RFCA Stakeholder Focus Group
August 8, 2001
Meeting Minutes

INTRODUCTION AND ADMINISTRATIVE

Please note, a participants list and all attachments mentioned herein for the August 8, 2001 Rocky Flats Cleanup Agreement (RFCA) Stakeholder Focus Group meeting were mailed and emailed on August 15, 2001.

Reed Hodgin of AlphaTRAC, Inc., meeting facilitator, reviewed the purpose of the RFCA Focus Group. Introductions were made.

Reed mentioned that the meeting minutes for the June 30, 2001 Focus Group meeting were electronically mailed out to the Stakeholders this day. He asked that the Focus Group look them over and let AlphaTRAC know of any corrections, additions, or deletions via email to Christine Bennett.

Ann Lockhart of the Colorado Department of Public Health and Environment (CDPHE) announced that she had brought copies of two reports produced for the Health Advisory Panel:

1. *Summary of Findings, Historical Public Exposures Studies on Rocky Flats, August 1999,* a nine year comprehensive study done by Radiological Assessments Corporation (RAC);

2. *Assessment Risks of Exposure to Plutonium, Revision 2, February 2000,* a technical report, also by the RAC, which changed their name to Risk Assessments Corporation

Christine Bennett noted that AlphaTRAC has copies of these reports and offered to make them available to anyone who is interested.

AGENDA

Reed reviewed the agenda for the Focus Group Meeting:

1/110

- RSALs: Task 3 – Parameter Discussion and Modeling Results
- Review of Peer Review Process for Task 3, Including Wind Tunnel Peer Review
- Clean-up Alternatives Matrix – Distribution of Draft Working Group Results

CLEAN-UP ALTERNATIVES MATRIX – DISTRIBUTION OF DRAFT WORKING GROUP RESULTS

Ken Brakken of the U. S. Department of Energy (DOE) talked about the Cleanup Alternatives Matrix being developed by a working group. He noted that a draft matrix was being distributed at the meeting. The matrix lists cleanup alternatives on the vertical axis and outcomes along the horizontal axis. The boxes will be filled in with information about how each alternative affects each outcome.

Ken asked that the members of the Focus Group review the draft matrix and provide comments back to the working group.

RSALS: TASK 3 – PARAMETER DISCUSSION AND MODELING RESULTS

Reed listed objectives for today's discussion on parameters and modeling results:

- Get information on key parameters
- Get information on first results
- Get information on path forward
- Get clarification and understanding of key parameters
- Provide feedback on key parameters
- Get clarification / understanding of first modeling results
- Set a path forward for next discussion

Reed stated that the focus of discussion at this meeting would be technical, rather than policy, issues. He indicated that the Focus Group would first identify and resolve all of the technical issues that it wished to. Once the technical bases of the RSAL calculations were well understood and feedback had been provided to the agencies, the policy discussion could begin.

Steve Gunderson of CDPHE introduced the technical presentation by the agencies. He indicated that he would provide and describe the first modeling results to the Focus Group. Then, Tim Rehder of EPA would describe the two land use scenarios for which calculations had been completed. Finally, Bob Nininger of Kaiser-Hill would make a presentation on key parameters.

First RSAL Modeling Results

Steve Gunderson passed out a matrix showing the first RSAL modeling results. He stated that preliminary results had been calculated for two land use scenarios: wildlife refuge worker and rural resident. He noted that potential RSAL values had been calculated for the 25 mrem dose limit specified in the State's Radiation Control Regulations and for three risk values (10^{-4}, 10^{-5}, and 10^{-6}) from the risk range specified in the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The RSALs Working Group applied the RESRAD model to the dose calculations and the standard U. S. Environmental Protection Agency (EPA) risk equations (the RAGS model) to the risk calculations. The dose and risk values are for Plutonium with Americium included, using the sum of ratios method.

The results are shown with the number of digits that were produced by the model. The actual precision of the results is one or two significant digits – the final numbers will be rounded to reflect the actual precision in the modeling results. Finally, Steve noted that the values shown in the matrix represent the 95^{th} percentiles from the ranges that were calculated for each box in the matrix. This means that 95% of the projected doses or risk in the distribution were lower than the value shown and 5% were higher than the value shown.

Steve noted the wide range in potential RSAL values corresponding to the CERCLA risk range. RSAL values for the wildlife refuge worker ranged from 5 to 512 pCi/g, while values for the rural resident ranged from 2 to 190 pCi/g. He stated that this two order of magnitude range relating to a two order of magnitude risk range was expected.

Steve also pointed out that the dose-based values (875 pCi/g for the wildlife refuge worker, 223 pCi/g for the adult rural resident, and 250 pCi/g for the child rural resident) all exceed 10^{-4} risk and were thus outside the CERCLA risk range.

Steve emphasized that the primary purpose for the matrix was in establishing a surface RSAL for Rocky Flats. He also said that there had been discussion among the agencies that the matrix could serve three other purposes as well. First, the matrix could be used to establish tier levels for RSALs. He said that there would have to be discussion, including discussion by the Focus Group, on how tiers could contribute to the cleanup process. He further stated that the matrix could be used to help define As Low As Reasonably Achievable (ALARA) goals for removal beyond required levels. Finally, the matrix could be used in another ALARA-like activity to establish limits for institutional controls (e.g., "do not dig" areas) where contamination exists, but at a level too low to trigger cleanup action.

Steve said that the Working Group was now turning its focus to calculating the results for the other three scenarios in the matrix. Calculations will also be performed for Uranium (there are some hot spots at Rocky Flats) once the Plutonium / Americium calculations are complete – probably in the next month or two.

Land Use Scenarios

Tim Rehder next briefed the Focus Group on the two land use scenarios for which calculations had been completed: wildlife refuge worker and rural resident.

Tim introduced the wildlife refuge worker as the likely anticipated future land user. He indicated that this land user would be a full time worker on site whose activities would include but not be limited to building trails, installing fences, and conducting controlled burns.

Tim introduced the rural resident land use as a good candidate for the ALARA goal, since the agencies consider it the most likely land use in the event of institutional control failure. The key characteristics of the rural resident are its location on the most contaminated areas, the large ranchette-sized property allowing horses and other dust-disturbing animals, and a very large garden with large crops and a heavy dependence on home-grown fruits and vegetables.

Key Parameters

Bob Nininger made a summary presentation and responded to questions concerning key input parameters for the RSAL modeling.

Bob stated that more than 60 input parameters had been evaluated with values developed for input to the RSAL models (RESRAD and RAGS). He said that most of these parameters were not sensitive – changes in the parameters did not cause significant changes in the model results. Single values were typically used as inputs for these parameters.

Bob said that there were a limited number of parameters to which the model was very sensitive. Variations in these "key parameters" could cause significant changes in model results. Single value inputs were used for those key parameters that were well characterized and that varied little. Probability distribution functions (distributions) were employed for those key parameters that either had large uncertainties or varied over a large range. Bob noted that the upper end of the distributions were most important as those portions contributed most to the 95^{th} percentile in the final results.

Bob identified four key parameters for use in the RSAL modeling:

- Soil ingestion,
- Inhalation rate,
- Mass loading, and
- Exposure frequency and exposure time.

Bob indicated that he would also discuss Dose Conversion Factors (DCFs) which, while not strictly model input parameters, involves an important choice which significantly affects modeling results.

Dose Conversion Factors

Bob stated that the RSAL Working Group had held extensive discussions on the choice of DCFs. The Working Group decided to apply the new International Council on Radiation Protection and Measurements (ICRP) 68/72 DCFs, rather than the historically used ICRP 26/30 DCFs, because:

- The ICRP 68/72 DCFs represent the latest consensus thinking by the international scientific community,
- In-tissue weighting factors have been updated,
- The methodologies for lung and ingestion pathways have been significantly changed, and
- Age-dependent DCFs are now available.

Two significant results of this choice are that the soil ingestion and plant ingestion pathways have increased in importance, while the inhalation pathway has decreased in importance.

Bob also noted that DCFs associated with the "Moderate" clearance class would be used rather than the "Slow" clearance class, and that estimated doses would be higher as a result.

Inhalation Rate

Bob stated that distributions had been created for breathing rate. EPA studies and data compilations formed the basis for the data distribution for the rural resident (adult and child). An unbounded lognormal distribution had been found to fit the data best. The arithmetic mean and standard deviation for the adult rural resident were 16.2 and 3.9 m^3/day, while the arithmetic mean and standard deviation for the child rural resident were 9.3 and 2.9 m^3/day. Bob emphasized that the arithmetic means do not represent the most important breathing rate values, as the values that would relate to the 95th percentile doses and risks would come from the tails of the distributions. Bob noted that the breathing rate is lower for the child primarily because of lower lung capacity.

The Working Group used a risk assessment performed for the Rocky Mountain Arsenal as the basis for the data distribution for the Wildlife Refuge Worker. The group found that a beta distribution best fitted the breathing rate data for this land use scenario. The beta distribution was characterized by a minimum breathing rate (1.1 m^3/hr), and maximum breathing rate (2.0 m^3/hr) and two shape factors.

Bob also showed breathing rate values as used in the RAC study.

A member of the Focus Group asked if the greater number of breaths per minute for a child had been taken into account. Bob responded that this effect had been considered.

A member of the Focus Group asked if the RAC number quoted (10,800 m^3/year) was for a resident rancher. Tim Rehder responded that the RAC number was for a resident rancher. There was a point made that the breathing rate for a resident rancher should be higher than that for a resident.

The discussion continued with a focus on comparing breathing rates among the 1996 RSAL calculations, the RAC study, and the current analysis. The group and agencies found it difficult to compare the current distributions against the point values used in 1996 and by RAC. The agencies agreed to find a way to present an "apples-to-apples" comparison and bring this back to the Focus Group.

Soil Ingestion Rate

Bob stated that the Working Group had reviewed a number of soil ingestion studies and had determined that the most appropriate study was the Calabrese study conducted in Montana. The key to the particular usefulness of this study was the careful control and monitoring of inputs and outputs from the test subjects. Bob stated that the study involved 63 test subjects.

The soil ingestion data for children based on the Calabrese study were best fit by a bounded lognormal distribution. Bob noted that the mean of the distribution is 16.6 g/year with a standard deviation of 40.9 g/year and upper and lower bounds of 1 and

365 g/year. Bob noted that the top end of the range represented a "Pica child," ingesting far more soil each year than a normal child.

Bob next summarized the data used for adult soil ingestion. The agencies emphasized that the Calabrese study had been intended to characterize soil intake by children. A limited amount of adult data had been gathered for confirmatory purposes. The Working Group determined that the adult dataset was not sufficiently large to use as the basis for either a point value or distribution. As a result, the RSALs Working Group decided to apply the EPA default value of 100 mg/day for the RSAL modeling. A model input value of 350 g/year was calculated based on an assumed overall residence time of 350 days / year.

Bob also noted that input values for the RESRAD model were multiplied by a factor of 3 to account for a model artifact that allowed soil ingestion only 8 hours per day.

Mass Loading

Bob provided a brief summary of the mass loading parameter, as more detailed briefings had already been provided to the Focus Group. Bob indicated that the RSALs Working Group had examined historical particulate air quality monitoring data for Rocky Flats, with a median concentration of 11 $\mu g/m^3$. This represented a very clean (dust-free) atmosphere. While this distribution is representative of conditions while Rocky Flats was operational and in shut down, it may not be representative of future conditions under other land uses. So, the Working Group decided to build a distribution based on the median particulate air quality conditions around the state of Colorado. This data distribution produces a median concentration of 21 $\mu g/m^3$, almost twice as high as the historical conditions at Rocky Flats.

The results of the wind tunnel experiments were used to characterize atmospheric particulate loadings following a wildfire or prescribed burn. Bob noted that this was an important input to the mass loading parameter, as the fire scenarios dominated mass loading along the tail of the mass loading distribution (the portion of the distribution with the greatest influence on the 95th percentile RSAL results).

Site-specific meteorological data were analyzed to determine historical precipitation patterns at the site. The data were used to define a dry period for Rocky Flats.

Site-specific particulate monitoring data were used to characterize particle size distributions in airborne dust. The fraction of particulates less than 10 μm in diameter (PM^{-10}) was used for modeling the inhalation pathway, while the total suspended particulate (TSP) fraction was used for the soil ingestion and plant intake pathways.

A member of the Focus Group asked for more detail on the use of the wind tunnel experiments and the evaluation of fires in the modeling. Bob responded that the upper 10% of the mass loading distribution is dedicated to fires, as it is assumed that a fire could occur 10% of the time. Fire frequency is dominated by prescribed burns, which are assumed to occur much more often than the historical incidence of wildfires at the site.

A member of the Focus Group asked if direct emissions from lightning strikes had been considered. Bob responded that the disturbance from a lightning strike impacting the soil was not considered. His feeling was that this was appropriate as such strikes were infrequent and affected a very small area. The real influence of lightning strikes shows in the frequency of wildfires.

There was a discussion of site-specific meteorology. Bob stated that meteorological data were available for the site back to 1953, but that all of the years were not used due to completeness of data and quality considerations. In response to a question about using state-wide precipitation data, Bob confirmed that site-specific meteorological data had been used exclusively.

Exposure Frequency and Exposure Time

Bob stated that the basic assumption on exposure frequency for the rural resident is that the person would be indoors 85% of the time and outdoors 15% of the time while at home. The values were based on literature surveys of the behavior of residential occupants. A triangular distribution was used to represent this in the models. Slightly different input parameters were developed for the RESRAD and RAGS models due to different model input requirements.

The Wildlife Refuge worker was assumed to be onsite 8 hours per day, with approximately 50% of the time spent indoors and 50% of the time spent outdoors.

A member of the Focus Group asked if the effects of high wind events on Wildlife Refuge Workers had been calculated. Bob responded that high wind events were incorporated in the mass loading. He emphasized that high wind events were not treated as individual occurrences but were included in the annual mass loading values.

Group Discussion

Bob concluded his presentation with a summary and opened the floor to discussion.

A member of the Focus Group asked what level of particulate concentration would be uncomfortable to breathe. The response was about 125 $\mu g/m^3$. It was emphasized that the 125 $\mu g/m^3$ value was associated with a short term exposure, while the values used in the RSAL modeling were annual averages.

The group discussed the fire scenario further. The agencies noted that the scenario assumes that the entire site is subjected to a controlled burn every 10 years; thus the contaminated area burns every 10 years.

The seasonal differences in fire impacts were discussed. The scenario considers that there will be slower regrowth following a prescribed burn in the fall as compared to a prescribed burn in the spring. A multiplier is used for mass loading due to prescribed burns in the fall.

It was noted by the agencies that the influence of the fire on mass loadings dominated the first year following the fire. It was also noted that there would be some smaller elevation of mass loading in the second year following the fire due to loss of thatch.

There was a discussion on the influence of time spent indoors vs time spent outdoors. The agencies indicated that exposures would be lower indoors because of shielding from gamma exposure and due to slow infiltration of outdoor air carrying contaminated particulates. A 70% shielding factor was assumed for both gamma shielding and infiltration (a note was later made that the gamma shielding factor was 60%). This means that a person indoors receives 70% of the exposure that would be received outdoors. A residence-like building was considered with windows that would open, as opposed to an office building with recirculated air and filtration.

The group discussed the differences between frequency distributions and cumulative frequency distributions and how the distributions were separated into bins for input to the models.

There was further discussion of how the state-wide particulate air quality data were used with Rocky Flats data to generate a mass loading distribution and how the fire data were added to the distribution.

A member of the Focus Group expressed concern that the soil ingestion data from the Calabrese study might not be representative of the high wind events that occur at Rocky Flats. He was concerned that more soil would be ingested during high winds. There was discussion among the group and with the agencies about the inhalation of dust during high wind events. It was noted that much of the dust resuspended during high winds is in the form of large particles, which would generally not penetrate far into the breathing pathways before being trapped and removed. It was pointed out that a conservative assumption was being made in this regard – that all particles less than 10µm in diameter would penetrate the lung system and cause exposure, while in practice only particles with diameters of 2.5µm or less penetrate far enough. The member of the Focus Group noted that his concern was about soil ingestion – both direct introduction of dust into the mouth and then swallowed during high wind events, and the swallowing of contaminated dust in mucus from the nose and upper respiratory tract.

AGENDA

Reed noted that time had run out before there was an opportunity to discuss the Task 3 Peer Review and Wind Tunnel studies Peer Review and promised to place this topic in a priority position on the agenda for the August 22, 2001 Focus Group meeting. The Group agreed to focus on technical issues associated with the RSAL modeling at the next meeting. The members of the Focus Group agreed to review the handouts from the key parameters discussion and identify specific technical questions to be addressed on August 22, 2001. The members agreed to submit their questions to AlphaTRAC by August 17, 2001 to be compiled into a list for discussion. An update on RSAL modeling results was requested, along with a request for a briefing on pathway contributions to RSAL results.

ADJOURN

The meeting was adjourned at 6:30 p.m.

