



Sandia
National
Laboratories

Turbo FRMAC Overview

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SAND2022-14530 PE



- Turbo FRMAC introduction
- Turbo FRMAC 2023 (v11.2) release overview
- Accessing Turbo FRMAC and web-based training opportunities
- Demonstration problem using a field measurement



Introduction



Introduction



- Sandia National Laboratories (SNL), located in Albuquerque, New Mexico, USA
- Government owned, contractor operated
- Provide research and technical solutions, expert analysis, and highly trained emergency response professionals to support the U.S. government's response to a nuclear or radiological accident



Federal Radiological Monitoring and Assessment Center (FRMAC)



Mission: Provide timely, high-quality predictions, measurements, analyses, and assessments to promote efficient and effective emergency response for the protection of the public from the consequences of nuclear or radiological incidents



Aerial Measurements



Field Monitoring



Sample Control and Analysis

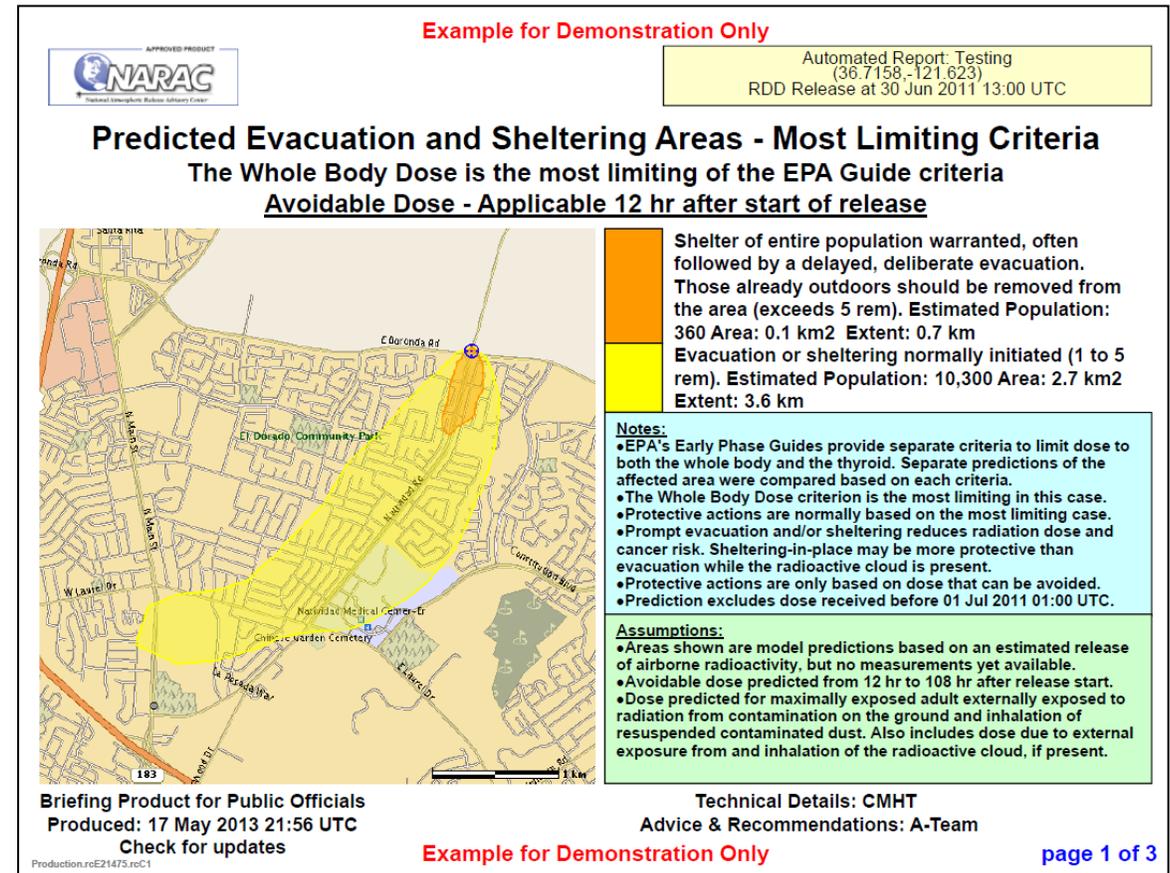


Data Assessment

Assessment Capability



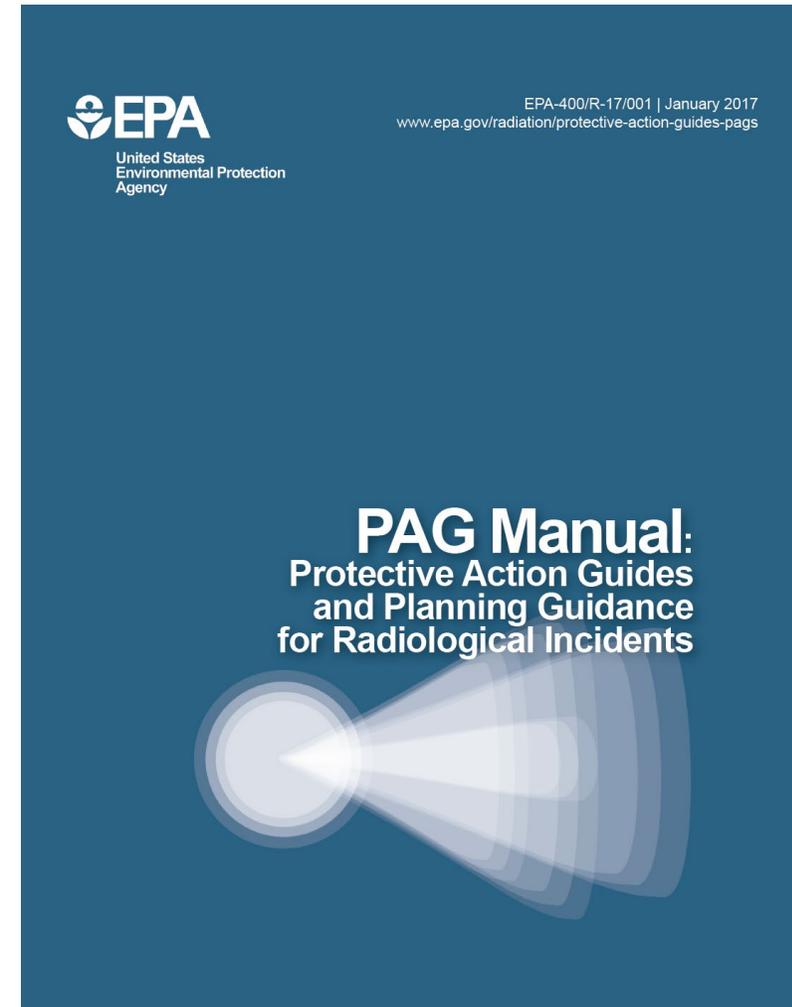
- Analyze models and data available to develop an understanding of the radiological environment
- Provide decision makers with radiological information that can be used to issue protective actions



