Table of Contents

EXECUTIVE SUMMARY ES-1

ACRONYMS AND ABBREVIATIONS v

1 INTRODUCTION 1

1.1 WHAT DOES THIS REPORT REPRESENT? 1
1.2 WHAT IS THE PCAPP? 1
1.3 WHAT IS THE MISSION OF THE PCD? 1
1.3.1 How Large is the PCD and What is Stored There? 1
1.3.2 What is the History of the PCD? 2
1.4 WHAT ARE THE GENERAL CHARACTERISTICS OF THE AREA AROUND THE PCD? 2
1.4.1 Location and Topography 2
1.4.2 Surface Water and Groundwater 5
1.4.3 Climate 5
1.4.4 Land Use and Demographics 6
1.5 WHY MUST A MPHRA BE PERFORMED FOR THE PCAPP? 6
1.6 WHO OVERSAW THE PLANNING AND CONDUCT OF THIS MPHRA? 6
1.7 WHAT WAS THE GENERAL METHOD FOR PERFORMING THIS MPHRA? 7
1.8 WHAT IS THE PROCESS FOR PERFORMING AN MPHRA? 7
1.9 WHAT SPECIFIC REQUIREMENTS EXIST FOR PERFORMING A MPHRA? 9
1.10 WHAT OTHER GUIDANCE WAS USED WHEN PERFORMING THE MPHRA? 10
1.11 HOW MIGHT CDPHE USE THE RESULTS OF THE MPHRA? 10
1.12 HOW IS THIS REPORT ORGANIZED? 10
1.13 WHAT OTHER INFORMATION SHOULD BE REVIEWED WHEN EVALUATING THIS REPORT? 11

2 FACILITY CHARACTERIZATION 13

2.1 SUMMARY OF PCAPP OPERATIONS 13
2.2 PCAPP FACILITIES 13
2.2.1 Emission Units 14
2.2.2 Process Offgas Treatment Systems 14
2.3 PCAPP WASTE DESCRIPTION 17
2.4 COPC SELECTION 18
2.5 EMISSION RATE DETERMINATIONS 18

3 AIR DISPERSION AND DEPOSITION MODELING 25

3.1 MODELING OVERVIEW 25
3.1.1 Averaging Times 25
3.1.2 Unit Response 25
3.1.3 Overview of Model Inputs 26
3.2 DETAILED AERMOD INPUT DATA 27
3.2.1 Control Options 27
3.2.2 Source Information 28
3.2.3 Receptor Information 34
3.2.4 Meteorological Information 40
3.2.5 Output Options 41
3.3 POST-PROCESSING AERMOD RESULTS 42

4 SELECTION OF EXPOSURE SCENARIOS 43

4.1 CONCEPTUAL SITE MODEL 43

4.1.1 Emission Sources 43
4.1.2 Emission Scenarios 44
4.1.3 Transport Pathways 44
4.1.4 Chronic Exposure Pathways and Receptors 44
4.1.5 Acute Exposure Pathways and Receptors 50
4.2 CUMULATIVE LIFETIME EXPOSURE SCENARIO 50

5 QUANTIFYING MEDIA CONCENTRATIONS AND EXPOSURES 53

5.1 QUANTIFYING MEDIA CONCENTRATIONS 53
5.1.1 COPC Concentrations in Air 55
5.1.2 COPC Concentrations in Soil 57
5.1.3 COPC Concentrations in Surface Water 57
5.1.4 COPC Concentrations in Produce for Human Consumption 59
5.1.5 COPC Concentrations in Animal Products and Fish 59
5.1.6 COPC Concentrations in Breast Milk 59
5.1.7 Results of Quantified Media Concentrations 60
5.2 QUANTIFICATION OF EXPOSURES 61
5.2.1 Direct Exposure Through Inhalation 61
5.2.2 Indirect Exposures 61

6 TOXICITY ASSESSMENT 67

6.1 TOXICITY VALUES FOR CHRONIC EXPOSURES 67
6.2 TOXICITY VALUES FOR SHORT-TERM EXPOSURES 68

7 RISK CHARACTERIZATION 73

7.1 CHARACTERIZATION OF CARCINOGENIC HEALTH EFFECTS 73
7.1.1 Carcinogenic Effects from Direct Exposures 73
7.1.2 Carcinogenic Effects from Indirect Exposures 73
7.1.3 Cumulative Carcinogenic Risk Characterization 74
7.2 CHARACTERIZATION OF NONCARCINOGENIC HEALTH EFFECTS 74
7.2.1 Noncarcinogenic Effects from Direct Exposures 74
7.2.2 Noncarcinogenic Effects from Indirect Exposures 74
7.2.3 Cumulative Noncarcinogenic Hazard Characterization 74
7.3 CHARACTERIZATION OF ACUTE HEALTH EFFECTS 76