RFCA Stakeholder Focus Group
August 8, 2001
Meeting Minutes

Appendix A
Participants List

RFCA Stakeholder Focus Group
August 8, 2001
Meeting Minutes

Appendix B

RFCA Stakeholder Focus Group
August 8, 2001
Meeting Minutes

Appendix C

RFCA Stakeholder Focus Group
August 8, 2001
Meeting Minutes

Appendix D

RFCA Stakeholder Focus Group
August 22, 2001
Participants List

NAME		ORGANIZATION / COMPANY
David	Abelson	RFCLOG
Melissa	Anderson	RFCLOG
Christine	Bennett	AlphaTRAC, Inc.
Kent	Brakken	U.S. DOE - RFFO
Lane	Butler	Kaiser-Hill Company, LLC
John	Corsi	Kaiser-Hill Company, LLC
Carol	Deck	Kaiser-Hill Co, LLC
Rick	DiSalvo	US DOE - RFFO
Sam	Dixion	City of Westminster
Joe	Goldfield	RFSALOP
Aaron	Grider	Jefferson County
Jerry	Henderson	RFCAB
Reed	Hodgin	AlphaTRAC, Inc.
Victor	Holm	RFCAB
Jeremy	Karpatkin	US DOE - RFFO
Ken	Korkia	RFCAB
Joe	Legare	DOE
Joshua	Levin	Decision Research
Ann	Lockhart	CDPHE
Carol	Lyons	City of Arvada
Sandi	MacLeod	U.S. DOE
Tom	Marshall	Rocky Mountain Peace and Justice Center
LeRoy	Moore	RMPJC
Bob	Nininger	Kaiser-Hill Company, LLC
Patricia	Powell	U.S. DOE - RFFO
Carla	Rellergert	Weston
Mark	Sattelberg	US Fish and Wildlife Service
Kathy	Schnoor	City of Broomfield
Joel	Selbin	
Carl	Spreng	CDPHE
Noelle	Stenger	RFCAB

RFCA Stakeholder Focus Group
Attachment B

Title:	Handouts and Presentations from the August 8, 2001 Focus Group Meeting
Date:	August 17, 2001
Author:	C. Reed Hodgin AlphaTRAC, Inc.
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Community Acceptance Factors

1. Protect offsite water quality, surface water

2. Minimize the source term, minimize the source of contamination

3. Minimize long-term stewardship, such as:
    - Monitoring
    - Operations and maintenance
    - Institutional controls

4. Best cleanup (this is to be defined in more detail)

5. The community values clean open space, bugs & bunnies, ecological values, natural resource values

6. The community values clean air

7. The remediated land is safe for future residents (a criteria, not a land use). That is, a refuge is planned, not residential use, but the community values having the affected land be safe for future residents.

8. Protect human health and the environment

9. No new burial of wastes. Existing wastes on site is one thing, but do not bury new wastes

What is our path forward, our plan?

1. This committee will consider these nine points, add to this list, suggest modifications or embellish some points, such as no. 4.

2. This committee will present this product to the larger focus group and ask the focus group or comments, input.

3. As appropriate, this group will meet again and lay out the path forward.

TASK 3 SECTION ON SELECTION OF DOSE CONVERSION FACTORS

Final Version, 8/9/01

Selection of Dose Conversion Factors (DCF): The RESRAD computer code requires the creation of and specification of a library of DCF's which is used for dose calculations. Separate values for dose per unit of radioactivity inhaled or ingested need to be specified for each isotope for which dose calculations are performed. Several isotopes of concern at Rocky Flats (notably the isotopes of plutonium) have different DCF's depending on their behavior in the body (rate of absorption into the blood, rate of clearance from the lung, target organs, etc.), so decisions must be made as to which DCF to use.

The computation of DCF's is fairly complicated, and requires the use of a separate computer model (outside the scope of RESRAD). The International Commission on Radiation Protection (ICRP) is a body of experts in all areas of the field of health physics which is tasked with developing and refining guidance on radiation protection, including the calculation of DCF's for radioisotopes. The ICRP periodically reviews the experimental literature, updates its model assumptions about the way radioisotopes behave inside the body, revises its radiation protection guidance and/or revises the values of the DCF's based upon the best available science at the time, and publishes their proceedings in numbered publications. The ICRP is recognized by all US Regulatory Agencies (NRC, DOE, EPA) as a highly credible source of radiation protection guidance.

ICRP originally created DCF's for radioisotopes entering the body in its Publication 2 (for worker exposure), and there have been two comprehensive revisions since then: the first revision is captured in Publications 26 and 30 for worker exposure(1979), and the second and most recent revisions take place in Publications 60 through 72 (1996) with compilations of DCF's in Publication 68 (worker exposure) and 72 (exposure of the public). Because of the timing of these revisions, the 1996 calculations of RSAL's utilized the DCF's from ICRP 30 (see Tables 1 and 2), and the RAC Independent Calculation utilized the DCF's from Publication 72. Since the later DCF's are based upon a more complete research base, and are explicitly applicable to environmental exposure of the public, as opposed to radiation worker exposure, it makes sound scientific sense to utilize them in the current calculations, and the RSAL Working Group proposes to do so.

Differences between ICRP 30 and 72 DCF's. The ICRP 72 DCF's represent a culmination of several revisions of the model and methodology used to compute doses in Publication 30. The most significant changes include the development of DCF's specific to various age groups, the revision of the lung model itself, a more extensive set of tissue weighting factors (which are used to calculate dose to the whole body which is equivalent to the sum of doses to individual organs - the effective dose equivalent) and, revisions to the ingestion DCF selections (specifically plutonium) to reflect the greater uncertainty inherent in environmental exposure to ingested radionuclides.

The revision of the lung model represents a refinement of the assumptions about distribution of inhaled radionuclides in the body – consideration is given to the particle size distribution in the inhaled aerosol and its deposition, transfer and site specific exposure to the various parts (compartments) of the system: mouth/nose, esophagus, tracheobronchial, alveolar, lymph and blood. As far as actinides, particularly plutonium is concerned, the revision of the lung model has the effect of somewhat increasing the inhaled, cleared and swallowed fraction, while reducing the fraction which deposits in and is retained in the lung - the DCF for inhalation decreases by a factor of 2-5, depending on clearance/absorption category from the DCF in ICRP 30 (see Table 1).

The addition of a number of tissue weighting factors generally has the effect of reducing the effective dose to the principle organs affected by ingested plutonium (liver and bone surfaces). This is due to two facts: the weighting factor for bone surfaces was reduced by a factor of 3 in the light of later research, and the apportionment of the ICRP 30 "remainder of the tissues in the body" factor of 0.3 to a number of specific organs (liver 0.05) has the effect of reducing the liver dose contribution by a factor of 6.

The revision in the value of the fractional absorption coefficient (f1) for plutonium has the effect of significantly increasing the ingestion dose coefficient. The single value for f1 in ICRP 72 is 50 times higher than the lowest f1 in ICRP 30, and this offsets the effect of the tissue weighting factors described above – the net effect is to increase the ingestion DCF for plutonium (oxide) by a factor of about 18 (see Table 2). Moreover, ICRP 72 essentially replaced the selection of different DCF's for ingestion based upon the chemical form of plutonium with a single value for the case of environmental exposure.

For plutonium (and for americium to a lesser degree) the overall change resulting from the modifications in ICRP 72 is to increase the relative importance of ingested plutonium over inhaled plutonium. This change is considered an improvement (although it appears to fly in the face of past radiation protection guidance concerning plutonium) for the following reasons:

1. The lung model on which ICRP 30 was based was admittedly oversimplified, and overly conservative assumptions about plutonium deposition and distribution in the lung were made to address the high degree of uncertainty in the model. Refinements in the lung model eliminated much of the uncertainty so such conservatism was no longer warranted.

2. At the time of ICRP 30, the wide differences in solubility which were observed in different chemical compounds of plutonium (most notably the oxides) were used as a basis for selecting different DCF's for different chemical forms present in occupational exposure conditions (these choices are retained in ICRP 68 for worker exposure). Subsequent research with animals (ICRP 48) has shown that these differences are not as consistent when influenced by a range of other factors which are likely to be present under conditions of environmental exposure (plutonium concentration and particle size in food, presence of chelating factors in food, whether food is ingested after fasting or not, etc.) To address this degree of variability, the ICRP, in publication 72, prudently selected

a reasonable single value of f1 and eliminated the compound based ingestion DCF choices for conditions of environmental exposure.

Choice of lung Absorption Type for inhalation DCF for plutonium: An additional change resulting from the revision of the lung model in ICRP 60-72 is that the system of lung clearance classes from ICRP 30 (Y, W, D representing year, week, and day timeframes for clearance of inhaled material from the lung) are replaced with a system of lung absorption types (S, M, F for slow, medium and fast respectively, absorption from the lung to the blood). While there are parallels between these two systems, they are not identical, since clearance is a combination of both mechanical removal and absorption to the blood. In addition, the boundary criteria for selecting S vs M (residence half time in lung greater than 700 days) is 7 times greater than for selecting Y vs W in ICRP 30 (half time greater than 100 days) – see ICRP 71, Annex D.

The ICRP 30 clearance classes for plutonium (as well as the choices for ingestion DCF) were based largely upon the chemical compound of the plutonium: Y was recommended for oxides and W for all other compounds and mixtures of compounds. This system is loosely retained in ICRP 68 (workers) reflecting the higher degree of confidence of the chemical and physical characteristics of the inhalation and ingestion exposures in the occupational setting. For ICRP 72 (public) the S, M and F absorption types are not to be strictly based upon compounds, but rather experimentally observed absorption rates in animals. For example, in ICRP publication 48 and 71, it is noted that plutonium oxides formed at temperatures less than 1000 degrees Centigrade are absorbed more like Type M in animal studies, whereas the "high fired oxides"(oxides produced commercially or in thermonuclear tests) behave more like Type S. In addition, plutonium oxides attached to submicron size particles and plutonium aerosols consisting of mixtures of plutonium and other metallic oxides (sodium, magnesium, etc.) are absorbed more rapidly into the blood than are larger particles of relatively pure plutonium dioxide. ICRP 71 additionally presents instances of plutonium attached to dried ocean sediments and certain fallout contamination of soil particles as demonstrating absorption characteristics of Type M compounds. It is important to note that the clearance classes and absorption type categories designated by ICRP are pertinent only to the mobility of plutonium in the human body – they have no apparent relationship to the mobility of plutonium compounds in the environment.

There has been considerable speculation, and certain confirmatory evidence, that the plutonium contamination of surface soils at Rocky Flats, resulting from the spill at the 903 Pad, exists in the environment in the form of oxide compounds, as a result of slow oxidation of the original metal particles present in the drums of cutting fluid which leaked. The relative immobility of the soil plutonium contamination is an observed point of fact. However, there is little doubt that the plutonium oxidation process proceeded at ambient temperatures not approaching the production temperatures of the "high fired" oxides. It is also quite likely that plutonium absorption from environmental exposures may be influenced by some or all of the mitigating factors described in ICRP 71. Based upon this, the majority of the RSAL working group prefers the selection of Type M for the Absorption Type to be used in connection with RESRAD calculations using ICRP 72 DCF's, as well as the selection of Type M for HEAST risk coefficients used in risk calculations. This appears to be a prudent choice which is consistent with the guidance offered in ICRP 71 for environmental exposure conditions.

Isotope	ICRP 30 DCF	ICRP 72 DCF (adult)	ICRP 72 DCF (child)
Plutonium 239/240	W 0.43	**M 0.19****	**M 0.29****
	Y 0.31*	S 0.06	S 0.14
Americium 241	**W 0.44***	**M 0.16****	**M 0.26****
		S 0.06	S 0.15

TABLE 1: Comparative Inhalation DCF's (millirem per picocurie)

Isotope	ICRP 30 DCF	ICRP 72 DCF (adult)	ICRP 72 DCF (child)
Plutonium 239/240	nitrates 0.0035	**all forms 0.00093****	**all forms 0.0016****
	all other 0.00037		
	oxides 0.000052*		
Americium 241	**all forms 0.0036***	**all forms 0.00074****	**all forms 0.0014****

TABLE 2: Comparative Ingestion DCF's (millirem/picocurie)

* Value used in 1996

** Value to be used in 2001

{Insert for Appendix A: Justification and supporting documents for all selected input values}

Exposure Duration (ED)

1. Rural Resident

Brief Description

Exposure duration (ED) refers to the number of years that a resident is present at the same residence. For the rural resident land use scenario, both children and adults comprise the population of concern, and exposure is assumed to begin at birth. Census data provide representations of a cross-section of the population at specific points in time, but the surveys are not designed to follow individual families through time (U.S. EPA, 1998). The U.S. EPA Exposure Factors Handbook (EPA, 1998) summarizes the key studies on population mobility. These studies use a variety of methods to estimate residential tenures, including, 1) calculate the average current and total residence times; 2) model current residence time; and 3) estimate the residential occupancy period. Each of the key studies and methodologies provides similar estimates as summarized in Table A1.

Table A1. Summary of Key Studies for Residential Exposure Duration, based on U.S. EPA (1998), Table 15-174.

Study	Summary Statistics (years)	Methodology
Isreali and Nelson, 1992	mean = 4.6 1/6 of a lifetime of 70 years, or 11.7 years	average current and total residence times
US Bureau of the Census, 1993	50^{th} percentile = 9 years 90^{th} percentile = 33 years	current residence time
Johnson and Capel, 1992	mean = 12 years 90^{th} percentile = 26 years 95^{th} percentile = 33 years 99^{th} percentile = 47 years	residential occupancy period

Probability Distribution

For this analysis, a probability distribution was generated from the empirical distribution function reported by Johnson and Capel (1992) for n = 500,000 simulated individuals (both male and female) given in Table A2.

Table A2. Empirical cumulative distribution function for residential occupancy period reported by Johnson and Capel (1992), based on U.S. EPA (1998), Table 15-167.

Percentile*	Years	Percentile	Years
0.05	2	0.95	33

0.10	2	0.98	41
0.25	3	0.99	47
0.50	9	0.995	51
0.75	16	0.998	55
0.90	26	0.999	59

* the maximu m observed value was 87 years.

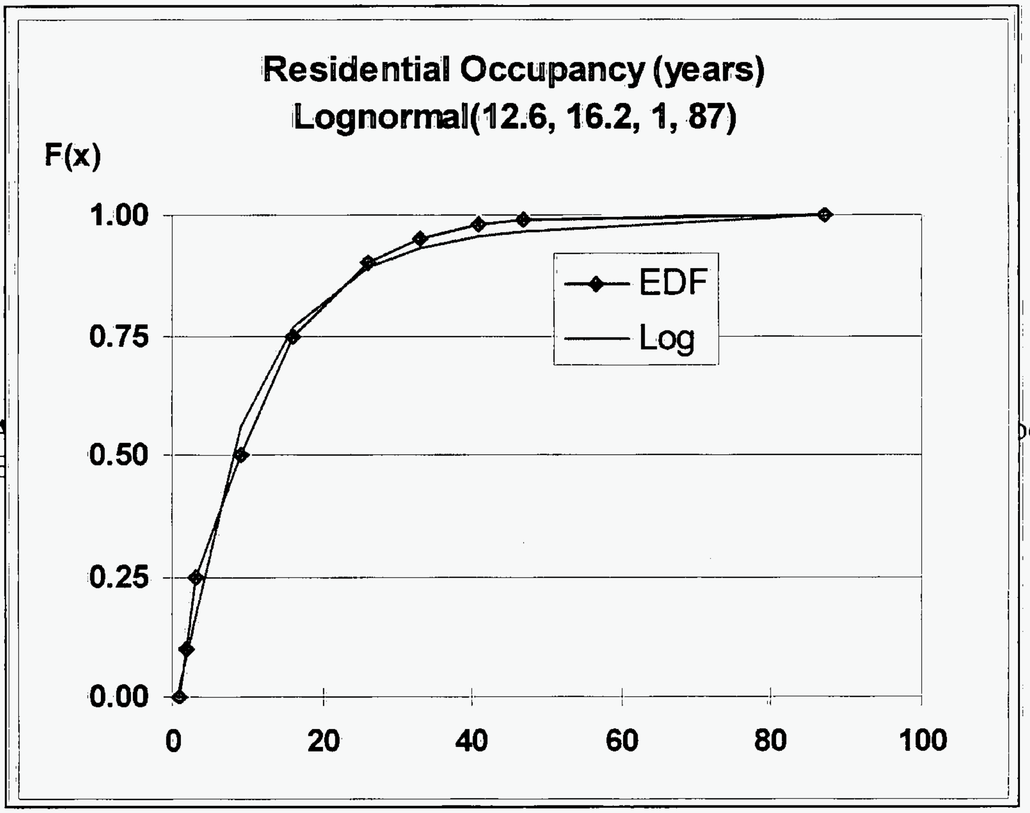


Figure A ccupancy period (E

These data were fit to a lognormal distribution using least squares regression to estimate the arithmetic mean of 12.6 years and standard deviation of 16.2 years. A comparison of the EDF to the fitted lognormal distribution is given by Figure A1. Truncation limits of 1 and 87 are based on professional judgment that the maximum observed values are plausible bounds given the large sample size of the survey. The corresponding probability distribution function is shown in Figure A2.