U.S. Protective Action Guidance

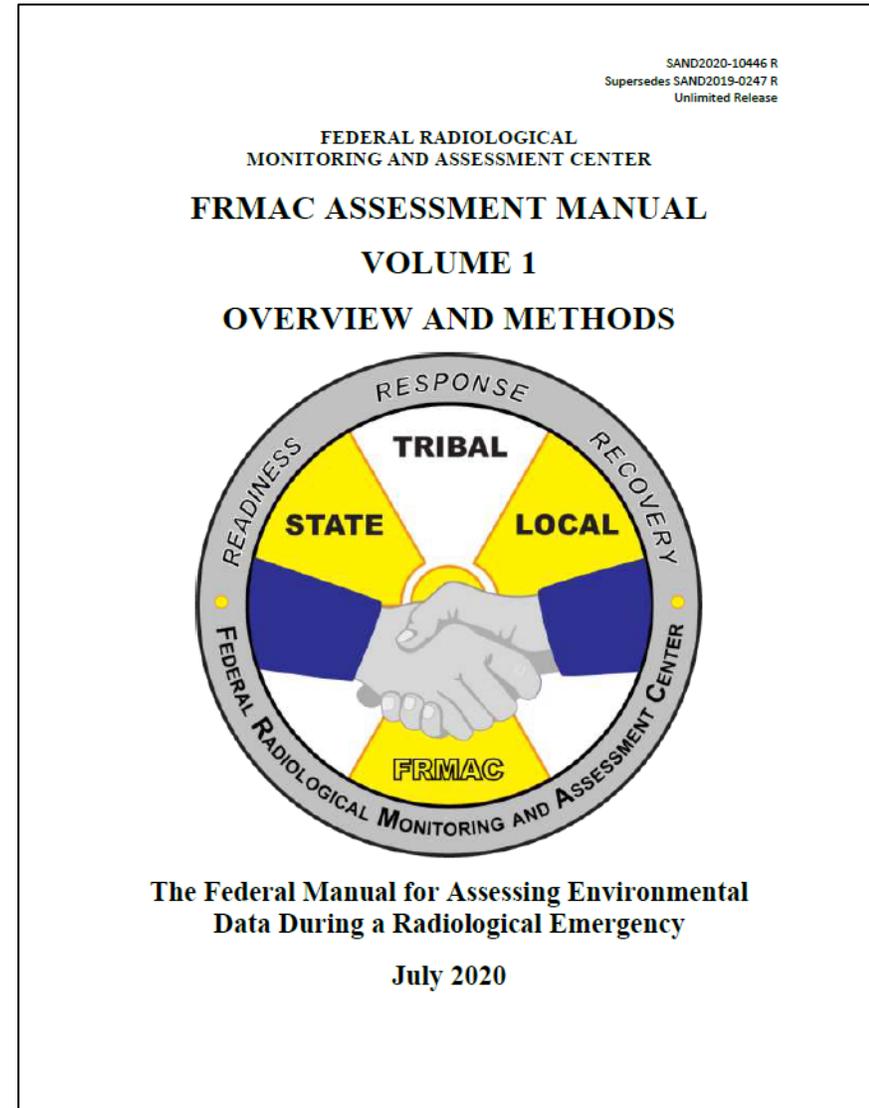


- Environmental Protection Agency (EPA) Protective Action Guide (PAG) Manual
- PAGs are based on 3 principles:
 - 1. Prevent acute effects
 - 2. Reduce risk of chronic effects
 - 3. Balance protection with other factors and ensure that actions result in more benefit than harm
- PAGs are predetermined for use in emergencies without regard to the magnitude or type of radiological release
- Decision makers may implement protective actions at higher or lower levels than the recommended PAGs



FRMAC Assessment Manual

- The technical consensus of multiple U.S. federal agencies with expertise in and authority over aspects of radiological emergency response
- Defines the standard dose assessment methods for responding to nuclear or radiological incidents
- Serves as the scientific basis for Turbo FRMAC
- SNL leads development of this manual
- https://www.nnss.gov/pages/programs/FRMAC/FRMAC_DocumentsManuals.html



Turbo FRMAC



- Software performs complex calculations to quickly evaluate radiological hazards during an emergency response by assessing impacts to the public, workers, and the food supply
- Automates FRMAC Assessment Manual methods
- Deployable software application developed by SNL
- Does not require internet connection
- Updated periodically to implement new and revised methods
- NOT a replacement for health physics knowledge and experience



Turbo FRMAC Purpose



Results are used to support protective action decisions, such as:

- Should a population be sheltered, evacuated, or relocated?
- When can a relocated population return home?
- What field measurements would indicate that a protective action is warranted?
- How long can a worker remain in a contaminated area?
- Might a food crop in an area need to be considered for removal from commerce?
- When can a crop be planted so as not to exceed food contamination guidelines?

	Public Protection Evaluate the potential impacts to members of the public from exposure to radiological materials in the air and/or deposited on the ground.
	Worker Protection Establish worker protection guidelines (e.g., stay-times, turn-back limits).
	Ingestion Evaluate the potential impacts from radiologically contaminated food.

Turbo FRMAC

HOME SHARE TOOLS HELP

Reset Inputs Results Collapse All Expand All Details Switch Calculations

Inputs Results View Window

Turbo FRMAC 2023

New Calculation Open Calculation Watch Help Videos

NNSA National Nuclear Security Administration FEMA Sandia National Laboratories

Ready. Memory Usage: 4%



*New Derived Response Levels Calculation - Turbo FRMAC

File NEW CALCULATION TOOLS HELP

Cancel Calculation
Cancel

Start Your Calculation | Choose the type of Calculation you wish to perform.

1 Browse Categories 2 Select Calculation 3 Choose Template

Public Protection
Evaluate the potential impacts to members of the public from exposure to radiological materials in the air and/or deposited on the ground.

Worker Protection
Establish worker protection guidelines (e.g., stay-times, turn-back limits).

Ingestion
Evaluate the potential impacts from radiologically contaminated food.

Supplemental
Perform additional calculations to support radiological assessments.

Derived Response Levels
Calculate the areal or integrated air activity of radionuclides at which the total dose from the mixture equals the PAG over the time phase.

Projected Public Dose
Calculate the dose from exposure to a release of radioactive material.

Dose Parameters
Calculate the External, Inhalation, and Total Dose Parameters.

Nuclear Fallout Calculations

Nuclear Fallout Doses
Calculate the Doses for a deposition of radioactive fallout after a nuclear detonation.

Nuclear Fallout Stay Time
Calculate the Stay Time for a deposition of radioactive fallout after a nuclear detonation.

Nuclear Fallout DRLs
Calculate the Nuclear Fallout DRLs for a deposition of radioactive fallout after a nuclear detonation.