8 UNCERTAINTY ANALYSIS OF RISK CHARACTERIZATION 79

8.1 UNCERTAINTY IN FACILITY CHARACTERIZATION 82
8.2 UNCERTAINTY IN AIR DISPERSION AND DEPOSITION MODELING 83
8.3 UNCERTAINTY IN EXPOSURE SCENARIO SELECTION 84
8.4 UNCERTAINTY IN ESTIMATES OF MEDIA CONCENTRATIONS 85
8.5 UNCERTAINTY IN QUANTIFYING EXPOSURE 86
8.6 UNCERTAINTY IN TOXICITY ASSESSMENT 87
8.7 PROBABLE RANGE OF RISK AND HAZARD 91

9 REFERENCES 93

Tables

2-1. Chemicals of Potential Concern 19
2-2. PCAPP Long-term Emission Rates 20
2-3. PCAPP Short-term Emission Rates 22
3-1. Control Option Specifications 27
3-2. Summary of Source Parameters for Future Emission Sources 29
3-3. Summary of COPC Gas Deposition Parameter Values 33
3-4. Summary of the Change in Model Results Based on Gas Deposition Parameters 34
4-1. PCAPP Scenario-specific Adult Exposure Parameters 45
4-2. PCAPP Scenario-specific Child Exposure Parameters 46
4-3. PCAPP Scenario-specific Infant Exposure Parameters 47
4-4. Exposure Pathway/Human Receptor Combinations Evaluated 49
5-1. Types of Parameters Needed to Quantify Media Concentrations and Exposures 55
5-2. Annual and 1-hour Chemical-specific Air Concentrations 56
5-3. Chemical-specific Annual Deposition Rates 58
5-4. COPCs Potentially Found in Breast Milk 60
5-5. Calculated Direct Inhalation Exposures to COPCs with Carcinogenic Effects for All Exposure Scenarios 62
5-6. Calculated Direct Inhalation Exposures to COPCs with Noncarcinogenic Effects for All Exposure Scenarios 63
5-7. Calculated Total Indirect Exposures to COPCs with Carcinogenic Effects 65
5-8. Calculated Total Indirect Exposures to COPCs with Noncarcinogenic Effects 66
6-1. Toxicity Values for Chronic Exposures 69
6-2. Toxicity Values for Acute Exposures 71
7-1. Total Carcinogenic Risks for Each Human Receptor by Pathway 75
7-2. Total Noncarcinogenic HI for Each Human Receptor by Pathway 77
7-3. Acute Hazards Associated With Short-term Emission Release Events 78
8-1. Evaluation of Impact of Potential Uncertainties on Calculated Risk 79
8-2. Comparison of Infant and Child Cancer Risks Using 2002 and 2006 CEFH Exposure Factors 86
8-3. Inhalation Unit Risk Estimates for Sulfur Mustard (HD) 90
8-4. Parameters Varied to Calculate Probable Range of Risk and Hazard 91
8-5. Probable Range of Risk and Hazard Presented by Uncertainty 92

Figures

1-1. Location of Pueblo Chemical Depot (regional setting). 3
1-2. Location of Pueblo Chemical Depot (local setting). 3
1-3. USGS topographical map of the PCD and surrounding area. 4
1-4. Overview of the MPHRA process. 8
2-1. PCAPP site layout. 15
3-1. Location of the downwash analysis structures and emission points 31
3-2. Aerial photograph depicting land use within a 3-km radius of the AFA stack 32
3-3. Tiered full receptor grid layout 36
3-4. Isopleths of annual unit response concentrations from AFA emissions 37
3-5. Tiered refined receptor grid layout 38
3-6. On-site receptor grid 39
3-7. Windrose of 3 years of AERMET-processed surface meteorological data 41
5-1. Transport of COPCs to evaluated media. 54

Appendixes

A COPC Selection Process
B Emission Calculation Package
C Summary of AERMET Meteorological Data Processing
D Formulae and Detailed Procedures for Estimating Media Concentrations and Quantifying Exposure and Risk
E Example Calculations - Vinyl Chloride, Adult Farmer Exposure Scenario
F Summary of Data Sources for Parameters Used in the Multiple Pathway Health Risk Assessment
G Summary Tables of Calculated Media Concentrations, Exposure Estimates, and Risks
H Output Tables from the Chronic Risk Calculator Spreadsheets
I Output Tables from the Acute Risk Calculator Spreadsheets