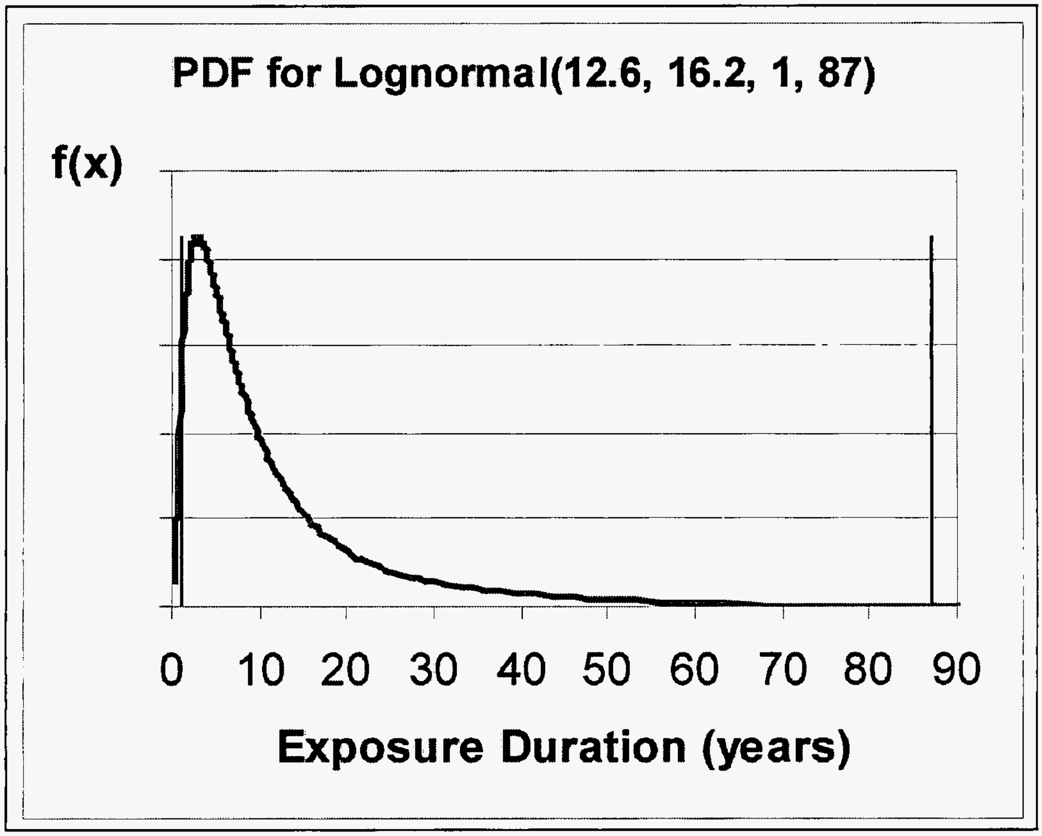


Figure A2. Probability density function (PDF) and cumulative distribution function (CDF) views of the lognormal distribution for exposure duration (years) for the rural resident.

Given reliable fit to the empirical distribution function the following lognormal distribution was selected to represent variability in exposure duration among rural residential populations:

ED ~ Truncated Lognormal (12.6, 16.2, 1, 87) years

The parameters for the truncated lognormal distribution are as follows:

- arithmetic mean 12.6 years
- arithmetic standard deviation 16.2 years
- minimum 1 year
- maximum 87 years

This use of truncation limits on this distribution does have a moderate effect on the parameter estimates used in the Monte Carlo simulation. The maximum value of 87 years truncates the distribution at the 99.3rd percentile, while the minimum value truncates the distribution at the 1.9th percentile. These truncation limits have the combined effect of reducing the mean to 12.0 years (4.8%) and reducing the standard deviation to 12.3 years (24.1%). This change reflects the relative high coefficient of variation for this distribution (CV = stdev/mean = 1.3), however, the maximum of 87 years is considered to be a reasonable approximation of an individual who lives at the same residence their entire life.

The 50th, 90th, 95th and 99th percentiles of this distribution are 7.7, 27.4, 39.3, and 77.0 years.

Justification for Input Variable

The is relatively high confidence in the data set and probability distribution used to characterize variability in residential exposure duration. The standard RME point estimate for use in Superfund risk assessments (for cancer) is 30 years, which is approximately the 91st percentile of this distribution.

1. Wildlife Refuge Worker

Brief Description

For the wildlife refuge worker scenario, exposure duration represents the number of years that a refuge worker spends on site. National survey data on occupational activity patterns are maintained by the U.S. Bureau of Labor Statistics. The Superfund default reasonable maximum exposure estimate for both full time and part-time workers is 25 years, based on the 95th percentile of the number of years worked at the same location reported in 1990.

There are a wide range of reported job tenures among different categories of occupations. The U.S. EPA Exposure Factors Handbook (1998, Table 15A-7) summarizes data reported by Carey (1988) for 109 million adults (16+ years). The median job tenure for the entire survey (all ages, male and female) is 6.6 years, however this varies by occupation and age. Examples of some of median job tenure for selected occupations are given in Table A3.

Table A3. Median job tenure for selected occupations based on Carey (1988) as reported by U.S. EPA (1988), Table 15A-7.

Occupation	Median Tenure (yrs)	Occupation	Median Tenure (yrs)
Barbers	24.8	Health Technologists and Technicians	6.3
Farmers, except horticulture	21.1	Supervisors; Ag Operations	5.2
Construction Inspectors	10.7	Machine Operators	4.5
Administrators and Officials, Public Admin	8.9	Biological Technicians	4.4
Surveying and Mapping Technicians	8.6	Animal Caretakers, except farm	3.5
Science Technicians	7.0	Information Clerks	2.7

The major limitation in using these data to estimate ED for risk assessment is that they reflect time spent in an occupation rather than time spent at a particular job site. In addition, these data reflect median job tenures, and whereas the complete distribution of tenures within a category are of interest. Ideally a sub-category representative of wildlife refuge workers at one site would be used to estimate exposure duration. Such occupation-specific information has been obtained by the U.S. Fish and Wildlife Service in a National Wildlife Refuge Survey, in which wildlife refuge workers were interviewed from three refuges (Crab Orchard, IL; Malheur, OR; and Minnesota Valley, MN). Data for 80 wildlife refuge workers are summarized in the RMA (1994). Of these workers, 33 values reflect incomplete tenures, and 47 values reflect completed tenures. The responses allow for estimates of years spent at one refuge, regardless of whether job activities changed. While the sample size is relatively small, the estimates are similar to that of the national survey data, and provide a more occupation-specific data set for the exposure scenario characterized in this analysis.

Probability Distribution

The following probability distribution is recommended for use in risk equations that are based on U.S. EPA Risk Assessment Guidance for Superfund (RAGS) in order to characterize *interindividual* variability in exposure duration among wildlife refuge workers:

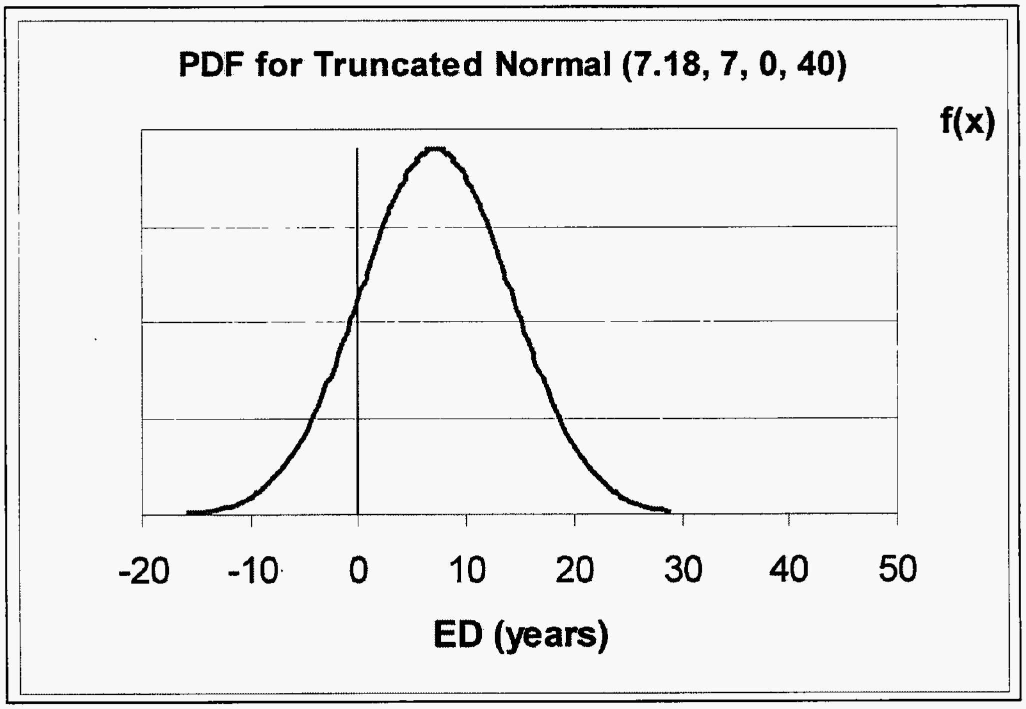
ED ~ Truncated Normal (7.18, 7, 0, 40) years

The truncated normal distribution is defined by four parameters:

- arithmetic mean 7.18 years
- arithmetic standard deviation 7 years
- minimum 0 years
- maximum 40 years

The probability distribution (PDF and CDF) is shown in Figure A3. Given that a normal distribution has infinite lower upper tails, it is reasonable to truncate the distribution at a plausible bounds. A minimum of 0 was chosen to avoid negative values, and a maximum of 40 years was chosen to be approximately 5 standard deviations from the mean, so as to minimize the effect on the parameter estimates in the Monte Carlo simulation. The effect of the truncation limit is to alter the original parameter estimates (mean, standard deviation) to (9.1, 5.6), an increase of 27% in the mean and reduction of 27% in the standard deviation. It is clear from Figure A3 that the truncation limit reduces a significant fraction of the low-end values; in such cases, it is generally preferable to use an alternative distribution that requires less truncation (e.g., lognormal). This was not done for this analysis given that the data were not reported in a manner that would allow for exploration of alternative PDFs.

The 50th, 90th, 95th, and 99th percentiles of this distribution are 7.2, 16.2, 18.7, and 23.5 years, respectively.



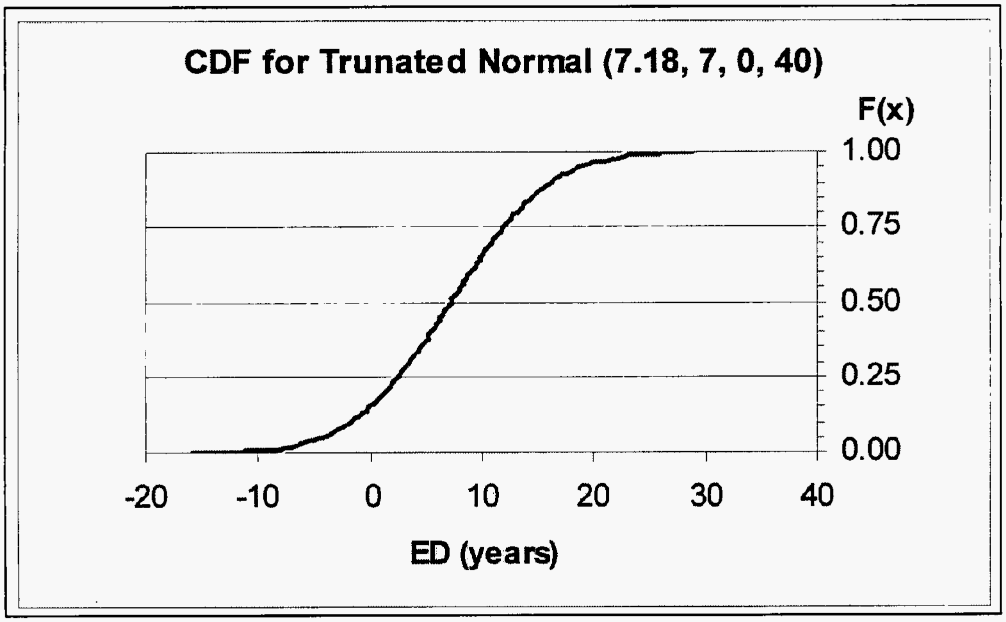


Figure A.3. Probability density function (PDF) and cumulative distribution function (CDF) views of the truncated normal distribution for exposure duration (years) for the wildlife refuge worker.

Justification for Input Variable

The use of a truncated normal distribution is supported by the data reported by U.S. Fish and Wildlife on wildlife refuge workers in three different locations. Data from Carey et al. (1988) for the U.S. population suggest that the highest median tenure at one job is less than 30 years, and the median tenure of all occupations is 6.6 years. The tenure for biological technicians is reported to be 4.4. years. The use of a normal distribution is professional judgment given the reported arithmetic mean and standard deviation for n = 33 biological refuge workers (or 80 tenures). The U.S. Fish and Wildlife Service fit the normal distribution to these data, although an alternative bounded distribution (e.g., beta, lognormal) may be preferable given the significant fraction of low-end values that are truncated below 0.

{Insert for Appendix A: Justification and supporting documents for all selected input values}

Exposure Frequency (EF)

1. **Rural Resident**

Brief Description

Exposure frequency (EF) refers to the number of days per year that a resident is present at home, rather than at work or on vacation. Given that the toxicity endpoint is a long-term average exposure (the endpoint of concern is cancer), this input variable will represent a long-term average time at the residence. For the rural resident land use scenario, it is assumed that if an individual is at home, they may be exposed via one or more exposure pathways for 24 hours per day (see Exposure Time). For this analysis, no distinction is made between exposure frequencies for men and women, or for children and adults. The maximum number of days per year is 365 days.

The U.S. EPA Exposure Factors Handbook (EPA, 1998) summarizes survey data on population mobility for the U.S. population. The sample sizes for the major studies are very large (n > 1000), reflecting national surveys. The difficulty in estimating population activity patterns and mobility from a survey is that it represents a snapshot in time, and there is uncertainty in determining the total duration that an individual will reside at the same house (see Exposure Duration). Extrapolations to a long time periods are required since personal diaries cover short periods of time. However, there is less uncertainty associated with estimating the days per year that an individual spends time at home.

The Superfund default central tendency estimate for residential exposure frequency is 234 days/year, which corresponds to the fraction of time spent at home (64%) for both men and women based on a study of time use patterns summarized in 1990. In other words, the available data suggest that, on average, individuals spend approximately two-thirds of the year at home.

Probability Distribution

For this analysis, a probability distribution was generated from the central tendency estimate given by U.S. EPA exposure factors handbook (234 days/year) and professional judgment regarding a plausible range among a residential population. The maximum value of 350 days was selected to reflect an average of approximately two weeks per year spent away from home, either on family vacation or business travel. A minimum of 175 days/year was selected to reflect a minimum of approximately 50% of the year spent at home.

Given reliable information regarding the central tendency, and plausible estimate for the minimum and maximum, the following triangular distribution was selected to represent variability in exposure frequency among rural residential populations:

EF ~ Triangular (175, 234, 350) days/year

The parameters for the triangular distribution are as follows:

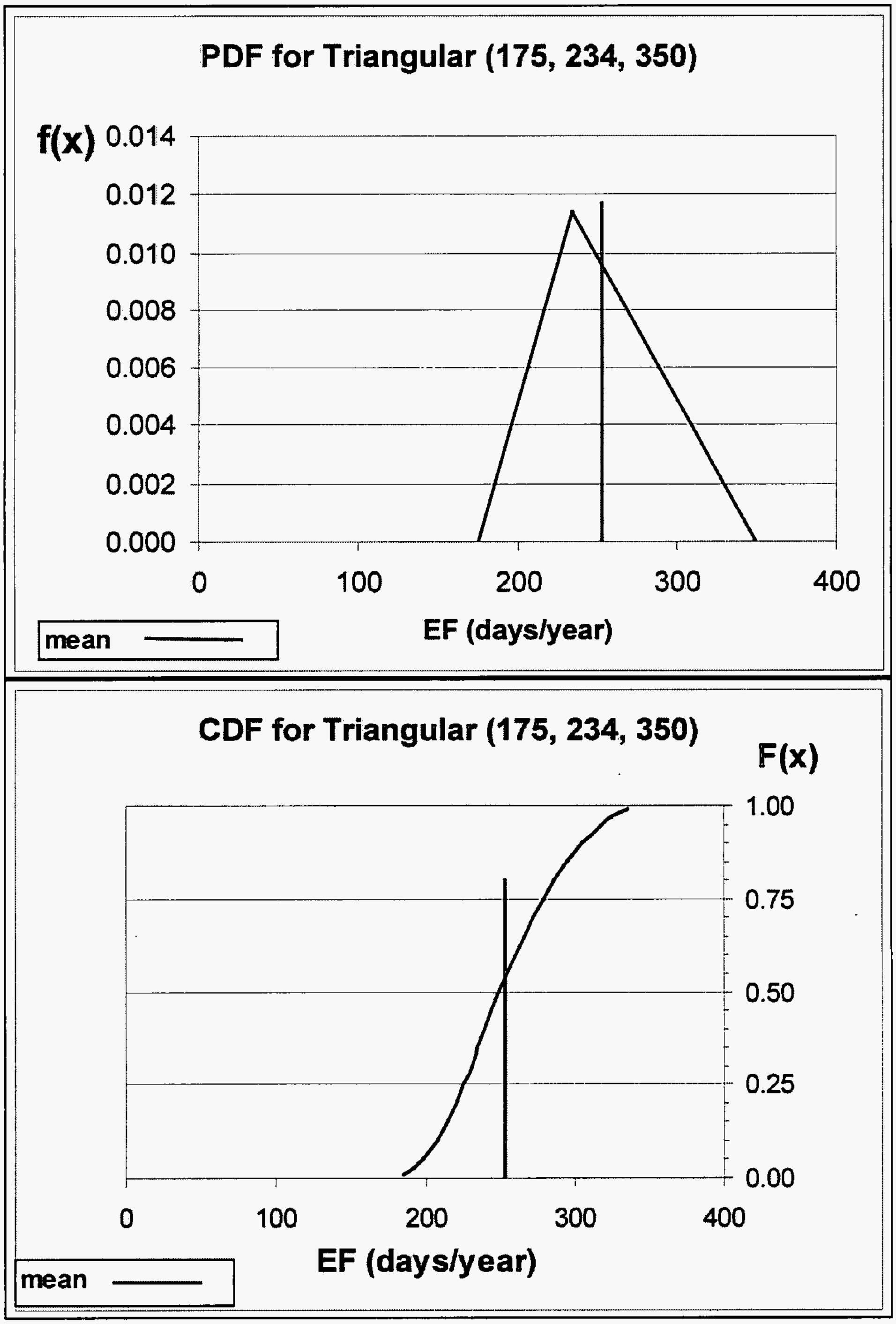
- minimum 175 days/year
- mode 234 days/year
- minimum 350 days/year

The mode characterizes the "most likely" value and will equal the mean for distributions that are symmetrical. Figure A1 presents the probability density and cumulative distribution views for this distributions. The mean, 90th, 95th and 99th percentiles are 253, 305, 318, and 336 days/year.

