I. E-mail your comments to EMS's Project Manager (N. Jay Bassin, jay.bassin@emsus.com, 301-589-5318), on or before February 15, 2008. An annotated copy of the user's guide document may be submitted as well your specific comments by e-mail.

II. Your responsibilities are described below:
Review the web site to become familiar with its structure, organization, subpages, and links. The SPRG Calculator, for purposes of this peer review, includes:

- The web site home page (Welcome and Introduction) and links to subpages
- The users guide, which includes instructions, explanations, equations used, default data used, assumptions, and sources
- Frequently Asked Questions (FAQs)
- SPRG Search page (the online calculator itself)

We suggest you consider a number of points, covered below, but we rely on your expertise and experience to cover any aspect of the SPRG Calculator. Assume that the SPRG Calculator is intened to assist risk assessors, remedial project managers, and others involved with risk assessment and decision-making at sites with contaminated outdoor hard surfaces such as buildings, slabs, outside building walls, sidewalk and roads.

III. SPRG Review Guidance

We request that you review three things: (1) the overall web site itself; (2) the User's Guide, and (3) the SPRG Search tool. You should focus your review on the "Users Guide," which provides a complete overview, explanation, and instructions, together with supporting data, models, equations, and references and citations. Based upon your review of the Users Guide, you should review the SPRG Search (the online calculator itself) to determine whether the calculator appears to apply the principles, models, equations, and data described in the Users Guide. Please note clearly any inconsistencies between the User's Guide and the calculator.

A. Overall Web Site
1. Is the web site clearly organized, described, easy to navigate, and generally "user friendly"? If not, what do you recommend?
2. Have the objectives of the SPRG Calcluator, as stated in the documentation, been realized? If not, what do you recommend?
3. Does the documentation (Users Guide) match the SPRG Search calculator (online tool) and vice-versa? If not, what do you recommend?
4. Do you have any other recommendations to improve the usability of the web site?

B. User's Guide
1. Is the tool and website clearly explained?
   a. Are the assumptions clear and reasonable? If not, what do you recommend?
   b. Does it adequately describe it's limitations? If not, what do you recommend?
   c. Is it well written and clearly organized? If not, what do you recommend?
   d. Is the technical support documentation complete, well organized, and easy to follow? If not, what do you recommend?

Summary of Comments on Microsoft Word - SPRG Peer Review Charge 01-16-08.doc

Page: 1

Sequence number: 1
Author: eldarois
Subject: Note
Date: 2/18/2008 12:44:38 PM
Finding the actual calculator was not initially obvious. I suggest making this easier. In the download section it was not initially obvious that the xls anf pdf files were simply the default SPRG values.

Sequence number: 2
Author: eldarois
Subject: Note
Date: 2/18/2008 12:42:55 PM
Yes

Sequence number: 3
Author: eldarois
Subject: Note
Date: 2/18/2008 12:43:39 PM
Yes, generally the user's guide is consistent with the calculator.

Sequence number: 4
Author: eldarois
Subject: Note
Date: 2/18/2008 12:47:25 PM
My specific comments on the user's guide is provided in an annotated pdf of the guide.

I am primarily concerned with the number of very conservative assumptions that are used as default values. This appears to compound into some values that are below the measurement capability of instrumentation. Also, there is no discussion of the presence of multiple nuclides.

Sequence number: 5
Author: eldarois
Subject: Note
Date: 2/18/2008 12:48:35 PM
I have also provided a separate word document that discusses the results of the various default analysis.

2. Are the sources/citations appropriate and do they represent the current state of knowledge? If not, what do you recommend?
3. Are the models comprehensive, accurate, and do they represent the current state of knowledge? Are they supported appropriately by citations?
   a. Residential exposure?
   b. Worker exposure?
   c. Children's exposure?
   d. Conceptual two-and three-dimensional?
4. Are the equations comprehensive, accurate, and do they represent the current state of knowledge? Are they supported appropriately by citations or derivations? If not, what do you recommend?
   a. Residential exposures?
   b. Worker exposures?
   c. Two-and three-dimensional?
   d. Are the equation variables adequately explained in terms of relative sensitivities?
   e. Are the equation constants adequately explained and sourced?
5. Are the toxicological and exposure data comprehensive, appropriate, accurate, and do they represent the current state of knowledge? Are they supported appropriately by citations? Are they appropriate for residential and worker exposures?
6. Are the assumptions and data for children's exposure reasonable and supportable?
7. Are the exposure parameters and default values appropriate and based on supportable reasoning?
8. SPRGs for Settled Dust
   a. Were appropriate exposure input parameters selected and logically supported to develop risk-based criteria?
   b. Are children adequately protected by the risk-based criteria as developed?
   c. Is the use of the external ground plane slope factor appropriate?
   d. Is the use of the mechanical resuspension approach appropriate?
   e. Is the use of the dissipation rate appropriate? Including a default input parameter of 0?
   f. Is the settled dust portion of the SPRG calculator reasonably consistent with other relevant EPA Superfund guidance? Are there aspects of other Superfund guidance which should have been used or incorporated into the calculator?
9. SPRGs for 3-D External
   a. Were appropriate exposure input parameters selected and logically supported to develop risk-based criteria?
   b. Are children adequately protected by the risk-based criteria as developed?
   c. Is the adjusted dose rate in for using the external slope factor on a contaminated urban street appropriate.
   d. Is the use of the various (e.g., ground plane, 1 cm, 5 cm, 15 cm) external slope factors appropriate?
   e. Is the 3-D external portion of the SPRG calculator reasonably consistent with other relevant EPA Superfund guidance? Are there aspects of other Superfund guidance which should have been used or incorporated into the calculator?

8\. SPRGs for 2-D External
   a. Were appropriate exposure input parameters selected and logically supported to develop risk-based criteria?
   b. Are children adequately protected by the risk-based criteria as developed?

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   c. Is the adjusted dose rate in for using the external slope factor on a contaminated slab.
   d. Is the use of the various (e.g., ground plane, 1 cm, 5 cm, 15 cm) external slope factors appropriate?
9. Are the standard recommended default factors adequately explained, sourced, and reasonable?
10. Are the radionuclides appropriate and does the ?
11. Is there anything else you recommend for the User's Guide to improve it for its stated purpose?

C. Calculator
1. Are the results clearly explained and presented?
2. Are the results appropriately described and qualified (to the extent that they may be relied upon and defended)?
3. Do the results provide defensible explanation of how they were derived, or are they the result of a "black box"?
4. Is the 2-D external portion of the SPRG calculator reasonably consistent with other relevant EPA Superfund guidance? Are there aspects of other Superfund guidance which should have been used or incorporated into the calculator?
5. Are the radionuclides appropriate, and do the results adequately explain the variability among radionuclides?

D. Anything Else?
Is there anything else you would recommend to improve the SPRG's utility, accuracy, completeness, or supportability?

This page contains no comments

Preliminary Remediation Goals for Radionuclides in Outdoor Surfaces (SPRG) User's Guide

Adobe PDF Version

Disclaimer

This guidance document sets forth recommended approaches based on EPA's best thinking to date with respect to risk assessment for response actions at CERCLA sites. This document does not establish binding rules. Alternative approaches for risk assessment may be found to be more appropriate at specific sites (e.g., where site circumstances do not match the underlying assumptions, conditions and models in the guidance). The decision whether to use an alternative approach and a description of any such approach should be placed in the Administrative Record for the site. Accordingly, if comments are received at individual sites questioning the use of the approaches recommended in this guidance, the comments should be considered and an explanation provided for the selected approach.

The policies set out in the Radionuclide SPRG User Guide provide guidance to EPA staff. The User's Guide also provides recommended guidance to the public and regulated community on how EPA intends the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) to be implemented. EPA may change this recommended guidance in the future, as appropriate. This calculator is intended for use by risk assessors, health physicists and other qualified environmental protection specialists.

It should also be noted that calculating a human radiological SPRG addresses neither human cancer risk from nonradiological (chemical) contaminants, noncancer toxicity, nor potential ecological risk. Of the radionuclides generally found at CERCLA sites, only uranium has potentially significant noncancer toxicity. When assessing sites with radiological contaminants which include uranium, it may also be necessary to consider the noncancer toxicity of uranium. Similarly, some sites with radiological contaminants in sensitive ecological settings may also need to be evaluated for potential ecological risk. EPA's guidance "Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessment" contains an eight step process for using benchmarks for ecological effects in the remedy selection process. Evaluation of radionuclides in soil should be conducted using the EPA's PRG calculator and the EPA's BPRG calculator should be used for evaluation inside buildings.

This web calculator is intended to be a generic steady-state screening assessment tool. The calculator is flexible and may also be used to derive site-specific risk assessments. Site-specific information should be gathered. The use of models reviewed by EPA in the Soil Screening Guidance - Radionuclide Technical Background Document at http://www.epa.gov/superfund/resources/radiation/tbd-part-3-clean.pdf, in Section 3-2, is recommended. This report provides a detailed technical analysis of five unsaturated zone fate and transport models for radionuclides. This report supports the information provided in Part 3 - Unsaturated Zone Models for Radionuclide Fate and Transport [PDF 383KB, 25 pages] of the Soil Screening Guidance for Radionuclides: Technical Background Document on determining the general applicability of the models to subsurface conditions and includes an assessment of each model's potential applicability to the soil screening process.

.. Introduction

Generally, these recommended radionuclide outdoor surfaces preliminary remediation goals (SPRGs) are reasonable maximum exposure (RME) concentrations derived from standardized equations that combine exposure information and toxicity information in the form of slope factors (SFs). Recommended SPRGs are presented for residential and worker exposure.

The intent of this calculator is to address hard outside surfaces such as building slabs, outside building walls, sidewalks and roads.

Generally under the NCP, PRGs are risk-based, conservative screening values to identify areas and contaminants of potential concern (COPCs) that either do or do not warrant further investigation.

This calculator is based on Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals) (RAGS Part B). RAGS Part B provides guidance on using EPA toxicity values and exposure information to calculate risk-based recommended SPRGs. Recommended for initial use at the scoping phase of a project using readily available information, risk-based recommended SPRGs may be modified based on site-specific data gathered during the RI/FS study. SPRG development and screening should assist staff in streamlining the consideration of remedial alternatives. Chemical-specific SPRGs typically are from two general sources: (1) concentrations based on potential Applicable or Relevant and Appropriate Requirements (ARARs) and (2) risk-based concentrations. ARARs include concentration limits set by other environmental regulations such as Safe Drinking Water Act maximum contaminant levels (MCLs). A second source for SPRGs, and the focus of this database tool, can be risk-based calculations that set concentration limits using carcinogenic toxicity values under specific exposure conditions.

The recommended approach for developing remediation goals is to identify SPRGs at scoping, modify them as needed at the end of the RI or during the FS based on site-specific information from the baseline risk assessment, and ultimately select remediation levels in the Record of Decision (ROD). In order to set radionuclide-specific SPRGs in a site-specific context, however, assessors should answer fundamental questions about the site. Information on the radionuclides that are present onsite, the specific contaminated media, land-use assumptions, and the exposure assumptions behind pathways of individual exposure normally is necessary in order to develop radionuclide-specific SPRGs. The recommended SPRG calculator provides the ability to modify the standard default SPRG exposure parameters to calculate site-specific SPRGs.

This database tool presents recommended standardized risk-based SPRGs and variable risk-based SPRG calculation equations for radioactive contaminants. Ecological effects are not considered in the calculator for radionuclides SPRGs.

SPRGs are presented for residents and workers using both soil volume and ground plane slope factors. The recommended risk-based SPRGs for radionuclides are based on the carcinogenicity of the contaminants. Cancer slope factors used are from HEAST.

Non-carcinogenic effects generally are not considered for radionuclide analytes, except for uranium for which both carcinogenic and non-carcinogenic effects are considered.

› standardized recommended SPRGs are based on default exposure parameters and incorporate exposure factors that present RME conditions. This database tool sents SPRGs in both activity and mass units. Once this database tool is used to retrieve recommended standard SPRGs or calculate site-specific SPRGs, it is important to clearly demonstrate the equations and exposure parameters used in the calculations. Discussion of the assumptions that go into the recommended SPRGs calculated should be included in the document where the SPRGs are presented, such as a Remedial Investigation (RI) Report or Feasibility Study.

This website combines current EPA recommended slope factors with "standard" exposure factors to estimate contaminant concentrations in environmental media (hard outside surfaces) that are designed to be protective of humans (including sensitive groups) over a lifetime. Sufficient knowledge about a given site may warrant the use of site-specific assumptions, which may differ from the recommended defaults. Exceeding a recommended SPRG usually suggests that further evaluation of the potential risks is appropriate. The recommended SPRG concentrations presented on this website can be used to screen pollutants in environmental media, trigger further

Summary of Comments on https://epa-sprg.ornl.gov/users_guide.shtml

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investigation, and provide initial cleanup goals, if applicable. The recommended SPRGs should be applied in accordance with guidance from EPA Regions.

2. Understanding the SPRG Website

2.1 General Considerations

Generally, these recommended SPRGs are isotope concentrations that correspond to certain levels of risk in dust, streets, sidewalks, finite slabs and building materials. ·pe factors (SFs), for a given radionuclide generally represent the risk equivalent per unit intake (i.e., ingestion or inhalation) or external exposure of that radionuclide. ·isk assessments, these SFs normally are used in calculations with radionuclide concentrations and exposure assumptions to estimate cancer risk from exposure to radioactive contamination. The calculations may be rearranged to generate SPRGs for a specified level of risk. SFs may be specified for specific body organs or tissues of interest, or as a weighted sum of individual organ dose, termed the effective dose equivalent. These SFs may be multiplied by the total activity of each radionuclide inhaled or ingested per year, or the external exposure concentration to which a receptor may be exposed, to estimate the risk to the receptor. Cancer slope factors from HEAST and FGR13 should be used.

The most common land uses and exposure assumptions are included in the equations on this website: Residential, Outdoor Worker, and Indoor Worker.

The recommended SPRGs are generated with standard exposure route equations using EPA SFs and exposure parameters.

2.2 Slope Factors (SFs)

EPA classifies all radionuclides as carcinogenic to humans. The radionuclide table from HEAST lists ingestion, inhalation and external exposure cancer slope factors (risk coefficients for total cancer morbidity) for radionuclides in conventional units of picocuries (pCi). Ingestion and inhalation slope factors are central estimates in a linear model of the age-averaged, lifetime attributable radiation cancer incidence (fatal and nonfatal cancer) risk per unit of activity inhaled or ingested, expressed as risk/pCi. External exposure slope factors are central estimates of lifetime attributable radiation cancer incidence risk for each year of exposure to external radiation from photon-emitting radionuclides distributed uniformly in a thick layer of soil, and are expressed as risk/yr per pCi/gram soil. When combined with site-specific media concentration data and appropriate exposure assumptions, slope factors can be used to estimate lifetime cancer risks to members of the general population due to radionuclide exposures.

2.2.1 When To Use "+D" SPRGs

Several of the isotopes are listed with a "+D" designation. This designation indicates that the SF includes the contribution from ingrowth of daughter isotopes out to 100 years. The intention of this designation is to make realistic PRGs by including the contributions from their short-lived decay products, assuming equal activity concentrations (i.e. ,secular equilibrium) with the principal or parent nuclide in the environment. (Note that there is one exception to the assumption of secular equilibrium. For the inhalation slope factor for Rn-222+D reported in the table, EPA assumes a 50% equilibrium value for radon decay products (Po-218, Pb-214, Bi-214 and Po-214) in air.) Before applying PRGs to a site, it should be determined if the isotopes present are in secular equilibrium. If the isotopes are found to be in secular equilibrium, the +D PRGs should be used for the parent isotope and the daughters included in the +D can be ignored. If the isotopes are not in secular equilibrium, PRGs should be applied for each daughter isotope. However, in the absence of empirical data, the "+D" values for radionuclides should be used unless there are compelling reasons not to.

For example, if analytical data from a site reveal that Th-228, Ra-224, Rn-220 are detected at a site and that they are in secular equilibrium, the PRG for Th-228+D should be applied and the Ra-224 and Rn-220 can be ignored.

Another example could concern a decay chain in secular equilibrium like Th-232. Even though the decay chain for Th-232 is very long, there is no Th-232+D slope factor. In this case the PRGs for Th-232, Ra-228+D, and Th-228+D should be used. If no part of the decay chain is in secular equilibrium, the user should use each of the PRGs · isotopes in the decay chain that have slope factors (e.g., Th-232, Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Po-212, and Tl-208). If part of : decay chain is in secular equilibrium, then the user may use that particular +D slope factor that covers that part of the decay chain, while using the slope factors for the other radionuclides.

2.2.2 Associated Decay Chains for "+D" SPRGs

Selected radionuclides and radioactive decay chain products are designated with the suffix "+D" to indicate that cancer risk estimates for these radionuclides include the contributions from their short-lived decay products, assuming equal activity concentrations (i.e., secular equilibrium) with the principal or parent nuclide in the environment. For all radionuclides without the "+D" suffix, only intake or external exposure to the single radionuclide is considered. Most radionuclides with a +D designation include the entire decay chain to the stable terminal nuclide in the slope factors. HEAST provides a table of +D radionuclides that decay for longer than 100 years. This table provides the associated decay chain included and the terminal radionuclide used in the slope factors. This table is reproduced below.

