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July 13, 1994

94-RF-07394

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DOE, RFFO

Attn N I Castaneda

PROGRAMMATIC RISK-BASED PRELIMINARY REMEDIATION  
GOALS (07299) - SGS-403-94

On June 20, 1994, the programmatic "Preliminary Remediation Goals" (PGRs) were delivered to the Department of Energy, Rocky Flats Field Office (DOE, RFFO) for their review. On July 6, 1994, EG&G Rocky Flats received RFFO comments on this draft final document. EG&G has incorporated RFFO comments and has enclosed eleven copies of the final Programmatic Risk-Based Preliminary Remediation Goal document for distribution to the Environmental Protection Agency and the Colorado Department of Health.

If you have any questions, please do not hesitate to call John Hopkins on extension 8636

*S G Stiger*  
S G Stiger, Director  
Environmental Restoration  
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# Programmatic Risk-Based Preliminary Remediation Goals

U S Department of Energy  
Rocky Flats Plant  
Golden Colorado

Final

July 1994

**PROGRAMMATIC RISK-BASED PRELIMINARY  
REMEDATION GOALS**

**U.S. Department of Energy  
Rocky Flats Plant  
Golden, Colorado**

**Final**

**July 1994**

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## LIST OF ACRONYMS

ACL	Alternative Concentration Limit
ARAR	Applicable or Relevant and Appropriate Requirement
BRA	Baseline Risk Assessment
CDH	Colorado Department of Health
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHWA	Colorado Hazardous Waste Act
CMS/FS	Corrective Measures Study/Feasibility Study
COC	Contaminant of Concern
DOE	U S Department of Energy
IAG	Interagency Agreement
IHSS	Individual Hazardous Substance Site
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
OU	Operable Unit
PPRG	Programmatic Preliminary Remediation Goal
RAGS	Risk Assessment Guidance for Superfund
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RFP	Rocky Flats Plant
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
TAL	Target Analyte List
TBC	To-Be-Considered
TCL	Target Compound List
USEPA	U S Environmental Protection Agency

## 1.0 INTRODUCTION

Various areas at the Rocky Flats Plant (RFP) are being closed and/or remediated in accordance with the provisions of the 1991 Interagency Agreement (IAG) signed between the U S Department of Energy (DOE), the U S Environmental Protection Agency (USEPA), and the State of Colorado (IAG 1991) to ensure protection of human health and the environment. The IAG integrates the closure and corrective action provisions of the Resource Conservation and Recovery Act (RCRA) and the Colorado Hazardous Waste Act (CHWA) with the hazardous substance response requirements contained in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The various areas to be closed or remediated, called Individual Hazardous Substance Sites (IHSSs), are divided into 16 Operable Units (OUs).

DOE is in the process of conducting a RCRA Facility Investigation/Remedial Investigation (RFI/RI) and Corrective Measures Study/Feasibility Study (CMS/FS) for each OU to select the most appropriate remedy for each OU. In order to identify, evaluate, and select a remedial alternative, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) states that "Alternatives shall be developed that protect human health and the environment by recycling waste or by eliminating, reducing, and/or controlling risks posed through each pathway by a site." The number and type of alternatives to be analyzed shall be determined at each site, taking into account the scope, characteristics, and complexity of the site problem that is being addressed. In developing and, as appropriate, screening the alternatives, the lead agency shall establish remedial action objectives specifying contaminants and media of concern, potential exposure pathways, and remediation goals." [See 40 CFR 300.430(e)(2)]

This document addresses the establishment of programmatic remediation goals which are contaminant- and medium-specific levels of exposure that are protective of human health and the environment. The combination of the Baseline Risk Assessment (BRA) results, Applicable or Relevant and Appropriate Requirements (ARARs), and To-Be-Considered documents (TBCs) are used as the basis to establish the remediation goals approved by the regulatory agencies in the Record of Decision (ROD). CERCLA Section 121 and 40 CFR 300.430 allow the following factors to be considered when establishing remediation goals:

- Chemical-specific standards established pursuant to a Federal environmental law or any promulgated State standard which is more stringent than a Federal standard are to be used to establish remediation goals. These environmental laws include, but are not limited to, the Toxic Substances Control Act; the Safe Drinking Water Act, the Clean Air Act, the Clean Water Act, the Marine Protection, Research and Sanctuaries Act, and the Solid Waste Disposal Act. In addition to the promulgated standards, the following items should be considered:
  - For systemic toxicants, remediation goals are to be established so that the human population, including sensitive subgroups, may be exposed without adverse effect through a given lifetime (i.e., Hazard Index less than 1.0). Remediation goals are to incorporate an adequate margin of safety.

- For known or suspected carcinogens, remediation goals are to be established to represent an excess upper-bound lifetime cancer risk to an individual ranging from  $10^{-4}$  to  $10^{-6}$  using information on the relationship between dose and response. The  $10^{-6}$  risk level shall be used as the point of departure for determining remediation goals for alternatives where specific ARARs are not available or protective due to multiple contaminants or exposure pathways. [NOTE: In cases where the chemical-specific ARARs result in a cumulative risk in excess of  $10^{-4}$ , more restrictive remediation goals may be established in accordance with this provision.]
- Factors related to uncertainties, technical limitations (i.e., detection limits), and other pertinent information
- Non-zero Maximum Contaminant Level Goals (MCLGs), where determined to be relevant and appropriate, are to be attained by remedial actions for ground or surface waters that are current or potential drinking water sources. For MCLGs set at zero, the corresponding Maximum Contaminant Level (MCL) is to be attained when determined to be relevant and appropriate
- An Alternative Concentration Limit (ACL) can be established pursuant to CERCLA Section 121
- Water quality standards established under the Clean Water Act Sections 303 and 304 are to be attained for releases to surface waters to be protective of aquatic life where determined to be relevant and appropriate
- Fauna, flora, and aquatic habitats are to be considered during the establishment of the remediation goals. Environmental evaluations are to be conducted to assess threats to the environment, especially sensitive and critical habitats protected under the Endangered Species Act

To the extent possible, chemical-specific ARARs are used to determine remediation goals. However, ARARs may not adequately consider the site-specific contamination or the cumulative effects associated with multiple contaminants and/or pathways. Therefore, chemical-specific ARARs are not always the sole determinant of protectiveness and are supplemented with risk assessments and consideration of other non-promulgated health-based criteria. The risk assessment process includes the evaluation of site-specific factors such as potential for exposure (e.g., future land use), the hazardous substances present, and the presence of sensitive populations and habitats. These factors will be considered during the development of the OU-specific BRA.

DOE proposes to develop Risk-Based Programmatic Preliminary Remediation Goals (PPRGs) which will establish initial sitewide clean up targets for each environmental medium.

The risk-based PPRGs incorporate BRA methodologies accepted on a sitewide basis. This report presents the purpose for risk-based PPRGs and methods used to calculate them. Section 2 provides information regarding the intended current and potential future uses of the risk-based PPRGs. Section 3.0 describes the exposure pathways and methodology used to calculate the risk-based PPRGs. Section 4.0 provides references for the toxicological information used for each specific contaminant. Section 5.0 gives a comprehensive list of risk-based PPRGs that are proposed to be used to develop and screen remedial technologies and alternatives.

## **2.0 PURPOSE OF RISK-BASED PROGRAMMATIC PRELIMINARY REMEDIATION GOALS**

As stated in Section 1.0, the intended purpose for calculating risk-based PPRGs is to establish sitewide clean up targets for environmental contaminants. The calculation of risk-based PPRGs is possible through the standardization of exposure pathways and risk assessment methodologies. The benefits associated with developing risk-based PPRGs include:

- Support the CMS/FS process by allowing the development of remedial technologies and alternatives to proceed without an OU-specific BRA,
- Support the Contaminant of Concern (COC) selection process within the BRA by providing "Risk-Based Concentrations",
- Support the Colorado Department of Health (CDH) conservative screen within the BRA, and
- Support the evaluation of sites where accelerated cleanup actions may be warranted.

In order to assure consistency with current risk assessment methodologies, Exposure Scenario Technical Memoranda were evaluated for use in the risk-based PPRG selection.

Although there is a certain level of risk associated with developing remedial technologies and alternatives prior to fully characterizing the risks associated with the OU contamination, the programmatic approach is consistent with the NCP. Specifically, 40 CFR 300.430(e)(2)(i) states that, "[I]nitially, preliminary remediation goals are developed based on readily available information, such as chemical-specific ARARs or other reliable information. Preliminary remediation goals should be modified, as necessary, as more information becomes available during the Remedial Investigation/Feasibility Study (RI/FS). Final remediation goals will be determined when the remedy is selected."

The "off-the-shelf" risk-based PPRGs will form the initial basis for identifying, screening, and evaluating potential remedial technologies and alternatives. However, the risk-based PPRGs are not intended to be the final justification for selecting a particular remedial alternative. Should the final BRA indicate that the risk-based PPRGs are not representative of

the actual risk posed by the contamination at the OU, the required changes will be incorporated as early as possible during the Development and Screening of Alternatives or Detailed Analysis of Alternatives

The extensive amount of data at each OU warranted a process that would reduce the number of chemicals needing assessment in the BRA USEPA, CDH, and DOE therefore approved a process by which COCs could be delineated at a site One part of this process evaluates low detection frequency chemicals with respect to a Risk-Based Concentration (RBC) value The value to be used for the RBC will be taken from the risk-based PPRG list using a residential scenario

Data aggregation within an OU has been discussed between USEPA, CDH, and DOE, and an agreement has been reached on how this data aggregation is to be performed To meet CDH requirements for data aggregation, the whole OU area is divided into sub-areas called "sources " Source area delineation is based on the environmental media data from the OU After source areas are delineated, a risk-based screening process is performed for each source area This screening process will use the residential exposure scenario values within the risk-based PPRG list

As required by Section IX A 1 of the IAG Statement of Work, DOE is to develop Corrective/Remedial Action objectives for each OU and document these objectives in OU-specific Technical Memoranda for submission to USEPA and/or the State for review The objectives are to specify the contaminants and media of interest, exposure pathways and receptors, and USEPA and State accepted levels or ranges for each exposure route The risk-based PPRGs will be used in conjunction with chemical-specific ARARs to establish acceptable PRGs for each OU These acceptable levels or ranges (e g., OU-specific PRGs) will be documented in the form of a Technical Memorandum

It is projected that a risk-based evaluation will be needed to screen OUs for potential early actions This screening evaluation will need to employ risk-based cleanup targets so that areas can be ranked with respect to human health risks Also, high risk sites will need to be assessed with respect to the amount of cleanup required It is projected that the risk-based PPRGs will be utilized for both of these exercises within an accelerated clean-up framework Based on the CDH conservative screen, accelerated actions will be implemented at sites where the cumulative risk ratio is greater than 100

### **3.0 EXPOSURE PATHWAYS**

In order to standardize the risk-based PPRGs across all of the OUs, programmatic exposure pathways and receptors were established. Table 1 identifies the receptors and exposure pathways selected for each environmental media A sand and gravel mining scenario is being examined for the possible incorporation into the risk-based PPRG document If it is determined that this exposure scenario is required, the risk-based PPRG document will be revised accordingly In addition, dermal exposure will be considered during the CDH conservative

**TABLE 1**  
**PROGRAMMATIC ENVIRONMENTAL MEDIA AND EXPOSURE PATHWAYS**

Environmental Media Exposure Scenario	Residential	Commercial/Industrial	Ecological Researcher
Surface Soil	Direct Ingestion of Soils <sup>a/</sup> Inhalation of Particulates <sup>b/</sup> External Radiation Exposure <sup>c/</sup>	<u>Office Worker Scenario</u> Direct Ingestion of Soils <sup>a/</sup> Inhalation of Particulates <sup>b/</sup> External Radiation Exposure <sup>c/</sup>	Direct Ingestion of Soils <sup>a/</sup> Inhalation of Particulates <sup>b/</sup> External Radiation Exposure <sup>c/</sup>
Subsurface Soil	Not Applicable	<u>Construction Worker Scenario</u> Direct Ingestion of Soils <sup>a/</sup> Inhalation of Particulates <sup>b/</sup> External Radiation Exposure <sup>c/</sup> Inhalation of Volatiles	Not Applicable
Ground Water	Direct Ingestion of Ground Water <sup>a/</sup> Inhalation During Domestic Use <sup>d/</sup>	Not Applicable	Not Applicable
Surface Water	Direct Ingestion While Swimming <sup>e/</sup>	Not Applicable	Direct Ingestion While Wading <sup>e/</sup>

**NOTES**

- <sup>a/</sup> Includes assessment of organics and inorganics
- <sup>b/</sup> Includes assessment of non-volatile organics and inorganics
- <sup>c/</sup> Includes assessment of radionuclides
- <sup>d/</sup> Includes assessment of volatile organics
- <sup>e/</sup> Includes assessment of organics and tritium

screen in accordance with DOE/USEPA/CDH agreements. Should the results of the CDH conservative screen indicate that the cumulative risk ratio is less than one, dermal exposure will be assessed per USEPA dermal exposure assessment guidance. Only organic compounds will be addressed for the dermal exposure pathway.

