concentration of 3,230 mg/kg at location 12SS23 exceeds both Eco-SSLs for plants and invertebrates. All other sample concentrations at the BDA were less than the Eco-SSLs; therefore, it appears that sample locations 12SS21 through 12SS24 represent a "hot spot" for unacceptable risks to ecological receptors. For this reason, lead is retained as a COPC for risks to these receptors in the vicinity of these locations at the BDA. Additionally, because lead is a bioaccumulative chemical, risks to wildlife from lead are evaluated in Section 8.4.2 of this ERA.

Manganese

Manganese was initially selected as a COPC because a Region 5 ESL or U.S. EPA Eco-SSLs are not available; therefore, manganese concentrations were compared to the following ORNL values to evaluate risks to plants and invertebrates:

- ORNL Plant – 500 mg/kg
- ORNL Soil Microorganisms and Microbial Processes – 100 mg/kg

Manganese was detected at a maximum concentration of 1,400 mg/kg at location 12SS23. Although the maximum manganese concentration at the BDA is greater than the ORNL values, concentrations of manganese are within the range of background concentrations for Soil Group 3 (268 mg/kg to 3,040 mg/kg) (see Table 3-2). Therefore, manganese in surface soil at the BDA does not appear to be related to historical activities, and site-related risks to plants and soil invertebrates are acceptable. Manganese is not retained as a COPC for risks to these receptors.

Mercury

Mercury was initially selected as a COPC because the maximum soil concentration of 0.31 mg/kg exceeded the ESL of 0.1 mg/kg. The ESL of 0.1 mg/kg is based on risks to earthworms; however, even though the derivation of the ESL is based on earthworms, the following alternate benchmark was used to further evaluate risks to plants and soil invertebrates:

- Canadian SQG – 12 mg/kg (CCME, 1997)

As presented in the supporting document for the Canadian SQG for mercury (EC, 1999f), the Canadian guideline of 12 mg/kg for mercury is based on the 25th percentile of effects and no effects data distribution for plants and invertebrates. The 25th percentile is the sixth of 22 data points and corresponds to an EC_{50}

for turnip seedling emergence (50 mg/kg). The EC_{50} value of 50 mg/kg was then divided by an uncertainty factor of four considering the importance of definitive effects data. In Appendix VIII of the supporting document, NOECs for earthworm survival were reported at 96 mg/kg and 100 mg/kg in soils of pH 4.0 to 4.2 and 7.4, respectively.

The maximum detected mercury concentration is less than the SQG; therefore risks to plants and soil invertebrates are acceptable. Mercury is not retained as a COPC for risks to plants and invertebrates; however, because mercury is a bioaccumulative chemical, risks to wildlife from mercury are evaluated in Section 8.4.2.

Nickel

Nickel was initially selected as a COPC because the maximum concentration of 44.6 mg/kg at location 12SS13 exceeded the Region 5 ESL of 13.6 mg/kg. However, the ESL is based on risks to wildlife (i.e., the masked shrew) and not risks to plants and invertebrates. Therefore, the maximum copper concentration was compared to the following Canadian SQG to evaluate risks to plants and invertebrates:

- Canadian SQG – 50 mg/kg (EC, 1999b)

The maximum concentration is less than the SQG and so risks to plants and invertebrates at the BDA are acceptable; nickel is not retained as a COPC for risks to plants and invertebrates. However, because nickel is a bioaccumulative chemical, risks to wildlife from nickel are evaluated in Section 8.4.2.

Selenium

Selenium was initially selected as a COPC because the maximum surface soil concentration of 0.61 mg/kg exceeded the ESL of 0.0276 mg/kg. However, the ESL is based on risks to wildlife and not plants and invertebrates. Therefore, selenium concentrations were compared to the following alternate benchmark to evaluate risks to these receptors:

- Canadian SQG – 1 mg/kg (EC, 2001)

The SQG is based on an approximately 60 percent reduction in sorgrass (*Sorghum vulgare*) shoot growth over 42 days. The maximum concentration of selenium is less than the SQG; therefore, risks to plants and soil invertebrates are acceptable. Selenium is not retained as a COPC for risks to plants and

invertebrates. Because selenium is a bioaccumulative chemical, risks to wildlife from selenium are evaluated in Section 8.4.2.

Silver

Silver was initially selected as a COPC because the detected soil concentration of 18.5 mg/kg exceeded the Region 5 ESL of 4.04 mg/kg. However, the ESL is based on risks to wildlife (i.e., the masked shrew) and not risks to plants and invertebrates so the following alternate benchmarks were used to further evaluate risks to plants and soil invertebrates:

- ORNL Microorganisms – 50 mg/kg (Efroymson et al., 1997a)
- ORNL Plant – 2 mg/kg (Efroymson et al., 1997b)

The ORNL plant benchmark of 2 mg/kg for silver is based on a report of unspecified toxic effects on plants grown in surface soil with 2 mg/kg silver (Efroymson et al, 1997b). No alternate benchmarks are available for risks to soil invertebrates; however, there is an ORNL value for risks to microorganisms of 50 mg/kg (Efroymson et al., 1997a). There is uncertainty in the sensitivity of an earthworm to silver versus the sensitivity of microorganisms to silver; however, ORNL values reported for other metals for earthworms and microorganisms are somewhat similar (i.e., less than two times difference between them) (Efroymson et al., 1997a).

The maximum concentration is less than the ORNL microorganism benchmark and so risks to soil invertebrates at the BDA are acceptable. Silver is not retained as a COPC for risks to soil invertebrates. As mentioned previously for HMX, contaminated soil was excavated from the BDA in September 2001 and June 2002. After excavation, the BDA was seeded and grass now covers the remediated area; therefore, plants, at least grasses, do not appear to be impacted by HMX in the soil. The surrounding vegetation and forested area were not affected by the remediation. Therefore, despite uncertainties in evaluating risks to plants at the BDA despite a lack of toxicity information, the potentially impacted area only represents a small percentage of potential habitat at the BDA and risks to the plant community are not expected to be significant. Because silver is a bioaccumulative chemical, risks to wildlife from silver are evaluated in Section 5.7.6.2.

Thallium

Thallium was initially selected as a COPC because the detected concentration of 6.4 mg/kg at location 12SS21 was greater than the ESL of 0.0569 mg/kg. However, the ESL is based on risks to wildlife (i.e.,

masked shrew) and not risks to plants and invertebrates. Therefore, thallium concentrations at the BDA were compared to the following Canadian SQG to evaluate risks to these receptors:

- Canadian SQG – 1.4 mg/kg (EC, 1999g)

The SQG of 1.4 mg/kg is based on a study in which root and top development of soybean, wheat, buckwheat, alfalfa, and rye grass was observed. Thallium was only detected in one of 11 samples at the BDA. Although 12SS21 is located within the "hot spot" area at the BDA, it was not detected at any other locations and the potentially contaminated area is insignificant when comparing to the overall size of the BDA. Therefore, although risks to plants and invertebrates are possible at location 12SS21, overall risks to plants and invertebrates at the BDA are acceptable, and thallium is not retained as a COPC for risks to these receptors.

Tin

Tin was initially selected as a COPC because the maximum detected soil concentration of 838 mg/kg exceeded the Region 5 ESL of 7.62 mg/kg. However, the ESL is based on risks to wildlife (i.e., the masked shrew) and not risks to plants and invertebrates so the following alternate benchmarks were used to further evaluate risks to plants and soil invertebrates:

- ORNL Microorganisms – 2,000 mg/kg (Efroymson et al., 1997a)
- ORNL Plant – 50 mg/kg (Efroymson et al., 1997b)

The ORNL benchmark for plants is the only alternate benchmark available for risks to plants. The 50 mg/kg value is based on two studies conducted in soil. Both studies measured growth as the endpoint. In the first study, shoot weight of bush beans were reduced by 22 percent when grown for 17 days in 500 mg/kg tin while 50 mg/kg had no effect. The second study reported unspecified toxic effects on plants grown in soil with 50 mg/kg tin. Tin was detected in 4 of the 11 samples collected and exceeded the ORNL plant benchmark at two locations (12SS21 and 12SS22); therefore, risks to plants are possible and tin is retained as a COPC for risks to plants.

No alternate benchmarks are available for risks to soil invertebrates; however, there is an ORNL value for risks to microorganisms of 2,000 mg/kg (Efroymson et al., 1997a). The maximum detected tin concentration at the BDA is less than the ORNL tin value for microorganisms. Therefore, it is unlikely that earthworms are being adversely impacted because the maximum tin detection is below the ORNL value

for microorganisms; therefore, risks to soil invertebrates from tin are acceptable and Tin is not retained as a COPC for risks to soil invertebrates.

Vanadium

Vanadium was initially selected as a COPC because the maximum concentration of 42.8 mg/kg exceeded the Eco-SSL for birds of 7.8 mg/kg. Because the Eco-SSL is based on risks to wildlife (i.e., masked shrew) and not risks to plants and invertebrates, vanadium concentrations at the BDA were compared to the following Canadian SQG to evaluate risks to these receptors:

- Canadian SQG – 130 mg/kg (EC, 1999c)

The maximum vanadium concentration is less than the SQG and so risks to plants and invertebrates from vanadium are acceptable; vanadium is not retained as a COPC.

Zinc

Zinc was initially selected as a COPC because the maximum soil concentration of 2,490 mg/kg exceeded the ESL of 6.62 mg/kg. However, even though the ESL is based on risks to invertebrates, the following alternate benchmark was used to further evaluate risks to plants and soil invertebrates:

- Canadian SQG – 200 mg/kg (EC, 1999d)

The greatest detected concentrations of zinc were at locations 12SS21 through 12SS24. These locations are also the location of elevated concentrations of many other metals at the BDA. The concentrations at these locations were greater than the SQG, particularly at locations 12SS21 (2,050 mg/kg) and 12SS22 (2,490 mg/kg). Although these benchmarks are likely conservative as discussed above, risks to terrestrial plants and invertebrates are possible at these locations. Therefore, risks to plants and invertebrates from zinc are unacceptable, and zinc is retained for further evaluation. Because zinc is a bioaccumulative chemical, risks to wildlife from zinc are evaluated in Section 8.4.2.

Summary of BDA Surface Soil Risks

Several chemicals initially selected as surface soil COPCs were retained as COPCs for further evaluation in the BDA including antimony, copper, lead, tin, and zinc because concentrations were greater than alternate toxicity information at multiple locations.

In particular, locations 12SS21 through 12SS24 represent a "hot spot" for ecological receptors where concentrations of multiple COPCs exceeded alternate benchmarks for plants and soil invertebrates and background concentrations for Soil Group 3. Contaminated soil was excavated from the BDA in September 2001 and June 2002. After excavation, the BDA was seeded and grass now covers the remediated area; therefore, it would not be expected that great plant diversity would exist in this area. Additionally, it does not appear the existing grasses in the area are being significantly impacted by current concentrations. The surrounding vegetation and forested area were not affected by the remediation. Therefore, despite uncertainties in evaluating risks to plants and invertebrates at the BDA due to a lack of toxicity information for some chemicals and exceedances of some chemicals of toxicity information, the potentially impacted area (locations 12SS21 through 12SS24) only represents a small percentage of potential habitat at the BDA and risks to the plant and invertebrate communities are not expected to be significant.

Concentrations at all other locations within the BDA were acceptable.

8.4.1.1.3 Historical Surface Soil Samples

As a part of the historical remedial activities at SWMU 12, initial characterization samples (ICS) were collected in 1997 and 1998 and analyzed for explosives, the eight RCRA metals plus aluminum, and nine VOCs. Based on the ICS results, areas surrounding Buildings 152, 153/154, 157, and 158/159 were excavated based on high concentrations of explosives, mainly RDX. The areas around Buildings 151 and 160 did not require remediation because explosive concentrations were less than cleanup goals. The excavated areas were subsequently backfilled with bioremediated soil that met human health cleanup goals. Bioremediated soil was analyzed for explosives only. For these historical samples, a weighted average was calculated because the concentrations of the historical samples represent different volumes of material left in place after remediation. Additionally, concentrations of bioremediated soil, which constitutes a large portion of the soil volume, are averages of windrows calculated in the IMR. Bioremediated soil from different windrows was placed in the same excavated grid area; therefore, windrow data represented by average concentrations were mixed with other windrows in the same excavated grid. Section 1.2.3 discusses in more detail the interim bioremediation effect at SWMU 12.

For the historical surface soil samples, contaminant concentrations at the individual buildings were discussed separately where the maximum concentration of a chemical detected in samples collected during the bioremediation activities exceeded the ESL. The evaluation of individual buildings was not conducted for each contaminant; rather, it was conducted on a chemical-specific basis and is discussed

below, where appropriate. An emphasis was placed on average concentrations for the chemicals initially selected as COPCs. This was done because of the uncertainty involved with the data collection and analysis (see Section 8.4.1.1). Table 8-11 presents a summary of the maximum and average concentrations of the COPCs at each of the buildings.

HMX

HMX was initially selected as a COPC because a Region 5 screening level is not available. The only alternate toxicity information available for HMX is a LOEC of 280 mg/kg for earthworm reproduction (Robidoux et al., 2001)

HMX was detected in over half of the surface soil samples collected at SWMU 12 with a maximum HMX concentration of 752 mg/kg detected at Building 153. As mentioned previously, average concentrations are better indicators of surface soil conditions at SWMU 12 given the nature of the remediated soil. The average concentration at Building 153 was 11.45 mg/kg, which is less than the LOEC for earthworm reproduction and the estimated NOEC of 28 mg/kg (i.e., if the LOEC is divided by an uncertainty factor of 10).

Maximum concentrations of HMX at the other buildings at SWMU 12 were 54.3 mg/kg and less. Average concentrations at the other buildings at SWMU 12 were even lower at 3.71 mg/kg and less; therefore, elevated levels and potential risks to terrestrial invertebrates appear to be isolated to the vicinity of Building 153. No toxicological data for plants could be located. Therefore, although risks to invertebrates appear to be acceptable at SWMU 12 buildings other than Building 153, the elevated concentrations in samples surrounding Building 153 and the lack of toxicity data for plants warrant retaining HMX as a COPC. Although, HMX is not considered a bioaccumulative chemical, risks to wildlife are evaluated in Section 8.4.2 of this ERA to be conservative.

RDX

RDX was initially selected as a COPC because a Region 5 screening level is not available. The only available alternate toxicity information for RDX was a plant benchmark of 100 mg/kg from Talmage et al. (1999) and a LOEC (95 mg/kg) for earthworm reproduction (Robidoux et al., 2000)

RDX was detected in over half of the samples collected at SWMU 12 with a maximum concentration of 5,940 mg/kg at Building 153. The next greatest maximum concentration was 358 mg/kg at Building 158. The average concentrations at Buildings 153 and 158 were 60 mg/kg and 6.1 mg/kg, respectively. The

average RDX concentrations are less than the alternate benchmarks for plants and invertebrates, but the average concentration at Building 153 is greater than the earthworm estimated NOEC of 9.5 mg/kg (i.e., if the LOEC is divided by an uncertainty factor of 10). Average concentrations at all other buildings, which are better indicators of surface soil conditions at SWMU 12 given the nature of the remediated soil, were less than the remediated soil. Although risks to invertebrates appear to be acceptable at all SWMU 12 buildings (other than Building 153 and in the vicinity of the maximum concentration at Building 158), the elevated concentrations at these locations warrant retaining RDX as a COPC. Although, RDX is not considered a bioaccumulative chemical, risks to wildlife are evaluated in Section 8.4.2 of this ERA to be conservative.

1,3,5-Trinitrobenzene

1,3,5-Trinitirobenzene was initially selected as a COPC because the maximum soil concentration of 5.26 mg/kg was greater than the ESL of 0.376 mg/kg. 1,3,5-Trinitrobenzene was detected in only four of 219 samples across all of SWMU 12. The ESL is based on exposure to wildlife (i.e., meadow vole) and not risks to invertebrates and plants, no other alternate toxicity data for plants and invertebrates exposed to 1,3,5-trinitrobenzene are available. Despite the uncertainties that exist in evaluating risks to invertebrates and plants because an alternate benchmark for these receptors could not be located, the four detections (at two buildings) out of 219 samples at SWMU 12 do not warrant retaining 1,3,5-trinitrobenzene as a COPC. Although 1,3,5-trinitrobenzene is not considered a bioaccumulative chemical, risks to wildlife are evaluated in Section 8.4.2 of this ERA to be conservative.

2,4,6-Trinitrotoluene

TNT was initially selected as a COPC because a Region 5 screening level is not available. The following toxicity information for TNT was located in the literature:

- LOEC for Plants – 2.4 mg/kg (Best et al., 2004)
- LOEC for Soil invertebrates (earthworms) – 1.2 mg/kg (Best et al., 2004)

The LOECs from Best et al. (2004) were based on EC_{20} values derived by linear regression of ln-transformed biomass to TNT concentrations in soil. The LOEC for plants is based on a 55-day study in which the EC_{50} was 7.3 mg/kg and the EC_{20} was 2.4 mg/kg. The values were derived from *L. perenne* linear regression of ln-transformed plant biomass to TNT soil concentrations. The LOEC for soil invertebrates were derived similarly from E. fetida by linear regression of ln-transformed earthworm

biomass to TNT soil concentrations. The EC_{50} from the E. fetida 28-day study was 3.6 mg/kg and the EC_{20} was 1.2 mg/kg.

The maximum detected TNT concentration (793 mg/kg) was in a surface soil sample from Building 153 and is greater than the LOECs for plants and soil invertebrates from Best et al. (2004). Also, maximum concentrations of TNT at all buildings are greater than LOEC values above, except Building 151 where explosives were not detected. Only LOEC values were reported in Best et al. (2004); therefore, estimated NOEC values for plants and soil invertebrates are 0.24 mg/kg and 0.12, respectively. The average concentrations of TNT are greater than the estimated NOEC values at all buildings at SWMU 12, except Building 151 where explosives were not detected.

Based on a comparison to the alternative toxicity information, risks to plants and invertebrates at SWMU 12 cannot be ruled out. TNT is retained as a COPC for risks to plants and soil invertebrates. Although, TNT is not considered a bioaccumulative chemical by U.S. EPA (2000), risks to wildlife are evaluated in Section 8.4.2 of this ERA to be conservative.

2-Amino-4,6-dinitrotoluene

2-amino-4,6-dinitrotoluene (2-ADNT) was initially selected as a COPC because a Region 5 screening level is not available. The following toxicity information for 2-ADNT was located in the literature:

- Plants Value – 80 mg/kg (Talmage et al., 1999)
- Soil Microbial Processes Value– 80 mg/kg (Talmage et al., 1999)

The plant value is based on a study in which soil amended with 80 mg/kg of 2-ADNT was not toxic to yellow nutsedge over a 42-day period (Talmage et al., 1999). No studies based on toxicity of 2-ADNT were located, but a soil microbial processes value of 80 mg/kg was reported as nontoxic (Talmage et al., 1999). Talmage et al. (1999) indicated that confidence in this value is low, and the value is unlikely to be conservative because the organisms were probably acclimated to the test compound.

2-ADNT was detected at a maximum concentration of 1.28 mg/kg at Building 157 at SWMU 12 and is less than the plant and soil microbe values reported in Talmage et al., 1999. Therefore, risks to plants and earthworms are acceptable, and 2-ADNT is not retained as a COPC for risks to plants and invertebrates. Although, 2-ADNT is not considered a bioaccumulative chemical, risks to wildlife are evaluated in Section 8.4.2 of this ERA to be conservative.

4-Amino-2,6-dinitrotoluene

4-Amino-2,6-dinitrotoluene (4-ADNT) was initially selected as a COPC because a Region 5 screening level is not available. Alternate benchmarks for 4-ADNT are not available; therefore, 2-ADNT is used as a surrogate for comparison of toxicity information to 4-ADNT concentrations (see above).

The frequencies of detections and magnitude of concentrations of 4-ADNT are similar to those of 2-ADNT. The maximum concentration of 4-ADNT of 5.8 mg/kg at Building 153 is less than the 2-ADNT benchmarks. Therefore, risks to plants and earthworms are acceptable, and 4-ADNT is not retained as a COPC for risks to plants and invertebrates. Although, 4-ADNT is not considered a bioaccumulative chemical, risks to wildlife are evaluated in Section 8.4.2 of this ERA to be conservative.

Arsenic

Arsenic was initially selected as a COPC because the maximum surface soil concentration of 57.3 mg/kg exceeded the U.S. EPA Eco-SSL of 18 mg/kg. Although the Eco-SSL is based on risks to plants, arsenic concentrations were compared to the following Canadian SQG for soil invertebrates and plants to further evaluate risks to these receptors:

- Canadian SQG – 17.1 mg/kg (EC, 1999e)

The maximum arsenic concentration was detected in surface soils at Building 158. The average concentration at this building was 29 mg/kg. Additionally, the maximum concentration at Building 160 of 23.4 mg/kg also exceeded the Canadian SQG; however, the average concentration at this building was lower at 7.97 mg/kg. Maximum concentrations at the other buildings at SWMU 12 were less than the SQG. Therefore, risks to plants and invertebrates at Building 158 and in the vicinity of the maximum concentration at Building 160 are possible; however, risks at other locations appear acceptable. Arsenic is retained as a COPC for further evaluation in the areas of Buildings 158 and 160. Because arsenic is a bioaccumulative chemical, risks to wildlife from arsenic in the surface soil are further evaluated in Section 8.4.2.

Cadmium

Cadmium was initially selected as a COPC because the maximum soil concentration of 2.4 mg/kg detected at Building 153 exceeded the U.S. EPA Eco-SSL for mammals of 0.36 mg/kg. Because the Eco-SSL used in the conservative COPC screening is based on risks to wildlife and not risks to plants

and invertebrates, cadmium concentrations were compared to the following U.S. EPA Eco-SSLs for soil invertebrates and plants to evaluate risks to these receptors:

- U.S. EPA Eco-SSL for soil invertebrates – 140 mg/kg (U.S. EPA, 2005d)
- U.S. EPA Eco-SSL for plants – 32 mg/kg (U.S. EPA, 2005d)

The maximum cadmium detection is less than the Eco-SSLs for plants and soil invertebrates. Therefore, risks to plants and invertebrates from cadmium are acceptable, and cadmium is not retained as a COPC for risks to these receptors. However, because cadmium is a bioaccumulative chemical, risks to wildlife from cadmium are evaluated in Section 8.4.2 of this ERA.

Chromium

Chromium was initially selected as a COPC because the maximum soil concentration of 60 mg/kg exceeded the Eco-SSL for birds of 26 mg/kg. Because the Eco-SSL used in the conservative COPC screening is based on risks to wildlife and not risks to plants and invertebrates, chromium concentrations were compared to the following Canadian SQG for soil invertebrates and plants to evaluate risks to these receptors:

- Canadian SQG – 64 mg/kg (EC, 1999a)

The maximum concentration of chromium is less than the SQG; therefore, chromium is not retained as a COPC for risks to plants and invertebrates. However, because chromium is a bioaccumulative chemical, risks to wildlife from chromium are evaluated in Section 8.4.2 of this ERA.

Lead

Lead was initially selected as a COPC because the maximum soil concentration of 71 mg/kg exceeded the U.S. EPA Eco-SSL for birds of 11 mg/kg. Because the Eco-SSL used in the conservative COPC screening is based on risks to wildlife and not risks to plants and invertebrates, lead concentrations were compared to the following U.S. EPA Eco-SSLs for soil invertebrates and plants to evaluate risks to these receptors:

- Eco-SSL for plants – 120 mg/kg (U.S. EPA, 2005b)
- Eco-SSL for soil invertebrates – 1,700 mg/kg (U.S. EPA, 2005b)

The maximum lead concentration at SWMU 12 is less than the U.S. EPA Eco-SSLs for plants and soil invertebrates. Therefore, risks to plants and invertebrates from lead are acceptable, and lead is not retained as a COPC for risks to these receptors. However, because lead is a bioaccumulative chemical, risks to wildlife from lead are evaluated in Section 8.4.2 of this ERA.

Mercury

Mercury was initially selected as a COPC because the maximum soil concentration of 0.16 mg/kg exceeded the ESL of 0.1 mg/kg. The ESL of 0.1 mg/kg is based on risks to earthworms; however, even though the derivation of the ESL is based on earthworms, the following alternate benchmark was used to further evaluate risks to plants and soil invertebrates:

- Canadian SQG – 12 mg/kg (CCME, 1997)

The maximum mercury concentration is less than the SQG; therefore risks to plants and soil invertebrates are acceptable. Mercury is not retained as a COPC for risks to plants and invertebrates; however, because mercury is a bioaccumulative chemical, risks to wildlife from mercury are evaluated in Section 8.4.2.

Selenium

Selenium was initially selected as a COPC because the maximum surface soil concentration of 1.4 mg/kg exceeded the ESL of 0.0276 mg/kg. However, the ESL is based on risks to wildlife and not plants and invertebrates. Therefore, selenium concentrations were compared to the following alternate benchmark to evaluate risks to these receptors:

- Canadian SQG – 1 mg/kg (EC, 2001)

The maximum concentrations at Building 153 (1.4 mg/kg) and Building 158 (1.1 mg/kg) only slightly exceed the SQG. Concentrations at the other buildings are less than the SQG. Therefore, although potential risks may exist in the vicinity of the maximum concentrations at Buildings 153 and 158, the slight exceedance of the SQG does not warrant retaining selenium for further evaluation in a BERA. For this reason, selenium is not retained as a COPC for further evaluating risks to plants and invertebrates. Because selenium is a bioaccumulative chemical, risks to wildlife from selenium are evaluated in Section 8.4.2.

Summary of Historical Surface Soil Sample Risks

Several chemicals initially selected as surface soil COPCs in historical samples collected immediately surrounding the buildings at SWMU 12 were retained as COPCs for further evaluation. HMX, RDX, TNT, and arsenic were retained as COPCs because concentrations are greater than alternate toxicity information at multiple locations. In particular, HMX and RDX concentrations were particularly elevated in samples surrounding Building 153. Similarly, arsenic concentrations were greatest in the vicinity of Buildings 158 and 160. TNT concentrations are greater than alternate benchmarks for plants and soil invertebrates surrounding all buildings at SMWU 12 except Building 151, where explosives were not detected. However, surface soil samples collected during the historical activities were collected in areas immediately surrounding the buildings at SWMU 12, which are maintained grassy areas. Therefore, it would not be expected that great plant diversity would exist in these areas. The areas in the middle of SWMU 12 and the areas along the SWMU boundaries are heavily vegetated (see Figure 8-5), so the potentially impacted areas adjacent to the buildings only represent a small percentage of potential habitat in that area.

8.4.1.2 Benthic Invertebrates – Sediment Risk

As presented in Sections 8.3.2.2 and 8.3.2.3, several sediment and surface water samples were collected in the intermittent drainage ditches/gullies leading from SWMU 12, and several chemicals detected in the samples were initially selected as COPCs because they were detected at concentrations that exceeded screening levels. Although surface water samples were collected from many of these locations, most of the samples were taken from small pools of standing water and areas of very slow flow (or no flow) as recorded in the sample log sheets (see Appendix C) and the photographs (see Appendix A). In fact, during the Round 1 sampling event, 20 of the 30 proposed surface water locations were dry during the first attempt to collect samples so the water samples were collected after a rain event when water was present (see Section 2.5.2). There is very little ecological habitat in these drainage ditches throughout most of the year (see photographs in Appendix A). Therefore, although some of the chemical concentrations in sediment and surface water samples exceeded the screening levels for aquatic receptors, there is very little exposure so any risks would not be significant. For that reason, none of the chemicals in the drainage ditch/gulley samples are retained as COPCs for further evaluation for risks to aquatic organisms. However, the chemical data from these samples are used in the Step 3a evaluation of the East Tributary and Turkey Creek samples (in Sections 8.4.1.2.1 and 8.4.1.2.2) to determine whether the chemicals may be related to site activities, where applicable.

Table 8-12 presents a summary of the common alternate benchmarks used in refining the list of COPCs in sediment, along with a summary of the Step 3a evaluation.

8.4.1.2.1 East Tributary Sediment

Aluminum

Aluminum was initially selected as a COPC because an ESL was not available. The alternate benchmark selected for aluminum is the Threshold Effects Level (TEL) of 25,500 mg/kg (Buchman, 1999). The TEL represents the concentration below which adverse effects on survival or growth of the amphipod *Hyalella azteca* are expected to occur only rarely in 28-day tests (MacDonald et al., 2000).

The maximum concentration of 17,200 mg/kg is less than the TEL; therefore, risks to sediment-dwelling biota are acceptable, and aluminum is not retained as a COPC.

Antimony

Antimony was initially selected as a COPC because an ESL was not available. The alternate benchmark selected for antimony is the ER-L of 2 mg/kg (Long and Morgan, 1991). The maximum detected concentration of 1.2 mg/kg is less than the conservative ER-L; therefore, risks to sediment-dwelling biota are acceptable, and antimony is not retained as a COPC.