Principal Radionuclide (half-life in years)	Associated decay chain	Terminal Radionuclide	Half-life (years)
Am-242m+D (152)	Am-242, Cm-242, Np-238	Pu-238	87.7
Am-243+D (7.4E+03)	Np-239	Pu-239	2.40E+04
Np-237+D (2.1E+06)	Pa-233	U-233	1.6E+05
Pu-244+D (8.3E+07)	U-240, Np-240m	Pu-240	6.50E+03
Ra-226+D (1.6E+03)	Rn-222, Po-218, Pb-214, At-218, Bi-214, Po-214, Tl-210	Pb-210	22
Ra-228+D (6)	Ac-228	Th-228	2
U-235+D (7.0E+08)	Th-231	Pa-231	3.3E+04
U-238+D (4.5E+09)	Th-234, Pa-234m, Pa-234	U-234	2.4E+05

Ingestion and inhalation slope factors are missing for some of the +D isotopes. These have not been derived yet. Use caution when selecting a SPRG to make sure that as many routes of exposure are accounted for.

2.3 SPRG in Context of Superfund Modeling Framework

This recommended SPRG calculator focuses on the application of generic and simple site-specific approaches that are part of a larger framework for calculating centration levels that are designed to be consistent with risk based criteria. Generic recommended SPRGs for a 1×10^{-6} cancer risk standard are provided by viewing .ner the tables in the Download Area section of this calculator or by running the SPRG Search section of this calculator with the "Get Default SPRGs" option. Part 3 of the Soil Screening Guidance for Radionuclides: Technical Background Document provides more information about more detailed approaches that are part of the same framework.

Generic recommended SPRGs can be calculated from the same equations presented in the site-specific portion of the calculator, but typically are based on a number of default assumptions chosen to be protective of human health for most site conditions. Generic recommended SPRGs can be used in place of site-specific SPRG levels; however, in general, they are expected to be more conservative than site-specific levels. The site manager should weigh the cost of collecting the data necessary to develop site-specific SPRGs with the potential for deriving a higher SPRG that provides an appropriate level of protection.

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3. Using the SPRG Table

The SPRG "Download Area" table provides generic recommended concentrations in the absence of site-specific exposure assessments. Screening concentrations can be used for:

- Prioritizing multiple sites within a facility or exposure units
- Setting risk-based detection limits for contaminants of potential concern (COPCs)
- Focusing future risk assessment efforts
- When appropriate for the site, consideration as risk-based cleanup levels

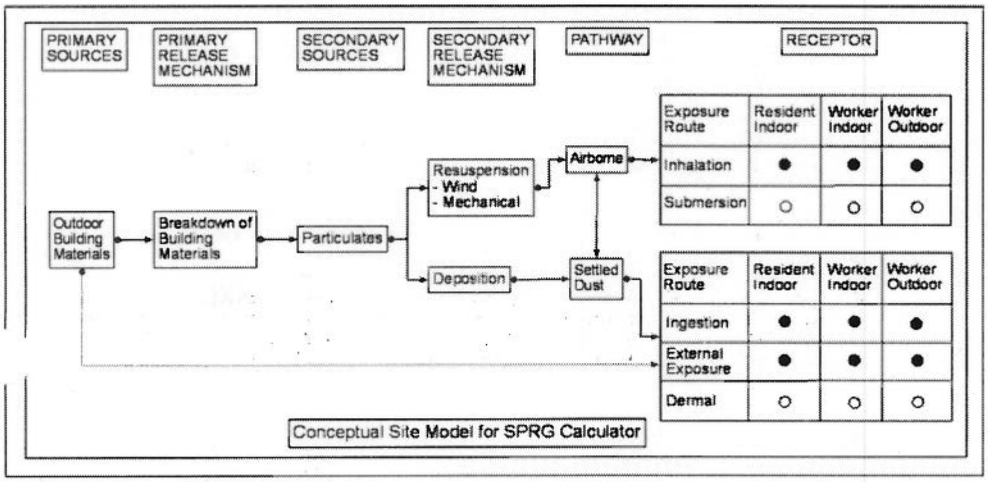
3.1 Developing a Conceptual Site Model

When using SPRGs, the exposure pathways of concern and site conditions should match those taken into account by the screening levels. (Note, however, that future uses may not match current uses. Future uses of a site should be logical as conditions which might occur at the site in the future.) Thus, it generally is necessary to develop a conceptual site model (CSM) to identify likely contaminant source areas, exposure pathways, and potential receptors. This information can be used to determine the applicability of screening levels at the site and the need for additional information. The final CSM represents linkages among contaminant sources, release mechanisms, exposure pathways, and routes and receptors based on historical information. It summarizes the understanding of the contamination problem. A separate CSM for ecological receptors can be useful. Part 2 and Attachment A of the Soil Screening Guidance for Radionuclides: Users Guide (EPA 2000a) contains the recommended steps for developing a CSM.

Existing EPA documents with additional CSM guidance are:

1. Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments). See Planning Table 1; and
2. Soil Screening Guidance for Radionuclides: User's Guide. See Attachment A.

CSMs can be tabular, graphical or stem-and-leaf. Section 4 of the user guide presents links to graphical CSMs for each scenario. Below is a stem-and-leaf CSM showing the exposure routes quantified and not quantified in this calculator.



Conceptual Site Model for SPRG Calculator

As a final check, the CSM generally should answer the following questions:

- Are there potential ecological concerns?
- Is there potential for land use other than those listed in the SPRG calculator (e.g., recreational, agricultural or trespasser)?
- Are there other likely human exposure pathways that were not considered in development of the SPRGs?
- Are there unusual site conditions (e.g. large areas of contamination, high fugitive dust levels, potential for indoor air contamination)?

The SPRGs may need to be adjusted to reflect the answers to these questions, and additional tools or assessment methodologies may need to be considered (e.g., if there may be potentially significant ecological risk). The recommended default scenarios in this calculator are the same default scenarios EPA addresses in its guidance. Other scenarios may be investigated, using the recommended SPRG calculator, by altering site-specific exposure parameters.

3.2 Radionuclide Background

Natural background radiation should be considered prior to applying SPRGs as cleanup levels. Background and site-related levels of radiation should be addressed as they are for other contaminants at CERCLA sites. For further information see EPA's guidance "Role of Background in the CERCLA Cleanup Program", April 2002, (OSWER 9285.6-07P). It should be noted that certain ARARs specifically address how to factor background into cleanup levels. For example, some radiation ARAR levels are established as increments above background concentrations. In these circumstances, background should be addressed in the manner prescribed by the ARAR. Additional information on radioactive materials present in building materials can be found in Volume 105, Number 2, March-April 2000, Journal of Research of the National Institute of Standards and Technology, Radioactivity Measurements on Glazed Ceramic Surfaces.

3.3 Potential Problems

As with any risk based tool, the potential exists for misapplication. In most cases, this results from not understanding the intended use of the recommended SPRGs. In order to prevent misuse of the recommended SPRGs, the following should be avoided:

- Applying recommended SPRG levels to a site without adequately developing a conceptual site model that identifies relevant exposure pathways and exposure scenarios.
- Use of recommended SPRG levels as cleanup levels without the consideration of other relevant criteria such as ARARs.
- Use of recommended SPRG levels as cleanup levels without verifying numbers with a health physicist/risk assessor.
- Use of outdated SPRG tables that have been superseded by more recent publications.
- Not considering the effects from the presence of multiple isotopes.

4. Technical Support Documentation

The recommended SPRGs consider human exposure from direct contact with contaminated outdoor dust on solid surfaces and external exposure to contaminated streets, sidewalks, finite slabs and building materials. The equations and technical discussion are aimed at developing concentration levels for risk-based SPRGs. The following text presents the recommended land use equations and their exposure routes. Table 1 presents the suggested definitions of the variables and their default values. Any alternative values or assumptions used in remedy evaluation or selection on a CERCLA site should be presented with supporting rationale in the Administrative Record.

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For a graphical representation and brief description of the routes of exposure for each exposure scenario, click on the name of the exposure scenarios below:

Resident - Exposure to Settled Dust on Outdoor Surfaces
Resident - 3-D Direct External Exposure to Fixed Contaminated Building Materials
Resident - 3-D Direct External Exposure to Fixed Settled Dust on Outdoor Surfaces
Resident - 2-D Direct External Exposure to Fixed Contaminated Finite Slabs
Resident - 2-D Direct External Exposure to Fixed Settled Dust on Finite Slabs
Outdoor Worker - Exposure to Settled Dust on Outdoor Surfaces
Outdoor Worker - 3-D Direct External Exposure to Fixed Contaminated Building Materials
Outdoor Worker - 3-D Direct External Exposure to Fixed Settled Dust on Outdoor Surfaces
Outdoor Worker - 2-D Direct External Exposure to Fixed Contaminated Finite Slabs
Outdoor Worker - 2-D Direct External Exposure to Fixed Settled Dust on Finite Slabs
Indoor Worker - Exposure to Settled Dust on Outdoor Surfaces
Indoor Worker - 3-D Direct External Exposure to Fixed Contaminated Building Materials
Indoor Worker - 3-D Direct External Exposure to Fixed Settled Dust on Outdoor Surfaces
Indoor Worker - 2-D Direct External Exposure to Fixed Contaminated Finite Slabs
Indoor Worker - 2-D Direct External Exposure to Fixed Settled Dust on Finite Slabs

4.1 Residential Surfaces

The recommended residential outdoor surfaces land use equation, presented here, contains the following exposure pathways and exposure routes:

- exposure to contamination deposited on streets and sidewalks (age-adjusted incidental ingestion, age-adjusted inhalation of particulates and external exposure to ionizing radiation from settled dust using ground plane toxicity values)

$$SPRG_{dr\text{-}total}\left(\frac{pCi}{cm^2}\right)=\frac{TR\times t_r\,(yrs)\times\lambda\left(\frac{1}{years}\right)}{\left(\frac{1-e^{-kt_r}}{kt_r}\right)\times\left(1-e^{-\lambda t_r}\right)\times EF_r\left(\frac{350\ d}{yr}\right)\times ED_r\,(30\ yr)\times\left[\begin{array}{l}\left(SF_{d\text{-}oral}\left(\frac{risk}{pCi}\right)\times IF_r\left(\frac{64.5\ cm^2}{d}\right)\right)+\\ \left(SF_{inh}\left(\frac{risk}{pCi}\right)\times HF_r\left(\frac{18\ m^3}{d}\right)\times\left(\frac{1\ d}{24\ hr}\right)\times\frac{1}{PEF\left(\frac{m^3}{Kg}\right)}\times SLF\left(\frac{6.\bar{6}E+08\ cm^2}{Kg}\right)\times\left[ET_{o,r}\left(\frac{1.752\ hr}{d}\right)+ET_{i,r}\left(\frac{16.4\ hr}{d}\right)\times DF_i\,(0.4)\right]\right)+\\ \left(SF_{d\text{-}ext}\left[\frac{\left(risk/yr\right)}{\left(pCi/cm^2\right)}\right]\times F_{AM}\times F_{OFF\text{-}SET}\times ACF\,(1.0)\times\left(\frac{1\ d}{24\ hr}\right)\times\left[ET_{o,r}\left(\frac{1.752\ hr}{d}\right)\times GSF_o\,(1.0)+ET_{i,r}\left(\frac{16.4\ hr}{d}\right)\times GSF_i\,(0.4)\right]\times\left(\frac{1yr}{365d}\right)\right)\end{array}\right]}$$

where

$$IF_r\left(\frac{64.5\ cm^2}{day}\right)=\left[\begin{array}{l}\left(FTSS_h\,(0.5)\times ET_{h,c}\left(\frac{4\ hrs}{day}\right)\times SE\,(0.5)\times ED_c\,(6\ yrs)\times SA_c\left(\frac{15\ cm^2}{event}\right)\times FQ_c\left(\frac{9.5\ events}{hour}\right)\right)+\\ \left(FTSS_h\,(0.5)\times ET_{h,a}\left(\frac{4\ hrs}{day}\right)\times SE\,(0.5)\times ED_a\,(24\ yrs)\times SA_a\left(\frac{45\ cm^2}{event}\right)\times FQ_a\left(\frac{1\ event}{hour}\right)\right)\end{array}\right]/\left(ED_a\,(24\ yrs)+ED_c\,(6\ yrs)\right)\text{ and}$$

$$HF_r\left(\frac{18\ m^3}{day}\right)=\left[\left(HR_a\left(\frac{20\ m^3}{day}\right)\times ED_a\,(24\ yrs)\right)+\left(HR_c\left(\frac{10\ m^3}{day}\right)\times ED_c\,(6\ yrs)\right)\right]/\left(ED_a\,(24\ yrs)+ED_c\,(6\ yrs)\right)$$

The resulting units for this recommended SPRG are in pCi/cm^2. The units are based on area because the SF used is the ground plane for external exposure and the ingestion route is based on hand surface area contacting dust on surfaces and subsequent hand to mouth transfer events. This equation is for values of k that are greater than 0; when k=0, the dissipation term is not quantified to avoid division by zero.

- 3-D Exposure to Direct External Exposure (Materials with fixed contamination at infinite depth in outside walls, streets and sidewalks using infinite soil volume toxicity values)

$$SPRG_{3\text{-}Dr\text{-}sv}\left(\frac{pCi}{g}\right)=\frac{TR\times t_r\,(years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_r\left(\frac{350\ days}{year}\right)\times ED_r\,(30\ years)\times\left(\frac{1day}{24hours}\right)\times ACF\,(1.0)\times\left(1-e^{-\lambda t_r}\right)\times\left[ET_{o,r}\left(\frac{1.752\ hours}{day}\right)\times GSF_o\,(1.0)+ET_{i,r}\left(\frac{16.4\ hours}{day}\right)\times GSF_i\,(0.4)\right]\times\left(\frac{1year}{365days}\right)\times F_{SURF}}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 3-D Exposure to Direct External Exposure (Materials with fixed contamination at 1cm in outside walls, streets and sidewalks using 1cm soil volume toxicity values)

$$SPRG_{3\text{-}Dr\text{-}1cm}\left(\frac{pCi}{g}\right)=\frac{TR\times t_r\,(years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext\text{-}1cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_r\left(\frac{350\ days}{year}\right)\times ED_r\,(30\ years)\times\left(\frac{1day}{24hours}\right)\times ACF\,(1.0)\times\left(1-e^{-\lambda t_r}\right)\times\left[ET_{o,r}\left(\frac{1.752\ hours}{day}\right)\times GSF_o\,(1.0)+ET_{i,r}\left(\frac{16.4\ hours}{day}\right)\times GSF_i\,(0.4)\right]\times\left(\frac{1year}{365days}\right)\times F_{SURF}}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 3-D Exposure to Direct External Exposure (Materials with fixed contamination at 5cm in outside walls, streets and sidewalks using 5cm soil volume toxicity values)

$$SPRG_{3\text{-}Dr\text{-}5cm}\left(\frac{pCi}{g}\right)=\frac{TR\times t_r\,(years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext\text{-}5cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_r\left(\frac{350\ days}{year}\right)\times ED_r\,(30\ years)\times\left(\frac{1day}{24hours}\right)\times ACF\,(1.0)\times\left(1-e^{-\lambda t_r}\right)\times\left[ET_{o,r}\left(\frac{1.752\ hours}{day}\right)\times GSF_o\,(1.0)+ET_{i,r}\left(\frac{16.4\ hours}{day}\right)\times GSF_i\,(0.4)\right]\times\left(\frac{1year}{365days}\right)\times F_{SURF}}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 3-D Exposure to Direct External Exposure (Materials with fixed contamination at 15cm in outside walls, streets and sidewalks using 15cm soil volume toxicity values)

$$SPRG_{3\text{-}Dr\text{-}15cm}\left(\frac{pCi}{g}\right)=\frac{TR\times t_r\,(years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext\text{-}15cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_r\left(\frac{350\ days}{year}\right)\times ED_r\,(30\ years)\times\left(\frac{1day}{24hours}\right)\times ACF\,(1.0)\times\left(1-e^{-\lambda t_r}\right)\times\left[ET_{o,r}\left(\frac{1.752\ hours}{day}\right)\times GSF_o\,(1.0)+ET_{i,r}\left(\frac{16.4\ hours}{day}\right)\times GSF_i\,(0.4)\right]\times\left(\frac{1year}{365days}\right)\times F_{SURF}}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 3-D Exposure to Direct External Exposure (Fixed contaminated dust on surface of outside walls, streets and sidewalks using ground plane toxicity values)

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Sequence number: 1
Author: eldarois
Subject: Note
Date: 2/18/2008 10:29:14 AM
The equations or the sections below should be numbered for easy reference.

Sequence number: 2
Author: eldarois
Subject: Note
Date: 2/18/2008 10:30:41 AM
The explanation of the differences and application of the 2D and 3D models is not well described..

Sequence number: 3
Author: eldarois
Subject: Note
Date: 2/18/2008 10:30:45 AM
Intuitively, it appears that the numerator should include (lambda + k) rather than lambda alone. Please verify that this is correct.