Standard assumptions given in Risk Assessment Guidance for Superfund (RAGS), Part B (USEPA, 1991) were used in developing risk-based PPRG 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 from Exposure Scenario Technical Memoranda for OUs 1 through 7 was used where appropriate to supplement assumptions given in USEPA guidance. Best professional judgement was applied when default values differed from site-specific information.

In addition to USEPA and site-specific information, CDH guidance (*Interim Final Policy and Guidance on Risk Assessments for Corrective Action at RCRA Facilities*) was consulted for exposure pathways and parameters. While this guidance has not been finalized, it was reviewed and CDH was consulted on its use during development of the risk-based PPRG equations.

Due to the many programs that these risk-based PPRGs will support, elements from USEPA and CDH guidance, as well as site-specific information, were used to develop the risk-based PPRGs. This compromise approach will assure that all objectives of the document are met while maintaining the health protectiveness of the risk-based PPRGs.

#### **4.0 METHODOLOGY, EQUATIONS, AND ASSUMPTIONS**

This section presents the methodology, equations, and assumptions that were used to calculate the risk-based PPRGs. In general, the following USEPA guidance documents were used as the basis to derive the risk-based equations and exposure default values to calculate the risk-based PPRGs:

- *Human Health Evaluation Manual, Part B Development of Risk-Based Preliminary Remediation Goals*, (USEPA 1991),
- *Risk Assessment Guidance for Superfund, Volume I Human Health Evaluation Manual (Part A)*, (USEPA 1989),
- *Changes to Equations in the Part B Guidance*, (Dinan 1992),
- *Revisions to Chapter 4 Risk-based PRGs for Radioactive Contaminants*, (USEPA 1993b), and
- *Human Health Evaluation Manual, Supplemental Guidance Standard Default Exposure Factors, OSWER Directive 9285 6-03*, (USEPA, 1991b)

To ensure that all of the contaminants that may be encountered at the RFP are addressed, risk-based PPRGs were developed for all Target Analyte List (TAL) metals, Target Compound List (TCL) organics and 12 radionuclides for each receptor (i.e., resident, office worker, construction worker, and ecological researcher) and environmental media (i.e., surface soil, subsurface soil, ground water, and surface water) combination identified on Table 1. Separate risk-based equations were developed to account for the carcinogenic, noncarcinogenic, and/or radiological effects of the contaminant. Risk-based PPRGs for carcinogens (including radionuclides) were calculated by setting the carcinogenic target risk level at  $10^{-6}$ . A target risk level of  $10^{-6}$  means an individual has a one-in-one-million probability of developing cancer over a lifetime as a result of exposure to a specific contaminant. This risk is in addition to the probability of an individual developing cancer from other factors such as those associated with heredity or lifestyle. Similarly, risk-based PPRGs for toxicants (non-carcinogens) were calculated by setting the hazard index equal to 1 for each contaminant. A hazard index is the ratio between the contaminant concentration and a reference dose. The reference dose represents the exposure level to the contaminant below which adverse effects are not expected. For some of the contaminants both carcinogenic and noncarcinogenic toxicity information was available. For these contaminants, both a carcinogenic and noncarcinogenic risk-based concentration were calculated and the more restrictive value was used as the risk-based PPRG. The risk-based equations for radiological effects were used to calculate the risk-based PPRGs for the 12 radionuclides.

The risk-based PPRG equations include all of the exposure pathways (e.g., Direct Ingestion of Soils) listed in Table 1 for each exposure scenario/environmental media combination, separate risk-based PPRGs were not be calculated for each exposure pathway. When available, USEPA-specified default values were used to calculate the risk-based PPRGs. In the absence of USEPA guidance on specific parameters, site-specific default values were established based on previous DOE reports on specific operable units.

#### 4.1 Surface Soils

Exposure pathways, equations, assumptions, and default values used to calculate the surface soil risk-based PPRGs for each receptor scenario are presented in this section. The receptors considered include residential use, office worker, and ecological researcher. The risk-based equations for all receptors included the following exposure pathways:

- Direct ingestion of soils contaminated with organic and inorganic (including radionuclides) contaminants,
- Inhalation of non-volatile organic and inorganic (including radionuclides) particulates; and
- External radiation exposure due to radionuclide contaminants.

#### **4.1.1 Residential Exposure**

For the residential exposure to surface soil, a combined adult and child exposure was assessed for the soil ingestion pathway. All other pathways were based on an adult exposure only.

The equations and assumptions used to derive risk-based PPRGs for surface soils with carcinogenic COCs are shown on Table 2, and the corresponding equation for COCs with noncarcinogenic effects is shown on Table 3. Table 4 shows the equation used to calculate risk-based PPRGs for radionuclides. All default values were based on USEPA guidance.

#### **4.1.2 Commercial/Industrial Exposure**

For the commercial/industrial exposure to surface soils, an office worker receptor was assessed. The equations and assumptions used to derive the risk-based PPRGs for surface soils are shown on Table 5 for COCs with carcinogenic effects, on Table 6 for COCs with noncarcinogenic effects, and on Table 7 for radionuclides. All default values were based on USEPA guidance.

#### **4.1.3 Ecological Researcher Exposure**

The risk-based PPRG equations and assumptions for exposure of an ecological researcher to surface soils are shown on Tables 8, 9, and 10 for potential carcinogens, noncarcinogens, and radionuclides, respectively. Because the ecological researcher is a site-specific receptor, site-specific exposure assumptions were developed. Specifically, the exposure frequency and duration were based on site-specific information. Other exposure assumptions were based on USEPA guidance pertaining to a commercial/industrial land use scenario.

### **4.2 Subsurface Soils**

This section presents the exposure pathways, equations, assumptions, and default values used to calculate the subsurface soil risk-based PPRGs. Only a construction worker scenario was considered for this environmental media and the risk-based PPRGs were based on the following exposure pathways:

- Direct ingestion of soils contaminated with organic and inorganic (including radionuclides) contaminants,
- Inhalation of non-volatile organic and inorganic (including radionuclides) particulates,
- External radiation exposure due to radionuclide contaminants, and
- Inhalation of volatiles

TABLE 2  
 SURFACE SOIL - RESIDENTIAL USE  
 CARCINOGENIC EFFECTS

$$PPRG_1 = \frac{TR \times AT \times 365 \text{ days/year}}{EF \times \left[ (SF_1 \times IRa \times ED \times \frac{1}{BW} \times \frac{1}{PEF}) + (SFO \times 10^{-6} \text{ kg/mg} \times IF) \right]}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>1</sub>	Risk-based PPRG for surface soil based on residential use (mg/kg)	-
TR	target excess lifetime cancer risk (unitless)	10 <sup>-6</sup>
AT	averaging time (years)	70 years
EF	exposure frequency (days/year)	350 days/year
SF <sub>1</sub>	inhalation cancer slope factor (mg/kg-day) <sup>-1</sup>	COC-Specific
IRa	daily inhalation rate (m <sup>3</sup> /day)	20 m <sup>3</sup> /day
ED	exposure duration (years)	30 years
BW	adult body weight (kg)	70 kg
PEF	particulate emission factor (m <sup>3</sup> /kg)	4 63 x 10 <sup>9</sup> m <sup>3</sup> /kg
SFO	oral cancer slope factor (mg/kg-day) <sup>-1</sup>	COC-Specific
IF	age-adjusted soil ingestion factor (mg-yr/kg-day)	114 mg-yr/kg-day

Source USEPA, 1991

Note Inhalation of particulates does not apply to volatile organics (i.e., Henry's Law Constant greater than 1x10<sup>-5</sup> atm-m<sup>3</sup>/mole and a molecular weight less than 200 g/mole)

TABLE 3  
 SURFACE SOIL - RESIDENTIAL USE  
 NONCARCINOGENIC EFFECTS

$$PPRG_2 = \frac{THI \times AT \times 365 \text{ days/year}}{EF \times \left[ (ED \times IRa \times \frac{1}{RfD_1} \times \frac{1}{BW} \times \frac{1}{PEF}) + (\frac{1}{RfDo} \times 10^{-6} \text{ kg/mg} \times IF) \right]}$$

where.

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>2</sub>	Risk-based PPRG for surface soil based on residential use (mg/kg)	-
THI	target hazard index (unitless)	1
AT	averaging time (years)	30 years
EF	exposure frequency (days/year)	350 days/year
ED	exposure duration (years)	30 years
IRa	daily inhalation rate (m <sup>3</sup> /day)	20 m <sup>3</sup> /day
RfD <sub>1</sub>	inhalation chronic reference dose (mg/kg-day)	COC-Specific
BW	adult body weight (kg)	70 kg
PEF	particulate emission factor (m <sup>3</sup> /kg)	4 63 x 10 <sup>9</sup> m <sup>3</sup> /kg
RfDo	oral chronic reference dose (mg/kg-day)	COC-Specific
IF	age-adjusted soil ingestion rate (mg-yr/kg-day)	114 mg-yr/kg-day

Source USEPA, 1991

Note Inhalation of particulates does not apply to volatile organics (i.e., Henry's Law Constant greater than 1x10<sup>-5</sup> atm-m<sup>3</sup>/mole and a molecular weight less than 200 g/mole)

TABLE 4  
 SURFACE SOIL - RESIDENTIAL USE  
 RADIOLOGICAL EFFECTS

$$PPRG_3 = \frac{TR}{(EF \times IRa \times ED \times SFI \times 10^3 \text{ g/kg} \times \frac{1}{PEF}) + (EF \times SFO \times 10^{-3} \text{ g/mg} \times IF) + (SFe \times ED \times (1 - Se) \times Te)}$$

where.

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>3</sub>	Risk-based PPRG for surface soil based on residential use (pCi/g)	-
TR	target excess lifetime cancer risk (unitless)	10 <sup>-6</sup>
EF	exposure frequency (days/year)	350 days/year
IRa	daily indoor inhalation rate (m <sup>3</sup> /day)	20 m <sup>3</sup> /day
ED	exposure duration (years)	30 years
SF1	inhalation cancer slope factor (risk/pCi)	COC-Specific
PEF	particulate emission factor (m <sup>3</sup> /kg)	4 63 x 10 <sup>9</sup> m <sup>3</sup> /kg
SFO	oral cancer slope factor (risk/pCi)	COC-Specific
IF	age-adjusted soil ingestion factor (mg-yr/day)	3600 mg-yr/day
SFe	external exposure slope factor (risk/yr per pCi/g)	COC-Specific
Se	gamma shielding factor (unitless)	0.2
Te	gamma exposure factor (unitless)	1

Source USEPA, 1991, USEPA, 1993b.