Justification for Input Variable

The triangular distribution is a reasonable approximation for the "true" distribution for exposure frequency given that the variable is truncated at the high end by definition (i.e., 365 days per year). It may be possible to obtain the original survey data results that formed the basis for the central tendency estimate (CTE) recommended by EPA for use in Superfund risk assessments. However, it is expected that use of an alternative right-skewed (and truncated) distribution would yield very similar percentile estimates, and would therefore have only a minor effect on the risk estimates.

Use of 350 days/year as a high-end truncation limit is viewed as a reasonably conservative estimate of exposure frequency in the absence of site-specific data.



A.1. Probability density function (PDF) and cumulative distribution function (CDF) views of the triangular distribution for exposure frequency (days/year) for the rural resident

1. Wildlife Refuge Worker

Brief Description

For the wildlife refuge worker scenario, exposure frequency represents the average number of days per year that a refuge worker spends on site. National survey data on occupational activity patterns are maintained by the Bureau of Labor Statistics. The Superfund default central tendency and reasonable maximum exposure estimates for both full time and part-time workers is 219 days/year and 250 days/year, respectively. The 250 days/year reflects an individual who works 5 days per week for 50 weeks of the year (thereby taking a single 2-week vacation, for example). These estimates are based on national survey data of the U.S. population from 1991.

Since it is likely that different occupations may reflect substantially different activity patterns, ideally a sub-category representative of wildlife refuge workers would be used to estimate exposure frequency. Such occupation-specific information has been obtained by the U.S. Fish and Wildlife Service in a National Wildlife Refuge Survey, in which wildlife refuge workers were interviewed from three refuges (Crab Orchard, IL; Malheur, OR; and Minnesota Valley, MN). Data for 33 wildlife refuge workers are summarized in the RMA (1994). The responses allow for estimates of either hours per day or days per year. While the sample size is relatively small, the estimates are similar to that of the national survey data, and provide a more occupation- specific data set for the exposure scenario characterized in this analysis.

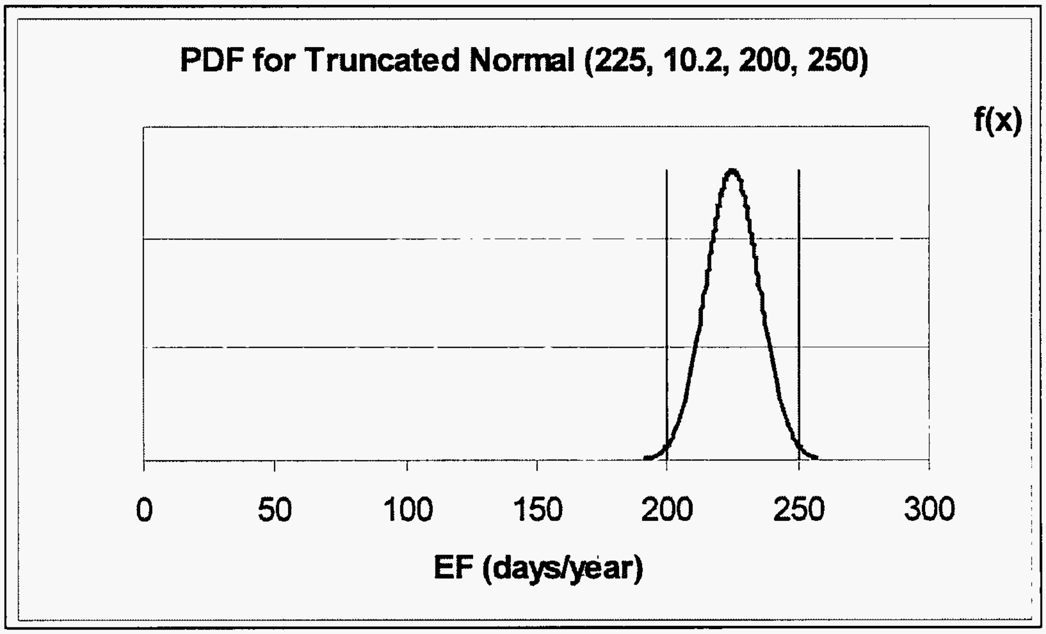
Probability Distribution

The following probability distribution is recommended for use in risk equations that are based on U.S. EPA Risk Assessment Guidance for Superfund (RAGS) in order to characterize *interindividual* variability in exposure frequency among wildlife refuge workers:

EF ~ Truncated Normal (225, 10.23, 200, 250) days/year

The truncated normal distribution is defined by four parameters:

- arithmetic mean 225 days/year
- arithmetic standard deviation 10.23 days/year
- minimum 200 days/year
- maximum 250 days/year



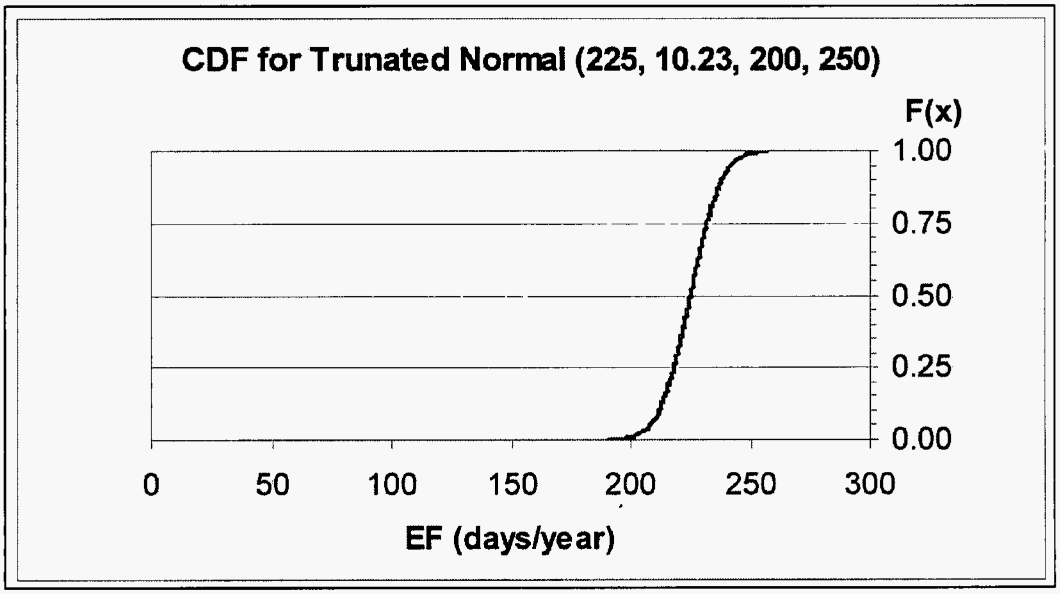


Figure A.2. Probability density function (PDF) and cumulative distribution function (CDF) views of the truncated normal distribution for (adult) exposure frequency (days/year) for the wildlife refuge worker.

The probability distribution (PDF and CDF) is shown in figure A2. Given that a normal distribution has infinite lower and upper tails, it is reasonable to truncate the distribution at plausible bounds. The affect of the truncation limit is to alter the original parameter estimates (mean, standard deviation) that is effectively used in a Monte Carlo simulation. For this analysis, the coefficient of variation (CV = stdev / mean) is very low (0.05), so truncating at 200 and 250 days/year has a minimal effect. These truncation limits remove 0.7% of the tail at both ends, and due to the symmetrical shape, there is no change in the mean or standard deviation.

Justification for Input Variable

The use of a normal distribution is supported by the data reported by U.S. Fish and Wildlife on wildlife refuge workers in three different locations. The arithmetic mean (225 days/year) is slightly greater than the central tendency estimate reported by the Bureau of Labor Statistics for all occupations (219 days/year). The maximum value of 250 days/year is consistent with the RME estimate recommended for use at Superfund sites, and may be viewed as a reasonable upper bound for individuals who work week days only, and take two weeks of vacation per year. The lower bound of 200 days per year suggests that the range among different workers at the refuge is relatively narrow (i.e., 50 days).

Key Points on Preliminary Surface RSAL Matrix

August 8, 2001

- Dose Calculations were made using RESRAD.
- Risk Calculations were made using standard EPA risk equations.

- These are plutonium values which account for contribution of dose or risk from americium by the sum of ratios method.

- Values are at 95 percentile (Based on EPA Guidance on Probabilistic Risk Assessment).

- 25 mR RESRAD values exceed 1×10^{-4} risk.
- Other scenarios will be run in the next couple of weeks.
- Uranium values remain to be calculated.

- Numbers are presented exactly as they are calculated. Final RSAL numbers will be rounded to one or two significant digits.

- Values on matrix will ultimately be used to select an RSAL, and may be used to establish Tier levels, ALARA goals and institutional control decisions.

RSAL Calculations: Key Parameters

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Key Parameters

"**key parameters**" -- inputs to RESRAD whose **variability, uncertainty or change** could have measurable influence on the outcome of the calculation. The majority of these parameters have been previously identified as "sensitive".

Parameters included in this discussion

- Dose Conversion Factors (DCF) - not sensitive parameters, but important to the discussion
- Inhalation Rate
- Soil Ingestion Rate
- Mass Loading
- Exposure Frequency

Approach to Assigning Parameter Values

RESRAD is designed with a number of relatively conservative features. In addition, the choice of input parameters can strongly influence the results of RESRAD calculations.

- Working group debated at length the need to balance conservatism in individual parameters against the net effect of many conservative inputs causing an unrealistically conservative result.
- Working group decided to exercise the probabilistic options available in RESRAD
- Sensitive parameters were identified
- Best available information was gathered to describe each
- Distributions were chosen to describe those with significant inherent variability.

Parameter Representation

Considerations:

- A parameter may be well measured yet have relatively large intrinsic variability due to potential future site conditions - use a **statistical** distribution **Example: annual mass loading**
- A parameter may not be well characterized due to insufficient data - use a conservative **deterministic** value
  Example: soil ingestion rate in adults
- A parameter may have large intrinsic variability and a well characterized distribution function – use a **statistical** distribution
  Example: soil ingestion rate in children

Other parameters, either well-characterized by a single value, or having little intrinsic variability over the period of concern, are input as single values.

Dose Conversion Factors

Use of ICRP 30 or ICRP 60/72

- Working Group has chosen to go with most recent scientific studies - uses ICRP 60/72 dose conversion factors
  - differences attributable to development of age specific DCFs
  - revisions to lung model,
  - more extensive tissue weighting data,
  - revisions to ingestion DCFs.
- DOE will use ICRP 30 dose conversion factors for regulatory compliance

COMPARISON		ICRP 30	ICRP 60 (Adult)	ICRP 60(Child)
Inhalation	Pu	0.43	0.19	0.29
(mrem/pCi)	Am	0.44	0.16	0.26
Ingestion	Pu	0.000052	0.00093	0.0016
	Am	0.0036	0.00074	0.0014

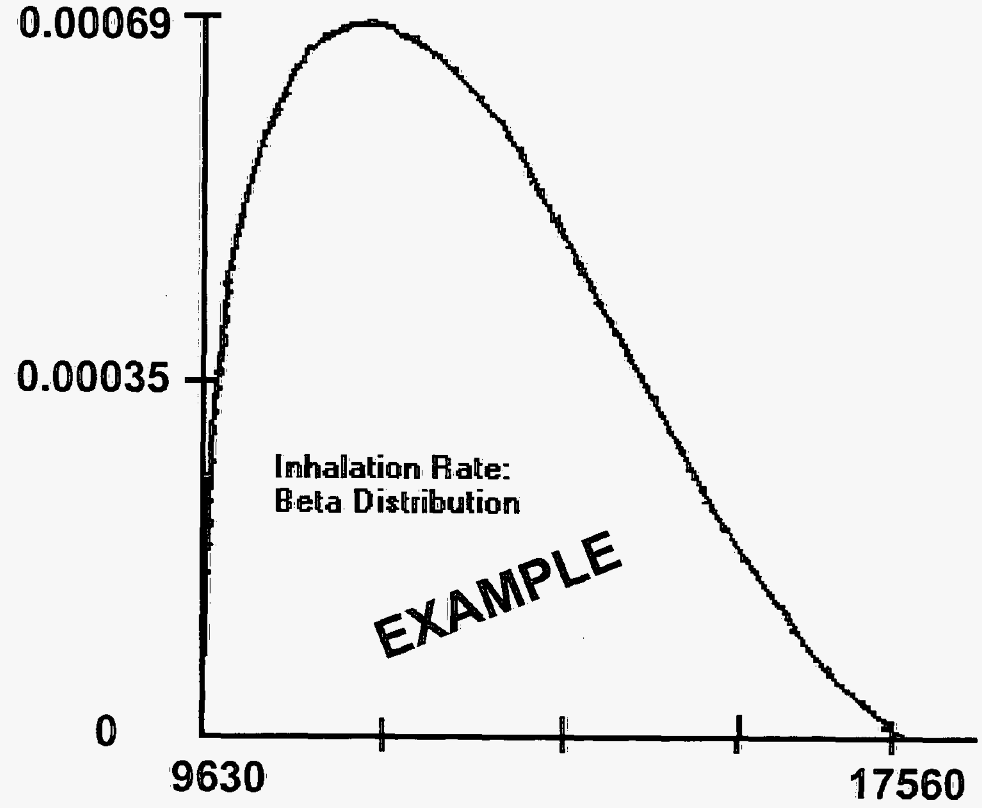
Inhalation Rate

Rural resident and wildlife refuge worker provide different exposure profiles

- Inhalation rate for resident adults is determined by WG to be best represented by a log-normal distribution with mean of 16.2 m^3/day and standard deviation of 3.9
- For a resident child, as a log-normal distribution with mean of 9.3 m^3/day and standard deviation of 2.9
- The wildlife refuge worker will typically experience a greater breathing rate; that rate is characterized by a beta distribution (17560, 9636, 1.79, 3.06) (m^3/y)

Adult:	**'96** -- 7000 m^3/y	**RAC** -- 10,800 m^3/y	**'01** -- as stated
Child:	--	8,600 m^3/y	

Inhalation Rate: Wildlife Refuge Worker



Soil Ingestion Rate

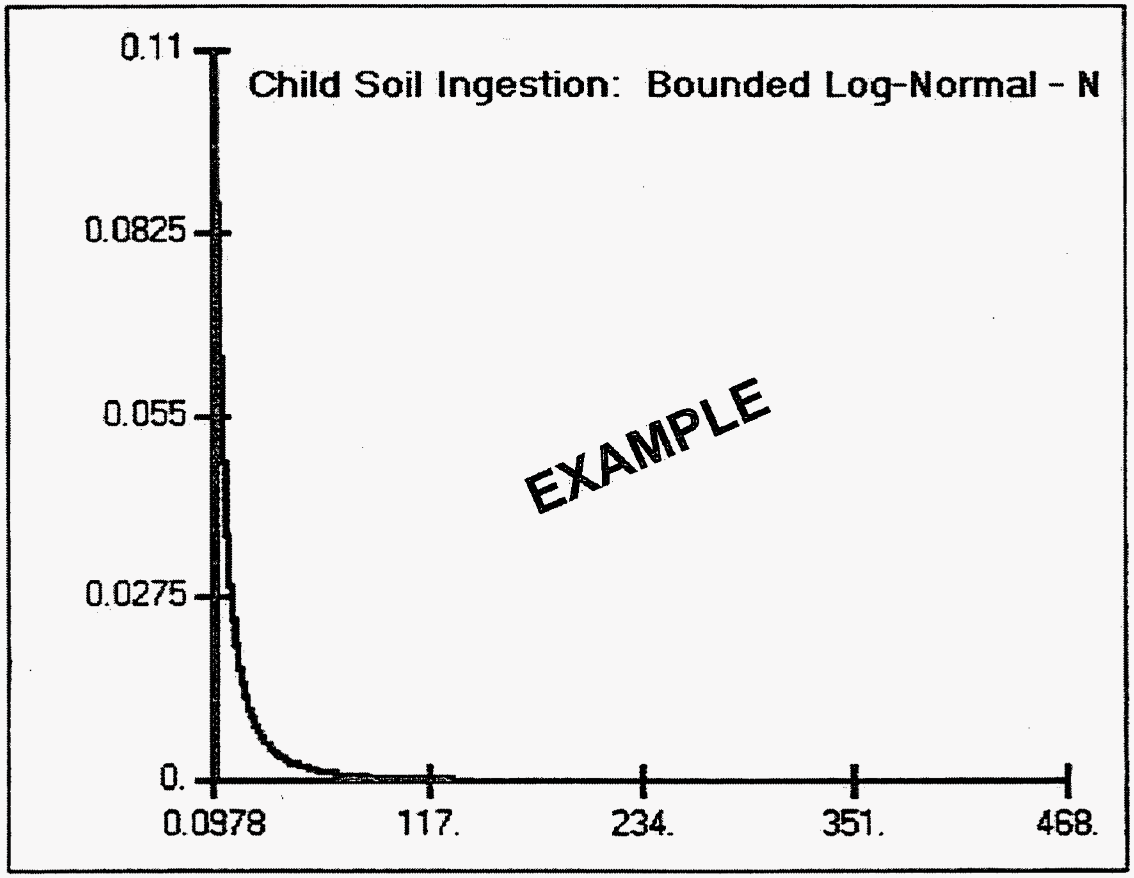
For residential soil ingestion, the adult and child parameters are treated differently

- The child soil ingestion rate is best characterized in Calabrese study - the result is a distribution function characterized by a bounded log-normal with mean of 16.62 g/y and a range from 1 to 365 g/y
- The adult soil ingestion rate, also best characterized by Calabrese, is based on a small data set, insufficient for defining a distribution -- working group chose to go with conservative 100 µg/day(35 g/y), based on EPA Superfund guidance, for reasonably maximally exposed individual.