Sequence number: 4
Author: eldarois
Subject: Note
Date: 2/18/2008 10:30:54 AM
This equation does not seem reasonable. These default values also seem unreasonable.

$$SPRG_{3\text{-}Dr\text{-}gp}\left(\frac{pCi}{cm^2}\right)=\frac{TR\times t_r\,(years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{cm^2}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_r\left(\frac{350\ days}{year}\right)\times ED_r\,(30\ years)\times\left(\frac{1day}{24hours}\right)\times ACF\,(1.0)\times\left(1\text{-}e^{-\lambda t_r}\right)\times\left[ET_{o,r}\left(\frac{1.752\ hours}{day}\right)\times GSF_o\,(1.0)+ET_{i,r}\left(\frac{16.4\ hours}{day}\right)\times GSF_i\,(0.4)\right]\times\left(\frac{1year}{365days}\right)\times F_{SURF}}$$

The resulting units for this recommended SPRG are in pCi/cm^2. The units are based on area because the SF used is the ground plane for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab using infinite soil volume toxicity values)

$$SPRG_{2\text{-}Dr\text{-}sv}\left(\frac{pCi}{g}\right)=\frac{TR\times t_r\,(years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_r\left(\frac{350\ days}{year}\right)\times ED_r\,(30\ years)\times\left(\frac{1day}{24hours}\right)\times ACF\times\left(1\text{-}e^{-\lambda t_r}\right)\times\left[ET_{o,r}\left(\frac{1.752\ hours}{day}\right)\times GSF_o\,(1.0)+ET_{i,r}\left(\frac{16.4\ hours}{day}\right)\times GSF_i\,(0.4)\right]\times\left(\frac{1year}{365days}\right)}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab at 1cm depth using 1cm soil volume toxicity values)

$$SPRG_{2\text{-}Dr\text{-}1cm}\left(\frac{pCi}{g}\right)=\frac{TR\times t_r\,(years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext\text{-}1cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_r\left(\frac{350\ days}{year}\right)\times ED_r\,(30\ years)\times\left(\frac{1day}{24hours}\right)\times ACF\times\left(1\text{-}e^{-\lambda t_r}\right)\times\left[ET_{o,r}\left(\frac{1.752\ hours}{day}\right)\times GSF_o\,(1.0)+ET_{i,r}\left(\frac{16.4\ hours}{day}\right)\times GSF_i\,(0.4)\right]\times\left(\frac{1year}{365days}\right)}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab at 5cm depth using 5cm soil volume toxicity values)

$$SPRG_{2\text{-}Dr\text{-}5cm}\left(\frac{pCi}{g}\right)=\frac{TR\times t_r\,(years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext\text{-}5cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_r\left(\frac{350\ days}{year}\right)\times ED_r\,(30\ years)\times\left(\frac{1day}{24hours}\right)\times ACF\times\left(1\text{-}e^{-\lambda t_r}\right)\times\left[ET_{o,r}\left(\frac{1.752\ hours}{day}\right)\times GSF_o\,(1.0)+ET_{i,r}\left(\frac{16.4\ hours}{day}\right)\times GSF_i\,(0.4)\right]\times\left(\frac{1year}{365days}\right)}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab at 15cm depth using 15cm soil volume toxicity values)

$$SPRG_{2\text{-}Dr\text{-}15cm}\left(\frac{pCi}{g}\right)=\frac{TR\times t_r\,(years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext\text{-}15cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_r\left(\frac{350\ days}{year}\right)\times ED_r\,(30\ years)\times\left(\frac{1day}{24hours}\right)\times ACF\times\left(1\text{-}e^{-\lambda t_r}\right)\times\left[ET_{o,r}\left(\frac{1.752\ hours}{day}\right)\times GSF_o\,(1.0)+ET_{i,r}\left(\frac{16.4\ hours}{day}\right)\times GSF_i\,(0.4)\right]\times\left(\frac{1year}{365days}\right)}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab using ground plane toxicity values)

$$SPRG_{2\text{-}Dr\text{-}gp}\left(\frac{pCi}{cm^2}\right)=\frac{TR\times t_r\,(years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{cm^2}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_r\left(\frac{350\ days}{year}\right)\times ED_r\,(30\ years)\times\left(\frac{1day}{24hours}\right)\times ACF\times\left(1\text{-}e^{-\lambda t_r}\right)\times\left[ET_{o,r}\left(\frac{1.752\ hours}{day}\right)\times GSF_o\,(1.0)+ET_{i,r}\left(\frac{16.4\ hours}{day}\right)\times GSF_i\,(0.4)\right]\times\left(\frac{1year}{365days}\right)}$$

The resulting units for this recommended SPRG are in pCi/cm^2. The units are based on area because the SF used is the ground plane for external exposure.

4.2 Worker

4.2.1 Outdoor Worker

The outdoor worker land use equation, presented here, contains the following exposure pathways and exposure routes:

- exposure to contamination deposited on streets and sidewalks (incidental ingestion, inhalation of particulates and external exposure to ionizing radiation from settled dust using ground plane toxicity values)

$$SPRG_{dow\text{-}total}\left(\frac{pCi}{cm^2}\right)=\frac{TR\times t_w\,(25\ years)\times\lambda\left(\frac{1}{year}\right)}{\left(\frac{1\text{-}e^{-kt_w}}{kt_w}\right)\times\left(1\text{-}e^{-\lambda t_w}\right)\times EF_w\left(\frac{225\ days}{year}\right)\times ED_w\,(25\ years)\times\left[\begin{array}{l}\left(SF_{d\text{-}oral}\left(\frac{risk}{pCi}\right)\times IF_w\left(\frac{90\ cm^2}{day}\right)\right)+\\ \left(SF_{inh}\left(\frac{risk}{pCi}\right)\times HR_w\left(\frac{2.5\ m^3}{hour}\right)\times\frac{1}{PEF\left(\frac{m^3}{Kg}\right)}\times SLF\left(\frac{6.6\bar{E}+08\ cm^2}{Kg}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\right)+\\ \left(SF_{d\text{-}ext}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{cm^2}\right)\right]\times F_{AM}\times F_{OFF\text{-}SET}\times GSF_o\,(1.0)\times ACF\,(1.0)\left(\frac{1day}{24hours}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\times\left(\frac{1year}{365days}\right)\right)\end{array}\right]}$$

where

$$IF_w\left(\frac{90\ cm^2}{day}\right)=FTSS_h\,(0.5)\times ET_w\left(\frac{8\ hours}{day}\right)\times SE\,(0.5)\times SA_w\left(\frac{45\ cm^2}{event}\right)\times FQ_w\left(\frac{1\ event}{hour}\right)$$

The resulting units for this recommended SPRG are in pCi/cm^2. The units are based on area because the SF used is the ground plane for external exposure and the ingestion route is based on hand surface area contacting dust on surfaces and subsequent hand to mouth transfer events. This equation is for values of k that are greater than 0; when k=0, the dissipation term is not quantified to avoid division by zero.

- 3-D Exposure to Direct External Exposure (Materials with fixed contamination at infinite depth in outside walls, streets and sidewalks using infinite soil volume toxicity values)

$$SPRG_{3\text{-}Dow\text{-}sv}\left(\frac{pCi}{g}\right)=\frac{TR\times t_w\,(25\ years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_w\left(\frac{225\ days}{year}\right)\times ED_w\,(25\ years)\times\left(\frac{1\ day}{24\ hours}\right)\times GSF_o\,(1.0)\times ACF\,(1.0)\times\left(1\text{-}e^{-\lambda t_w}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ year}{365\ days}\right)\times F_{SURF}}$$

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Author: eldarois
Subject: Note
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It would appear that this equation should be the same as the external component of the 1st equation, but it is quite different.

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 3-D Exposure to Direct External Exposure (Materials with fixed contamination at 1cm in outside walls, streets and sidewalks using 1cm soil volume toxicity values)

$$SPRG_{3\text{-Dow-1cm}}\left(\frac{pCi}{g}\right)=\frac{TR\times t_{w}\,(25\text{ years})\times\lambda\left(\frac{1}{\text{years}}\right)}{SF_{ext\text{-}1cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_{w}\left(\frac{225\text{ days}}{\text{year}}\right)\times ED_{w}\,(25\text{ years})\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times GSF_{o}\,(1.0)\times ACF\,(1.0)\times\left(1-e^{-\lambda t_{w}}\right)\times ET_{w}\left(\frac{8\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ year}}{365\text{ days}}\right)\times F_{SURF}}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 3-D Exposure to Direct External Exposure (Materials with fixed contamination at 5cm in outside walls, streets and sidewalks using 5cm soil volume toxicity values)

$$SPRG_{3\text{-Dow-5cm}}\left(\frac{pCi}{g}\right)=\frac{TR\times t_{w}\,(25\text{ years})\times\lambda\left(\frac{1}{\text{years}}\right)}{SF_{ext\text{-}5cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_{w}\left(\frac{225\text{ days}}{\text{year}}\right)\times ED_{w}\,(25\text{ years})\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times GSF_{o}\,(1.0)\times ACF\,(1.0)\times\left(1-e^{-\lambda t_{w}}\right)\times ET_{w}\left(\frac{8\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ year}}{365\text{ days}}\right)\times F_{SURF}}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 3-D Exposure to Direct External Exposure (Materials with fixed contamination at 15cm in outside walls, streets and sidewalks using 15cm soil volume toxicity values)

$$SPRG_{3\text{-Dow-15cm}}\left(\frac{pCi}{g}\right)=\frac{TR\times t_{w}\,(25\text{ years})\times\lambda\left(\frac{1}{\text{years}}\right)}{SF_{ext\text{-}15cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_{w}\left(\frac{225\text{ days}}{\text{year}}\right)\times ED_{w}\,(25\text{ years})\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times GSF_{o}\,(1.0)\times ACF\,(1.0)\times\left(1-e^{-\lambda t_{w}}\right)\times ET_{w}\left(\frac{8\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ year}}{365\text{ days}}\right)\times F_{SURF}}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 3-D Exposure to Direct External Exposure (Fixed contaminated dust on surfaces of outside walls, streets and sidewalks using ground plane toxicity values)

$$SPRG_{3\text{-Dow-gp}}\left(\frac{pCi}{cm^{2}}\right)=\frac{TR\times t_{w}\,(25\text{ years})\times\lambda\left(\frac{1}{\text{years}}\right)}{SF_{ext}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{cm^{2}}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_{w}\left(\frac{225\text{ days}}{\text{year}}\right)\times ED_{w}\,(25\text{ years})\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times GSF_{o}\,(1.0)\times ACF\,(1.0)\times\left(1-e^{-\lambda t_{w}}\right)\times ET_{w}\left(\frac{8\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ year}}{365\text{ days}}\right)\times F_{SURF}}$$

The resulting units for this recommended SPRG are in pCi/cm^2. The units are based on area because the SF used is the ground plane for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab using infinite soil volume toxicity values)

$$SPRG_{2\text{-Dow-sv}}\left(\frac{pCi}{g}\right)=\frac{TR\times t_{w}\,(25\text{ years})\times\lambda\left(\frac{1}{\text{years}}\right)}{SF_{ext}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_{w}\left(\frac{225\text{ days}}{\text{year}}\right)\times ED_{w}\,(25\text{ years})\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times GSF_{o}\,(1.0)\times ACF\times\left(1-e^{-\lambda t_{w}}\right)\times ET_{w}\left(\frac{8\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ year}}{365\text{ days}}\right)}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab at 1cm depth using 1cm soil volume toxicity values)

$$SPRG_{2\text{-Dow-1cm}}\left(\frac{pCi}{g}\right)=\frac{TR\times t_{w}\,(25\text{ years})\times\lambda\left(\frac{1}{\text{years}}\right)}{SF_{ext\text{-}1cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_{w}\left(\frac{225\text{ days}}{\text{year}}\right)\times ED_{w}\,(25\text{ years})\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times GSF_{o}\,(1.0)\times ACF\times\left(1-e^{-\lambda t_{w}}\right)\times ET_{w}\left(\frac{8\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ year}}{365\text{ days}}\right)}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab at 5cm depth using 5cm soil volume toxicity values)

$$SPRG_{2\text{-Dow-5cm}}\left(\frac{pCi}{g}\right)=\frac{TR\times t_{w}\,(25\text{ years})\times\lambda\left(\frac{1}{\text{years}}\right)}{SF_{ext\text{-}5cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_{w}\left(\frac{225\text{ days}}{\text{year}}\right)\times ED_{w}\,(25\text{ years})\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times GSF_{o}\,(1.0)\times ACF\times\left(1-e^{-\lambda t_{w}}\right)\times ET_{w}\left(\frac{8\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ year}}{365\text{ days}}\right)}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab at15cm depth using 15cm soil volume toxicity values)

$$SPRG_{2\text{-Dow-15cm}}\left(\frac{pCi}{g}\right)=\frac{TR\times t_{w}\,(25\text{ years})\times\lambda\left(\frac{1}{\text{years}}\right)}{SF_{ext\text{-}15cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_{w}\left(\frac{225\text{ days}}{\text{year}}\right)\times ED_{w}\,(25\text{ years})\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times GSF_{o}\,(1.0)\times ACF\times\left(1-e^{-\lambda t_{w}}\right)\times ET_{w}\left(\frac{8\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ year}}{365\text{ days}}\right)}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab using ground plane toxicity values)

$$SPRG_{2\text{-Dow-gp}}\left(\frac{pCi}{cm^{2}}\right)=\frac{TR\times t_{w}\,(25\text{ years})\times\lambda\left(\frac{1}{\text{years}}\right)}{SF_{ext}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{cm^{2}}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_{w}\left(\frac{225\text{ days}}{\text{year}}\right)\times ED_{w}\,(25\text{ years})\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times GSF_{o}\,(1.0)\times ACF\times\left(1-e^{-\lambda t_{w}}\right)\times ET_{w}\left(\frac{8\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ year}}{365\text{ days}}\right)}$$

The resulting units for this recommended SPRG are in pCi/cm^2. The units are based on area because the SF used is the ground plane for external exposure.

.2 Indoor Worker

The indoor worker land use equation, presented here, contains the following exposure pathways:

- exposure to contamination deposited on streets and sidewalks (incidental ingestion, inhalation of particulates and external exposure to ionizing radiation from settled dust using ground plane toxicity values)

This page contains no comments

$$SPRG_{diw\text{-}total}\left(\frac{pCi}{cm^2}\right)=\frac{TR\times t_w\,(25\ years)\times\lambda\left(\frac{1}{year}\right)}{\left(\frac{1-e^{-kt_w}}{kt_w}\right)\times\left(1-e^{-\lambda t_w}\right)\times EF_w\left(\frac{250\ days}{year}\right)\times ED_w\,(25\ years)\times\left[\begin{array}{l}\left(SF_{d\text{-}oral}\left(\frac{risk}{pCi}\right)\times IF_w\left(\frac{90\ cm^2}{day}\right)\right)+\\ \left(SF_{inh}\left(\frac{risk}{pCi}\right)\times HR_w\left(\frac{2.5\ m^3}{hour}\right)\times\frac{1}{PEF\left(\frac{m^3}{Kg}\right)}\times SLF\left(\frac{6.\bar{6}E+08\ cm^2}{Kg}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\times DF_i\,(0.4)\right)+\\ \left(SF_{d\text{-}ext}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{cm^2}\right)\right]\times F_{AM}\times F_{OFF\text{-}SET}\times GSF_i\,(0.4)\times ACF\,(1.0)\times\left(\frac{1day}{24hours}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\times\left(\frac{1year}{365days}\right)\right)\end{array}\right]}$$

where

$$IF_w\left(\frac{90\ cm^2}{day}\right)=FTSS_h\,(0.5)\times ET_w\left(\frac{8\ hours}{day}\right)\times SE\,(0.5)\times SA_w\left(\frac{45\ cm^2}{event}\right)\times FQ_w\left(\frac{1\ event}{hour}\right)$$

The resulting units for this recommended SPRG are in pCi/cm^2. The units are based on area because the SF used is the ground plane for external exposure and the ingestion route is based on hand surface area contacting dust on surfaces and subsequent hand to mouth transfer events. This equation is for values of k that are greater than 0; when k=0, the dissipation term is not quantified to avoid division by zero.