TABLE 5  
SURFACE SOIL - OFFICE WORKER  
CARCINOGENIC EFFECTS

$$PPRG_4 = \frac{TR \times BW \times AT \times 365 \text{ days/year}}{EF \times ED \times \left[ (SF_1 \times IRa \times \frac{1}{PEF}) + (SF_0 \times 10^{-6} \text{ kg/mg} \times IRs) \right]}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>4</sub>	Risk-based PPRG for surface soil based on office worker use (mg/kg)	-
TR	target excess lifetime cancer risk (unitless)	10 <sup>-6</sup>
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	70 years
EF	exposure frequency (days/year)	250 days/year
ED	exposure duration (years)	25 years
SF <sub>1</sub>	inhalation cancer slope factor (mg/kg-day) <sup>-1</sup>	COC-Specific
IRa	workday inhalation rate (m <sup>3</sup> /day)	6 64 m <sup>3</sup> /day <sup>a/</sup>
PEF	particulate emission factor (m <sup>3</sup> /kg)	4 63 x 10 <sup>9</sup> m <sup>3</sup> /kg
SF <sub>0</sub>	oral cancer slope factor (mg/kg-day) <sup>-1</sup>	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day

Source USEPA, 1989, USEPA, 1991

<sup>a/</sup> Based on a total inhalation rate of 20 m<sup>3</sup>/day adjusted for an 8-hour workday

Note: Inhalation of particulates does not apply to volatile organics (i.e., Henry's Law Constant greater than 1x10<sup>-5</sup> atm-m<sup>3</sup>/mole and a molecular weight less than 200 g/mole)

**TABLE 6**  
**SURFACE SOIL - OFFICE WORKER**  
**NONCARCINOGENIC EFFECTS**

$$PPRG_5 = \frac{THI \times BW \times AT \times 365 \text{ days/year}}{EF \times ED \times \left[ (IRa \times \frac{1}{RfD_i} \times \frac{1}{PEF}) + (\frac{1}{RfDo} \times 10^{-6} \text{ kg/mg} \times IRs) \right]}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>5</sub>	Risk-based PPRG for surface soil based on office worker use (mg/kg)	-
THI	target hazard index (unitless)	1
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	25 years
EF	exposure frequency (days/year)	250 days/year
ED	exposure duration (years)	25 years
IRa	workday inhalation rate (m <sup>3</sup> /day)	6 64 m <sup>3</sup> /day <sup>a/</sup>
RfD <sub>i</sub>	inhalation chronic reference dose (mg/kg-day)	COC-Specific
PEF	particulate emission factor (m <sup>3</sup> /kg)	4 63 x 10 <sup>9</sup> m <sup>3</sup> /kg
RfD <sub>o</sub>	oral chronic reference dose (mg/kg-day)	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day

Source USEPA, 1989, USEPA, 1991

<sup>a/</sup> Based on a total inhalation rate of 20 m<sup>3</sup>/day adjusted for an 8-hour workday  
 Note Inhalation of particulates does not apply to volatile organics (i.e., Henry's Law Constant greater than 1x10<sup>-5</sup> atm-m<sup>3</sup>/mole and molecular weight less than 200 g/mole)

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**TABLE 7**  
**SURFACE SOIL - OFFICE WORKER**  
**RADIOLOGICAL EFFECTS**

$$PPRG_6 = \frac{ED \times \left[ (EF \times IRa \times SF_1 \times 10^3 \text{ g/kg} \times \frac{1}{PEF}) + (EF \times SF_0 \times 10^{-3} \text{ g/mg} \times IRS) + (SFe \times (1 - Se) \times Te) \right]}{TR}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>6</sub>	Risk-based PPRG for surface soil based on office worker use (pCi/g)	-
TR	target excess lifetime cancer risk (unitless)	10 <sup>-6</sup>
ED	exposure duration (years)	25 years
EF	exposure frequency (days/year)	250 days/year
IRa	workday inhalation rate (m <sup>3</sup> /day)	6 64 m <sup>3</sup> /day <sup>a/</sup>
SF <sub>1</sub>	inhalation cancer slope factor (risk/pCi)	COC-Specific
PEF	particulate emission factor (m <sup>3</sup> /kg)	4 63 x 10 <sup>9</sup> m <sup>3</sup> /kg
SF <sub>0</sub>	oral cancer slope factor (risk/pCi)	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day
SFe	external exposure slope factor (risk/yr per pCi/g)	COC-Specific
Se	gamma shielding factor (unitless)	0 2
Te	gamma exposure factor (unitless)	0 3

Source USEPA, 1989, USEPA, 1991

<sup>a/</sup> Based on a total inhalation rate of 20 m<sup>3</sup>/day adjusted for an 8-hour workday

**TABLE 8**  
**SURFACE SOIL - ECOLOGICAL RESEARCHER**  
**CARCINOGENIC EFFECTS**

$$PPRG_7 = \frac{TR \times BW \times AT \times 365 \text{ days/year}}{EF \times ED \times \left[ (SF_i \times IR_a \times \frac{1}{PEF}) + (SF_o \times 10^{-6} \text{ kg/mg} \times IR_s) \right]}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>7</sub>	Risk-based PPRG for surface soil based on ecological researcher use (mg/kg)	-
TR	target excess lifetime cancer risk (unitless)	10 <sup>-6</sup>
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	70 years
EF	exposure frequency (days/year)	65 days/year <sup>b/</sup>
ED	exposure duration (years)	2.5 years <sup>b/</sup>
SF <sub>i</sub>	inhalation cancer slope factor (mg/kg-day) <sup>-1</sup>	COC-Specific
IR <sub>a</sub>	workday inhalation rate (m <sup>3</sup> /day)	6 64 m <sup>3</sup> /day <sup>a/</sup>
PEF	particulate emission factor (m <sup>3</sup> /kg)	4 63 x 10 <sup>9</sup> m <sup>3</sup> /kg
SF <sub>o</sub>	oral cancer slope factor (mg/kg-day) <sup>-1</sup>	COC-Specific
IR <sub>s</sub>	workday ingestion rate (mg/day)	50 mg/day

Source USEPA, 1991, DOE, 1993b, DOE, 1993c, DOE, 1993d

<sup>a/</sup> Based on a total inhalation rate of 20 m<sup>3</sup>/day adjusted for an 8-hour workday

<sup>b/</sup> Site-specific exposure factors for Rocky Flats Plant

Note Inhalation of particulates does not apply to volatile organics (i.e., Henry's Law Constant greater than 1x10<sup>-5</sup> atm-m<sup>3</sup>/mole and a molecular weight less than 200 g/mole)

TABLE 9  
 SURFACE SOIL - ECOLOGICAL RESEARCHER  
 NONCARCINOGENIC EFFECTS

$$PPRG_8 = \frac{THI \times BW \times AT \times 365 \text{ days/year}}{EF \times ED \times \left[ (IRa \times \frac{1}{RfD_1} \times \frac{1}{PEF}) + (\frac{1}{RfDo} \times 10^{-6} \text{ kg/mg} \times IRs) \right]}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>8</sub>	Risk-based PPRG for surface soil based on ecological researcher use (mg/kg)	-
THI	target hazard index (unitless)	1
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	2 5 years
EF	exposure frequency (days/year)	65 days/year <sup>b/</sup>
ED	exposure duration (years)	2 5 years <sup>b/</sup>
IRa	workday inhalation rate (m <sup>3</sup> /day)	6 64 m <sup>3</sup> /day <sup>a/</sup>
RfD <sub>1</sub>	inhalation chronic reference dose (mg/kg-day)	COC-Specific
PEF	particulate emission factor (m <sup>3</sup> /kg)	4 63 x 10 <sup>9</sup> m <sup>3</sup> /kg
RfDo	oral chronic reference dose (mg/kg-day)	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day

Source USEPA, 1991, DOE, 1993b; DOE, 1993c, DOE, 1993d

<sup>a/</sup> Based on a total inhalation rate of 20 m<sup>3</sup>/day adjusted for an 8-hour workday

<sup>b/</sup> Site-specific exposure factor for Rocky Flats Plant

Note Inhalation of particulates does not apply to volatile organics (i e , Henry's Law Constant greater than 1x10<sup>-5</sup> atm-m<sup>3</sup>/mole and a molecular weight less than 200 g/mole)

TABLE 10  
 SURFACE SOIL - ECOLOGICAL RESEARCHER  
 RADIOLOGICAL EFFECTS

$$PPRG_9 = \frac{TR}{ED} \times \left[ (EF \times IRa \times SFI \times 10^3 \text{ g/kg} \times \frac{1}{PEF}) + (EF \times SFo \times 10^{-3} \text{ g/mg} \times IRs) + (SFe \times (1 - Se) \times Te) \right]$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>9</sub>	Risk-based PPRG for surface soil based on ecological researcher use (pCi/g)	
TR	target excess lifetime cancer risk (unitless)	10 <sup>-6</sup>
ED	exposure duration (years)	2.5 years <sup>b/</sup>
EF	exposure frequency (days/year)	65 days/year <sup>b/</sup>
IRa	workday inhalation rate (m <sup>3</sup> /day)	6.64 m <sup>3</sup> /day <sup>a/</sup>
SF1	inhalation cancer slope factor (risk/pCi)	COC-Specific
PEF	particulate emission factor (m <sup>3</sup> /kg)	4.63 x 10 <sup>9</sup> m <sup>3</sup> /kg
SFo	oral cancer slope factor (risk/pCi)	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day
SFe	external exposure slope factor (risk/yr per pCi/g)	COC-Specific
Se	gamma shielding factor (unitless)	0.2
Te	gamma exposure factor (unitless)	0.3

Source USEPA, 1991, USEPA, 1993b, DOE, 1993b, DOE, 1993c, DOE, 1993d

<sup>a/</sup> Based on a total inhalation rate of 20 m<sup>3</sup>/day adjusted for an 8-hour workday

<sup>b/</sup> Site-specific exposure factor for Rocky Flats Plant

#### **4.2.1 Residential Exposure**

A scenario involving residential exposure to subsurface soils was not considered to be credible and was therefore not included in the calculation of risk-based PPRGs

#### **4.2.2 Commercial/Industrial Exposure**

The risk-based PPRG equations and assumptions are shown on Tables 11, 12, and 13 for potential carcinogens, noncarcinogens, and radionuclides, respectively. USEPA guidance does not specify exposure assumptions specific to a construction worker receptor. Therefore, site-specific information was used to develop assumptions for exposure frequency, exposure duration, and ingestion rate. All other exposure assumptions were based on USEPA guidance for a commercial/industrial land use scenario.

For the pathway involving inhalation of volatiles, a volatilization factor was calculated according to USEPA guidance as shown in Table 14. The volatilization model is applicable only if the soil concentration is at or below soil saturation. Thus, for those compounds for which the risk-based PPRG exceeds the soil saturation limit, the risk-based PPRG is set at the soil saturation limit. The soil saturation was calculated as shown on Table 15.

#### **4.2.3 Ecological Researcher Exposure**

The likelihood of having an ecological researcher exposed to subsurface soils was not considered to be credible and was therefore not included in the calculation of risk-based PPRGs.

### **4.3 Ground Water**

This section presents the exposure pathways, equations, assumptions, and default values used to calculate the ground water risk-based PPRGs. Residential use of the ground water was the only receptor considered. The risk-based equations included the following exposure pathways:

- Direct ingestion of ground water contaminated with organic and inorganic (including radionuclides) contaminants, and
- Inhalation of volatile organics during domestic use

#### **4.3.1 Residential Exposure**

The equations and assumptions used to derive risk-based PPRGs for residential use of ground water are shown on Table 16 for carcinogens, Table 17 for noncarcinogens, and Table 18 for radionuclides. All default exposure assumptions were based on USEPA guidance.