Time Varying Calculations

Varying Evaluation Time
Calculate a curve of the DRL for a fixed time phase at different evaluation times.

Projected Return Time
Calculate a curve of the DRL at the fixed evaluation time for shifting time phases. Answers questions like: "When can I go home?" or "When will the limit not be exceeded?"

Return Thresholds
Calculate the DRL for the beginning of the time phase for a shifting time phase. Answers questions like: "Can they go home today?" or "Will the limit be exceeded now?"

Projected Public Dose Over Time
Calculates a curve of the dose from exposure to a release of radioactive material over time intervals for a selected Time Phase.

Blank
Create a Calculation using all default inputs.

Copy from Existing
Make a copy of a saved Calculation to get started.

Ready. Memory Usage: 17%

***New Derived Response Levels Calculation - Turbo FRMAC**

HOME SHARE TOOLS HELP

Required Other Show All 1992 EPA PAG Manual Emulation Mode Reset Inputs

DRL Dose and Exposure DRL Deposition DRL Integrated Air Dose Parameters More Mixture Properties Age Group: Adult Organ: Whole Body Dose Rollup Tool Input Report Briefing Products Collapse All Expand All Details Search Switch Calculations

1 **Radionuclide Mixture:** The Mixture must contain 1 or more Radionuclides. Add Radionuclides or Import a Mixture. **Other Inputs Warning:** Only users with a sufficient understanding of these inputs and their effects on the calculated values should modify these inputs. Use caution when editing these values!

Derived Response Levels | Show all inputs (both Required and Other) that can impact the calculations.

Show All Inputs

- Name and Description
- Time Settings
- Radionuclide Mixture
- ICRP Guidance
- Protective Action Guides (PAGs)
- Relative Biological Effectiveness
- Breathing Rates
- Building Protection Factors
- Exposure to Dose Factors
- ICRP and Lung Clearance
- Instrument Thresholds
- KI Protection Factors
- Occupancy Factors
- Particle Size Distribution
- Resuspension
- Weathering Correction

Radionuclide Mixture

Name: Unknown

Description:

Mixture and Measurement Type

Generic Activity per Area Mass per Area

What Values are Known for the Mixture?

Activity per Area *Integrated Air Concentration values will be calculated using the Deposition Velocity.*
 Integrated Air Concentration
 Both

Add Radionuclide: Search... Import Export & Email Manage Daughters Age Scale View

Form	Radionuclide	Activity per Area	Integrated Air Concentration	Deposition Velocity	Particle Size Distribution

0 parents, 0 daughters, 0 total radionuclides, 0 total forms Truncation: ON Equilibrium: ON

$\mu\text{Ci} / \text{m}^2$ $(\mu\text{Ci} \cdot \text{s}) / \text{m}^3$ m / s

[-4.86E303, 4.86E303] [-4.86E303, 4.86E303] [-∞, ∞]

Daughters are assigned the Deposition Velocity of their parent.

The Mixture must contain 1 or more Radionuclides. Add Radionuclides or Import a Mixture.

ICRP Guidance

ICRP Guidance: ICRP 60

Commitment Period: Chronic

Protective Action Guides (PAGs)

Evacuation/Shelter/Relocation

	Early Phase (TD)	Early Phase (AD)	First Year	Second Year	Fifty Year
Total Effective Dose (TED)	1.00	1.00	2.00	0.500	5.00
Thyroid	5.00	5.00	10.0	2.50	25.0
Skin	50.0	50.0	100	25.0	2.50E2

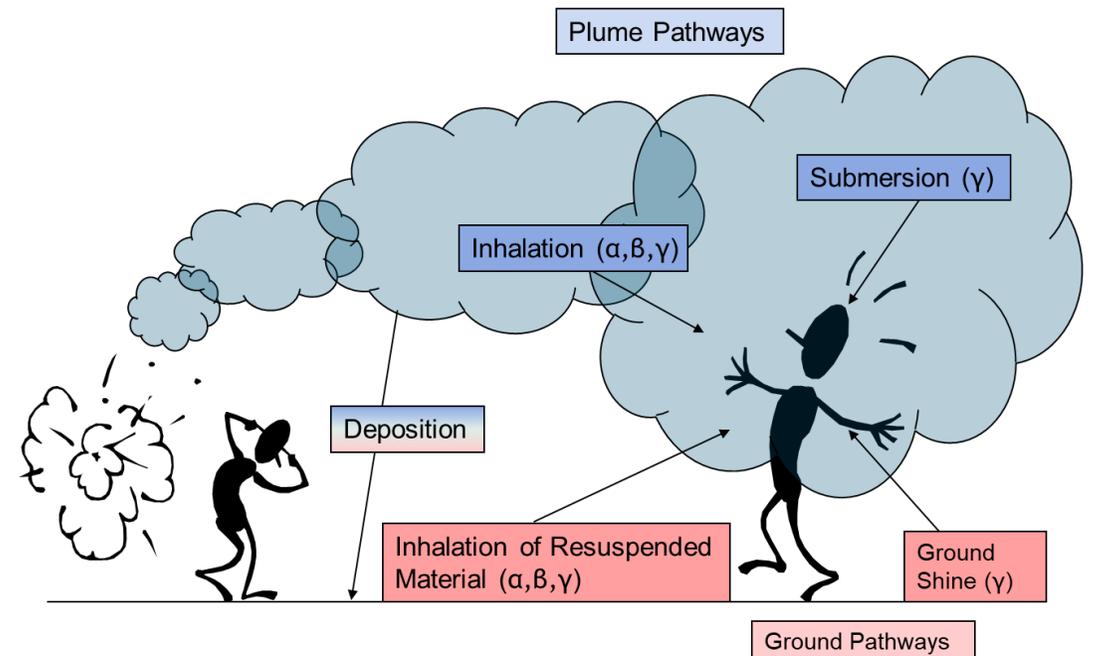
Ready. Memory Usage: 12%

Derived Response Level (DRL) -
 A level of radioactivity in an environmental medium that would be expected to produce a dose equal to the corresponding PAG

How are public protection doses calculated in Turbo FRMAC?