Soil ingestion is adjusted for wildlife refuge worker, multiplying by three (an artifact of the RESRAD model formulation).

Adult:	**'96** -- 70g/y	**RAC** -- 75 g/y	**'01** -- 36.5 g/y
Child:	--	75 g/y	as stated

Child Soil - Ingestion Distribution



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Mass Loading

Mass Loading is the ambient mass concentration that could exist in the future at Rocky Flats

- Distribution of possible values developed using:
  - representative Statewide PM-10 data
  - empirical results from post-fire wind erosion studies
  - site-specific meteorological data
  - site-specific size-distribution data
- Resulting mass-loading distribution reflects fire influence for upper 10% of values
- Final risk-based RSAL, and 25 mrem dose calculation, will reflect that same fire influence

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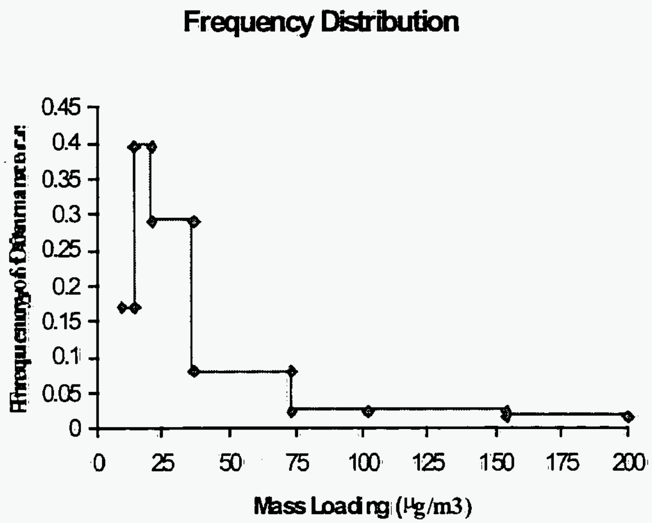
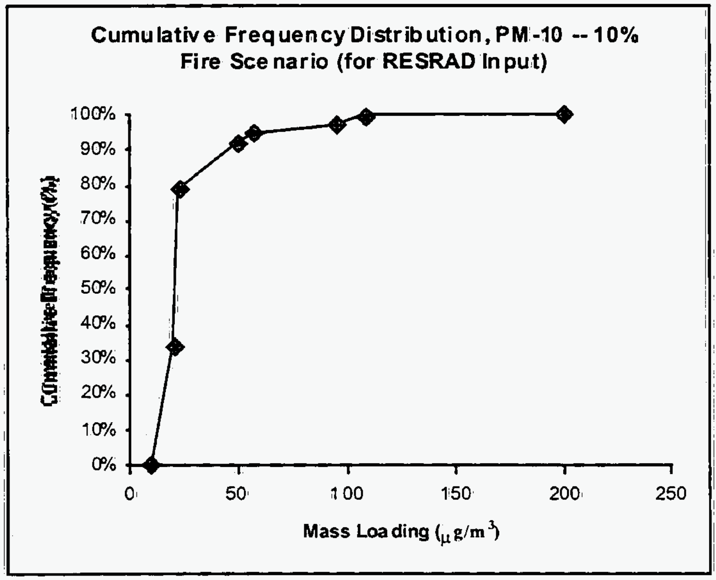
Mass Loading Distribution - for Inhalation

Frequency distribution:



Cumulative distribution, as input:



'96 --26 µg/m³ **RAC** -- 35 µg/m³ * **'01** -- as shown

* For Pu/Am, RAC applied a customized distribution not directly reproducible in RESRAD

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Exposure Frequency & Exposure Time

RESRAD and RAGS require different sets of inputs for exposure frequency and exposure time

- In RESRAD, exposure frequency indoors and out for a Rural Resident is represented by a triangular distribution of indoor time fraction equal to 0.408 minimum, 0.545 midpoint and 0.815 maximum; outdoor time fraction of 0.072 minimum, 0.096 midpoint and 0.144 maximum.
- This is consistent with RAGs triangular distribution for exposure frequency of (175, 234, 350) days per year, coupled with an exposure time of 24 hours/day, an exposure fraction indoors of 0.85 and outdoors of 0.15
- Distributions for Wildlife Refuge Worker were developed from refuge worker surveys. The resulting distribution for time indoors, and outdoors, is a normal distribution with mean of 0.103, standard deviation of 0.005, minimum of 0.091 and maximum of 0.114

Resident: **'96** -- find=1, fotd=0 **RAC** -- 0.6, 0.4 **'01** -- .85/.15 equiv.

Conclusion

- **Working Group has characterized all key parameters**
- **RESRAD is being exercised probabilistically**
  - Results represent entire range of statistically distributed input parameters
  - Upper 10th percentile of the results will be considered when making final RSAL recommendation
  - That upper 10th percentile contains the results driven by the more conservative input values.

August 8, 2001

Preliminary Surface Plutonium Dose & Risk Calculations for Potential Future Land Users at Rocky Flats – 95 percentile (pCi/g)

Land Use Scenario	Risk Levels 10^{-4}	Risk Levels 10^{-5}	Risk Levels 10^{-6}	25-mrem annual dose
Wildlife refuge worker	512	51	5	875**
Rural Resident – adult	190	19	2	223**
Rural Resident– child				250**
Open Space User – adult	*	*	*	*
Open Space User – child				*
Office Worker	*	*	*	*
RAC Resident Rancher	*	*	*	*

** **Dose value exceeds 1 X 10^{-4} risk**

* **To be Completed**

Soil Ingestion Rate for Adults (IRs_adult, ages 7+ years)

Brief Description of Empirical Data

The soil ingestion rate variable represents the average daily mass of soil or dust that enters the human GI tract. For adults, soil ingestion is thought to reflect a combination of direct ingestion from materials placed in the mouth (e.g., hands, food, cigarettes) or indirectly via inhalation when larger particles are transferred from the upper respiratory tract to the mouth (via mucociliary transport) and swallowed.

Empirical data on adult soil ingestion rates are available from a single study (Calabrese et al., 1990), conducted concurrently with a study of childhood soil ingestion rates in Amherst, MA. The purpose of the adult study was to verify the tracer mass balance methodology used in the child study, rather than to investigate the amount of soil normally ingested by adults. Nevertheless, as indicated by the authors, it does offer an estimate of the amount of soil ingested by the six adult subjects in the study over a period of three consecutive days for each of three weeks. Stanek and Calabrese (1995) recommend estimating a distribution of soil ingestion rates from this type of study based on the median of the four best tracers for each subject week. On the basis of percent recoveries, the four best tracers for this study were determined to be Al, Si, Y, and Zr. Results of the study reported by week and tracer are given in Table A1.

Table A1. Calabrese et al. 1990 study results by week and tracer element based on median Amherst soil concentrations [mean / median for n = 6 subjects].

Study Week	Soil Ingestion (mg/day) by Tracer [mean / median]			
	Al	Si	Y	Zr
1	110 / 60	30 / 31	63 / 44	134 / 124
2	98 / 85	14 / 15	21 / 35	58 / 65
3	28 / 66	-23 / -27	67 / 60	-74 / -144

Probability Distribution

For this analysis, it was determined that insufficient data existed to develop a probability distribution for purposes of calculating risks and remediation goals. **Therefore, a point estimate of <u>100 mg/day</u> is used in the analysis**, based on the value recommend by EPA policy (1991) for adult populations in residential and agricultural scenarios.

For purposes of sensitivity analysis, it may still be useful to develop a probability distribution in order to evaluate the influence of this variable on the risk distribution. If a Monte Carlo sensitivity analysis is run, the following probability distribution is recommended for use in risk equations that are based on U.S. EPA Risk Assessment Guidance in order to characterize *interindividual* variability in adult soil ingestion rate:

Irs_adult ~Uniform (30,100) mg/day

The uniform distribution is defined by two parameters:

- minimum 30 mg/day
- maximum 100 mg.day

For the RESRAD model, the same point estimate can be used by converting the units from (mg/day) to (g/year):

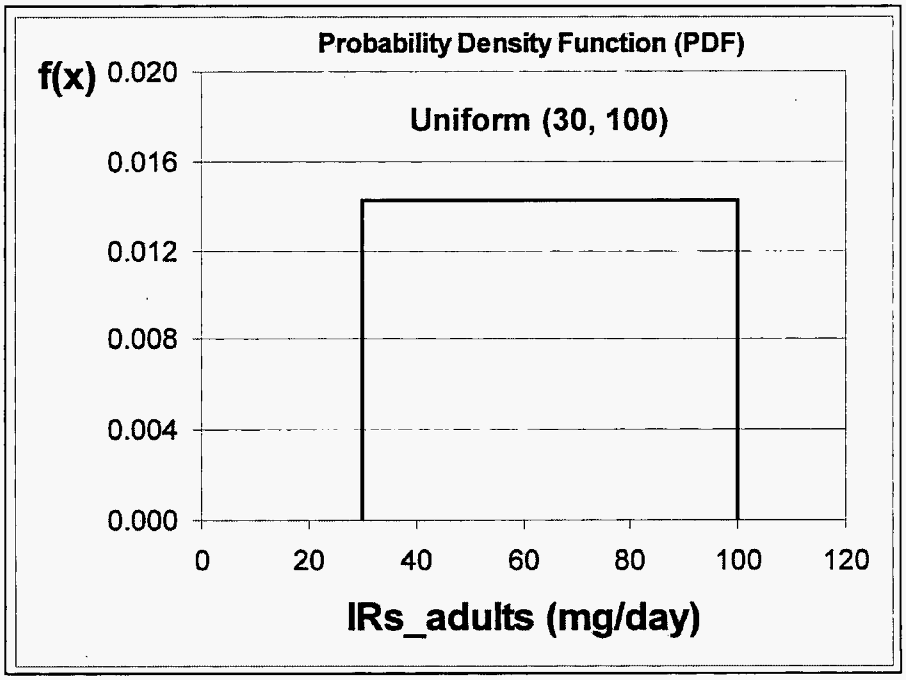
point estimate 100 mg/day x 0.001 g/mg x 350 day/yr = **35 g/year**

Similarly, a probability distribution used in a sensitivity analysis would have the following parameters:

- minimum 30 mg/day x 0.001 g/mg x 350 day/yr = 10.5 g/year
- maximum 100 mg/day x 0.001 g/mg x 350 day/yr = 35 g/year

Therefore, the equivalent distribution for use in RESRAD is:

IRs_adult ~ Uniform (10.5, 35) g/year



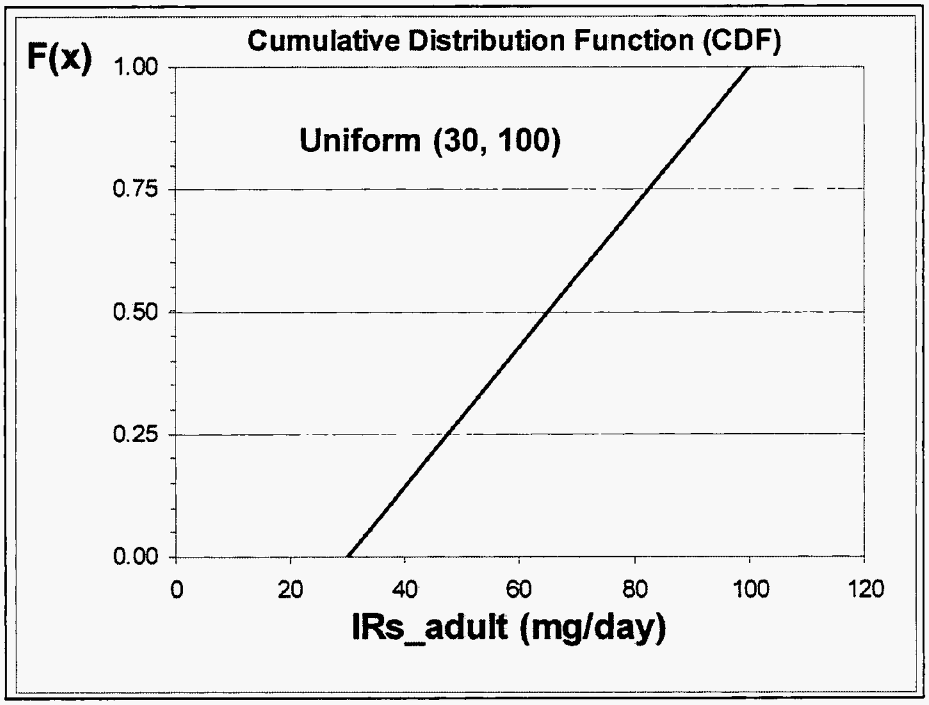


Figure A.1. Probability density function (PDF) and cumulative distribution function (CDF) views of the uniform distribution for adult soil ingestion rate (mg/day).

Soil Ingestion Rate (IR_{s_child}), Children (ages 1 - 7 years)

Brief Description of Methodology and Empirical Data

FECAL TRACER METHODOLOGY FOR ESTIMATING SOIL INGESTION RATE

Empirical estimates of soil ingestion rates (IR_{soil}) in children have been made by backcalculating the mass of soil and/or dust a subject would need to ingest to achieve a tracer element mass measured in collected excreta (i.e., feces and urine) (Calabrese et al., 1996). The general expression for the trace element ("tracer") mass balance is given by Equation 1:
where $[tracer]_{out}$ is the average daily tracer mass (_g) measured in feces and urine, $[tracer]_{in,\ non\text{-}soil}$ is the average daily tracer mass measured in non-soil ingesta (i.e., food, water, toothpaste, and medicines), and $[tracer]_{in,\ soil}$ is the estimated average daily tracer mass in ingested soil. Dividing all terms by the measured tracer concentration in soil (_g/g) yields an estimate of the average daily soil ingestion rate, as given by Equation 2:

EMPIRICAL DATA

Calabrese et al. (1997a) - Eight trace elements (Al, Si, Ti, Ce, Nd, La, Y, and Zr) were measured in a mass-balance study of 64 children ages 1 to 3 years over 7 consecutive days during September. Participants were selected from a stratified simple random sample of approximately 200 households from 6 geographic areas in and around Anaconda, MT. A single composite soil sample was collected from up to 3 outdoor play areas identified by parents as locations where subjects spent the most time. Similarly, indoor dust samples were vacuumed from floor surfaces that parents reported to be common play areas during the study. Duplicate food and fecal tracer element samples were collected for 448 and 339 subject-days, respectively. A total of 64 subject-week estimates of IR_{soil} were made; subject-day estimates of IR_{soil} have recently been published (Stanek and Calabrese, 1999; 2000; Schulz, 2001). Three trace elements (Ce, La, and Nd) were not used to estimate IR_{soil} because soil concentrations of these elements were found to vary by particle size (Calabrese et al., 1996). For each subject-week, a maximum of 5 estimates of IR_{soil} were made, each estimate corresponding to a unique trace element. Final soil ingestion estimates are based on soil particle size < 250 _m (as opposed to 2 mm).
Three seminal studies, briefly summarized below, used this mass-balance approach and were considered appropriate for quantifying variability and uncertainty in IR_{soil}. Pathways for non-soil/non-food intake of tracers (e.g., inhalation and dermal absorption) and excretion (e.g., sweat and hair) were not measured in these studies and are thought to be minor components of the overall tracer mass balance (Barnes, 1990).

