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94 RF 02810

EG&G ROCKY FLATS



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EG&G ROCKY FLATS, INC.
ROCKY FLATS PLANT, P.O. BOX 464, GOLDEN, COLORADO 80402-0464 • (303) 966-7000

DIST.	LTR	ENC
AMARAL, M.E.		
BERMAN, H.S.		
BRANCH, D.B.		
CARNIVAL, G.J.		
COPP, R.D.		
DAVIS, J.G.		
FERREIRA, D.W.		
HANNI, B.J.		
HARMAN, L. K.		
HEALY, T.J.		
HEDAHL, T.		
HILBIG, J.G.		
HUTCHINGS, N.M.	X	
KELL, R.E.		
KIRBY, W.A.		
KUESTER, A.W.		
MAHAFFEY, J.W.		
MANN, H.P.	X	
MARX, G.E.		
McDONALD, M.M.		
McKENNA, F.G.		
MONTROSE, J.K.		
MORGAN, R.V.		
POTTER, G.L.		
PIZZUTO, V.M.		
RISING, T.L.		
SANDLIN, N.B.		
SETLOCK, G.H.		
STEWART, D.L.		
STIGER, S.G.	X	
SULLIVAN, M.T.		
SWANSON, E.R.		
WILKINSON, R.B.	X	
WILSON, J. M.		
WYANT, R.D.		

March 8, 1994

94-RF-02810

Jessie M. Roberson
Acting Assistant Manager for
Environmental Restoration
DOE, RFO

Attn: E. A. Howard, S. J. Olinger, B. Wienard

PROGRAMMATIC PRELIMINARY REMEDIATION GOALS - SGS-164-94

Attached are the risk based programmatic Preliminary Remediation Goals (PRGs) for EG&G Rocky Flats, Inc. These PRGs were requested by the Department of Energy/Rocky Flats office in a meeting with the Environmental Protection Agency and the Colorado Department of Health on the programmatic aspects of Feasibility Studies at Rocky Flats Plant. The risk based, programmatic PRGs will be evaluated with Applicable or Relevant and Appropriate Requirements (ARARS) to determine Operable Unit specific remediation goals. These remediation goals will be used to assess remediation strategies in the Feasibility Studies.

Please review and comment on the attached risk based, programmatic PRGs by March 23, 1994. If you have any questions, please contact John K. Hopkins of Environmental Engineering & Technology at extension 8636.

Anderson, G.M.
Hopkins, J.K. X X
Roberts, R.C. X X
O'Rourke, T.P. X X
A.L. Armitage X X
Bueby, W.J. X X
Peterson, B.D. X X

S. G. Stiger
Associate General Manager
Environmental Restoration Management

RSR:cet

Orig. and 1 cc - J. M. Roberson

Attachment:
As Stated

- cc:
- M. H. McBride - DOE/RFO
 - R. J. Schassburger - DOE/RFO
 - M. N. Silverman - DOE/RFO
 - L. W. Smith - DOE/RFO

Best Available Copy

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ADMIN RECCRD

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PATS/T130G		

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UNCLASSIFIED	
CONFIDENTIAL	
SECRET	

AUTHORIZED CLASSIFIER
SIGNATURE
*Not req'd per
Class. office*

DATE *Exemption*

IN REPLY TO RFP, CC NO:
N/A

ACTION ITEM STATUS
 PARTIAL/OPEN
 CLOSED

LTR APPROVALS *MA*

ORIG & TYPIST INITIALS
KSK/cet

**PROGRAMMATIC PRELIMINARY
REMEDATION GOALS FOR ROCKY FLATS PLANT**

*Please
make me a
copy.
JW*

Prepared for:

EG&G ROCKY FLATS, INC.

Prepared by:

**ENGINEERING-SCIENCE, INC.
1700 BROADWAY, SUITE 900
DENVER, COLORADO 80290**

MARCH 7, 1994

DISCLAIMER

These programmatic Preliminary Remediation Goals (PRG) are generally applicable to all Operable Units (OU) at the Rocky Flats Plant. OU-specific circumstances may disqualify some or all of these PRGs from consideration at an OU. For example, the ground water PRGs may not be applicable at OUs where the ground water is not of sufficient quantity or quality to support a household. Also, an exposure scenario such as a residential area may not be applicable in areas where commercial/industrial facilities are present and are expected to continue for the long term.

PROGRAMMATIC PRELIMINARY REMEDIATION GOALS FOR ROCKY FLATS PLANT

INTRODUCTION

Risk-based programmatic preliminary remediation goals (PRGs) were calculated for target analyte list (TAL) metals, target compound list (TCL) organics, and select Rocky Flats Plant-specific radionuclides. The PRGs were based on a residential exposure, commercial/industrial exposure, and exposure of onsite ecological researchers. PRG calculations followed Environmental Protection Agency guidance (USEPA, 1989 and 1991) and were supplemented with site-specific information. These PRGs provide benchmark concentrations for use during analysis and screening of remedial alternatives. The following sections provide a discussion of the exposure assumptions and the toxicity information used in the calculation of the programmatic PRGs.

EXPOSURE ASSUMPTIONS

Programmatic PRGs were calculated for three exposure scenarios: residential, commercial/industrial, and ecological researcher. The pathways addressed for each of these scenarios are:

residential - ingestion of drinking groundwater;
 inhalation of volatiles from groundwater;
 ingestion of surface water while swimming;
 ingestion of soil; and
 direct external exposure to soils.

commercial/industrial - ingestion of soil;
inhalation of soil particulates; and
direct external exposure to soils.

ecological researcher - ingestion of surface water during wading;
ingestion of soil; and
direct external exposure to soils.

Standard assumptions given in Risk Assessment Guidance for Superfund (RAGS), Part B (USEPA, 1991) were used in developing PRG equations where available. For situations not addressed by RAGS, Part B, standard assumptions given in RAGS, Part A (USEPA, 1989) were used. In addition, site-specific information was used where appropriate to supplement assumptions given in USEPA guidance. Separate carcinogenic and non-carcinogenic risk-based PRGs were calculated for each compound for each receptor where toxicity information was available. Equations are provided in the attached Tables 1 through 18.

For residential use of groundwater and soil (Tables 1, 2, 5, 6 and 16) all exposure parameters were taken from RAGS Part B. For ingestion of surface water while swimming (Tables 3, 4, and 17), exposure parameters were taken from RAGS Part A, and RAGS Part B with the exposure time taken from site-specific information. For commercial/industrial exposure to soils (Tables 7 and 8), exposure parameters were taken from RAGS Part B, except that site-specific information was used for the workday inhalation rate and particulate emissions. The workday inhalation rate was based on an inhalation rate of 0.83 cubic meters per hour over an 8-hour day. The particulate emission rate was based on information presented in the Rocky Flats Plant Site Environmental Report (1991). For exposure of ecological workers to surface water while wading (Tables 9 and 10), to soil via ingestion (Tables 11 and 12), and to radionuclides (Tables 15 and 18), standard assumptions in RAGS Part A and RAGS Part B were supplemented with site-specific information on exposure frequency and exposure duration. Radionuclide exposure equations were updated from RAGS Part B in accordance with guidance

received from USEPA Region VIII in order to make units compatible with the most recent toxicity information.

TOXICITY INFORMATION

Toxicity information used in the calculation of risk-based PRGs included the reference dose (RfD) and the reference concentration (RfC) for evaluating noncarcinogenic effects and the slope factor and unit risk for evaluating carcinogenic potential. Values were obtained from the Integrated Risk Information System (IRIS) (January 1994). If values were not available from IRIS, the Health Effects Assessment Summary Table (HEAST) (USEPA, 1993) was consulted. Toxicity information is included in Table 19.

DEVELOPMENT OF PROGRAMMATIC PRELIMINARY REMEDIAL GOALS

PRGs were calculated for each of the three future scenarios: residential, commercial/industrial, and ecological worker. For the residential scenario, PRGs were calculated for target analytes in soil, groundwater, and surface water. For the commercial/industrial scenario, PRGs were calculated for target analytes in soil. For the ecological worker scenario, PRGs were calculated for target analytes in soil and surface water. In accordance with RAGS Part B, PRGs for potential carcinogens were calculated to correspond to a lifetime excess cancer risk of one in a million, and PRGs for noncarcinogens were calculated to correspond to a target hazard index of one. Where a chemical had both carcinogenic and noncarcinogenic endpoints, the lower of the two resulting PRGs was the selected PRG. Programmatic PRGs are presented in Table 19.