Arsenic

Arsenic was initially selected as a COPC because the maximum detected sediment concentration of 10.9 mg/kg slightly exceeded the Region 5 ESL of 9.79 mg/kg, which is based on the consensus-based TEC. The TEC is the geometric mean of the TEL (Smith et al., 1996), ER-L (Long and Morgan, 1991), lowest effect level (LEL) (Persaud et al., 1993), minimal effect threshold (MET) (EC and MENVIQ, 1992), and sediment quality advisory levels (SQALs) (U.S. EPA, 1997b) for arsenic. These individual effect levels for each of the studies cited above were calculated using slightly different methods, but they all represent concentrations below which impacts to sediment invertebrates are either unlikely or not expected. For that reason, the TEC is intended to identify contaminant concentrations below which harmful effects on sediment dwelling organisms are not expected.

The maximum arsenic concentration is greater than the TEC and therefore, was compared to the consensus-based probable effects concentration (PEC) to provide an estimate of the overall risk range. The PEC is 33 mg/kg (MacDonald et al., 2000). The PEC was derived similarly to the TEC but is the

geometric mean of the probable effect levels (PELs) (Smith et al., 1996), effect range median values (ER-Ms) (Long and Morgan, 1991), severe effect levels (SELs) (Persaud et al., 1993) and Toxic Effect Thresholds (TETs) (EC and MENVIQ, 1992). The PEC is the level above which harmful effects on sediment dwelling organisms are expected to frequently occur (MacDonald, et al., 2000).

The maximum concentration is only slightly greater than the TEC and is much closer to the TEC than the PEC. Additionally, the maximum concentration is less than the upgradient concentration of 15.3 mg/kg (see Table 3-31). Therefore, risks to sediment-dwelling biota are acceptable, and arsenic is not retained as a COPC.

Barium

Barium was initially selected as a COPC because an ESL is not available. The only available alternate benchmark for barium is the Apparent Effects Threshold (AET) of 48 mg/kg (Buchman, 1999). Based on the Navy's agreement with U.S. EPA, if a chemical only has a higher effects level such as an AET, the chemical will not be eliminated as a COPC even if the maximum detection is less than the higher effects level, unless other Step 3a factors can be used to justify the chemical's elimination as a COPC.

The maximum detected barium concentration of 65 mg/kg is greater than the AET. However, the maximum concentration is less than the upgradient barium concentration of 108 mg/kg. Therefore, site-related risks to biota from barium are acceptable and barium is not retained as a COPC for further evaluation.

Iron

Iron was initially selected as a COPC because an ESL is not available. Because an ESL and a consensus-based TEC are not available for the screening, iron concentrations are compared to the following Canadian SQGs:

- Canadian Sediment LEL – 20,000 mg/kg (OMOE, 1993)
- Canadian Sediment SEL – 40,000 mg/kg (OMOE, 1993)

The LEL indicates the level of sediment contamination that has no effect on and can be tolerated by the majority of sediment-dwelling organisms. The Canadian sediment guidelines were developed by first calculating the 90th percentile of the concentrations evaluated in toxicity studies where a species was present, and then plotting the 90th percentile concentrations for all of the species considered to develop

the guideline. The 5th percentile of the plot was selected as the LEL for metals. The maximum detected concentration of iron (70,700 mg/kg) at location 12SD24 is greater than the LEL. Therefore, concentrations of iron are compared to the SEL to further evaluate potential risks to benthic organisms. The SEL is the level at which sediment is considered heavily polluted and detrimental to the overall health of the majority of sediment-dwelling organisms. The maximum concentration is also greater than the SEL of 40,000 mg/kg.

Iron was detected in both East Tributary sediment samples. The second detected concentration was 31,900 mg/kg, which is less than the SEL and less than the upgradient East Tributary concentration of 44,600 mg/kg. Additionally, the maximum concentration of 70,700 mg/kg is less than the upgradient gully sediment concentration of 210,000 mg/kg (see Table 3-30). Therefore, despite elevated concentrations with respect to the alternate benchmarks, there is no reason to suspect that iron concentrations in sediment are related to SWMU 12 based on the history of SWMU operations. In fact, when comparing to upgradient gully concentrations it appears that sediment concentrations in the East Tributary are related to background conditions. Therefore, site-related risks to sediment-dwelling organisms are acceptable and iron is not retained as a COPC for further evaluation.

Lead

Lead was initially selected as a COPC because the maximum concentration (58.2 mg/kg) at location 12SD24 exceeded the ESL of 35.8 mg/kg which is based on the TEC. Therefore, concentrations of lead in the sediment were compared to the consensus-based PEC to further evaluate potential risks to benthic organisms. The maximum lead concentration is greater than the TEC but less than the PEC of 128 mg/kg. The lead concentration at location 12SD23 of 22.8 mg/kg is less than the TEC and the East Tributary upgradient concentration of 25.2 mg/kg (see Table 3-31) as well as the upgradient maximum gully concentration of 43.9 mg/kg (see Table 3-30).

Therefore, although the maximum concentration is between the TEC and the PEC, impacts to benthic invertebrates are possible at this location, but not probable. Additionally, lead concentrations were low in SWMU 12 Proper surface soil samples (i.e., maximum concentration of 31.2 mg/kg), and the lead concentration in the downgradient Turkey Creek sediment sample (at location 12SD27) was similar at 39.6 mg/kg, indicating lead is not likely migrating downstream, at least not in significant quantities. Therefore, although risks to sediment invertebrates from lead are possible at location 12SD24, the potential risks from lead are not great enough to warrant retaining it as a COPC for further evaluation.

Manganese

Manganese was initially selected as a COPC because an ESL is not available. Because an ESL and a consensus-based TEC are not available for screening, manganese concentrations were compared to the following Canadian SQGs:

- Canadian Sediment Guidelines LEL – 460 mg/kg (OMOE, 1993)
- Canadian Sediment Guidelines SEL – 1,100 mg/kg (OMOE, 1993)

As stated previously, the LEL indicates the level of sediment contamination that has no effect on and can be tolerated by the majority of sediment-dwelling organisms, and the SEL is the level at which sediment is considered detrimental to the health of the majority of sediment-dwelling organisms.

Manganese was detected in both East Tributary sediment samples at concentrations (1,480 mg/kg and 2,910 mg/kg) exceeding the SEL; however, the upgradient manganese concentration of 2,060 mg/kg also exceeded the SEL. Additionally, the maximum concentration in upgradient gully samples is even greater at 4,430 mg/kg (see Table 3-30). Therefore, although there is uncertainty with regard to the potential risks to sediment-dwelling invertebrates because concentrations exceeded alternate benchmarks, these risks appear to be related to background conditions and not the SWMU itself. For these reasons, site-related risks to sediment invertebrates from manganese are acceptable, and manganese is not retained as a COPC for these receptors.

Nickel

Nickel was initially selected as a COPC because the maximum detected sediment concentration of 32.1 mg/kg exceeded the ESL of 22.7 mg/kg, which is based on the TEC. Because the maximum concentration exceeds the TEC, nickel concentrations were compared to the consensus-based PEC to further evaluate risks to sediment invertebrates.

The consensus-based PEC is 48.6 mg/kg (MacDonald et al., 2000). The maximum concentration exceeds the TEC but not the PEC. Although concentrations in some samples are between the TEC and the PEC, impacts to benthic invertebrates are possible but not probable. Additionally, the maximum sediment concentration is only slightly greater than the upgradient sediment concentration of 31.3 mg/kg. Therefore, site-related risks to benthic invertebrates from nickel are acceptable and nickel is not retained as a COPC for risks to sediment-dwelling invertebrates.

Vanadium

Vanadium was initially selected as a COPC because an ESL is not available. The only available alternate benchmark for vanadium is the AET of 57 mg/kg (Buchman, 1999), which is based on marine organisms. Based on the Navy's agreement with U.S. EPA, if a chemical only has a higher effects level such as an AET, the chemical will not be eliminated as a COPC even if the maximum detection is less than the higher effects level, unless other Step 3a factors can be used to justify the chemicals elimination as a COPC.

Vanadium was detected in both samples with concentrations of 31 mg/kg at location 12SD23 and 36 mg/kg at location 12SD24. Both concentrations are less than the AET. Additionally, the detected concentrations are similar to the upgradient concentration of 30.7 mg/kg. Therefore, site-related risks to benthic organisms are acceptable, and vanadium is not retained as a COPC.

Summary of East Tributary Sediment Sample Risks

In summary, the list of chemicals initially selected as COPCs were further evaluated in Step 3a, the first step of the BERA. After a review of alternate toxicity information (based on sediment invertebrates) for the initial COPCs was conducted, maximum concentrations were compared to the alternate toxicity information, as appropriate.

No chemicals initially selected as sediment COPCs in East Tributary samples were retained as COPCs for further evaluation because concentrations were less than alternate toxicity information and/or upgradient concentrations.

8.4.1.2.2 Turkey Creek Sediment

Aluminum

Aluminum was initially selected as a COPC because an ESL was not available. The alternate benchmark selected for aluminum is the TEL of 25,500 mg/kg (Buchman, 1999). The maximum concentration of 11,400 mg/kg is less than the TEL; therefore, risks to sediment-dwelling biota are acceptable, and aluminum is not retained as a COPC.

Arsenic

Arsenic was initially selected as a COPC because the maximum detected sediment concentration of 27.8 mg/kg exceeded the Region 5 ESL of 9.79 mg/kg, which is based on the consensus-based TEC. The maximum arsenic concentration at location 12SD27 is greater than the TEC and therefore, was compared to the consensus-based PEC to provide an estimate of the overall risk range. The PEC is 33 mg/kg (MacDonald et al., 2000). The maximum concentration (27.8 mg/kg) is less than the consensus-based PEC; therefore, impacts to benthic invertebrates are possible at this location, but not probable.

Concentrations at locations downgradient from 12SD27 are 5 mg/kg (location 13SD44) and less; therefore, it does not appear that arsenic concentrations are accumulating downstream. Additionally, the maximum arsenic concentration is less than the maximum upgradient gully concentration of 34.5 mg/kg (see Table 3-30). Arsenic concentrations in SWMU 12 Proper surface soil samples are low (i.e., less than the Eco-SSL), and arsenic was not selected as a COPC in surface soils. Therefore, although there are uncertainties regarding risks to sediment invertebrates at location 12SD27 because the concentration at this location is greater than the TEC, the risks do not appear to be related to SWMU 12. For this reason, arsenic is not retained as a COPC for further evaluation.

Barium

Barium was initially selected as a COPC because an ESL was not available. The only available alternate benchmark for barium is the AET of 48 mg/kg (Buchman, 1999). Based on the Navy's agreement with U.S. EPA, if a chemical only has a higher effects level such as an AET, the chemical will not be eliminated as a COPC even if the maximum detection is less than the higher effects level, unless other Step 3a factors can be used to justify the chemical's elimination as a COPC.

The maximum barium concentration (82.4 mg/kg) was detected at location 12SD27. Samples collected downstream from location 12SD27 had barium concentrations of 52.1 mg/kg (13SD45) and 51.6 mg/kg (13SD44); however, these three concentrations are greater than the AET and the Turkey Creek upgradient concentration of 45.1 mg/kg. However, the maximum barium concentration is less than the maximum concentration of 196 mg/kg in upgradient gully samples. Barium concentrations in gully sediment and surface soil samples were similar to those seen in Turkey Creek sediments and ranged from 64.6 mg/kg to 182 mg/kg and 50.2 mg/kg to 128 mg/kg, respectively. Additionally, these concentrations are within the range of background concentrations for Soil Group 3 (46.1 mg/kg to 153 mg/kg) (see Table 3-2). Therefore, it does not appear that barium concentrations in sediment are related to site activities. The paucity of toxicity data inhibits a complete evaluation of risks posed by

barium. However, barium is a common element in sediments and is not generally associated with significant toxicity (ATSDR, 1992). Although potential risks may exist from barium in Turkey Creek sediment, these risks do not appear to be related to SWMU 12. Site-related risks to benthic organisms are acceptable and barium is not retained as a COPC.

Beryllium

Beryllium was initially selected as a COPC because an ESL is not available. No alternate benchmarks are available for beryllium.

Beryllium was not detected at location 12SD27 and was detected in samples collected from locations 13SD45 and 13SD44 at similar concentrations (0.43 and 0.49 mg/kg). Beryllium was not detected at the upgradient location. Beryllium was also not detected in the gully sediment samples and was detected only at low concentrations (i.e., less than the Eco-SSL) in surface soil samples. Based on the past operations that occurred at SWMU 12 (i.e., production and manufacture of explosives), it is unlikely that the low beryllium concentrations are related to former SWMU activities. Therefore, although risks to benthic invertebrates cannot be ruled out because of the lack of toxicity data, any potential site-related risks from beryllium are not great enough to warrant carrying beryllium further through the BERA process. Risks to sediment-dwelling invertebrates are acceptable, and beryllium is not retained as a COPC.

Chromium

Chromium was initially selected as a COPC because the maximum concentration of 70.4 mg/kg exceeded the ESL of 43.4 mg/kg, which is based on the TEC. Therefore, chromium concentrations were compared to the PEC to further evaluate risks to sediment invertebrates from exposure to chromium in sediment. The consensus-based PEC is 111 mg/kg (MacDonald et al., 2000).

The maximum chromium concentration at location 12SD27 is less than the PEC; therefore, impacts to benthic invertebrates are possible but not probable at this location. Concentrations at the downstream locations decreased and were less than the TEC. Additionally, the maximum concentration is less than the maximum concentration of 72.6 mg/kg in upgradient gully samples. Chromium concentrations in SWMU 12 proper surface soil samples were low and ranged from 18.1 mg/kg to 26.9 mg/kg. Therefore, a definitive link between SWMU 12 and the elevated chromium concentration at location 12SD27 can not be made. Although potential risks to benthic invertebrates are possible at location 12SD27, chromium concentrations do not appear to be related to SWMU 12. For this reason, site-related risks to chromium are acceptable, and chromium is not retained as a COPC for further evaluation.

Iron

Iron was initially selected as a COPC because an ESL is not available. Because an ESL and a consensus-based TEC are not available for the screening, iron concentrations were compared to the following Canadian SQGs:

- Canadian Sediment Guidelines LEL – 20,000 mg/kg (OMOE, 1993)
- Canadian Sediment Guidelines SEL – 40,000 mg/kg (OMOE, 1993)

The LEL indicates the level of sediment contamination which has no effect on and can be tolerated by the majority of sediment-dwelling organisms.

The maximum detected concentration of iron (157,000 mg/kg) at location 12SD27 is greater than the LEL and SEL. Iron was detected in all three Turkey Creek sediment samples; however, only the maximum concentration exceeded the SEL and the upgradient Turkey Creek concentration of 40,000 mg/kg (see Table 3-32). Concentrations decreased at locations 13SD45 and 13SD44, downstream of the maximum concentration and were less than the LEL.

The maximum sediment concentration is within the upgradient gully concentration range (22,900 mg/kg to 210,000 mg/kg), and the maximum concentration of 30,600 mg/kg in SWMU 12 Proper surface soil samples is within the maximum background concentration for Soil Group 3 (36,200 mg/kg) (see Table 3-2). Therefore, iron concentrations in Turkey Creek sediments do not appear to be related to SWMU 12, and iron is not retained as a COPC for risks to sediment invertebrates.

Lead

Lead was initially selected as a COPC because the maximum Turkey Creek sediment concentration (39.6 mg/kg) slightly exceeded the ESL of 35.8 mg/kg, which is based on the TEC. Therefore, concentrations of lead in sediment were compared to the consensus-based PEC to further evaluate potential risks to benthic organisms. The maximum lead concentration at location 12SD27 is less than the PEC of 128 mg/kg; therefore, impacts to benthic invertebrates are possible but not probable. Concentrations at locations downstream of location 12SD27 are less than the TEC.

Although the maximum concentration is greater than the upgradient Turkey Creek concentration of 12.4 mg/kg, the maximum lead concentration (39.6 mg/kg) is less than the maximum concentration in

upgradient gully samples of 43.9 mg/kg. Additionally, lead concentrations were low in surface soil samples (10.7 mg/kg to 31.2 mg/kg) and concentrations were either less than or similar to the TEC in sediment samples from most gullies that drain to Turkey Creek [the maximum concentration of 178 mg/kg at location 12SD17 in gully sediment samples drains to the East Tributary and the next downgradient East Tributary sample (location 12SD23) is much lower at 22.8 mg/kg]. Therefore, although risks to sediment invertebrates from lead in Turkey Creek sediments are possible at location 12SD27, the potential risks from lead are not great enough to warrant retaining it as a COPC.

Manganese

Manganese was initially selected as a COPC because an ESL is not available. Because an ESL and a consensus-based TEC are not available for the screening, manganese concentrations were compared to the following Canadian SQGs:

- Canadian Sediment Guidelines LEL – 460 mg/kg (OMOE, 1993)
- Canadian Sediment Guidelines SEL – 1,100 mg/kg (OMOE, 1993)

Manganese was detected in all three Turkey Creek sediment samples collected at SWMU 12 but only the maximum concentration exceeded the SEL. Downstream samples had concentrations of 444 mg/kg (13SD45) and 564 mg/kg (13SD44), which are less than the upgradient manganese concentration of 708 mg/kg.

Manganese concentrations in SWMU 12 Proper surface soil samples were slightly less than the maximum sediment concentration, ranging from 140 to 1,080 mg/kg, and were also less than the maximum background concentration for Soil Group 3 of 3,060 mg/kg (see Table 3-2); therefore, it does not appear that elevated manganese sediment concentrations (with respect to the LEL) are related to SWMU 12. Additionally, the maximum manganese concentration was within the upgradient gully sample range (253 mg/kg to 4,430 mg/kg). Therefore, although risks to benthic invertebrates at location 12SD27 are possible, the potential site-related risks are not great enough to warrant retaining manganese as a COPC for further evaluation.

Nickel

Nickel was initially selected as a COPC because the maximum detected sediment concentration of 52.1 mg/kg exceeded the ESL of 22.7 mg/kg, which is based on the TEC. Because the maximum

concentration exceeds the TEC, nickel concentrations were compared to the consensus-based PEC to further evaluate risks to sediment invertebrates.

The consensus-based PEC is 48.6 mg/kg (MacDonald et al., 2000). The maximum concentration at location 12SD27 exceeds the TEC and the PEC. Concentrations at downstream locations were less than the TEC and the upgradient nickel concentration of 22.8 mg/kg. The maximum concentration is within the range of upgradient gully sample concentrations (16.1 mg/kg to 63.9 mg/kg); therefore, it does not appear that nickel sediment concentrations are related to SWMU 12. Although it is possible that nickel concentrations in the sediment are adversely impacting benthic invertebrates at some locations, nickel in sediment does not appear to be related to site activities. For that reason, site-related risks to benthic invertebrates from nickel are acceptable, and nickel is not retained as a COPC for risks to sediment invertebrates.

Selenium

Selenium was initially selected as a COPC because an ESL is not available. No alternate benchmarks are available for selenium so other Step 3a factors, as discussed in Section 8.4, were used to evaluate risks to sediment invertebrates.

Selenium was detected in two of the three Turkey Creek sediment samples collected at concentrations of 0.13 mg/kg at location 13SD45 and 0.16 mg/kg at location 13SD44. Selenium was not detected at location 12SD27, the location nearest SWMU 12. Selenium was not detected in gully or East Tributary sediment samples and in SWMU 12 proper and historical surface soil samples; therefore, the paucity of data precludes a complete evaluation of selenium concentrations in sediment. However, because selenium was detected in only two of 11 BDA surface soil samples and not any other SWMU 12 samples, it does not appear that selenium is related to site activities so selenium is not retained as a COPC for further evaluation for sediment invertebrates.

Vanadium

Vanadium was initially selected as a COPC because an ESL is not available. The only available alternate benchmark for vanadium is the AET of 57 mg/kg (Buchman, 1999), which is based on marine organisms. Based on the Navy's agreement with U.S. EPA, if a chemical only has a higher effects level such as an AET, the chemical will not be eliminated as a COPC even if the maximum detection is less than the higher effects level, unless other Step 3a factors can be used to justify the chemical's elimination as a COPC.

Vanadium was detected in all three Turkey Creek sediment samples with concentrations ranging from 14 mg/kg to 57.8 mg/kg. Concentrations of vanadium in gully sediment samples were comparable to those detected in Turkey Creek samples and ranged from 23.4 mg/kg to 71 mg/kg. Additionally, the maximum concentration is within the range of upgradient gully sample concentrations (29.6 mg/kg to 62.4 mg/kg). Therefore, vanadium concentrations in SWMU 12 sediment samples do not appear elevated relative to all upgradient sediment concentrations. Although risks to benthic invertebrates cannot be ruled out because of the lack of lower-effects toxicity data, any potential site-related risks from vanadium are not great enough to warrant carrying vanadium further through the BERA process. Site-related risks to benthic organisms are acceptable, and vanadium is not retained as a COPC.

Acid Volatile Sulfides/Simultaneously Extracted Metals

Six sediment samples in the drainage ditch/gully samples were analyzed for acid volatile sulfides (AVS) and simultaneously extracted metals (SEMs). AVSs bind, on a molar basis, a number of cationic metals of environmental concern (e.g., cadmium, copper, lead, nickel, silver, and zinc) (U.S. EPA, 2005e). In sediment samples where AVS molar concentrations are greater than SEM molar concentrations, the SEMs metal are not expected to be bioavailable or directly toxic to benthic invertebrates. However, in sediment samples where AVS molar concentrations are less than SEM molar concentrations, the SEMs metal are not necessarily bioavailable or directly toxic to benthic invertebrates because other parameters such as TOC may reduce the bioavailability and toxicity of metals in the sediment. Sediments that are anoxic typically have greater AVS concentrations than sediments that are well aerated. The metals included in the SEM analysis at SWMU 12 included cadmium, copper, lead, mercury, nickel, silver, and zinc.

As discussed above, because of the poor habitat in the drainage ditches/gullies, it is not likely that benthic invertebrates will be present for significant periods of time, if at all. AVSs were not detected in four of the six samples analyzed and the SEMs metal at these locations are potentially bioavailable. At the other two locations, SEM-AVS results were less than 1, indicating that SEMs metal at these locations are likely not bioavailable (see Table 3-39). The SEMs metal that have the greatest molar concentrations are zinc in samples from 12SD01 and 12SD13 (the only two locations where AVSs were detected) (see Table 3-39). The bulk sediment concentrations of zinc in those samples were not particularly elevated compared to other locations, as can also be see from Table 3-39, so the slightly elevated AVS/SEM ratios may be an artifact of the variability observed at low concentrations of AVSs and SEMs.

Based on the habitat at location 12SD27 (see photographs in Appendix A and the sample log sheets in Appendix C), AVS at Turkey Creek is not expected to be present. Turkey Creek is a perennial stream and location 12SD27 is noted as approximately 1.5 feet deep with no foul odors, and although not flowing at the sample point, it is noted as flowing downstream (see sample log sheet in Appendix C).

Summary of Turkey Creek Sediment Sample Risks

In summary, the list of chemicals initially selected as COPCs were further evaluated in Step 3a, the first step of the BERA. After a review of alternate toxicity information (based on sediment invertebrates) for the initial COPCs was conducted, maximum concentrations were compared to benchmarks based on the alternate toxicity information, as appropriate.

No chemicals initially selected as COPCs in Turkey Creek sediment samples were retained as COPCs for further evaluation because concentrations were less than alternate toxicity information and/or upgradient concentrations.

8.4.1.3 Aquatic Organisms – Surface Water Risk

Table 8-13 presents a summary of the common alternate benchmarks used in refining the list of COPCs in the surface water samples, along with a Step 3a evaluation.

WQS for surface water have been developed for Indiana (IDEM, 1998). In addition, U.S. EPA has established AWQC for several contaminants (U.S. EPA, 2002). IDEM WQSs and AWQCs were reviewed. The AWQCs were used first for further evaluating chemicals initially selected as COPCs, where appropriate, because the AWQCs have been updated more recently than the WQS. However, in the absence of AWQCs, the IDEM WQS were also used. Other, non-regulatory surface water screening values were also used to evaluate the data, where necessary. The following sections discuss these values, as appropriate.

As stated previously in Section 8.4.1.2, although some chemical concentrations in surface water samples exceeded screening levels for aquatic receptors, there is very little exposure and so any risks would not be significant. For this reason, none of the chemicals in the drainage ditch/gulley samples are retained as COPCs for further evaluation for risks to aquatic organisms.

8.4.1.3.1 East Tributary Surface Water

4-Amino-2,6-dinitrotoluene

4-ADNT was initially selected as a COPC because no Region 5 surface water screening level was available. No alternate benchmarks for 4-ADNT are available; therefore, concentrations were compared to the secondary chronic value (SCV) of 20 µg/L for 2-ADNT developed in Talmage et al. (1999). The maximum concentration of 4-ADNT of 0.56 µg/L in sample 12SW2401 is significantly less than the SCV for 2-ADNT; therefore, 4-ADNT is not likely to cause adverse effects to aquatic receptors and risks are considered acceptable. 4-ADNT is not retained as a COPC for risks to aquatic receptors.

Aluminum

Aluminum was initially selected as a COPC in unfiltered samples because the maximum concentration of 257 µg/L exceeded the chronic AWQC of 87 µg/L. Aluminum was detected in filtered samples but was not retained as a COPC because the maximum concentration was less than the screening value. Because the filtered samples represent the bioavailable portion of inorganics (U.S. EPA, 1992), the filtered surface water results are most indicative of the level of direct risk to aquatic receptors. Therefore, risks to aquatic receptors from aluminum are considered acceptable, and aluminum is not retained as a COPC for risks to aquatic organisms.

Copper

Copper was initially selected as a COPC in unfiltered and filtered metal samples because maximum concentrations (3.4 µg/L and 2.8 µg/L, respectively) exceeded the Region 5 ESL of 1.58 µg/L. As stated previously, an emphasis is placed on filtered samples instead of the unfiltered sample results because the filtered samples results represent the bioavailable portion of the inorganics (U.S. EPA, 1992). The chronic AWQC for copper is 12.64 µg/L when using a water hardness of 143 mg/L (e.g., calculated using the average dissolved calcium concentration of 42,800 µg/L and average dissolved magnesium concentration of 8,703 µg/L in East Tributary surface water samples); both the unfiltered and filtered metal sample concentrations were less than the chronic AWQC.

The maximum concentration of copper was detected at location 12SW24, which is typically dry (see photographs in Appendix A), and even after heavy storm events (see photograph in Appendix A taken in March 2005), surface water at the location is very shallow and the substrate is rocky. Copper was not detected at the only other location in the East Tributary (12SW23). Therefore, overall risks to aquatic organisms from copper are acceptable because copper concentrations at location 12SW24 are less than

the AWQC. For these reasons, risks to aquatic organisms are acceptable, and copper is not retained as a COPC for risks to aquatic organisms.

Manganese

Manganese was initially selected as a COPC in unfiltered and filtered East Tributary surface water samples because an ESL is not available. Because an ESL and AWQC are not available for manganese, concentrations in surface water were compared to the following benchmarks:

- Indiana water criteria for chronic aquatic life – 748 µg/L

The Indiana water criteria was calculated using a water hardness of 143 mg/L (e.g., calculated using the average dissolved calcium concentration of 42,800 µg/L and average dissolved magnesium concentration of 8,703 µg/L in East Tributary surface water samples). The maximum detected concentrations of manganese in the East Tributary were 7.1 µg/L (unfiltered samples) and 3.5 µg/L (filtered samples) and are less than the Indiana chronic aquatic life criteria. Therefore, risks to aquatic life from manganese are acceptable, and manganese is not retained as a COPC for these receptors.

Nitrite/Nitrate-N

Nitrite/Nitrate-N was initially selected as a COPC because an ESL is not available. The form of N that is present in surface waters is based on the amount of oxygen present (CCME, 2003). In well oxygenated (i.e., aerated) waters, anionic species of nitrogen such as nitrate are easily transported and stable (USGS, 1992). Nitrite, on the other hand, is considered unstable in well-oxygenated (and shallow) surface waters (USGS, 1992). In fact, nitrite is rapidly oxidized to nitrate in well-oxygenated waters, such as typical surface water bodies. Location 12SW23 (the only location where nitrite/nitrate-N was detected) in the East Tributary is considered to be well oxygenated with an average dissolved oxygen (DO) concentration of 7.04 mg/L. Therefore, nitrate is expected to be the predominant form of nitrogen available to aquatic organisms at this location and is the more appropriate nitrogen species for evaluating toxicity to these receptors.

The Canadian water quality guideline for freshwater aquatic life (CCME, 2003) for nitrate is 13 mg/L. This value is based on a 10-day chronic study in which the toxicity of nitrate as sodium nitrate to the Pacific treefrog (P. regilla) was studied. A significant decrease in larval weight was observed at 133 mg/kg. The water quality guideline for freshwater aquatic life of 13 mg/L was derived by multiplying the LOEC from this study by a safety factor of 0.1. Other literature studies based on other freshwater aquatic life (i.e.,

invertebrates, amphibians, and fish) were reviewed in deriving the water quality guideline; however, amphibians were identified as the most sensitive species. The maximum concentration of 0.11 mg/L at location 12SW2301 is less than the Canadian water quality guideline for freshwater species; therefore, risks to aquatic organisms are acceptable. Nitrate (and the N-complex) is not retained as a COPC for aquatic organisms.