Acronyms and Abbreviations

Acronym/ Abbreviation	Definition
° C	degrees Centigrade
° F	degrees Fahrenheit
AEGL	Acute Inhalation Exposure Guideline
AERMAP	AERMOD Terrain Data Preprocessor Program
AERMET	AERMOD Meteorological Data Preprocessor Program
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
AFA	Agent Filter Area
Agent T	bis-2-[2-chloroethyl thio] ethyl or $C_8H_{16}Cl_2OS_2$
AIEC	Acute Inhalation Exposure Criteria
ANS	Agent Neutralization System
APB	Agent Processing Building
ATSDR	Agency for Toxic Substances and Disease Registry
BPT	Bechtel Pueblo Team
BRS	Brine Reduction System
BTA	Biotreatment Area
$C_{(air)}$	calculated chemical-specific concentration in air
CAS	Chemical Abstracts Service
CBRNIAC	Chemical, Biological, Radiological & Nuclear Defense Information Analysis Information Center
CCR	Code of Colorado Regulations
CDC	Centers for Disease Control and Prevention
CDPHE	Colorado Department of Public Health and Environment
CEFH	Child-specific Exposure Factors Handbook
CFR	Code of Federal Regulations
CHWRs	Colorado Hazardous Waste Regulations
Cl_2	chlorine
cm	centimeter
cm^2/s	square centimeters per second
COPC	chemical of potential concern
CSF	cancer slope factor
Cy	maximum ground-level unit response concentration
D_a	diffusivity in air
D_R	calculated chemical-specific deposition rate
D_S	deposition term
D_W	diffusivity in water
D_Y	maximum ground-level unit response deposition rate
day/yr	days per year
DEM	digital elevation model
DPE	demilitarization protective ensemble
ERB	Enhanced Reconfiguration Building
ERPG	Emergency Response Planning Guideline
ft	feet
ft/s	feet per second
g/m^2-yr	grams per square meter per year
g/s	grams per second
GEP	Good Engineering Practice

Acronym/ Abbreviation	Definition
GPL	general population air exposure limit
H	Henry's Law constant
ha	hectare
HCl	hydrogen chloride
HD	sulfur mustard or bis-(2-chloroethyl) sulfide or $C_4H_8Cl_2S$
HEPA	high-efficiency particulate air
HHRAP	Human Health Risk Assessment Protocol
HI	hazard index
HI_A	acute hazard index
hr/day	hours per day
HT	mixture of approximately 60 percent HD and 40 percent Agent T (bis-2-[2-chloroethyl thio] ethyl, or $C_8H_{16}Cl_2OS_2$)
HQ	hazard quotient
HQ_A	acute hazard quotient
ICB™	Immobilized Cell Bioreactor
IRIS	Integrated Risk Information System
K	Kelvin
kg	kilogram
kg/day	kilograms per day
km	kilometer
kse	soil loss constant due to soil erosion
lb/hr	pounds per hour
LOAEL	lowest observed adverse effect level
$\mu g/m^3$	microgram(s) per cubic meter
m	meter
m/s	meter(s) per second
m^2	square meter
m^3/hr	cubic meter(s) per hour
MEK	methyl ethyl ketone
mg COPC/kg of body weight-day	milligram(s) of COPC per kilogram of body weight per day
mg/m^3	milligram(s) per cubic meter
MIBK	methyl isobutyl ketone
mℓ/hr	milliliter(s) per hour
mm	millimeter
mph	mile(s) per hour
MPHRA	Multiple Pathway Health Risk Assessment
MRL	minimal risk level
MTU	Munitions Treatment Unit
MWS	Munitions Washout System
NCEA	National Center for Environmental Assessment
NOAEL	No Observed Adverse Effect Level
OEHHA	Office of Environmental Health Hazard Assessment
OSWER	Office of Solid Waste and Emergency Response
OTS	Offgas Treatment System
$Pa\text{-}m^3/mol$	Pascal-cubic meter(s) per mole
PCAPP	Pueblo Chemical Agent-Destruction Pilot Plant
PCB	polychlorinated biphenyl
PCD	Pueblo Chemical Depot

Acronym/ Abbreviation	Definition
PPE	personal protective equipment
PRG	preliminary remediation goal
Q	estimated chemical-specific stack emission rate
RAGS	Risk Assessment Guidance for Superfund
rcl	cuticular resistance
RCRA	Resource Conservation and Recovery Act
RD&D	Research, Development, and Demonstration
RDX	Royal Demolition Explosive
REL	Reference Exposure Level
RfD	reference dose
RfD_i	inhalation RfD
RfD_o	oral RfD
RME	reasonably maximally exposed
s/cm	second(s) per centimeter
scfm	standard cubic feet per minute
SDU	Supplemental Decontamination Unit
SO_2	sulfur dioxide
TEEL	Temporary Emergency Exposure Limit
TNT	trinitrotoluene
UF	uncertainty factor
US	United States
USACHPPM	US Army Center for Health Promotion and Preventive Medicine
USDA	US Department of Agriculture
USEPA	US Environmental Protection Agency
USGS	US Geological Survey
UTM	Universal Transverse Mercator
VOC	volatile organic compound
VSL	vapor screening level
WRS	Water Recovery System
yr	year

THIS PAGE INTENTIONALLY BLANK