REFERENCES

EG&G Rocky Flats, Inc., 1991. Rocky Flats Plant Site Environmental Report.

USEPA, 1989. Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response. Office of Emergency and Remedial Response. Washington, D.C.
EPA/540/1-89/002.

USEPA, 1991. Human Health Evaluation Manual, Part B: Development of Risk-based Preliminary Remediation Goals. Office of Emergency and Remedial Response. Washington, D.C.

USEPA, 1993a. Health Effects Assessment Summary Tables. Annual Update, March 1993. Office of Emergency and Remedial Response, Washington, D.C.

USEPA, 1993b. Revisions to Chapter 4: Risk-based PRGs for Radioactive Contaminants. Received from USEPA Region VIII October 1993.

USEPA, 1994. Integrated Risk Information System (IRIS). January, 1994.

USEPA, 1993. Research and Development - Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons. Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, U.S. Environmental Protection Agency. ECAO-CIN-842.

TABLE 1

RESIDENTIAL USE OF GROUNDWATER - PRG CALCULATIONS FOR NONCARCINOGENIC EFFECTS
ROCKY FLATS PLANT, GOLDEN, CO

$$\text{THI} = \frac{C \times \text{IRw} \times \text{EF} \times \text{ED}}{\text{RfDo} \times \text{BW} \times \text{AT}} + \frac{C \times K \times \text{IRa} \times \text{EF} \times \text{ED}}{\text{RfDi} \times \text{BW} \times \text{AT}}$$

$$C \text{ (mg/L)} = \frac{\text{THI} \times \text{BW} \times \text{AT}}{\text{EF} \times \text{ED} \times [(1/\text{RfDi} \times K \times \text{IRa}) + (1/\text{RfDo} \times \text{IRw})]}$$

where:

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
C	chemical concentration in water (mg/L)	-
THI	target hazard index (unitless)	1
RfD _o	oral chronic reference dose (mg/kg-day)	chemical-specific
RfDi	inhalation chronic reference dose (mg/kg/day)	chemical-specific
BW	adult body weight (kg)	70 kg
AT	average time (days)	ED x 365 days/yr
EF	exposure frequency (days/yr)	350 days/yr
ED	exposure duration (yr)	30 yr
IRw	daily water ingestion rate (L/day)	2 L/day
IRa	daily indoor inhalation rate (m ³ /day)	15 m ³ /day
K	volatilization factor (unitless)	0.0005 x 1000 L/m ³

Source: RAGS Part B

TABLE 2

RESIDENTIAL USE OF GROUNDWATER - PRG CALCULATIONS FOR CARCINOGENIC EFFECTS
ROCKY FLATS PLANT, GOLDEN, CO

$$TR = \frac{SF_o \times C \times IR_w \times EF \times ED}{BW \times AT} + \frac{SF_i \times C \times K \times IR_a \times EF \times ED}{BW \times AT}$$

$$C \text{ (mg/L)} = \frac{TR \times BW \times AT}{EF \times ED \times [(SF_i \times K \times IR_a) + (SF_o \times IR_w)]}$$

where:

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
C	chemical concentration in soil (mg/kg)	-
TR	target excess individual lifetime cancer risk (unitless)	10 ⁻⁶
SF _o	oral cancer slope factor (1/mg/kg-day)	chemical-specific
SF _i	inhalation cancer slope factor (1/mg/kg-day)	chemical-specific
BW	adult body weight (kg)	70 kg
AT	average time (days)	70 yr x 365 days/yr
EF	exposure frequency (days/yr)	350 days/yr
ED	exposure duration (yr)	30 yr
IR _a	daily indoor inhalation rate (m ³ /day)	15 m ³ /day
IR _w	daily water ingestion (L/day)	2 L/day
K	volatilization factor (unitless)	0.0005 x 1000 L/m ³

Source: RAGS Part B

TABLE 3

RESIDENTIAL USE OF SURFACE WATER WHILE SWIMMING- PRG CALCULATIONS FOR NONCARCINOGENIC EFFECTS
ROCKY FLATS PLANT, GOLDEN, CO

$$\text{THI} = \frac{\text{C} \times \text{CRw} \times \text{ET} \times \text{EF} \times \text{ED}}{\text{RfDo} \times \text{BW} \times \text{AT}}$$

$$\text{C (mg/L)} = \frac{\text{THI} \times \text{BW} \times \text{AT} \times \text{RfDo}}{\text{CRw} \times \text{ET} \times \text{EF} \times \text{ED}}$$

where:

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
C	chemical concentration in water (mg/L)	-
THI	target hazard index (unitless)	1
RfDo	oral chronic reference dose (mg/kg-day)	chemical-specific
BW	adult body weight (kg)	70 kg
AT	average time (days)	ED x 365 days/yr
EF	exposure frequency (days/yr)	7 days/yr
ED	exposure duration (yr)	30 yr
CRw	contact rate (L/hour)	0.05 L/hour
ET	exposure time (hours/day)	2.6 hours/day

Source: RAGS PART A; Site-specific information from OUs 2,5 and 6.

TABLE 4

RESIDENTIAL USE OF SURFACE WATER WHILE SWIMMING - PRG CALCULATIONS FOR CARCINOGENIC EFFECTS
ROCKY FLATS PLANT, GOLDEN, CO

$$TR = \frac{C \times CRw \times ET \times EF \times ED \times SFo}{BW \times AT}$$

$$C \text{ (mg/L)} = \frac{TR \times BW \times AT}{CRw \times ET \times EF \times ED \times SFo}$$

where:

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
C	chemical concentration in water (mg/L)	-
TR	target excess individual lifetime cancer risk (unitless)	10 ⁻⁶
SF _o	oral cancer slope factor (1/mg/kg-day)	chemical-specific
BW	adult body weight (kg)	70 kg
AT	average time (days)	70 x 365 days/yr
EF	exposure frequency (days/yr)	7 days/yr
ED	exposure duration (yr)	30 yr
CRw	contact rate (L/hour)	0.05 L/hour
ET	exposure time (hours/day)	2.6 hours/day

Source: RAGS Part A; Site-specific information from OUs 2,3, and 5.

TABLE 5
RESIDENTIAL SOIL - PRG CALCULATIONS FOR NONCARCINOGENIC EFFECTS
ROCKY FLATS PLANT, GOLDEN, CO

$$\text{THI} = \frac{C \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{IFsoil-adj}}{\text{RfDo} \times \text{AT}}$$

$$C \text{ mg/kg} = \frac{\text{THI} \times \text{AT}}{1/\text{RfDo} \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{IFsoil-adj}}$$

where:

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
C	chemical concentration in soil (mg/kg)	-
THI	target hazard index (unitless)	1
RfDo	oral chronic reference dose (mg/kg-day)	chemical-specific
AT	average time (days)	ED x 365 days/yr
EF	exposure frequency (days/yr)	350 days/yr
ED	exposure duration (yr)	30 yr
IFsoil-adj	age-adjusted ingestion factor (mg-yr/kg-day)	114 mg-yr/kg-day

$$\text{where: IFsoil-adj (mg-yr/kg-day)} = \frac{\text{IRsoil-age 1-6} \times \text{EDage 1-6}}{\text{BW age 1-6}} + \frac{\text{IR soil-age 7-31} \times \text{EDage 7-31}}{\text{BWage 7-31}}$$

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
BWage 1-6	average body weight from ages 1-6 (kg)	15 kg
BWage 7-31	average body weight from ages 7-31 (kg)	70 kg
EDage 1-6	exposure duration during ages 1-6 (yr)	6 yr
EDage 7-31	exposure duration during ages 7-31 (yr)	24 yr
IRsoil-age 1-6	ingestion rate of soil age 1 to 6 (mg/kg)	200 mg/day
IRsoil-age 7-31	ingestion rate of soil age 7 to 31 (mg/kg)	100 mg/day