8.4.1.3.2 Turkey Creek Surface Water

Manganese

Manganese was initially selected as a COPC in unfiltered and filtered Turkey Creek surface water samples because an ESL is not available. Because an ESL and AWQC are not available for manganese, concentrations in the surface water are compared to the following benchmark:

- Indiana water criteria for chronic aquatic life – 686 µg/L

The Indiana water criteria was calculated using a water hardness of 129 mg/L (e.g., calculated using the average dissolved calcium concentration of 39,700 µg/L and average dissolved magnesium concentration of 7,350 µg/L in East Tributary surface water samples). The maximum detected concentrations of manganese in Turkey Creek were 133 µg/L (unfiltered samples) and 124 µg/L (filtered samples) and are less than the Indiana chronic aquatic life criteria. Therefore, risks to aquatic life from manganese are acceptable, and manganese is not retained as a COPC for these receptors.

Summary of Surface Water Risk

In summary, the list of chemicals initially selected as COPCs in East Tributary and Turkey Creek surface water samples was further evaluated in Step 3a, the first step of the BERA. After a review of alternate toxicity information (based on aquatic organisms) for the initial COPCs was conducted, concentrations were compared to the alternate toxicity information, as appropriate. No chemicals initially selected as COPCs were retained as COPCs for further evaluation because concentrations were less than benchmarks based on alternate toxicity information.

8.4.2 Food-Chain Modeling

Most of the referenced alternate benchmark values are not designed to evaluate risks to terrestrial wildlife via the ingestion of the soil, surface water, plants, and invertebrates. Therefore, a terrestrial intake model was used to estimate exposure of terrestrial receptors to COPCs. As presented in Figures 8-2, 8-3, and

8-4, food-chain modeling was conducted only on chemicals considered to be bioaccumulative [i.e., included in the list of important bioaccumulative chemicals in U.S. EPA (2000)] and that also exceeded Region 5 ESLs. Although energetics are not listed as important bioaccumulative chemicals in U.S. EPA (2000), they were also included in the food-chain models as a conservative measure. If the chemical was less than the ESL or is not bioaccumulative, it was not carried through the food-chain model. It was concluded that these chemical are not causing an unacceptable risk to wildlife at SWMU 12.

As mentioned previously, three surface soil and three sediment/surface water data sets for SWMU 12 exist. Food-chain modeling was conducted for the representative herbivorous and insectivorous receptors individually for all three surface soil data sets. Gully surface water COPCs (and concentrations) were used as the drinking water source for representative small mammals and birds. This is most likely the case because small mammals and birds that are potentially exposed to the surface soil concentrations at the SWMU 12 Proper, surrounding the buildings at SWMU 12, and at the BDA are most likely exposed to gully surface water concentrations as their drinking water source. It is not practical to assume that small mammals and birds with relatively small home ranges (i.e., just a few acres) exposed to surface soil COPCs would also be exposed to East Tributary and Turkey Creek surface water chemical concentrations. These species would be limited by mobility.

Additionally, food-chain modeling was conducted for representative piscivorous receptors for the Turkey Creek sediment and surface water data sets only. As mentioned previously, the intermittent gullies and East Tributary at SWMU 12 do not support small fish that these species would need to sustain their diet; however, Turkey Creek is a perennial stream that does support fish year-round. It is possible that piscivorous birds and mammals feed on fish exposed to concentrations in Turkey Creek.

Several energetics were retained as COPCs in gully surface water samples but not in surface soil samples. These energetics include 2,4-diamino-6-nitrotoluene, 2,6-diamino-4-nitrotoluene, 3-nitrotoluene, 4-amino-2,6-dinitrotoluene, and MNX. In order to avoid redundancy, these chemicals were included in only the food-chain models using historical surface soil sample concentrations. This is appropriate because the calculated surface water dosage would be the same in all three food-chain models because the water ingestion rate for the surrogate receptors would be the same.

Tables 8-1, 8-2, 8-3 (surface soil), 8-6 (sediment), 8-7, and 8-9 (surface water) list the chemicals retained for food-chain modeling.

8.4.2.1 Food-Chain Modeling Methodology

Risks to terrestrial receptors as a result of exposure to COPCs in the soil and surface water were determined by estimating the chronic daily intake (CDI) and comparing the CDI to TRVs representing acceptable daily doses in mg/kg-day. The TRVs were developed from NOAELs and lowest-observed-adverse-effect-levels (LOAELs) obtained from wildlife studies, when available. The majority of the TRVs came from the ORNL Toxicological Benchmarks for Wildlife: 1996 Revision (Sample, et al., 1996).

For avian species, the NOAEL (or LOAEL) for the test species was used as the NOAEL (or LOAEL) for the surrogate species in accordance with Sample et al. (1996) or other sources used. For mammalian species, the NOAEL (or LOAEL) from one species was adjusted to a NOAEL (or LOAEL) for the surrogate species using the following modified body weight scaling equation (from Sample et al., 1996):

$$NOAEL_w = NOAEL_t * (bw_t / bw_w)$$

Where: $NOAEL_w$ = no observed-adverse-effect level for the surrogate wildlife species
$NOAEL_t$ = no observed-adverse-effect level for the test species
bw_t = body weight of the test species
bw_w = body weight of the surrogate test species

Based on more recent publications (Sample and Arenal, 1999), U.S. EPA Region 5 indicated that the use of the metabolic scaling factor may not be appropriate for toxicity/body weight extrapolation factors. Therefore, U.S. EPA recommended that the toxicity/body weight equation be performed without the use of the scaling factor of 0.25. Body weight scaling is performed because studies have shown that, for mammals, numerous physiological functions such as metabolic rate and responses to toxic chemicals are a function of body size (Sample et al., 1996).

Appendix J.4 presents the derivation of TRVs. Tables J.4-2, J.4-3, and J.4-4 in Appendix J.4 present the TRVs as they were used in the food-chain modeling. Table J.4-2 presents the mammalian TRVs used in the conservative food-chain models. Table J.4-3 presents the mammalian TRVs used in the less conservative food-chain models and Table J.4-4 presents the avian TRVs used in both conservative and less conservative food-chain models. The difference between the mammalian TRVs used in the conservative and less conservative food-chain models is that the values have been adjusted using body weight scaling. The maximum body weights were used in adjusting the TRVs for the conservative food-chain models and the average body weights were used in adjusting the TRVs for the less conservative food-chain models (see Tables J.4-2 and J.4-3 for the equations used to derive the TRVs). If a

subchronic study was used to develop the TRV, the final value was multiplied by a factor of 0.1 to account for uncertainty between subchronic and chronic effects. If a LOAEL study was used to develop the NOAEL TRV, the LOAEL was multiplied by a factor of 0.1 to obtain the NOAEL.

Terrestrial soil invertebrates and plants are exposed to contaminants in surface soil through direct contact and/or ingestion. Aquatic organisms are exposed to contaminants in surface water and sediment through direct contact and/or ingestion.

COPC intake for wildlife exposed to the COPCs in surface soil, sediment, and surface water were estimated as daily dose (mg/kg-day) using exposure equations. The contaminant concentrations in surface soil, sediment, and surface water were used to calculate CDI doses. The following equations presents the CDI equations used in calculating a total daily dose for the surrogate species selected for modeling:

$$\text{Dose, surface soil/sediment (mg/kg - day)} = \frac{(SC * SI)}{BW}$$

$$\text{Dose, surface water (mg/kg - day)} = \frac{(SW * WI)}{BW}$$

$$\text{Dose, food (mg/kg - day)} = \frac{(FC * FI)}{BW}$$

$$\text{Total CDI (mg/kg - day)} = [\text{Dose (surface soil/sediment)} + \text{Dose (surface water)} + \text{Dose (food)}] * H$$

Where:

	FI	= Food ingestion rate (kg/day)
	FC	= Food concentration (mg/kg)
	WI	= Surface water ingestion rate (L/day)
	SW	= Surface water concentration (mg/L)
	BW	= Body weight (kg)
	SI	= Incidental soil/sediment ingestion rate (kg/day)
	SC	= Soil concentration (mg/kg)
	H	= Home Range/Contaminated Area (assume = 1 for maximum exposure)

For energetics and metals in surface soil and metals in sediment, contaminant concentrations of prey items for the insectivorous and herbivorous species (e.g., earthworms, vegetation, and fish) is calculated using the following equation:

$$FC = SC * BAF$$

Where:

FC = Contaminant concentration in food (e.g., earthworms, vegetation, and fish, kg/day)

SC = Contaminant concentration in surface soil/sediment (mg/kg)

BAF = Soil-to-plant, soil-to-invertebrate, or sediment-to-benthic invertebrate bioaccumulation factor (unitless)

The following sources of BAFs were used in the SERA:

- Plant BAFs (Organics): Toxicity and Chemical-Specific Factors Database (ORNL, 2002).
- Plant BAFs (Inorganics): Empirical Model for the Uptake of Inorganic Chemicals from Soil by Plants (ORNL, 1998a).
- Soil Invertebrate BAFs: Development and Validation of Bioaccumulation Models for Earthworms (Sample et al., 1998).
- BSAFs (Inorganics): Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation (ORNL, 1998b).

Table J.2-1 in Appendix J.2 presents chemical-specific BAFs and other BAF data from the literature that were used in this SERA. A default value of 1.0 was used for the BAF if chemical-specific data were not available in the above sources. Because sediment-to-fish BSAFs were not available for inorganic chemicals, sediment-to-aquatic invertebrate BSAFs from ORNL (1998b) were used to estimate tissue concentrations of inorganic chemicals in food items of the mink and belted kingfisher.

The exposure assumptions (e.g., ingestion rates and body weight) were obtained from the Wildlife Exposure Factors Handbook (U.S. EPA, 1993) or other literature sources, as necessary. Studies conducted in Indian or surrounding states were used, when available, to estimate the exposure factors. If only one value was available for a given exposure parameter, the value was used regardless of where the study was conducted in developing the value. The exposure parameters from U.S. EPA (1993) are wet weight values. However, the BAFs presented in the above sources estimate the tissue concentrations in dry weight and concentrations in soil and sediment are reported on a dry weight basis. Therefore, the exposure parameters from U.S. EPA 1993 were converted to dry weight values for the food-chain model

calculations. Table 8-14 presents the exposure parameters used in the SERA, and Appendix J.3 presents the values used to calculate the exposure parameters and a discussion of how they were calculated.

An EEQ approach was used to characterize the risk to terrestrial receptors. This approach characterizes the potential effects by comparing exposure concentration with effects data. An EEQ of greater than 1.0 is considered indicative of a potential risk. The EEQ is not an expression of probability, and the meaning of values greater than 1.0 must be interpreted in light of attendant uncertainties in risk management.

The EEQ for the terrestrial wildlife model was calculated as follows:

$$EEQ = \frac{\text{Total CDI}}{\text{TRV}}$$

Where:	EEQ	= Ecological effects quotient (unitless)
	Total CDI	= Total daily intake dose (mg/kg-day)
	TRV	= Toxicity reference value (NOAEL or LOAEL) (mg/kg-day)

8.4.2.2 Results and Discussion

Appendix J.5 presents the calculations associated with the food-chain modeling. Food-chain modeling was conducted separately for the surface soil data sets including: (1) SWMU 12 proper surface soil samples and gully surface water samples, (2) historical surface soil samples from remedial activities and gully surface water samples, and (3) BDA surface soil samples and gully surface water samples. Additionally, food-chain modeling was conducted using the sediment and surface water samples from Turkey Creek for piscivorous receptors.

Two scenarios were considered for each of the three data sets including: (1) maximum detected concentrations in surface soil/sediment, conservative exposure factors, and 90th percentile BAFs and (2) average detected concentration in surface soil/sediment, less conservative exposure factors, and average BAFs.

Upper-level carnivorous birds and mammals were not chosen as assessment endpoints because persistent and bioaccumulative chemicals are not expected and were not detected in SWMU 12 media. There is some uncertainty in this approach; however, because the area surrounding SWMU 12 likely supports large enough numbers of small mammals to comprise a significant portion of the diet for upper-

level carnivorous birds and mammals. The uncertainty with not conducting food-chain modeling for upper-level birds and mammals is reduced however, because it is unlikely that the small mammals that upper-level carnivores are feeding on are actually living and feeding in the contaminated portions of SWMU 12 only. Additionally, the potentially contaminated areas at SWMU 12 represent only a very small fraction of these large carnivores' home ranges. The ridge top at SWMU 12 covers approximately 60 acres, although actual SWMU boundaries extend beyond the ridge top (see Figure 8-5). However, the potentially contaminated areas represent a small portion of the ridge top (i.e., surrounding some buildings and the BDA, see Figure 2-1). The home ranges of the red fox and red-tailed hawk are approximately 1,300 acres and 1,000 acres, respectively (U.S. EPA, 1993), so the potentially contaminated areas surrounding the buildings and the BDA (less than 10 acres total) represents only a fraction (i.e., approximately 0.71 and 1 percent for the fox and hawk, respectively) of these species' feeding areas. Separate discussions are provided below for evaluations of potential risk to herbivorous receptors, insectivorous receptors, and piscivorous receptors. Table 8-15 presents a summary of the Step 3a evaluation for terrestrial wildlife.

SWMU 12 Proper Surface Soil Samples

Under the conservative food-chain scenario, NOAEL-based EEQs were all less than 1.0 for representative herbivorous receptors (see Table 8-16). Because EEQs were less than 1.0 under the most conservative scenario, an average exposure scenario for herbivorous receptors was not necessary. Risks to herbivorous receptors from SWMU 12 Proper surface soil locations are acceptable.

For insectivorous receptors, COPCs with EEQs greater than 1.0 under the conservative food-chain scenario included chromium, lead, mercury, and zinc. EEQs were greater than 1.0 for the insectivorous bird only (see Table 8-16). Under the average food-chain scenario, only chromium and zinc had NOAEL-based EEQs slightly greater than 1.0 at 1.2 and 1.6, respectively. LOAEL-based EEQs were less than 1.0 (see Table 8-17).

The avian TRVs for chromium are based on a study in which black duck duckling survival was reduced at a dose level of 50 mg/kg chromium; however, no significant differences were observed at a dose level of 10 mg/kg chromium. Chromium was detected in all nine SWMU 12 Proper surface soil samples at concentrations ranging from 18.1 mg/kg to 26.9 mg/kg. These concentrations are similar to the background concentrations from Soil Group 3 with a maximum background concentration of 21.7 mg/kg (see Table 3-2). In fact, the NOAEL-based EEQ for chromium in the woodcock food-chain model is also greater than 1.0 when using the maximum background concentration of 21.7 mg/kg and the average

exposure parameters (EEQ = 1.1). Therefore, it appears that risks to insectivorous birds are similar to background risks.

The avian NOAEL and LOAEL for zinc were developed from a study in which no adverse effects were observed among hens consuming 48 and 228 mg/kg zinc, but where egg hatchability was less than 20 percent of controls among hens consuming 2,028 mg/kg zinc (Sample et al., 1996). Because the study was greater than 10 weeks in duration and considered exposure during reproduction, the 228 mg/kg dose was considered a chronic NOAEL (14.5 mg/kg-day), and the 2,028 mg/kg dose was considered a chronic LOAEL (131 mg/kg-day). Zinc was detected in all nine SWMU 12 Proper surface soil samples and only the maximum concentration was greater than the maximum background concentration for Soil Group 3 of 60.2 mg/kg (see Table 3-2). The maximum SWMU 12 Proper sample concentration of 165 mg/kg was detected at location 12SB07. This location is bounded to the south, west, and north by locations 12SB04, 12SB05, and 12SB06 where concentrations were 47.7 mg/kg, 57.8 mg/kg, and 45.6 mg/kg, respectively. Location 12SB07 is additionally bounded to the east by a roadway; therefore, the area of the maximum concentration is small and isolated. It is very unlikely that insectivorous birds will obtain any significant portion of their diet from the vicinity of this isolated location. The NOAEL-based EEQ for zinc in the woodcock food-chain model is also greater than 1.0 when using the maximum background concentration of 60.2 mg/kg and the average exposure parameters (EEQ = 1.8). Therefore, when the food-chain model is calculated for the woodcock excluding the area of location 12SB07, which is small and isolated, it appears that risks to insectivorous birds are similar to background risks.

In summary, risks to herbivorous birds and mammals and insectivorous mammals are acceptable because NOAEL-based EEQs were less than 1.0 under the average exposure scenario. Additionally, risks to insectivorous birds are also acceptable. Even though NOAEL-based EEQs were slightly greater than 1.0 under the average exposure scenario for insectivorous birds, these risks are similar to background risks.

BDA Surface Soil Samples

Under the conservative food-chain scenario, eight metals, including arsenic, cadmium, chromium, copper, lead, mercury, silver, and zinc, had NOAEL-based EEQs greater than 1.0 for representative herbivorous and insectivorous receptors (see Table 8-18). Under the average food-chain scenario, only lead NOAEL-based EEQs were greater than 1.0 for representative herbivorous receptors, and five metals (arsenic, chromium, lead, mercury, and zinc) had NOAEL-based EEQs greater than 1.0 for representative insectivorous receptors (see Table 8-19). LOAEL-based EEQs were greater than 1.0 for lead (woodcock

and quail) and zinc (woodcock) only (Table 8-19). Risks to representative herbivorous and insectivorous receptors are largely attributable to elevated metals concentrations at four locations including 12SB21, 12SB22, 12SB23, and 12SB24. Concentrations at this "hot spot" area were particularly elevated for certain metals and are discussed further below.

The avian TRVs for mercury were derived from a study using the Mallard duck as the test species. Significant effects (fewer eggs and ducklings were produced) were observed at a dose level of 0.5 mg/kg. Because the study considered exposure over three generations, the dose was considered a chronic LOAEL and was multiplied by an uncertainty factor of 0.1 to develop a chronic NOAEL. The avian NOAEL and LOAEL for lead were developed from a study in which no adverse effects were observed among Japanese quail consuming 10 mg/kg lead, but where reproduction was less impaired at 100 mg/kg (Sample et al., 1996). Because the study was greater than 12 weeks in duration and considered exposure during reproduction, the 10 mg/kg dose was considered a chronic NOAEL (1.13 mg/kg-day) and the 100 mg/kg dose was considered a chronic LOAEL (11.3 mg/kg-day). The avian NOAELs and LOAELs for chromium and zinc are discussed above under the SWMU 12 Proper surface soil samples discussion.

The mammalian TRVs for arsenic were derived from a reproduction study over three generations in which mice were fed arsenic at 5 mg/L in their drinking water supply and 0.06 mg/kg in their food. Mice exposed to arsenic had declining litter sizes with each successive generation, so the dose was considered a chronic LOAEL. The chronic NOAEL was estimated by multiplying the chronic LOAEL by an uncertainty factor of 0.1. The mammalian TRVs for lead were derived from a reproduction study over three generations in which mice were fed five dose levels of lead (10, 50, 100, 1000, and 2000 ppm) in their diet. Lead exposure at a dose of 1,000 ppm resulted in reduced offspring weight and kidney damage; therefore, the 1,000 mg/kg/d dose was considered the chronic LOAEL and the 100 mg/kg/d dose was considered the chronic NOAEL.

Only lead had NOAEL and LOAEL-based EEQs greater than 1.0 for herbivorous receptors. The EEQs were greater than 1.0 due to the maximum concentration at location 12SB21. The average concentration excluding the maximum is 421 mg/kg. NOAEL-based EEQs were less than 1.0 with a soil concentration of 421 mg/kg and average exposure parameters. Clearly, it is the location of the maximum concentration that is generating potential risks to herbivorous receptors.

The NOAEL-based EEQ for arsenic was greater than 1.0 for the representative insectivorous mammal only (EEQ = 2.8). The EEQ was greater than 1.0 due to the two greatest concentrations at locations 12SB21 and 12SB24 of 94.2 mg/kg and 158 mg/kg, respectively. The average concentration excluding

those two locations is 5.4 mg/kg. Concentrations at all other BDA surface soil locations are less than the maximum background concentration of 10.2 mg/kg for Soil Group 3 (see Table 3-2). The NOAEL-based EEQ for arsenic is less than 1.0 with a soil concentration of 5.4 mg/kg and average exposure parameters. These two locations present unacceptable risks to insectivorous mammals.

The NOAEL-based EEQ for chromium was greater than 1.0 at 1.6 for the representative insectivorous bird only. Although concentrations of chromium were greater at locations 12SB21, 12SB22, and 12SB24, concentrations at other locations were similar ranging from 18.3 mg/kg to 40.3 mg/kg. The average concentration excluding the three greatest was 24.2 mg/kg. Although the NOAEL-based EEQ is still greater than 1.0 using a soil concentration of 24.2 mg/kg and average exposure parameters, the concentration is only slightly greater than the maximum background concentration from Soil Group 3 of 21.7 mg/kg. Therefore, although risks to insectivorous birds are possible as a result of concentrations at the "hot spot" area, risks to insectivorous birds at other locations at the BDA are similar to background risks.

The NOAEL- and LOAEL-based EEQs for lead were greater than 1.0 for the representative insectivorous mammal (NOAEL EEQ only) and bird. As discussed above for herbivorous receptors, risks are driven in large part due to the maximum concentration. The NOAEL-based EEQ was less than 1.0 with the average soil concentration excluding the maximum detection (421 mg/kg) and average exposure parameters for the insectivorous mammal. However, risks to the insectivorous bird were still likely under this revised average scenario because the NOAEL- and LOAEL-based EEQs remained greater than 1.0. In fact, the NOAEL-based EEQ is greater than 1.0 when including any of the locations from the "hot spot" in the average soil concentration. It appears; therefore, that the "hot spot" area presents unacceptable risks to insectivorous birds.

The NOAEL-based EEQ for mercury is greater than 1.0 for the representative insectivorous bird only. As discussed above, risks are driven by the maximum concentration. The NOAEL-based EEQ was less than 1.0 with the average soil concentration excluding the maximum detection (0.0261 mg/kg) and average exposure parameters for the insectivorous bird.

The NOAEL and LOAEL-based EEQs for zinc were greater than 1.0 for the representative insectivorous bird only. The average concentration of 76 mg/kg when excluding the four locations from the "hot spot" area is only slightly greater than the maximum background concentration for Soil Group 3 (60.2 mg/kg). In fact, the NOAEL-based EEQ using the average concentration of 76 mg/kg and average exposure parameters is 2.3 while the NOAEL-based EEQ using the maximum background concentration for Soil

Group 3 and average exposure parameters is 1.8. Therefore, risks are possible due primarily to locations in the "hot spot" area whereas risks from other locations are similar to background risks.

In summary, risks to herbivorous mammals and birds from lead concentrations are unacceptable in the vicinity of the location with the maximum concentration. Risks to herbivorous mammals and birds from other locations within the BDA are acceptable. Risks to insectivorous mammals and birds are unacceptable at various locations within the "hot spot" for various metals including arsenic, chromium, lead, and mercury. However, zinc concentrations are elevated across the BDA at various locations including and outside the "hot spot" area and present unacceptable risks to insectivorous birds and mammals.

Historical Surface Soil Samples

Under the conservative food-chain scenario, three energetics and five metals had NOAEL-based EEQs greater than 1.0 for representative herbivorous and insectivorous receptors (see Table 8-20). Under the average food-chain scenario, only HMX, RDX, and mercury had NOAEL-based EEQs greater than 1.0 for representative herbivorous and insectivorous receptors (see Table 8-21). LOAEL-based EEQs were greater than 1.0 for HMX (vole) and RDX (woodcock) only (Table 8-21).

The mammalian TRV for HMX is based on a study in which no significant increase in mortality was observed among mice consuming 30 mg/kg-day HMX, but a significant increase in mortality was noted at a concentration of 75 mg/kg-day. The avian TRVs for RDX are based on a subchronic study by Gogal et al., (2003) in which a high incidence of female mortality of Northern bobwhite was observed at 26.3 mg/kg/d. A NOAEL of 22.3 mg/kg/d was estimated from the study. Because the study was subchronic, the NOAEL and LOAEL were multiplied by an uncertainty factor of 0.1 to estimate a chronic NOAEL and LOAEL. The avian TRVs for mercury are discussed above under the BDA surface soil samples discussion.

NOAEL- and LOAEL-based EEQs for HMX were greater than 1.0 for the herbivorous mammal only. This is because of the elevated HMX concentrations in samples surrounding Building 153. The maximum concentration at Building 153 was 752 mg/kg; concentrations at other buildings were 54.3 mg/kg (Building 158) and less. In fact, HMX was not detected in samples surrounding Building 151 and Building 156. NOAEL- and LOAEL-based EEQs were still greater than 1.0 using the maximum concentrations at Buildings 152 and 157; therefore, it appears that risks to herbivorous mammals from HMX in surface soil are possible at least at some locations surrounding Buildings 152, 153, 157, and 158. Risks are

acceptable at Buildings 151 and 160 because HMX was not detected in soils surrounding these two buildings.

NOAEL- and LOAEL-based EEQs for RDX were greater than 1.0 for the insectivorous bird only. The average concentration is elevated due to concentrations at Buildings 153 and 158. When the food-chain model is calculated using the maximum concentration from Buildings 152, 157, and 160 and average exposure parameters the NOAEL-based EEQs are either at 1.0 or less than 1.0. RDX was not detected at Building 151 and so risks are acceptable at this location.

Only the mercury NOAEL-based EEQ exceeded 1.0 for the insectivorous bird; the LOAEL-based EEQ was less than 1.0. The NOAEL-based EEQ is greater than 1.0 using the maximum detected concentrations at the buildings where mercury was detected (i.e., Buildings 152, 153, 157, and 158). Mercury was not detected at Buildings 151 and 160 and so risks are acceptable at these locations.

It should be noted that some energetics were not retained for further evaluation for risks to the insectivorous and herbivorous receptors because TRVs are not available to evaluate energetics. This does not significantly impact the risk assessment, however, because the energetics that lack TRVs were only detected in surface water samples and the drinking water dose is very low compared to food doses of other explosives. The uncertainties with not evaluating some of the energetics due to a lack of toxicity information are discussed further in Section 8.5.

Turkey Creek Sediment Samples

Under the conservative food-chain scenario, arsenic, chromium, and lead had NOAEL-based EEQs greater than 1.0 for the piscivorous receptors (see Table 8-22). Under the average scenario, only arsenic had NOAEL- and LOAEL-based EEQs greater than 1.0 for the representative piscivorous mammal (see Table 8-23). The source of the mammalian TRVs for arsenic are presented above with the BDA surface soil samples discussion.

The maximum arsenic sediment concentration was detected at location 12SD27 and was twice that of the next greatest arsenic concentration. However, when the average arsenic concentration is calculated without the maximum concentration, NOAEL- and LOAEL-based EEQs still exceed 1.0 for the mink. However, it does not appear that arsenic concentrations in Turkey Creek sediment are related to SWMU 12. As discussed above in Section 8.4.1.2.2, arsenic was not selected as a COPC in surface soils because concentrations are low (i.e., less than the U.S. EPA Eco-SSL). Additionally, arsenic concentrations in gully sediment samples are within the same range (9.3 mg/kg to 36 mg/kg) as those

detected in the East Tributary and Turkey Creek sediment samples. Therefore, although risks to piscivorous mammals are possible in Turkey Creek, these risks are not likely attributable to SWMU 12, and arsenic is not retained as a COPC for piscivorous receptors.

8.5 ECOLOGICAL RISK UNCERTAINTY ANALYSIS

This section discusses some of the uncertainties associated with the SWMU 12 ERA.

8.5.1 Measurement and Assessment Endpoints

Measurement endpoints are used to evaluate the assessment endpoints selected for the SERA. For the SERA, the measures of effects are not the same as the assessment endpoints. Therefore, the measures are used to predict effects to the assessment endpoints by selecting surrogate species to be evaluated. For example, a decrease in reproduction of a shrew is used to assess a decrease in reproduction of the small mammal population. However, predicting a decrease in reproduction of a shrew may either underprotect or overprotect the small mammal population based on differences in ingestion rates, toxicity, food preferences, home ranges, etc. between different species.

Risks to reptiles and amphibians are not quantitatively evaluated because exposure factors are not established for most species and toxicity data are very limited. Using aquatic organisms as surrogate species, risks to amphibians exposed to sediment are possible; however, risks from surface water contaminants are expected to be low based on the Step 3a evaluations. Potential risks to reptiles cannot be evaluated in this ERA because of a lack of toxicity and exposure data (see below for a discussion of potential risks to the timber rattlesnake).