- 3-D Exposure to Direct External Exposure (Materials with fixed contamination at infinite depth in outside walls, streets and sidewalks using infinite soil volume toxicity values)

$$SPRG_{3\text{-}Diw\text{-}sv}\left(\frac{pCi}{g}\right)=\frac{TR\times t_w\,(25\ years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_w\left(\frac{250\ days}{year}\right)\times ED_w\,(25\ years)\times\left(\frac{1\ day}{24\ hours}\right)\times GSF_i\,(0.4)\times ACF\,(1.0)\times\left(1-e^{-\lambda t_w}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ year}{365\ days}\right)\times F_{SURF}}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 3-D Exposure to Direct External Exposure (Materials with fixed contamination at 1cm in outside walls, streets and sidewalks using 1cm soil volume toxicity values)

$$SPRG_{3\text{-}Diw\text{-}1cm}\left(\frac{pCi}{g}\right)=\frac{TR\times t_w\,(25\ years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext\text{-}1cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_w\left(\frac{250\ days}{year}\right)\times ED_w\,(25\ years)\times\left(\frac{1\ day}{24\ hours}\right)\times GSF_i\,(0.4)\times ACF(1.0)\times\left(1-e^{-\lambda t_w}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ year}{365\ days}\right)\times F_{SURF}}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 3-D Exposure to Direct External Exposure (Materials with fixed contamination at 5cm in outside walls, streets and sidewalks using 5cm soil volume toxicity values)

$$SPRG_{3\text{-}Diw\text{-}5cm}\left(\frac{pCi}{g}\right)=\frac{TR\times t_w\,(25\ years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext\text{-}5cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_w\left(\frac{250\ days}{year}\right)\times ED_w\,(25\ years)\times\left(\frac{1\ day}{24\ hours}\right)\times GSF_i\,(0.4)\times ACF(1.0)\times\left(1-e^{-\lambda t_w}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ year}{365\ days}\right)\times F_{SURF}}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 3-D Exposure to Direct External Exposure (Materials with fixed contamination at 15cm in outside walls, streets and sidewalks using 15cm soil volume toxicity values)

$$SPRG_{3\text{-}Diw\text{-}15cm}\left(\frac{pCi}{g}\right)=\frac{TR\times t_w\,(25\ years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext\text{-}15cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_w\left(\frac{250\ days}{year}\right)\times ED_w\,(25\ years)\times\left(\frac{1\ day}{24\ hours}\right)\times GSF_i\,(0.4)\times ACF\,(1.0)\times\left(1-e^{-\lambda t_w}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ year}{365\ days}\right)\times F_{SURF}}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 3-D Exposure to Direct External Exposure (Fixed contaminated dust on outside walls, streets and sidewalks using ground plane toxicity values)

$$SPRG_{3\text{-}Diw\text{-}gp}\left(\frac{pCi}{cm^2}\right)=\frac{TR\times t_w\,(25\ years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{cm^2}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_w\left(\frac{250\ days}{year}\right)\times ED_w\,(25\ years)\times\left(\frac{1\ day}{24\ hours}\right)\times GSF_i\,(0.4)\times ACF(1.0)\times\left(1-e^{-\lambda t_w}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ year}{365\ days}\right)\times F_{SURF}}$$

The resulting units for this recommended SPRG are in pCi/cm^2. The units are based on area because the SF used is the ground plane for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab using infinite soil volume toxicity values)

$$SPRG_{2\text{-}Diw\text{-}sv}\left(\frac{pCi}{g}\right)=\frac{TR\times t_w\,(25\ years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_w\left(\frac{250\ days}{year}\right)\times ED_w\,(25\ years)\times\left(\frac{1\ day}{24\ hours}\right)\times GSF_i\,(0.4)\times ACF\times\left(1-e^{-\lambda t_w}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ year}{365\ days}\right)}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab at 1cm depth using 1cm soil volume toxicity values)

$$SPRG_{2\text{-}Diw\text{-}1cm}\left(\frac{pCi}{g}\right)=\frac{TR\times t_w\,(25\ years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext\text{-}1cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_w\left(\frac{250\ days}{year}\right)\times ED_w\,(25\ years)\times\left(\frac{1\ day}{24\ hours}\right)\times GSF_i\,(0.4)\times ACF\times\left(1-e^{-\lambda t_w}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ year}{365\ days}\right)}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab at 5cm depth using 5cm soil volume toxicity values)

This page contains no comments

$$SPRG_{2\text{-}Diw\text{-}5cm}\left(\frac{pCi}{g}\right)=\frac{TR\times t_w\,(25\ years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext\text{-}5cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_w\left(\frac{250\ days}{year}\right)\times ED_w\,(25\ years)\times\left(\frac{1\ day}{24\ hours}\right)\times GSF_i\,(0.4)\times ACF\times\left(1-e^{-\lambda t_w}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ year}{365\ days}\right)}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab at 15cm depth using 15cm soil volume toxicity values)

$$SPRG_{2\text{-}Diw\text{-}15cm}\left(\frac{pCi}{g}\right)=\frac{TR\times t_w\,(25\ years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext\text{-}15cm}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{g}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_w\left(\frac{250\ days}{year}\right)\times ED_w\,(25\ years)\times\left(\frac{1\ day}{24\ hours}\right)\times GSF_i\,(0.4)\times ACF\times\left(1-e^{-\lambda t_w}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ year}{365\ days}\right)}$$

The resulting units for this recommended SPRG are in pCi/g. The units are based on mass because the SF used is the soil volume for external exposure.

- 2-D Exposure to Direct External Exposure (Materials with fixed contamination in a finite slab using ground plane toxicity values)

$$SPRG_{2\text{-}Diw\text{-}gp}\left(\frac{pCi}{cm^2}\right)=\frac{TR\times t_w\,(25\ years)\times\lambda\left(\frac{1}{years}\right)}{SF_{ext}\left[\left(\frac{risk}{year}\right)/\left(\frac{pCi}{cm^2}\right)\right]\times F_{CD}\times F_{AM}\times F_{OFF\text{-}SET}\times EF_w\left(\frac{250\ days}{year}\right)\times ED_w\,(25\ years)\times\left(\frac{1\ day}{24\ hours}\right)\times GSF_i\,(0.4)\times ACF\times\left(1-e^{-\lambda t_w}\right)\times ET_w\left(\frac{8\ hours}{day}\right)\times\left(\frac{1\ year}{365\ days}\right)}$$

The resulting units for this recommended SPRG are in pCi/cm^2. The units are based on area because the SF used is the ground plane for external exposure.

4.3 Exposure Parameter Justification

The following sections describe the exposure parameter default variables and the values selected.

4.3.1 Exposure Time (ET)

The exposure time represents the hours per day that a receptor spends exposed to a source. The exposure times vary by exposure scenario, age of the receptor and whether the source is located on a hard or soft surface. This calculator only calculates exposure to hard surfaces. For the resident ingestion pathway the hard surface exposure time of 4 hours per day is used for adult and child. This value is from the EPA Office of Pesticide Programs (OPP). For inhalation and external exposure the exposure time indoors is set at 16.4 hours per day and the exposure time outdoors is set at 1.752 hours per day. These values are from the 1997 Exposure Factors Handbook. Note, that inhalation and subsequent ingestion of dust particles trapped in mucous is not quantified in the SPRG equations due to lack of exposure information.

For the outdoor and indoor worker, exposure time for the dust ingestion exposure route is based on exposure to hard surfaces. For this calculator, the defaults were set at 8 hr/d. The exposure time for direct external exposure is the entire work day or 8 hr/d.

4.3.2 Fraction Transferred from Surface to Skin (FTSS)

In general, this is the fraction of residue on a surface that can be transferred to skin. US EPA 2003 (pg D-5) states that hand press experiments were conducted on dry [illegible]n. Transfers of 50% were observed for hard surfaces. These are considered representative of the WTC situation and were adopted for this calculator.

4.3.3 Surface Area (SA)

In general, this is the skin area contacted during the mouthing event. The OPP default is 20 cm^2 based on the surface area of the 3 fingers that a child will most likely use for hand to mouth transfer. Total skin surface area increases by about 3 fold from age 2 to an adult. Average area of both hands for an adult is about 900 cm^2, so it would be about 300 cm^2 for a 2 year old. Assuming 3 fingers of one hand represents about 5% of the total area of both hands, it would increase from 15 cm^2 to 45 cm^2 from age 2 to adult. On this basis, the SA values used here are assumed to start at 15 cm^2 and increase linearly to 45 cm^2 at age 17 and remain constant after that.

4.3.4 Frequency of Hand to Mouth (FQ)

The OPP defaults suggest 9.5 events/hr for toddlers, based on observations at day care centers. This will decline with age, but very little data are available for other ages. Michaud et al (1994) assumed a mouthing frequency of twice per day for adults. It was decided to group the age cohort-specific hand-to-mouth frequency as follows: 1 to 6 yr - 9.5 times/hr, 7 to 12yr - 5 times/hr, 8 to 18 yr - 2 times/hr and 19 to 31 yr - 1 time/hr.

4.3.5 Saliva Extraction Factor (SE)

In general, the fraction transferred from skin to mouth will depend on the contaminant, mouthing time and other behavioral patterns. The OPP default is 50%, based on pesticide studies. Michaud et al (1994) assumed that all of the residues deposited on the fingertips would be transferred to the mouth, twice per day. In the Binghamton re-entry guideline derivation, a range of factors were used: 0.05, 0.1, and 0.25 representing the fraction of residue on hand that is transferred to the mouth (Kim and Hawley, 1985). For purposes of this assessment, the OPP default of 50% was selected for all ages.

4.3.6 Resident Age-Adjusted Dust Ingestion Rate (IF_r)

To account for the variability in exposure activities between children and adults, the age-adjusted dust ingestion rate equation was developed. This equation takes into account the differences in hand to mouth behavior, hand surface area, and exposure to hard and soft surfaces over the exposure durations of an adult and child.

4.3.7 Worker Dust Ingestion Rate (IF_w)

This dust ingestion equation calculates the intake for a worker based on exposure to hard surfaces.

4.3.8 Dissipation Rate Constant (k)

In some circumstances, the load of dust on a contaminated surface, to which receptors are exposed, may decline over time. Dissipation of dust may result from weather, cleaning and transfer to skin and clothing. Different surfaces may be cleaned at different rates and any dissipation rate used should consider a representative cleaning frequency. To determine whether dissipation is a factor at a given site, the site manager should establish whether a significant reservoir of contaminated dust is present. Such reservoirs may function as sources of dust and negate the impacts of dissipation mechanisms. The first step in identifying the presence of a reservoir is to examine the history. If a waste site was created through disposal, deposition or equipment leaks over an extended period of time, then the contaminant may have seeped deep into the surface. Porous surfaces such as cement or wood are also more likely to have subsurface contamination. When reservoirs are less likely to exist, such as at sites where contamination is the result of a single spill, dust cloud or event, it may be more important to account for dissipation of surface loads. For fixed contamination in materials (outside walls, streets and pavement), or on material surfaces, in the 3-D and 2-D equations, the dissipation term is not included as dissipation is not expected.

The recommended default value for the dissipation rate constant is 0.0. This assumes that a contaminant reservoir is present. However, the variable is adjustable in the SPRG calculator. If a dissipation rate constant is used, it is assumed that the dust was deposited as a one time event (i.e.; dust cloud). Also, if a dissipation rate is applied, it is assumed that it is applicable from the point in time the SPRG is calculated into the future. The discussion below provides a review of the indoor surfaces

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Sequence number: 1
Author: eldarois
Subject: Note
Date: 2/18/2008 10:32:24 AM

I know of no adults that put three fingers in their mouth regularly. This is an ultra-conservative assumption.

Sequence number: 2
Author: eldarois
Subject: Note
Date: 2/18/2008 10:32:07 AM

Yes but, these frequency values are linked to the SA values. So an adult will place 45cm^2 of hand surface to his mouth 1 time per hour? I do not think this is reasonable.

Sequence number: 3
Author: eldarois
Subject: Note
Date: 2/18/2008 10:32:38 AM

Also quite high, especially for indoor workers where the hands are washed several times per day.

literature related to this issue and provides an alternative dissipation rate constant value. Site specific outdoor dissipation rate constants can be used. This equation is for values of k that are greater than 0; when k=0, the dissipation term is not quantified to avoid division by zero. See the following text.

Based on many indoor studies presented in EPA 2003 (pg. D-5), there is strong support for considering dissipation in setting criteria for outdoor building clean-ups. A study of the Binghamton State office Building found that dioxin has dissipated over time according to first order kinetics with a 20 to 22 month half life. Even though this was an indoor study, the same principles would apply for outdoor surfaces. This dissipation is thought to occur from a combination of cleaning, resuspension and dilution with uncontaminated dust (and possibly some volatilization). These same physical dissipation processes would apply to other compounds addressed in this study as well. Therefore, the other compounds were assumed to dissipate at the same rate as dioxin. In summary, a 22 month half life (dissipation rate constant of 0.38 yr^{-1}) was [illegible]pted. Exposures were calculated in a series of time steps where the residue level was assumed to dissipate according to first order kinetics:

[illegible] = $CSL_{initial}\ e^{-kt}$
CSL = Contaminant Surface Load (ug/cm^2)
$CSL_{initial}$ = Initial Contaminant Surface Load (ug/cm^2)
k = Dissipation Rate Constant (yr^{-1})
t = Time (yr)

The above equation steps are shown for completeness. This SPRG calculator computes a concentration of contaminants in dust that will not exceed a target risk. The equation above simply derives the amount of dust. For this SPRG calculator, the only parts of the above equation that are relevant are the dissipation rate constant and time. By putting these variables in the denominator of the recommended SPRG resident and worker ingestion of dust equations, a higher recommended SPRG concentration would be calculated.

Further evidence that care should be taken in selecting a dissipation rate comes from the classic example of leaded gasoline. According to "*The Role of Resuspended Soil in Lead Flows in the California South Coast Air Basin*" the soil lead concentration is still over 6 times the baseline lead level from 1919 to 1933 levels. Despite leaded gasoline being phased out from 1967 to 1970 (40 years ago), the lead dissipation rate in soil is not expected to reach a steady state for more than 100 years.

WARNING: Using a dissipation rate constant or changing the value of *t* should only be done once a complete understanding of the mathematics involved in deriving the equation is gained and the [illegible]ditions have been fully investigated. The following exhibit displays the results obtained by changing the value *t*. *t* is equal to ED in all equations.

In the simplified SPRG equation: SPRG=TR/CDI*SF*$(1-e^{(-kt)})/(kt)$ where SPRG is preliminary remediation goal, TR is target risk, CDI is chronic daily intake, SF is the radionuclide-specific slope factor and $(1-e^{(-kt)})/(kt)$ is the dissipation term, Exhibit 1 shows the results of changing t. Exhibit 2 shows the results of changing k.

Exhibit 1. Results Obtained By Changing The Value *t*.

t	k	SF	CDI	TR	$(1-e^{(-kt)})/(kt)$	SPRG
year	year-1	risk/pCi	cm^2	risk	unitless	pCi/cm^2
0	0.38	1.00E-05	400	1.00E-06	1.00E+01	2.5E-04
1	0.38	1.00E-05	400	1.00E-06	8.32E-01	3.01E-04
2	0.38	1.00E-05	400	1.00E-06	7.00E-01	3.57E-04
3	0.38	1.00E-05	400	1.00E-06	5.97E-01	4.19E-04
4	0.38	1.00E-05	400	1.00E-06	5.14E-01	4.86E-04
[illegible]	0.38	1.00E-05	400	1.00E-06	4.48E-01	5.59E-04
[illegible]	0.38	1.00E-05	400	1.00E-06	3.94E-01	6.35E-04
7	0.38	1.00E-05	400	1.00E-06	3.50E-01	7.15E-04
8	0.38	1.00E-05	400	1.00E-06	3.13E-01	7.98E-04
9	0.38	1.00E-05	400	1.00E-06	2.83E-01	8.84E-04
10	0.38	1.00E-05	400	1.00E-06	2.57E-01	9.72E-04
11	0.38	1.00E-05	400	1.00E-06	2.36E-01	1.06E-03
12	0.38	1.00E-05	400	1.00E-06	2.17E-01	1.15E-03
13	0.38	1.00E-05	400	1.00E-06	2.01E-01	1.24E-03
14	0.38	1.00E-05	400	1.00E-06	1.87E-01	1.34E-03
15	0.38	1.00E-05	400	1.00E-06	1.75E-01	1.43E-03
16	0.38	1.00E-05	400	1.00E-06	1.64E-01	1.52E-03
17	0.38	1.00E-05	400	1.00E-06	1.55E-01	1.62E-03
18	0.38	1.00E-05	400	1.00E-06	1.46E-01	1.71E-03
19	0.38	1.00E-05	400	1.00E-06	1.38E-01	1.81E-03
20	0.38	1.00E-05	400	1.00E-06	1.32E-01	1.90E-03
21	0.38	1.00E-05	400	1.00E-06	1.25E-01	2.00E-03
22	0.38	1.00E-05	400	1.00E-06	1.20E-01	2.09E-03
23	0.38	1.00E-05	400	1.00E-06	1.14E-01	2.19E-03
24	0.38	1.00E-05	400	1.00E-06	1.10E-01	2.28E-03
25	0.38	1.00E-05	400	1.00E-06	1.05E-01	2.38E-03
26	0.38	1.00E-05	400	1.00E-06	1.01E-01	2.47E-03
27	0.38	1.00E-05	400	1.00E-06	9.75E-02	2.57E-03
28	0.38	1.00E-05	400	1.00E-06	9.40E-02	2.66E-03
29	0.38	1.00E-05	400	1.00E-06	9.07E-02	2.76E-03
[illegible]	0.38	1.00E-05	400	1.00E-06	8.77E-02	2.85E-03

Exhibit 2. Results Obtained By Changing The Value k.

t	k	SF	CDI	TR	$(1-e^{(-kt)})/(kt)$	PRG
year	year-1	risk/pCi	cm^2	risk	unitless	pCi/cm^2

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Sequence number: 1
Author: eldarois
Subject: Note
Date: 2/18/2008 10:34:35 AM

This is all true. However, for the first case where fixed contamination is on an outdoor surface, a k factor from weathering should be encouraged and applied. Also, more guidance on K factors from weathering must be available and should be included. This guidance discourages the use of K unless it is well understood and documented but it is likely a rare event that a zero value of K is actually found.