Source: RAGS Part B

TABLE 6
RESIDENTIAL SOIL - PRG CALCULATIONS FOR CARCINOGENIC EFFECTS

ROCKY FLATS PLANT, GOLDEN, CO

$$TR = \frac{C \times SFo \times 10^{-6} \text{ kg/mg} \times EF \times IF_{\text{soil-adj}}}{AT}$$

$$C \text{ mg/kg} = \frac{TR \times AT}{SFo \times 10^{-6} \text{ kg/mg} \times EF \times IF_{\text{soil-adj}}}$$

where:

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
C	chemical concentration in soil (mg/kg)	-
TR	target excess individual lifetime cancer risk (unitless)	10 ⁻⁶
SFo	oral cancer slope factor (1/mg/kg-day)	chemical-specific
AT	average time (days)	ED x 365 days/yr
EF	exposure frequency (days/yr)	350 days/yr
ED	exposure duration (yr)	30 yr
IFsoil-adj	age-adjusted ingestion factor (mg-yr/kg-day)	114 mg-yr/kg-day

$$\text{where: } IF_{\text{soil-adj}} \text{ (mg-yr/kg-day)} = \frac{IR_{\text{soil-age 1-6}} \times ED_{\text{age 1-6}}}{BW_{\text{age 1-6}}} + \frac{IR_{\text{soil-age 7-31}} \times ED_{\text{age 7-31}}}{BW_{\text{age 7-31}}}$$

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
BWage 1-6	average body weight from ages 1-6 (kg)	15 kg
BWage 7-31	average body weight from ages 7-31 (kg)	70 kg
EDage 1-6	exposure duration during ages 1-6 (yr)	6 yr
EDage 7-31	exposure duration during ages 7-31 (yr)	24 yr
IRsoil-age 1-6	ingestion rate of soil age 1 to 6 (mg/kg)	200 mg/day
IRsoil-age 7-31	ingestion rate of soil age 7 to 31 (mg/kg)	100 mg/day

Source: RAGS Part B

TABLE 7
COMMERCIAL/INDUSTRIAL SOILS -
PRG CALCULATIONS FOR NONCARCINOGENIC EFFECTS

ROCKY FLATS PLANT, GOLDEN, CO

$$\text{THI} = \frac{C \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{ED} \times \text{IR}_{\text{soil}}}{\text{RfD}_o \times \text{BW} \times \text{AT}} + \frac{C \times \text{EF} \times \text{ED} \times \text{IR}_{\text{air}} \times (\text{PE})}{\text{RfD}_i \times \text{BW} \times \text{AT}}$$

$$C \text{ mg/kg} = \frac{\text{THI} \times \text{BW} \times \text{AT}}{\text{ED} \times \text{EF} \times [((1/\text{RfD}_o) \times 10^{-6} \text{ kg/mg} \times \text{IR}_{\text{soil}}) + ((1/\text{RfD}_i) \times \text{IR}_{\text{air}} \times (\text{PE}))]}$$

where:

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
C	chemical concentration in soil (mg/kg)	-
THI	target hazard index (unitless)	1
RfD _o	oral chronic reference dose (mg/kg-day)	chemical-specific
RfD _i	inhalation chronic reference dose (mg/kg-day)	chemical-specific
BW	adult body weight (kg)	70 kg
AT	average time (days)	ED yr x 365 days/yr
EF	exposure frequency (days/yr)	250 days/yr
ED	exposure duration (yr)	25 yr
IR _{soil}	soil ingestion rate (mg/day)	50 mg/day
IR _{air}	workday inhalation rate (m ³ /day)	6.64 m ³ /hr
PE	site-specific particulate emissions (kg/m ³)	3.98 x 10 ⁻⁵ Kg/m ³

Source: RAGS Part B; RFP Site Environmental Report, 1991.

7/1

TABLE 8
COMMERCIAL/INDUSTRIAL SOIL - PRG CALCULATIONS FOR CARCINOGENIC EFFECTS

ROCKY FLATS PLANT, GOLDEN, CO

$$TR = \frac{SF_o \times C \times 10^{-6} \text{ kg/mg} \times EF \times ED \times IR_{soil}}{BW \times AT} + \frac{SF_i \times C \times EF \times ED \times IR_{air} \times (PE)}{BW \times AT}$$

$$C \text{ mg/kg; } = \frac{TR \times BW \times AT}{EF \times ED \times [(SF_o \times 10^{-6} \text{ kg/mg} \times IR_{soil}) + (SF_i \times IR_{air} \times (PE))]}$$

where:

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
C	chemical concentration in soil (mg/kg)	-
TR	target excess individual lifetime cancer risk (unitless)	10 ⁻⁶
SF _i	inhalation cancer slope factor ((mg/kg-day) ⁻¹)	chemical-specific
SF _o	oral cancer slope factor ((mg/kg-day) ⁻¹)	chemical-specific
BW	adult body weight (kg)	70 kg
AT	average time (days)	70 yr x 365 days/yr
EF	exposure frequency (days/yr)	250 days/yr
ED	exposure duration (yr)	25 yr
IR _{soil}	workday ingestion rate (mg/day)	50 mg/day
IR _{air}	workday inhalation rate (m ³ /day)	6.64 m ³ /day
PE	site-specific particulate emissions (kg/m ³)	4.63 x 10 ⁻⁵ kg/m ³

Source: RAGS Part B; RFP Site Environmental Report, 1991

TABLE 9

ECOLOGICAL WORKER EXPOSURE TO SURFACE WATER VIA WADING- PRG CALCULATIONS FOR NONCARCINOGENIC EFFECTS
ROCKY FLATS PLANT, GOLDEN, CO

$$\text{THI} = \frac{\text{C} \times \text{IRw} \times \text{EF} \times \text{ED}}{\text{RfDo} \times \text{BW} \times \text{AT}}$$

$$\text{C (mg/L)} = \frac{\text{THI} \times \text{BW} \times \text{AT} \times \text{RfDo}}{\text{IRw} \times \text{EF} \times \text{ED}}$$

where:

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
C	chemical concentration in water (mg/L)	-
THI	target hazard index (unitless)	1
RfDo	oral chronic reference dose (mg/kg-day)	chemical-specific
BW	adult body weight (kg)	70 kg
AT	average time (days)	ED x 365 days/yr
EF	exposure frequency (events/yr)	7 events/yr
ED	exposure duration (yr)	2.5 yr
IRw	intake rate (L/event)	0.05 L/event

Source: RAGS Part A; Site-specific information from OUs 5 and 6.

TABLE 10

ECOLOGICAL WORKER EXPOSURE TO SURFACE WATER VIA WADING - PRG CALCULATIONS FOR CARCINOGENIC EFFECTS
ROCKY FLATS PLANT, GOLDEN, CO

$$TR = \frac{C \times IRw \times EF \times ED \times SFo}{BW \times AT}$$

$$C \text{ (mg/L)} = \frac{TR \times BW \times AT}{IRw \times EF \times ED \times SFo}$$

where:

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
C	chemical concentration in water (mg/L)	-
TR	target excess individual lifetime cancer risk (unitless)	10 ⁻⁶
SF _o	oral cancer slope factor (1/mg/kg-day)	chemical-specific
BW	adult body weight (kg)	70 kg
AT	average time (days)	70 x 365 days/yr
EF	exposure frequency (events/yr)	7 events/yr
ED	exposure duration (yr)	2.5 yr
IRw	ingestion rate (L/event)	0.05 L/event

Source: RAGS Part A; Site-specific information from OUs 5 and 6.

TABLE 11
ECOLOGICAL WORKER SOILS -
PRG CALCULATIONS FOR NONCARCINOGENIC EFFECTS
ROCKY FLATS PLANT, GOLDEN, CO

$$\text{THI} = \frac{C \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{ED} \times \text{IR}_{\text{soil}}}{\text{RfD}_o \times \text{BW} \times \text{AT}}$$

$$C \text{ mg/kg} = \frac{\text{THI} \times \text{BW} \times \text{AT} \times \text{RfD}_o}{\text{ED} \times \text{EF} \times (10^{-6} \text{ kg/mg} \times \text{IR}_{\text{soil}})}$$

where:

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
C	chemical concentration in soil (mg/kg)	-
THI	target hazard index (unitless)	1
RfD _o	oral chronic reference dose (mg/kg-day)	chemical-specific
BW	adult body weight (kg)	70 kg
AT	average time (days)	ED yr x 365 days/yr
EF	exposure frequency (days/yr)	65 days/yr
ED	exposure duration (yr)	2.5 yr
IR _{soil}	soil ingestion rate (mg/day)	50 mg/dayRfD _i

Source: RAGS Part B; Site-specific information from OUs 4,5, and 6.