**TABLE 11**  
**SUBSURFACE SOIL - CONSTRUCTION WORKER**  
**CARCINOGENIC EFFECTS**

$$PPRG_{10} = \frac{TR \times BW \times AT \times 365 \text{ days/year}}{EF \times ED \times \left[ (SF_1 \times IRa \times \left( \frac{1}{PEF} + \frac{1}{VF} \right)) + (SF_0 \times 10^{-6} \text{ kg/mg} \times IRs) \right]}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>10</sub>	Risk-based PPRG for subsurface soil based on construction worker use (mg/kg)	-
TR	target excess lifetime cancer risk (unitless)	10 <sup>-6</sup>
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	70 years
EF	exposure frequency (days/year)	30 days/year <sup>b/</sup>
ED	exposure duration (years)	1 year <sup>b/</sup>
SF <sub>1</sub>	inhalation cancer slope factor (mg/kg-day) <sup>-1</sup>	COC-Specific
IRa	workday inhalation rate (m <sup>3</sup> /day)	6 64 m <sup>3</sup> /day <sup>a/</sup>
PEF	particulate emission factor (m <sup>3</sup> /kg)	4 63 x 10 <sup>9</sup> m <sup>3</sup> /kg
VF	soil-to-air volatilization factor (m <sup>3</sup> /kg)	COC-Specific (See Table 14)
SF <sub>0</sub>	oral cancer slope factor (mg/kg-day) <sup>-1</sup>	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day <sup>b/</sup>

Source USEPA, 1991, DOE, 1993a, DOE, 1993b, DOE, 1993c, DOE, 1993d

<sup>a/</sup> Based on a total inhalation rate of 20 m<sup>3</sup>/day adjusted for an 8-hour workday

<sup>b/</sup> Site-specific exposure factor for Rocky Flats Plant

**TABLE 12**  
**SUBSURFACE SOIL - CONSTRUCTION WORKER**  
**NONCARCINOGENIC EFFECTS**

$$PPRG_{11} = \frac{THI \times BW \times AT \times 365 \text{ days/year}}{EF \times ED \times \left[ (IRa \times \frac{1}{RfD1} \times (\frac{1}{PEF} + \frac{1}{VF})) + (\frac{1}{RfDo} \times 10^{-6} \text{ kg/mg} \times IRs) \right]}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>11</sub>	Risk-based PPRG for subsurface soil based on construction worker use (mg/kg)	-
THI	target hazard index (unitless)	1
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	1 year
EF	exposure frequency (days/year)	30 days/year <sup>b/</sup>
ED	exposure duration (years)	1 year <sup>b/</sup>
IRa	workday inhalation rate (m <sup>3</sup> /day)	6 64 m <sup>3</sup> /day <sup>a/</sup>
RfD1	inhalation chronic reference dose (mg/kg-day)	COC-Specific
PEF	particulate emission factor (m <sup>3</sup> /kg)	4 63 x 10 <sup>9</sup> m <sup>3</sup> /kg
VF	soil-to-air volatilization factor (m <sup>3</sup> /kg)	COC-Specific (See Table 14)
RfDo	oral chronic reference dose (mg/kg-day)	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day <sup>b/</sup>

Source USEPA, 1991, DOE, 1993a, DOE, 1993b, DOE, 1993c, DOE, 1993d

<sup>a/</sup> Based on a total inhalation rate of 20 m<sup>3</sup>/day adjusted for an 8-hour workday

<sup>b/</sup> Site-specific exposure factor for Rocky Flats Plant

TABLE 13  
 SUBSURFACE SOIL - CONSTRUCTION WORKER  
 RADIOLOGICAL EFFECTS

$$PPRG_{12} = \frac{TR}{ED \times \left[ (EF \times IRa \times SF1 \times 10^3 \text{ g/kg} \times \frac{1}{PEF}) + (EF \times SFo \times 10^{-3} \text{ g/mg} \times IRs) + (SFe \times (1 - Se) \times Te) \right]}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>12</sub>	Risk-based PPRG for subsurface soil based on construction worker use (pCi/g)	
TR	target excess lifetime cancer risk (unitless)	10 <sup>-6</sup>
ED	exposure duration (years)	1 year <sup>b/</sup>
EF	exposure frequency (days/year)	30 days/year <sup>b/</sup>
IRa	workday inhalation rate (m <sup>3</sup> /day)	6 64 m <sup>3</sup> /day <sup>a/</sup>
SF1	inhalation cancer slope factor (risk/pCi)	COC-Specific
PEF	particulate emission factor (m <sup>3</sup> /kg)	4 63 x 10 <sup>9</sup> m <sup>3</sup> /kg
SFo	oral cancer slope factor (risk/pCi)	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day <sup>b/</sup>
SFe	external exposure slope factor (risk/yr per pCi/g)	COC-Specific
Se	gamma shielding factor (unitless)	0 2
Te	gamma exposure factor (unitless)	0.3

Source USEPA, 1991, DOE, 1993a, DOE, 1993b, DOE, 1993c, DOE, 1993d

<sup>a/</sup> Based on a total inhalation rate of 20 m<sup>3</sup>/day adjusted for an 8-hour workday

<sup>b/</sup> Site-specific exposure factor for Rocky Flats Plant

**TABLE 14**  
**SUBSURFACE SOIL - CONSTRUCTION WORKER**  
**VOLATILIZATION FACTOR**

$$VF = \frac{(LS \times V \times DH)}{A} \times (3.14 \times \alpha \times T)^{1/2}$$

$$2 \times D_{ei} \times P_a \times K_{as}$$

where,

$$\alpha = \frac{D_{ei} \times P_a}{P_a + \frac{(\rho_s)(1 - P_a)}{K_{as}}}$$

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
VF	volatilization factor (m <sup>3</sup> /kg)	--
LS	length of side area (m)	45
V	wind speed in mixing zone (m/s)	2
DH	diffusion height (m)	2
A	area of contamination (cm <sup>2</sup> )	20,250,000
D <sub>ei</sub>	effective diffusivity (cm <sup>2</sup> /s)	D <sub>i</sub> x (P <sub>a</sub> <sup>3.33</sup> /P <sub>t</sub> <sup>2</sup> )
P <sub>a</sub>	air-filled soil porosity (unitless)	P <sub>t</sub> - Θβ
P <sub>t</sub>	total soil porosity (unitless)	1-(β/ρ <sub>s</sub> )
Θ	soil moisture content (cm <sup>3</sup> /water/g-soil)	10% or 0.1
β	soil bulk density (g/cm <sup>3</sup> )	1.5
ρ <sub>s</sub>	true soil density or particle density (g/cm <sup>3</sup> )	2.65
K <sub>as</sub>	soil-air partition coefficient (g-soil/cm <sup>3</sup> -air)	(H/K <sub>d</sub> ) x 41, (41 is a conversion factor)
T	exposure interval (s)	7.9 x 10 <sup>8</sup>
D <sub>i</sub>	diffusivity in air (cm <sup>2</sup> /s)	COC-specific
H	Henry's Law constant (atm-m <sup>3</sup> /mole)	COC-specific
K <sub>d</sub>	soil-water partition coefficient (cm <sup>3</sup> /g)	K <sub>oc</sub> x OC
K <sub>oc</sub>	organic carbon partition coefficient (cm <sup>3</sup> )	COC-specific
OC	organic carbon content of soil (fraction)	2% or 0.02

Source Dinan, 1992

**TABLE 15**  
**SUBSURFACE SOIL - CONSTRUCTION WORKER**  
**VOLATILIZATION FACTOR - SATURATED CONDITIONS**

$$C_{sat} = \frac{(K_d \times C_w \times \beta) + (C_w \times P_w) + (C_w \times H^1 \times P_a)}{\beta}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
$C_{sat}$	soil saturation concentration (mg/kg)	--
$K_d$	soil-water partition coefficient (L/kg)	$K_{oc} \times OC$
$K_{oc}$	organic carbon partition coefficient (L/kg)	2% or 0.02
OC	organic carbon content of soil fraction	COC-specific
$C_w$	upper-limit of free moisture in soil (mg/L water)	$S \times \Theta_m$
$\Theta_m$	soil moisture content (kg-water/kg-soil)	10% or 0.1
S	solubility in water (mg/L water)	COC-specific
$\beta$	soil bulk density (kg/L)	1.5
$P_w$	water filled soil porosity (unitless)	$P_t - P_a$
$P_a$	air-filled soil porosity (unitless)	$P_t - \Theta\beta$
$\Theta$	soil moisture content (L water/kg soil)	10% or 0.1
$P_t$	total soil porosity (unitless)	$1 - (\beta/\rho_s)$
$\rho_s$	true soil density or particle density (kg/L)	2.65
$H^1$	Henry's Law constant (unitless)	$H \times 41$ , (41 is a conversion factor)
H	Henry's Law constant (atm-m <sup>3</sup> /mole)	COC-specific

Source: Dman, 1992

**TABLE 16**  
**GROUND WATER - RESIDENTIAL USE**  
**CARCINOGENIC EFFECTS**

$$PPRG_{13} = \frac{TR \times BW \times AT \times 365 \text{ days/year}}{EF \times ED \times [ (SF1 \times IRa \times K) + (SFo \times IRw) ]}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>13</sub>	Risk-based PPRG for ground water based on residential use (mg/L)	-
TR	target excess lifetime cancer risk (unitless)	10 <sup>-6</sup>
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	70 years
EF	exposure frequency (days/year)	350 days/year
ED	exposure duration (years)	30 years
SF1	inhalation cancer slope factor (mg/kg-day) <sup>-1</sup>	COC-Specific
IRa	daily indoor inhalation rate (m <sup>3</sup> /day)	15 m <sup>3</sup> /day
K	volatilization factor (L/m <sup>3</sup> )	0 0005 x 1000 L/m <sup>3</sup>
SFo	oral cancer slope factor (mg/kg-day) <sup>-1</sup>	COC-Specific
IRw	daily water ingestion rate (L/day)	2 L/day

Source USEPA, 1991

Note Inhalation component applies only to volatile organics (i e , Henry's Law Constant greater than 1x10<sup>-5</sup> atm-m<sup>3</sup>/mole and molecular weight less than 200 g/mole )

TABLE 17  
GROUND WATER - RESIDENTIAL USE  
NONCARCINOGENIC EFFECTS

$$PPRG_{14} = \frac{THI \times BW \times AT \times 365 \text{ days/year}}{EF \times ED \times \left[ (IRa \times \frac{1}{RfD_i} \times K) + (\frac{1}{RfDo} \times IRw) \right]}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>14</sub>	Risk-based PPRG for ground water based on residential use (mg/L)	-
THI	target hazard index (unitless)	1
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	30 years
EF	exposure frequency (days/year)	350 days/year
ED	exposure duration (years)	30 years
IRa	daily indoor inhalation rate (m <sup>3</sup> /day)	15 m <sup>3</sup> /day
RfD <sub>i</sub>	inhalation chronic reference dose (mg/kg-day)	COC-Specific
K	volatilization factor (L/m <sup>3</sup> )	0 0005 x 1000 L/m <sup>3</sup>
RfDo	oral chronic reference dose (mg/kg-day)	COC-Specific
IRw	daily water ingestion rate (L/day)	2 L/day

Source USEPA, 1991

Note Inhalation component applies only to volatile organics (i.e., Henry's Law Constant greater than 1x10<sup>-5</sup> atm-m<sup>3</sup>/mole and molecular weight less than 200 g/mole)

**TABLE 18**  
**GROUND WATER - RESIDENTIAL USE**  
**RADIOLOGICAL EFFECTS**

$$PPRG_{15} = \frac{TR}{EF \times ED \times (SFo \times IRw)}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>15</sub>	Risk-based PPRG for ground water based on residential use (pCi/L)	-
TR	target excess lifetime cancer risk (unitless)	10 <sup>-6</sup>
EF	exposure frequency (days/year)	350 days/year
ED	exposure duration (years)	30 years
SFo	oral cancer slope factor (risk/pCi)	COC-Specific
IRw	daily water ingestion rate (L/day)	2 L/day

Source USEPA, 1991

#### **4.3.2 Commercial/Industrial Exposure**

A scenario involving commercial/industrial exposure to ground water was not considered to be credible and was therefore not included in the calculation of risk-based PPRGs

#### **4.3.3 Ecological Researcher Exposure**

A scenario involving exposure of an ecological researcher to ground water was not considered to be credible and was therefore not included in the calculation of risk-based PPRGs

### **4.4 Surface Water**

This section presents the exposure pathways, equations, assumptions, and default values used to calculate the surface water risk-based PPRGs for each receptor scenario. The receptors considered include residential use and ecological researcher. The risk-based equations for the residential receptor were based on exposure via swimming, while the risk-based equations for the ecological researcher were based on exposure via wading. For both receptors, the exposure pathways included direct ingestion of surface water.

#### **4.4.1 Residential Exposure**

The equations and assumptions used to derive risk-based PPRGs for residential exposure to surface water while swimming are shown on Tables 19 through 21 for carcinogens, noncarcinogens, and radionuclides, respectively. All assumptions were based on USEPA guidance.

#### **4.4.2 Commercial/Industrial Exposure**

The likelihood of having a commercial/industrial exposure to surface water was not considered to be credible and was therefore not included in the calculation of risk-based PPRGs.