- Public protection calculations include four exposure pathways:
 - Plume Inhalation
 - Plume Submersion
 - Resuspension Inhalation
 - Groundshine
- Ingestion exposure pathway is handled separately
- Bateman equations used for decay and in-growth
- Dose is integrated over a user-specified time period



FRMAC Default Assumptions

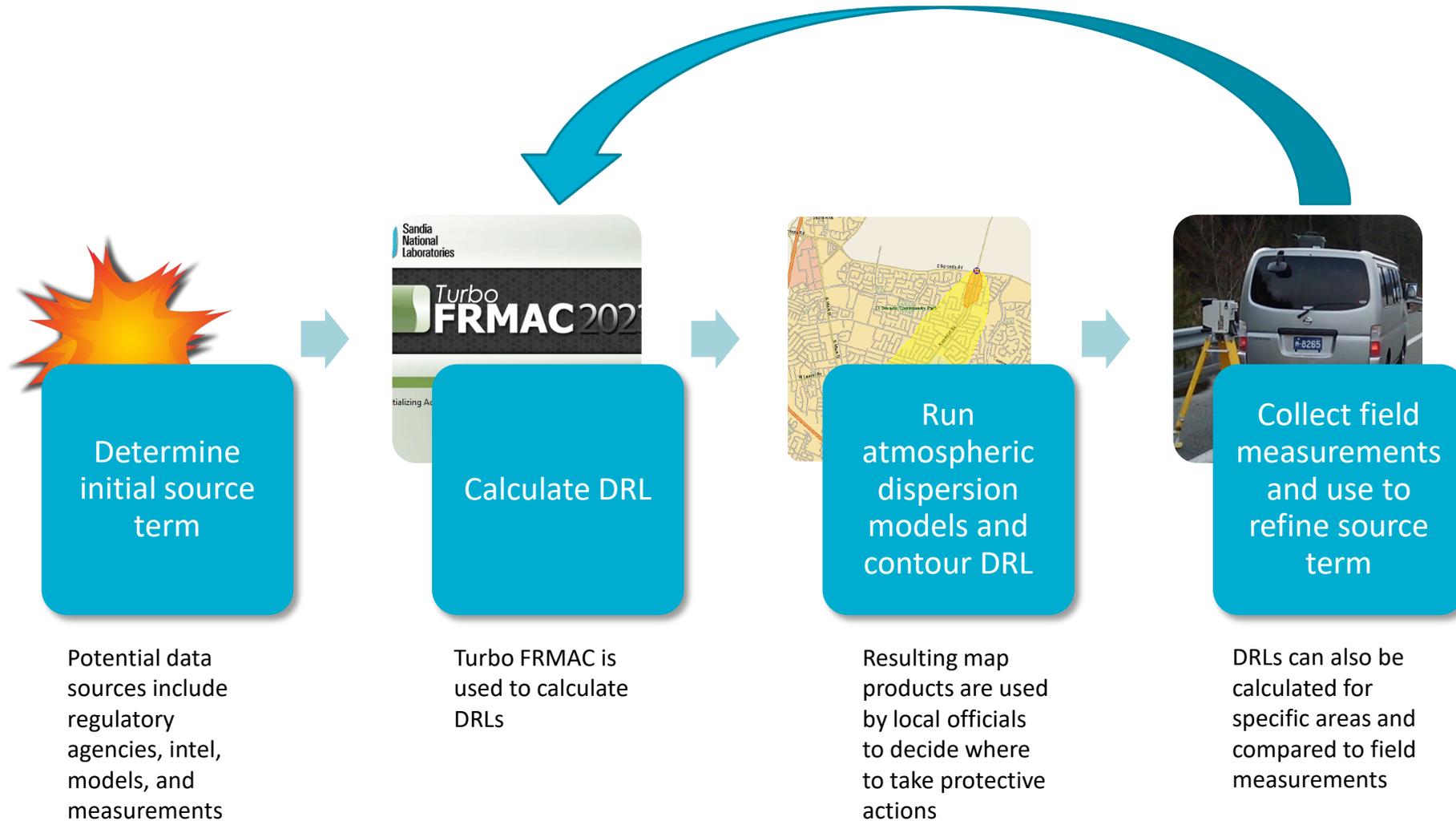


- Adult receptor, Whole Body (Effective) dose
- The receptor is outside and unprotected
- The plume is in contact with the ground
- Airborne noble gases are not deposited
- Deposition is immediate
- Deposition is assumed to be dry particulates with a default particle size of 1-micron Activity Median Aerodynamic Diameter (AMAD)
- ICRP Recommended Lung Clearance Type
- ICRP 60 based dose coefficients and breathing rates
- Maxwell and Anspaugh (2011) resuspension model¹
- Anspaugh (2002) weathering model²

Turbo FRMAC settings can be adjusted to use different models or event-specific data

¹ Maxwell, R. and Anspaugh, L., "An Improved Model for Prediction of Resuspension" in *Health Physics*, Vol. 101, pp. 722-730, December 2011

² Anspaugh, L., et al., "Movement of Radionuclides in Terrestrial Ecosystems by Physical Processes" in *Health Physics*, Vol. 82, pp. 670-679, April 2002



Model Limitations



- Turbo FRMAC is not an atmospheric dispersion model, so assumptions are used to estimate the relative radionuclide activities in the air and on the ground
- However, monitoring and sampling, and atmospheric dispersion model data can be entered to improve the accuracy of dose projections and DRLs
- Because Turbo FRMAC does not perform atmospheric dispersion, DRLs are calculated for a single radionuclide mixture that does not account for spatial variance

Examples of Turbo FRMAC Use



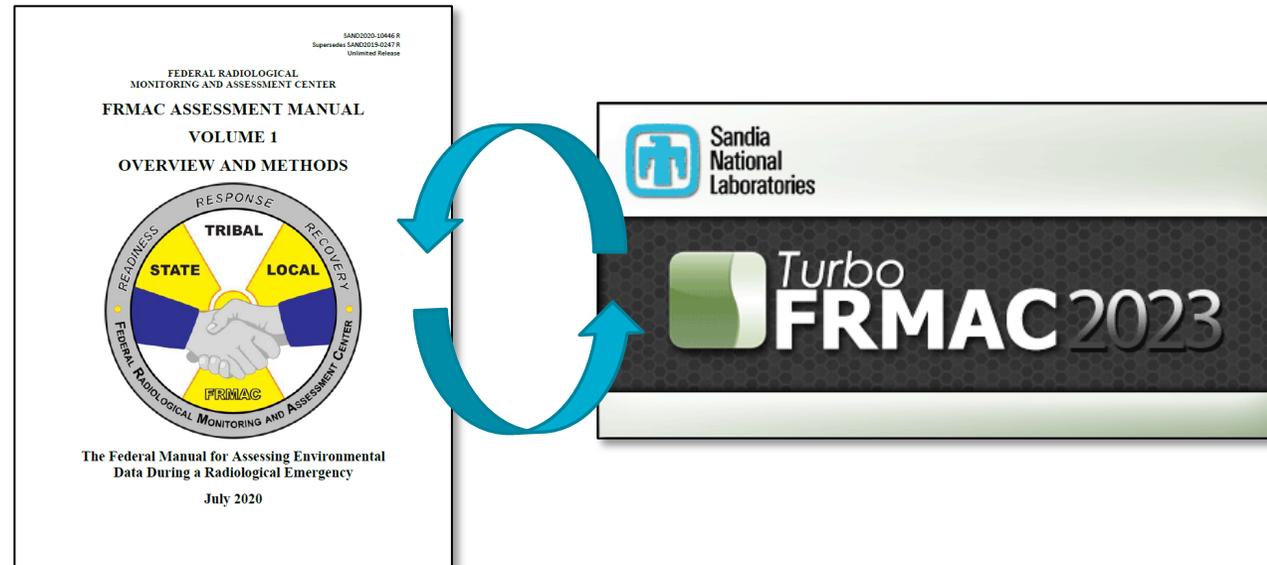
- Turbo FRMAC has proved to be a valuable tool to guide protective action decisions following real-world releases including the 2011 Fukushima Daiichi Nuclear Power Plant disaster, the 2017 Ru-106 release, and other accidental releases in the U.S.
- Turbo FRMAC is also used to support Federal, State, and Local emergency response planning and preparedness activities