30	0.000001	1.00E-05	400	1.00E-06	1.00E+00	2.50E-04
30	0.033331	1.00E-05	400	1.00E-06	6.32E-01	3.95E-04
30	0.066661	1.00E-05	400	1.00E-06	4.32E-01	5.78E-04
30	0.099991	1.00E-05	400	1.00E-06	3.17E-01	7.89E-04
30	0.133321	1.00E-05	400	1.00E-06	2.45E-01	1.02E-03
30	0.166651	1.00E-05	400	1.00E-06	1.99E-01	1.26E-03
[illegible]	0.199981	1.00E-05	400	1.00E-06	1.66E-01	1.50E-03
30	0.233311	1.00E-05	400	1.00E-06	1.43E-01	1.75E-03
30	0.266641	1.00E-05	400	1.00E-06	1.25E-01	2.00E-03
30	0.299971	1.00E-05	400	1.00E-06	1.11E-01	2.25E-03
30	0.333301	1.00E-05	400	1.00E-06	1.00E-01	2.50E-03
30	0.366631	1.00E-05	400	1.00E-06	9.09E-02	2.75E-03
30	0.399961	1.00E-05	400	1.00E-06	8.33E-02	3.00E-03
30	0.433291	1.00E-05	400	1.00E-06	7.69E-02	3.25E-03
30	0.466621	1.00E-05	400	1.00E-06	7.14E-02	3.50E-03
30	0.499951	1.00E-05	400	1.00E-06	6.67E-02	3.75E-03
30	0.533281	1.00E-05	400	1.00E-06	6.25E-02	4.00E-03
30	0.566611	1.00E-05	400	1.00E-06	5.88E-02	4.25E-03
30	0.599941	1.00E-05	400	1.00E-06	5.56E-02	4.50E-03
30	0.633271	1.00E-05	400	1.00E-06	5.26E-02	4.75E-03
30	0.666601	1.00E-05	400	1.00E-06	5.00E-02	5.00E-03
30	0.699931	1.00E-05	400	1.00E-06	4.76E-02	5.25E-03
30	0.733261	1.00E-05	400	1.00E-06	4.55E-02	5.50E-03
30	0.766591	1.00E-05	400	1.00E-06	4.35E-02	5.75E-03
30	0.799921	1.00E-05	400	1.00E-06	4.17E-02	6.00E-03
30	0.833251	1.00E-05	400	1.00E-06	4.00E-02	6.25E-03
30	0.866581	1.00E-05	400	1.00E-06	3.85E-02	6.50E-03
30	0.899911	1.00E-05	400	1.00E-06	3.70E-02	6.75E-03
30	0.933241	1.00E-05	400	1.00E-06	3.57E-02	7.00E-03
30	0.966571	1.00E-05	400	1.00E-06	3.45E-02	7.25E-03
30	1	1.00E-05	400	1.00E-06	3.33E-02	7.50E-03

4.3.9 Dermal Exposure

Other possible exposure pathways to be considered in a radiological analysis of contaminated outside surfaces would include internal contamination due to puncture wounds and dermal absorption of radionuclides deposited on the skin. However, the radiation doses caused by these two pathways would be de minimis and much smaller than the doses caused by the other potential pathways already considered for most radionuclides (Kennedy and Strenge 1992 in Section 3.1.2). Therefore, dermal pathways are not included in the current version of this SPRG calculator. If one desires to calculate dermal risk, one method would be to calculate the dose based on either adherence of dust/soil to dry or wet skin. The mobility of the radionuclide, the range of the emitted beta particles, and the assumed exposure parameters could be used to determine the percentage contribution of each component to the total calculated risk. The partitioning coefficient (Kd) of the beta-emitting radionuclide of concern could be used to determine the significance of the sweat layer. If this value approaches zero, then contaminated soil particulates are expected to dissolve, and diluted concentrations should be estimated from the original soil concentrations. If Kd is greater than zero, then the range of the emitted beta particles becomes the most important factor in determining if the radionuclide yields an unacceptable dose. If the range exceeds the average distribution of the sweat layer, then risk calculations are generally warranted. The dry deposition scenario typically dominates the whole exposure interval. Otherwise, the radionuclide is shielded by the sweat layer, and the corresponding indirect deposition contributions to the total risk are negligible.

4.3.10 Silt Loading Factor 1

It 2 [illegible]sumed that dust is being resuspended from the road surface. The amount of dust on an area of road is called the silt loading factor (SLF). For this calculator, a default value of 0.015 (g/m^2) was selected from *DOCUMENTATION FOR THE DRAFT 2002 NONPOINT SOURCE NATIONAL EMISSION INVENTORY FOR CRITERIA AND HAZARDOUS AIR POLLUTANTS (MARCH 2005 VERSION)*, Table 2, Page A-67, concerning paved roads. This value, combined with the California daily vehicle miles traveled by the length of the California interstates resulted in the most conservative PEF. Multiple SLFs were given for specific circumstances. The values range from 0.015 to 0.6 (g/m^2). The Table is reproduced below.

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Sequence number: 1
Author: eldarois
Subject: Note
Date: 2/18/2008 10:37:08 AM

So we have this factor but the value of K is set to 0? these assumptions are inconsistent.

Sequence number: 2
Author: eldarois
Subject: Note
Date: 2/18/2008 10:36:58 AM

This factor assumes that the silt is the source. This is an inconsistent assumption. I believe the introduction of "clean" silt will effectively reduce the inhalation intakes.

Table 2. 2002 Silt Loadings by State and Roadway Class Modeled in Paved Road Emission Factor Calculations (g/m²)

	Rural Roadway Classes						Urban Roadway Classes					
State	Inter-state	Other Principal Arterial	Minor Arterial	Major Collector	Minor Collector	Local	Inter-state	Freeways & Express-ways	Other Principal Arterial	Minor Arterial	Collector	Local
Alabama	0.015	0.06	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Alaska	0.015	0.2	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.03	0.2	0.2
'zona	0.015	0.06	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.03	0.06	0.2
ansas	0.015	0.06	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.6
alifomia	0.015	0.03	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.03	0.2	0.2
Colorado	0.015	0.06	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Connecticut	0.015	0.03	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Delaware	0.015	0.03	0.03	0.2	0.2	0.2	0.015	0.015	0.03	0.03	0.06	0.2
Dist. of Columbia	0.015	0.6	0.6	0.6	0.6	0.6	0.015	0.015	0.03	0.03	0.06	0.2
Florida	0.015	0.03	0.06	0.2	0.2	0.2	0.015	0.015	0.03	0.03	0.06	0.2
Georgia	0.015	0.06	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.03	0.06	0.2
Hawaii	0.015	0.03	0.06	0.2	0.2	0.2	0.015	0.015	0.03	0.03	0.06	0.2
Idaho	0.015	0.2	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Illinois	0.015	0.06	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.03	0.06	0.2
Indiana	0.015	0.06	0.06	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Iowa	0.015	0.2	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Kansas	0.015	0.2	0.2	0.6	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Kentucky	0.015	0.06	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.03	0.2	0.2
Louisiana	0.015	0.06	0.06	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.6
Maine	0.015	0.06	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Maryland	0.015	0.03	0.06	0.2	0.2	0.6	0.015	0.015	0.03	0.03	0.06	0.2
Massachusetts	0.015	0.03	0.06	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Michigan	0.015	0.06	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.03	0.2	0.2
Minnesota	0.015	0.06	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Mississippi	0.015	0.06	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Missouri	0.015	0.06	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Montana	0.015	0.2	0.2	0.6	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Nebraska	0.015	0.2	0.2	0.6	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Nevada	0.015	0.2	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.03	0.06	0.2
New Hampshire	0.015	0.03	0.06	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.2
New Jersey	0.015	0.03	0.06	0.2	0.2	0.2	0.015	0.015	0.03	0.06	0.2	0.2
New Mexico	0.015	0.2	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.2
New York	0.015	0.06	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.03	0.06	0.2
North Carolina	0.015	0.03	0.06	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.2
North Dakota	0.015	0.2	0.2	0.6	0.6	0.6	0.015	0.015	0.03	0.2	0.2	0.2
Ohio	0.015	0.03	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Oklahoma	0.015	0.06	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Oregon	0.015	0.2	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Pennsylvania	0.015	0.03	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Rhode Island	0.015	0.03	0.06	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.6
South Carolina	0.015	0.06	0.06	0.2	0.2	0.6	0.015	0.015	0.03	0.03	0.2	0.6
South Dakota	0.015	0.2	0.2	0.6	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.6
Tennessee	0.015	0.06	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Texas	0.015	0.06	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.6
Utah	0.015	0.2	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.03	0.06	0.2
Vermont	0.015	0.06	0.2	0.2	0.2	0.2	0.015	0.015	0.03	0.06	0.2	0.2
Virginia	0.015	0.03	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.03	0.2	0.2
Washington	0.015	0.06	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.2
West Virginia	0.015	0.06	0.2	0.2	0.2	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Wisconsin	0.015	0.06	0.2	0.2	0.6	0.6	0.015	0.015	0.03	0.06	0.2	0.2
Wyoming	0.015	0.2	0.2	0.2	0.6	0.6	0.015	0.015	0.06	0.2	0.2	0.2

properly use this calculator, the SLF should be measured in the field. Table 13.2.1-4 from AP42 is reproduced below showing the high end typical industrial facility SLF ıges. The values range from 0.09 to 400 (g/m^2). AP 42 suggests the following:

"Limited access roadways pose severe logistical difficulties in terms of surface sampling, and few silt loading data are available for such roads. Nevertheless, the available data do not suggest great variation in silt loading for limited access roadways from one part of the country to another. For annual conditions, a default value of 0.015 g/m^2 is recommended for limited access roadways. Even fewer of the available data correspond to worst-case situations, and elevated loadings are observed to be quickly depleted because of high traffic speeds and high ADT rates. A default value of 0.2 g/m^2 is recommended for short periods of time following application of snow/ice controls to limited access roads."

Table 13.2.1-4 (Metric And English Units). TYPICAL SILT CONTENT AND LOADING VALUES FOR PAVED ROADS AT INDUSTRIAL FACILITIES[a]

Industry	No. Of Sites	No. Of Samples	Silt Content (%)		No. Of Travel Lanes	Total Loading x 10^{-3}			Silt Loading (g/m^2)	
			Range	Mean		Range	Mean	Units[b]	Range	Mean
Copper smelting	1	3	15.4-21.7	19.0	2	12.9-19.5 45.8-69.2	15.9 55.4	kg/km lb/mi	188-400	292
Iron and steel production	9	48	1.1-35.7	12.5	2	0.006-4.77 0.020-16.9	0.495 1.75	kg/km lb/mi	0.09-79	9.7
Asphalt batching	1	3	2.6-4.6	3.3	1	12.1-18.0 43.0-64.0	14.9 52.8	kg/km lb/mi	76-193	120
Concrete batching	1	3	5.2-6.0	5.5	2	1.4-1.8 5.0-6.4	1.7 5.9	kg/km lb/mi	11-12	12
Sand and gravel processing	1	3	6.4-7.9	7.1	1	2.8-5.5 9.9-19.4	3.8 13.3	kg/km lb/mi	53-95	70
Municipal solid waste landfill	2	7	—	—	2	—	—	—	1.1-32.0	7.4
Quarry	1	6	—	—	2	—	—	—	2.4-14	8.2

[a] References 1-2,5-6,11-13. Values represent samples collected from *industrial* roads. Public road silt loading values are presented in Table-13.2.1-2. Dashes indicate information not available.

[b] Multiply entries by 1000 to obtain stated units; kilograms per kilometer (kg/km) and pounds per mile (lb/mi).

The default of 0.015 (g/m^2) was chosen, with California interstate ADTV, for this calculator as a conservative value suitable for producing default SPRGs. However, selecting a site-specific state and roadway class will provide a more accurate SLF and ADTV. For example, the North Dakota rural road class combined with local road type yields a mechanical PEF of 6.04×10^8 while the default state, road class and road type yields a mechanical PEF of 1.34×10^5. The United States Department of Transportation's Federal Highway Administration maintains an interactive HEPGIS website that supplies a map of the 50 States and Puerto Rico depicting functional

This page contains no comments

roadway classes. Simple website navigation instructions are available. To quickly get to the functional class information make sure the "Highway Information" tab is selected and then make sure the drop-down-menu under "General Maps" indicates "Functional Class". Now the user can use the zoom controls to reach the area of interest. This resource could be consulted to apply site-specific inputs for calculating ADTV and SLF for a risk assessment. Further state-specific information can be found by consulting the contact list.

4.3.11 Area Correction Factor

The RAGS/HHEM Part B model assumes that an individual is exposed to a source geometry that is effectively an infinite slab. The concept of an infinite slab means that thickness of the contaminated zone and its aerial extent are so large that it behaves as [1] re infinite in its physical dimensions. In practice, soil contaminated to a pth greater than about 15 cm and with an aerial extent greater than about 1,000 m^2 reate a radiation field comparable to that of an infinite slab. (U.S. EPA. 2000a)

To accommodate the fact that in most residential settings the assumption of an infinite slab source will result in overly conservative SSLs, an adjustment for source area is considered to be an important modification to the RAGS/HHEM Part B model. Thus, an area correction factor, ACF, has been added to the calculation of recommended SPRGs. Because of the likely variation in the dimensions/geometry of outdoor surface contamination, a default ACF of 1.0 is presented for all isotopes for the 3-D exposure models addressing outside walls, streets and sidewalks. For the 2-D exposure models addressing finite slabs, the ACF is made variable by isotope and area for site-specific analysis. This calculator allows the user to select from 8 different slab area sizes. If no size is selected for the finite slab analysis, the ACF from the most protective slab size is selected. For further information on the derivation of the isotope-specific/area-specific ACF values for 2-D slabs see Contaminated Slabs. For a description of other EPA default ACF values, follow the link here.

4.3.12 Surfaces Factor

The 3-D direct external exposure equations (building materials and dust) without F_{SURF} are single surface equations. The surfaces factor, in the default and site-specific equations, are based on exposure to 2 vertical surfaces (outside building surfaces on either side of a street) and a horizontal surface (road and sidewalk). This calculator uses the relationship between the dose rate coefficients for exposures in a contaminated outdoor setting and dose rate coefficients for an infinite source to calculate a surfaces factor (F_{SURF}). The dose quantity evaluated is the air kerma rate one meter above the sidewalk. The outdoor surfaces are as [2] o be contaminated to the same level. Locations in the midpoint of the sidewalk, next to the buildings and in the middle of the street for building heights of 12.5 ... 59 and 150 and 200 feet, were modeled to account for the dose contribution from multiple surfaces. Further, photon energies of each radioisotope were incorporated into the modeling. Please see the attached PDF file for detailed explanation of the process. Side Walk Dose Rate shows that building height doesn't effect the dose rate significantly after 150 feet. The above link shows a table of the F_{SURF} values used in this calculator for each radioisotope. F_{SURF} values were calculated for each position-specific and building-height specific combination.

4.4 Supporting Equations

There are two parts in the above land use equations that require further explanation. First is the use of the radionuclide decay constant (λ). Second is the variable particulate emission factor feature of this calculator.

4.4.1 Radionuclide Decay Constant

Each equation (where appropriate by media) has a decay constant term which is based on the half-life of the isotope (λ). λ = Decay constant (0.693/half-life in years). The intention of this term is to derive realistic SPRGs for isotopes with relatively short half-lives, compared to the exposure duration (ED). The term ($1 - e^{-\lambda t}$) takes into account the number of half-lives that will occur within the ED to calculate an appropriate value. Definitions of the input variables are in Table 1.

4.4.2 Particulate Emission Factor (PEF) [3]

Two particulate emission factors can be selected for this calculator: mechanically driven and the traditional wind driven emission factor.

4.4.2.1 Mechanically Driven PEF

This equation allows the user to input vehicle weight, road dimensions, distance traveled and time. Although developed for unpaved roads, this equation can be used to simulate emission factors after an incident. The receptor is assumed to be exposed to contaminants in the form of particulate matter with an aerodynamic particle diameter of less than 10 microns (PM10). Fugitive dust emissions are generated by vehicle traffic on roads. In addition, fugitive dust emissions are generated by wind blowing on surfaces. PEF for wind erosion emissions are assumed to occur at the center of the emission source. The ambient air dispersion of emissions, therefore, is different for these two classes of emission sources. For this reason, the PEF for unpaved road traffic and the PEF for wind erosion are calculated separately.

The following fugitive dust emission equation represents approximations of actual emissions at a specific site. Sensitive emission model parameters include the soil silt content and moisture content. Silt is defined as soil particles smaller than 75 micrometers (Fm) in diameter and can be measured as that proportion of soil passing a 200-mesh screen, using the American Society for Testing and Materials (ASTM) Method C-136. Soil moisture content is defined on a percent gravimetric basis [(g-water/g-soil) x 100] and should be approximated as the mean value for the duration of the construction project. In general, soil silt and moisture content are the most sensitive model parameters for which default values have been assigned, however, site-specific values will produce more accurate modeling results. Other emission model parameters have not been assigned default values and are typically defined on a site-specific basis. These parameters include the total distance traveled by vehicles, mean vehicle weight, average vehicle speed, and the area of roadway.

Mean vehicle weight (W) in tons is calculated by determining vehicle weight classes and numbers in that class. An example is presented below for site specific data. The default mean vehicle weight selected for this calculator is 3.2 tons based on page 4-285 in *PROCEDURES DOCUMENT FOR NATIONAL EMISSION INVENTORY, CRITERIA AIR POLLUTANTS 1985-1999*. EPA-454/R-01-006. However, there is wide variation in vehicle weights when considering industrial facilities. AP42 supporting documentation reveals in Table A1-6 that the mean vehicle weight can range up to 42 tons. Site-specific conditions should be considered or measured. The table is reproduced below.

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This is true for external gamma radiation. However, for factors such as SLF and PEF, this does not appear to be true since clean silt will be introduced into the contaminated area. The ACF adjustments do not consider inhalation pathways.

Sequence number: 2
Author: eldarois
Subject: Note
Date: 2/18/2008 10:37:43 AM

I am unaware of any outside structure that has been contaminated to any appreciable height. This is an overly conservative estimate and may lead to confusion of the end user. I suggest limiting the height choices to more realistic values.

Sequence number: 3
Author: eldarois
Subject: Note
Date: 2/18/2008 10:38:01 AM

This should be related to the value of K since the particles are assumed to be source particles. I would suggest that most of these particles would not be source particles.