#### **4.4.3 Ecological Researcher Exposure**

The risk-based PPRG equations and assumptions for exposure of an ecological researcher to surface water while wading are shown on Tables 22 through 24 for carcinogens, noncarcinogens, and radionuclides, respectively. USEPA guidance does not provide default values specific to this receptor. Therefore, site-specific information was used to determine exposure frequency and duration. All other exposure assumptions were based on USEPA guidance for swimming.

TABLE 19  
SURFACE WATER - RESIDENTIAL USE  
CARCINOGENIC EFFECTS

$$PPRG_{16} = \frac{TR \times BW \times AT \times 365 \text{ days/year}}{CRW \times ET \times EF \times ED \times SF_0}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>16</sub>	Risk-based PPRG for surface water based on residential use (mg/L)	-
TR	target excess lifetime cancer risk (unitless)	10 <sup>-6</sup>
SF <sub>0</sub>	oral cancer slope factor (mg/kg-day) <sup>-1</sup>	COC-Specific
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	70 years
EF	exposure frequency (days/year)	7 days/year
ED	exposure duration (years)	30 years
CRW	contact rate (L/hour)	0.05 L/hour
ET	exposure time (hours/day)	2.6 hours/day

Source USEPA, 1989.

TABLE 20  
SURFACE WATER - RESIDENTIAL USE  
NONCARCINOGENIC EFFECTS

$$PPRG_{17} = \frac{THI \times BW \times AT \times 365 \text{ days/year} \times RfDo}{CRw \times ET \times EF \times ED}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>17</sub>	Risk-based PPRG for surface water based on residential use (mg/L)	-
THI	target hazard index (unitless)	1
RfDo	oral chronic reference dose (mg/kg-day)	COC-Specific 70 kg
BW	adult body weight (kg)	30 years
AT	averaging time (years)	7 days/year
EF	exposure frequency (days/year)	30 years
ED	exposure duration (years)	0.05 L/hour
CRw	contact rate (L/hour)	2.6 hours/day
ET	exposure time (hours/day)	

Source USEPA, 1989

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**TABLE 21**  
**SURFACE WATER - RESIDENTIAL USE**  
**RADIOLOGICAL EFFECTS**

$$PPRG_{18} = \frac{TR}{SF_0 \times EF \times ED \times CR_w \times ET}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>18</sub>	Risk-based PPRG for surface water based on residential use (pCi/L)	-
TR	target excess lifetime cancer risk (unitless)	10 <sup>-6</sup>
SF <sub>0</sub>	oral cancer slope factor (mg/kg-day) <sup>-1</sup>	COC-Specific
EF	exposure frequency (days/year)	7 days/year
ED	exposure duration (years)	30 years
CR <sub>w</sub>	contact rate (L/hour)	0.05 L/hour
ET	exposure time (hours/day)	2.6 hours/day

Source USEPA, 1989, USEPA, 1991

TABLE 22  
 SURFACE WATER - ECOLOGICAL RESEARCHER  
 CARCINOGENIC EFFECTS

$$PPRG_{19} = \frac{TR \times BW \times AT \times 365 \text{ days/year}}{IRw \times EF \times ED \times SFO}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>19</sub>	Risk-based PPRG for surface water based on ecological researcher use (mg/L)	-
TR	target excess lifetime cancer risk (unitless)	10 <sup>-6</sup>
SFO	oral cancer slope factor (mg/kg-day) <sup>-1</sup>	COC-Specific
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	70 years
EF	exposure frequency (events/year)	7 events/year <sup>a/</sup>
ED	exposure duration (years)	25 years <sup>a/</sup>
IRw	ingestion rate (L/event)	0.05 L/event

Source USEPA, 1989, DOE, 1993c, DOE, 1993d

<sup>a/</sup> Site-specific exposure factor for Rocky Flats Plant

**TABLE 23**  
**SURFACE WATER - ECOLOGICAL RESEARCHER**  
**NONCARCINOGENIC EFFECTS**

$$PPRG_{20} = \frac{THI \times BW \times AT \times 365 \text{ days/year} \times RfDo}{IRw \times EF \times ED}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>20</sub>	Risk-based PPRG for surface water based on ecological researcher use (mg/L)	-
THI	target hazard index (unitless)	1
RfDo	oral chronic reference dose (mg/kg-day)	COC-Specific 70 kg
BW	adult body weight (kg)	2 5 years
AT	averaging time (years)	7 events/year <sup>a/</sup>
EF	exposure frequency (events/year)	2 5 years <sup>a/</sup>
ED	exposure duration (years)	0 05 L/event
IRw	ingestion rate (L/event)	

Source USEPA, 1989, DOE, 1993c, DOE, 1993d

<sup>a/</sup> Site-specific exposure factor for Rocky Flats Plant

**TABLE 24**  
**SURFACE WATER - ECOLOGICAL RESEARCHER**  
**RADIOLOGICAL EFFECTS**

$$PPRG_{21} = \frac{TR}{SF_0 \times EF \times ED \times IRw}$$

where

<u>Variable</u>	<u>Explanation (Units)</u>	<u>Default Value</u>
PPRG <sub>21</sub>	Risk-based PPRG for surface water based on ecological researcher use (pC <sub>1</sub> /L)	-
TR	target excess lifetime cancer risk (unitless)	10 <sup>-6</sup>
SF <sub>0</sub>	oral cancer slope factor (mg/kg-day) <sup>-1</sup>	COC-Specific
EF	exposure frequency (events/year)	7 events/year <sup>a/</sup>
ED	exposure duration (years)	2.5 years <sup>a/</sup>
IRw	ingestion rate (L/event)	0.05 L/event

Source USEPA, 1991, DOE, 1993c, DOE, 1993d

<sup>a/</sup> Site-specific exposure factor for Rocky Flats Plant

## 5.0 CONTAMINANT TOXICITY INFORMATION

The COC-specific toxicology values used for the calculation of the risk-based PPRGs are presented in Table 25. The toxicity information used to calculate the risk-based PPRGs included the slope factor and unit risk for evaluating carcinogenic effects and the reference dose (RfD) and the reference concentration (RfC) for evaluating noncarcinogenic effects. Toxicity values were obtained from the latest information contained on the Integrated Risk Information System (IRIS). If values were not available from IRIS, the *Health Effects Assessment Summary Tables Annual Update*, (USEPA 1993a) was consulted. Values for polycyclic aromatic hydrocarbons were calculated using USEPA guidance entitled *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons* (USEPA 1993c).

## 6.0 RISK-BASED PROGRAMMATIC PRELIMINARY REMEDIATION GOALS

For each potential COC, the calculated risk-based PPRG for the exposure scenario (i.e., receptor and environmental media combination identified on Table 1) are given on Table 26. Where a chemical has both carcinogenic and noncarcinogenic effects, the more stringent of the calculated risk-based levels was selected as the risk-based PPRG. The calculated risk-based PPRGs are generally pertinent to all of the OUs should the contaminant be identified as an OU-specific COC. However, OU-specific factors may disqualify some or all of the risk-based PPRGs should these factors preclude one or more of the exposure pathways which formed the basis of the risk-based equations. For example, the risk-based PPRGs for the ground water media may not be applicable at OUs where the ground water is not of sufficient quantity or quality to support domestic residential use. Also, residential use risk-based PPRGs may not be appropriate for areas where the future land use will be solely devoted to commercial and/or industrial facilities.

As stated early, the programmatic risk-based PRGs presented in Table 26 are not intended to be the final cleanup standards listed in the ROD. Other factors such as, but not limited to, background contaminant concentrations, results of the OU-specific BRA, technology limitations, detection methods, chemical-specific ARARs, cost-benefit evaluations, worker safety, and ecological effects will need to be considered when establishing the final cleanup standards. The risk-based PPRGs are to be used as a standardized set of limits to enable screening of potential remedial technologies and alternatives. As additional information is obtained through the RFI/RI and CMS/FS processes, it may be determined that the risk-based PPRGs are not representative of the actual risk posed by the contamination at the OU. If this situation occurs, the required changes will be incorporated as soon as possible during the Development and Screening of Alternatives or Detailed Analysis of Alternatives.



TABLE 25  
COC-Specific Toxicity Values\*

Target Analyte List Chemical	Oral RID (mg/kg-day)	Oral Slope Factor (mg/kg-day) <sup>-1</sup>	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) <sup>-1</sup>	External Slope Factor (risk/yr per pC/g)	Henry's Law Constant (atm-m <sup>3</sup> /mol)	Koc (ml/g)	Water Solubility (mg/L)	Diffusivity
Cesium	-	-	-	-	-	-	-	-	-
alpha-Chlordane	6 00E-05 d	1 30E+00 d	-	1 30E+00 d	-	9 63E-06 k	14000 k	-	-
beta-Chlordane	6 00E-05 d	1 30E+00 d	-	1 30E+00 d	-	9 63E-06 k	14000 k	-	-
gamma-Chlordane	6 00E-05 d	1 30E+00 d	-	1 30E+00 d	-	9 63E-06 k	14000 k	-	-
4-Chloroaniline	4 00E-03	-	-	-	-	-	-	-	-
Chlorobenzene#	2 00E-02	-	5 71E-03 b	-	-	3 72E-03 k	330 k	4 66E+02 k	0 07627 l
Chloroethane#	-	-	2 86E+00	-	-	8 48E-03	33	-	0 11031 l
Chloroform#	1 00E-02	6 10E-03	-	8 05E-02	-	2 87E-03 k	31 k	8 20E+03 k	0 09404 l
Chloromethane#	-	1 30E-02	-	6 30E-03	-	8 82E-02	-	-	0 11827 l
4-Chloro-3-methylphenol	-	-	-	-	-	-	-	-	-
2-Chloronaphthalene#	8 00E-02	-	-	-	-	-	-	-	-
2-Chlorophenol#	5 00E-03	-	-	-	-	1 30E-05	15	-	-
4-Chlorophenyl phenyl ether	-	-	-	-	-	-	-	-	-
Chromium III	1 00E+00	-	-	-	-	-	-	-	-
Chromium VI	5 00E-03	-	-	4 10E+01 b	-	-	-	-	-
Chrysene	-	7 30E-03 i	-	-	-	1 05E-06 k	20000 k	-	-
Cobalt	-	-	-	-	-	-	-	-	-
Copper	4 00E-02 b	-	-	-	-	-	-	-	-
Cyanide	2 00E-02	-	-	-	-	-	-	-	-
4,4-DDD	-	2 40E-01	-	-	-	7 96E-06 k	77000 k	-	-
4,4-DDE	-	3 40E-01	-	-	-	6 80E-05 k	440000 k	-	-
4,4-DDT	5 00E-04	3 40E-01	-	3 40E-01 h	-	5 13E-04 k	24300 k	-	-
Dibenz(a,h)anthracene	-	7 30E+00 i	-	-	-	7 33E-08 k	330000 k	-	-
Dibenzofuran	-	-	-	-	-	-	-	-	-
Dibromochloromethane	2 00E-02	8 40E-02	-	-	-	-	-	-	-
Di-n-butylphthalate	1 00E-01	-	-	-	-	2 82E-07 k	17000 k	-	-
1,2-Dichlorobenzene#	9 00E-02	-	5 71E-02	-	-	1 93E-03 k	1700 k	1 00E+02 k	-
1,3-Dichlorobenzene#	-	-	-	-	-	3 59E-03 k	1700 k	1 23E+02 k	-
1,4-Dichlorobenzene#	-	2 40E-02 b	2 29E-01 b	-	-	2 89E-03 k	1700 k	7 90E+01 k	-
3,3-Dichlorobenzidine	-	4 50E-01	-	-	-	8 33E-07 k	1553 k	-	-
1,1-Dichloroethane#	1 00E-01 b	-	1 43E-01	-	-	4 31E-03 k	30 k	5 50E+03 k	0 09643 l
1,2-Dichloroethane#	-	9 10E-02	-	9 10E-02	-	9 78E-04 k	14 k	8 52E+03 k	0 09643 l
1,1-Dichloroethene#	9 00E-03	6 00E-01	-	1 20E+00 b	-	3 40E-02 k	65 k	2 25E+03 k	0 08386 l
1,2-Dichloroethene (total)#	9 00E-03 b	-	-	-	-	-	36	-	0 08386 l
2,4-Dichlorophenol	3 00E-03	-	-	-	-	2 75E-06 k	380 k	-	-
1,2-Dichloropropane#	-	6 80E-02 b	1 14E-03	-	-	2 31E-03 k	51 k	2 70E+03 k	-
cis-1,3-Dichloropropene#	3 00E-04	1 80E-01 b,c	5 71E-03	1 30E-01 b,e	-	2 40E-03	23	-	-
trans-1,3-Dichloropropene#	3 00E-04	1 80E-01 b,c	5 71E-03	1 30E-01 b,e	-	1 80E-03	26	-	-
Dieldrin	5 00E-05	1 60E+01	-	2 91E-02 b	-	4 58E-07 k	1700 k	-	-
Diethylphthalate	8 00E-01	-	-	-	-	1 14E-06 k	142 k	-	-
2,4-Dimethylphenol#	2 00E-02	-	-	-	-	6 00E-07	425	-	-
Dimethylphthalate	1 00E+01	-	-	-	-	-	-	-	-
4,6-Dinitro-2-methylphenol#	-	-	-	-	-	4 80E-11	225	-	-