Probability Distribution

The following probability distribution was developed for use in probabilistic risk and RSAL calculations:

IRs_child ~ Truncated Lognormal (47.5, 112, 0, 1000) mg/day

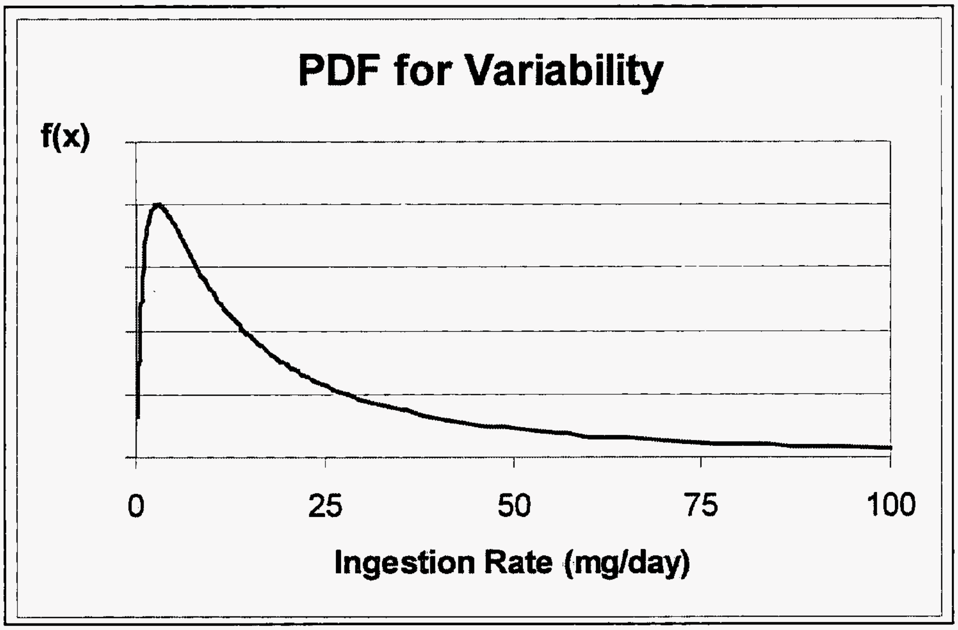
The truncated lognormal distribution is defined by four parameters:

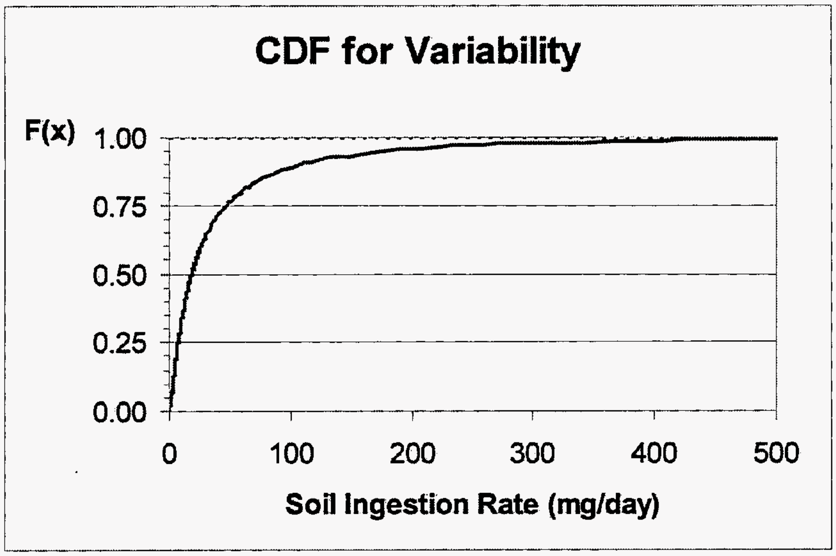
- arithmetic mean 47.5 mg/day
- standard deviation 112 mg/day
- minimum 0 mg/day
- maximum 1000 mg/day

FINAL SELECTION OF PROBABILITY DISTRIBUTION FOR SOIL INGESTION RATE

The Anaconda data is generally considered to be more representative of the potentially exposed population of children at the Rocky Flats:

- a mass balance approach was used wherein tracers were measured going into the children (food, water, toothpaste, medicine) and going out of the children (feces, urine)
- tracers used to develop the soil estimates were selected based on minimizing outside source error, such as tracers with high concentrations in food)
- soil was sieved at 250 _m, a more representative size fraction for particle adherence to hands;
- the geography and climate of Anaconda is more representative of the geography and climate of Rocky Flats (as compared to Amherst, MA)





Summary Statistics	IRsd (mg/day)
mean	47.5
stdev	112
50th %ile	18.5
75th %ile	46.8
90th %ile	107.5
95th %ile	177.0
95.8th %ile	200.0
99th %ile	450.7
Max	1000

Figure A.1. Probability density function (PDF) and cumulative distribution function (CDF) views of the probability distribution for child soil ingestion rate (mg/day).

RFCA Stakeholder Focus Group
Meeting Agenda

When: **August 8, 2001 3:30 - 6:30 p.m.**

Where: **Broomfield Municipal Hall, Bal Swan and Zang's Spur Rooms**

3:30-3:40	Agenda Review, 6/20, 7/11/01 Meeting Minutes Review, Objectives for this Meeting
3:40-4:50	RSALs: Task 3 – Parameter Discussion and Modeling Results
4:50-5:00	Break
5:00–5:50	RSALs: Task 3 – Parameter Discussion and Modeling Results (Continued)
5:50-6:10	Review of Peer Review Process for Task 3, Including Wind Tunnel Peer Review
6:10-6:20	Clean-up Alternatives Matrix – Distribution of Draft Working Group Results
6:20-6:30	Set Future Agendas and Review Meeting
6:30	Adjourn

RFCA Stakeholder Focus Group
Attachment A

Title:	Agenda for August 8, 2001 Focus Group Meeting
Date:	August 7, 2001
Author:	C. Reed Hodgin AlphaTRAC, Inc.
Phone Number:	(303) 428-5670
Email Address:	cbennett@alphatrac.com

Notes from RSAL's Working Group Meeting on 7/26/01

Items covered on 7/26:

Plant uptake factors - proved acceptable to Ward Whicker

QA/QC of dose conversion factors

Occupancy factors

QA/QC of RESRAD input parameters

Actions:

Action Item	Who	When	Notes
Get confirmation of plant uptake factors from Ward Wicker	Carl Spreng	8/2	
Write up justification for dose conversion factors	Jim Benetti	7/27	
Run Resrad using ICRP 72	Tom Pentecost	8/2	
Complete RAGS runs	Phil Goodrum	8/2	
Revise parameter value spreadsheet per discussion in working group mtg	Tom Pentecost	8/2	
Look into variance for the requirement to running ICRP 30	Joe Legare	8/2	
Participate in discussion concerning veg. consumption and breathing rates for office worker and open space scenario	Carl Spreng Phil Goodrum Jim Benetti	7/31	Send results of discussion on to working group
Gather materials for packet to be distributed to Focus Group	Patricia Powell	8/2	Workgroup members send directly to Patricia or Jean

Decisions:

Tom Pentecost will only run RESRAD using ICRP 72. If a variance is not obtained, ICRP 30 will also need to be used.

The following plant uptake factors will be used - Pu: 6.7 x 10-5, Am: 1.3 x 10-3.

<u>Next Meeting: Thursday, August 2, 2001, 8:30 am at the EPA Conference Center</u>

Agenda Items:

1. **Discuss results of Resrad Runs and RAGS runs**
2. **Comments on Jim's proposal for simplifying the indoor/outdoor time fractions for RESRAD**
3. **Resolution of dose conversion factor**
4. **Complete assignments for writing each section of the Task 3 report**
5. **Discuss proposed open space and office worker scenario parameter values**
6. **Discuss details for presentation at 8/8 Focus Group meeting**

Notes from RSAL's Working Group Meeting on 7/26/01

Items covered on 7/26:

Plant uptake factors - proved acceptable to Ward Whicker

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Get confirmation of plant uptake factors from Ward Wicker	Carl Spreng	8/2	
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Participate in discussion concerning veg. consumption and breathing rates for office worker and open space scenario	Carl Spreng Phil Goodrum Jim Benetti	7/31	Send results of discussion on to working group
Gather materials for packet to be distributed to Focus Group	Patricia Powell	8/2	Workgroup members send directly to Patricia or Jean

Decisions:

Tom Pentecost will only run RESRAD using ICRP 72. If a variance is not obtained, ICRP 30 will also need to be used.

The following plant uptake factors will be used - Pu: 6.7 x 10-5, Am: 1.3 x 10-3.

__Next Meeting: Thursday, August 2, 2001, 8:30 am at the EPA Conference Center__

Agenda Items:

1. **Discuss results of Resrad Runs and RAGS runs**
2. **Comments on Jim's proposal for simplifying the indoor/outdoor time fractions for RESRAD**
3. **Resolution of dose conversion factor**
4. **Complete assignments for writing each section of the Task 3 report**
5. **Discuss proposed open space and office worker scenario parameter values**
6. **Discuss details for presentation at 8/8 Focus Group meeting**

NOTES FROM RSALs WORKING GROUP MEETING ON 7/12/01

ITEMS COVERED ON 7/12:

1. RESRAD runs for 3 scenarios (rural resident adult, rural resident child, and wildlife refuge worker) for the purpose of QA/QC of the input parameters.
2. Adult soil ingestion rate parameter.
3. Plant uptake factor.
4. Task 3 report outline and responsibilities.

ACTIONS

Action Item	Who	When	Notes
Provide RESRAD runs to Jim Benetti.	Tom Pentecost	ASAP	
QA/QC input parameters used in 3 RESRAD runs by Tom Pentecost (distributed at 7/12/01 working group meeting).	All	7/19/01	Be prepared to discuss any issues from QA/QC of input parameters. Please have proposals for changes if you disagree with any of the inputs.
QA/QC dose conversion factors (e-mailed on 7/10/01).	All	7/19/01	Be prepared to discuss any issues from QA/QC of dose conversion factors. Please have proposals for changes if you disagree with any of the factors.
Talk to Ward Whicker (& submit in writing) to get his recommendation on which plant uptake factor to use.	Carl Spreng	7/19/01	Working group decided to accept and use Ward Whicker's recommendation.
Add new assignees to Task 3 report outline and provide to Sandi.	Tricia Powell	7/18/01	Sandi will distribute to working group. Group members should review outline prior to 7/19 meeting and be prepared to complete the assignments.
Tom Pentecost will prepare a spreadsheet of current input parameter values for each scenario. Susan Griffin will use the spreadsheet to propose values for office worker & open space scenarios.	Tom Pentecost & Susan Griffin	7/19/01	

DECISIONS

1. The working group will accept and use Ward Whicker's recommendation on plant uptake factor.
2. For the adult soil ingestion rate parameter, the working group will use the point estimate value in the Exposure Factors Handbook. For the office worker scenario this is 50 mg/day and for all other scenarios it is 100 mg/day. The information from Syracuse Research Corporation on this parameter, which helped lead the working group to this conclusion, will be included in the written justification for this parameter value.

NEXT MEETING: THURSDAY, 7/19, 8:30 a.m. at the EPA CONFERENCE CENTER

Agenda Items:

1. Present plant uptake factor results.
2. Discuss results/comments of the working group's QA/QC of the RESRAD input parameters.
3. Discuss results/comments of the working group's QA/QC of the dose conversion factors.
4. Finish assigning responsibility for writing each section of the Task 3 report.
5. Discuss proposed open space and office worker scenario parameter values.

RFCA Stakeholder Focus Group
Attachment C

Title:	RSALs Working Group Notes for July 12, July 26, and August 2, 2001
Date:	August 7, 2001
Phone Number:	(303) 428-5670
Email Address:	cbennett@alphatrac.com

From: Mary Harlow
To: Victor Holm
Date: 8/7/01

Thanks for the update Victor. I would like to point out some inconsistencies in your statements regarding the soil ingest and inhalation risks are not in the same place. You state that one thousand feet to east of the 903 pad the plutonium values are about 10 pCi/g and at the east fence line they are less than 1 piC/g.

I refer you to the Plutonium 239/240 Distribution in Surface Soil (1999 Kriging Analysis) which shows that along the East fence line the contamination levels for plutonium for much of the soil along Indiana the levels is greater than 1.0 and less 5.0 which amounts to 945.7 acres(onsite). This contamination level does not stop at Indiana but also continues across the road to offsite property to the East.

The contamination coming off the 903 pad at Indiana (east Gate Area) is shown to be great than 5.0 and less than 10 picocuries per gram. This level of contamination amounts to 184.8 acres (not all contiguous to Indiana but close by). The MEI (Maximally Exposed Individual)for offsite contamination was shown to be located at Mower Reservoir in 1999. I haven't seen where that individual would be located in 2000.

I would like to have information from the working group members as to whether they have considered:

1. That the Wildlife Refuge Worker may be caught in high winds while doing his job and therefore be exposed to higher levels of dust.
2. Cumulative effects from other contaminants such as VOC's in the soil. There may be some areas where putting a building may not be prudent. Fumes do come up from the soil and could enter buildings.
3. Radon that could enter buildings from natural occurring uranium at the site should also be factored in.
4. That plant litter as well as soil will contain plutonium contamination. The contamination comes from wind blown plutonium being deposited on plants. Rain, snow, die-back, more wind will result in the contamination being washed to the ground/litter that is in the area. You will have some concentrating effects with Rills (cracks in the soil).

RFCA Stakeholder Focus Group
Attachment D

Title:	Modeling Assumptions memorandum
Author:	Victor Holm
Date:	August 6, 2001
Phone Number:	(303) 989-9086
Email Address:	vholm@aol.com

To: RFCA Focus Group
From: V Holm
July 9, 2001

Vholm@AOL.COM
(303) 989-9086

I would like to recommend the following approach to setting soil cleanup levels at Rocky Flats. These cleanup levels are for the purpose of protecting future users of the site; they are not meant to protect off-site residents or surface water. These are important considerations; but they must be considered separately.

Current policy and guidance (OSWER Directive 9355.7-7p) directs that the most likely future user must be considered in the setting of cleanup levels. The wildlife refuge bill now before Congress is likely to pass. If for some reason it were to fail, the entire community is on record as opposing future development of the site. We must conclude that the most likely future user will be a wildlife refuge or open space worker. The same OSWER guidance permits the consideration of future residential use. The RSAL Working group is considering this scenario.

ALARA (as low as reasonably achievable) is part of the NRC site closure guidance but not part of CERCLA. Although ALARA has been used for years to reduce worker exposure; its use in cleanup decisions is fairly new and up to now the results have been spotty. It is not clear to me how the NRC guidance on ALARA will be reconciled with EPA guidance. I have other problems with ALARA. Cost and efficiency are major considerations in applying ALARA. Are these to be applied on a case by case basis or globally? If case by case the community will not know until the cleanup of a particular site is started what will form the cleanup level. If globally the result will not be the best cleanup since for one site it may be reasonable to excavate the entire contaminated area while for another it will have to stop somewhere. Most in the community have assumed up till now that the RSAL is a huddle that must be meet. Whether it is 25 mrem or 10^{-4} cancer risk it is assumed that this will trigger an action. After this action is triggered then an ALARA study will also be triggered. What happens if the particular contaminated area is just below the action level. Since no action is required then ALARA is never triggered and the area is not cleaned up. This is what I call a top down approach.

I propose we consider a bottom up approach instead. The minimum risk that is considered in EPA guidance is 10^{-6} cancer risk. This risk should be applied to the Wildlife Refuge Worker scenario. It is impractical to attempt remediation at levels that can not be measured in the field (EPA ROD on Johnson Atoll). This level is somewhere between 10 and 15 pCi/g. The larger of the detection limit or the 10^{-6} risk level should form the RSAL. Clearly it will not be possible to cleanup the entire site to this level. It must also be understood that no current guidance requires a cleanup to 10^{-6}. What I am proposing is that each contaminated site that exceeds the RSAL be individually examined to determine the cleanup level. The nine CERCLA criteria will form the basis of this evaluation. As cost is one of these criteria it must be considered; but stewardship, and low term effectiveness must also be considered. I feel this approach is far superior to the ALARA approach and will result in a better cleanup. It will also result in a cleanup that will be less than a 10^{-4} risk to a future resident. This will mean that regulatorially the entire site would qualify as free release. I would continue to support all institutional controls in order to provide additional protection.

August 7, 2001

Dear Stakeholder:

The Rocky Flats Cleanup Agreement (RFCA) Stakeholder Focus Group will meet at the Broomfield Municipal Center at One DesCombes Drive on August 8, 2001 from 3:30 to 6:30 p.m.

The agenda for the August 8, 2001 meeting is enclosed (Attachment A). We will discuss the following topics:

- RSALs: Task 3 – Parameter Discussion and Modeling Results
- Review of Peer Review Process for Task 3, Including Wind Tunnel Peer Review
- Clean-up Alternatives Matrix – Distribution of Draft Working Group Results

The meeting minutes for the July 11, 2001 meeting are enclosed as Attachment B.

The RSALs Working Group met July 12, July 22, and August 2, 2001. The action items and notes resulting from the meetings are enclosed as Attachment C.

Also attached is a paper by Victor Holm entitled "Model Assumptions" (Attachment D).

If you need additional information to prepare you for the Focus Group discussion on August 8, 2001, please contact Christine Bennett of AlphaTRAC, Inc. at 303 428-5670 (cbennett@alphatrac.com). Christine will help to find the appropriate resource for you.

You may call either Christine or me if you have any questions, comments, or suggestions concerning the RFCA Stakeholder Focus Group or the upcoming meeting.

Sincerely,

C. Reed Hodgin, CCM

Facilitator / Process Manager

RSAL Calculations: Key Parameters

Bob Nininger
Environmental Systems and Stewardship
303-966-4663

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Key Parameters

"key parameters" -- inputs to RESRAD whose **variability, uncertainty or change** could have measurable influence on the outcome of the calculation. The majority of these parameters have been previously identified as "sensitive".

Parameters included in this discussion

- Dose Conversion Factors (DCF) - not sensitive parameters, but important to the discussion
- Inhalation Rate
- Soil Ingestion Rate
- Mass Loading
- Exposure Frequency

Approach to Assigning Parameter Values

RESRAD is designed with a number of relatively conservative features. In addition, the choice of input parameters can strongly influence the results of RESRAD calculations.