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TABLE 12
 ECOLOGICAL WORKER SOIL -
 PRG CALCULATIONS FOR CARCINOGENIC EFFECTS
 ROCKY FLATS PLANT, GOLDEN, CO

$$TR = \frac{SF_o \times C \times 10^{-6} \text{ kg/mg} \times EF \times ED \times IR_{soil}}{BW \times AT}$$

$$C \text{ mg/kg;} = \frac{TR \times BW \times AT}{EF \times ED \times (SF_o \times 10^{-6} \text{ kg/mg} \times IR_{soil})}$$

where:

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
C	chemical concentration in soil (mg/kg)	-
TR	target excess individual lifetime cancer risk (unitless)	10 ⁻⁶
SF _o	oral cancer slope factor ((mg/kg-day) ⁻¹)	chemical-specific
BW	adult body weight (kg)	70 kg
AT	average time (days)	70 yr x 365 days/yr
EF	exposure frequency (days/yr)	65 days/yr
ED	exposure duration (yr)	2.5 yr
IR _{soil}	soil ingestion rate (mg/day)	50 mg/day

Source: RAGS Part B; Site-specific information from OUs 4,5, and 6.

TABLE 13

RADIONUCLIDE PRGs: RESIDENTIAL SOIL -
PRG CALCULATIONS FOR CARCINOGENIC EFFECTS

ROCKY FLATS PLANT, GOLDEN, CO

$$\text{Total risk} = \text{RS} \times [(\text{SF}_o \times 10^{-3} \text{ g/mg} \times \text{EF} \times \text{IF}_{\text{soil adj}}) + (\text{SF}_o \times \text{ED} \times (1-\text{S}_o) \times \text{T}_o)]$$

$$\text{RS (pCi/g; risk based)} = \frac{\text{TR}}{(\text{SF}_o \times 10^{-3} \text{ g/mg} \times \text{EF} \times \text{IF}_{\text{soil adj}}) + (\text{SF}_o \times \text{ED} \times (1-\text{S}_o) \times \text{T}_o)}$$

where:

Parameters	Definition (units)	Default Value
RS	radionuclide PRG in soil (pCi/g)	-
TR	target excess individual lifetime cancer risk (unitless)	10 ⁻⁶
SF _o	oral (ingestion) slope factor (risk/pCi)	radionuclide-specific
SF _e	external exposure slope factor (risk/yr per pCi/g)	radionuclide-specific
EF	exposure frequency (days/yr)	350 days/yr
ED	exposure duration (yr)	30 yr
IF _{soil adj}	age-adjusted soil ingestion factor (mg-yr/day)	3600 mg-yr/day
S _o	gamma shielding factor (unitless)	0.2
T _o	gamma exposure time factor (unitless)	1

Source: RAGS Part B; USEPA Region VIII update

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TABLE 14
RADIONUCLIDE PRGs: COMMERCIAL/INDUSTRIAL SOIL -
PRG CALCULATIONS FOR CARCINOGENIC EFFECTS

ROCKY FLATS PLANT, GOLDEN, CO

$$\text{Total risk} = \text{RS} \times \text{ED} \times [(\text{SF}_o \times 10^{-3} \text{ g/mg} \times \text{EF} \times \text{IR}_{\text{soil}}) + (\text{SF}_i \times 10^3 \text{ g/kg} \times \text{EF} \times \text{IR}_{\text{air}} \times (1/\text{PEF})) + (\text{SF}_o \times (1-\text{S}_o) \times \text{T}_o)]$$

$$\text{RS (pCi/g; = risk based)} = \frac{\text{TR}}{\text{ED} \times [(\text{SF}_o \times 10^{-3} \text{ g/mg} \times \text{EF} \times \text{IR}_{\text{soil}}) + (\text{SF}_i \times 10^3 \text{ g/kg} \times \text{EF} \times \text{IR}_{\text{air}} \times (1/\text{PEF})) + (\text{SF}_o \times (1-\text{S}_o) \times \text{T}_o)]}$$

where:

Parameters	Definition (units)	Default Value
RS	radionuclide PRG in soil (pCi/g)	-
TR	target excess individual lifetime cancer risk (unitless)	10 ⁻⁶
SF _i	inhalation slope factor (risk/pCi)	radionuclide-specific
SF _o	oral (ingestion) slope factor (risk/pCi)	radionuclide-specific
SF _o	external exposure slope factor (risk/yr per pCi/g)	radionuclide-specific
EF	exposure frequency (days/yr)	250 days/yr
ED	exposure duration (yr)	25 yr
IR _{air}	workday inhalation rate of air (m ³ /day)	20 m ³ /day
IF _{soil}	daily soil ingestion rate (mg/day)	50 mg/day
PEF	particulate emissions factor (m ³ /kg)	4.63 x 10 ⁹ m ³ /kg
S _o	gamma shielding factor (unitless)	0.2
T _o	gamma exposure time factor (unitless)	0.3

Source: RAGS Part B; USEPA Region VIII update

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TABLE 15

RADIONUCLIDE PRGs: ECOLOGICAL WORKER
PRG CALCULATIONS FOR CARCINOGENIC EFFECTS

ROCKY FLATS PLANT, GOLDEN, CO

$$\text{Total risk} = \text{RS} \times \text{ED} \times [(\text{SF}_o \times 10^{-3} \text{ g/mg} \times \text{EF} \times \text{IF}_{\text{soil}}) + (\text{SF}_i \times 10^{-3} \text{ g/kg} \times \text{EF} \times \text{IR}_{\text{air}} \times (1/\text{PEF})) + (\text{SF}_o \times (1-\text{S}_o) \times \text{T}_o)]$$

RS (pCi/g;
risk based)

=

TR

$$\text{ED} \times [(\text{SF}_o \times 10^{-3} \text{ g/kg} \times \text{EF} \times \text{IR}_{\text{soil}}) + (\text{SF}_i \times 10^{-3} \text{ g/kg} \times \text{EF} \times \text{IR}_{\text{air}} \times (1/\text{PEF})) + (\text{SF}_o \times (1-\text{S}_o) \times \text{T}_o)]$$

where:

Parameters	Definition (units)	Default Value
RS	radionuclide PRG in soil (pCi/g)	-
TR	target excess individual lifetime cancer risk (unitless)	10 ⁻⁶
SF _i	inhalation slope factor (risk/pCi)	radionuclide-specific
SF _o	oral (ingestion) slope factor (risk/pCi)	radionuclide-specific
SF _e	external exposure slope factor (risk/yr per pCi/g)	radionuclide-specific
EF	exposure frequency (days/yr)	65 days/yr
ED	exposure duration (yr)	2.5 yr
IR _{air}	workday inhalation rate of air (m ³ /day)	20 m ³ /day
IF _{soil}	daily soil ingestion rate (mg/day)	50 mg/day
PEF	particulate emission factor (m ³ /kg)	4.63 x 10 ⁹ m ³ /kg
S _o	gamma shielding factor (unitless)	0.2
T _o	gamma exposure time factor (unitless)	0.3

Source: RAGS Part B; Site-specific information from OUs 4,5, and 6; USEPA Region VIII update.

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TABLE 16

RADIONUCLIDE PRGs: RESIDENTIAL GROUNDWATER USE
PRG CALCULATIONS FOR CARCINOGENIC EFFECTS

ROCKY FLATS PLANT, GOLDEN, CO

$$\text{Total risk} = \text{SF}_o \times \text{RW} \times \text{IR}_w \times \text{EF} \times \text{ED}$$

$$\text{RW (pCi/L; risk based)} = \frac{\text{TR}}{\text{EF} \times \text{ED} \times \text{SF}_o \times \text{IR}_w}$$

where:

Parameters	Definition (units)	Default Value
RW	radionuclide PRG in water (pCi/L)	-
TR	target excess individual lifetime cancer risk (unitless)	10 ⁻⁶
SF _o	oral (ingestion) slope factor (risk/pCi)	radionuclide-specific
EF	exposure frequency (days/yr)	350 days/yr
ED	exposure duration (yr)	30 yr
IR _w	daily water ingestion rate (L/day)	2 L/day

Source: RAGS Part B.