Ongoing Development



- We release new versions of Turbo FRMAC about twice a year
- New versions include bug fixes as well as new calculations and features developed to fill gaps identified during drills, exercises, and real world responses
- All new calculations must be approved by the FRMAC Assessment Working Group
- We do our best to sync Turbo FRMAC releases with updates to the FRMAC Assessment Manual





Turbo FRMAC 2023 (v11.2)

Released October 2022



What's New in Turbo FRMAC



- Added new Interactive Dose Parameter Rollup tool to Public Protection calculations
- Added new Public Protection DRL Calculation Report
- Added ability to convert “grab” air sample results into integrated air sample results using Mixture Adjustment Tool in Mixture Manager
- Updated RASCAL import feature to recognize RASCAL 4.3.4 files
- Added ability to optionally include software (tfx) files with bug submissions
- Other bug fixes

A complete list of improvements and bug fixes is available by viewing the [Release Notes](#) located on the website



Interactive D



File HOME SHARE TOOLS HELP

Required Other Show All

1992 EPA PAG Manual Emulation Mode

OFF

Inputs

Derived Response Levels | View th

Interactive Dose Rollup Tool

View radionuclide dose parameters ranked by their contribution to total dose by dose pathway or mixture total dose.

Select an Age Group, Organ, and Time Phase, and then choose the Sort order.

Age Group: **Adult** Sort by: **Total Dose**

Organ: **Whole Body** Commitment Period: **Chronic**

Time Phase: **Early Phase (TD)**

Rolled-up Dose Parameters (summed over decay chain)

A Radionuclide node that is collapsed displays the sum of the doses from the radionuclide and the daughters in the decay chain.

i Cumulative % values include the entire decay chain contribution.

Radionuclide	Rank	Form	Plume Inhalation	Plume Submersion	Resuspension Inhalation	Groundshine	Total Dose	% of Mixture Total	Cumulative % of Mixture Total
Cs-134	1	P	8.18E8	2.07E7	4.55E6	3.68E8	1.21E9	64.23	64.23
▶ Cs-137	2	P	5.14E8	6.73E6	2.86E6	1.23E8	6.46E8	34.28	98.52
▶ Ru-106	3	P	1.15E7	1.06E4	6.38E4	2.89E5	1.19E7	0.63	99.15
Nb-95	4	P	4.71E6	2.66E5	2.53E4	4.52E6	9.53E6	0.51	99.65
▶ Te-127m	5	P	4.65E6	6.50E2	2.56E4	2.34E4	4.70E6	0.25	99.90
▶ Sr-90	6	P	1.03E6	35.62	5.75E3	4.61E3	1.04E6	5.50E-2	99.96
▶ Te-129m	7	P	6.87E5	8.67E2	3.68E3	2.69E4	7.18E5	3.81E-2	99.99
▶ Ru-103	8	P	4.71E4	1.03E3	2.54E2	1.81E4	6.65E4	3.53E-3	100.0
Sr-89	9	P	1.72E4	2.96	93.33	3.84E2	1.77E4	9.37E-4	100.0
▶ Cm-244	10	P	8.75E3	3.16E-6	48.74	3.92E-4	8.80E3	4.67E-4	100.0
▶ Pu-238	11	P	8.40E3	1.46E-6	46.8	2.22E-4	8.45E3	4.48E-4	100.0
▶ Pu-241	12	P	3.40E3	9.46E-7	18.93	2.38E-5	3.42E3	1.81E-4	100.0
Cs-136	13	P	7.01E2	1.34E2	3.54	2.08E3	2.92E3	1.55E-4	100.0
▶ Cm-242	14	P	1.86E3	3.34E-6	10.28	4.82E-4	1.87E3	9.92E-5	100.0
▶ Pu-240	15	P	9.23E2	1.45E-7	5.14	2.13E-5	9.28E2	4.92E-5	100.0
▶ Am-241	16	P	7.60E2	2.94E-5	4.23	8.09E-4	7.64E2	4.05E-5	100.0
Rb-86	17	P	4.53E2	5.67	2.35	1.51E2	6.12E2	3.25E-5	100.0
▶ Pu-239	18	P	3.91E2	7.05E-8	2.18	4.86E-6	3.94E2	2.09E-5	100.0
Te-127	19	P	3.77E2	2.38	0.33	8.91	3.88E2	2.06E-5	100.0
▶ Ce-144	20	P	2.77E2	6.00E-2	1.54	2.78	2.82E2	1.49E-5	100.0
▶ I-131	21	P	37.61	0.21	0.39	6.93	45.13	2.39E-6	100.0
▶ Ba-140	22	P	18.94	0.71	9.84E-2	13.0	32.75	1.74E-6	100.0
▶ Zr-95	23	P	5.04	8.79E-2	2.78E-2	1.58	6.74	3.58E-7	100.0
Y-91	24	P	4.0	8.12E-4	2.18E-2	8.33E-2	4.11	2.18E-7	100.0
Y-90	25	P	1.8	2.46E-3	6.39E-3	0.18	1.99	1.06E-7	100.0
Ce-141	26	P	0.44	1.02E-3	2.33E-3	1.85E-2	0.46	2.43E-8	100.0
▶ Te-131m	27	P	0.18	6.71E-3	8.90E-4	5.60E-2	0.25	1.30E-8	100.0
▶ Te-132	28	P	5.99E-2	7.80E-3	2.28E-4	9.35E-2	0.16	8.56E-9	100.0
▶ I-133	29	P	3.10E-2	1.49E-3	1.19E-4	2.15E-2	5.41E-2	2.87E-9	100.0

57 radionuclides

Mixture Total Dose:	1.35E9	2.77E7	7.54E6	4.96E8	1.89E9
Percent Contribution:	71.85%	1.47%	0.40%	26.28%	

Units: **mrem**

Briefing Products ▾

Details ▾

Switch Calculations ▾

View Window

Public Protection DRL Calculation Report



The screenshot displays the software's main interface with a toolbar at the top. The 'Calculation Report' button is highlighted with a red circle. Below the toolbar, a 'Generate a Calculation Report' dialog box is open, showing the 'Protective Action Guidelines' section. The dialog box includes a text area for an explanation and a list of buttons at the bottom.