As discussed in Section 8.2.1.1, several endangered and threatened species or species of special concern are present at NSWC Crane and may potentially inhabit SWMU 12. Risks to these species were not specifically calculated, so the uncertainties of not calculating risks to these species are presented here. As discussed above, risks to carnivorous mammals and birds were not evaluated because the potentially contaminated area is only a small fraction of these species home ranges; therefore, risks to the bobcat, bald eagle, Northern harrier, and osprey, and to carnivorous reptiles such as the timber rattlesnake cannot be quantified. However, most endangered and threatened species or species of special concern are listed as such due to the absence of suitable habitat and not necessarily because they are more sensitive to chemical contamination. Nevertheless, risks to these species were not specifically calculated, so uncertainties exist as to how these species would be affected if an exposure to site chemical concentrations occurred. Loggerhead shrikes and the sedge wren consume mostly

aboveground insects such as caterpillars, beetles, spiders, and flies, as opposed to the worms that are consumed by the American woodcock in the food-chain model. Because worms are in direct contact with exposure to the soil, it is expected that they would have greater levels of contaminants at SWMU 12 than aboveground insects; therefore, risks to the woodcock from consuming worms are expected to be greater than risks to the loggerhead shrike and sedge wren from consuming aboveground insects. Risks to the worm-eating American woodcock from chemicals in the surface soil and surface water were not acceptable at the BDA for some metals including arsenic, chromium, lead, mercury, and zinc; therefore, risks to the loggerhead shrike and sedge wren are also considered possible if these species are present at SWMU 12. The American bittern is a marshland-loving bird that feeds on fish, frogs, eels, insects, and water snakes. Risks to piscivorous wildlife in Turkey Creek were evaluated; however, all risks from SWMU 12 were considered acceptable; therefore, any potential risks to the American bittern, if present at SWMU 12, would also be acceptable.

Finally, there are uncertainties in risks to reptiles because there is a lack of exposure factors for reptiles and a lack of reptile toxicity data for the detected chemicals. As discussed in Section 8.2.1.1, one threatened reptilian species is listed as potentially present at NSWC Crane. Based on the preferred habitat of the timber rattlesnake and the ecology of SWMU 12 (i.e., located on a ridge top), this species may potentially inhabit areas of SWMU 12. Risks to this species was not specifically calculated so uncertainties exist as to how this species would be affected if an exposure to site chemical concentrations occurred.

8.5.2 Exposure Characterization

The contaminant dose to terrestrial wildlife is calculated using an equation that incorporates ingestion rates, body weights, BAFs, and other exposure factors. These exposure factors are obtained from literature studies or predicted using various equations. Ingestion rates and body weights vary among species, especially among species inhabiting different areas. This was taken into account when selecting exposure parameters from U.S. EPA (1993), and an attempt was made to minimize the uncertainties associated with the exposure characterization by selecting exposure parameters from studies conducted in Indiana and surrounding states.

Bioaccumulation of contaminants into various biological media (e.g., plants, invertebrates, and fish) depends on characteristics of the media such as pH, TOC, etc. Therefore, actual BAFs at the sites may be different than those used in the SERA and obtained from the literature. BAFs for estimating concentrations of some explosives in plant and earthworm tissue were not available, so a BAF of 1.0 was used in the food-chain models. Explosives have relatively high water solubility values and low Koc values

so they are not expected to accumulate to any significant degree in animal tissue. Therefore, using a BAF of 1.0 is likely causing the concentrations of explosives in animal tissue to be overestimated in the food-chain model.

Also, the bioavailability of contaminants reported in toxicity studies is typically greater than the contaminants in environmental media. Typically, high bioavailable forms of the chemicals are used when conducting toxicity tests and or when conducting dosing studies for wildlife. For example, many of the toxicity tests used to develop screening levels for metals use highly bioavailable forms of the metal, such as metal salts, which in many cases are much more toxic than equivalent concentrations of the metals in field collected soils (Allen, 2002).

There is uncertainty in the chemical data collected at the site. Measured levels of chemicals are only estimates of the true site chemical concentrations. At SWMU 12, samples were deliberately biased toward known or suspected high concentrations (e.g., surface soil samples collected surrounding buildings at SWMU 12), so predicted doses are higher than actual doses. Whereas this is a conservative approach in predicting exposure concentrations, actual exposure of ecological receptors to chemical concentrations at SWMU 12 is likely overestimated. In particular, wildlife, which typically roam over multiple sample locations are unlikely to obtain all their food from within the most contaminated areas at SMWU 12. Also, because the areas immediately surrounding the buildings only occupy a very small portion of the overall ecological habitat at SWMU 12, a discussion of the overall risks to ecological receptors was included in the ERA.

The exposure to and potential risks to ecological receptors from chemicals in gullies were only evaluated in the conservative COPC screening table. In the first part of the Step 3a refinement, it was determined that risks to aquatic receptors from chemicals in the gullies were low because the intermittent nature of the gullies precludes a significant aquatic community from being present and therefore exposed to chemicals. There is some uncertainty in not further evaluating risks to aquatic receptors in the gullies, but the overall conclusion of the ERA is not likely to be impacted because the lack of exposure would limit the ecological significance of any potential risks.

There is uncertainty involved with the collection of samples and therefore, sample concentrations, as a result of the historical remedial activities at SWMU 12 as discussed in Section 8.4.1.1. Recent surface soil was collected from the 0- to 2-foot below ground surface (bgs) interval, but the exact depth of some of the historic samples is not known. Some of the samples may have been as deep as 3 feet bgs. The uncertainty in the sampling depth is not expected to be significant because a much greater weight was given to the samples collected from the remediated soil because this soil comprised a majority of the soil

volume immediately adjacent to each building. The samples collected from remediated soil represent the soil concentrations in the top 2 feet of soil.

Finally, there is uncertainty in the concentrations of explosives in the historical soil samples. The samples were taken from the remediated soil prior to being placed back around each building. It is expected that the explosives concentrations in the soil are continuing to decrease through bioremediation. It is likely that the concentrations of explosives around each building are now less than the concentrations used in the ERA so risks to ecological receptors will continue to decrease.

8.5.3 Ecological Effects Data

Toxicological data for a few of the chemicals are limited or do not exist. This occurred for several COPCs in surface soil, sediment, and surface water, but it did not affect the outcome of the risk assessment because the chemicals without toxicity data were evaluated using the other Step 3a factors discussed in Section 8.4.

Several alternative benchmark values were used to gain a better understanding of the relationship between the maximum concentration values of the selected COPCs to the overall ecological assessment of the site. There is some uncertainty involved when using these alternative benchmarks; however, attempts have been made to lessen the uncertainties by providing the toxicological basis of the alternate benchmarks when they were used.

8.5.4 Risk Characterization

Risks are possible if an EEQ is greater than or equal to 1.0 regardless of the magnitude of the EEQ. However, the magnitude of effects to ecological receptors cannot be inferred based on the magnitude of the EEQ. Rather, an EEQ greater than 1.0 simply indicates that the dose used to derive the toxicity reference value was exceeded.

Finally, there is uncertainty in how the predicted risks to a species at a site translate into risk to the population in the area as a whole.

8.6 ECOLOGICAL RISK SUMMARY AND CONCLUSIONS

A SERA was performed for MFA. Several chemicals were retained as COPCs as a result of the initial screening of surface water, sediment, and surface soil. These chemicals were further evaluated and data were scrutinized as a part of the Step 3a refinement. Tables 8-10, 8-11, 8-12, and 8-14 present

summaries of the Step 3a evaluation including the overall conclusion of whether chemicals initially selected as COPCs are retained as COPCs after the refined evaluation.

Surface Soil

No chemicals initially selected as COPCs in SWMU 12 Proper surface soil samples were retained as COPCs.

Several chemicals initially selected as surface soil COPCs were retained as COPCs for further evaluation in the BDA including antimony, copper, lead, tin, and zinc because concentrations were greater than alternate toxicity information at multiple locations. In particular, locations 12SS21 through 12SS24 represent a "hot spot" for ecological receptors where concentrations of multiple COPCs exceeded alternate benchmarks for plants and soil invertebrates and background concentrations for Soil Group 3. Concentrations at all other locations within the BDA were acceptable.

Several chemicals initially selected as surface soil COPCs in historical samples collected immediately surrounding the buildings at SWMU 12 were retained as COPCs for further evaluation. HMX, RDX, TNT, and arsenic were retained as COPCs because concentrations were greater than alternate toxicity information at multiple locations. In particular, HMX and RDX concentrations were particularly elevated in samples surrounding Building 153. Similarly, arsenic concentrations were greatest in the vicinity of Buildings 158 and 160. TNT concentrations were greater than alternate benchmarks for plants and soil invertebrates surrounding all buildings at SMWU 12, except Building 151, where explosives were not detected. However, surface soil samples collected during the historical activities were collected in areas immediately surrounding the buildings at SWMU 12, which are maintained grassy areas. Therefore, great plant diversity would not be expected to exist in these areas. The areas in the middle of SWMU 12 and the areas along the SWMU boundaries are heavily vegetated (see photographs in Appendix A), so the potentially impacted areas adjacent to the buildings only represent a small percentage of potential habitat in that area.

Sediment

No chemicals initially selected as COPCs in East Tributary and Turkey Creek sediment samples were retained as COPCs for further evaluation because concentrations were less than benchmarks based on alternate toxicity information and/or upgradient concentrations.

Surface Water

No chemicals initially selected as surface water COPCs in the East Tributary and Turkey Creek were retained as COPCs for further evaluation in surface water because concentrations were less than alternate toxicity information.

Food-Chain modeling

Food-chain modeling was conducted separately for the surface soil data sets including: (1) SWMU 12 Proper surface soil samples and gully surface water samples, (2) Historical surface soil samples from remedial activities and gully surface water samples, and (3) BDA surface soil samples and gully surface-water samples. Additionally, food-chain modeling was conducted using the sediment and surface water samples from Turkey Creek for piscivorous receptors.

After a review of the refinement of food-chain modeling risks (average exposure scenario) to herbivorous/insectivorous receptors in SWMU 12 Proper surface soil, all potential risks were determined to be acceptable.

In the BDA surface soil data set, risks to herbivorous mammals and birds from lead concentrations are unacceptable in the vicinity of the maximum location. Risks to herbivorous mammals and birds from other locations within the BDA are acceptable. Risks to insectivorous mammals and birds are unacceptable from various locations within the "hot spot" for various metals including arsenic, chromium, lead, and mercury. However, zinc concentrations are elevated across the BDA at various locations including and outside the "hot spot" area and present unacceptable risks to insectivorous birds and mammals.

In the historical surface soil data set, risks to herbivorous mammals from HMX are possible at least at some locations surrounding Buildings 152, 153, 157, and 158. Due to the nature of the historical sample data, averages were not calculated; however, it is unlikely that risks exist to herbivorous mammals at all locations at the four buildings.

After a review of the refinement of food-chain modeling risks (average exposure scenario) to piscivorous receptors in Turkey Creek sediment and surface water, all potential risks were determined to be acceptable.

TABLE 8-1

ECOLOGICAL COPC SELECTION FOR SWMU 12 PROPER
SURFACE SOIL SAMPLES, ROUND 1 ONLY
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mean Concentration	Average of Positive Detections	Sample with Maximum Detection	Region 5 ESL	EEQ	COPC[4] Plants/ Invertebrates	COPC[4] Wildlife	Rationale[5]
Inorganics (mg/kg)											
ALUMINUM	9/9	17,500 J	29,800 J	23378	23378	12SS070002	pH[1][2]	NA	NO	NO	BSL
ANTIMONY	5/9	0.35 J	1.4 J	0.448	0.648	12SS070002	0.27[1]	5.2	YES	NO	ASL/NONBIO
ARSENIC	9/9	4 J	9 J	6.76	6.76	12SS010002	18[1]	0.5	NO	NO	BSL
BARIUM	9/9	50.2 J	128 J	90.5	90.5	12SS010002	330[1]	0.4	NO	NO	BSL
BERYLLIUM	8/9	0.53 J	0.98 J	0.738	0.799	12SS080002	21[1]	0.05	NO	NO	BSL
CALCIUM	9/9	285 J	26,000 J	4525	4525	12SS060002	NA	NA	NO	NO	NUT
CHROMIUM	9/9	18.1 J	26.9 J	24.0	24.0	12SS050002	26[1]	1.03	YES	YES	ASL/BIO
COBALT	9/9	4.6 J	15.7 J	8.52	8.52	12SS010002	13[1]	1.2	YES	NO	ASL/NONBIO
COPPER	9/9	8.1 J	19 J	13.1	13.1	12SS070002	5.4	3.5	YES	YES	ASL/BIO
IRON	9/9	18,800 J	30,600 J	24389	24389	12SS050002	pH[1][3]	NA	YES	NO	NC/NONBIO
LEAD	9/9	10.7 J	31.2 J	16.1	16.1	12SS070002	11[1]	2.8	YES	YES	ASL/BIO
MAGNESIUM	9/9	1,360 J	3,050 J	2293	2293	12SS060002	NA	NA	NO	NO	NUT
MANGANESE	9/9	140 J	1,080 J	404	404	12SS010002	NA	NA	YES	NO	NC/NONBIO
MERCURY	9/9	0.009 J	0.041 J	0.0250	0.0250	12SS040002	0.1	0.4	NO	NO	BSL
NICKEL	9/9	12.1 J	21.4 J	16.9	16.9	12SS050002	13.6	1.6	YES	YES	ASL/BIO
POTASSIUM	9/9	1,130 J	2,120 J	1714	1714	12SS070002	NA	NA	NO	NO	NUT
SILVER	1/9	0.21 J	0.21 J	0.0502	0.210	12SS080002	4.04	0.05	NO	NO	BSL
SODIUM	1/9	59.8 J	59.8 J	28.2	59.8	12SS060002	NA	NA	NO	NO	NUT
TIN	2/9	0.58 J	0.61 J	0.321	0.595	12SS080002	7.62	0.1	NO	NO	BSL
VANADIUM	9/9	28.4 J	48.6 J	39.4	39.4	12SS070002	7.8[1]	6.2	YES	NO	ASL/NONBIO
ZINC	9/9	23.3 J	165 J	53.5	53.5	12SS070002	6.62	25	YES	YES	ASL/BIO
Miscellaneous Parameters (mg/kg)											
AMMONIA-N	2/2	0.82 J	0.98 J	0.900	0.900	12SS020002	NA	NA	NA	NA	NZ
CATION EXCHANGE CAPACITY (MEQ/1)	2/2	14	15	14.5	14.5	12SS030002	NA	NA	NA	NA	NZ
PH (S.U.)	2/2	6	7.7	6.85	6.85	12SS030002	NA	NA	NA	NA	NZ
TOTAL ORGANIC CARBON	2/2	2200	11000	6600	6600	12SS020002	NA	NA	NA	NA	NZ

Data qualifiers (e.g., U, J) are defined in Section 3.
mg/kg - milligrams per kilogram.
MEQ/1 - milliequivalents per 100 grams.
S.U. - Standard units.
COPC = Chemicals of potential concern.
ESL = Region 5 Ecological Screening Level.
EEQ = Ecological Effects Quotient.
NA = Not available or Not applicable.
1 - USEPA Ecological Soil Screening Level.
2- Aluminum is only considered a COPC when the soil pH is less than 5.5. Average soil pH at SWMU 12 was 6.85 S.U.
3 - Iron is not expected to be toxic to plants with a soil pH between 5 and 8. Average soil pH at SWMU 12 was 6.85 S.U. Iron is retained as a COPC for risks to invertebrates.

TABLE 8-1

ECOLOGICAL COPC SELECTION FOR SWMU 12 PROPER
SURFACE SOIL SAMPLES, ROUND 1 ONLY
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

4 - Chemicals retained as COPCs are further evaluated in the Step 3a evaluation (see Section 8.4.1.1.1).
5 - Rationale for COPC selection/deletion:
ASL = Above Screening Level
BIO = Bioaccumulative chemical
BSL = Below Screening Level
NONBIO = Nonbioaccumulative chemical
NC = No Criteria available
NUT = Essential Nutrient
NZ = Field Parameter only

TABLE 8-2

ECOLOGICAL COPC SELECTION FOR BATTERY DISPOSAL AREA
SURFACE SOIL SAMPLES, ROUND 1 ONLY
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mean Concentration	Average of Positive Detections	Sample with Maximum Detection	Region 5 ESL	EEQ	COPC[4] Plants/ Invertebrates	COPC[4] Wildlife	Rationale[5]
Volatile Organics (ug/kg)											
DICHLORODIFLUOROMETHANE	9/11	2 J	15	7.02	8.44	12SS210002	39500	0.0004	NO	NO	BSL
METHYLENE CHLORIDE	3/11	1 J	2 J	0.866	1.67	12SS220002, 12SS230002	4050	0.0005	NO	NO	BSL
Semivolatile Organics (ug/kg)											
ACENAPHTHENE	1/11	4 J	4 J	2.04	4.00	12SS150002	682000	0.00001	NO	NO	BSL
ACENAPHTHYLENE	1/11	19	19	3.40	19.0	12SS150002	682000	0.00003	NO	NO	BSL
ANTHRACENE	1/11	21	21	3.58	21.0	12SS150002	1480000	0.00001	NO	NO	BSL
BENZO(A)ANTHRACENE	5/11	5 J	98	13.8	28.2	12SS150002	5210	0.02	NO	NO	BSL
BENZO(A)PYRENE	4/11	12	110	15.1	38.3	12SS150002	1520	0.1	NO	NO	BSL
BENZO(B)FLUORANTHENE	5/11	13	150	24.0	50.6	12SS150002	59800	0.003	NO	NO	BSL
BENZO(G,H,I)PERYLENE	5/11	13	93	15.4	31.6	12SS150002	119000	0.001	NO	NO	BSL
BENZO(K)FLUORANTHENE	5/11	4 J	90	12.0	24.2	12SS150002	148000	0.001	NO	NO	BSL
BIS(2-ETHYLHEXYL) PHTHALATE	1/11	1300	1300	152	1300	12SS150002	925	1.4	YES	NO	ASL/NONBIO
CHRYSENE	5/11	12	110	23.9	50.4	12SS210002	4730	0.02	NO	NO	BSL
DI-N-BUTYL PHTHALATE	1/11	170 J	170 J	49.7	170	12SS210002	150	1.1	YES	NO	ASL/NONBIO
DIBENZO(A,H)ANTHRACENE	1/11	21	21	3.58	21.0	12SS150002	18400	0.001	NO	NO	BSL
FLUORANTHENE	5/11	11	140	22.1	46.4	12SS150002	122000	0.001	NO	NO	BSL
FLUORENE	1/11	4 J	4 J	2.04	4.00	12SS150002	122000	0.00003	NO	NO	BSL
INDENO(1,2,3-CD)PYRENE	5/11	11	80	12.8	26.0	12SS150002	109000	0.001	NO	NO	BSL
ISOSAFROLE	2/11	2300	8400	1003	5350	12SS180002	9940	0.8	NO	NO	BSL
NAPHTHALENE	3/11	4 J	38	5.80	16.3	12SS210002	99.4	0.4	NO	NO	BSL
PHENANTHRENE	5/11	9 J	140 J	19.6	41.0	12SS210002	45700	0.003	NO	NO	BSL
PYRENE	5/11	19	180	26.4	55.8	12SS150002	78500	0.002	NO	NO	BSL
Energetics (mg/kg)											
1,3,5-TRINITROBENZENE	1/11	0.84	0.84	0.190	0.840	12SS210002	0.376	2.2	YES	YES	ASL/BIO
HMX	1/11	1.7	1.7	0.268	1.70	12SS210002	NA	NA	YES	YES	NC/BIO
RDX	1/11	6.1	6.1	0.668	6.10	12SS210002	NA	NA	YES	YES	NC/BIO
Inorganics (mg/kg)											
ALUMINUM	11/11	8780 J	23700	16825	16825	12SS190002	pH[1][2]	NA	NO	NO	BSL
ANTIMONY	5/11	0.38 J	3610 J	352	774	12SS210002	0.27[1]	13370	YES	NO	ASL/NONBIO
ARSENIC	11/11	2.6 J	158 J	27.4	27.4	12SS240002	18[1]	8.8	YES	YES	ASL/BIO
BARIUM	11/11	54.1 J	505 J	158	158	12SS210002	330[1]	1.5	YES	NO	ASL/NONBIO
BERYLLIUM	7/11	0.72 J	1.5 J	0.818	1.05	12SS130002, 12SS140002	21[1]	0.1	NO	NO	BSL
CADMIUM	2/11	5.8 J	6.3 J	1.26	6.05	12SS220002	0.36[1]	18	YES	YES	ASL/BIO
CALCIUM	11/11	299 J	17800 J	4350	4350	12SS150002	NA	NA	NO	NO	NUT
CHROMIUM	11/11	18.3 J	51.7 J	32.7	32.7	12SS240002	26[1]	2.0	YES	YES	ASL/BIO
COBALT	11/11	5 J	13.6 J	9.22	9.22	12SS220002	13[1]	1.05	YES	NO	ASL/NONBIO
COPPER	11/11	8.7 J	345 J	70.7	70.7	12SS210002	5.4	64	YES	YES	ASL/BIO
IRON	11/11	7160 J	65900 J	26705	26705	12SS130002	pH[1][3]	NA	YES	NO	NC/NONBIO
LEAD	11/11	8.2 J	429000 J	39382	39382	12SS210002	11[1]	39000	YES	YES	ASL/BIO

TABLE 8-2

ECOLOGICAL COPC SELECTION FOR BATTERY DISPOSAL AREA
SURFACE SOIL SAMPLES, ROUND 1 ONLY
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mean Concentration	Average of Positive Detections	Sample with Maximum Detection	Region 5 ESL	EEQ	COPC[4] Plants/ Invertebrates	COPC[4] Wildlife	Rationale[5]
MAGNESIUM	11/11	940 J	2750 J	1789	1789	12SS220002	NA	NA	NO	NO	NUT
MANGANESE	11/11	68.7 J	1400	566	566	12SS230002	NA	NA	YES	NO	NC/NONBIO
MERCURY	9/11	0.009 J	0.31	0.0519	0.0627	12SS210002	0.1	3.1	YES	YES	ASL/BIO
NICKEL	11/11	14 J	44.6 J	23.4	23.4	12SS130002	13.6	3.3	YES	YES	ASL/BIO
POTASSIUM	11/11	558 J	4370 J	2104	2104	12SS140002	NA	NA	NO	NO	NUT
SELENIUM	2/11	0.49 J	0.61 J	0.244	0.550	12SS240002	0.0276	22	YES	YES	ASL/BIO
SILVER	1/11	18.5 J	18.5 J	1.75	18.5	12SS210002	4.04	4.6	YES	YES	ASL/BIO
SODIUM	3/11	78.2 J	370 J	98.3	249	12SS220002	NA	NA	NO	NO	NUT
THALLIUM	1/11	6.4 J	6.4 J	0.690	6.40	12SS210002	0.0569	112	YES	NO	ASL/NONBIO
TIN	4/11	12.4 J	838 J	89.9	247	12SS210002	7.62	110	YES	NO	ASL/NONBIO
VANADIUM	11/11	16.8 J	42.8 J	30.4	30.4	12SS190002	7.8[1]	5.5	YES	NO	ASL/NONBIO
ZINC	11/11	31 J	2490 J	494	494	12SS220002	6.62	376	YES	YES	ASL/BIO

Data qualifiers (e.g., U, J) are defined in Section 3.
ug/kg - micrograms per kilogram
mg/kg - milligrams per kilogram

COPC = Chemical of potential concern.
ESL = Region 5 Ecological Screening Level.
EEQ = Ecological Effects Quotient.
NA = Not available or not applicable.
1 - U.S. EPA Ecological Soil Screening Level.
2- Aluminum is only considered a COPC when the soil pH is less than 5.5. Average soil pH at SWMU 12 was 6.85 S.U.
3 - Iron is not expected to be toxic to plants with a soil pH between 5 and 8. Average soil pH at SWMU 12 was 6.85 S.U. Iron is retained as a COPC for risks to invertebrates.
4 - Chemicals retained as COPCs are further evaluated in the Step 3a evaluation (see Section 8.4.1.1.2).
5 - Rationale for COPC selection/deletion:
ASL = Above Screening Level
BIO = Bioaccumulative chemical
BSL = Below Screening Level
NONBIO = Nonbioaccumulative chemical
NC = No Criteria available
NUT = Essential Nutrient
NZ = Field Parameter only

TABLE 8-3

ECOLOGICAL COPC SELECTION FOR SURFACE SOIL SAMPLES COLLECTED DURING REMEDIAL ACTIVITIES
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Region 5 ESL	EEQ	COPC[3] Plants/ Invertebrates	COPC[3] Wildlife	Rationale[4]
Volatile Organic Compounds (ug/kg)								
METHYL ETHYL KETONE	1/50	12	12	89600	0.0001	NO	NO	BSL
ACETONE	26/50	2	190	2500	0.1	NO	NO	BSL
METHYLENE CHLORIDE	22/50	2	24	4050	0.01	NO	NO	BSL
TOLUENE	7/50	1	3	5450	0.001	NO	NO	BSL
XYLENES	8/50	6	13	10000	0.001	NO	NO	BSL
Explosives (mg/kg)								
HMX	181/219	0.261	752	NA	NA	YES	YES	NC/BIO
RDX	158/219	0.0849	5940	NA	NA	YES	YES	NC/BIO
1,3,5-TRINITROBENZENE	4/219	0.244	5.26	0.376	14	YES	YES	ASL/BIO
2,4,6-TRINITROTOLUENE	151/219	0.06	793	NA	NA	YES	YES	NC/BIO
2-AMINO-4,6-DINITROTOLUENE	17/219	0.0548	1.28	NA	NA	YES	YES	NC/BIO
4-AMINO-2,6-DINITROTOLUENE	28/219	0.0664	5.8	NA	NA	YES	YES	NC/BIO
Inorganics (mg/kg)								
ALUMINUM	50/50	5300	35200	pH[1][2]	NA	NO	NO	BSL
ARSENIC	36/36	3.2	57.3	18[1]	3.2	YES	YES	ASL/BIO
BARIUM	112/112	14.4	233	330[1]	0.7	NO	NO	BSL
CADMIUM	56/112	0.04	2.4	0.36[1]	6.7	YES	YES	ASL/BIO
CHROMIUM	112/112	7	60	26[1]	2.3	YES	YES	ASL/BIO
LEAD	112/112	7	71	11[1]	6.5	YES	YES	ASL/BIO
MERCURY	26/50	0.008	0.16	0.1	1.6	YES	YES	ASL/BIO
SELENIUM	9/36	0.68	1.4	0.0276	50.7	YES	YES	ASL/BIO
SILVER	1/36	0.14	0.14	4.04	0.03	NO	NO	BSL

COPC = Chemical of potential concern.
ESL = Region 5 Ecological Screening Level.
EEQ = Ecological Effects Quotient.
NA = Not available or not applicable.
1 - U.S. EPA Ecological Soil Screening Level.
2- Aluminum is only considered a COPC when the soil pH is less than 5.5. Average soil pH at SWMU 12 was 6.85 S.U.
3 - Chemicals retained as COPCs are further evaluated in the Step 3a evaluation (see Section 8.4.1.1.3).
4 - Rationale for COPC selection/deletion:
ASL = Above Screening Level
BIO = Bioaccumulative chemical
BSL = Below Screening Level
NC = No Criteria available