TABLE A1-6. DETAILED INFORMATION FOR PAVED ROAD TESTS FOR REFERENCE 3

Run No.	Industrial category	Traffic	PM-10 emission factor, lb/VMT	Duration, min.	Mean wind speed, mph	Road width, ft	No. of vehicle passes	Vehicle characteristics: Mean vehicle weight, tons	No. of wheels	Mean vehicle speed, mph	Moisture content, %	Silt loading, g/m²	Silt, %
Y-1	Asphalt Batching	Medium Duty	0.257	274	5.37	13.8	47	3.6	6	10	0.22	91	2.6
Y-2	Asphalt Batching	Medium Duty	0.401	344	4.70	14.1	76	3.7	7	10	0.51	76	2.7
Y-3	Asphalt Batching	Medium Duty	0.0801	95	6.04	14.1	100	3.8	6.5	10	0.32	193	4.6
Y-4	Asphalt Batching	Medium Duty	0.441	102	5.59	14.1	150	3.7	6	10	0.32	193	4.6
Z-1	Concrete Batching	Medium Duty	0.699	170	6.71	24.3	149	8.0	10	10	a	11.3	6.0
Z-2	Concrete Batching	Medium Duty	1.63	143	9.84	24.9	161	8.0	10	15	a	12.4	5.2
Z-3	Concrete Batching	Medium Duty	4.01	109	9.62	24.9	62	8.0	10	15	a	12.4	5.2
AC-4	Copper Smelting	Medium Duty	3.86	38	8.72	34.8	45	5.7	7.4	10	0.43	287	19.8
AC-5	Copper Smelting	Medium Duty	3.13	36	9.62	34.8	36	7.0	6.2	15	0.43	188	15.4
AC-6	Copper Smelting	Medium Duty	1.35	33	4.92	34.8	42	3.1	4.2	20	0.53	400	21.7
AD-1	Sand and Gravel	Heavy Duty	3.27	110	7.61	12.1	11	42	11	23	a	94.8	6.4
AD-2	Sand and Gravel	Heavy Duty	0.753	69	5.15	12.1	16	39	17	23	a	63.6	7.9
AD-3	Sand and Gravel	Heavy Duty	0.513	76	3.13	12.1	20	40	15	23	a	52.6	7.0

1 lb/VMT = 281.9 g/VKT.
1 g/m² = 1.434 gr/ft²
a Not measured.

1-8

W = [(20 cars × 2 tons/car) + (10 trucks × 20 tons/truck)]/30 vehicles = 8 tons mean vehicle weight.

Sum of vehicle kilometers traveled (VKT), is estimated based on the size of the area of the contamination, the configuration of the road and amount of traffic. The default number of vehicles is based on California interstate statistics. The value of 171,796 vehicles was calculated by dividing the daily vehicle kilometers traveled by the length of the California interstates. These values resulted in the most conservative PEF. The area of the site contamination is assumed to be a square. Therefore, the square root of the area gives the distance traveled. A half acre site is 0.002024 km^2. The square root is 0.045 km. The number of times that each vehicle travels the road per day is also determined. An example is presented below.

VKT = 30 vehicles × 0.045 km/trip × 1 trips/day × 26 weeks/year × 5 days/week = 175.5 km/yr.

- Mechanical

$$PEF_m = \frac{Q}{C_m} \times \frac{1}{F_D} \times \frac{T \times A_R}{\dfrac{2.6 \times (s/12)^{.8} \times (W/3)^{0.4}}{(M_{dry}/0.2)^{0.3}} \times \left[\dfrac{(365-p)}{365}\right] \times 281.9 \times \Sigma VKT}$$

where

$$PEF_m = \text{mechanical particulate emission factor} \left(\frac{m^3}{kg}\right)$$

$$A_R = L_R \times W_R \times 0.092903 m^2/ft^2$$

$$F_D = 0.1852 + \frac{5.3537}{t_c} + \frac{-9.6318}{t_c^2}$$

$$\frac{Q}{C_m} = A \times \exp\left[\frac{(\ln A_s - B)^2}{C}\right]$$

$$W \text{ (mean vehicle weight in tons)} = \frac{\left[\left(\text{Number of cars} \times \dfrac{tons}{car}\right) + \left(\text{Number of trucks} \times \dfrac{tons}{truck}\right)\right]}{\text{Total number of vehicles}}$$

$$\Sigma VKT \text{ (sum of vehicle km/yr traveled)} = \text{Total number of vehicles} \times \frac{km}{trip} \times \frac{trips}{day} \times \frac{weeks}{yr} \times \frac{days}{week}$$

4.4.2.2 Wind Driven PEF

This equation allows the user to select geographical regions and input fraction of vegetative cover and wind speed. Inhalation of isotopes adsorbed to respirable particles (PM10) was assessed using default input parameters. This equation relates the contaminant concentration in soil with the concentration of respirable particles in the air due to fugitive dust emissions from contaminated soils. Regional-specific PEFs are derived using default values that correspond to a receptor point concentration of approximately 0.76 ug/m^3. The relationship is derived by Cowherd (1985) for a rapid assessment procedure applicable to a typical hazardous waste site, where the surface contamination provides a relatively continuous and constant potential for emission over an extended period of time (e.g. years). This represents an annual average emission rate based on wind erosion that should be compared with chronic health criteria; it is not appropriate for evaluating the potential for more acute exposures. Definitions of the input variables are in Table 1.

The equation below forms the basis for deriving a generic PEF for the inhalation pathway. For more details regarding specific parameters used in the PEF model, refer to Soil Screening Guidance for Radionuclides: Technical Background Document. The use of alternate values on a specific site should be justified and presented in an Administrative Record if considered in CERCLA remedy selection.

- Wind-driven

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Sequence number: 1
Author: eldarois
Subject: Note
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This assumes soil and is inconsistent with concrete surfaces. Especially if the K value is set to 0.

$$PEF_w = Q/C \times \frac{3{,}600}{0.036 \times (1-V) \times \left(U_m / U_t\right)^3 \times F(x)}$$

where

$$\frac{Q}{C_w} = A \times \exp\left[\frac{\left(\ln A_s - B\right)^2}{C}\right]$$

Table 1. Standard Recommended Default Factors

Symbol	Definition (units)	Default	Reference
	SPRG Units		
$SPRG_{dr\text{-}total}$	Residential SPRG for Exposure to Settled Dust on Surfaces (pCi/cm^2)	Isotope-specific	Determined in this calculator
$SPRG_{3\text{-}Dr\text{-}sv}$	3-D Residential SPRG for Direct External Exposure to Contaminated Building Materials using infinite soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{3\text{-}Dr\text{-}1cm}$	3-D Residential SPRG for Direct External Exposure to Contaminated Building Materials using 1cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{3\text{-}Dr\text{-}5cm}$	3-D Residential SPRG for Direct External Exposure to Contaminated Building Materials using 5 cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{3\text{-}Dr\text{-}15cm}$	3-D Residential SPRG for Direct External Exposure to Contaminated Building Materials using 15 cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{3\text{-}Dr\text{-}gp}$	Residential SPRG for Direct External Exposure to Contaminated Dust (pCi/cm^2)	Isotope-specific	Determined in this calculator
$SPRG_{2\text{-}Dr\text{-}sv}$	2-D Residential SPRG for Direct External Exposure to Finite Slabs using infinite soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{2\text{-}Dr\text{-}1cm}$	2-D Residential SPRG for Direct External Exposure to Finite Slabs using 1cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{2\text{-}Dr\text{-}5cm}$	2-D Residential SPRG for Direct External Exposure to Finite Slabs using 5 cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{2\text{-}Dr\text{-}15cm}$	2-D Residential SPRG for Direct External Exposure to Finite Slabs using 15 cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{2\text{-}Dr\text{-}gp}$	Residential SPRG for Direct External Exposure to Contaminated Dust on Finite Slabs (pCi/cm^2)	Isotope-specific	Determined in this calculator
$SPRG_{dow\text{-}total}$	Outdoor Worker SPRG for Exposure to Settled Dust on Surfaces (pCi/cm^2)	Isotope-specific	Determined in this calculator
$SPRG_{3\text{-}Dow\text{-}sv}$	3-D Outdoor Worker SPRG for Direct External Exposure to Contaminated Building Materials using infinite soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{3\text{-}Dow\text{-}1cm}$	3-D Outdoor Worker SPRG for Direct External Exposure to Contaminated Building Materials using 1 cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{3\text{-}Dow\text{-}5cm}$	3-D Outdoor Worker SPRG for Direct External Exposure to Contaminated Building Materials using 5cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{3\text{-}Dow\text{-}15cm}$	3-D Outdoor Worker SPRG for Direct External Exposure to Contaminated Building Materials using 15cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{3\text{-}Dow\text{-}gp}$	3-D Outdoor Worker SPRG for Direct External Exposure to Contaminated Dust (pCi/cm^2)	Isotope-specific	Determined in this calculator
$SPRG_{2\text{-}Dow\text{-}sv}$	2-D Outdoor Worker SPRG for Direct External Exposure to Finite Slabs using infinite soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{2\text{-}Dow\text{-}1cm}$	2-D Outdoor Worker SPRG for Direct External Exposure to Finite Slabs using 1 cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{2\text{-}Dow\text{-}5cm}$	2-D Outdoor Worker SPRG for Direct External Exposure to Finite Slabs using 5cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{2\text{-}Dow\text{-}15cm}$	2-D Outdoor Worker SPRG for Direct External Exposure to Finite Slabs using 15cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{2\text{-}Dow\text{-}gp}$	2-D Outdoor Worker SPRG for Direct External Exposure to Contaminated Dust on Finite Slabs (pCi/cm^2)	Isotope-specific	Determined in this calculator
$SPRG_{diw\text{-}total}$	Indoor Worker SPRG for Exposure to Settled Dust	Isotope-specific	Determined in this calculator

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	on Surfaces (pCi/cm^2)		
$SPRG_{3-Diw-sv}$	3-D Indoor Worker SPRG for Direct External Exposure to Contaminated Building Materials using infinite soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{3-Diw-1cm}$	3-D Indoor Worker SPRG for Direct External Exposure to Contaminated Building Materials using 1 cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{3-Diw-5cm}$	3-D Indoor Worker SPRG for Direct External Exposure to Contaminated Building Materials using 5 cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{3-Diw-15cm}$	3-D Indoor Worker SPRG for Direct External Exposure to Contaminated Building Materials using 15 cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{3-Diw-gp}$	3-D Indoor Worker SPRG for Direct External Exposure to Contaminated Dust (pCi/cm^2)	Isotope-specific	Determined in this calculator
$SPRG_{2-Diw-sv}$	2-D Indoor Worker SPRG for Direct External Exposure to Finite Slabs using infinite soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{2-Diw-1cm}$	2-D Indoor Worker SPRG for Direct External Exposure to Finite Slabs using 1 cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{3-Diw-5cm}$	2-D Indoor Worker SPRG for Direct External Exposure to Finite Slabs using 5 cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{2-Diw-15cm}$	2-D Indoor Worker SPRG for Direct External Exposure to Finite Slabs using 15 cm soil volume (pCi/g)	Isotope-specific	Determined in this calculator
$SPRG_{2-Diw-gp}$	2-D Indoor Worker SPRG for Direct External Exposure to Contaminated Dust on Finite Slabs (pCi/cm^2)	Isotope-specific	Determined in this calculator
Slope Factors			
SF_{d-oral}	Ingestion Slope Factor - dust (risk/pCi)	Isotope-specific	HEAST
SF_{d-ext}	External Exposure Slope Factor - dust (risk/yr per pCi/100cm^2)	Isotope-specific	Developed for SPRG calculator (based on ground plane risk coefficients from FGR 13)
SF_i	Inhalation Slope Factor - air (risk/pCi)	Isotope-specific	HEAST
SF_{ext}	External Exposure Slope Factor - direct (risk/yr per pCi/g)	Isotope-specific	HEAST (based on soil volume risk coefficients from FGR 13)
$SF_{ext-1cm}$	External Exposure Slope Factor - direct (risk/yr per pCi/g)	Isotope-specific	HEAST (based on soil volume risk coefficients from FGR 13)
$SF_{ext-5cm}$	External Exposure Slope Factor - direct (risk/yr per pCi/g)	Isotope-specific	HEAST (based on soil volume risk coefficients from FGR 13)
$SF_{ext-15cm}$	External Exposure Slope Factor - direct (risk/yr per pCi/g)	Isotope-specific	HEAST (based on soil volume risk coefficients from FGR 13)
Dose and Decay Constant Variables			
TR	Target Risk	1E-06	EPA 1990 (pg. 8718-8719)
t_w	Time - worker (years)	25	U.S. EPA 1991 (pg. 15)
t_r	Time - resident (years)	30	U.S. EPA 1991 (pg. 15)
λ	Decay Constant = 0.693/halflife	--	Developed for Radionuclide Soil Screening Calculator (EPA 2000c)
k	Dissipation Rate Constant - (years^{-1})	0.0	EPA 2003 (pg. D-8)
Miscellaneous Variables			
CF	Area Correction Factor (unitless)	1.0 Resident 1.0 Outdoor Worker 1.0 Indoor Worker	U.S. EPA 2000a. (pg. 2-22). U.S. EPA 2000b. (pg. 5-1)
ACF	Area Correction Factor (unitless)	For 2-D analysis (isotope-specific)	Eckerman 2007
SLF	Silt Loading Factor (cm^2/kg)	6.67E+08	Converted from 0.015 gram/m^2. A default number for California highway from Table 2, pg A-67 EPA 2005.
DF_i	Indoor Air Dilution Factor - Outdoor (unitless)	0.4 (assumes dilution)	EPA 2000a (pg 2-20)
GSF_o	Gamma Shielding Factor - Outdoor (unitless)	1 (assumes no shielding)	Other GSFs are presented in these reports. U.S. EPA 2000a. (pg. 2-22). U.S.

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Author: eldarois
Subject: Note
Date: 2/5/2008 10:35:03 PM
This variable is labelled SFinh in the 1st equation.

Sequence number: 2
Author: eldarois
Subject: Note
Date: 2/18/2008 10:43:13 AM
Using this value as a default does not recognize the acceptable range of risk values. As with most default values, this will likely cause most decision makers to apply these very conservative values in order to maintain a safety margin. This results in clean-up values that compound the conservatisms such that the actual risk is much lower than the assumed value. I generally suggest that the calculator consider a range of default values for some of the critical parameters such that a range of clean-up values is provided. This may give the end user a "feel" for the uncertainties involved and less likely to interpret these values and sacrosanct limits.

Sequence number: 3
Author: eldarois
Subject: Highlight
Date: 2/5/2008 10:47:02 PM

			EPA 2000b. (pg. 2-18)
GSF_i	Gamma Shielding Factor - Indoor (unitless)	0.4 (assumes shielding)	Other GSFs are presented in these reports. U.S. EPA 2000a. (pg. 2-22). U.S. EPA 2000b. (pg. 2-18)
2 1 $_{M}$ 3	Area and Material Factor (unitless)	1.0	ANL 2001 (Fig 8.6)
$_{D}$	Depth and Cover Function (unitless)	1.0	ANL 2001 (Fig 8.6)
5 $_{OFF\text{-}SET}$	Off-set Factor (unitless)	1.0	ANL 2001 (Fig 8.6)
6 $_{SURF}$	Surfaces Factor (unitless)	isotope-specific	Eckerman 2007
Inhalation and Ingestion Rates			
IF_w	Worker Dust Ingestion Rate - Worker (cm^2/day)	90	Calculated Value based on EPA 2003 (pg. D-4)
IF_r	Age-Adjusted Dust Ingestion Rate - Resident (cm^2/day)	64.5	Calculated Value based on EPA 2003 (pg. D-4)
HF_r	Age adjusted Inhalation Rate (m^3/day)	18	Calculated Value based on U.S. EPA 1991 (pg. 15)
HR_a	Adult Inhalation Rate (m^3/day; based on IRIS default)	20	U.S. EPA 1991 (pg. 15)
HR_c	Child Inhalation Rate (m^3/day; based on IRIS default)	10	U.S. EPA 1991 (pg. 15)
HR_w	Worker Inhalation Rate (m^3/hr)	2.5	U.S. EPA 1997 (pg. 5-25)
Ingestion Rate Variables			
$FTSS_h$	Fraction Transferred Surface to Skin - Hard Surface (unitless)	0.5	EPA 2004 (Exhibit E-1 pg. E-6)
SA_a	Surface Area of Fingers - Adult (cm^2)	45	EPA 2003 (pg. D-5)
SA_c	Surface Area of Fingers - Child (cm^2)	15	EPA 2003 (pg. D-5)
SA_w	Surface Area of Fingers - Worker (cm^2)	45	EPA 2003 (pg. D-5)
FQ_a	Frequency of Hand to Mouth - Adult (events/hour)	1	EPA 2003 (pg. D-5)
FQ_c	Frequency of Hand to Mouth - Child(events/hour)	9.5	EPA 2003 (pg. D-5)
$_{w}$	Frequency of Hand to Mouth - Worker (events/hour)	1	EPA 2003 (pg. D-5)
SE	Saliva Extraction Factor (unitless)	0.5	EPA 2003 (pg. D-5)
$ET_{h,a}$	Exposure Time - Adult Hard Surface (hours/day)	4	EPA 2003 (pg. D-4)
$ET_{h,c}$	Exposure Time - Child Hard Surface (hours/day)	4	EPA 2003 (pg. D-4)
$ET_{h,w}$	Exposure Time - Worker Hard Surface (hours/day)	8	EPA 2003 (pg. D-4)
$ET_{o,r}$	Exposure Time Outdoor - Resident (hours/day)	1.752	EPA 1997 (Table 15-132)
$ET_{i,r}$	Exposure Time Indoor - Resident (hours/day)	16.4	EPA 1997 (Table 15-131)
ET_w	Air Exposure Time - Worker (hours/day)	8	EPA 2003 (pg. D-4)
Exposure Frequency, Exposure Duration, and Exposure Time Variables			
EF_{iw}	Exposure Frequency - indoor worker (days/year)	250	U.S. EPA 1991 (pg. 15)
EF_{ow}	Exposure Frequency - outdoor worker (days/year)	225	U.S. EPA 1991 (pg. 15)
EF_r	Exposure Frequency - resident (days/year)	350	U.S. EPA 1991 (pg. 15)
ED_w	Exposure Duration - worker (years)	25	U.S. EPA 1991 (pg. 15)
ED_r	Exposure Duration - resident (years)	30	U.S. EPA 1991 (pg. 15)
ED_a	Exposure Duration - adult resident (years)	24	U.S. EPA 1991 (pg. 15)
ED_c	Exposure Duration - child resident (years)	6	U.S. EPA 1991 (pg. 15)
Particulate Emission Factor Variables			
PEF_w	Wind Particulate Emission Factor - Minneapolis (m^3/kg)	1.36×10^9 Minneapolis-specific	U.S. EPA 1996a (pg. 23), U.S. EPA 1996b (pg. 31)
Q/C_w	Inverse of the Mean Concentration at the Center of a 0.5-Acre-Square Source - wind(g/m^2-s per kg/m^3)	93.77 Minneapolis-specific	U.S. EPA 1996a (pg. 23), U.S. EPA 1996b (pg. 31)
V	(fraction of vegetative cover) unitless	0.5	U.S. EPA 1999b, U.S. EPA 1996a (pg. 23), U.S. EPA 1996b (pg. 31)
U_m	mean annual wind speed) m/s	4.69	U.S. EPA 1999b, U.S. EPA 1996a (pg. 23), U.S. EPA 1996b (pg. 31)
U_t	equivalent threshold value of wind speed at 7m)	11.32	U.S. EPA 1999b, U.S. EPA 1996a

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Author: eldarois
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Sequence number: 2
Author: eldarois
Subject: Highlight
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Sequence number: 3
Author: eldarois
Subject: Note
Date: 2/18/2008 10:43:54 AM
These factors (highlighted in yellow) can take on a large range. Probably needs more guidance on using any parameter values including the defaults.