- Working group debated at length the need to balance conservatism in individual parameters against the net effect of many conservative inputs causing an unrealistically conservative result.
- Working group decided to exercise the probabilistic options available in RESRAD
- Sensitive parameters were identified
- Best available information was gathered to describe each
- Distributions were chosen to describe those with significant inherent variability.

Parameter Representation

Considerations:

- A parameter may be well measured yet have relatively large intrinsic variability due to potential future site conditions - use a **statistical** distribution **Example: *annual mass loading***
- A parameter may not be well characterized due to insufficient data - use a conservative **deterministic** value
  Example: *soil ingestion rate in adults*
- A parameter may have large intrinsic variability and a well characterized distribution function – use a **statistical** distribution
  Example: *soil ingestion rate in children*

Other parameters, either well-characterized by a single value, or having little intrinsic variability over the period of concern, are input as single values.

Dose Conversion Factors

Use of ICRP 30 or ICRP 60/72

- Working Group has chosen to go with most recent scientific studies - uses ICRP 60/72 dose conversion factors
  - differences attributable to development of age specific DCFs
  - revisions to lung model,
  - more extensive tissue weighting data,
  - revisions to ingestion DCFs.
- DOE will use ICRP 30 dose conversion factors for regulatory compliance

COMPARISON		ICRP 30	ICRP 60 (Adult)	ICRP 60(Child)
Inhalation	Pu	0.43	0.19	0.29
(mrem/pCi)	Am	0.44	0.16	0.26
Ingestion	Pu	0.000052	0.00093	0.0016
	Am	0.0036	0.00074	0.0014

Inhalation Rate

Rural resident and wildlife refuge worker provide different exposure profiles

- Inhalation rate for resident adults is determined by WG to be best represented by a log-normal distribution with mean of 16.2 m^3/day and standard deviation of 3.9
- For a resident child, as a log-normal distribution with mean of 9.3 m^3/day and standard deviation of 2.9
- The wildlife refuge worker will typically experience a greater breathing rate; that rate is characterized by a beta distribution (17560, 9636, 1.79, 3.06) (m^3/y)

Adult:	**'96** -- 7000 m^3/y	**RAC** -- 10,800 m^3/y	**'01** -- as stated
Child:	--	8,600 m^3/y	

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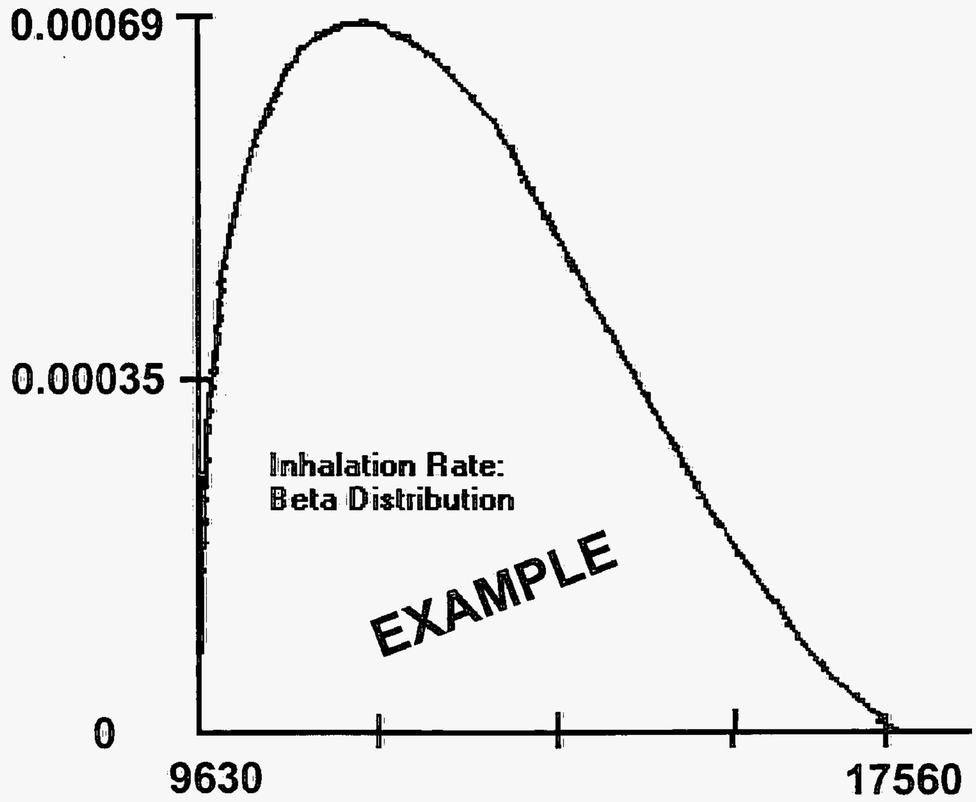
Inhalation Rate: Wildlife Refuge Worker



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Soil Ingestion Rate

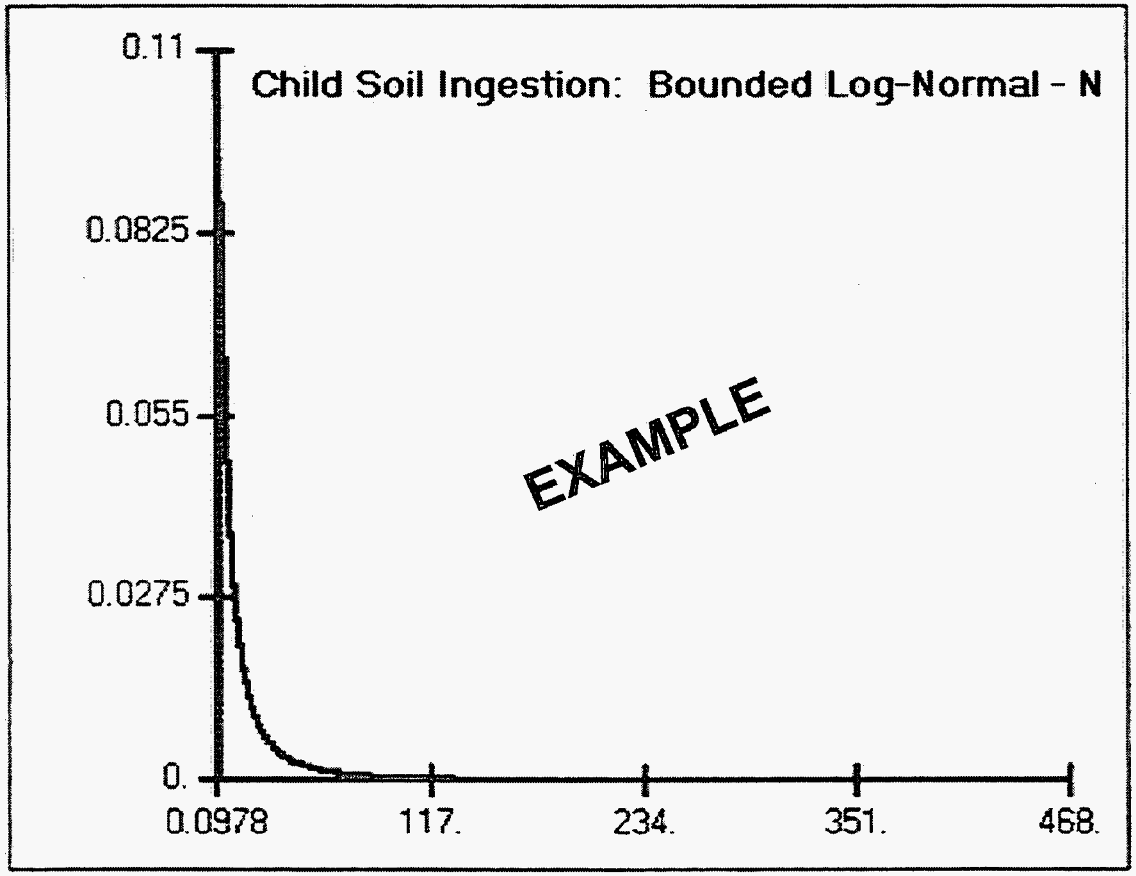
For residential soil ingestion, the adult and child parameters are treated differently

- The child soil ingestion rate is best characterized in Calabrese study - the result is a distribution function characterized by a bounded log-normal with mean of 16.62 g/y and a range from 1 to 365 g/y
- The adult soil ingestion rate, also best characterized by Calabrese, is based on a small data set, insufficient for defining a distribution -- working group chose to go with conservative 100 μg/day(35 g/y), based on EPA Superfund guidance, for reasonably maximally exposed individual.

Soil ingestion is adjusted for wildlife refuge worker, multiplying by three (an artifact of the RESRAD model formulation).

Adult:	**'96** -- 70g/y	**RAC** -- 75 g/y	**'01** -- 36.5 g/y
Child:	--	75 g/y	as stated

Child Soil - Ingestion Distribution



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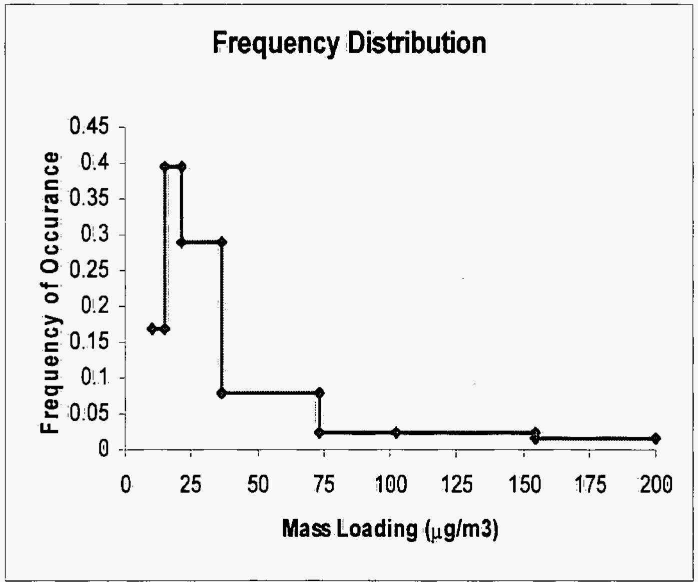
Mass Loading

Mass Loading is the ambient mass concentration that could exist in the future at Rocky Flats

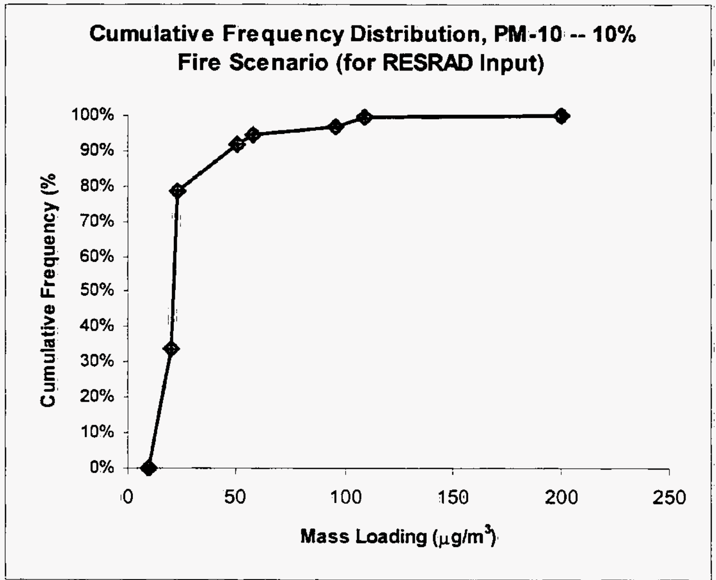
- Distribution of possible values developed using:
  - representative Statewide PM-10 data
  - empirical results from post-fire wind erosion studies
  - site-specific meteorological data
  - site-specific size-distribution data
- Resulting mass-loading distribution reflects fire influence for upper 10% of values
- Final risk-based RSAL, and 25 mrem dose calculation, will reflect that same fire influence

Mass Loading Distribution - for Inhalation

Frequency distribution:



Cumulative distribution, as input:



'96 --26 $\mu g/m^3$ **RAC** -- 35 $\mu g/m^3$ * **'01** -- as shown

* For Pu/Am, RAC applied a customized distribution not directly reproducible in RESRAD

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Exposure Frequency & Exposure Time

RESRAD and RAGS require different sets of inputs for exposure frequency and exposure time

- In RESRAD, exposure frequency indoors and out for a Rural Resident is represented by a triangular distribution of indoor time fraction equal to 0.408 minimum, 0.545 midpoint and 0.815 maximum; outdoor time fraction of 0.072 minimum, 0.096 midpoint and 0.144 maximum.
- This is consistent with RAGs triangular distribution for exposure frequency of (175, 234, 350) days per year, coupled with an exposure time of 24 hours/day, an exposure fraction indoors of 0.85 and outdoors of 0.15
- Distributions for Wildlife Refuge Worker were developed from refuge worker surveys. The resulting distribution for time indoors, and outdoors, is a normal distribution with mean of 0.103, standard deviation of 0.005, minimum of 0.091 and maximum of 0.114

Resident: **'96** -- find=1, fotd=0 **RAC** -- 0.6, 0.4 **'01** -- .85/.15 equiv.

Conclusion

- **Working Group has characterized all key parameters**
- **RESRAD is being exercised probabilistically**
  - Results represent entire range of statistically distributed input parameters
  - Upper 10th percentile of the results will be considered when making final RSAL recommendation
  - That upper 10th percentile contains the results driven by the more conservative input values.

NS: Tom Pentacost email. Two items stood out to me. One was that 25 mrem dose level equals unrestricted use, and "if you cannot comply with that 25 mrem, this is where the ALARA ... comes in and he interprets the NRC rule to mean that the ALARA process only comes in when you can't meet that 25 mrem. Is that the State's, DOE's, or EPA's interpretation?

TR: I don't believe that's the way they're interpreted. It seems to me it was 25 and ALARA.

NS: He says here the ALARA analysis only comes in to justify not meeting the 25 mrem.

RR: If it's not feasible to meet 25 mrem, then you have to show ... May not be able to meet whatever standard is following the ALARA process even after a ... ALARA process, you still can't show the cost-effective, beneficial, or achievement. In essence, these are more achievable and .. the higher dose wouldn't effect them. The higher dose ... can achieve the 25 which is ...

NS: Say you have a situation like this and you use ALARA and you show that you cannot achieve the 25 mrem, will you still be able to ...? CERCLA?

JL: What's the regulatory implication of that? Wouldn't we also have to answer the question: what the total site risk was at the end of the cleanup and not just that spot?

?: The state, as far as I know, does not have any guidance on ALARA. They use the NRC. I think he's just trying to summarize what the NRC guidance says and recognizes that in some instances we can't reasonably comply to 25 and they would allow an unrestricted or restricted ... only if the ALARA process shows that's the road to go after looking at the ALARA factor.

LM: I want to make a comment on this memo. The memo seems to be completely unaware of the discussion that we've had in here about the relationship between risk and dose and that the soil action levels are going to be calculated according to CERCLA risk range as well as according to dose. I'd like to be shown that the 25 mrem submitted by NRC at it's particular facilities and brought into this process as an ARAR corresponds to the CERCLA risk range. Since the EPA says 15 mrem is for 83 ... 10-4. We've talked about this before and I bring it up because the memo seems to be written without the awareness of this discussion. There's a paper on the table I brought in written by ... who's a consultant for us on the relationship between risk and dose.

JL: Rather than speculate on what this person meant in their email, and whether it represents EPA policy, we're not making news here that 25 mrem is an ARAR. It is an ARAR. I think, in most cases, there would be more limiting criteria, for example how this table turns out, we may find that it's an ARAR, but it's not the most important one if we find that the RSAL's based on something in the risk range and that's higher than the

RSAL based on the 25 mrem. The only question is, how relevant it will be when we get to this task 3 table and choose an RSAL.

1. The smoke released and subsequent dust resuspension associated with major wildfires at DOE sites during the summer of 2000,
2. Recent studies, including those at the Nevada Test Site, on transport of plutonium in a colloidal suspension form,
3. **A study from the Colorado Climate Center that may have a bearing on mass loading,**
4. **Studies on legacy plutonium deposition in the Walnut Creek drainage,**

Have you received this information yet? John Stover (966-9735), DOE, would have copies
of the information related to the Walnut Creek sources studies. MH answer to my request 7/16/01

5. Studies by the Colorado Department of Public Health and Environment regarding speciation of uranium at Rocky Flats,
6. Information on americium vs. plutonium distributions, especially where americium is found unassociated with plutonium (this may be a parameter issue rather than a new science issue),
7. **The health study on exposures to Rocky Flats workers,**
8. Historical information on exceedances at RFETS air quality monitoring stations,
9. **A report prepared by John Till on uncertainty in risk coefficients.** John Till sent to Christine Bennett 7/9/01. CB took to Sandra 7/16/01.