Protective Action Guidelines

Please provide an explanation for why these defaults were changed:

- PAG - TEDE/Early Phase (TD): The default value '1.0 (rem)' was changed to '5.0 (rem)'.
- PAG - TEDE/Early Phase (AD): The default value '1.0 (rem)' was changed to '5.0 (rem)'.

Enter Explanation: State would like to use higher PAG

Use the Back, Next, and Finish buttons to continue. You need to complete each Step in the order specified.

Buttons: Cancel, Reset, Back, Next, Finish

Turbo FRMAC Calculation

Public Protection DRLs Calculation

Assessment Scientist(s)

Name	Telephone	Email
Lainy Cochran	(505) 844-1890	ldcochr@sandia.gov

RFI Information

RFI Number: 0001

Name and Description

Calculation Name: Derived Response Levels Calculation

Calculation Description: 2nd Exercise NPP 2021-12-02

Changed Defaults

Input	Default	Changed Values	Reason for Change
Radionuclide Mixture Type	Generic	Nuclear Power Plant	
Daughters Always Populated Using Equilibrium Rules	true	false	
PAG - TEDE/Early Phase (TD)	1.0 (rem)	5.0 (rem)	State would like to use higher PAG
PAG - TEDE/Early Phase (AD)	1.0 (rem)	5.0 (rem)	State would like to use higher PAG

Results

In all results, Whole Body values are displayed for Adult for a Chronic Commitment Period.

Dose Rate DRLs (mrem/hr)

Early Phase (TD)	Early Phase (AD)	First Year	Second Year	Fifty Year
14.63	93.7	4.42	2.1	2.31

Exposure Rate DRLs (mR/hr)

Early Phase (TD)	Early Phase (AD)	First Year	Second Year	Fifty Year
14.63	93.7	4.42	2.1	2.31

Ground Concentration Alpha DRLs ($\mu\text{Ci}_\alpha/\text{m}^3$)

Early Phase (TD)	Early Phase (AD)	First Year	Second Year	Fifty Year
N/A	N/A	N/A	N/A	N/A

Ground Concentration Beta DRLs ($\mu\text{Ci}_\beta/\text{m}^3$)

Early Phase (TD)	Early Phase (AD)	First Year	Second Year	Fifty Year
1.29E3	8.24E3	3.88E2	1.85E2	2.03E2

Radionuclide Specific Ground Concentration DRLs ($\mu\text{Ci}/\text{m}^3$)

Radionuclide	Form	Early Phase (TD)	Early Phase (AD)	First Year	Second Year	Fifty Year
Ba-137m	Particulate	23.37	1.50E2	7.05	3.35	3.68
Ba-139	Particulate	1.13E-5	7.23E-5	3.41E-6	1.62E-6	1.78E-6
Cs-134	Particulate	36.54	2.34E2	11.02	5.24	5.76
Cs-135	Particulate	3.65E-8	2.34E-7	1.10E-8	5.24E-9	5.75E-9
Cs-136	Particulate	11.43	73.18	3.45	1.64	1.8
Cs-137	Particulate	24.75	1.59E2	7.47	3.55	3.9
Cs-138	Particulate	7.37E-6	4.72E-5	2.22E-6	1.06E-6	1.16E-6
Cs-139	Particulate	1.52E-25	9.74E-25	4.59E-26	2.18E-26	2.40E-26
I-129	Multiple	8.53E-6	5.46E-5	2.57E-6	1.22E-6	1.35E-6
I-130	Multiple	2.35	15.03	0.71	0.34	0.37
I-131	Multiple	2.79E2	1.79E3	84.21	40.05	44.0
I-132	Multiple	2.86E2	1.83E3	86.24	41.02	45.06
I-133	Multiple	3.62E2	2.32E3	1.09E2	51.91	57.03
I-134	Multiple	1.42E-2	9.08E-2	4.28E-3	2.03E-3	2.24E-3
I-135	Multiple	1.10E2	7.03E2	33.12	15.75	17.3
Kr-85	Gas	N/A	N/A	N/A	N/A	N/A
Kr-85m	Gas	N/A	N/A	N/A	N/A	N/A
Kr-87	Gas	N/A	N/A	N/A	N/A	N/A
Kr-88	Gas	N/A	N/A	N/A	N/A	N/A
Rb-87	Particulate	N/A	N/A	N/A	N/A	N/A
Rb-88	Particulate	N/A	N/A	N/A	N/A	N/A
Te-125m	Multiple	0.6	3.84	0.18	8.60E-2	9.44E-2
Te-127	Multiple	12.31	78.8	3.71	1.77	1.94
Te-127m	Multiple	3.3	21.11	0.99	0.47	0.52
Te-129	Multiple	7.75	49.64	2.34	1.11	1.22
Te-129m	Multiple	12.19	78.04	3.68	1.75	1.92
Te-131	Multiple	5.18	33.17	1.56	0.74	0.82
Te-131m	Multiple	23.01	1.47E2	6.94	3.3	3.63
Te-132	Multiple	2.75E2	1.76E3	83.1	39.52	43.41
Te-133	Multiple	5.92E-4	3.79E-3	1.79E-4	8.49E-5	9.33E-5
Te-133m	Multiple	2.62E-3	1.68E-2	7.90E-4	3.76E-4	4.13E-4
Te-134	Multiple	1.22E-4	7.79E-4	3.67E-5	1.75E-5	1.92E-5
Xe-131m	Gas	9.66E-2	0.62	2.91E-2	1.39E-2	1.52E-2
Xe-133	Gas	27.63	1.77E2	8.34	3.96	4.36
Xe-133m	Gas	1.87	11.96	0.56	0.27	0.29
Xe-135	Gas	1.20E2	7.68E2	36.17	17.2	18.9
Xe-135m	Gas	18.92	1.21E2	5.71	2.71	2.98
Xe-138	Gas	N/A	N/A	N/A	N/A	N/A

Integrated Air Concentration Alpha DRLs ($\mu\text{Ci}_\alpha^*\text{s}/\text{m}^3$)

Early Phase (TD)	Early Phase (AD)	First Year	Second Year	Fifty Year
N/A	N/A	N/A	N/A	N/A

Integrated Air Concentration Beta DRLs ($\mu\text{Ci}_\beta^*\text{s}/\text{m}^3$)

Early Phase (TD)	Early Phase (AD)	First Year	Second Year	Fifty Year
1.39E7	8.90E7	4.19E6	1.99E6	2.19E6

Radionuclide Specific Integrated Air Concentration DRLs ($\mu\text{Ci}^*\text{s}/\text{m}^3$)



Convert “Grab” Air Sample Results to Integrated Air Concentration



Mixture Adjustment Tool

Specify Type of Input Data

What kind of data is to be adjusted?
What type of data is included in your input data file?