TABLE 8-4

ECOLOGICAL COPC SELECTION FOR DOWNGRADIENT GULLY
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mean Concentration	Average of Positive Detections	Sample with Maximum Detection	Region 5 ESL	EEQ	COPC Aquatic Organisms	Rationale[1]
Semivolatile Organics (ug/kg)										
BENZO(A)ANTHRACENE	1/3	9	9	4.32	9.00	12SD030004	108	0.1	NO	BSL
BENZO(A)PYRENE	1/3	10	10	4.66	10.0	12SD030004	150	0.1	NO	BSL
BENZO(B)FLUORANTHENE	1/3	15	15	6.32	15.0	12SD030004	10400	0.001	NO	BSL
BENZO(K)FLUORANTHENE	1/3	7 J	7 J	3.66	7.00	12SD030004	240	0.03	NO	BSL
BIS(2-ETHYLHEXYL) PHTHALATE	1/3	340 J	340 J	140	340	12SD070004	NA	NA	YES	NC
CHRYSENE	1/3	11	11	4.99	11.0	12SD030004	166	0.1	NO	BSL
FLUORANTHENE	3/3	4 J	15	8.67	8.67	12SD030004	423	0.04	NO	BSL
NAPHTHALENE	1/3	7 J	7 J	3.65	7.00	12SD070004	176	0.04	NO	BSL
PHENANTHRENE	2/3	6 J	10	5.94	8.00	12SD030004	204	0.05	NO	BSL
PYRENE	2/3	6 J	18	8.61	12.0	12SD030004	195	0.1	NO	BSL
Energetics (mg/kg)										
2,4,6-TRINITROTOLUENE	4/19	0.4 J	2.4 J	0.301	0.960	12SD020004	NA	NA	YES	NC
Inorganics (mg/kg)										
ALUMINUM	19/19	10300 J	25700 J	16563	16563	12SD120004	NA	NA	YES	NC
ANTIMONY	4/19	0.85 J	4.2 J	0.811	2.21	12SD130004	NA	NA	YES	NC
ARSENIC	12/19	9.3 J	36 J	16.1	22.8	12SD170004	9.79	3.7	YES	ASL
BARIUM	16/19	64.6 J	182 J	111	114	12SD090004	NA	NA	YES	NC
CADMIUM	2/19	6.2 J	7.4 J	1.17	6.80	12SD150004	0.99	7.5	YES	ASL
CALCIUM	19/19	893 J	65300 J	9290	9290	12SD030004	NA	NA	NO	NUT
CHROMIUM	16/19	19.1 J	141 J	42.7	49.2	12SD210004	43.4	3.2	YES	ASL
COBALT	14/19	5.5 J	108 J	26.1	33.1	12SD130004	50	2.2	YES	ASL
COPPER	14/19	10.6 J	22.5 J	14.3	17.3	12SD140004, 12SD170004	31.6	0.7	NO	BSL
IRON	19/19	14100 J	217000 J	69958	69958	12SD100004	NA	NA	YES	NC
LEAD	19/19	12.6 J	178 J	36.3	36.3	12SD170004	35.8	5.0	YES	ASL
MAGNESIUM	19/19	670 J	8190 J	1832	1832	12SD140004	NA	NA	NO	NUT
MANGANESE	17/19	217 J	6780 J	2097	2313	12SD130004	NA	NA	YES	NC
MERCURY	19/19	0.019 J	0.063 J	0.0386	0.0386	12SD140004	0.174	0.4	NO	BSL
NICKEL	16/19	14.9 J	80.9 J	27.3	31.2	12SD130004	22.7	3.6	YES	ASL
POTASSIUM	19/19	969 J	2440 J	1487	1487	12SD140004	NA	NA	NO	NUT
SODIUM	2/19	89.7 J	102 J	31.5	95.9	12SD020004	NA	NA	NO	NUT
TIN	3/19	2.6 J	3.1 J	0.643	2.80	12SD100004	NA	NA	YES	NC
VANADIUM	17/19	23.4 J	71 J	43.5	44.2	12SD090004	NA	NA	YES	NC
ZINC	16/19	46.1 J	263 J	106	102	12SD120004	121	2.2	YES	ASL

TABLE 8-4

ECOLOGICAL COPC SELECTION FOR DOWNGRADIENT GULLY
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mean Concentration	Average of Positive Detections	Sample with Maximum Detection	Region 5 ESL	EEQ	COPC Aquatic Organisms	Rationale[1]
AVS/SEM (UMO/G)										
ACID VOLATILE SULFIDE	2/6	0.47 J	3.08 J	0.724	1.78	12SD010004	NA	NA	NO	NZ
CADMIUM	3/6	0.0025	0.0044	0.00196	0.00320	12SD130004	NA	NA	NO	NZ
COPPER	6/6	0.035	0.14	0.0828	0.0828	12SD070004, 12SD010004	NA	NA	NO	NZ
LEAD	6/6	0.03	0.058 J	0.0447	0.0447	12SD010004, 12SD130004	NA	NA	NO	NZ
MERCURY	4/6	0.0001	0.0003	0.000163	0.000193	12SD010004	NA	NA	NO	NZ
NICKEL	6/6	0.042	0.49 J	0.162	0.162	12SD130004	NA	NA	NO	NZ
SILVER	1/6	0.0381 J	0.0381 J	0.00842	0.0381	12SD070004	NA	NA	NO	NZ
ZINC	5/6	0.12 J	1.1 J	0.418	0.484	12SD010004	NA	NA	NO	NZ
Miscellaneous Parameters										
CATION EXCHANGE CAPACITY (MEQ/1	4/4	6.9 J	22 J	11.2	11.2	12SD070004	NA	NA	NO	NZ
PH (S.U.)	4/4	6.1	8.1	7.20	7.20	12SD100004	NA	NA	NO	NZ
TOTAL ORGANIC CARBON (mg/kg)	4/4	2600 J	31000 J	12850	12850	12SD070004	NA	NA	NO	NZ

Data qualifiers (e.g., U, J) are defined in Section 3.
ug/kg - micrograms per kilogram.
mg/kg - milligrams per kilogram.
AVS - Acid volatile sulfide.
SEM - Simultaneously extracted metals.
UMO/G - micromoles per gram.
MEQ/1 - milliequivalents per 100 grams.
S.U. - Standard units.

COPC = Chemical of potential concern.
ESL = Region 5 Ecological Screening Level.
EEQ = Ecological Effects Quotient.
NA = Not available or not applicable.
1 - Rationale for COPC selection/deletion:
ASL = Above Screening Level
BSL = Below Screening Level
NC = No Criteria available
NUT = Essential Nutrient
NZ = Field Parameter only

TABLE 8-5

ECOLOGICAL COPC SELECTION FOR DOWNGRADIENT EAST TRIBUTARY
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mean Concentration	Average of Positive Detections	Sample with Maximum Detection	Region 5 ESL	EEQ	COPC[1] Aquatic Organisms	Rationale[2]
Inorganics (mg/kg)										
ALUMINUM	2/2	8080 J	17200 J	12640	12640	12SD230004	NA	NA	YES	NC
ANTIMONY	1/2	1.2 J	1.2 J	0.975	1.20	12SD230004	NA	NA	YES	NC
ARSENIC	1/2	10.9 J	10.9 J	9.33	10.9	12SD230004	9.79	1.1	YES	ASL
BARIUM	1/2	65 J	65 J	76.8	65.0	12SD240004	NA	NA	YES	NC
CALCIUM	2/2	897 J	1920 J	1409	1409	12SD230004	NA	NA	NO	NUT
CHROMIUM	2/2	26.8 J	32.8 J	29.8	29.8	12SD240004	43.4	0.8	NO	BSL
COBALT	2/2	19.4 J	40.4 J	29.9	29.9	12SD230004	50	0.8	NO	BSL
COPPER	2/2	13 J	29.4 J	21.2	21.2	12SD240004	31.6	0.9	NO	BSL
IRON	2/2	31900 J	70700 J	51300	51300	12SD240004	NA	NA	YES	NC
LEAD	2/2	22.8 J	58.2 J	40.5	40.5	12SD240004	35.8	1.6	YES	ASL
MAGNESIUM	2/2	710 J	1340 J	1025	1025	12SD230004	NA	NA	NO	NUT
MANGANESE	2/2	1480 J	2910 J	2195	2195	12SD230004	NA	NA	YES	NC
MERCURY	2/2	0.012 J	0.038 J	0.0250	0.0250	12SD230004	0.174	0.2	NO	BSL
NICKEL	2/2	26 J	32.1 J	29.1	29.1	12SD230004	22.7	1.4	YES	ASL
POTASSIUM	2/2	838 J	1210 J	1024	1024	12SD230004	NA	NA	NO	NUT
VANADIUM	2/2	31 J	36 J	33.5	33.5	12SD240004	NA	NA	YES	NC
ZINC	1/2	75.7 J	75.7 J	77.4	75.7	12SD230004	121	0.6	NO	BSL

Data qualifiers (e.g., U, J) are defined in Section 3.
mg/kg - milligrams per kilogram.

COPC = Chemical of potential concern.
ESL = Region 5 Ecological Screening Level.
EEQ = Ecological Effects Quotient.
NA = Not available or not applicable.
1 - Chemicals retained as COPCs are further evaluated in the Step 3a evaluation (see Section 8.4.1.2.1).
2 - Rationale for COPC selection/deletion:
ASL = Above Screening Level
BSL = Below Screening Level
NC = No Criteria available
NUT = Essential Nutrient
NZ = Field Parameter only

TABLE 8-6

ECOLOGICAL COPC SELECTION FOR DOWNGRADIENT TURKEY CREEK
SEDIMENT SAMPLES, ROUND 1 ONLY
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mean Concentration	Average of Positive Detections	Sample with Maximum Detection	Region 5 ESL	EEQ	COPC[1] Aquatic Organisms	COPC[1] Wildlife	Rationale[2]
Inorganics (mg/kg)											
ALUMINUM	3/3	5360 J	11400 J	7427	7427	12SD270004	NA	NA	YES	NO	NC/NONBIO
ARSENIC	3/3	4.5 J	27.8 J	12.4	12.4	12SD270004	9.79	2.8	YES	YES	ASL/BIO
BARIUM	3/3	51.6 J	82.4 J	62.0	62.0	12SD270004	NA	NA	YES	NO	NC/NONBIO
BERYLLIUM	2/3	0.43 J	0.49 J	0.740	0.460	13SD4401	NA	NA	YES	NO	NC/NONBIO
CADMIUM	2/3	0.17 J	0.19 J	0.255	0.180	13SD4401	0.99	0.19	NO	NO	BSL
CALCIUM	3/3	703 J	1830 J	1123	1123	12SD270004	NA	NA	NO	NO	NUT
CHROMIUM	3/3	11.8 J	70.4 J	31.4	31.4	12SD270004	43.4	1.6	YES	YES	ASL/BIO
COBALT	3/3	7 J	27.1 J	15.1	15.1	12SD270004	50	0.54	NO	NO	BSL
COPPER	3/3	6.3 J	19.8 J	11.2	11.2	12SD270004	31.6	0.63	NO	NO	BSL
IRON	3/3	14100 J	157000 J	62267	62267	12SD270004	NA	NA	YES	NO	NC/NONBIO
LEAD	3/3	9.4 J	39.6 J	19.9	19.9	12SD270004	35.8	1.1	YES	YES	ASL/BIO
MAGNESIUM	3/3	565 J	748 J	642	642	12SD270004	NA	NA	NO	NO	NUT
MANGANESE	3/3	444	1760 J	923	923	12SD270004	NA	NA	YES	NO	NC/NONBIO
MERCURY	1/1	0.01 J	0.01 J	0.0100	0.0100	12SD270004	0.174	0.06	NO	NO	BSL
NICKEL	3/3	10.7 J	52.1 J	25.5	25.5	12SD270004	22.7	2.3	YES	YES	ASL/BIO
POTASSIUM	3/3	748 J	810 J	782	782	12SD270004	NA	NA	NO	NO	NUT
SELENIUM	2/3	0.13 J	0.16 J	0.187	0.145	13SD4401	NA	NA	YES	YES	NC/BIO
VANADIUM	3/3	14 J	57.8 J	28.8	28.8	12SD270004	NA	NA	YES	NO	NC/NONBIO
ZINC	2/3	27.2 J	32 J	53.7	29.6	13SD4401	121	0.26	NO	NO	BSL

Data qualifiers (e.g., U, J) are defined in Section 3.
mg/kg - milligrams per kilogram.\

COPC = Chemical of potential concern.
ESL = Region 5 Ecological Screening Level.
EEQ = Ecological Effects Quotient.
NA = Not available or not applicable.
1 - Chemicals retained as COPCs are further evaluated in the Step 3a evaluation (see Section 8.4.1.2.2).
2 - Rationale for COPC selection/deletion:
ASL = Above Screening Level
BIO = Bioaccumulative chemical
BSL = Below Screening Level
NONBIO = Nonbioaccumulative chemical
NC = No Criteria available
NUT = Essential Nutrient

TABLE 8-7

ECOLOGICAL COPC SELECTION FOR DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mean Concentration	Average of Positive Detections	Sample with Maximum Detection	Region 5 ESL	EEQ	COPC Aquatic Organisms	COPC Wildlife	Rationale[1]
Energetics (ug/L)											
1,3,5-TRINITROBENZENE	1/39	0.96 J	0.96 J	0.148	0.960	12SW3101	11[3]	0.1	NO	NO	BSL
2,4,6-TRINITROTOLUENE	4/39	0.56	79	3.08	28.9	12SW3101	90[4]	0.9	NO	NO	BSL
2,4-DIAMINO-6-NITROTOLUENE	3/39	0.79 J	1.6 J	0.217	1.30	12SW3101	NA	NA	YES	YES	NC/BIO
2,4-DINITROTOLUENE	3/39	0.27 J	0.47 J	0.145	0.367	12SW1201	44	0.01	NO	NO	BSL
2,6-DIAMINO-4-NITROTOLUENE	1/39	0.27 J	0.27 J	0.131	0.270	12SW3601	NA	NA	YES	YES	NC/BIO
2,6-DINITROTOLUENE	1/39	0.27 J	0.27 J	0.131	0.270	12SW1201	81	0.003	NO	NO	BSL
2-AMINO-4,6-DINITROTOLUENE	12/39	0.27 J	19 J	1.34	4.07	12SW1201	20[3]	0.95	NO	NO	BSL
3,5-DINITROANILINE	3/39	0.6	1.9	0.212	1.23	12SW1301	60[3]	0.03	NO	NO	BSL
3-NITROTOLUENE	1/39	0.71 J	0.71 J	0.142	0.710	12SW1401	NA	NA	YES	YES	NC/BIO
4-AMINO-2,6-DINITROTOLUENE	17/39	0.28 J	74	3.65	8.22	12SW1201	NA	NA	YES	YES	NC/BIO
HMX	29/39	0.9	98	8.08	10.8	12SW3401	330[3]	0.3	NO	NO	BSL
MNX	10/39	0.32 J	1.9	0.310	0.844	12SW3401	NA	NA	YES	YES	NC/BIO
RDX	30/39	0.36 J	140	15.3	19.8	12SW3401	190[3]	0.74	NO	NO	BSL
Total Metals (ug/L)											
ALUMINUM	33/39	90.6	67700	3491	4116	12SW3501	87[5]	778	YES	NO	ASL/NONBIO
ARSENIC	35/39	0.16 J	20.3	2.58	2.86	12SW3501	148	0.14	NO	NO	BSL
BARIUM	38/39	17.9 J	589 J	92.9	95.4	12SW3501	220	2.7	YES	NO	ASL/NONBIO
BERYLLIUM	19/39	0.02 J	5.2	0.231	0.455	12SW3501	3.6	1.4	YES	NO	ASL/NONBIO
CADMIUM	18/39	0.06 J	43.7 J	1.67	3.38	12SW3501	0.15	291	YES	YES	ASL/BIO
CALCIUM	39/39	1100 J	119000 J	44296	44296	12SW3501	NA	NA	NO	NO	NUT
CHROMIUM	17/39	1.6 J	105 J	4.90	10.6	12SW3501	42	2.5	YES	YES	ASL/BIO
COBALT	39/39	0.14 J	123	5.87	5.87	12SW3501	24	5.1	YES	NO	ASL/NONBIO
COPPER	38/39	0.74 J	1650 J	48.5	49.7	12SW3501	1.58	1044	YES	YES	ASL/BIO
IRON	39/39	161 J	95400 J	5229	5229	12SW3501	1000[5]	95	YES	NO	ASL/NONBIO
LEAD	30/39	0.095 J	458	15.0	19.4	12SW3501	1.17	391	YES	YES	ASL/BIO
MAGNESIUM	39/39	315	34500	8688	8688	12SW3501	NA	NA	NO	NO	NUT
MANGANESE	39/39	1.7 J	24200 J	1125	1125	12SW0101	NA	NA	YES	NO	NC/NONBIO
MERCURY	4/39	0.06 J	1.7	0.0665	0.518	12SW3501	0.0013	1308	YES	YES	ASL/BIO
NICKEL	39/39	1.6 J	140 J	9.05	9.05	12SW3501	28.9	4.8	YES	YES	ASL/BIO
POTASSIUM	38/39	107 J	167000 J	22013	22593	12SW1401	NA	NA	NO	NO	NUT
SELENIUM	3/39	1 J	9.6 J	0.507	3.93	12SW3501	5	1.9	YES	YES	ASL/BIO
SILVER	1/39	2.6 J	2.6 J	0.0834	2.60	12SW3501	0.12	22	YES	YES	ASL/BIO
SODIUM	36/39	571 J	30900 J	10200	10629	12SW1401	NA	NA	NO	NO	NUT
THALLIUM	22/39	0.05 J	0.67 J	0.0809	0.127	12SW3501	10	0.07	NO	NO	BSL
TIN	1/39	2.1 J	2.1 J	0.142	2.10	12SW3501	180	0.01	NO	NO	BSL
VANADIUM	23/39	1.3 J	138	7.65	12.6	12SW3501	12	12	YES	NO	ASL/NONBIO
ZINC	27/39	1.6 J	5220	158	228	12SW3501	65.7	79	YES	YES	ASL/BIO

TABLE 8-7

ECOLOGICAL COPC SELECTION FOR DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mean Concentration	Average of Positive Detections	Sample with Maximum Detection	Region 5 ESL	EEQ	COPC Aquatic Organisms	COPC Wildlife	Rationale[1]
Dissolved Metals (ug/L)											
ALUMINUM, FILTERED	16/39	9.9 J	966	67.8	147	12SW0202-F	87[5]	11	YES	NO	ASL/NONBIO
ARSENIC, FILTERED	24/39	0.06 J	16.2 J	1.41	2.23	12SW1701-F	148	0.11	NO	NO	BSL
BARIUM, FILTERED	39/39	17.1 J	227 J	55.1	55.1	12SW1101-F	220	1.03	YES	NO	ASL/NONBIO
BERYLLIUM, FILTERED	3/39	0.03 J	0.14 J	0.0162	0.0767	12SW1301-F	3.6	0.04	NO	NO	BSL
CADMIUM, FILTERED	15/39	0.07 J	1.2	0.308	0.619	12SW1402-F	0.15	8	YES	YES	ASL/BIO
CALCIUM, FILTERED	39/39	3080 J	103000 J	40071	40071	12SW1802-F	NA	NA	NO	NO	NUT
CHROMIUM, FILTERED	9/39	0.96 J	1.4 J	0.590	1.15	2SW1702-F, 12SW3101-	42	0.03	NO	NO	BSL
COBALT, FILTERED	33/39	0.1 J	8.5 J	0.876	1.02	12SW3201-F	24	0.4	NO	NO	BSL
COPPER, FILTERED	34/39	0.57 J	16.5 J	3.26	3.65	12SW1401-F	1.58	10	YES	YES	ASL/BIO
IRON, FILTERED	39/39	85 J	1320 J	297	297	12SW3201-F	1000[5]	1.3	YES	NO	ASL/NONBIO
LEAD, FILTERED	30/39	0.125 J	1.8	0.297	0.358	12SW0202-F	1.17	1.5	YES	YES	ASL/BIO
MAGNESIUM, FILTERED	39/39	1480 J	21300	8704	8704	12SW3401-F	NA	NA	NO	NO	NUT
MANGANESE, FILTERED	33/39	0.77 J	7170 J	332	392	12SW1101-F	NA	NA	YES	NO	NC/NONBIO
MERCURY, FILTERED	6/39	0.053 J	0.27	0.0347	0.143	12SW3401-F	0.0013	208	YES	YES	ASL/BIO
NICKEL, FILTERED	39/39	1.5 J	9.9 J	3.58	3.58	12SW1301-F	28.9	0.3	NO	NO	BSL
POTASSIUM, FILTERED	39/39	356 J	168000 J	22850	22850	12SW1401-F	NA	NA	NO	NO	NUT
SELENIUM, FILTERED	5/39	0.61 J	1.1 J	0.270	0.786	12SW0201-F	5	0.2	NO	NO	BSL
SILVER, FILTERED	1/39	0.04 J	0.04 J	0.0175	0.0400	12SW1802-F	0.12	0.3	NO	NO	BSL
SODIUM, FILTERED	36/39	1630 J	40100 J	11779	12336	12SW1402-F	NA	NA	NO	NO	NUT
THALLIUM, FILTERED	4/32	0.05 J	0.06 J	0.0296	0.0525	12SW1401-F	10	0.01	NO	NO	BSL
TIN, FILTERED	4/39	0.08 J	7.4 J	0.390	3.38	12SW1701-F	180	0.04	NO	NO	BSL
VANADIUM, FILTERED	6/39	1.6 J	6.3	1.05	3.72	12SW0201-F	12	0.5	NO	NO	BSL
ZINC, FILTERED	27/39	1.2 J	34.9 J	8.62	11.2	12SW0202-F	65.7	0.5	NO	NO	BSL
Field Parameters											
DISSOLVED OXYGEN (mg/L)	39/39	1.19	13.11	6.51	6.51	12SW1201	NA	NA	NA	NA	NZ
OXIDATION REDUCTION POTENTIAL (MV)	39/39	38.2	241	102	102	12SW1402	NA	NA	NA	NA	NZ
PH (S.U.)	39/39	5.99	8.5	7.32	7.32	12SW0701	NA	NA	NA	NA	NZ
SPECIFIC CONDUCTANCE (MS/CM)	39/39	0.081	0.86	0.247	0.247	12SW1401	NA	NA	NA	NA	NZ
TEMPERATURE (C)	39/39	2.86	19.39	11.5	11.5	12SW2001	NA	NA	NA	NA	NZ
TURBIDITY (NTU)	39/39	2.7	1000 >	61.8	61.8	12SW3501	NA	NA	NA	NA	NZ
Miscellaneous Parameter (mg/L)											
AMMONIA-N	34/39	0.019 J	4.2 J	0.225	0.258	12SW1101	5.97[5][6]	0.7	NO	NO	BSL
NITRITE/NITRATE-N	26/39	0.044 J	8.2	0.991	1.48	12SW0601	NA	NA	YES	NO	NC/NONBIO

TABLE 8-7

ECOLOGICAL COPC SELECTION FOR DOWNGRADIENT GULLY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mean Concentration	Average of Positive Detections	Sample with Maximum Detection	Region 5 ESL	EEQ	COPC		Rationale[1]
									Aquatic Organisms	Wildlife	

Data qualifiers (e.g., U, J) are defined in Section 3.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
MV - millivolts.
S.U. - Standard units.
MS/CM - milliSiemens per centimeter.
°C - Degrees Celsius.
NTU - nephelometric turbidity units.

COPC = Chemical of potential concern.
ESL = Region 5 Ecological Screening Level.
EEQ = Ecological Effects Quotient.
NA = Not available or not applicable.
1 - Rationale for COPC selection/deletion:
ASL = Above Screening Level
BIO = Bioaccumulative chemical
BSL = Below Screening Level
NONBIO = Nonbioaccumulative chemical
NC = No Criteria available
NUT = Essential Nutrient
NZ = Field Parameter only
3 - Secondary Chronic Value (Talmage et al., 1999).
4 - Chronic WQC (Talmage et al., 1999).
5 - U.S. EPA Ambient Water Quality Criteria.
6 - Value is for in the case where fish are present and is based on an average water pH of 7.2 S.U. and an average water temperature of 10.3°C.

TABLE 8-8

ECOLOGICAL COPC SELECTION FOR DOWNGRADIENT EAST TRIBUTARY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mean Concentration	Average of Positive Detections	Sample with Maximum Detection	Region 5 ESL	EEQ	COPC[1] Aquatic Organisms	Rationale[2]
Energetics (ug/L)										
4-AMINO-2,6-DINITROTOLUENE	3/4	0.252 J	0.56	0.339	0.411	12SW2401	NA	NA	YES	ASL
HMX	3/4	0.28 J	0.55	0.333	0.403	12SW2401	330[3]	0.002	NO	BSL
RDX	3/4	0.39 J	0.8	0.471	0.587	12SW2401	190[3]	0.0042	NO	BSL
Total Metals (ug/L)										
ALUMINUM	2/4	40.7 J	257 J	91.7	149	12SW2401	87[4]	3.0	YES	ASL
ARSENIC	1/4	0.33 J	0.33 J	0.140	0.330	12SW2401	148	0.002	NO	BSL
BARIUM	4/4	38.2 J	64.2 J	49.1	49.1	12SW2301	220	0.3	NO	BSL
CALCIUM	4/4	40400	59300 J	50000	50000	12SW2301	NA	NA	NO	NUT
COBALT	3/4	0.15 J	0.26 J	0.170	0.193	12SW2401	24	0.01	NO	BSL
COPPER	2/4	1.4 J	3.4 J	1.45	2.40	12SW2401	1.58	2.2	YES	ASL
IRON	4/4	252 J	584 J	359	359	12SW2401	1000[4]	0.6	NO	BSL
LEAD	1/4	0.136 J	0.136 J	0.139	0.136	12SW2402	1.17	0.1	NO	BSL
MAGNESIUM	4/4	6740 J	10400 J	8395	8395	12SW2301	NA	NA	NO	NUT
MANGANESE	4/4	1.2 J	7.1 J	4.40	4.40	12SW2301	NA	NA	YES	NC
NICKEL	4/4	1.6 J	2.4 J	1.90	1.90	12SW2401	28.9	0.1	NO	BSL
POTASSIUM	4/4	1140 J	2940 J	1953	1953	12SW2301	NA	NA	NO	NUT
SODIUM	4/4	11600 J	25000 J	15625	15625	12SW2301	NA	NA	NO	NUT
THALLIUM	3/4	0.07 J	0.07 J	0.0579	0.0700	12SW2301, 12SW2302, 12SW2402	10	0.01	NO	BSL
Dissolved Metals (ug/L)										
ALUMINUM, FILTERED	2/4	8.7 J	9.6 J	7.98	9.15	12SW2302-F	87[4]	0.1	NO	BSL
ARSENIC, FILTERED	1/4	0.21 J	0.21 J	0.104	0.210	12SW2401-F	148	0.001	NO	BSL
BARIUM, FILTERED	4/4	44.4 J	66.8 J	51.9	51.9	12SW2301-F	220	0.3	NO	BSL
CALCIUM, FILTERED	4/4	36200 J	57500 J	42800	42800	12SW2301-F	NA	NA	NO	NUT
CHROMIUM, FILTERED	2/4	1.2 J	1.6 J	0.884	1.40	12SW2302-F	42	0.04	NO	BSL
COBALT, FILTERED	2/4	0.17 J	0.17 J	0.124	0.170	12SW2302-F, 12SW2401-F	24	0.01	NO	BSL
COPPER, FILTERED	3/4	1.3 J	2.8 J	1.56	1.87	12SW2401-F	1.58	1.8	YES	ASL
IRON, FILTERED	4/4	229 J	305 J	278	278	12SW2301-F	1000[4]	0.3	NO	BSL
LEAD, FILTERED	2/4	0.2 J	0.254 J	0.187	0.227	12SW2302-F	1.17	0.2	NO	BSL
MAGNESIUM, FILTERED	4/4	6920 J	10600 J	8703	8703	12SW2301-F	NA	NA	NO	NUT
MANGANESE, FILTERED	3/4	0.82 J	3.5 J	2.01	1.97	12SW2401-F	NA	NA	YES	NC
NICKEL, FILTERED	4/4	2.2 J	2.8 J	2.45	2.45	12SW2302-F	28.9	0.1	NO	BSL
POTASSIUM, FILTERED	4/4	1240 J	3040 J	2093	2093	12SW2301-F	NA	NA	NO	NUT
SODIUM, FILTERED	4/4	12000 J	23800 J	16550	16550	12SW2301-F	NA	NA	NO	NUT
THALLIUM, FILTERED	1/4	0.07 J	0.07 J	0.0454	0.0700	12SW2301-F	10	0.01	NO	BSL
ZINC, FILTERED	2/4	2.1 J	5.2 J	3.05	3.65	12SW2402-F	65.7	0.1	NO	BSL

TABLE 8-8

ECOLOGICAL COPC SELECTION FOR DOWNGRADIENT EAST TRIBUTARY
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mean Concentration	Average of Positive Detections	Sample with Maximum Detection	Region 5 ESL	EEQ	COPC[1] Aquatic Organisms	Rationale[2]
Field Parameters										
DISSOLVED OXYGEN (mg/L)	4/4	2.79	11.74	7.16	7.16	12SW2401	NA	NA	NA	NZ
OXIDATION REDUCTION POTENTIAL	4/4	61.8	264.6	141	141	12SW2301	NA	NA	NA	NZ
PH (S.U.)	4/4	6.81	7.55	7.21	7.21	12SW2401	NA	NA	NA	NZ
SPECIFIC CONDUCTANCE (MS/CM)	4/4	0.14	0.331	0.224	0.224	12SW2301	NA	NA	NA	NZ
TEMPERATURE (C)	4/4	5.59	15.66	10.3	10.3	12SW2401	NA	NA	NA	NZ
TURBIDITY (NTU)	4/4	3.1	18.3	7.38	7.38	12SW2401	NA	NA	NA	NZ
Miscellaneous Parameter (mg/L)										
AMMONIA-N	2/4	0.021 J	0.13 J	0.0390	0.0755	12SW2301	5.39[4][5]	0.02	NO	BSL
NITRITE/NITRATE-N	2/4	0.1	0.11	0.0588	0.105	12SW2301	NA	NA	YES	NC

Data qualifiers (e.g., U, J) are defined in Section 3.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
MV - millivolts.
S.U. - Standard units.
MS/CM - milliSiemens per centimeter.
°C - Degrees Celsius.
NTU - nephelometric turbidity units,

COPC = Chemical of potential concern.
ESL = Region 5 Ecological Screening Level.
EEQ = Ecological Effects Quotient.
NA = Not available or not applicable.
1 - Chemicals retained as COPCs are further evaluated in the Step 3a evaluation (see Section 8.4.1.3.1).
2 - Rationale for COPC selection/deletion:
ASL = Above Screening Level
BSL = Below Screening Level
NC = No Criteria available
NUT = Essential Nutrient
NZ = Field Parameter only
3 - Secondary Chronic Value (Talmage et al., 1999).
4 - U.S. EPA Ambient Water Quality Criteria.
5 - Value is for in the case where fish are present and is based on an average water pH of 7.2 S.U. and an average water temperature of 10.3°C.