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TABLE 17

RADIONUCLIDE PRGs: RESIDENTIAL USE OF SURFACE WATER WHILE SWIMMING
PRG CALCULATIONS FOR CARCINOGENIC EFFECTS

ROCKY FLATS PLANT, GOLDEN, CO

$$\text{Total risk} = \text{RW} \times \text{SF}_o \times \text{EF} \times \text{ED} \times \text{CR}_w \times \text{ET}$$

$$\text{RW (pCi/L; risk based)} = \frac{\text{TR}}{\text{SF}_o \times \text{EF} \times \text{ED} \times \text{CR}_w \times \text{ET}}$$

where:

Parameters	Definition (units)	Default Value
RW	radionuclide PRG in water (pCi/L)	-
TR	target excess individual lifetime cancer risk (unitless)	10 ⁻⁶
SF _o	oral (ingestion) slope factor (risk/pCi)	radionuclide-specific
EF	exposure frequency (days/yr)	7 days/yr
ED	exposure duration (yr)	30 yr
CR _w	contact rate (L/hour)	0.05 L/hour
ET	exposure time (hours/day)	2.6 hours/day

Source: RAGS Part B; Site-specific information from OUs 2,5, and 6.

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TABLE 18

RADIONUCLIDE PRGs: ECOLOGICAL WORKER EXPOSURE TO SURFACE WATER VIA WADING
PRG CALCULATIONS FOR CARCINOGENIC EFFECTS

ROCKY FLATS PLANT, GOLDEN, CO

$$\text{Total risk} = \text{RW} \times \text{SF}_o \times \text{EF} \times \text{ED} \times \text{IR}_w$$

$$\text{RW (pCi/L; risk based)} = \frac{\text{TR}}{\text{SF}_o \times \text{EF} \times \text{ED} \times \text{IR}_w}$$

where:

<u>Parameters</u>	<u>Definition (units)</u>	<u>Default Value</u>
RW	radionuclide PRG in water (pCi/L)	-
TR	target excess individual lifetime cancer risk (unitless)	10 ⁻⁶
SF _o	oral (ingestion) slope factor (risk/pCi)	radionuclide-specific
EF	exposure frequency (events/yr)	7 events/yr
ED	exposure duration (yr)	2.5 years
IR _w	ingestion rate (L/event)	0.05 L/event

Source: RAGS Part B; Site-specific information from OUs 5 and 6.

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TABLE 19
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT^a

Target Analyte List Chemical	Oral RfD (mg/kg-day)	Oral Slope Factor (mg/kg-day) ⁻¹	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) ⁻¹	External Slope Factor (risk/yr per pCi/g)	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Commercial Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
Acenaphthene	6.00E-02	-	-	-	-	2.19E+00	1.68E+03	1.65E+04	1.23E+05	4.38E+03	4.72E+05
Acenaphthylene	-	-	-	-	-	-	-	-	-	-	-
Acetone	1.00E-01	-	-	-	-	3.85E+00	2.81E+03	2.74E+04	2.04E+05	7.30E+03	7.86E+05
Aldrin	3.00E-05	1.70E+01	-	1.72E+01 b	-	5.00E-06	3.85E-03	3.77E-02	5.31E-02	1.20E-01	1.29E+01
Aluminum	-	-	-	-	-	-	-	-	-	-	-
Anthracene	3.00E-01	-	-	-	-	1.09E+01	8.42E+03	8.23E+04	6.13E+05	2.19E+04	2.36E+06
Antimony	4.00E-04	-	-	-	-	1.46E-02	1.12E+01	1.10E+02	8.18E+02	2.92E+01	3.14E+03
Aroclor-1016	7.00E-05 c	7.70E+00 c	-	-	-	1.10E-05	8.51E-03	8.32E-02	7.43E-01	2.65E-01	2.86E+01
Aroclor-1221	7.00E-05 c	7.70E+00 c	-	-	-	1.10E-05	8.51E-03	8.32E-02	7.43E-01	2.65E-01	2.86E+01
Aroclor-1232	7.00E-05 c	7.70E+00 c	-	-	-	1.10E-05	8.51E-03	8.32E-02	7.43E-01	2.65E-01	2.86E+01
Aroclor-1242	7.00E-05 c	7.70E+00 c	-	-	-	1.10E-05	8.51E-03	8.32E-02	7.43E-01	2.65E-01	2.86E+01
Aroclor-1248	7.00E-05 c	7.70E+00 c	-	-	-	1.10E-05	8.51E-03	8.32E-02	7.43E-01	2.65E-01	2.86E+01
Aroclor-1254	7.00E-05 c	7.70E+00 c	-	-	-	1.10E-05	8.51E-03	8.32E-02	7.43E-01	2.65E-01	2.86E+01
Aroclor-1260	7.00E-05 c	7.70E+00 c	-	-	-	1.10E-05	8.51E-03	8.32E-02	7.43E-01	2.65E-01	2.86E+01
Arsenic	3.00E-04	1.75E+00 i	-	5.00E+01 b	-	4.86E-05	4.35E-03	4.26E-02	2.05E-02	1.36E-01	1.46E+01
Barium	7.00E-02	-	-	-	-	2.56E+00	1.97E+03	1.92E+04	1.43E+05	5.11E+03	5.50E+05
Benzene	-	2.90E-02	-	2.91E-02 b	-	6.15E-04	2.26E+00	2.21E+01	3.13E+01	7.05E+01	7.59E+03
alpha-BHC	-	6.30E+00	-	6.30E+00 j	-	1.35E-05	1.04E-02	1.02E-01	1.45E-01	3.24E-01	3.49E+01
beta-BHC	-	1.80E+00	-	1.86E+00 j	-	4.72E-05	3.64E-02	3.56E-01	4.92E-01	1.14E+00	1.22E+02
delta-BHC	-	-	-	-	-	-	-	-	-	-	-
gamma-BHC (Lindane)	3.00E-04	1.30E+00	-	-	-	6.54E-05	5.04E-02	4.93E-01	4.40E+00	1.57E+00	1.69E+02
Benzo(a)anthracene	-	7.30E-01 k	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene	-	7.30E+00	-	-	-	1.16E-05	8.97E-03	8.77E-02	7.84E-01	2.80E-01	3.02E+01
Benzo(b)fluoranthene	-	7.30E-01 k	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	7.30E-02 k	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	7.30E-02 k	-	-	-	-	-	-	-	-	-
Benzoic acid	4.00E+00	-	-	-	-	1.46E+02	1.12E+05	1.10E+06	8.18E+06	2.92E+05	3.14E+07
Benzyl alcohol	-	-	-	-	-	-	-	-	-	-	-
Beryllium	5.00E-03	4.30E+00	-	8.40E+00 b	-	1.98E-05	1.52E-02	1.49E-01	1.18E-01	4.75E-01	5.12E+01
bis(2-Chloroethoxy)methane	-	-	-	-	-	-	-	-	-	-	-
bis(2-Chloroethyl)ether	-	1.10E+00	-	1.16E+00 b	-	7.73E-05	5.95E-02	5.82E-01	7.92E-01	1.66E+00	2.00E+02
bis(2-Chloroisopropyl)ether	4.00E-02	7.00E-02 b	-	3.50E-02 b	-	4.22E-04	9.36E-01	9.15E+00	2.24E+01	2.92E+01	3.14E+03
bis(2-Ethylhexyl)phthalate	2.00E-02	1.40E-02	-	-	-	6.07E-03	4.68E+00	4.57E+01	4.09E+02	1.46E+02	1.57E+04
Bromodichloromethane	2.00E-02	6.20E-02	-	-	-	1.37E-03	1.06E+00	1.03E+01	9.23E+01	3.30E+01	3.55E+03
Bromoform	2.00E-02	7.90E-03	-	3.85E-03 b	-	1.08E-02	8.29E+00	8.11E+01	2.03E+02	2.59E+02	2.79E+04

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TABLE 19
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT*