[Download Example Data Files](#)

<input type="button" value="In-situ"/>	Decay and weather adjust in-situ measurements to a desired evaluation time
<input type="button" value="Lab Analysis by Mass"/>	Decay adjust lab analysis mass results to a desired evaluation time
<input type="button" value="Lab Analysis by Volume"/>	Decay adjust lab analysis volume results to a desired evaluation time
<input type="button" value="Dose Rate"/>	Decay and weather adjust dose rate measurements to a desired evaluation time based on a radionuclide mixture
<input type="button" value="Exposure Rate"/>	Decay and weather adjust exposure rate measurements to a desired evaluation time based on a radionuclide mixture
<input checked="" type="button" value="Grab Air Sample to Integrated Air Concentration"/>	Convert grab air samples collected in the field and analyzed by a laboratory to integrated air concentration, for use in Turbo FRMAC calculations by integrating over the sample collection time

Convert grab air samples collected in the field and analyzed by a laboratory to integrated air concentration, for use in Turbo FRMAC calculations by integrating over the sample collection time

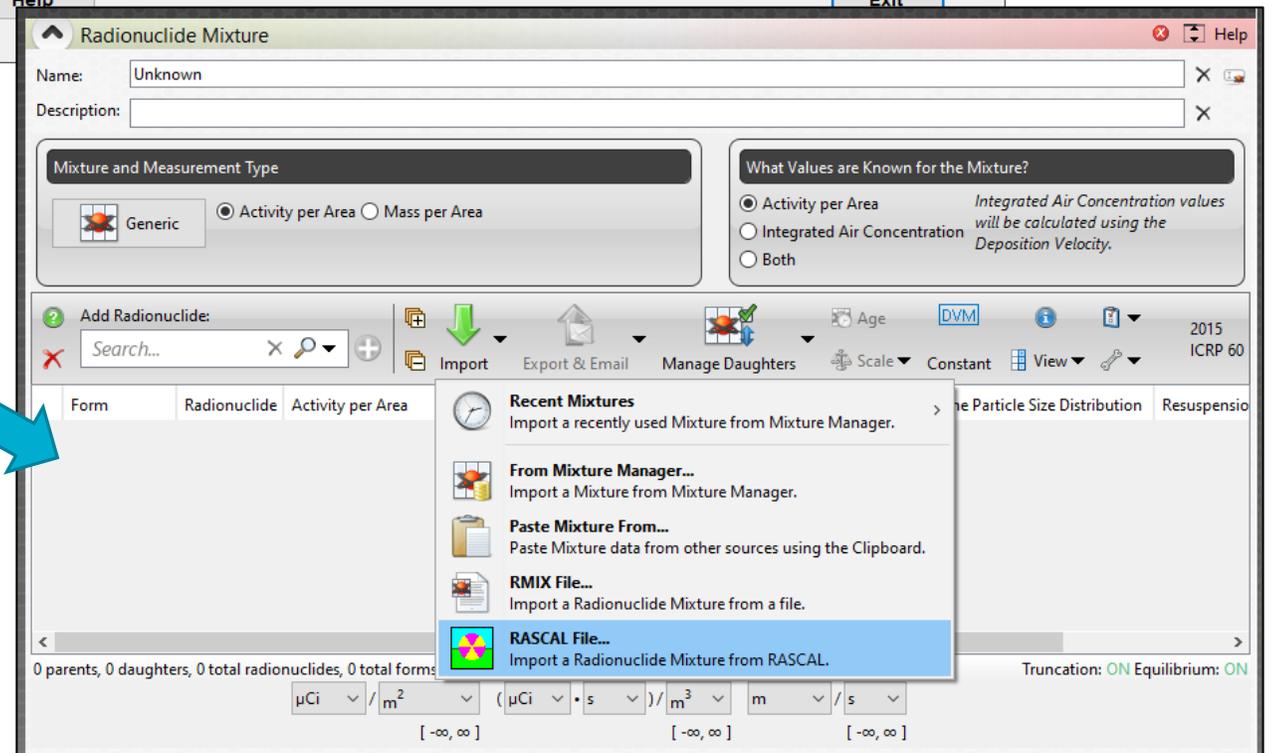
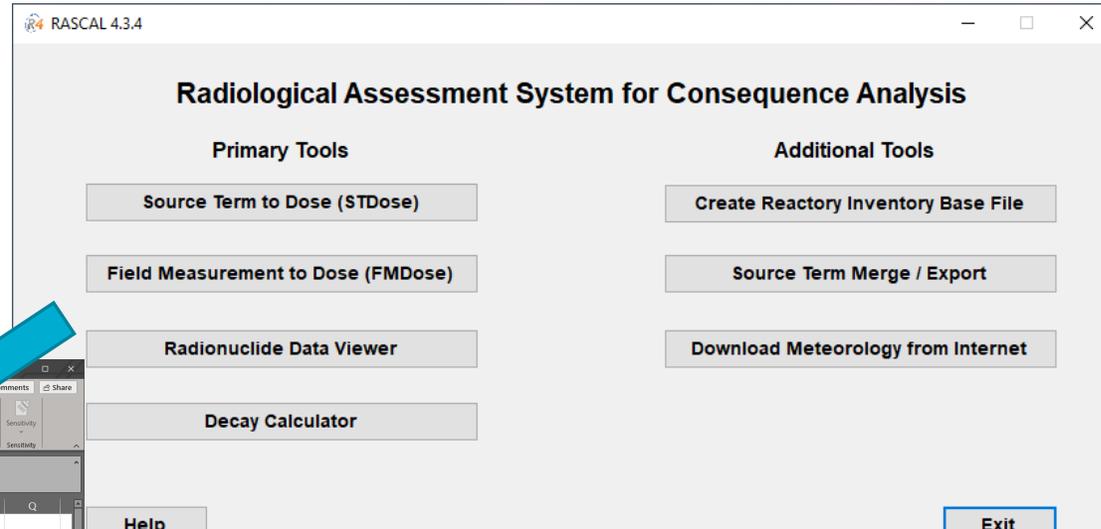
[Submit Feedback](#) [Back](#) [Next](#)