TABLE 8-9

ECOLOGICAL COPC SELECTION FOR DOWNGRADIENT TURKEY CREEK
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mean Concentration	Average of Positive Detections	Sample with Maximum Detection	Region 5 ESL	EEQ	COPC[1] Aquatic Organisms	COPC[1] Wildlife	Rationale[2]
Total Metals (ug/L)											
ALUMINUM	1/2	24.1 J	24.1 J	24.5	24.1	12SW2701	87[3]	0.3	NO	NO	BSL
BARIUM	2/2	41 J	69.8 J	55.4	55.4	12SW2701	220	0.3	NO	NO	BSL
BERYLLIUM	1/2	0.02 J	0.02 J	0.0150	0.0200	12SW2701	3.6	0.01	NO	NO	BSL
CALCIUM	2/2	34800 J	54500 J	44650	44650	12SW2701	NA	NA	NO	NO	NUT
COBALT	1/2	0.22 J	0.22 J	0.188	0.220	12SW2702	24	0.01	NO	NO	BSL
IRON	2/2	275 J	456 J	366	366	12SW2701	1000[3]	0.5	NO	NO	BSL
MAGNESIUM	2/2	5120 J	9220 J	7170	7170	12SW2701	NA	NA	NO	NO	NUT
MANGANESE	2/2	43.1 J	131 J	87.1	87.1	12SW2701	NA	NA	YES	NO	NC/NONBIO
NICKEL	1/2	1.7 J	1.7 J	0.875	1.70	12SW2701	28.9	0.1	NO	NO	BSL
POTASSIUM	2/2	915 J	1600 J	1258	1258	12SW2701	NA	NA	NO	NO	NUT
SODIUM	2/2	4630 J	9630 J	7130	7130	12SW2701	NA	NA	NO	NO	NUT
Dissolved Metals (ug/L)											
BARIUM, FILTERED	2/2	36.9 J	64.4 J	50.7	50.7	12SW2701-F	220	0.3	NO	NO	BSL
CALCIUM, FILTERED	2/2	25500 J	53900 J	39700	39700	12SW2701-F	NA	NA	NO	NO	NUT
COBALT, FILTERED	1/2	0.18 J	0.18 J	0.160	0.180	12SW2702-F	24	0.01	NO	NO	BSL
COPPER, FILTERED	1/2	0.41 J	0.41 J	0.400	0.410	12SW2702-F	1.58	0.3	NO	NO	BSL
IRON, FILTERED	2/2	172 J	288 J	230	230	12SW2701-F	1000[3]	0.3	NO	NO	BSL
MAGNESIUM, FILTERED	2/2	5800 J	8900 J	7350	7350	12SW2701-F	NA	NA	NO	NO	NUT
MANGANESE, FILTERED	2/2	33.5 J	124 J	78.8	78.8	12SW2701-F	NA	NA	YES	NO	NC/NONBIO
NICKEL, FILTERED	2/2	1.7 J	1.8 J	1.75	1.75	12SW2702-F	28.9	0.1	NO	NO	BSL
POTASSIUM, FILTERED	2/2	875 J	1600 J	1238	1238	12SW2701-F	NA	NA	NO	NO	NUT
SODIUM, FILTERED	2/2	5240 J	9440 J	7340	7340	12SW2701-F	NA	NA	NO	NO	NUT
ZINC, FILTERED	1/2	1.9 J	1.9 J	1.63	1.90	12SW2702-F	65.7	0.03	NO	NO	BSL
Field Parameters											
DISSOLVED OXYGEN (mg/L)	2/2	1.95	7.44	4.70	4.70	12SW2701	NA	NA	NA	NA	NZ
OXIDATION REDUCTION POTENTIAL (MV)	2/2	113	266.2	190	190	12SW2701	NA	NA	NA	NA	NZ
PH (S.U.)	2/2	6.76	6.81	6.79	6.79	12SW2701	NA	NA	NA	NA	NZ
SPECIFIC CONDUCTANCE (MS/CM)	2/2	0.092	0.267	0.180	0.180	12SW2701	NA	NA	NA	NA	NZ
TEMPERATURE (C)	2/2	5.21	13.55	9.38	9.38	12SW2701	NA	NA	NA	NA	NZ
TURBIDITY (NTU)	1/1	9.15	9.15	9.15	9.15	12SW2702	NA	NA	NA	NA	NZ
Miscellaneous Parameter (mg/L)											
AMMONIA-N	1/2	0.18 J	0.18 J	0.0913	0.180	12SW2701	6.29[3][4]	0.03	NO	NO	BSL

Data qualifiers (e.g., U, J) are defined in Section 3.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
MV - millivolts.
S.U. - Standard units.
MS/CM - milliSiemens per centimeter.
°C - Degrees Celsius.
NTU - nephelometric turbidity units.

TABLE 8-9

ECOLOGICAL COPC SELECTION FOR DOWNGRADIENT TURKEY CREEK
SURFACE WATER SAMPLES, ROUNDS 1 AND 2
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

COPC = Chemical of potential concern.
ESL = Region 5 Ecological Screening Level.
EEQ = Ecological Effects Quotient.
NA = Not available or not applicable.
1 - Chemicals retained as COPCs are further evaluated in the Step 3a evaluation (see Section 8.4.1.3.2).
2 - Rationale for COPC selection/deletion:
BSL = Below Screening Level
NONBIO = Nonbioaccumulative chemical
NC = No Criteria available
NUT = Essential Nutrient
NZ = Field Parameter only
3 - U.S. EPA Ambient Water Quality Criteria.
4 - Value is for in the case where fish are present and is based on an average water pH of 6.8 S.U. and an average water temperature of 9.4°C.

TABLE 8-10

STEP 3A EVALUATION FOR RISKS TO PLANTS AND INVERTEBRATES
SWMU 12 PROPER SURFACE SOIL COPCs
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Surface Soil Data Set	Chemical of Potential Concern (COPC)	Frequency of Detection	Maximum Detected Concentration (mg/kg)	Ecological Screening Level (ESL) (mg/kg)[1]	Maximum EEQ[2]	Number of Samples > ESL[3]	Step 3a Evaluation[5]						Risk Determination (Acceptable/ Unacceptable)	Retained as a COPC?
							Alternate Benchmarks					Other Step 3a Factors Considered in Evaluation		
							Eco-SSL (soil inverts)	Eco-SSL (plants)	Canadian SQG[4]	ORNL Benchmarks[4] Plants	ORNL Benchmarks[4] Earthworms			
SWMU 12 Proper	**METALS**													
	Antimony	5/9	1.4	0.27 (Eco-SSL)	5.2	5	78	NA	NA	5	NA	-The maximum concentration is less than plant and soil invertebrate values.	Acceptable	No
	Chromium	9/9	26.9	26 (Eco-SSL)	1.03	1	NA	NA	64	NA	NA	-The Eco-SSL used in the screening is based on birds; the maximum concentration is less than the Canadian SQG.	Acceptable	No
	Cobalt	9/9	15.7	13 (Eco-SSL)	1.2	2	NA	NA	NA	NA	NA	-The maximum concentration is less than the maximum background concentration for soil group 3 (27.1 mg/kg).	Acceptable	No
	Copper	9/9	19	5.4	3.5	9	NA	NA	63	NA	NA	-The maximum concentration is less than the Canadian SQG.	Acceptable	No
	Iron	9/9	30,600	pH[6]	NA	NA	NA	NA	NA	NA	NA	-Initially selected as a COPC for soil invertebrates only; however, no toxicity data is available to evaluate risks to soil invertebrates. -Concentrations are within the range of background concentrations for soil group 3 (10,700 mg/kg - 30,600 mg/kg). -Generally considered nontoxic.	Acceptable	No
	Lead	9/9	31.2	11 (Eco-SSL)	2.8	8	1,700	120	NA	NA	NA	-The Eco-SSL used in the screening is based on birds; the maximum concentration is less than the Eco-SSLs for plants and soil invertebrates.	Acceptable	No
	Manganese	9/9	1,080	NA	NA	NA	NA	NA	NA	500	NA	-The maximum concentration exceeds the ORNL plant benchmark and the ORNL soil microorganisms and microbial processes benchmark (100 mg/kg); however, concentrations are within the range of background concentrations for soil group 3 (268 mg/kg - 3,040 mg/kg).	Acceptable	No
	Nickel	9/9	21.4	13.6	1.6	7	NA	NA	50	NA	NA	-The ESL used in the screening is based on wildlife; the maximum concentration is less than the Canadian SQG.	Acceptable	No
	Vanadium	9/9	48.6	7.8 (Eco-SSL)	6.2	9	NA	NA	130	NA	NA	-The Eco-SSL used in the screening is based on birds; the maximum concentration is less than the Canadian SQG.	Acceptable	No
	Zinc	9/9	165	6.62	25	9	NA	NA	200	NA	NA	-The ESL is overly conservative; the Canadian SQG is a better toxicity value for comparison because it is based on more studies (see Section 8.4.1.1.1). The maximum concentration is less than the Canadian SQG.	Acceptable	No
Battery Disposal Area	**SEMIVOLATILE ORGANICS**													
	Bis(2-ethylhexyl) phthalate	1/11	1.3	0.925	1.4	1	NA	NA	NA	100	NA	-Maximum concentrations only slightly exceed screening values.	Acceptable	No
	Di-n-butyl phthalate	1/11	0.17	0.15	1.1	1	NA	NA	NA	200	NA	-Maximum concentrations of these phthalates are less than the ORNL plant value and less than the ORNL earthworm value for dimethyl phthalate (200 mg/kg) -Phthalates are frequent laboratory contaminants.	Acceptable	No
	ENERGETICS													
	1,3,5-Trinitrobenzene	1/11	0.84	0.376	2.2	1	NA	NA	NA	NA	NA	-The ESL used in the screening is based on risks to wildlife; however, no alternate toxicity data is available to evaluate risks to plants and soil invertebrates. -Detected once out of 11 samples.	Acceptable	No
	HMX	1/11	1.7	NA	NA	NA	NA	NA	NA	NA	NA	-The detected concentration is less than a LOEC of 280 mg/kg for earthworm reproduction reported in Robidoux et al., 2001, and the estimated NOEC of 28 mg/kg if the LOEC is divided by an uncertainty factor of 10. -HMX was detected in only one of 11 samples.	Acceptable	No
	RDX	1/11	6.1	NA	NA	NA	NA	NA	NA	NA	NA	-The detected concentration is less than a LOEC of 95 mg/kg for earthworm reproduction reported in Robidoux et al., 2000, and the estimated NOEC of 9.5 mg/kg if the LOEC is divided by an uncertainty factor of 10; the detected concentration is also less than the plant benchmark of 100 mg/kg reported in Rodbidoux et al., 2000. -RDX was detected in only one of 11 samples.	Acceptable	No

TABLE 8-10

STEP 3A EVALUATION FOR RISKS TO PLANTS AND INVERTEBRATES
SWMU 12 PROPER SURFACE SOIL COPCs
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Surface Soil Data Set	Chemical of Potential Concern (COPC)	Frequency of Detection	Maximum Detected Concentration (mg/kg)	Ecological Screening Level (ESL) (mg/kg)[1]	Maximum EEQ[2]	Number of Samples > ESL[3]	Step 3a Evaluation[5]						Risk Determination (Acceptable/ Unacceptable)	Retained as a COPC?
							Alternate Benchmarks					Other Step 3a Factors Considered in Evaluation		
							Eco-SSL (soil inverts)	Eco-SSL (plants)	Canadian SQG[4]	ORNL Benchmarks[4] Plants	ORNL Benchmarks[4] Earthworms			
Battery Disposal Area (continued)	**METALS**													
	Antimony	5/11	3,610	0.27 (Eco-SSL)	13,370	5	78	NA	NA	5	NA	-Antimony concentrations exceeded the ORNL plant benchmark at locations 12SS21 through 12SS24 and also the Eco-SSL for soil invertebrates at locations 12SS21 and 12SS24; concentrations at other locations were less than plant and soil invertebrate values. Concentrations of other metals were also elevated with respect to criteria at these locations.	Unacceptable (at locations 12SS21 through 12SS24 only)	Yes
	Arsenic	11/11	158	18 (Eco-SSL)	8.8	2	NA	NA	17.1	NA	NA	-Concentrations at two locations (12SS21 and 12SS24) exceed the Canadian SQG; concentrations of other metals were also elevated at these locations.	Unacceptable (at locations 12SS21 and 12SS24 only)	Yes
	Barium	11/11	505	330 (Eco-SSL)	1.5	1	330	NA	NA	500	NA	-Only the maximum concentration exceeds the Eco-SSL for soil invertebrates and the ORNL plant benchmark.	Acceptable	No
	Cadmium	2/11	6.3	0.36 (Eco-SSL)	18	2	140	32	NA	NA	NA	-The maximum concentration is less than the Eco-SSLs for soil invertebrate and plants.	Acceptable	No
	Chromium	11/11	51.7	26 (Eco-SSL)	2	6	NA	NA	64	NA	NA	-The maximum concentration is less than the Canadian SQG.	Acceptable	No
	Cobalt	11/11	13.6	13 (Eco-SSL)	1.05	1	NA	NA	NA	NA	NA	-Concentrations are within the range of background concentrations for soil group 3 (6 mg/kg to 27.1 mg/kg).	Acceptable	No
	Copper	11/11	345	5.4	64	11	NA	NA	63	NA	NA	-Copper concentrations exceeded the SQG at locations 12SS21 and 12SS22; concentrations at other locations were less than the SQG. Concentrations of other metals were also elevated with respect to criteria at these locations.	Unacceptable (at locations 12SS21 and 12SS22 only)	Yes
	Iron	11/11	65,900	pH[6]	NA	NA	NA	NA	NA	NA	NA	-Initially selected as a COPC for soil invertebrates only; however, no toxicity data is available to evaluate risks to soil invertebrates. -Generally considered nontoxic.	Acceptable	No
	Lead	11/11	429,000	11 (Eco-SSL)	39,000	8	1,700	120	NA	NA	NA	-Concentrations at locations 12SS21 through 12SS24 are greater than the Eco-SSLs for soil invertebrates and/or plants; concentrations at other locations were less than plant and soil invertebrate values. Concentrations of other metals were also elevated with respected to criteria at these locations.	Unacceptable (at locations 12SS21 through 12SS24 only)	Yes
	Manganese	11/11	1,400	NA	NA	NA	NA	NA	NA	500	NA	-The maximum concentration exceeds the ORNL plant benchmark and the ORNL soil microorganisms and microbial processes benchmark (100 mg/kg); however, concentrations are within the range of background concentrations for soil group 3 (268 mg/kg to 3,040 mg/kg).	Acceptable	No
	Mercury	9/11	0.31	0.1	3.1	1	NA	NA	12	NA	NA	-The maximum concentration is less than the Canadian SQG.	Acceptable	No
	Nickel	11/11	44.6	13.6	3.3	11	NA	NA	50	NA	NA	-The maximum concentration is less than the Canadian SQG.	Acceptable	No
	Selenium	2/11	0.61	0.0276	22	2	NA	NA	1	NA	NA	-The maximum concentration is less than the Canadian SQG.	Acceptable	No
	Silver	1/11	18.5	4.04	4.6	1	NA	NA	NA	2	NA	-The maximum concentration is less than the ORNL microorganisms and microbial processes benchmark (50 mg/kg). -The BDA was seeded after remedial activities in 2001 and 2002 and does not represent an area where great plant diversity would be expected; the surrounding forest and plant community were not affected by the remediation. The BDA only represents a small percentage of potential habitat.	Acceptable	No
	Thallium	1/11	6.4	0.0569	112	1	NA	NA	1.4	NA	NA	-Only the maximum concentration is greater than the SQG.	Acceptable	No
	Tin	4/11	838	7.62	110	4	NA	NA	NA	50	NA	-Concentrations at locations 12SS21 through 12SS24 are greater than the ORNL plant value. Concentrations of other metals were also elevated with respect to criteria at these locations. -The maximum concentration is less than the ORNL microorganisms and microbial processes benchmark (2,000 mg/kg).	Unacceptable (at locations 12SS21 through 12SS24 only)	Yes
	Vanadium	11/11	42.8	7.8 (Eco-SSL)	5.5	11	NA	NA	130	NA	NA	-The maximum concentration is less than the Canadian SQG.	Acceptable	No
	Zinc	11/11	2,490	6.62	376	11	NA	NA	200	NA	NA	-Concentrations at locations 12SS21 through 12SS24 are greater than the values for soil invertebrates and/or plants; concentrations at other locations were less than plant and soil invertebrate values. Concentrations of other metals were also elevated with respected to criteria at these locations.	Unacceptable (at locations 12SS21 through 12SS24 only)	Yes

TABLE 8-10

STEP 3A EVALUATION FOR RISKS TO PLANTS AND INVERTEBRATES
SWMU 12 PROPER SURFACE SOIL COPCs
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Surface Soil Data Set	Chemical of Potential Concern (COPC)	Frequency of Detection	Maximum Detected Concentration (mg/kg)	Ecological Screening Level (ESL) (mg/kg)[1]	Maximum EEQ[2]	Number of Samples > ESL[3]	Step 3a Evaluation[5]						Risk Determination (Acceptable/ Unacceptable)	Retained as a COPC?
							Alternate Benchmarks					Other Step 3a Factors Considered in Evaluation		
							Eco-SSL (soil inverts)	Eco-SSL (plants)	Canadian SQG[4]	ORNL Benchmarks[4] Plants	ORNL Benchmarks[4] Earthworms			
Historical Samples	**ENERGETICS**													
	HMX	181/219	752	NA	NA	NA	NA	NA	NA	NA	NA	-The maximum concentration is greater than the LOEC of 280 mg/kg for earthworm reproduction reported in Robidoux et al., 2001; however, the average at Building 153 is less than the LOEC and the estimated NOEC of 28 mg/kg, if the LOEC is divided by an uncertainty factor of 10. Maximum concentrations at all other buildings were less than the LOEC and averages were less than the estimated NOEC. -No toxicity data for plants is available.	Unacceptable (in the vicinity of Building 153 only)	Yes
	RDX	158/219	5,940	NA	NA	NA	NA	NA	NA	NA	NA	-The maximum concentration (at Building 153) is greater than the plant benchmark of 100 mg/kg from Talmage et al., 1999 and a LOEC of 95 mg/kg for earthworm reproduction reported in Robidoux et al., 2000. The next greatest maximum concentration at Building 158 also exceeded the plant and earthworm values. Although the average concentrations at these buidings were less than the plant and earthworm values, the average concentration at Building 153 is greater than the estimated NOEC of 9.5 mg/kg, if the earthworm LOEC is divided by an uncertainty factor of 10. -Concentrations at other buildings were less than the plant and earthworm values.	Unacceptable (in the vicinity of Building 153 and the maximum detection at Building 158)	Yes
	1,3,5-Trinitrobenzene	4/219	5.26	0.376	14	NA	NA	NA	NA	NA	NA	-No toxicity information is available for plants and soil invertebrates. -Detected infrequently in only four of 219 samples.	Acceptable	No
	2,4,6-Trinitrotoluene	151/219	793	NA	NA	NA	NA	NA	NA	NA	NA	-The maximum concentrations at all buildings are greater than LOECs for plants and soil invertebrates of 2.4 mg/kg and 1.2 mg/kg reported in Best et al., 2004. Additionally, the average concentrations at all buildings are greater than estimated NOECs for plants and soil invertebrates of 0.24 mg/kg and 0.12 mg/kg if the LOECs are divided by an uncertainty factor of 10.	Unacceptable	Yes
	2-Amino-4,6-dintrotoluene	17/219	1.28	NA	NA	NA	NA	NA	NA	NA	NA	-The maximum concentration is less than a plant value of 80 mg/kg and a soil microbial processes value of 80 mg/kg reported in Talmage et al., 1999.	Acceptable	No
	4-Amino-2,6-dinitrotoluene	28/219	5.8	NA	NA	NA	NA	NA	NA	NA	NA	-The maximum concentration is less than plant and soil microbiaf processes values reported for 2-amino-4,6-dinitrotoluene reported in Talmage et al., 1999.	Acceptable	No
	METALS													
	Arsenic	36/36	57.3	18 (Eco-SSL)	3.2	NA	NA	18	17.1	NA	NA	-The maximum concentrations at Buildings 158 and 160 and the average concentration at Building 158 exceeded the Canadian SQG. Maximum concentrations at other buildings were less than the SQG.	Unacceptable (in the vicinity of Building 158 and the maximum detection at Building 160)	Yes
	Cadmium	56/112	2.4	0.36 (Eco-SSL)	6.7	NA	140	32	NA	NA	NA	-The maximum concentration is less than the Eco-SSLs for plants and soil invertebrates.	Acceptable	No
	Chromium	112/112	60	26 (Eco-SSL)	2.3	NA	NA	NA	64	NA	NA	-The maximum concentration is less than the Canadian SQG.	Acceptable	No
	Lead	112/112	71	11 (Eco-SSL)	6.5	NA	1,700	120	NA	NA	NA	-The maximum concentration is less than the Eco-SSLs for plants and soil invertebrates.	Acceptable	No
	Mercury	26/50	0.16	0.1	1.6	NA	NA	NA	12	NA	NA	-The maximum concentration is less than the Canadian SQG.	Acceptable	No
	Selenium	9/36	1.4	0.0276	50.7	NA	NA	NA	1	NA	NA	-The maximum concentrations at Building 153 and 158 only slightly exceed the SQG. -Concentrations at all other buildings were less thant he SQG.	Acceptable	No

Footnotes:
1 ESL is the Region 5 Ecological Screening Level, unless a U.S. EPA Ecological Soil Screening Level is available, as noted.
2 Maximum EEQ = Maximum detection divided by the screening level.
3 Number of samples with concentrations greater than the screening level.
4 Canadian and ORNL benchmarks were used only in the absence of Eco-SSLs.
5 See Section 8.4.1.1.1 (SWMU 12 Proper), Section 8.4.1.1.2 (BDA) and Section 8.4.1.1.3 (Historical) for a more detailed Step 3a evaluation.
6 Iron is not expected to be toxic to plants with a soil pH between 5 and 8. Average soil pH at SWMU 12 was 6.85 S.U. Iron is retained as a COPC for risks to invertebrates.

EEQ = Ecological Effects Quotient
NA = Not Available or Not Applicable
SQG = Soil Quality Guideline
Eco-SSL = U.S. EPA Ecological Soil Screening Level
ORNL = Oak Ridge National Laboratory

TABLE 8-11

MAXIMUM AND AVERAGE ECOLOGICAL COPC CONCENTRATIONS FOR EACH BUILDING - HISTORICAL SURFACE SOIL SAMPLES
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

	Building 151		Building 152		Building 153		Building 157		Building 158		Building 160	
Parameter	Maximum Concentration	Average Concentration	Maximum Concentration	Average Concentration	Maximum Concentration	Average Concentration	Maximum Concentration	Average Concentration	Maximum Concentration	Average Concentration	Maximum Concentration	Average Concentration
Energetics (mg/kg)												
HMX	ND	ND	10.7	2.84	752	11.45	6.93	2.17	54.3	3.71	ND	ND
RDX	ND	ND	16	4.39	5940	60	16.5	2.74	358	6.1	0.682	0.53
1,3,5-Trinitrobenzene	ND	ND	5.02	0.47	ND	ND	5.26	0.44	ND	ND	ND	ND
2,4,6-TRINITROTOLUENE	ND	ND	53.9	2.81	793	5.44	27.8	2.28	4.66	0.49	39.4	--
2-AMINO-4,6-DINITROTOLUENE	ND	ND	0.845	0.33	0.822	1.33	1.28	0.37	0.571	0.3	1.03	--
4-AMINO-2,6-DINITROTOLUENE	ND	ND	1.12	0.38	5.8	1.35	1.59	0.42	0.398	0.32	1.68	0.38
Inorganics (mg/kg)												
Arsenic	8.2	6.78	9	8	13	9.7	12.9	10.98	57.3	29	23.4	7.97
Cadmium	0.57	0.16	0.52	0.13	2.4	0.35	0.47	0.16	0.7	0.19	0.84	0.3
Chromium	25.9	21	24.5	19.4	60	21.1	23.6	17.1	20.8	13.7	26.2	22.1
Lead	36.1	24.4	36	18.9	61	19.2	40.2	20.5	71	18	47.6	26.1
Mercury	ND	ND	0.04	0.035	0.16	0.024	0.09	0.065	0.05	0.03	ND	ND
Selenium	ND	ND	ND	ND	1.4	1.46	1	0.88	1.1	0.82	0.72	0.32

ND - Not detected.