TABLE 25  
COC--Specific Toxicity Values\*

Target Analyte List Chemical	Oral RfD (mg/kg-day)	Oral Slope Factor (mg/kg-day) <sup>-1</sup>	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) <sup>-1</sup>	External Slope Factor (risk/yr per pCi/g)	Henry's Law Constant (atm-m <sup>3</sup> /mol)	Koc (ml/g)	Water Solubility (mg/L)	Diffusivity
2,4-Dinitrophenol	2.00E-03	-	-	-	-	6.45E-10 k	16.6 k	-	-
2,4-Dinitrotoluene	2.00E-03	-	-	-	-	5.09E-06 k	43 k	-	-
2,6-Dinitrotoluene	2.00E-03 b	-	-	-	-	3.27E-06 k	92 k	-	-
Di-n-octylphthalate	2.00E-02	-	-	-	-	-	-	-	-
Endosulfan I	5.00E-05 b,f	-	-	-	-	-	-	-	-
Endosulfan II	5.00E-05 b,f	-	-	-	-	-	-	-	-
Endosulfan sulfate	5.00E-05 b,f	-	-	-	-	-	-	-	-
Endosulfan (technical)	5.00E-05 b	-	-	-	-	-	-	-	-
Endrin ketone	-	-	-	-	-	-	-	-	-
Endrin (technical)	3.00E-04	-	-	-	-	-	-	-	-
Ethylbenzene#	1.00E-01	-	2.86E-01	-	-	6.43E-03 k	1100 k	1.52E+02 k	0.0707 l
Fluoranthene	4.00E-02	-	-	-	-	6.46E-06 k	38000 k	-	-
Fluorene#	4.00E-02	-	-	-	-	6.42E-05 k	7300 k	1.69E+00 k	-
Hepachlor	5.00E-04	4.50E+00	-	4.50E+00 b	-	8.19E-04 k	12000 k	-	-
Hepachlor epoxide	1.30E-05	9.10E+00	-	9.10E+00 b	-	4.39E-04 k	220 k	-	-
Hexachlorobenzene	8.00E-04	1.60E+00	-	1.60E+00 b	-	6.81E-04 k	3900 k	-	-
Hexachlorobutadiene	-	-	-	7.70E-02	-	4.57E+00 k	29000 k	-	-
Hexachlorocyclopentadiene	7.00E-03	-	2.00E-05	-	-	1.37E-02 k	4800 k	-	-
Hexachloroethane	1.00E-03	1.40E-02	-	1.40E-02	-	2.49E-03 k	20000 k	-	-
2-Heptanone#	-	-	-	-	-	3.39E-05	134	-	-
Indeno(1,2,3-cd)pyrene	-	7.30E-01 1	-	-	-	6.86E-08 k	1600000 k	-	-
Iron	-	-	-	-	-	-	-	-	-
Isophorone	2.00E-01	9.50E-04	-	-	-	-	-	-	-
Lead	-	-	-	-	-	-	-	-	-
Lithium	-	-	-	-	-	-	-	-	-
Magnesium	-	-	-	-	-	-	-	-	-
Manganese	5.00E-03	-	1.43E-05	-	-	-	-	-	-
Mercury	3.00E-04 b	-	8.57E-05	-	-	-	-	-	-
Methoxychlor	5.00E-03	-	-	-	-	-	-	-	-
Methylene chloride#	6.00E-02	7.50E-03	8.57E-01	1.64E-03	-	-	48	-	-
2-Methylnaphthalene#	-	-	-	-	-	5.18E-04	8500	-	-
4-Methyl-2-pentanone#	5.00E-02	-	2.29E-02	-	-	9.40E-05	19	-	-
2-Methylphenol	5.00E-02	-	-	-	-	-	-	-	-
4-Methylphenol	5.00E-03 b	-	-	-	-	-	-	-	-
Molybdenum	5.00E-03	-	-	-	-	-	594	-	-
Naphthalene#	4.00E-02 b	-	-	-	-	-	-	-	-
Nickel	2.00E-02	-	-	-	-	-	-	-	-
2-Nitroaniline	-	-	-	-	-	-	-	-	-
3-Nitroaniline	-	-	-	-	-	-	-	-	-
4-Nitroaniline	-	-	-	-	-	-	-	-	-
Nitrobenzene#	5.00E-04	-	5.71E-04	-	-	2.20E-05	36	1.90E+03 k	-
2-Nitrophenol	-	-	-	-	-	-	-	-	-
4-Nitrophenol#	-	-	-	-	-	-	21	-	-

TABLE 25  
COC-Specific Toxicity Values\*

Target Analyte List Chemical	Oral RfD (mg/kg-day)	Oral Slope Factor (mg/kg-day) <sup>-1</sup>	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) <sup>-1</sup>	External Slope Factor (risk/yr per µCi/g)	Henry's Law Constant (atm-m <sup>3</sup> /mol)	Koc (ml/g)	Water Solubility (mg/L)	Diffusivity
n-Nitrosodiphenylamine#	-	4.90E-03	-	-	-	6.40E-04	1200	-	-
n-Nitrosodipropylamine	-	7.00E+00	-	-	-	6.92E-06 k	15 k	9.90E+03 k	-
Pentachlorophenol	3.00E-02	1.20E-01	-	-	-	2.75E-06 k	53000 k	-	-
Phenanthrene#	-	-	-	-	-	1.59E-04 k	14000 k	1.00E+00 k	-
Phenol	6.00E-01	-	-	-	-	4.54E-07 k	142 k	-	0.06924 l
Potassium	-	-	-	-	-	-	-	-	-
Pyrene	3.00E-02	-	-	-	-	5.04E-06 k	38000 k	-	-
Selenium	5.00E-03	-	-	-	-	-	-	-	-
Silver	5.00E-03	-	-	-	-	-	-	-	-
Sodium	-	-	-	-	-	-	-	-	-
Strontium	6.00E-01	-	-	-	-	-	-	-	-
Styrene#	2.00E-01	-	2.86E-01	-	-	5.20E-03	270	-	0.0746 l
1,1,2,2-Tetrachloroethane#	-	2.00E-01	-	2.00E-01 b	-	3.81E-04 k	118 k	2.90E+03 k	-
Tetrachloroethene#	1.00E-02	5.20E-02 j	-	2.03E-03	-	2.59E-02 k	364 k	-	0.07852 l
Thallium	-	-	-	-	-	-	-	-	-
Tin	6.00E-01 b	-	-	-	-	-	-	-	-
Toluene#	2.00E-01	-	1.14E-01	-	-	6.37E-03 k	300 k	5.35E+02 k	0.08301 l
Toxaphene	-	1.10E+00	-	1.10E+00 b	-	4.36E-01 k	964 k	-	-
1,2,4-Trichlorobenzene#	1.00E-02	-	2.57E-03	-	-	2.31E-03 k	9200 k	3.00E+01 k	-
1,1,1-Trichloroethane#	-	-	-	-	-	1.44E-02 k	152 k	-	-
1,1,2-Trichloroethane#	4.00E-03	5.70E-02	-	5.60E-02	-	1.17E-03 k	56 k	4.50E+03 k	-
Trichloroethene#	-	1.10E-02	-	5.95E-03	-	9.10E-03 k	126 k	1.10E+03 k	0.08606 l
2,4,5-Trichlorophenol	1.00E-01	-	-	-	-	2.18E-04 k	89 k	-	-
2,4,6-Trichlorophenol	-	1.10E-02	-	1.00E-02 b	-	3.90E-06 k	2000 k	-	-
Vanadium	7.00E-03 b	-	-	-	-	-	-	-	-
Vinyl acetate	1.00E+00 b	-	5.71E-02	-	-	-	-	-	-
Vinyl chloride#	-	1.90E+00 b	-	3.00E-01 b	-	8.19E-02 k	57 k	2.67E+03 k	0.11375 l
Xylene (total)#	2.00E+00	-	-	-	-	7.04E-03 k	240 k	1.98E+02 k	0.07597 l
Zinc	3.00E-01	-	-	-	-	-	-	-	-
Nitrate	1.60E+00	-	-	-	-	-	-	-	-
Nitrite	1.00E-01	-	-	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-	-
Sulfide	-	-	-	-	-	-	-	-	-
Ammonium	-	-	-	-	-	-	-	-	-
Bicarbonate	-	-	-	-	-	-	-	-	-
Bromide	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-
Chloride	-	-	-	-	-	-	-	-	-
Cyanide	-	-	-	-	-	-	-	-	-
Fluoride	6.00E-02	-	-	-	-	-	-	-	-
Orthophosphate	-	-	-	-	-	-	-	-	-

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TABLE 25  
COC--Specific Toxicity Values\*

Target Analyte List Chemical	Oral RfD (mg/kg-day)	Oral Slope Factor (mg/kg-day) <sup>-1</sup>	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) <sup>-1</sup>	External Slope Factor (risk/yr per pCi/g)	Henry's Law Constant (atm-m <sup>3</sup> /mol)	Koc (ml/g)	Water Solubility (mg/L)	Diffusivity
Silica (as Si and SiO <sub>2</sub> )	-	-	-	-	-	-	-	-	-
Sulfate	-	-	-	-	-	-	-	-	-
Americium-241	-	2.40E-10 b*	-	3.20E-08 b*	4.90E-09 b	-	-	-	-
Cesium-137	-	2.80E-11 b*	-	1.90E-11 b*	0.00E+00 b	-	-	-	-
Plutonium-239	-	2.30E-10 b*	-	3.80E-08 b*	1.70E-11 b	-	-	-	-
Plutonium-240	-	2.30E-10 b*	-	3.80E-08 b*	2.70E-11 b	-	-	-	-
Radium-226	-	1.20E-10 b*	-	3.00E-09 b*	1.20E-08 b	-	-	-	-
Radium-228	-	1.00E-10 b*	-	6.60E-10 b*	0.00E+00 b	-	-	-	-
Strontium-89	-	3.00E-12 b*	-	2.90E-12 b*	4.70E-10 b	-	-	-	-
Strontium-90	-	3.30E-11 b*	-	5.60E-11 b*	0.00E+00 b	-	-	-	-
Tritium	-	5.40E-14 b*	-	7.80E-14 b*	0.00E+00 b	-	-	-	-
Uranium-233	-	1.60E-11 b*	-	2.70E-08 b*	4.20E-11 b	-	-	-	-
Uranium-234	-	1.60E-11 b*	-	2.60E-08 b*	3.00E-11 b	-	-	-	-
Uranium-235	-	1.60E-11 b*	-	2.50E-08 b*	2.40E-07 b	-	-	-	-
Uranium-238	-	1.60E-11 b*	-	2.40E-08 b*	2.10E-11 b	-	-	-	-

# = Chemicals listed are volatile

\* = Values given are in units of risk/pCi

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

b = Values given are 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 for arsenic is calculated from an oral unit risk of 5E-5 (1/μg)

h = Values given for chemicals were calculated from HEAST

i = Values given for PAHs were found in the EPA guidance document "Research and Development--

Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons."

j = Values given for tetrachloroethene are from a U.S. EPA memo from the Office of Research and