Inhalation Rate (IR_air)

Rural Resident

Brief Description

Inhalation rate refer to the volume of air that is inhaled over a period of time. Studies of human inhalation rates have demonstrated variability associated with age, gender, weight, health status, and activity patterns (i.e., resting, walking, jogging, etc.). Although an individual's inhalation rate will vary day-to-day and week-to-week, inhalation rates used in risk assessment general describe an average daily rate (m^3/day) over a long period of time (i.e, the exposure duration). If acute exposures associated with moderate to heavy activities may be of concern, estimates of average hourly inhalation (m^3/hour) would generally be preferred over of daily averages. Average daily or hourly inhalation rates will vary between people, and it is this interindividual variability that is characterized by a probability distribution for this analysis. Short-term measurements, referred to as "minute volumes" (L/min), form the basis for long-term average ingestion rates. The literature on inhalation rates is fairly robust, and can be loosely grouped into two categories based on study methodology: 1) direct measurements using a spirometer, or 2) indirect measurements based on correlations with heart rate, energy requirements, and/or other physiological factors. Data from U.S. EPA Exposure Factors Handbook (EPA, 1997), and a subsequent publication by Allan and Richardson (1998) on 24-hour inhalation rates formed the basis for the estimates described below.

Probability Distribution

The following probability distribution was developed for use in probabilistic risk and RSAL calculations for the rural resident land use scenario:

IR_air_child ~ Lognormal (9.3, 2.9) m^3/day
IR_air_adult ~ Lognormal (16.2, 3.9) m^3/day

The lognormal distributions are defined by two parameters:

- arithmetic mean 9.3 and 16. 2 m^3/day
- standard deviation 2.9 and 3.9 m^3/day

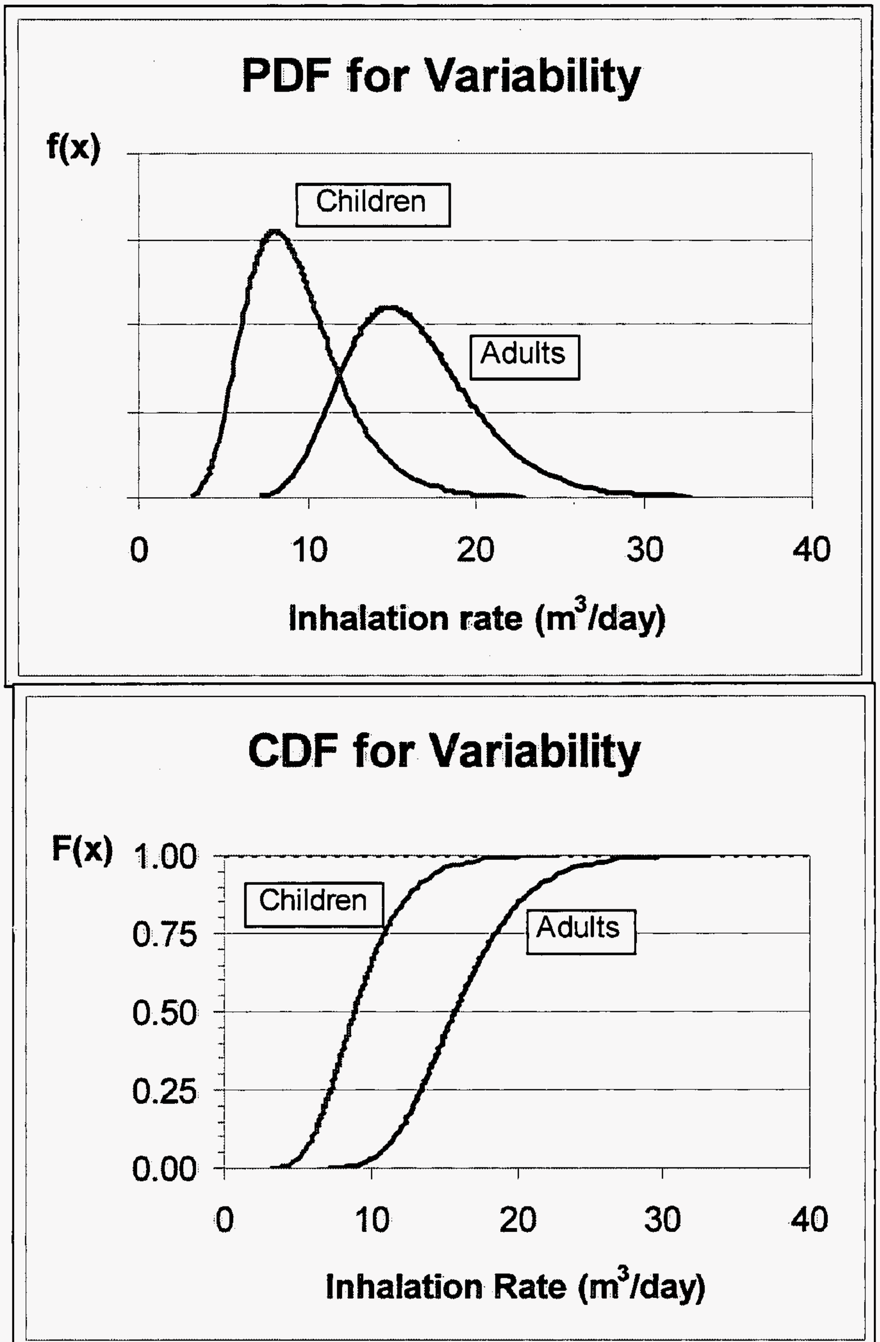

Figure A.1. Probability density function (PDF) and cumulative distribution function (CDF) views of the probability distribution for child and adult inhalation rate (m^3/day).

Uncertainties in the Probability Distribution

The U.S. EPA Exposure Factors Handbook (EFH) (U.S. EPA, 1997) provides a comprehensive summary of the available data on inhalation rates. In addition, U.S. EPA ORD recently presented recommendations for probability distributions for inhalation rates (EPA ORD. 2000. Options for Development of Parametric Probability Distributions for Exposure Factors, EPA/600/R-00/058. July).

Table A2 summarizes some of data available from some of the key studies on inhalation rates. Variability in inhalation rates at most activity levels are generally positively skewed, with more minute volumes nearer the lower end of the reported ranges (Allan and Richardson, 1998). Since inhalation is a non-negative quantity, the literature tends to report lognormal distributions fit to the available data. Allan and Richardson provide graphical summaries of the fits, but no description of goodness-of-fit test statistics. Adult males tend to exhibit the highest inhalation rates, with an average of approximately 17.5 m^3/day. More importantly, there is remarkable consistency in estimates for both children and adults:

- estimates of average inhalation rates among toddlers and young children exhibit a range of approximately 1 m^3/day (a minimum of approximately 8.7 m^3/day to a maximum of 9.7 m^3/day.
- estimates of average inhalation rates among adults exhibit a range of approximately 6 m^3/day (11.3 - 17.5 m^3/day).
- within study groups, the interindividual variability is very low, as shown by coefficients of variation (ratio of standard deviation to the mean) of approximately 0.25.

For children (males/females combined, ages 7 months to 4 years) the available data fit a lognormal distribution with parameters (arithmetic mean, standard deviation) of [9.25, 2.57] m^3/day. For adults (males/females combined) the available data also fit a lognormal distribution [16.2, 3.86] m^3/day. These results are within the range of all reported values, as well as the values recommended by U.S. EPA for risk assessment (EPA, 1997):

Table A1. Summary of recommended values for inhalation rates (U.S. EPA, 1997, Table 5–23).

Age Group	Inhalation Rate (m^3/day)	
	Long-term Exposure	Short-term Exposure
Child, 1-2 years	6.8	rest - 0.3 sedentary - 0.4 light activity - 1.0 moderate activity - 1.6 heavy activity - 1.9
Child, 3-5 years	8.3	
Child, 6-8 years	10.0	
Adult, 19+ years	11.3 - 15.2	rest - 0.4 sedentary - 0.5 light activity - 1.0

		moderate activity - 1.6 heavy activity - 1.9
Adult Worker	hourly average - 1.3 m^3/hr hourly average, high end - 3.3 m^3/hr slow activities - 1.1 m^3/hr moderate activities - 1.5 m^3/hr heavy activities - 2.5 m^3/hr	

Breathing Rates Used by RAC

Resident Rancher - 10,800 m^3/year (8760 hours/year)
10 year old child of rancher - 8600 m^3/year (8760 hours/year)
2 year old infant of rancher - 1900 m^3/year (8760 hours/year)

Table 3. Summary of point estimates and probability distribution parameters for inhalation rates.

[1]Lognormal distribution parameters are the arithmetic mean and standard deviation. Primary Reference: Allan, M. and Richardson, G. 1998. Probability density functions describing 24-hour inhalation rates for use in human health risk assessments. *Hum. Ecol. Risk Assess.* 4(2): 379-408.

Point Estimate				
Population	***CTE, RME***	***Units***	***Source***	***Comments***
Child (? 6 yrs), M/F	8.7, --	m3/day	U.S. EPA, 1996	Long-term exposures for children 1-12 years
Adult (> 6 yrs), male	15.2, --	m3/day	U.S. EPA, 1996	Long-term exposures for adult males
Adult (> 6 yrs), female	11.3, --	m3/day	U.S. EPA, 1996	Long-term exposures for adult females
Outdoor worker	1.3, 3.5	m3/hr	U.S. EPA, 1996	Short-term exposures for outdoor workers, hourly average
Probability Distribution - U.S. EPA EFH				
Population	***Type***	***Parameters (m3/day)***	***Source***	***Comments***
Child (? 6 yrs), male	Lognormal[1]	**9.30, 2.85**	U.S. EPA, 2000 (Moya)	Based on Layton (1993) study in which inhalation rates were based on BMR and energy expenditures; children aged 3-10 years
Child (? 6 yrs), female	Lognormal[1]	8.65, 2.65	U.S. EPA, 2000	Children aged 3-10 years
Adult (> 6 yrs), male	Lognormal[1]	**16.75, 5.32**	U.S. EPA, 2000	Adults aged 18-30 years
Adult (> 6 yrs), female	Lognormal[1]	11.14, 5.37	U.S. EPA, 2000	Adults aged 18-30 years
Probability Distribution - Other Sources				
Population	***Type***	***Parameters (m3/day)***	***Source***	***Comments***
Child (? 6 yrs), male	Lognormal[1]	9.67, 2.67	Allan and Richardson, 1998	Study of Canadian subjects using time-activity patterns and minute volumes from USA studies; values represent 24-hr inhalation rates; male children 7 months to 4 years of age
Child (? 6 yrs), female	Lognormal[1]	8.81, 2.37	Allan and Richardson, 1998	Female children 7 months to 4 years of age
Child (? 6 yrs), M/F	Lognormal[1]	**9.25, 2.57**	Allan and Richardson, 1998	M/F children 7 months to 4 years of age
Adult (> 6 yrs), male	Lognormal[1]	17.54, 4.06	Allan and Richardson, 1998	Male adults 20 to 59 years of age
Adult (> 6 yrs), female	Lognormal[1]	14.89, 3.13	Allan and Richardson, 1998	Female adults 20 to 59 years of age
Adult (> 6 years), M/F	Lognormal[1]	**16.2, 3.86**	Allan and Richardson, 1998	M/F adults 20 to 59 years of age

Inhalation Rate (IR_air)

Wildlife Refuge Worker

Brief Description

Inhalation rates for workers will vary greatly, depending on the time spent at different levels of activity. While inhalation may be expressed on as an average daily rate (by averaging over an 8-hour workday), the basic unit of interest is the short-term average rate (e.g., minutes or hours). The Rocky Mountain Arsenal (RMA) risk assessment (reference) provides estimates of inhalation for biological workers based on a calculation of the time-weighted average breathing rates (see Section B.3.4.1.4 of RMA). These estimates formed the basis for the probability distributions used in this analysis.

Probability Distribution

The following probability distribution was developed for use in probabilistic risk and RSAL calculations for the rural resident land use scenario:

$$\textbf{IR\_air\_wildlife} \sim \textbf{min} + (\textbf{max} - \textbf{min}) \times \textbf{Beta}(a, b)\ \ m^3/hr$$

The beta distributions are defined by four parameters:

•	shape parameter a	1.79	m^3/hr
•	shape parameter b	3.06	m^3/hr
•	minimum	1.1	m^3/hr
•	maximum	2.0	m^3/hr

Information on the beta distribution is provided at the end of this Section.

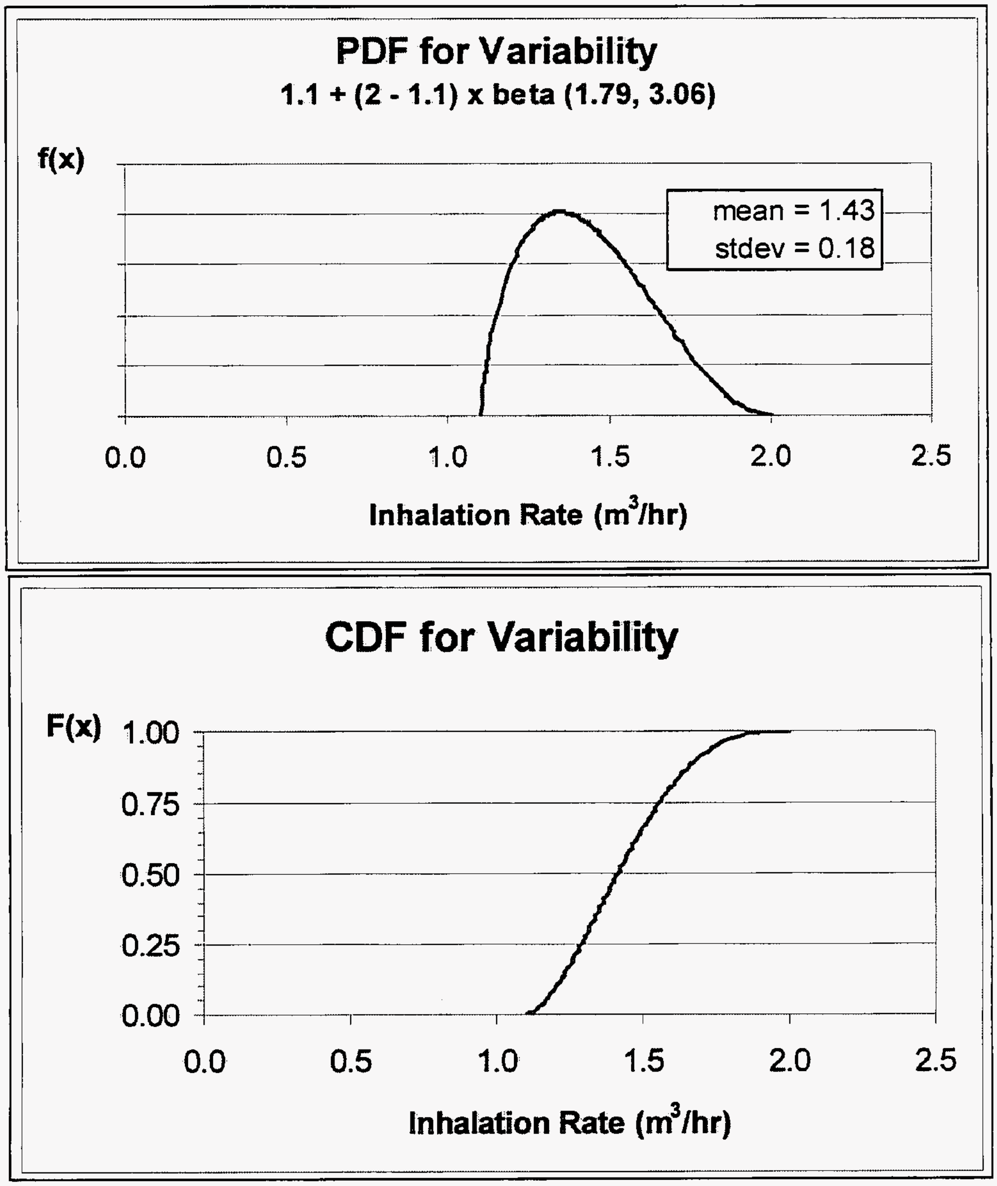

Figure A.12 Probability density function (PDF) and cumulative distribution function (CDF) views of the probability distribution for wildlife refuge worker inhalation rate (m^3/hr).

Uncertainties in the Probability Distribution

The RMA report describes the methodology use to generate the estimates of the time-weighted average breathing rates among biological workers. A brief description is given here. Activity patterns were divided into three categories based on the extent of contact with site soils:

P1 (indoor), P2 (middle), and P3 (higher)

Survey data on activity patterns among biological workers were used to develop a discrete probability distribution for the amount of time engaged in each category. In addition, three categories of breathing rates were specified:

BR (lower = **0.66**), BR (middle = **2.0**), and BR (heavy = **3.8**)

The time-weighted average was calculated based on the following equation:

$$TWA = (P_{lower})(BR_{lower}) + (P_{middle})(BR_{middle}) + (P_{high})(BR_{high})$$

A Monte Carlo simulation was run to randomly sample from the probability distribution for ***P***, with each iteration yielding a different estimate of the time-weighted average breathing rate. The summary statistics for the cumulative distribution are given below.

EDF = {percentiles, values} = {0.01, 0.025, 0.05, 0.075, 0.10, 0.25, 0.50, 0.75, 0.90, 0.925, 0.95, 0.975, 0.99}, {0.72, 0.72, 0.72, 0.73, 0.73, 0.80, 1.14, 1.47, 1.96, 2.07, 2.12, 2.45, 2.45}

These data could be incorporated into a probabilistic model directly as an empirical distribution. A beta distribution was fit to the summary statistics because it is both flexible in shape and defined by a minimum and maximum value. The process used to generate the PDF, as described above, will generate a plausible estimate of the minimum (100% of exposure time at lowest breathing rate) and maximum (100% of exposure time at highest breathing rate). This characteristic of the data set lends itself to a close fit to the beta distribution.

Breathing rate Used by RAC

3700 m^3 /year - industrial worker (2100 hours.year)