Sequence number: 4
Author: eldarois
Subject: Highlight
Date: 2/5/2008 10:47:35 PM
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Sequence number: 5
Author: eldarois
Subject: Highlight
Date: 2/5/2008 10:47:41 PM
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Sequence number: 6
Author: eldarois
Subject: Highlight
Date: 2/5/2008 10:47:44 PM
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	m/s		(pg. 23), U.S. EPA 1996b (pg. 31)
F(x)	function dependent on U_m/U_t) unitless	0.194	U.S. EPA 1999b, U.S. EPA 1996a (pg. 23), U.S. EPA 1996b (pg. 31)
A	Dispersion constant unitless	PEF and region-specific	U.S. EPA 2002 (pg. D-6 to D-8)
A_s	Areal extent of the site or contamination (acres)	0.5 (range 0.5 to 500)	U.S. EPA 2002 (pg. D-2)
	Dispersion constant unitless	PEF and region-specific	U.S. EPA 2002 (pg. D-6 to D-8)
C	Dispersion constant unitless	PEF and region-specific	U.S. EPA 2002 (pg. D-6 to D-8)
PEF_m	Mechanical Particulate Emission Factor - Phoenix (m^3/kg)	3.05×10^7Phoenix-specific	EPA 2002 (Equation E-18)
Q/C_m	Inverse of the ratio of the 1-h. geometric mean air concentration to the emission flux along a straight road segment bisecting a square site, (g/m^2-s per kg/m^3)	90.54 Phoenix-specific	EPA 2002 (Equation E-18)
F_D	Dispersion correction factor (unitless)	0.1858 (calculated)	EPA 2002 (Equation E-18)
t_c	Total time over which exposure occurs (hr) t_c=T changing units to hrs.	262,800 (30 yrs resident) 219,000 (25 yrs worker)	EPA 2002 (Equation E-18)
T	Total time over which exposure occurs. equal to ED (s)	946,080,000 (30 yrs resident) 788,400,000 (25 yrs worker)	EPA 2002 (Equation E-18)
A_R	Surface area of contaminated road segment (m^2), AR = L_R x W_R x 0.092903 m^2/ft^2	274.2	EPA 2002 (Equation E-18)
s	Road surface silt content (%)	8.5	EPA 2002 (Equation E-18)
W	Mean vehicle weight (tons)	3.2	EPA 2001 (Page 4-285)
M_{dry}	Road surface material moisture content under dry, uncontrolled conditions (%)	0.2	EPA 2002 (Equation E-18)
p	Number of days per year with at least 0.01 inches of precipitation	Region-specific (150)	EPA 2002 (Exhibit E-4)
VKT	Sum of fleet vehicle kilometers traveled during the exposure duration (km/year)	2,814,018 (based on annualized urban California road and traffic data)	DOT 2004 (hm20 and vm2)
	Length of road segment (ft) L_R = square root of site surface contamination used for $A_{s=}$=0.5 acres	147.6	EPA 2002 (Equation E-18)
W_R	Width of road segment (ft)	20	EPA 2002 (Equation E-18)

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4.5 Equation Details

This section presents details on some of the equation sources and parameters.

Exposure to settled dust on surfaces equations:

Inadvertent ingestion from materials deposited on surfaces equation was modeled after the equation found in ANL 2001 (Fig 8.3). The ingestion rate term in this equation was modeled after EPA 2003 (pg. D-4). External exposure from deposited materials equation was modeled after the equation found in ANL 2001 (Fig 8.7).

Direct external exposure equation:

The direct external exposure from a volume and surface of a large area equation was modeled after ANL 2001 (Fig 8.6).

4.5.1 External Exposure Pathway Equation Derivation

The external exposure pathway dose from exposure to an area or a volume source containing radionuclide *n* in compartment *i*, D^n_{ir}, is expressed as:

$$D^n_{ir} = F_{in} \times F_i \times C^n_s \times DCF^n_v \times F^n_G,$$

where

F_{in} = fraction of time spent indoors;

F_i = fraction of time spent in compartment *i*;

C^n_s =average concentration of radionuclide n;

DCF^n_v = FGR-12 dose conversion factor for infinite volume source; and

F^n_G = geometrical factor for finite area, source thickness, shielding, source material, and position of receptor relative to the source for radionuclide *n*.

The geometrical factor, F^n_G, is the ratio of the effective dose equivalent for the actual source to the effective dose equivalent for the standard source. The standard source is a contaminated soil of infinite depth and lateral extent with no cover. The geometrical factor is expressed as the product of the depth-and-cover factor, F_{CD}, an area and material factor, F_{AM}, and the off-set factor, $F_{OFF\text{-}SET}$.

So, F^n_G = effective dose from actual source/effective dose from standard source.

Then, F^n_G = $F_{CD} \times F_{AM} \times F_{OFF\text{-}SET}$.

4.5.1.1 F_{CD}

Note: The F_{CD} is not included in the equations for this calculator. However, the discussion is still presented in following text. It would generally not be appropriate for the settled dust exposure pathway because the dust layer is so thin. It would not be necessary for the direct external exposure pathway because the soil volume risk coefficients are not concerned with depth.

Dose conversion factors in FGR-12 (Eckerman and Ryman 1993) are given for surface and uniformly distributed volume sources at four specific thicknesses (1, 5, and 15 cm, and effectively infinite) with a soil density of 1.6 g/cm^3. FGR-12 assumes that sources are infinite in lateral extent. In actual situations, sources can have any depth, shape, cover, and size. A depth and-cover factor function, F_{CD}, was developed with regression analysis to express the attenuation for radionuclides. Three independent radionuclide-specific parameters were determined by using the effective dose equivalent values of FGR-12 at different depths. Kamboj et al. (1998) describes how the depth-and-cover function was derived using the effective dose equivalent values of FGR-12 at different depths. A depth-and-cover factor function was derived from the depth factor function by considering both dose contribution and attenuation from different depths:

$$\frac{D(T_c = t_c, T_s = t_s)}{D(T_c = 0, T_s = \infty)} = Ae^{-K_A \rho_c t_c}(1 - e^{-K_A \rho_s t_s}) + Be^{-K_B \rho_c t_c}(1 - e^{-K_B \rho_s t_s}),$$

where

A, B = fit parameters (dimensionless);

K_A, K_B = fit parameters (cm^2/g);

t_c = shielding thickness (cm) (the sum of all shielding thicknesses between the source and the receptor), the shielding is placed immediately adjacent to the source;

ρ_c = shielding density (g/cm^3) (the thickness-averaged density between the source and receptor);

t_s = source thickness (cm);

ρ_s = source density (g/cm^3);

T_c = shielding parameter (m); and

= source depth parameter (m).

The following constraints were put on the four fitting parameters:

1. All the parameters were forced to be positive;

2. A + B = 1; and

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3. In the limit source depth, $t_s \rightarrow$ zero, the DCF should match the contaminated surface DCF.

All the four unknown parameters (A, B, K_A, and K_B) were found for 67 radionuclides available in the RESRAD-BUILD computer code. The fitted values of A, B, K_A, and K_B for radionuclides were used in the dose calculations.

4.5.1.2 F_{AM}

For actual geometries (finite area and different materials), the area and material factor, F_{AM}, was derived by using the point-kernel method. This factor depends not only the lateral extent of the contamination but also on source thickness, shielding thickness, gamma energies, and source material through its attenuation and buildup factors. All energies from radionuclide decay were considered separately and weighted by its yield, y, energy, E, and an energy dependent coefficient, K, to convert from air-absorbed dose to effective dose equivalent:

$$F_{AM} = \frac{\sum_{\text{Energies}\,j} y_j E_j K_j \int_{V'} \frac{B(x')e^{-\mu x'}}{(x')^2}\,dV'}{\sum_{\text{Energies}\,j} y_j E_j K_j \int_{V} \frac{B(x)e^{-\mu x}}{(x)^2}\,dV},$$

where

$(x')^2 = r^2 + (t_a + t_c + t)^2$;

$(x)^2 = r^2 + (1\text{m} + t)^2$;

$$\mu = \frac{(t_a\mu_a + t_c\mu_c + t\mu_s)}{(t_a + t_c + t)}; \quad \text{and}$$

$$B(\chi) = B_a\left(\frac{t_a}{t_a + t_c + t_s}\chi\right) B_c\left(\frac{t_c}{t_a + t_c + t_s}\chi\right) B_s\left(\frac{t_s}{t_a + t_c + t_s}\chi\right).$$

B and μ□ are the buildup factor and the attenuation factor, respectively, for the appropriate material (a for air, c for shield material, and s for source material or soil reference). The integration volume V' is the desired geometry of specified material with radius R, shielding thickness t_c, and air thickness t_a; whereas V is the reference geometry of soil extending infinitely laterally with no shield and the receptor midpoint located 1 m from the surface.

4.5.1.3 $F_{OFF\text{-}SET}$

The off-set factor, $F_{OFF\text{-}SET}$, is the ratio of the dose estimates from a noncircular shaped contaminated material to a reference shape. The concept of the shape factor is used to calculate the off-set factor. The reference shape is a fully contaminated circular area encompassing the given shape, centered about the receptor. This factor is derived by considering the area, material factors of a series of concentric circles, and the corresponding contamination fraction of the annular regions. The off-set factor is obtained by enclosing the irregularly shaped contaminated area in a circle, multiplying the area factor of each annulus by the fraction of the contaminated annulus area, f_i, summing the products, and dividing by the area factor of a circular contaminated material that is equivalent in area:

$$F_{OFF\text{-}SET} = \frac{\sum_{i=0}^{n} f_i\left[F_{AM}(A_i) - F_A(A_{i-1})\right]}{F_{AM}\left[\sum_{i=0}^{n} f_i(A_i - A_{i-1})\right]}.$$

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Eric Darois Summary of SPRG Default Value Observations
February 18, 2008

Review Methods

1. The default values were selected for a variety of "common" radionuclides for each exposure case. These nuclides represent applications from a wide array of industries.
2. These were separated and re-combined to allow for visual comparison.
3. Results were reviewed to determine trends, rationale, detectability, and general comparability to previous DCGLs developed by RESRAD and RESRAD-Build.
4. SPRG values in units of pCi/g were converted to dpm/100cm^2.

Observations

1. The data tables below provide specific examples below the tables.
2. In general, the ratio of Cs-137 to Co-60 does not follow logical intuition. The value for Cs-137 is significantly larger than for Co-60 and many of the Co-60 values are not measureable.
3. Similar trends are observed for Cs-137 to Cs-134.
4. The values are based on a risk factor of 1E-6. This is likely too low for such an application. Consider providing a range of values based on an acceptable risk range of 1e-4 to 1E-6.
5. The DUST cases result in extremely low values.
6. It is not clear when to apply each of the cases to an actual field condition.

Dust Cases

	SPRG_Resident_Dust		SPRG_Outdoor_Worker_Dust		SPRG_Indoor_Worker_Dust	
Isotope	(Wind, dpm/100cm^2)	(Mechanical, dpm/100cm^2)	(Wind, dpm/100cm^2)	(Mechanical, dpm/100cm^2)	(Wind, dpm/100cm^2)	(Mechanical, dpm/100cm^2)
H-3	2.95E+03	7.06E+00	3.37E+03	3.09E+00	3.22E+03	6.95E+00
C-14	1.05E+02	9.66E-02	2.04E+02	4.68E-02	2.33E+02	1.05E-01
Fe-55	1.19E+03	6.55E+00	4.66E+03	2.66E+00	4.60E+03	5.97E+00
Co-60	1.78E+01	7.64E-02	4.48E+01	3.15E-02	7.59E+01	7.08E-02
Sr-90	4.73E+00	9.08E-03	9.19E+00	4.17E-03	9.28E+00	9.39E-03
Tc-99m	5.62E+06	3.40E+05	9.81E+06	1.44E+05	2.09E+07	3.24E+05
I-125	7.35E+02	8.04E+00	2.51E+03	3.29E+00	2.35E+03	7.35E+00
Cs-134	4.17E+01	4.13E-01	6.06E+01	1.68E-01	6.48E+01	3.77E-01
Cs-137	1.04E+01	7.88E-02	1.75E+01	3.64E-02	1.61E+01	8.19E-02
Pm-147	4.60E+02	3.35E-01	1.19E+03	1.36E-01	1.87E+03	3.06E-01
Tl-204	1.17E+02	1.52E+00	5.88E+02	6.24E-01	5.57E+02	1.40E+00
Th-232	1.43E-01	1.58E-05	9.12E-02	7.64E-06	2.00E-01	1.72E-05
Th-234+D	1.91E+05	1.91E+05	3.09E+05	3.09E+05	6.93E+05	6.93E+05
U-238	5.59E-01	7.33E-05	4.13E-01	3.55E-05	8.70E-01	7.99E-05
U-238+D	5.02E-01	7.30E-05	4.08E-01	3.53E-05	8.50E-01	7.95E-05
Pu-238	1.97E-01	2.29E-05	1.28E-01	1.09E-05	2.75E-01	2.44E-05
Am-241	2.17E-01	2.49E-05	1.42E-01	1.20E-05	3.06E-01	2.71E-05

General Comment:
Values in Yellow are nominally below detectability.

SPRG Indoor Worker

Isotope	3D Soil Volume pCi/g	3D Soil Volume at 1cm pCi/g	3D Soil Volume at 5cm pCi/g	3D Soil Volume at 15cm pCi/g	3D Ground Plane dpm/100cm^2	2D Soil Volume pCi/g	2D Soil Volume at 1cm pCi/g	2D Soil Volume at 5cm pCi/g	2D Soil Volume at 15cm pCi/g	2D Ground Plane dpm/100cm^2
H-3	-	-	-	-	-	-	-	-	-	-
C-14	1.98E+04	5.53E+07	2.13E+04	1.98E+04	3.56E+06	6.04E+04	1.68E+08	6.47E+04	6.04E+04	1.08E+07
Fe-55	-	-	-	-	-	-	-	-	-	-
Co-60	4.64E-02	4.08E+02	8.88E-02	5.53E-02	5.81E+01	1.45E-01	1.27E+03	2.77E-01	1.72E-01	1.81E+02
Sr-90	4.27E+02	1.98E+06	5.46E+02	4.32E+02	1.21E+05	1.30E+03	6.03E+06	1.66E+03	1.31E+03	3.70E+05
Tc-99m	9.89E+03	5.82E+07	1.36E+04	1.00E+04	8.10E+06	2.96E+04	1.74E+08	4.07E+04	3.00E+04	2.42E+07
I-125	2.16E+03	3.74E+06	2.16E+03	2.16E+03	1.52E+05	6.45E+03	1.11E+07	6.45E+03	6.45E+03	4.53E+05
Cs-134	1.94E-01	1.54E+03	3.42E-01	2.19E-01	2.18E+02	5.99E-01	4.76E+03	1.05E+00	6.75E-01	6.73E+02
Cs-137	3.83E+02	1.76E+06	4.98E+02	3.91E+02	8.43E+04	1.17E+03	5.36E+06	1.52E+03	1.19E+03	2.55E+05
Pm-147	3.19E+04	1.18E+08	3.75E+04	3.20E+04	1.00E+07	9.58E+04	3.55E+08	1.13E+05	9.61E+04	3.01E+07
Tl-204	2.36E+02	9.78E+05	2.81E+02	2.38E+02	6.23E+04	7.63E+02	3.16E+06	9.08E+02	7.69E+02	2.02E+05
Th-232	3.93E+02	1.55E+06	4.68E+02	3.95E+02	9.24E+04	1.28E+03	5.07E+06	1.53E+03	1.29E+03	3.01E+05
Th-234+D	3.90E+02	2.64E+06	6.39E+02	4.35E+02	2.66E+05	1.02E+03	6.90E+06	1.67E+03	1.14E+03	6.93E+05
U-238	2.72E+03	5.73E+06	2.76E+03	2.72E+03	1.14E+05	8.78E+03	1.85E+07	8.92E+03	8.78E+03	3.67E+05
U-238+D	1.39E+00	9.42E+03	2.27E+00	1.55E+00	9.39E+02	3.92E+00	2.66E+04	6.43E+00	4.39E+00	2.66E+03
Pu-238	2.10E+03	4.82E+06	2.30E+03	2.10E+03	8.65E+04	6.69E+03	1.54E+07	7.33E+03	6.72E+03	2.75E+05
Am-241	5.17E+00	1.65E+04	5.53E+00	5.17E+00	1.60E+03	1.68E+01	5.37E+04	1.79E+01	1.68E+01	5.19E+03