TABLE 8-12

STEP 3A EVALUATION FOR RISKS TO BENTHIC INVERTEBRATES
SEDIMENT COPCs
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Sediment Data Set	Chemical of Potential Concern (COPC)	Frequency of Detection	Maximum Detected Concentration (mg/kg)	Screening Level (mg/kg)	Maximum EEQ[1]	Number of Samples > Screening Level[2]	Step 3a Evaluation[3]						Risk Determination (Acceptable/ Unacceptable)	Retained as a COPC?
							Alternate Benchmarks							
							TEL	Consensus-based TEC	ER-L	Canadian LEL	AET	Other Step 3a Factors Considered in Evaluation		
East Tributary	**Inorganics**													
	Aluminum	2/2	17,200	NA	NA	NA	25,500	NA	NA	NA	NA	-The maximum concentration is less than the TEL.	Acceptable	No
	Antimony	1/2	1.2	NA	NA	NA	NA	NA	2	NA	NA	-The maximum concentration is less than the ER-L.	Acceptable	No
	Arsenic	1/2	10.9	9.79	1.1	1	NA	9.79	NA	NA	NA	-The maximum concentration only slightly exceeds the screening level (TEC) and is less than the upgradient concentration of 15.3 mg/kg.	Acceptable	No
	Barium	1/2	65	NA	NA	NA	NA	NA	NA	NA	48	-The maximum concentration is less than the upgradient concentration of 108 mg/kg.	Acceptable	No
	Iron	2/2	70,700	NA	NA	NA	NA	NA	NA	20,000	NA	-The maximum concentration is greater than the LEL and also the severe effects level (SEL) of 40,000 mg/kg and the upgradient concentration of 44,600 mg/kg; however, the maximum concentration is less than several concentrations in the up-gradient gully sediment samples (87,000 mg/kg, 104,000 mg/kg, and 210,000 mg/kg).	Acceptable	No
	Lead	2/2	58.2	35.8	1.6	1	NA	35.8	NA	NA	NA	-Although the maximum concentration is greater than the screening level (TEC) it is less than the probable effects concentration (PEC) of 128 mg/kg. -The maximum concentration is less than the upgradient East Tributary concentration (25.2 mg/kg) and the maximum upgradient gully concentration (43.9 mg/kg). -Lead concentrations were low in surface soil samples and in the downgradient Turkey Creek sediment sample, indicating lead is not accumulating downstream in significant quantities.	Acceptable	No
	Manganese	2/2	2,910	NA	NA	NA	NA	NA	NA	460	NA	-Concentrations at both locations exceeded the SEL of 1,100 mg/kg; however, the maximum concentration is less than several concentrations in the upgradient gully sediment samples (3,310 mg/kg and 4,430 mg/kg). -Extent of contamination is unknown.	Acceptable	No
	Nickel	2/2	32	22.7	1.4	2	NA	22.7	NA	NA	NA	-The maximum concentration only slightly exceeds the upgradient concentration of 31.3 mg/kg and is less than nickel concentrations in the upgradient gully sediment samples.	Acceptable	No
	Vanadium	2/2	36	NA	NA	NA	NA	NA	NA	NA	57	-Concentrations are less than the ATE. -Concentrations are similar to the upgradient concentration of 30.7 mg/kg and are less than concentrations in the upgradient gully sediment samples.	Acceptable	No
Turkey Creek	**Inorganic**													
	Aluminum	3/3	11,400	NA	NA	NA	25,500	NA	NA	NA	NA	-The maximum concentration is less than the TEL.	Acceptable	No
	Arsenic	3/3	27.8	9.79	2.84	1	NA	9.79	NA	NA	NA	-Concentrations in gully and East Tributary samples are similar to those detected in Turkey Creek. -Concentrations in surface soil samples are low (less than 9 mg/kg) and arsenic was not selected as a COPC in surface soils. -Concentrations downstream from the maximum detection are less than the screening level (TEC).	Acceptable	No
	Barium	3/3	82.4	NA	NA	NA	NA	NA	NA	NA	48	-Concentrations in gully sediment and surface soil samples were within the range of background concentrations for soil group 3 (46.1 mg/kg to 153 mg/kg). -Barium is a common element in sediments and it is not generally associated with significant toxicity.	Acceptable	No
	Beryllium	2/3	0.49	NA	NA	NA	NA	NA	NA	NA	NA	-Beryllium was not detected at location 12SD27 (the location closest to SWMU 12). -Beryllium was not detected in gully sediment samples -Beryllium was detected at low concentrations in surface soil samples.	Acceptable	No
	Chromium	3/3	70.4	43.4	1.62	1	NA	43.4	NA	NA	NA	-Only the maximum concentration exceeds the screening level (TEC). -Concentrations in surface soil samples were low and ranged from 18.1 mg/kg to 26.9 mg/kg; the source of chromium concentrations does not appear to be SWMU 12. -The maximum concentration is less than the maximum concentration of 72.6 mg/kg in upgradient gully samples.	Acceptable	No

TABLE 8-12

STEP 3A EVALUATION FOR RISKS TO BENTHIC INVERTEBRATES
SEDIMENT COPCs
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Sediment Data Set	Chemical of Potential Concern (COPC)	Frequency of Detection	Maximum Detected Concentration (mg/kg)	Screening Level (mg/kg)	Maximum EEQ[1]	Number of Samples > Screening Level[2]	Step 3a Evaluation[3]						Risk Determination (Acceptable/ Unacceptable)	Retained as a COPC?
							Alternate Benchmarks					Other Step 3a Factors Considered in Evaluation		
							TEL	Consensus-based TEC	ER-L	Canadian LEL	AET			
Turkey Creek (continued)	**Inorganics**													
	Iron	3/3	157,000	NA	NA	NA	NA	NA	NA	20,000	NA	-Only the maximum concentration exceeded the LEL and the severe effects level (SEL) of 40,000 and the upgradient concentration (also 40,000 mg/kg). -The maximum concentration is within the upgradient gully concentration range (22,900 mg/kg to 210,000 mg/kg). -The maximum concentration of 30,600 mg/kg in surface soil samples is less than the maximum background concentration for soil group 3 (36,200 mg/kg).	Acceptable	No
	Lead	3/3	39.6	35.8	1.11	1	NA	35.8	NA	NA	NA	-Only the maximum concentration exceeds the screening level (TEC). -Concentrations in surface soil samples were low and ranged from 10.7 mg/kg to 31.2 mg/kg. -Concentration were either less than or similar to the TEC in most gully sediment samples that drain to Turkey Creek. -The maximum concentration is less than the maximum concentration in upgradient gully samples of 43.9 mg/kg.	Acceptable	No
	Manganese	3/3	1,760	NA	NA	NA	NA	NA	NA	460	NA	-Only the maximum concentration is greater than the upgradient sediment concentration of 708 mg/kg. -The maximum concentration is within the upgradient gully sample range (253 mg/kg to 4,430 mg/kg). -Surface soil samples were less than the maximum background concentration for soil group 3 of 3,060 mg/kg.	Acceptable	No
	Nickel	3/3	52.1	22.7	2.30	1	NA	22.7	NA	NA	NA	-Only the maximum concentration is greater than the screening level (TEC) and the upgradient concentration of 22.8 mg/kg. -The maximum concentration is within the upgradient gully sample range (16.1 mg/kg to 63.9 mg/kg).	Acceptable	No
	Selenium	2/3	0.16	NA	NA	NA	NA	NA	NA	NA	NA	-Selenium was not detected at location 12SD27, the location nearest SWMU 12. -Selenium was not detected in gully or East Tributary sediment samples and surface soil samples.	Acceptable	No
	Vanadium	3/3	57.8	NA	NA	NA	NA	NA	NA	NA	57	-Only the maximum concentration slightly exceeds the AET. -The maximum concentration is within the range of upgradient gully sample concentrations (29.6 mg/kg to 62.4 mg/kg).	Acceptable	No

Footnotes:
1 Maximum EEQ = Maximum detection divided by the screening level.
2 Number of samples with concentrations greater than the screening level.
3 See Section 8.4.1.2.1 (East Tributary) and Section 8.4.1.2.2 (Turkey Creek) for a more detailed Step 3a Evaluation.

EEQ = Ecological Effects Quotient
NA = Not Available or Not Applicable
TEL = Threshold Effects Level
TEC = Threshold Effect Concentration
ER-L = Effects Range-Low
LEL = Lowest Effects Level
AET = Apparent Effects Threshold

TABLE 8-13

STEP 3A EVALUATION FOR RISKS TO AQUATIC ORGANISMS
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA

Surface Water Data Set	Chemical of Potential Concern (COPC)	Frequency of Detection	Maximum Detected Concentration (ug/L)	Screening Level (ug/L)	Maximum EEQ[1]	Number of Samples > Screening Level[2]	Step 3a Factors Considered in Evaluation[3]	Risk Determination (Acceptable/ Unacceptable)	Retained as a COPC?
East Tributary	**Energetics**								
	4-Amino-2,6-dinitrotoluene	3/4	0.56	NA	NA	NA	-The maximum concentration is less than the SCV of 20 ug/L for 2-amino-4,6-dinitrotoluene reported in Talmage et al., 1999.	Acceptable	No
	Metals								
	Aluminum	2/4	257	87 (AWQC)	3	1	-Not retained as a COPC in filtered samples which represent bioavailable portion of the inorganics (U.S. EPA, 1992).	Acceptable	No
	Copper	2/4	3.4	1.58	2.2	1	-Both the unfiltered and filtered concentrations are less than the AWQC of 12.64 ug/L. -Copper was not detected at the other location in the East Tributary.	Acceptable	No
	Copper, filtered	3/4	2.8	1.58	1.8	1			
	Manganese	4/4	7.1	NA	NA	NA	-The maximum concentrations of manganese in unfiltered and filtered samples are less than the Indiana water criteria for chronic aquatic life (748 ug/L). -The U.S. EPA 1986 Gold Book indicates that tolerance values range from 1.5 mg/L to 1,000 mg/L. Concentrations are well below these values.	Acceptable	No
	Manganese, filtered	3/4	3.5	NA	NA	NA			
	Miscellaneous Parameters								
	Nitrite/Nitrate - N	2/4	0.11	NA	NA	NA	-Surface water at location 12SW23 where nitrite/nitrate-N was detected is well oxygenated and so nitrate is likely the predominant form of N present; the maximum concentration is less than the Canadian water quality guideline of 13 mg/L.	Acceptable	No
Turkey Creek	**Metals**								
	Manganese	2/2	131	NA	NA	NA	-The maximum concentrations of manganese in unfiltered and filtered samples are less than the Indiana water criteria for chronic aquatic life (686 ug/L). -The U.S. EPA 1986 Gold Book indicates that tolerance values range from 1.5 mg/L to 1,000 mg/L. Concentrations are well below these values.	Acceptable	No
	Manganese, filtered	2/2	124	NA	NA	NA			

Footnotes:
1 Maximum EEQ = Maximum detection divided by the screening level.
2 Number of samples with concentrations greater than the screening level.
3 See Section 8.4.1.3 for a more detailed Step 3a Evaluation.

EEQ = Ecological Effects Quotient
NA = Not Available or Not Applicable
AWQC = Ambient Water Quality Criteria

TABLE 8-14

EXPOSURE PARAMETERS FOR THE TERRESTRIAL WILDLIFE MODEL
SWMU 12 (MINE FILL A)
NSWC CRANE, INDIANA

Species/Exposure Inputs	Conservative Inputs		Average Inputs		Source
	Value	Unit	Value	Unit	
Meadow Vole					
Body Weight = BW	3.290E-02	kg	3.663E-02	kg	USEPA, 1993
Food Ingestion Rate = If	1.920E-03	kg/day	1.785E-03	kg/day	USEPA, 1993
Water Ingestion Rate = Iw	7.700E-03	L/day	6.400E-03	L/day	USEPA, 1993
Soil Ingestion Rate - Is (3.2%, 1.2%)	6.144E-05	kg/day	2.142E-05	kg/day	USEPA, 2005
Home Range = HR	Assume 100% on site		1.640E-01	acres	USEPA, 1993
Short-Tailed Shrew					
Body Weight = BW	1.525E-02	kg	1.687E-02	kg	USEPA, 1993
Food Ingestion Rate = If	2.592E-03	kg/day	1.648E-03	kg/day	USEPA, 1993
Water Ingestion Rate = Iw	4.300E-03	L/day	3.800E-03	L/day	USEPA, 1993
Soil Ingestion Rate - Is (3%, 0.9%)	7.776E-05	kg/day	1.483E-05	kg/day	USEPA, 2005
Home Range = HR	Assume 100% on site		9.700E-01	acres	USEPA, 1993
American Woodcock					
Body Weight = BW	1.660E-01	kg	1.895E-01	kg	USEPA, 1993
Food Ingestion Rate = If	3.032E-02	kg/day	2.526E-02	kg/day	USEPA, 1993
Water Ingestion Rate = Iw	1.900E-02	L/day	1.900E-02	L/day	USEPA, 1993
Soil Ingestion Rate - Is(16.4%, 6.4%)	4.972E-03	kg/day	1.617E-03	kg/day	USEPA, 2005
Home Range = HR	Assume 100% on site		6.133E+01	acres	USEPA, 1993
Bobwhite Quail					
Body Weight = BW	1.620E-01	kg	1.770E-01	kg	USEPA, 1993
Food Ingestion Rate = If	2.460E-03	kg/day	2.160E-03	kg/day	USEPA, 1993
Water Ingestion Rate = Iw	2.310E-02	L/day	1.840E-02	L/day	USEPA, 1993
Soil Ingestion Rate - Is (13.9%, 6.1%)	3.419E-04	kg/day	1.318E-04	kg/day	USEPA, 2005
Home Range = HR	Assume 100% on site		2.860E+01	acres	USEPA, 1993
Mink					
Body Weight = BW	5.500E-01	kg	1.020E+00	kg	USEPA, 1993
Food Ingestion Rate = If	5.608E-02	kg/day	4.015E-02	kg/day	USEPA, 1993
Water Ingestion Rate = Iw	1.907E-01	L/day	8.050E-02	L/day	USEPA, 1993
Sediment Ingestion Rate - Is (4.3%, 1.3%)	1.850E-03	kg/day	1.325E-03	kg/day	USEPA, 2005
Home Range = HR	Assume 100% on site		3.484E+01	acres	USEPA, 1993
Belted Kingfisher					
Body Weight = BW	1.360E-01	kg	1.520E-01	kg	USEPA, 1993
Food Ingestion Rate = If	1.895E-02	kg/day	1.723E-02	kg/day	USEPA, 1993
Water Ingestion Rate = Iw	1.870E-02	L/day	1.670E-02	L/day	USEPA, 1993
Sediment Ingestion Rate - Is (3.3%)	6.254E-04	kg/day	5.684E-04	kg/day	Beyer, 1994
Home Range = HR	Assume 100% on site		1.160E+00	km	USEPA, 1993

Notes:
-The food ingestion rates listed in Table J.3-1 were multiplied by the following in order to convert the ingestion rates from a wet-weight to a dry-weight value:
Insectivores - 16% (percent solids of earthworms, Sample et al., 1997)
Herbivores - 15% (percent solids of plant foliage, U.S. EPA, 2005)
Piscivores - 25% (percent solids of fish, Sample et al., 1997)

-The incidental soil/sediment ingestion rates used for the conservative and average inputs food-chain models, respectively are listed above in parentheses.

TABLE 8-15

STEP 3A EVALUATION FOR RISKS TO TERRESTRIAL WILDLIFE
SURFACE SOIL COPCS
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Data Set	Chemical of Potential Concern (COPC)	Frequency of Detection[1]	Maximum Detected Concentration (mg/kg)[1]	EEQs Using Average Concentrations and Average Exposure Parameters				Basis of Wildlife Toxicity Reference Value	Other Step 3a Factors Considered in Evaluation[3]	Risk Determination (Acceptable/ Unacceptable)	Retained as a COPC?
				NOAEL[2]		LOAEL[2]					
				EEQ > 1.0	Species	EEQ > 1.0	Species				
SWMU 12 Proper Surface Soil	Insectivorous/Herbivorous Wildlife										
	Chromium	9/9	26.9	1.2	Woodcock	None	NA	Black duckling survival was reduced at a dose level of 50 mg/kg and no differences were observed at a dose level of 10 mg/kg.	-Concentrations are similar to background concentrations from soil group 3; in fact the NOAEL-based EEQ using the maximum background concentration and average exposure parameters is also greater than 1.0 (EEQ = 1.1); risks appear to be similar to background risks.	Acceptable	No
	Zinc	9/9	165	1.6	Woodcock	None	NA	No effects were observed among hens consuming 48 and 228 mg/kg zinc, but egg hatchability was reduced by 20% among hens consuming 2,028 mg/kg zinc.	-Only the maximum concentration at location 12SB07 is greater than the maximum background concentration for soil group 3 of 60.2 mg/kg and this location is well bounded by locations where concentrations are within background concentrations for soil group 3; in fact t he NOAEL-based EEQ using the maximum background concentration and average exposure parameters is also greater than 1.0 (EEQ = 1.8); risks appear to be related to background and not the SWMU itself.	Acceptable	No
BDA Surface Soil	Insectivorous/Herbivorous Wildlife										
	Arsenic	11/11	158	2.8	Shrew	None	NA	Declining litter sizes over multiple mice generations when fed 5 mg/L arsenic in their drink water and 0.06 mg/kg in their food (LOAEL).	-The NOAEL-based EEQs were greater than 1.0 due to the two greatest concentrations at locations 12SB21 and 12SB24; the NOAEL-based EEQ is less than 1.0 excluding these two locations. Additionally, concentrations at all other locations are less than the maximum background concentration of 10.2 mg/kg for soil group 3.	Unacceptable	Yes
	Chromium	11/11	51.7	1.6	Woodcock	None	NA	Black duckling survival was reduced at a dose level of 50 mg/kg and no differences were observed at a dose level of 10 mg/kg.	-The average concentration is only slightly greater than the maximum concentration for soil group 3 of 21.7 mg/kg, when excluding the three greatest concentrations at locations 12SB21, 12SB22, and 12SB24. Risks are possible in the "hot spot" area but are similar to background risks at other locations.	Unacceptable	Yes
	Lead	11/11	429,000	1500	Woodcock	150	Woodcock	No adverse effects were observed among Japanese quail consuming 10 mg/kg lead but reproduction was impaired at 100 mg/kg.	-NOAEL and LOAEL-based EEQs were greater than 1.0 when calculating using concentrations from the "hot spot" area.	Unacceptable	Yes
	Mercury	9/11	0.31	1.9	Woodcock	None	NA	Fewer eggs and ducklings were produced in mallard ducks fed 0.5 mg/kg/day dose (LOAEL).	-The NOAEL-based EEQ is greater than 1.0 due to the maximum concentration; the NOAEL-based EEQ is less than 1.0 with the average concentration excluding the maximum detection.	Unacceptable	Yes
	Zinc	11/11	2,490	15	Woodcock	1.6	Woodcock	No effects were observed among hens consuming 48 and 228 mg/kg zinc, but egg hatchability was reduced by 20% among hens consuming 2,028 mg/kg zinc.	-The average concentration is only slightly greater than the maximum concentration for soil group 3 of 60.2 mg/kg, when excluding the four concentrations from the "hot spot" area. Risks are possible in the "hot spot" area but are similar to background risks at other locations.	Unacceptable	Yes

TABLE 8-15

STEP 3A EVALUATION FOR RISKS TO TERRESTRIAL WILDLIFE
SURFACE SOIL COPCS
SWMU 12 - MINE FILL A
NSWC CRANE
CRANE, INDIANA

Data Set	Chemical of Potential Concern (COPC)	Frequency of Detection[1]	Maximum Detected Concentration (mg/kg)[1]	EEQs Using Average Concentrations and Average Exposure Parameters				Basis of Wildlife Toxicity Reference Value	Other Step 3a Factors Considered in Evaluation[3]	Risk Determination (Acceptable/ Unacceptable)	Retained as a COPC?
				NOAEL[2]		LOAEL[2]					
				EEQ > 1.0	Species	EEQ > 1.0	Species				
	Insectivorous/Herbivorous Wildlife										
Historical Surface Soil	HMX	181/219	752	3.8	Vole	1.5	Vole	No significant increase in mortality was observed among mice consuming 30 mg/kg-day HMX, but a significant increase in mortality was observed among mice consuming 75 mg/kg-day.	-NOAEL and LOAEL-based EEQs were greater than 1.0 using maximum concentrations at Buildings 152, 153, and 157. Average concentrations were not calculated in historical samples; however, so it is unlikely that risks exist at all locations at these buildings.	Unacceptable	Yes
	RDX	158/219	5,940	4.0	Woodcock	3.4	Woodcock	Mortality was observed at a subchronic dose of 26.3 mg/kg/day in female Northern bobwhite (LOAEL); estimated NOAEL of 22.3 mg/kg/day from 90-day study.	-NOAEL and LOAEL-based EEQs were greater than 1.0 using maximum concentrations at Buildings 153 and 158. NOAEL and LOAEL-based EEQs are less than 1.0 using the maximum concentrations at other buildings.	Unacceptable	Yes
	Mercury	26/50	0.16	1.4	Woodcock	None	NA	Fewer eggs and ducklings were produced in mallard ducks fed 0.5 mg/kg/day dose (LOAEL).	-The NOAEL-based EEQ is greater than 1.0 when calculated using maximum concentrations at Buildings 152, 153, 157, and 158.	Unacceptable	Yes
	Piscivorous Wildlife										
Turkey Creek Sediment	Arsenic	3/3	27.8	24	Mink	2.4	Mink	Declining litter sizes over multiple mice generations when fed 5 mg/L arsenic in their drink water and 0.06 mg/kg in their food (LOAEL).	-Arsenic concentrations in Turkey Creek do not appear to be related to SWMU 12. Arsenic was not selected as a COPC in surface soils (i.e., concentrations were less than the Eco-SSL), and concentrations in gully sediment samples were similar to those detected in the East Tributary and Turkey Creek.	Acceptable	No

Footnotes:
1 - These columns present the Frequency of Detection and maximum concentrations for chemicals detected in the BDA surface soil samples.
2 - The maximum NOAEL and LOAEL-based EEQs are shown; see Table 8-18 for all EEQs greater than 1.0.
3 - See Section 8.4.2.2 for a more detailed Step 3a evaluation.

EEQ - Ecological Effects Quotient
NA - Not available or not applicable
NOAEL = No Observed Adverse Effect Level
LOAEL = Lowest Observed Adverse Effect Level

TABLE 8-16

TERRESTRIAL WILDLIFE MODEL-MAXIMUM CONCENTRATIONS, MAXIMUM BAF, AND MAXIMUM EXPOSURE PARAMETERS
SWMU 12 PROPER SURFACE SOIL SAMPLES
SWMU 12 (MINE FILL A)
NSWC CRANE, INDIANA

	HERVIVORES				INSECTIVORES			
	Meadow Vole		Bobwhite Quail		Short-Tailed Shrew		American Woodcock	
Parameter	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ
Energetics								
2,4-DIAMINO-6-NITROTOLUENE								
2,6-DIAMINO-4-NITROTOLUENE								
3-NITROTOLUENE	9.3E-07	9.3E-08			5.5E-07	5.5E-08		
4-AMINO-2,6-DINITROTOLUENE								
MNX								
Inorganics								
CADMIUM	1.3E-03	1.3E-04	4.3E-03	3.1E-04	7.8E-04	7.8E-05	3.4E-03	2.5E-04
CHROMIUM	7.0E-03	1.8E-03	1.1E-01	2.1E-02	2.4E-01	6.1E-02	1.6E+01	3.3E+00
COPPER	3.7E-03	2.9E-03	9.7E-03	7.4E-03	9.0E-03	7.0E-03	1.3E-01	9.8E-02
LEAD	1.4E-02	1.4E-03	3.1E-01	3.1E-02	5.7E-02	5.7E-03	8.5E+00	8.5E-01
MERCURY	3.2E-02	1.9E-02	5.4E-01	5.4E-02	1.8E-01	1.1E-01	2.4E+01	2.4E+00
NICKEL	5.1E-03	2.6E-03	6.8E-03	4.9E-03	2.4E-02	1.2E-02	2.5E-01	1.8E-01
SELENIUM	1.3E-03	7.6E-04	3.4E-03	1.7E-03	7.4E-04	4.5E-04	2.7E-03	1.4E-03
SILVER	1.0E-03	1.0E-04			1.9E-01	1.9E-02	#VALUE!	#VALUE!
ZINC	1.3E-02	6.7E-03	3.9E-01	4.3E-02	1.2E-01	6.2E-02	2.7E+01	3.0E+00

Notes:
Cells are shaded black if the EEQ is greater than 1.0
Blank - No value available.
EEQ - Ecological Effects Quotient.
NOAEL - No observed adverse effects level.
LOAEL - Lowest observed adverse effects level.

TABLE 8-17

TERRESTRIAL WILDLIFE MODEL-AVERAGE CONCENTRATIONS, AVERAGE BAFs, AND AVERAGE EXPOSURE PARAMETERS
SWMU 12 PROPER SURFACE SOIL SAMPLES
SWMU 12 (MINE FILL A)
NSWC CRANE, INDIANA

	HERVIVORES				INSECTIVORES			
	Meadow Vole		Bobwhite Quail		Short-Tailed Shrew		American Woodcock	
Parameter	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ
Energetics								
2,4-DIAMINO-6-NITROTOLUENE								
2,6-DIAMINO-4-NITROTOLUENE								
3-NITROTOLUENE	1.3E-07	1.3E-08			7.7E-08	7.7E-09		
4-AMINO-2,6-DINITROTOLUENE								
MNX								
Inorganics								
CADMIUM	3.5E-05	3.5E-06	1.2E-04	8.7E-06	2.1E-05	2.1E-06	1.2E-04	8.4E-06
CHROMIUM	2.0E-03	5.0E-04	3.0E-02	6.1E-03	1.1E-02	2.7E-03	1.2E+00	2.4E-01
COPPER	3.0E-04	2.3E-04	7.4E-04	5.6E-04	9.8E-04	7.6E-04	2.2E-02	1.7E-02
LEAD	5.6E-04	5.6E-05	1.9E-02	1.9E-03	2.6E-03	2.6E-04	6.3E-01	6.3E-02
MERCURY	2.0E-03	1.2E-03	3.5E-02	3.5E-03	4.7E-03	2.8E-03	9.2E-01	9.2E-02
NICKEL	6.9E-05	3.4E-05	2.2E-04	1.6E-04	2.1E-03	1.1E-03	3.3E-02	2.4E-02
SELENIUM	4.6E-05	2.8E-05	1.3E-04	6.6E-05	2.8E-05	1.7E-05	1.3E-04	6.4E-05
SILVER	5.3E-05	5.3E-06			3.1E-03	3.1E-04	#VALUE!	#VALUE!
ZINC	6.6E-04	3.3E-04	2.0E-02	2.3E-03	5.1E-03	2.5E-03	1.6E+00	1.8E-01

Notes:
Cells are shaded black if the EEQ is greater than 1.0.
Blank - No value available.
EEQ - Ecological Effects Quotient.
NOAEL - No observed adverse effects level.
LOAEL - Lowest observed adverse effects level.

TABLE 8-18

TERRESTRIAL WILDLIFE MODEL-MAXIMUM CONCENTRATIONS, MAXIMUM BAFs, AND MAXIMUM EXPOSURE PARAMETERS
SWMU 12 BATTERY DISPOSAL AREA SURFACE SOIL SAMPLES
SWMU 12 (MINE FILL A)
NSWC CRANE, INDIANA

	HERBIVORES				INSECTIVORES			
	Meadow Vole		Bobwhite Quail		Short-Tailed Shrew		American Woodcock	
Parameter	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ
Energetics								
1,3,5-TRINITROBENZENE	1.6E-02	3.2E-03			3.1E-03	6.1E-04		
2,4-DIAMINO-6-NITROTOLUENE			#N/A	#N/A			#N/A	#N/A
2,6-DIAMINO-4-NITROTOLUENE			#N/A	#N/A			#N/A	#N/A
3-NITROTOLUENE	9.3E-07	9.3E-08			5.5E-07	5.5E-08		
4-AMINO-2,6-DINITROTOLUENE								
HMX	7.4E-01	3.0E-01			6.9E-02	2.8E-02		
MNX			#N/A	#N/A			#N/A	#N/A
RDX	3.9E-02	7.7E-03	3.4E-02	2.9E-02	1.0E-01	2.0E-02	5.9E-01	5.0E-01
Inorganics								
ARSENIC	1.1E+02	1.1E+01	1.2E+00	4.0E-01	7.6E+01	7.6E+00	8.1E+00	2.7E+00
CADMIUM	1.6E-01	1.6E-02	2.3E-01	1.7E-02	2.8E+00	2.8E-01	3.2E+01	2.4E+00
CHROMIUM	1.3E-02	3.2E-03	1.9E-01	3.8E-02	4.7E-01	1.2E-01	3.1E+01	6.3E+00
COPPER	4.5E-02	3.5E-02	9.0E-02	6.9E-02	1.5E-01	1.2E-01	2.3E+00	1.7E+00
LEAD	1.7E+02	1.7E+01	3.5E+03	3.5E+02	7.8E+02	7.8E+01	1.2E+05	1.2E+04
MERCURY	2.4E-01	1.4E-01	3.8E+00	3.8E-01	1.4E+00	8.4E-01	1.8E+02	1.8E+01
NICKEL	1.1E-02	5.3E-03	1.4E-02	1.0E-02	5.0E-02	2.5E-02	5.2E-01	3.7E-01
SELENIUM	6.2E-02	3.7E-02	7.6E-02	3.8E-02	4.0E-02	2.4E-02	4.2E-01	2.1E-01
SILVER	5.4E-02	5.4E-03			1.7E+01	1.7E+00	#VALUE!	#VALUE!
ZINC	1.9E-01	9.4E-02	5.2E+00	5.7E-01	1.9E+00	9.4E-01	4.1E+02	4.5E+01

Notes:
Cells are shaded if the EEQ is greater than 1.0.
Blank - No value available.
EEQ - Ecological Effects Quotient.
NOAEL - No observed adverse effects concentration.
LOAEL - Lowest observed adverse effects concentration.

TABLE 8-19

TERRESTRIAL WILDLIFE MODEL-AVERAGE CONCENTRATIONS, AVERAGE BAFs, AND AVERAGE EXPOSURE PARAMETERS
SWMU 12 BATTERY DISPOSAL AREA SURFACE SOIL SAMPLES
SWMU 12 (MINE FILL A)
NSWC CRANE, INDIANA

	HERBIVORES				INSECTIVORES			
	Meadow Vole		Bobwhite Quail		Short-Tailed Shrew		American Woodcock	
Parameter	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ
Energetics								
1,3,5-TRINITROBENZENE	2.8E-03	5.6E-04			3.4E-04	6.7E-05		
2,4-DIAMINO-6-NITROTOLUENE			#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
2,6-DIAMINO-4-NITROTOLUENE			#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
3-NITROTOLUENE	1.3E-07	1.3E-08			7.7E-08	7.7E-09		
4-AMINO-2,6-DINITROTOLUENE								
HMX	9.1E-02	3.6E-02			5.3E-03	2.1E-03		
MNX				#N/A	#N/A	#N/A	#N/A	#N/A
RDX	3.1E-03	6.3E-04	2.6E-03	2.2E-03	5.6E-03	1.1E-03	4.3E-02	3.7E-02
Inorganics								
ARSENIC	6.4E-01	6.4E-02	1.3E-02	4.5E-03	2.8E+00	2.8E-01	4.3E-01	1.4E-01
CADMIUM	4.5E-03	4.5E-04	7.0E-03	5.1E-04	5.3E-02	5.3E-03	9.0E-01	6.5E-02
CHROMIUM	2.7E-03	6.8E-04	4.1E-02	8.2E-03	1.5E-02	3.7E-03	1.6E+00	3.2E-01
COPPER	1.5E-03	1.2E-03	3.5E-03	2.7E-03	5.2E-03	4.0E-03	1.2E-01	8.9E-02
LEAD	1.3E+00	1.3E-01	4.2E+01	4.2E+00	6.4E+00	6.4E-01	1.5E+03	1.5E+02
MERCURY	4.1E-03	2.5E-03	7.2E-02	7.2E-03	9.7E-03	5.8E-03	1.9E+00	1.9E-01
NICKEL	9.4E-05	4.7E-05	3.0E-04	2.2E-04	2.9E-03	1.5E-03	4.5E-02	3.3E-02
SELENIUM	4.3E-03	2.6E-03	5.6E-03	2.8E-03	5.7E-03	3.5E-03	8.5E-02	4.3E-02
SILVER	1.5E-03	1.5E-04			1.1E-01	1.1E-02	#VALUE!	#VALUE!
ZINC	6.0E-03	3.0E-03	1.8E-01	2.0E-02	4.7E-02	2.3E-02	1.5E+01	1.6E+00

Notes:
Cells are shaded if the EEQ is greater than 1.0.
Blank - No value available.
EEQ - Ecological Effects Quotient.
NOAEL - No observed adverse effects concentration.
LOAEL - Lowest observed adverse effects concentration.