Target Analyte List Chemical	Oral RfD (mg/kg-day)	Oral Slope Factor (mg/kg-day) ⁻¹	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) ⁻¹	External Slope Factor (risk/yr per pCi/g)	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Commercial Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
Bromomethane	1.40E-03	-	1.43E-03	-	-	1.09E-02	3.93E+01	3.84E+02	8.75E-07	1.02E+02	1.10E+04
4-Bromophenyl phenyl ether	-	-	-	-	-	-	-	-	-	-	-
2-Butanone	6.00E-01	-	2.86E-01	-	-	2.19E+01	1.68E+04	1.65E+05	1.75E-04	4.38E+04	4.72E+06
Butybenzylphthalate	2.00E-01	-	-	-	-	7.30E+00	5.62E+03	5.49E+04	4.09E+05	1.46E+04	1.57E+06
Cadmium	5.00E-04	6.30E+00	-	6.30E+00	-	1.35E-05	1.04E-02	1.02E-01	1.45E-01	3.24E-01	3.49E+01
Calcium	-	-	-	-	-	-	-	-	-	-	-
Carbon disulfide	1.00E-01	-	2.86E-03 b	-	-	2.76E-02	2.81E+03	2.74E+04	1.75E-06	7.30E+03	7.86E+05
Carbon tetrachloride	7.00E-04	1.30E-01	-	5.25E-02	-	2.60E-04	5.04E-01	4.93E+00	1.40E+01	1.57E+01	1.69E+03
Cesium	-	-	-	-	-	-	-	-	-	-	-
alpha-Chlordane	6.00E-05 d	1.30E+00 d	-	1.29E+00 d	-	6.54E-05	5.04E-02	4.93E-01	7.03E-01	1.57E+00	1.69E+02
beta-Chlordane	6.00E-05 d	1.30E+00 d	-	1.29E+00 d	-	6.54E-05	5.04E-02	4.93E-01	7.03E-01	1.57E+00	1.69E+02
gamma-Chlordane	6.00E-05 d	1.30E+00 d	-	1.29E+00 d	-	6.54E-05	5.04E-02	4.93E-01	7.03E-01	1.57E+00	1.69E+02
4-Chloroaniline	4.00E-03	-	-	-	-	1.46E-01	1.12E+02	1.10E+03	8.18E+03	2.92E+02	3.14E+04
Chlorobenzene	2.00E-02	-	5.71E-03 b	-	-	5.17E-02	5.62E+02	5.49E+03	3.50E-06	1.46E+03	1.57E+05
Chloroethane	-	-	2.86E+00	-	-	2.78E+01	-	-	1.75E-03	-	-
Chloroform	1.00E-02	6.10E-03	-	5.80E-01 b	-	3.90E-05	1.07E+01	1.05E+02	1.86E+00	3.35E+02	3.61E+04
Chloromethane	-	1.30E-02	-	6.30E-03	-	2.32E-03	5.04E+00	0.00E+00	1.24E+02	1.57E+02	1.69E+04
4-Chloro-3-methylphenol	-	-	-	-	-	-	-	-	-	-	-
2-Chloronaphthalene	8.00E-02	-	-	-	-	2.92E+00	2.25E+03	2.20E+04	1.64E+05	5.84E+03	6.29E+05
2-Chlorophenol	5.00E-03	-	-	-	-	1.82E-01	1.40E+02	1.37E+03	1.02E+04	3.65E+02	3.93E+04
4-Chlorophenyl phenyl ether	-	-	-	-	-	-	-	-	-	-	-
Chromium III	1.00E+00	-	-	-	-	3.65E+01	2.81E+04	2.74E+05	2.04E+06	7.30E+04	7.86E+06
Chromium VI	5.00E-03	-	-	4.10E+01 b	-	1.82E-01	1.40E+02	1.37E+03	2.64E-02	3.65E+02	3.93E+04
Chrysene	-	7.30E-03 k	-	-	-	1.16E-02	8.97E+00	8.77E+01	7.84E+02	2.80E+02	3.02E+04
Cobalt	-	-	-	-	-	-	-	-	-	-	-
Copper	4.00E-02 b	-	-	-	-	1.46E+00	1.12E+03	1.10E+04	8.18E+04	2.92E+03	3.14E+05
Cyanide	2.00E-02	-	-	-	-	7.30E-01	5.62E+02	5.49E+03	4.09E+04	1.46E+03	1.57E+05
4,4'-DDD	-	2.40E-01	-	-	-	3.54E-04	2.73E-01	2.67E+00	2.38E+01	8.52E+00	9.17E+02
4,4'-DDE	-	3.40E-01	-	-	-	2.50E-04	1.93E-01	1.88E+00	1.68E+01	6.01E+00	6.47E+02
4,4'-DDT	5.00E-04	3.40E-01	-	3.40E-01 j	-	2.50E-04	1.93E-01	1.88E+00	2.68E+00	6.01E+00	6.47E+02
Dibenz(a,h)anthracene	-	7.30E+00 k	-	-	-	1.16E-05	8.97E-03	8.77E-02	7.84E-01	2.80E-01	3.02E+01
Dibenzofuran	-	-	-	-	-	-	-	-	-	-	-
Dibromochloromethane	2.00E-02	8.40E-02	-	-	-	1.01E-03	7.80E-01	7.62E+00	6.81E+01	2.43E+01	2.62E+03
Di-n-butylphthalate	1.00E-01	-	-	-	-	3.65E+00	2.81E+03	2.74E+04	2.04E+05	7.30E+03	7.86E+05
1,2-Dichlorobenzene	9.00E-02	-	-	-	-	3.28E+00	2.53E+03	2.47E+04	1.84E+05	6.57E+03	7.08E+05
1,3-Dichlorobenzene	-	-	-	1.72E+01	-	1.04E-06	3.82E-03	3.73E-02	5.30E-02	1.19E-01	1.28E+01

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TABLE 19
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT*