Development Environmental Criteria and Assessment Office

k = Values given are found in the Superfund Public Health Evaluation Manual, 1986

l = Values given are found in the Superfund Exposure Assessment Manual, 1988

TABLE 26  
PROGRAMMATIC PRGS FOR ROCKY FLATS PLANT

Target Analyte Lst Chemical	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Office Worker Soil (mg/kg)	Construction Worker Subsurface Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
Acenaphthene#	2.19E+00	1.68E+03	1.65E+04	1.23E+05	1.02E+06	4.38E+03	1.48E+05
Acenaphthylene#	-	-	-	-	-	-	-
Acetone#	3.65E+00	2.81E+03	2.74E+04	2.04E+05	1.70E+06	7.30E+03	2.47E+05
Aldrin	5.00E-06	3.85E-03	3.77E-02	3.36E-01	7.01E+01	1.20E-01	4.07E-01
Aluminum	-	-	-	-	-	-	-
Anthracene#	1.09E+01	8.42E+03	8.23E+04	6.13E+05	5.11E+06	2.19E+04	7.41E+05
Antimony	1.46E-02	1.12E+01	1.10E+02	8.18E+02	6.81E+03	2.92E+01	9.87E+02
Aroclor-1016	1.10E-05	8.51E-03	8.32E-02	7.43E-01	1.55E+02	2.65E-01	8.98E-01
Aroclor-1221	1.10E-05	8.51E-03	8.32E-02	7.43E-01	1.55E+02	2.65E-01	8.98E-01
Aroclor-1232	1.10E-05	8.51E-03	8.32E-02	7.43E-01	1.55E+02	2.65E-01	8.98E-01
Aroclor-1242	1.10E-05	8.51E-03	8.32E-02	7.43E-01	1.55E+02	2.65E-01	8.98E-01
Aroclor-1248	1.10E-05	8.51E-03	8.32E-02	7.43E-01	1.55E+02	2.65E-01	8.98E-01
Aroclor-1254	1.10E-05	8.51E-03	8.32E-02	7.43E-01	1.55E+02	2.65E-01	8.98E-01
Aroclor-1260	1.10E-05	8.51E-03	8.32E-02	7.43E-01	1.55E+02	2.65E-01	8.98E-01
Arsenic	4.86E-05	3.74E-02	3.66E-01	3.27E+00	6.81E+02	1.17E+00	3.95E+00
Barium	2.56E+00	1.97E+03	1.92E+04	1.41E+05	1.19E+06	5.11E+03	1.73E+05
Benzene#	6.15E-04	2.26E+00	2.21E+01	1.66E-01	3.27E+00	7.05E+01	2.38E+02
alpha-BHC	1.35E-05	1.04E-02	1.02E-01	9.08E-01	1.89E+02	3.24E-01	1.10E+00
beta-BHC	4.72E-05	3.64E-02	3.56E-01	3.18E+00	6.62E+02	1.14E+00	3.84E+00
delta-BHC	-	-	-	-	-	-	-
gamma-BHC (Lindane)	6.54E-05	5.04E-02	4.93E-01	4.40E+00	9.17E+02	1.57E+00	5.32E+00
Benzo(a)anthracene	1.16E-04	8.97E-02	8.77E-01	7.84E+00	1.63E+03	2.80E+00	9.47E+00
Benzo(a)pyrene	1.16E-05	8.97E-03	8.77E-02	7.84E-01	1.63E+02	2.80E-01	9.47E-01
Benzo(b)fluoranthene	1.16E-04	8.97E-02	8.77E-01	7.84E+00	1.63E+03	2.80E+00	9.47E+00
Benzo(g,h,i)perylene	-	-	-	-	-	-	-
Benzo(k)fluoranthene	1.16E-03	8.97E-01	8.77E+00	7.84E+01	1.63E+04	2.80E+01	9.47E+01
Benzoic Acid	1.46E+02	1.12E+05	1.10E+06	8.18E+06	6.81E+07	2.92E+05	9.87E+06
Benzyl Alcohol	1.09E+01	8.42E+03	8.23E+04	6.13E+05	5.11E+06	2.19E+04	7.41E+05
Beryllium	1.98E-05	1.52E-02	1.49E-01	1.33E+00	2.77E+02	4.75E-01	1.61E+00
bis(2-Chloroethoxy)methane#	-	-	-	-	-	-	-
bis(2-Chloroethyl)ether#	1.56E-05	5.95E-02	5.82E-01	6.29E+00	1.08E+03	1.86E+00	6.28E+00
bis(2-Chloroisopropyl)ether#	4.22E-04	9.36E-01	9.15E+00	4.00E-01	1.70E+04	2.92E+01	9.87E+01
bis(2-Ethylhexyl)phthalate	6.07E-03	4.68E+00	4.57E+01	4.09E+02	8.51E+04	1.46E+02	4.94E+02
Bromodichloromethane#	1.37E-03	1.06E+00	1.03E+01	3.55E-01	1.92E+04	3.30E+01	1.11E+02
Bromoform#	3.81E-03	8.29E+00	8.11E+01	4.52E-02	1.51E+05	2.59E+02	8.75E+02
Bromomethane#	1.09E-02	3.93E+01	3.84E+02	2.86E+03	2.38E+04	1.02E+02	3.46E+03

TABLE 26  
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT

Target Analyte List Chemical	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Office Worker Soil (mg/kg)	Construction Worker Subsurface Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
4-Bromophenyl phenyl ether	-	-	-	-	-	-	-
2-Butanone#	2.47E+00	1.68E+04	1.65E+05	1.23E+06	1.02E+07	4.38E+04	1.48E+06
Butylbenzylphthalate	7.30E+00	5.62E+03	5.49E+04	4.09E+05	3.41E+06	1.46E+04	4.94E+05
Cadmium	1.82E-02	1.40E+01	1.37E+02	1.02E+03	8.52E+03	3.65E+01	1.23E+03
Calcium	-	-	-	-	-	-	-
Carbon disulfide#	2.76E-02	2.81E+03	2.74E+04	2.04E+05	1.70E+06	7.30E+03	2.47E+05
Carbon tetrachloride#	2.60E-04	5.04E-01	4.93E+00	4.40E+01	1.03E+00	1.57E+01	5.32E+01
Cesium	-	-	-	-	-	-	-
alpha-Chlordane	6.54E-05	5.04E-02	4.93E-01	4.40E+00	9.17E+02	1.57E+00	5.32E+00
beta-Chlordane	6.54E-05	5.04E-02	4.93E-01	4.40E+00	9.17E+02	1.57E+00	5.32E+00
gamma-Chlordane	6.54E-05	5.04E-02	4.93E-01	4.40E+00	9.17E+02	1.57E+00	5.32E+00
4-Chloroaniline	1.46E-01	1.12E+02	1.10E+03	8.18E+03	6.81E+04	2.92E+02	9.87E+03
Chlorobenzene#	5.16E-02	5.62E+02	5.49E+03	4.09E+04	2.11E+01	1.46E+03	4.94E+04
Chloroethane#	2.78E+01	-	-	-	1.77E+03	-	-
Chloroform#	2.76E-04	1.07E+01	1.05E+02	3.49E-02	1.70E+05	3.35E+02	1.13E+03
Chloromethane#	2.32E-03	5.04E+00	4.93E+01	7.44E-02	9.17E+04	1.57E+02	5.32E+02
4-Chloro-3-methylphenol	-	-	-	-	-	-	-
2-Chloronaphthalene#	2.92E+00	2.25E+03	2.20E+04	1.64E+05	1.36E+06	5.84E+03	1.97E+05
2-Chlorophenol#	1.82E-01	1.40E+02	1.37E+03	1.02E+04	8.52E+04	3.65E+02	1.23E+04
4-Chlorophenyl phenyl ether	-	-	-	-	-	-	-
Chromium III	3.65E+01	2.81E+04	2.74E+05	2.04E+06	1.70E+07	7.30E+04	2.47E+06
Chromium VI	1.82E-01	1.40E+02	1.37E+03	4.88E+03	8.52E+04	3.65E+02	1.23E+04
Chrysene	1.16E-02	8.97E+00	8.77E+01	7.84E+02	1.63E+05	2.80E+02	9.47E+02
Cobalt	-	-	-	-	-	-	-
Copper	1.46E+00	1.12E+03	1.10E+04	8.18E+04	6.81E+05	2.92E+03	9.87E+04
Cyanide	7.30E-01	5.62E+02	5.49E+03	4.09E+04	3.41E+05	1.46E+03	4.94E+04
4,4-DDD	3.54E-04	2.73E-01	2.67E+00	2.38E+01	4.97E+03	8.52E+00	2.88E+01
4,4-DDE	2.50E-04	1.93E-01	1.88E+00	1.68E+01	3.51E+03	6.01E+00	2.03E+01
4,4-DDT	2.50E-04	1.93E-01	1.88E+00	1.68E+01	3.51E+03	6.01E+00	2.03E+01
Dibenz(a,h)anthracene	1.16E-05	8.97E-03	8.77E-02	7.84E-01	1.63E+02	2.80E-01	9.47E-01
Dibenzofuran	-	-	-	-	-	-	-
Dibromochloromethane	1.01E-03	7.80E-01	7.62E+00	6.81E+01	1.42E+04	2.43E+01	8.23E+01
D1-n-butylphthalate	3.65E+00	2.81E+03	2.74E+04	2.04E+05	1.70E+06	7.30E+03	2.47E+05
1,2-Dichlorobenzene#	4.76E-01	2.53E+03	2.47E+04	1.84E+05	1.53E+06	6.57E+03	2.22E+05
1,3-Dichlorobenzene#	-	-	-	-	-	-	-
1,4-Dichlorobenzene#	3.54E-03	2.73E+00	2.67E+01	1.37E-01	4.97E+04	8.52E+01	2.88E+02
3,3-Dichlorobenzidine	1.89E-04	1.46E-01	1.42E+00	1.27E+01	2.65E+03	4.54E+00	1.54E+01