TABLE 8-20

TERRESTRIAL WILDLIFE MODEL-MAXIMUM CONCENTRATIONS, MAXIMUM BAFs, AND MAXIMUM EXPOSURE PARAMETERS
SWMU 12 HISTORICAL SURFACE SOIL SAMPLES
SWMU 12 (MINE FILL A)
NSWC CRANE, INDIANA

	HERBIVORES				INSECTIVORES			
	Meadow Vole		Bobwhite Quail		Short-Tailed Shrew		American Woodcock	
Parameter	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ
Energetics								
1,3,5-TRINITROBENZENE	1.0E-01	2.0E-02			1.9E-02	3.8E-03		
2,4,6-TRINITROTOLUENE	5.9E+00	5.9E-01	3.3E+00	1.3E-01	4.8E+00	4.8E-01	2.4E+01	9.5E-01
2,4-DIAMINO-6-NITROTOLUENE							#N/A	#N/A
2,6-DIAMINO-4-NITROTOLUENE							#N/A	#N/A
2-AMINO-4,6-DINITROTOLUENE								
3-NITROTOLUENE	9.3E-07	9.3E-08			5.5E-07	5.5E-08		
4-AMINO-2,6-DINITROTOLUENE								
HMX	3.2E+02	1.3E+02			2.8E+01	1.1E+01		
MNX							#N/A	#N/A
RDX	3.2E+01	6.4E+00	2.4E+01	2.1E+01	9.5E+01	1.9E+01	5.7E+02	4.8E+02
Inorganics								
ARSENIC	3.9E+01	3.9E+00	4.4E-01	1.5E-01	2.7E+01	2.7E+00	2.9E+00	9.7E-01
CADMIUM	6.1E-02	6.1E-03	8.9E-02	6.5E-03	1.1E+00	1.1E-01	1.2E+01	9.0E-01
CHROMIUM	1.5E-02	3.7E-03	2.2E-01	4.4E-02	5.5E-01	1.4E-01	3.6E+01	7.3E+00
COPPER	1.3E-03	1.0E-03	5.0E-03	3.8E-03	7.6E-04	5.9E-04	4.0E-03	3.1E-03
LEAD	3.0E-02	3.0E-03	6.4E-01	6.4E-02	1.3E-01	1.3E-02	1.9E+01	1.9E+00
MERCURY	1.2E-01	7.4E-02	2.0E+00	2.0E-01	7.2E-01	4.3E-01	9.5E+01	9.5E+00
NICKEL	9.2E-05	4.6E-05	2.6E-04	1.9E-04	5.4E-05	2.7E-05	2.1E-04	1.5E-04
SELENIUM	1.4E-01	8.5E-02	1.7E-01	8.5E-02	9.0E-02	5.5E-02	9.6E-01	4.8E-01
SILVER	8.4E-04	8.4E-05			1.3E-01	1.3E-02	#VALUE!	#VALUE!
ZINC	8.5E-04	4.3E-04	5.1E-02	5.7E-03	5.0E-04	2.5E-04	4.1E-02	4.6E-03

Notes:
Cells are shaded if the EEQ is greater than 1.0.
Blank - No value available.
EEQ - Ecological Effects Quotient.
NOAEL - No observed adverse effects concentration.
LOAEL - Lowest observed adverse effects concentration.

TABLE 8-21

TERRESTRIAL WILDLIFE MODEL-AVERAGE CONCENTRATIONS, AVERAGE BAFs, AND AVERAGE EXPOSURE PARAMETERS
SWMU 12 HISTORICAL SURFACE SOIL SAMPLES
SWMU 12 (MINE FILL A)
NSWC CRANE, INDIANA

	HERBIVORES				INSECTIVORES			
	Meadow Vole		Bobwhite Quail		Short-Tailed Shrew		American Woodcock	
Parameter	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ
Energetics								
1,3,5-TRINITROBENZENE	8.9E-03	1.7E-03			1.1E-03	2.1E-04		
2,4,6-TRINITROTOLUENE	3.4E-02	3.4E-03	1.9E-02	7.5E-04	1.7E-02	1.7E-03	1.2E-01	4.7E-03
2,4-DIAMINO-6-NITROTOLUENE			#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
2,6-DIAMINO-4-NITROTOLUENE			#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
2-AMINO-4,6-DINITROTOLUENE								
3-NITROTOLUENE	2.1E-04	2.1E-05			1.3E-04	1.3E-05		
4-AMINO-2,6-DINITROTOLUENE								
HMX	3.8E+00	1.5E+00			2.1E-01	8.2E-02		
MNX			#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
RDX	2.5E-01	5.0E-02	1.8E-01	1.5E-01	5.0E-01	9.9E-02	4.0E+00	3.4E+00
Inorganics								
ARSENIC	2.3E-01	2.3E-02	4.9E-03	1.6E-03	1.0E+00	1.0E-01	1.5E-01	5.1E-02
CADMIUM	7.5E-04	7.5E-05	1.2E-03	8.9E-05	8.5E-03	8.5E-04	1.5E-01	1.1E-02
CHROMIUM	1.5E-03	3.8E-04	2.3E-02	4.7E-03	8.3E-03	2.1E-03	9.1E-01	1.8E-01
COPPER	2.7E-05	2.1E-05	1.1E-04	8.2E-05	1.6E-05	1.2E-05	1.0E-04	7.9E-05
LEAD	7.1E-04	7.1E-05	2.4E-02	2.4E-03	3.1E-03	3.1E-04	7.4E-01	7.4E-02
MERCURY	3.0E-03	1.8E-03	5.3E-02	5.3E-03	7.1E-03	4.3E-03	1.4E+00	1.4E-01
NICKEL	4.1E-06	2.1E-06	1.2E-05	8.8E-06	2.5E-06	1.2E-06	1.2E-05	8.5E-06
SELENIUM	3.1E-02	1.9E-02	4.0E-02	2.0E-02	4.2E-02	2.5E-02	6.2E-01	3.1E-01
SILVER	1.5E-04	1.5E-05			1.0E-02	1.0E-03	#VALUE!	#VALUE!
ZINC	1.8E-05	9.0E-06	1.1E-03	1.3E-04	1.1E-05	5.4E-06	1.1E-03	1.2E-04

Notes:
Cells are shaded if the EEQ is greater than 1.0.
Blank - No value available.
EEQ - Ecological Effects Quotient.
NOAEL - No observed adverse effects concentration.
LOAEL - Lowest observed adverse effects concentration.

TABLE 8-22

TERRESTRIAL WILDLIFE MODEL
MAXIMUM CONCENTRATIONS AND MAXIMUM INPUTS
SWMU 12 (MINE FILL A)
NSWC CRANE, INDIANA

	PISCIVORES			
	Mink		Belted Kingfisher	
Parameter	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ
Inorganics				
ARSENIC	9.4E+02	9.4E+01	1.1E+00	3.8E-01
CHROMIUM	5.4E+00	1.4E+00	4.9E+00	9.8E-01
LEAD	1.6E+00	1.6E-01	3.1E+00	3.1E-01
NICKEL	1.5E+00	7.7E-01	2.2E-01	1.6E-01
SELENIUM	4.2E-01	2.5E-01	5.8E-02	2.9E-02

Notes:
Cells are shaded black if the EEQ is greater than 1.0.
EEQ - Ecological Effects Quotient.
NOAEL - No observed adverse effects level.
LOAEL - Lowest observed adverse effects level.

TABLE 8-23

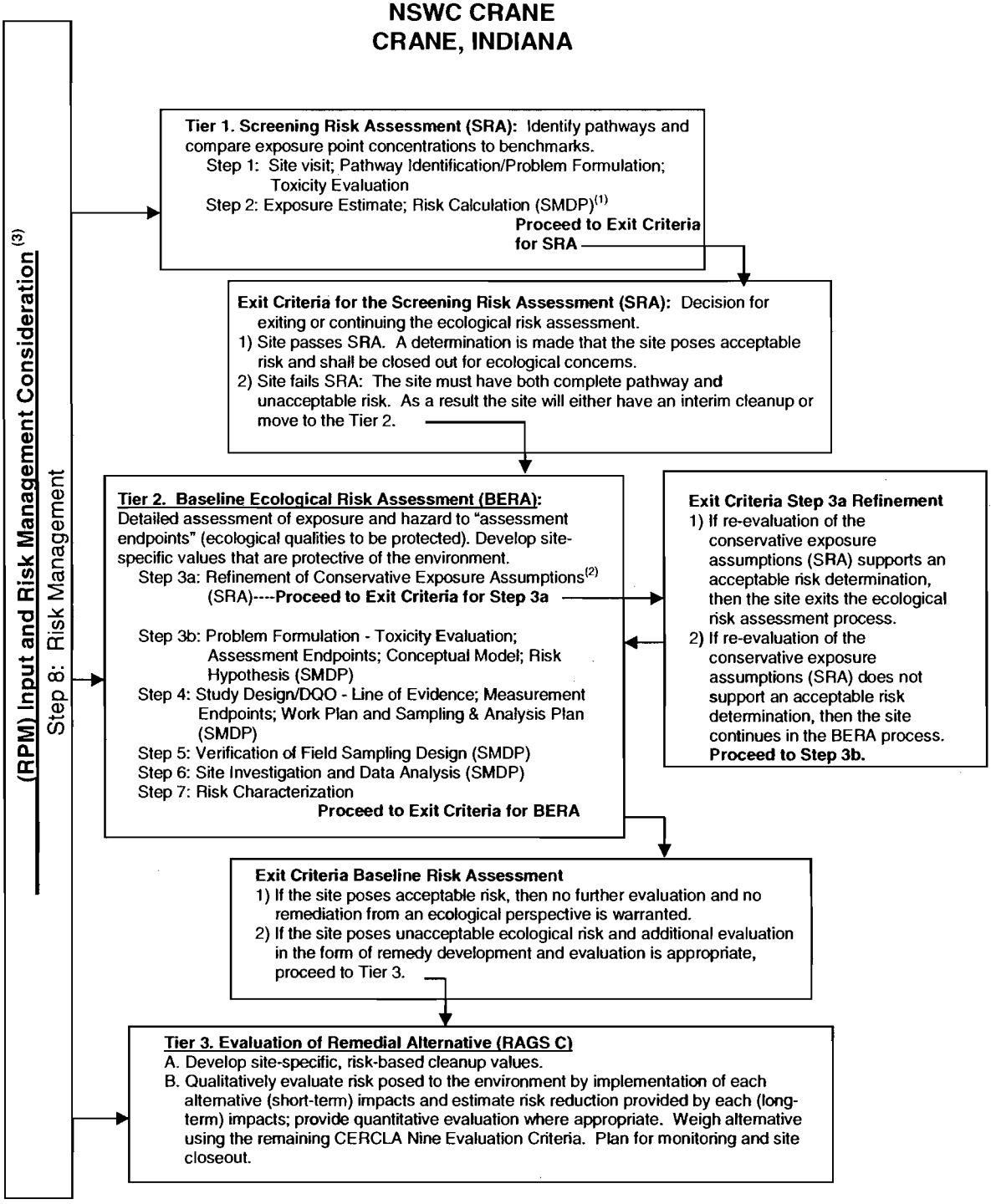
TERRESTRIAL WILDLIFE MODEL
AVERAGE CONCENTRATIONS AND AVERAGE INPUTS
SWMU 12 (MINE FILL A)
NSWC CRANE, INDIANA

	PISCIVORES			
	Mink		Belted Kingfisher	
Parameter	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ
Inorganics				
ARSENIC	2.3E+01	2.3E+00	1.0E-01	3.4E-02
CHROMIUM	1.5E-01	3.6E-02	4.7E-01	9.5E-02
LEAD	3.0E-02	3.0E-03	2.1E-01	2.1E-02
NICKEL	3.8E-02	1.9E-02	1.9E-02	1.4E-02
SELENIUM	9.5E-02	5.7E-02	4.7E-02	2.3E-02

Notes:
Cells are shaded black if the EEQ is greater than 1.0.
EEQ - Ecological Effects Quotient.
NOAEL - No observed adverse effects level.
LOAEL - Lowest observed adverse effects level.

FIGURE 8-1

NAVY ECOLOGICAL RISK ASSESSMENT TIERED APPROACH
SWMU 12 (MINE FILL A)
NSWC CRANE
CRANE, INDIANA



1 See U.S. EPA's 8-Step ERA Process for requirements for each Scientific Management Decision Point (SMDP).
2 Refinement includes but is not limited to background, bioavailability, and detection frequency.
3 Risk management is incorporated throughout the tiered approach.

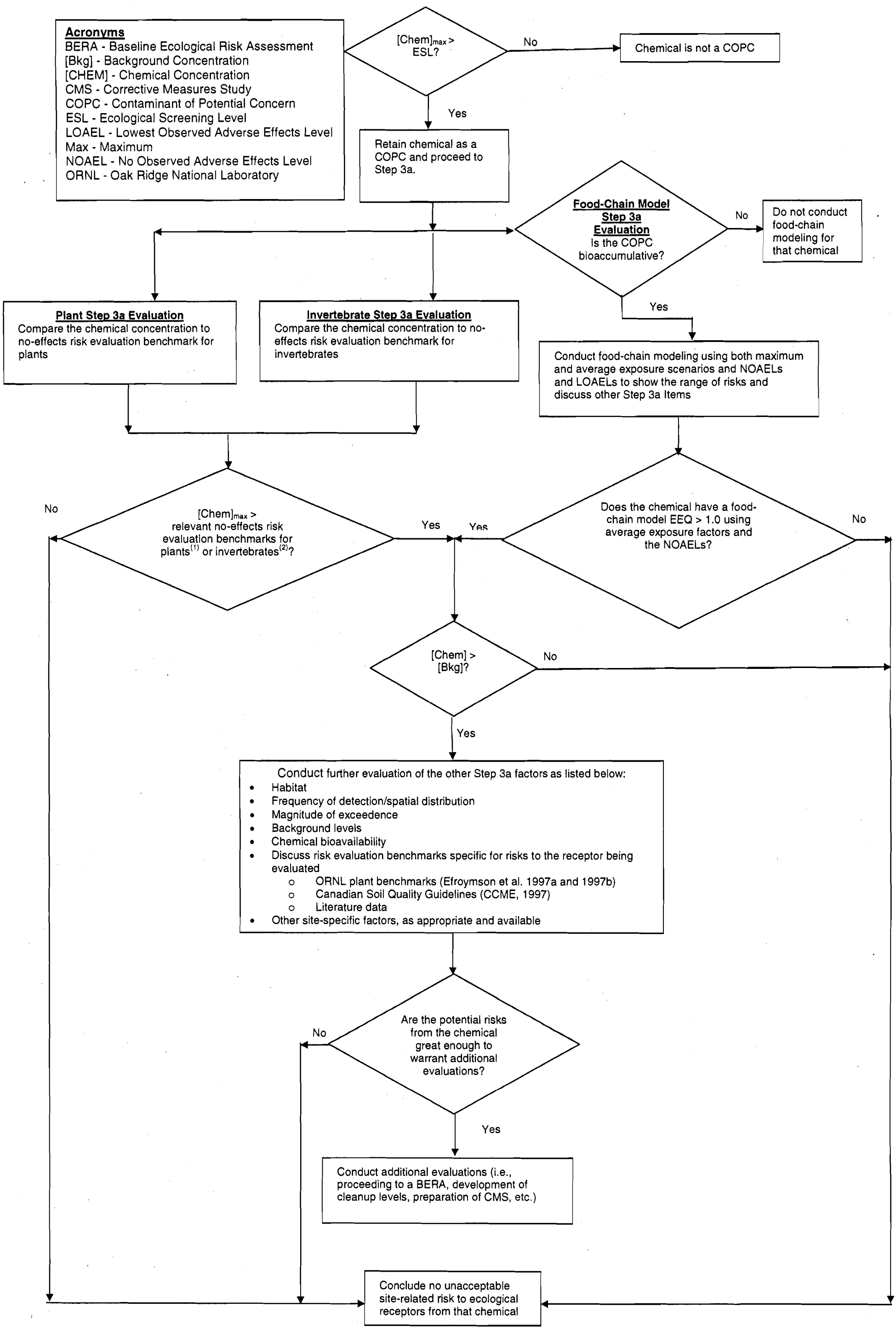


FIGURE 8-2

GENERAL ERA PROCESS FOR EVALUATION OF RISKS TO CHEMICALS IN SURFACE SOIL
SWMU 12 (MINE FILL A)
NSWC CRANE, CRANE, INDIANA

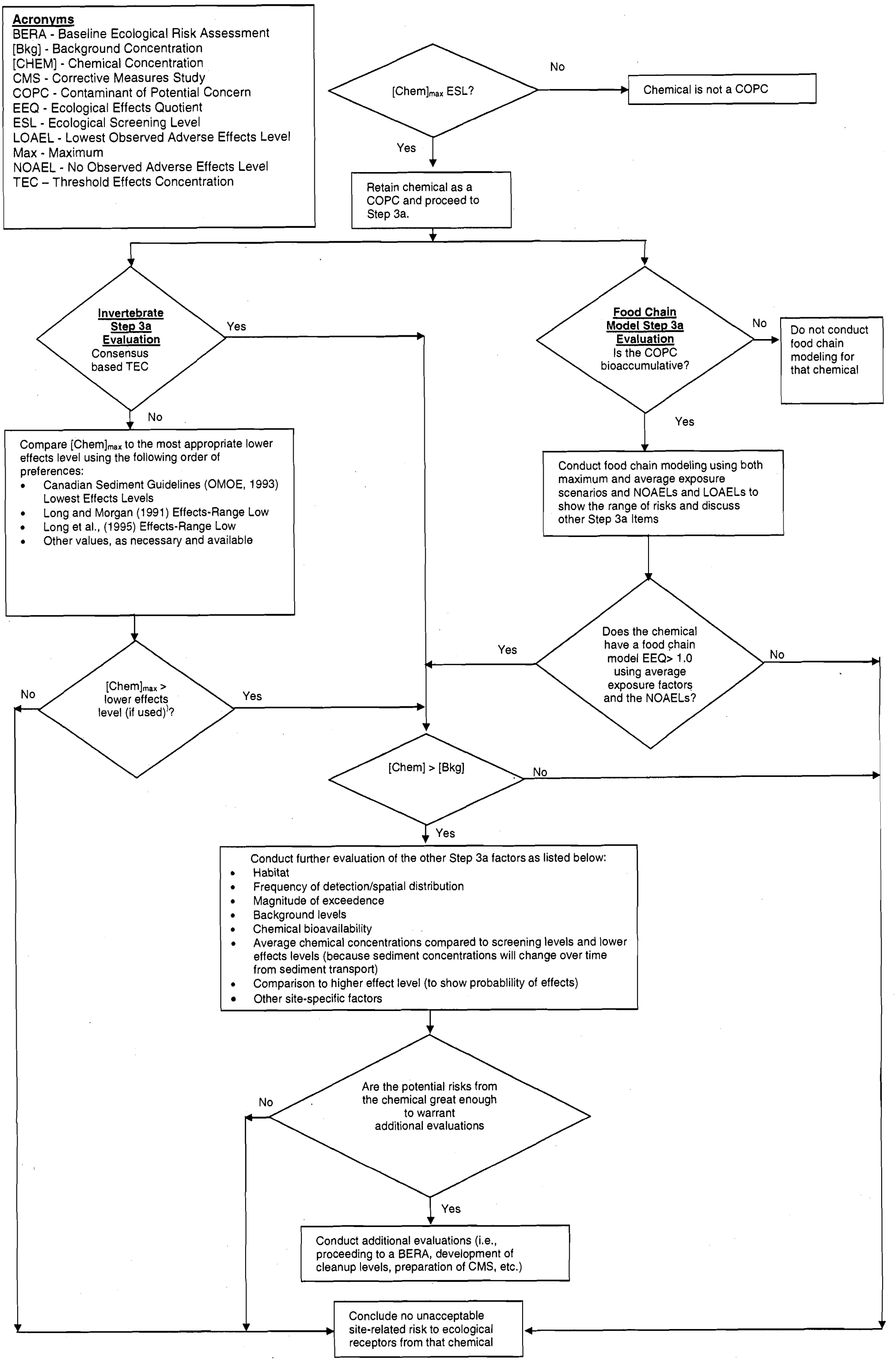
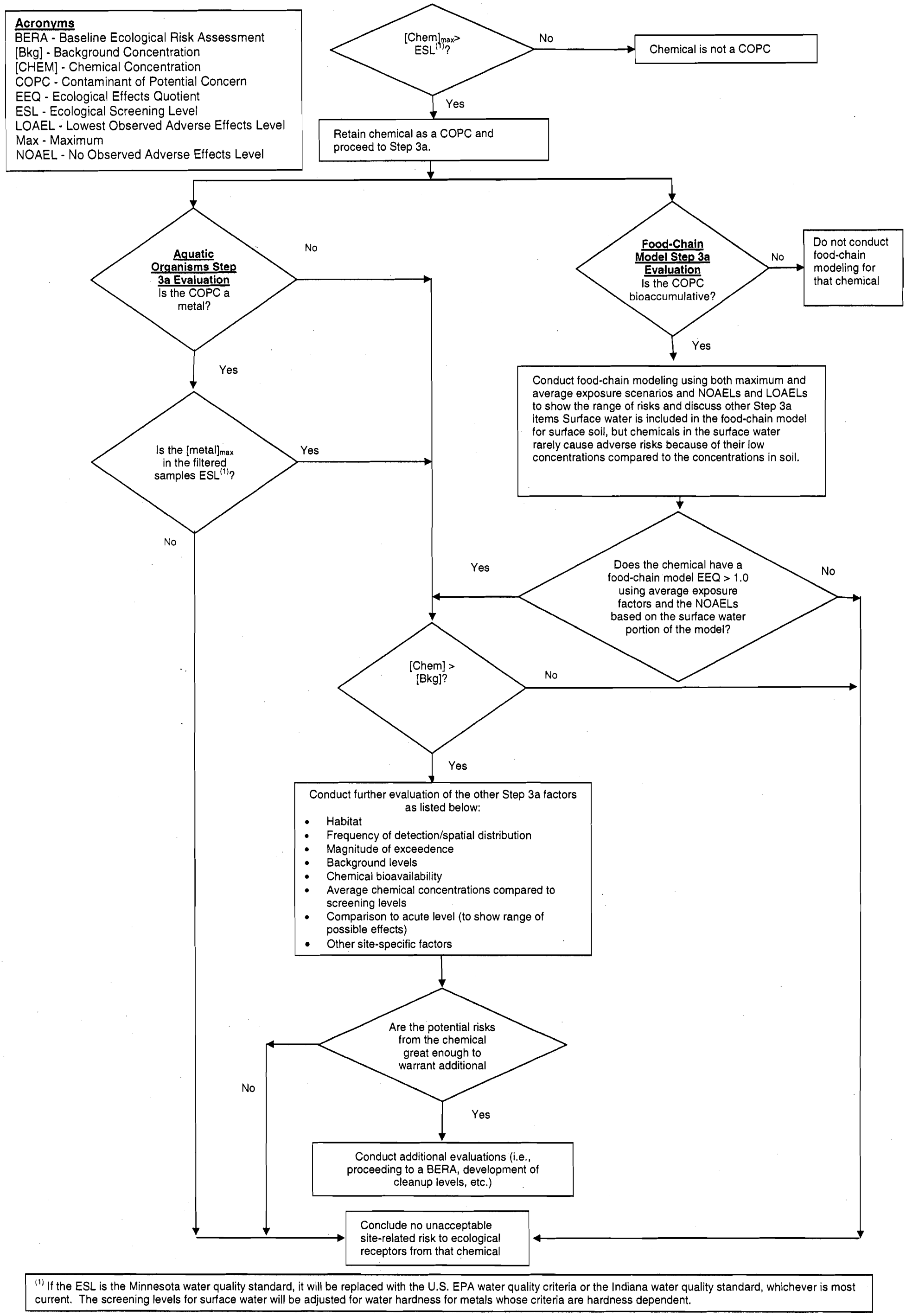


FIGURE 8-3

GENERAL ERA PROCESS FOR EVALUATION OF RISKS TO CHEMICALS IN SEDIMENT
SWMU 12 (MINE FILL A)
NSWC CRANE, CRANE, INDIANA



(1) If the ESL is the Minnesota water quality standard, it will be replaced with the U.S. EPA water quality criteria or the Indiana water quality standard, whichever is most current. The screening levels for surface water will be adjusted for water hardness for metals whose criteria are hardness dependent.

FIGURE 8-4

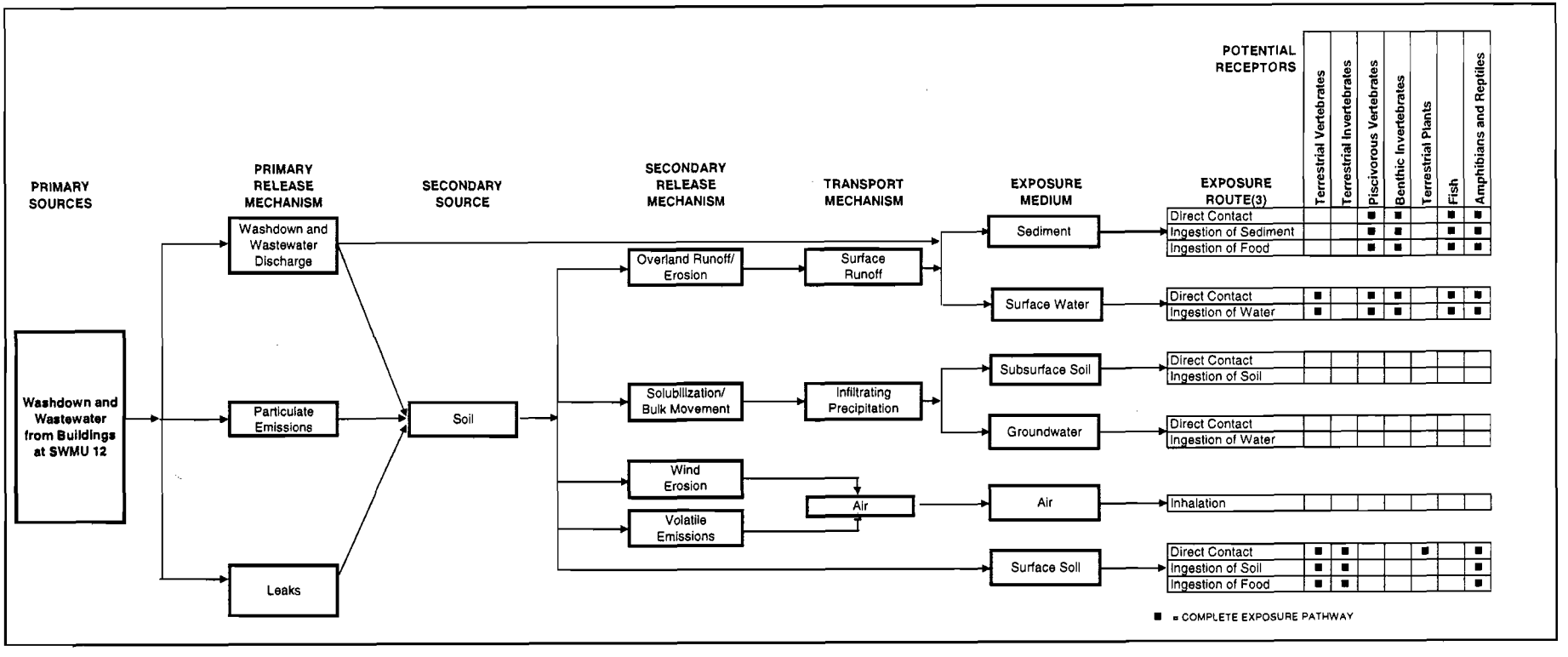
GENERAL ERA PROCESS FOR EVALUATION OF RISKS TO CHEMICALS IN SURFACE WATER
SWMU 12 (MINE FILL A)
NSWC CRANE, CRANE, INDIANA

P:\NSWC, CRANE\MXD\SWMU12_BOUNDARY.MXD 8/30/05 CS

DRAWN BY C. SPEHAR	DATE 8/30/05	SWMU 12 AERIAL PHOTOGRAPH - SWMU 12 BOUNDARY SWMU 12 (MINE FILL A) NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER
CHECKED BY R. YOUNG	DATE 8/30/05		APPROVED BY DATE
REVISED BY	DATE		APPROVED BY DATE
SCALE AS NOTED	NAVFAC		FIGURE NO. FIGURE 8 - 5 / REV 0

FIGURE 8-6

ECOLOGICAL CONCEPTUAL SITE MODEL
SWMU 12 (MINE FILL A)
NSWC CRANE, INDIANA



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