Target Analyte List Chemical	Oral RfD (mg/kg-day)	Oral Slope Factor (mg/kg-day) ⁻¹	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) ⁻¹	External Slope Factor (risk/yr per pCi/g)	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Commercial Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
1,4-Dichlorobenzene	-	2.40E-02 b	2.29E-01 b	-	-	3.54E-03	2.73E+00	2.67E+01	1.40E-04	8.52E+01	9.17E+03
3,3'-Dichlorobenzidine	-	4.50E-01	2.86E-02	-	-	1.89E-04	1.46E-01	1.42E+00	1.75E-05	4.54E+00	4.89E+02
1,1-Dichloroethane	1.00E-01 b	-	-	-	-	3.65E+00	2.81E+03	2.74E+04	2.04E+05	7.30E+03	7.86E+05
1,2-Dichloroethane	-	9.10E-02	-	-	-	1.97E-04	7.20E-01	7.04E+00	1.00E+01	2.25E+01	2.42E+03
1,1-Dichloroethene	9.00E-03	6.00E-01	-	1.20E+00 b	-	1.67E-05	1.09E-01	1.07E+00	8.25E-01	3.41E+00	3.67E+02
1,2-Dichloroethene (Total)	9.00E-03 b	-	-	-	-	3.28E-01	2.53E+02	2.47E+03	1.84E+04	6.57E+02	7.08E+04
2,4-Dichlorophenol	3.00E-03	-	-	-	-	1.10E-01	8.42E+01	8.23E+02	6.13E+03	2.19E+02	2.36E+04
1,2-Dichloropropane	-	6.80E-02 b	-	-	-	1.25E-03	9.63E-01	9.42E+00	8.41E+01	3.01E+01	3.24E+03
cis-1,3-Dichloropropene	-	1.80E-01 b,e	-	1.30E-01 b,e	-	1.27E-04	3.64E-01	3.56E+00	6.80E+00	1.14E+01	1.22E+03
trans-1,3-Dichloropropene	-	1.80E-01 b,e	-	1.30E-01 b,e	-	1.27E-04	3.64E-01	3.56E+00	6.80E+00	1.14E+01	1.22E+03
Dieldrin	5.00E-05	1.60E+01	-	1.60E+01 b	-	5.31E-06	4.09E-03	4.00E-02	5.69E-02	1.28E-01	1.38E+01
Diethylphthalate	8.00E-01	-	-	-	-	2.92E+01	2.25E+04	2.20E+05	1.64E+06	5.84E+04	6.29E+06
2,4-Dimethylphenol	2.00E-02	-	-	-	-	7.30E-01	5.62E+02	5.49E+03	4.09E+04	1.46E+03	1.57E+05
Dimethylphthalate	1.00E+01	-	-	-	-	3.65E+02	2.81E+05	2.74E+06	2.04E+07	7.30E+05	7.86E+07
4,6-Dinitro-2-methylphenol	-	-	-	-	-	-	-	-	-	-	-
2,4-Dinitrophenol	2.00E-03	-	-	-	-	7.30E-02	5.62E+01	5.49E+02	4.09E+03	1.46E+02	1.57E+04
2,4-Dinitrotoluene	2.00E-03	-	-	-	-	7.30E-02	5.62E+01	5.49E+02	4.09E+03	1.46E+02	1.57E+04
2,6-Dinitrotoluene	1.00E-03 b	6.80E-01 g	-	-	-	1.25E-04	9.63E-02	9.42E-01	8.41E+00	3.01E+00	3.24E+02
Di-n-octylphthalate	2.00E-02	-	-	-	-	7.30E-01	5.62E+02	5.49E+03	4.09E+04	1.46E+03	1.57E+05
Endosulfan I	5.00E-05 b,f	-	-	-	-	1.83E-03	1.40E+00	1.37E+01	1.02E+02	3.65E+00	3.93E+02
Endosulfan II	5.00E-05 b,f	-	-	-	-	1.83E-03	1.40E+00	1.37E+01	1.02E+02	3.65E+00	3.93E+02
Endosulfan sulfate	5.00E-05 b,f	3.85E-03 f	-	3.85E-03 f	-	1.83E-03	1.40E+00	1.37E+01	1.02E+02	3.65E+00	3.93E+02
Endosulfan (technical)	5.00E-05 b,f	-	-	-	-	1.83E-03	1.40E+00	1.37E+01	1.02E+02	3.65E+00	3.93E+02
Endrin ketone	-	-	2.86E-01	-	-	-	-	-	1.75E-04	-	-
Endrin (technical)	3.00E-04	-	-	-	-	1.09E-02	8.42E+00	8.23E+01	6.13E+02	2.19E+01	2.36E+03
Ethylbenzene	1.00E-01	-	2.86E-01	-	-	1.58E+00	2.81E+03	2.74E+04	1.75E-04	7.30E+03	7.86E+05
Fluoranthene	4.00E-02	-	-	-	-	1.46E+00	1.12E+03	1.10E+04	8.18E+04	2.92E+03	3.14E+05
Fluorene	4.00E-02	-	-	-	-	1.46E+00	1.12E+03	1.10E+04	8.18E+04	2.92E+03	3.14E+05
Heptachlor	5.00E-04	4.50E+00	-	4.50E+00 b	-	1.89E-05	1.46E-02	1.42E-01	2.02E-01	4.54E-01	4.89E+01
Heptachlor epoxide	1.30E-05	9.10E+00	-	9.10E+00 b	-	9.34E-06	7.20E-03	7.04E-02	1.00E-01	2.25E-01	2.42E+01
Hexachlorobenzene	8.00E-04	1.60E+00	-	1.60E+00 b	-	5.31E-05	4.09E-02	4.00E-01	5.69E-01	1.28E+00	1.38E+02
Hexachlorobutadiene	-	7.80E-02	-	7.80E-02 b	-	1.09E-03	8.40E-01	8.21E+00	1.17E+01	2.62E+01	2.82E+03
Hexachlorocyclopentadiene	7.00E-03	2.45E-01	-	1.30E+00	-	3.47E-04	2.67E-01	2.61E+00	8.05E-01	8.34E+00	8.98E+02
Hexachloroethane	1.00E-03	1.40E-02	-	1.40E-02 b	-	6.07E-03	4.68E+00	4.57E+01	6.51E+01	7.30E+01	7.86E+03
2-Hexanone	-	-	-	1.30E+00	-	1.74E-05	-	-	8.33E-01	-	-
Indeno(1,2,3-cd)pyrene	-	7.30E-01 k	-	-	-	-	-	-	-	-	-

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TABLE 19
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT^a

Target Analyte List Chemical	Oral RfD (mg/kg-day)	Oral Slope Factor (mg/kg-day) ⁻¹	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) ⁻¹	External Slope Factor (risk/yr per pCi/g)	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Commercial Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
Iron	-	-	-	-	-	-	-	-	-	-	-
Isophorone	2.00E-01	9.50E-04	-	-	-	8.95E-02	6.89E+01	6.74E+02	6.02E+03	2.15E+03	2.32E+05
Lead	-	-	-	-	-	-	-	-	-	-	-
Lithium	-	-	-	-	-	-	-	-	-	-	-
Magnesium	-	-	-	-	-	-	-	-	-	-	-
Manganese	5.00E-03	-	1.14E-04	-	-	1.82E-01	1.40E+02	1.37E+03	7.00E-08	3.65E+02	3.93E+04
Mercury	3.00E-04 b	-	-	-	-	1.09E-02	8.42E+00	8.23E+01	6.13E+02	2.19E+01	2.38E+03
Methoxychlor	5.00E-03	-	-	-	-	1.82E-01	1.40E+02	1.37E+03	1.02E+04	3.65E+02	3.93E+04
Methylene chloride	6.00E-02	7.50E-03	8.57E-01 b	-	-	8.34E+00	-	-	5.25E-04	-	-
2-Methylnaphthalene	-	-	-	-	-	-	-	-	-	-	-
4-Methyl-2-pentanone	5.00E-02	-	-	-	-	1.83E+00	1.40E+03	1.37E+04	1.02E+05	3.65E+03	3.93E+05
2-Methylphenol	5.00E-02	-	-	-	-	1.83E+00	1.40E+03	1.37E+04	1.02E+05	3.65E+03	3.93E+05
4-Methylphenol	5.00E-03	-	-	-	-	1.82E-01	1.40E+02	1.37E+03	1.02E+04	3.65E+02	3.93E+04
Molybdenum	5.00E-03	-	-	-	-	1.82E-01	1.40E+02	1.37E+03	1.02E+04	3.65E+02	3.93E+04
Naphthalene	4.00E-02 b	-	-	-	-	1.46E+00	1.12E+03	1.10E+04	8.18E+04	2.92E+03	3.14E+05
Nickel	2.00E-02	-	-	8.40E-01 b,h	-	7.30E-01	5.62E+02	5.49E+03	1.29E+00	1.46E+03	1.57E+05
2-Nitroaniline	-	-	-	-	-	-	-	-	-	-	-
3-Nitroaniline	-	-	-	-	-	-	-	-	-	-	-
4-Nitroaniline	-	-	-	-	-	-	-	-	-	-	-
Nitrobenzene	5.00E-04	-	-	-	-	1.82E-02	1.40E+01	1.37E+02	1.02E+03	3.65E+01	3.93E+03
2-Nitrophenol	-	1.30E-01	5.71E-03	1.30E-01	-	6.56E-04	5.06E-01	4.95E+00	3.50E-06	1.58E+01	1.70E+03
4-Nitrophenol	-	-	-	-	-	-	-	-	-	-	-
n-Nitrosodiphenylamine	-	-	-	-	-	1.79E-01	1.38E+02	1.34E+03	1.00E+04	3.58E+02	3.85E+04
n-Nitrosodipropylamine	-	-	-	-	-	2.56E+02	1.97E+05	1.92E+06	1.43E+07	5.11E+05	5.50E+07
Pentachlorophenol	3.00E-02	1.20E-01	-	-	-	7.08E-04	5.48E-01	5.34E+00	4.77E+01	1.70E+01	1.83E+03
Phenanthrene	-	-	-	-	-	-	-	-	-	-	-
Phenol	6.00E-01	-	-	-	-	2.19E+01	1.68E+04	1.65E+05	1.23E+06	4.38E+04	4.72E+06
Potassium	-	-	-	-	-	-	-	-	-	-	-
Pyrene	3.00E-02	-	-	-	-	1.09E+00	8.42E+02	8.23E+03	6.13E+04	2.19E+03	2.38E+05
Selenium	5.00E-03	-	-	-	-	1.82E-01	1.40E+02	1.37E+03	1.02E+04	3.65E+02	3.93E+04
Silver	-	-	-	-	-	-	-	-	-	-	-
Sodium	-	-	-	-	-	-	-	-	-	-	-
Strontium	6.00E-01	-	-	-	-	2.19E+01	1.68E+04	1.65E+05	1.23E+06	4.38E+04	4.72E+06
Styrene	2.00E-01	-	-	-	-	7.30E+00	5.62E+03	5.49E+04	4.09E+05	1.46E+04	1.57E+06
1,1,2,2-Tetrachloroethane	-	2.00E-01	-	2.00E-01 b	-	8.95E-05	3.28E-01	3.20E+00	4.55E+00	1.02E+01	1.10E+03
Tetrachloroethene	1.00E-02	5.20E-02 l	-	2.00E-03 l	-	3.65E-01	1.26E+00	1.23E+01	9.14E+01	3.93E+01	4.23E+03