General Observations:
Cs-137 to Co-60 Ratios vary from 1400 to 8250.
Cs-137 to Cs-134 Ratios vary from 379 to 1970
The highlighted Co-60 values will ver very challenging for measurement.
Note that the groundplane values have been converted to from pCi/cm^2 to dpm/100cm^2

SPRG Outdoor Worker

Isotope	3D					2D				
	Soil Volume pCi/g	Soil Volume at 1cm pCi/g	Soil Volume at 5cm pCi/g	Soil Volume at 15cm pCi/g	Ground Plane pCi/cm^2	Soil Volume pCi/g	Soil Volume at 1cm pCi/g	Soil Volume at 5cm pCi/g	Soil Volume at 15cm pCi/g	Ground Plane pCi/cm^2
H-3	-	-	-	-	-	-	-	-	-	-
C-14	1.98E+04	5.53E+07	2.13E+04	1.98E+04	1.62E+04	2.68E+04	7.48E+07	2.88E+04	2.68E+04	2.19E+04
Fe-55	-	-	-	-	-	-	-	-	-	-
Co-60	4.64E-02	4.08E+02	8.88E-02	5.53E-02	2.64E-01	6.43E-02	5.65E+02	1.23E-01	7.66E-02	3.66E-01
Sr-90	4.27E+02	1.98E+06	5.46E+02	4.32E+02	5.51E+02	5.78E+02	2.68E+06	7.39E+02	5.84E+02	7.45E+02
Tc-99m	9.89E+03	5.82E+07	1.36E+04	1.00E+04	3.68E+04	1.32E+04	7.74E+07	1.81E+04	1.33E+04	4.89E+04
I-125	2.16E+03	3.74E+06	2.16E+03	2.16E+03	6.90E+02	2.87E+03	4.95E+06	2.87E+03	2.87E+03	9.15E+02
Cs-134	1.94E-01	1.54E+03	3.42E-01	2.19E-01	9.93E-01	2.66E-01	2.12E+03	4.68E-01	3.00E-01	1.36E+00
Cs-137	3.83E+02	1.76E+06	4.98E+02	3.91E+02	3.83E+02	5.19E+02	2.38E+06	6.74E+02	5.29E+02	5.18E+02
Pm-147	3.19E+04	1.18E+08	3.75E+04	3.20E+04	4.55E+04	4.26E+04	1.58E+08	5.01E+04	4.27E+04	6.07E+04
Tl-204	2.36E+02	9.78E+05	2.81E+02	2.38E+02	2.83E+02	3.39E+02	1.41E+06	4.04E+02	3.42E+02	4.07E+02
Th-232	3.93E+02	1.55E+06	4.68E+02	3.95E+02	4.20E+02	5.70E+02	2.25E+06	6.80E+02	5.74E+02	6.10E+02
Th-234+D	3.90E+02	2.64E+06	6.39E+02	4.35E+02	1.21E+03	4.52E+02	3.07E+06	7.42E+02	5.05E+02	1.40E+03
U-238	2.72E+03	5.73E+06	2.76E+03	2.72E+03	5.16E+02	3.90E+03	8.21E+06	3.96E+03	3.90E+03	7.40E+02
U-238+D	1.39E+00	9.42E+03	2.27E+00	1.55E+00	4.27E+00	1.74E+00	1.18E+04	2.86E+00	1.95E+00	5.36E+00
Pu-238	2.10E+03	4.82E+06	2.30E+03	2.10E+03	3.93E+02	2.97E+03	6.84E+06	3.26E+03	2.99E+03	5.58E+02
Am-241	5.17E+00	1.65E+04	5.53E+00	5.17E+00	7.27E+00	7.46E+00	2.38E+04	7.98E+00	7.46E+00	1.05E+01

General Observations:
Same comments as for Indoor Worker Cases

SPRG Resident Cases

	3D					2D				
Isotope	Soil Volume pCi/g	Soil Volume at 1cm pCi/g	Soil Volume at 5cm pCi/g	Soil Volume at 15cm pCi/g	Ground Plane pCi/cm^2	Soil Volume pCi/g	Soil Volume at 1cm pCi/g	Soil Volume at 5cm pCi/g	Soil Volume at 15cm pCi/g	Ground Plane pCi/cm^2
H-3	-	-	-	-	-	-	-	-	-	-
C-14	1.02E+04	2.85E+07	1.10E+04	1.02E+04	8.34E+03	1.38E+04	3.86E+07	1.48E+04	1.38E+04	1.13E+04
Fe-55	-	-	-	-	-	-	-	-	-	-
Co-60	2.82E-02	2.48E+02	5.39E-02	3.36E-02	1.60E-01	3.90E-02	3.43E+02	7.47E-02	4.65E-02	2.22E-01
Sr-90	2.32E+02	1.08E+06	2.97E+02	2.35E+02	2.99E+02	3.14E+02	1.46E+06	4.02E+02	3.18E+02	4.05E+02
Tc-99m	6.12E+03	3.60E+07	8.40E+03	6.20E+03	2.28E+04	8.15E+03	4.79E+07	1.12E+04	8.25E+03	3.03E+04
I-125	1.34E+03	2.31E+06	1.34E+03	1.34E+03	4.27E+02	1.77E+03	3.07E+06	1.77E+03	1.77E+03	5.66E+02
Cs-134	1.20E-01	9.55E+02	2.11E-01	1.36E-01	6.14E-01	1.65E-01	1.31E+03	2.90E-01	1.86E-01	8.42E-01
Cs-137	2.08E+02	9.56E+05	2.71E+02	2.12E+02	2.08E+02	2.82E+02	1.29E+06	3.66E+02	2.87E+02	2.81E+02
Pm-147	1.97E+04	7.32E+07	2.32E+04	1.98E+04	2.81E+04	2.63E+04	9.77E+07	3.09E+04	2.64E+04	3.75E+04
Tl-204	1.45E+02	6.01E+05	1.73E+02	1.46E+02	1.74E+02	2.09E+02	8.64E+05	2.48E+02	2.10E+02	2.50E+02
Th-232	2.02E+02	8.00E+05	2.41E+02	2.04E+02	2.16E+02	2.94E+02	1.16E+06	3.50E+02	2.96E+02	3.14E+02
Th-234+D	2.41E+02	1.64E+06	3.95E+02	2.69E+02	7.47E+02	2.80E+02	1.90E+06	4.59E+02	3.13E+02	8.67E+02
U-238	1.40E+03	2.95E+06	1.43E+03	1.40E+03	2.66E+02	2.01E+03	4.24E+06	2.04E+03	2.01E+03	3.82E+02
U-238+D	7.16E-01	4.86E+03	1.17E+00	8.00E-01	2.20E+00	8.99E-01	6.10E+03	1.47E+00	1.01E+00	2.76E+00
Pu-238	1.10E+03	2.53E+06	1.21E+03	1.11E+03	2.06E+02	1.56E+03	3.59E+06	1.71E+03	1.57E+03	2.93E+02
Am-241	2.67E+00	8.55E+03	2.86E+00	2.67E+00	3.77E+00	3.86E+00	1.23E+04	4.13E+00	3.86E+00	5.44E+00

General Observations:
Similar comments and trends as for Indoor Worker Cases

RSCS
Radiation Safety & Control Services

Curriculum Vitae

Eric L. Darois, M.S., CHP

Professional Experience

4/89 - Present
Corporate Director: Radiation Safety and Control Services, Inc. (RSCS): Stratham, NH.

Provide radiation protection consulting and project services for operating and decommissioning nuclear power plants and other users of radioactive material. These services include calculations and measurements as well as serving in an advisory role for program operations, data management, internal doseimetry and external dosimetry. Participated in the technical review of a draft revision of the Marssim manual. Authored three industry EPRI guidance documents for groundwater monitoring and for transuranic controls at decommissioning and operating nuclear power facilities, principal contributor to performing groundwater assessments at operating nuclear power plants for EPRI, principal investigator for an LNT evaluation document for EPRI. Served as an expert pannel member for the NRC's advisory committee on nuclear waste and on groundwater modelling and modelling.

Principal designer of several software products including DeCAT – Decommissioning Cost Analysis Tool, and, ADMS – Analytical Data Management System. Also performmed many decommissioing cost estimated in support of a variety of projects.

Director Lead for the development of a decommissioing cost estimation computer program for the Korean PWR nuclear power plants (KHNP) in conjunction with KOPEC. Project completion date March 2009.

Participating in the NIOSH dose reconstruction project for the Department of Energy performing Dose Reconstruction calculations.

7/03 – 4/06
Yankee Rowe License Termination Project Manager: Radiation Safety & Control Services, Inc.

Responsible for radiological closure of the site including development of the License Termination Plan, Groundwater Monitoring Program, site exposure model development and development/calculation of DCGLs, and Final Status Survey methodologies.

7/99 – 7/03
Bechtel Integrated Site Closure Manager: Radiation Safety & Control Services, Inc.

LTP Technical Project Manager, Project Health Physicist, and HP Technical Group Lead. Responsible for radiological and non-radiological closure of the CY site including development of the License Termination Plan. Groundwater Monitoring Program, site exposure model development and development/calculation of DCGLs .

6/97 – 7/99
Connecticut Yankee Atomic Power Company Technical Specialist: Radiation Safety & Control Services, Inc.

Responsible for HP count room, internal dosimetry program, and radiological analysis. Performed many radiological safety analysis (10CFR50.59), FSAR changes, internal dose evaluations, and offsite dose calculations. Participated in an extensive re-write of HP procedures to support the Radiation Protection Improvement Program. Instituted alpha contamination and internal dosimetry controls, and provided HP and site-wide training

4/91 - 7/97
Health Physics Supervisor/Sr. Health Physicist/HP Support Group: North Atlantic Energy Services Corporation: Seabrook, NH

Responsible for the technical maintenance and development of the Radiation protection program at Seabrook Station. Served as the HP department training liason responsible for implementation of the training and qualification programs for department staff and technicians. Served on the Health Physics Curriculum Advisory Committee (CAC).

Emergency response positions included: 1) Emergency Operations Facility (EOF) Coordinator, and 2) Dose Assessment Specialist.

Provided technical oversight and direction for regulatory compliance, radiation measurements, dosimetry and other areas. Performed HP program assessments and procedure maintenance and development. Also responsible to provide direction in technical projects and evaluations. Participated in QA and regulatory audits. Member, Radiation Data Management System (General Atomic) Oversight Committee, and the Station Operating Review Committee (SORC).

4/87 - 4/91
Health Physics Supervisor Dosimetry: New Hampshire Yankee, Seabrook, NH.

Responsible for the operation of the Internal and External Dosimetry laboratory employing 5 people (Technicians and professional staff).

Provided technical oversight and direction of the routine operation of each laboratory and to many other projects including: development and use of a neutron spectroscopy system using He 3 and TEPC detectors, development of a Hot Particle Dose Rate Meter, and dose analysis of PASS operation against 10CFR50, GDC 19. Member, RDMS oversight committee.

8/86- 4/87
Sr. Health Physicist HP Support Group: New Hampshire Yankee: Seabrook, NH.

Work involved providing technical direction, review and development for a variety of HP areas. These areas included the Digital Radiation Monitoring System, the Radiation Calibration Facility, Emergency Planning offsite dose assessment, HP training, instrument calibration, and contamination monitoring. Member, RDMS oversight committee.

1/85 - 8/86
Titled Engineer HP Methods and Measurements Section: Yankee Atomic Electric Company Environmental Laboratory Westboro, MA.

Work involved a variety of activities relative to radiation measurement needs of operational and pre operational nuclear power plants and of the Environmental Laboratory. This involvement included the development of a Panasonic Environmental Dosimetry Program, a Vinten Instruments Extremity Dosimetry Program, and a Portable Automated Extrapolation Chamber Measurement System. Additional activities included assistance to the Radiation Dosimetry Section in dosimetry algorithm development, TLD badge design, in plant beta radiation field measurements (Steam Generators) and evaluation utilizing the Extrapolation chamber System, software design and development, plant process and effluent monitor calibrations, special plant audits in support of RETS and dosimetry areas, INVIVO and INVITRO program specifications, and an alpha analysis program for an air sampling program. Also involved in upgrade of the Laboratory NRC by product material license and served on the Laboratory Radiation Safety Committee.

10/81 - 1/85
Radiation Dosimetry Section Lead: Yankee Atomic Electric Company Environmental Laboratory: Westboro, MA.

Work involved the support of dosimetry service provided to three nuclear power stations. This work included primary and secondary calibrations of equipment and sources for measurements of beta and gamma personnel doses, operation of the in house dosimetry systems, and maintenance of the systems within the quality control program. Duties also included special projects work within radiation measurements activities for the power stations.

8/79 - 10/81
Radiation Protection Engineer: Yankee Atomic Electric Company

Work included Health Physics and Emergency Planning Responsibilities in support of three nuclear power stations. HP responsibilities involved assisting the plant HP departments in various disciplines ranging from administrative control of personnel exposures to technical considerations of radiation measurements. Emergency Plan responsibilities ranged from the design and calibration of accident area and process radiation monitoring systems to the development of detailed technical and administrative Emergency Plans and Emergency Plan Implementation Procedures including dose assessment nomogram and computer program development. Duties also included the development and administration of several detailed Emergency Exercise Scenarios which included radiological and operational sequences.

9/78 - 8/79
Research Consultant: Yankee Atomic Electric Company: Westboro, MA.

Work involved a comprehensive analysis of the response of a state of the art personnel dosimetry system to different types of radiations and the effect of environmental stresses on it. An extensive study of the beta response of TLD systems and subsequent correlation to average absorbed skin dose was also evaluated.

6/77 - 5/78
Various full and part time HP positions at the University of Lowell and other licensed facilities. Details upon request.

Education/ Qualifications

University of Lowell, Lowell, MA.

- M.S. Radiological Sciences and Protection, January 1985. Thesis: LiF TLD Beta Particle Dosimetry
- B.S. Radiological Health Physics, June 1978.
- American Board of Health Physics Comprehensive Certification, October, 1985.

Short Courses

During the past 29 years, attended Many Technical and Managerial Special Training Courses

Presentations / Publications

Presented and authored numerous technical papers for a wide array of conferences and professional meetings as well as for several industry periodicals and journals. A complete listing will be provided upon request.

Industry Committees

- Advisory Committee on Nuclear Waste (ACNW) Working Group on NRC Decommissioning Guidance, June 2005, November 2006, June 2007, December 2007; Expert Panel Member.
- Connecticut Yankee License Termination Plan ASLB Hearings, April 2003, Expert Witness Panel.BS Joint Planning Committee for Radiation Survey Instrument and Calibration, 1983.
- STM Task Group E 10.04.16, How to Perform Field Measurements of Beta Spectra, 1985.

Professional Societies

- National Health Physics Society
- New England Chapter Health Physics Society

Peer Reviewer Conflict of Interest Certification

Peer Review: Preliminary Remediation Goals for Radionuclides in Outdoor Surfaces (SPRG)

A conflict of interest or lack of impartiality exists when the proposed peer reviewer personally (or the peer reviewer's immediate family), or his or her employer, has financial interests that may be affected by the results of the peer review; or may provide an unfair competitive advantage to the peer reviewer (or employer); or if the peer reviewer's objectivity in performing the peer review may be impaired due to other factors. When the Peer Reviewer knows that a reasonable person with knowledge of the facts may question the peer reviewer's impartiality or financial involvement, an apparent lack of impartiality or conflict of interest exists.

The following questions, if answered affirmatively, represent potential or apparent lack of impartiality (*any affirmative answers should be explained on the back of this form or in an attachment*):

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- Have you served on previous advisory panels, committees, or subcommittees that have addressed the topic under consideration? ☒ No ☐ Yes
- Have you made any public statements (written or oral) on the issue? ☒ No ☐ Yes
- Have you made any public statements that would indicate to an observer that you have taken a position on the issue under consideration? ☒ No ☐ Yes
- Do you, your family, or your employer have any financial interest(s) in the matter or topic under peer review, or could someone with access to relevant facts reasonably conclude that you (or your family or employer) stand to benefit from a particular outcome of this peer review? ☒ No ☐ Yes

With regard to real or apparent conflicts of interest or questions of impartiality, the following provisions shall apply for the duration of this peer review:

(a) Peer Reviewer warrants, to the best of his/her knowledge and belief, that there are no relevant facts or circumstances that could give rise to an actual, apparent, or potential organizational or personal conflict of interest, or that Peer Reviewer has disclosed all such relevant information to EMS or to EPA.
(b) Peer Reviewer agrees that if an actual, apparent, or potential personal or organizational conflict of interest is identified during performance of this peer review, he/she immediately will make a full disclosure in writing to EMS. This disclosure shall include a description of actions that Peer Reviewer (or his/her employer) has taken or proposes to take after consultation with EMS to avoid, mitigate, or neutralize the actual, apparent, or potential organizational conflict of interest. Peer Reviewer shall continue performance until notified by EMS of any contrary action to be taken.

[signature] 1/17/08

Signature Date

☐ Check here if any explanation is attached

ERIC L. DAROIS

Printed Name

RSCS, INC.

Affiliation/Organization