TABLE 26  
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT

Target Analyte List Chemical	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Office Worker Soil (mg/kg)	Construction Worker Subsurface Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
1,1-Dichloroethane#	1 01E+00	2 81E+03	2 74E+04	2 04E+05	1 29E+02	7 30E+03	2 47E+05
1,2-Dichloroethane#	1 97E-04	7 20E-01	7 04E+00	5 21E-01	1 31E+04	2 25E+01	7 60E+01
1,1-Dichloroethene#	1 67E-05	1 09E-01	1 07E+00	3 43E+00	1 99E+03	3 41E+00	1 15E+01
1,2-Dichloroethene (total)#	3 28E-01	2 53E+02	2 47E+03	1 84E+04	1 53E+05	6 57E+02	2 22E+04
2,4-Dichlorophenol	1 10E-01	8 42E+01	8 23E+02	6 13E+03	5 11E+04	2 19E+02	7 41E+03
1,2-Dichloropropane#	1 25E-03	9 63E-01	9 42E+00	3 89E-01	1 75E+04	3 01E+01	1 02E+02
cis-1,3-Dichloropropene#	1 27E-04	3 64E-01	3 56E+00	1 03E+00	5 11E+03	1 14E+01	3 84E+01
trans-1,3-Dichloropropene#	1 27E-04	3 64E-01	3 56E+00	1 03E+00	5 11E+03	1 14E+01	3 84E+01
Dieldrin	5 31E-06	4 09E-03	4 00E-02	3 57E-01	7 45E+01	1 28E-01	4 32E-01
Diethylphthalate	2 92E+01	2 25E+04	2 20E+05	1 64E+06	1 36E+07	5 84E+04	1 97E+06
2,4-Dimethylphenol#	7 30E-01	5 62E+02	5 49E+03	4 09E+04	3 41E+05	1 46E+03	4 94E+04
Dimethylphthalate	3 65E+02	2 81E+05	2 74E+06	2 04E+07	1 70E+08	7 30E+05	2 47E+07
4,6-Dinitro-2-methylphenol#	-	-	-	-	-	-	-
2,4-Dinitrophenol	7 30E-02	5 62E+01	5 49E+02	4 09E+03	3 41E+04	1 46E+02	4 94E+03
2,4-Dinitrotoluene	7 30E-02	5 62E+01	5 49E+02	4 09E+03	3 41E+04	1 46E+02	4 94E+03
2,6-Dinitrotoluene	3 65E-02	2 81E+01	2 74E+02	2 04E+03	1 70E+04	7 30E+01	2 47E+03
Di-n-octylphthalate	7 30E-01	5 62E+02	5 49E+03	4 09E+04	3 41E+05	1 46E+03	4 94E+04
Endosulfan I	1 83E-03	1 40E+00	1 37E+01	1 02E+02	8 52E+02	3 65E+00	1 23E+02
Endosulfan II	1 83E-03	1 40E+00	1 37E+01	1 02E+02	8 52E+02	3 65E+00	1 23E+02
Endosulfan sulfate	1 83E-03	1 40E+00	1 37E+01	1 02E+02	8 52E+02	3 65E+00	1 23E+02
Endosulfan (technical)	1 83E-03	1 40E+00	1 37E+01	1 02E+02	8 52E+02	3 65E+00	1 23E+02
Endrin ketone	-	-	-	-	-	-	-
Endrin (technical)	1 09E-02	8 42E+00	8 23E+01	6 13E+02	5 11E+03	2 19E+01	7 41E+02
Ethylbenzene#	1 58E+00	2 81E+03	2 74E+04	2 04E+05	1 52E+03	7 30E+03	2 47E+05
Fluoranthene	1 46E+00	1 12E+03	1 10E+04	8 18E+04	6 81E+05	2 92E+03	9 87E+04
Fluorene#	1 46E+00	1 12E+03	1 10E+04	8 18E+04	6 81E+05	2 92E+03	9 87E+04
Heptachlor	1 89E-05	1 46E-02	1 42E-01	1 27E+00	2 65E+02	4 54E-01	1 54E+00
Heptachlor epoxide	9 34E-06	7 20E-03	7 04E-02	6 29E-01	1 31E+02	2 25E-01	7 60E-01
Hexachlorobenzene	5 31E-05	4 09E-02	4 00E-01	3 57E+00	7 45E+02	1 28E+00	4 32E+00
Hexachlorobutadiene	-	-	-	2 60E+06	5 40E+08	-	-
Hexachlorocyclopentadiene	2 56E-01	1 97E+02	1 92E+03	1 42E+04	1 19E+05	5 11E+02	1 73E+04
Hexachloroethane	6 07E-03	4 68E+00	4 57E+01	4 09E+02	1 70E+04	7 30E+01	4 94E+02
2-Hexanone#	-	-	-	-	-	-	-
Indeno(1,2,3-cd)pyrene	1 16E-04	8 97E-02	8 77E-01	7 84E+00	1 63E+03	2 80E+00	9 47E+00
Iron	-	-	-	-	-	-	-
Isophorone	8 95E-02	6 89E+01	6 74E+02	6 02E+03	1 25E+06	2 15E+03	7 28E+03
Lead	-	-	-	-	-	-	-

TABLE 26  
PROGRAMMATIC PRGS FOR ROCKY FLATS PLANT

Target Analyte Lst Chemical	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Office Worker Soil (mg/kg)	Construction Worker Subsurface Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
Lithium	-	-	-	-	-	-	-
Magnesium	-	-	-	-	-	-	-
Manganese	1 82E-01	1 40E+02	1 37E+03	1 01E+04	8 52E+04	3 65E+02	1 23E+04
Mercury	1 09E-02	8 42E+00	8 23E+01	6 13E+02	5 11E+03	2 19E+01	7 41E+02
Methoxychlor	1 82E-01	1 40E+02	1 37E+03	1 02E+04	8 52E+04	3 65E+02	1 23E+04
Methylene chloride#	6 22E-03	8 73E+00	8 54E+01	4 29E-02	1 59E+05	2 73E+02	9 22E+02
2-Methylnaphthalene#	-	-	-	-	-	-	-
4-Methyl-2-pentanone#	1 98E-01	1 40E+03	1 37E+04	1 02E+05	8 52E+05	3 65E+03	1 23E+05
2-Methylphenol	1 83E+00	1 40E+03	1 37E+04	1 02E+05	8 52E+05	3 65E+03	1 23E+05
4-Methylphenol	1 82E-01	1 40E+02	1 37E+03	1 02E+04	8 52E+04	3 65E+02	1 23E+04
Molybdenum	1 82E-01	1 40E+02	1 37E+03	1 02E+04	8 52E+04	3 65E+02	1 23E+04
Naphthalene#	1 46E+00	1 12E+03	1 10E+04	8 18E+04	6 81E+05	2 92E+03	9 87E+04
Nickel	7 30E-01	5 62E+02	5 49E+03	4 09E+04	3 41E+05	1 46E+03	4 94E+04
2-Nitroaniline	-	-	-	-	-	-	-
3-Nitroaniline	-	-	-	-	-	-	-
4-Nitroaniline	-	-	-	-	-	-	-
Nitrobenzene#	4 26E-03	1 40E+01	1 37E+02	1 02E+03	8 52E+03	3 65E+01	1 23E+03
2-Nitrophenol	-	-	-	-	-	-	-
4-Nitrophenol#	-	-	-	-	-	-	-
n-Nitrosodiphenylamine#	1 73E-02	1 34E+01	1 31E+02	2 80E-02	2 43E+05	4 17E+02	1 41E+03
n-Nitrosodipropylamine	1 21E-05	9 36E-03	9 15E-02	8 17E-01	1 70E+02	2 92E-01	9 87E+01
Pentachlorophenol	7 08E-04	5 46E-01	5 34E+00	4 77E+01	9 93E+03	1 70E+01	5 76E+01
Phenanthrene#	-	-	-	-	-	-	-
Phenol	2 19E+01	1 68E+04	1 65E+05	1 23E+06	1 02E+07	4 38E+04	1 48E+06
Potassium	-	-	-	-	-	-	-
Pyrene	1 09E+00	8 42E+02	8 23E+03	6 13E+04	5 11E+05	2 19E+03	7 41E+04
Selenium	1 82E-01	1 40E+02	1 37E+03	1 02E+04	8 52E+04	3 65E+02	1 23E+04
Silver	1 82E-01	1 40E+02	1 37E+03	1 02E+04	8 52E+04	3 65E+02	1 23E+04
Sodium	-	-	-	-	-	-	-
Strontium	2 19E+01	1 68E+04	1 65E+05	1 23E+06	1 02E+07	4 38E+04	1 48E+06
Styrene#	2 01E+00	5 62E+03	5 49E+04	4 09E+05	3 41E+06	1 46E+04	4 94E+05
1,1,2-Tetrachloroethane#	8 95E-05	3 28E-01	3 20E+00	1 14E+00	5 96E+03	1 02E+01	3 46E+01
Tetrachloroethene#	1 43E-03	1 26E+00	1 23E+01	2 97E-01	4 94E+01	3 93E+01	1 33E+02
Thallium	-	-	-	-	-	-	-
Tin	2 19E+01	1 68E+04	-	1 23E+06	1 02E+07	4 38E+04	1 48E+06
Toluene#	9 65E-01	5 62E+03	5 49E+04	4 09E+05	2 94E+02	1 46E+04	4 94E+05
Toxaphene	7 73E-05	5 95E-02	5 82E-01	5 20E+00	1 08E+03	1 86E+00	6 28E+00

TABLE 26  
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT

Target Analyte Lst Chemical	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Office Worker Soil (mg/kg)	Construction Worker Subsurface Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
1,2,4-Trichlorobenzene#	2.34E-02	2.81E+02	2.74E+03	2.04E+04	1.70E+05	7.30E+02	2.47E+04
1,1,1-Trichloroethane#	-	-	-	-	-	-	-
1,1,2-Trichloroethane#	3.18E-04	1.15E+00	1.12E+01	3.26E-01	2.09E+04	3.59E+01	1.21E+02
Trichloroethene#	2.55E-03	5.95E+00	5.82E+01	6.29E-02	1.08E+05	1.86E+02	6.28E+02
2,4,5-Trichlorophenol	3.65E+00	2.81E+03	2.74E+04	2.04E+05	1.70E+06	7.30E+03	2.47E+05
2,4,6-Trichlorophenol	7.73E-03	5.95E+00	5.82E+01	5.20E+02	1.08E+05	1.86E+02	6.28E+02
Vanadium	2.56E-01	1.97E+02	1.92E+03	1.43E+04	1.19E+05	5.11E+02	1.73E+04
Vinyl acetate	3.65E+01	2.81E+04	2.74E+05	2.04E+06	1.70E+07	7.30E+04	2.47E+06
Vinyl chloride#	2.81E-05	3.45E-02	3.37E-01	1.09E+01	6.27E+02	1.08E+00	3.64E+00
Xylene (total)#	7.30E+01	5.62E+04	5.49E+05	4.09E+06	3.41E+07	1.46E+05	4.94E+06
Zinc	1.09E+01	8.42E+03	8.23E+04	6.13E+05	5.11E+06	2.19E+04	7.41E+05
Nitrate	5.84E+01	4.49E+04	4.39E+05	3.27E+06	2.73E+07	1.17E+05	3.95E+06
Nitrite	3.65E+00	2.81E+03	2.74E+04	2.04E+05	1.70E+06	7.30E+03	2.47E+05
pH	-	-	-	-	-	-	-
Sulfide	-	-	-	-	-	-	-
Ammonium	-	-	-	-	-	-	-
Bicarbonate	-	-	-	-	-	-	-
Bromide	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-
Chloride	-	-	-	-	-	-	-
Cyanide	-	-	-	-	-	-	-
Fluoride	2.19E+00	1.68E+03	1.63E+04	1.23E+05	1.02E+06	4.38E+03	1.48E+05
Orthophosphate	-	-	-	-	-	-	-
Silica (as Si and SiO <sub>2</sub> )	-	-	-	-	-	-	-
Sulfate	-	-	-	-	-	-	-
Americium-241	1.98E-01 *	1.53E+02 *	2.37E+00 **	9.55E+00 **	6.50E+02 **	4.76E+03 *	1.09E+01 **
Cesium-137	1.70E+00 *	1.31E+03 *	2.83E+01 **	1.14E+02 **	2.38E+04 **	4.08E+04 *	1.38E+02 **
Plutonium-239	2.07E-01 *	1.59E+02 *	3.43E+00 **	1.38E+01 **	2.85E+03 **	4.97E+03 *	1.67E+01 **
Plutonium-240	2.07E-01 *	1.59E+02 *	3.42E+00 **	1.38E+01 **	2.83E+03 **	4.97E+03 *	1.67E+01 **
Radium-226	3.97E-01 *	3.05E+02 *	2.28E+00 **	9.13E+00 **	3.27E+02 **	9.52E+03 *	9.70E+00 **
Radium-228	4.76E-01 *	3.66E+02 *	7.93E+00 **	3.20E+01 **	6.67E+03 **	1.14E+04 *	3.86E+01 **
Strontium-89	1.59E+01 *	1.22E+04 *	6.64E+01 **	2.66E+02 **	8.53E+03 **	3.81E+05 *	2.78E+02 **
Strontium-90	1.44E+00 *	1.11E+03 *	2.40E+01 **	9.70E+01 **	2.02E+04 **	3.46E+04 *	1.17E+02 **

TABLE 26  
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT

Target Analyte List Chemical	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Office Worker Soil (mg/kg)	Construction Worker Subsurface Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
Tritium	8 82E+02 *	6 78E+05 *	1 47E+04 **	5 93E+04 **	1 23E+07 **	2 12E+07 *	7 16E+04 **
Uranium--233	2 98E+00 *	2 29E+03 *	4 47E+01 **	1 82E+02 **	2 84E+04 **	7 14E+04 *	2 18E+02 **
Uranium--234	2 98E+00 *	2 29E+03 *	4 53E+01 **	1 85E+02 **	3 09E+04 **	7 14E+04 *	2 22E+02 **
Uranium--235	2 98E+00 *	2 29E+03 *	1 73E-01 **	6 92E-01 **	1 74E+01 **	7 14E+04 *	6 92E-01 **
Uranium--238	2 98E+00 *	2 29E+03 *	4 60E+01 **	1 87E+02 **	3 33E+04 **	7 14E+04 *	2 25E+02 **

# = Chemicals listed are volatile

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

\*\* = Values given are in pCi/g

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