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**TABLE 19
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT^a**

Target Analyte List Chemical	Oral RfD (mg/kg-day)	Oral Slope Factor (mg/kg-day) ⁻¹	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) ⁻¹	External Slope Factor (risk/yr per pCi/g)	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Commercial Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
Thallium	-	-	-	-	-	-	-	-	-	-	-
Tin	-	-	-	-	-	-	-	-	-	-	-
Toluene	2.00E-01	-	2.86E-01	-	-	2.02E+00	5.62E+03	5.49E+04	1.75E-04	1.46E+04	1.57E+06
Toxaphene	-	1.10E+00	-	1.10E+00 b	-	1.63E-05	5.95E-02	5.82E-01	8.28E-01	1.86E+00	2.00E+02
1,2,4-Trichlorobenzene	1.00E-02	-	-	-	-	3.65E-01	2.81E+02	2.74E+03	2.04E+04	7.30E+02	7.86E+04
1,1,1-Trichloroethane	-	-	-	-	-	-	-	-	-	-	-
1,1,2-Trichloroethane	4.00E-03	5.70E-02	-	5.70E-02 b	-	3.14E-04	1.15E+00	1.12E+01	1.60E+01	3.59E+01	3.86E+03
Trichloroethene	-	1.10E-02	2.00E-05	-	-	1.95E-04	5.95E+00	5.82E+01	1.23E-08	1.86E+02	2.00E+04
2,4,5-Trichlorophenol	1.00E-01	-	-	-	-	3.65E+00	2.81E+03	2.74E+04	2.04E+05	7.30E+03	7.86E+05
2,4,6-Trichlorophenol	-	1.10E-02	-	1.00E-02 b	-	7.73E-03	5.95E+00	5.82E+01	8.97E+01	1.86E+02	2.00E+04
Vanadium	7.00E-03 b	-	-	-	-	2.56E-01	1.97E+02	1.92E+03	1.43E+04	5.11E+02	5.50E+04
Vinyl Acetate	1.00E+00 b	-	-	-	-	3.65E+01	2.81E+04	2.74E+05	2.04E+06	7.30E+04	7.86E+06
Vinyl Chloride	-	1.90E+00 b	-	3.00E-01 b	-	2.81E-05	3.45E-02	3.37E-01	1.64E+00	1.08E+00	1.16E+02
Xylene (Total)	2.00E+00	-	-	-	-	7.30E+01	5.62E+04	5.49E+05	4.09E+06	1.46E+05	1.57E+07
Zinc	3.00E-01	-	-	-	-	1.09E+01	8.42E+03	8.23E+04	6.13E+05	2.19E+04	2.36E+06
Nitrate	1.60E+00	-	-	-	-	5.84E+01	4.49E+04	4.39E+05	3.27E+06	1.17E+05	1.26E+07
Nitrite	1.00E-01	-	-	-	-	3.65E+00	2.81E+03	2.74E+04	2.04E+05	7.30E+03	7.86E+05
pH	-	-	-	-	-	-	-	-	-	-	-
Sulfide	-	-	-	-	-	-	-	-	-	-	-
Ammonium	-	-	-	-	-	-	-	-	-	-	-
Bicarbonate	-	-	-	-	-	-	-	-	-	-	-
Bromide	-	-	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-
Chloride	-	-	-	-	-	-	-	-	-	-	-
Cyanide	-	-	-	-	-	-	-	-	-	-	-
Fluoride	6.00E-02	-	-	-	-	2.19E+00	1.68E+03	1.65E+04	1.23E+05	4.38E+03	4.72E+05
Orthophosphate	-	-	-	-	-	-	-	-	-	-	-
Silica (as Si and SiO ₂)	-	-	-	-	-	-	-	-	-	-	-
Sulfate	-	-	-	-	-	-	-	-	-	-	-
Americium-241	-	2.40E-10 b*	-	3.20E-08 b*	4.90E-09 b	1.98E-01 **	1.53E+02 **	2.38E+00 ***	6.28E-03 ***	4.76E+03 **	2.04E+02 ***
Cesium-137	-	2.80E-11 b*	-	1.90E-11 b*	0.00E+00 b	1.70E+00 **	1.31E+03 **	2.83E+01 ***	9.68E+00 ***	4.08E+04 **	4.40E+03 ***
Plutonium-239	-	2.30E-10 b*	-	3.80E-08 b*	1.70E-11 b	2.07E-01 **	1.59E+02 **	3.45E+00 ***	5.29E-03 ***	4.97E+03 **	5.32E+02 ***
Plutonium-240	-	2.30E-10 b*	-	3.80E-08 b*	2.70E-11 b	2.07E-01 **	1.59E+02 **	3.44E+00 ***	5.29E-03 ***	4.97E+03 **	5.31E+02 ***

**TABLE 19
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT***

Target Analyte List Chemical	Oral RfD (mg/kg-day)	Oral Slope Factor (mg/kg-day) ⁻¹	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) ⁻¹	External Slope Factor (risk/yr per pCi/g)	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Commercial Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
Radium-226	-	1.20E-10 b*	-	3.00E-09 b*	1.20E-08 b	3.97E-01 **	3.05E+02 **	2.28E+00 ***	6.65E-02 ***	9.52E+03 **	1.22E+02 ***
Radium-228	-	1.00E-10 b*	-	6.60E-10 b*	0.00E+00 b	4.76E-01 **	3.68E+02 **	7.94E+00 ***	3.02E-01 ***	1.14E+04 **	1.23E+03 ***
Strontium-89	-	3.00E-12 b*	-	2.90E-12 b*	4.70E-10 b	1.59E+01 **	1.22E+04 **	6.64E+01 ***	5.50E+01 ***	3.81E+05 **	3.26E+03 ***
Strontium-90	-	3.30E-11 b*	-	5.60E-11 b*	0.00E+00 b	1.44E+00 **	1.11E+03 **	2.41E+01 ***	3.46E+00 ***	3.46E+04 **	3.73E+03 ***
Tritium	-	-	-	-	-	-	-	-	-	-	-
Uranium-233	-	1.60E-11 b*	-	2.70E-08 b*	4.20E-11 b	2.98E+00 **	2.29E+03 **	4.72E+01 ***	7.44E-03 ***	7.14E+04 **	6.44E+03 ***
Uranium-234	-	1.60E-11 b*	-	2.60E-08 b*	3.00E-11 b	2.98E+00 **	2.29E+03 **	4.79E+01 ***	7.73E-03 ***	7.14E+04 **	6.76E+03 ***
Uranium-235	-	1.60E-11 b*	-	2.50E-08 b*	2.40E-07 b	2.98E+00 **	2.29E+03 **	1.73E-01 ***	7.95E-03 ***	7.14E+04 **	6.94E+00 ***
Uranium-238	-	1.60E-11 b*	-	2.40E-08 b*	2.10E-11 b	2.98E+00 **	2.29E+03 **	4.84E+01 ***	8.37E-03 ***	7.14E+04 **	7.01E+03 ***

* = Values given are in units of risk/yr per pCi/g.

** = Values given are in units of pCi/L.

*** = Values given are in units of pCi/G.

a = All toxicity values are from IRIS, February 1994 unless otherwise noted.

b = Value from HEAST, 1993.

c = Values given are for PCBs.

d = Values given are for chlordane.

e = Values given are for 1,3-dichloropropene.

f = Values given are for endosulfan.

g = Value given is for a 2,4-DNT/2,6-DNT mixture.

h = Value given is for nickel refinery dust.

i = Value given for arsenic is calculated from an oral unit risk of 5E-5 (L/μg).

j = Values given for chemicals were calculated from HEAST.

k = Values given for PAHs were found in the EPA guidance document "Research and Development - Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons."

l = Values given for tetrachloroethene are from a U.S. EPA memo from Office of Research and Development, Environmental Criteria and Assessment Office.

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