RASCAL 4.3.4 Import



RASCAL Source Term

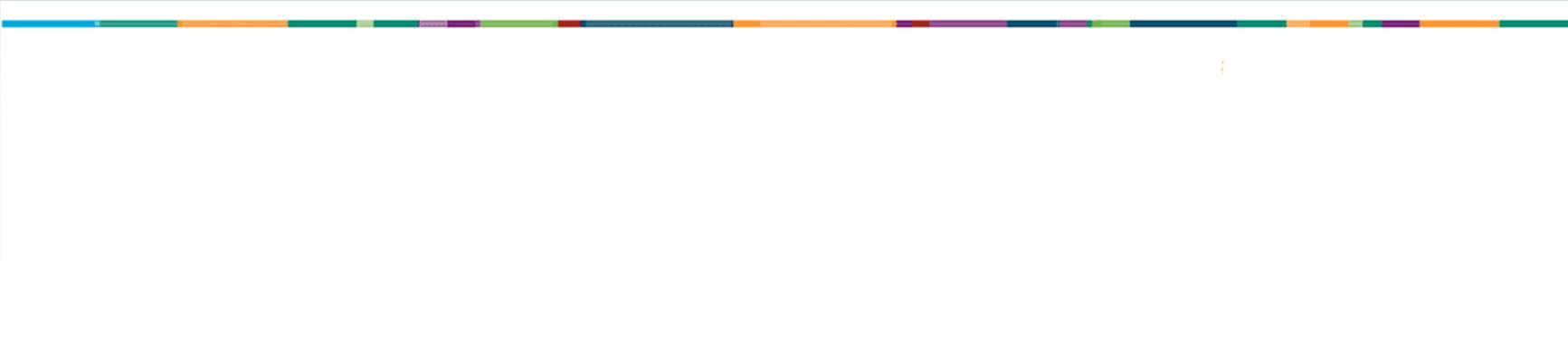
File	Home	Insert	Page Layout	Formulas	Data	Review	Developer	Add-ins	Help	Acrobat							
1	Creator	RASCAL 4.3.4															
2	File_Created	2022/08/30 13:41															
3	Site_Name	Zion - Unit 2															
4	Release_Latitude	42.44556															
5	Release_Longitude	-87.80222															
6	UTC_Offset	-6															
7	Release_Height	10.0 m															
8	Case_Title	test															
9	Case_Runtime	2022/07/11 14:30															
10	Case_Desc																
11	Activity_Units	Ci															
12	Other_Info	Importance filter: None															
13	Interval	7/11/2022															
14	Start	0:00	0:15	0:30	0:45	1:00	1:15	1:30	1:45	2:00	2:15	2:30	2:45	3:00	3:15	3:30	3:45
15	Am-241	1.64E-06	1.65E-06	1.65E-06	1.66E-06	1.67E-06	1.67E-06	1.67E-06	1.68E-06	1.68E-06	1.69E-06	1.69E-06	1.70E-06	1.71E-06	1.71E-06	1.72E-06	1.73E-06
16	Ba-140	2.74E+02	2.74E+02	2.74E+02	2.73E+02	2.73E+02	2.73E+02	2.73E+02	2.72E+02	2.71E+02	2.71E+02						
17	Ce-141	9.36E-01	9.36E-01	9.36E-01	9.36E-01	9.36E-01	9.36E-01	9.36E-01	9.36E-01	9.36E-01	9.36E-01	9.36E-01	9.36E-01	9.36E-01	9.27E-01	9.27E-01	9.27E-01
18	Ce-143	2.00E-01	1.99E-01	1.98E-01	1.97E-01	1.96E-01	1.95E-01	1.94E-01	1.93E-01	1.92E-01	1.91E-01	1.90E-01	1.89E-01	1.88E-01	1.87E-01	1.86E-01	1.85E-01
19	Ce-144	7.93E-01	7.93E-01	7.93E-01	7.93E-01	7.93E-01	7.93E-01	7.93E-01	7.93E-01	7.93E-01	7.93E-01	7.93E-01	7.93E-01	7.93E-01	7.93E-01	7.93E-01	7.93E-01
20	Cm-242	2.49E-02	2.49E-02	2.49E-02	2.49E-02	2.49E-02	2.49E-02	2.49E-02	2.49E-02	2.49E-02	2.49E-02	2.49E-02	2.49E-02	2.49E-02	2.49E-02	2.49E-02	2.49E-02
21	Cs-134	2.05E+04	2.05E+04	2.05E+04	2.05E+04	2.05E+04	2.05E+04	2.05E+04	2.05E+04	2.05E+04	2.05E+04	2.05E+04	2.05E+04	2.05E+04	2.05E+04	2.05E+04	2.05E+04
22	Cs-136	4.30E+03	4.30E+03	4.30E+03	4.29E+03	4.29E+03	4.29E+03	4.29E+03	4.28E+03	4.27E+03	4.27E+03						
23	Cs-137	1.42E+04	1.42E+04	1.42E+04	1.42E+04	1.42E+04	1.42E+04	1.42E+04	1.42E+04	1.42E+04	1.42E+04	1.42E+04	1.42E+04	1.42E+04	1.42E+04	1.42E+04	1.42E+04
24	I-131	1.67E+05	1.67E+05	1.67E+05	1.67E+05	1.67E+05	1.67E+05	1.67E+05	1.67E+05	1.67E+05	1.67E+05	1.66E+05	1.66E+05	1.66E+05	1.66E+05	1.66E+05	1.66E+05
25	I-132	1.64E+05	1.52E+05	1.41E+05	1.31E+05	1.22E+05	1.13E+05	1.04E+05	9.72E+04	9.00E+04	8.38E+04	7.79E+04	7.23E+04	6.71E+04	6.24E+04	5.79E+04	5.38E+04
26	I-133	3.89E+04	3.86E+04	3.83E+04	3.80E+04	3.76E+04	3.74E+04	3.70E+04	3.67E+04	3.64E+04	3.61E+04	3.58E+04	3.55E+04	3.52E+04	3.49E+04	3.47E+04	3.43E+04
27	I-135	2.12E+02	2.07E+02	2.02E+02	1.97E+02	1.92E+02	1.86E+02	1.82E+02	1.77E+02	1.73E+02	1.68E+02	1.64E+02	1.59E+02	1.56E+02	1.51E+02	1.48E+02	1.43E+02
28	Kr-83m	5.02E-08	4.56E-08	4.16E-08	3.78E-08	3.44E-08	3.13E-08	2.84E-08	2.59E-08	2.36E-08	2.14E-08	1.95E-08	1.77E-08	1.61E-08	1.47E-08	1.33E-08	1.22E-08



Turbo FRMAC will also try to import unknown versions of RASCAL files in a similar way to the latest version handled



Accessing Turbo FRMAC



Turbo FRMAC and RAMP

- Turbo FRMAC is a part of RAMP to promote awareness of the software and provide training opportunities to RAMP members
- We currently cannot recognize RAMP registrants and maintain a separate process for gaining Turbo FRMAC access

Sponsored by the U.S. Nuclear Regulatory Commission - NRC.gov

Register Log in

Search...

RAMP Website
Radiation Protection Computer Code
Analysis and Maintenance Program

CODES + MEMBERSHIP + MEETINGS + PARTNERS ABOUT + CONTACT

Home > Codes > Turbo FRMAC

Code Menu

- Turbo FRMAC Overview
- Documentation
- Request Support

Updates

- RAMPED UP - April 2021**
April 08, 2021
- Oct.-Nov. 2020 User Group Virtual Webinar**
October 12, 2020
- RAMPED UP - May 2020**
May 01, 2020

VIEW ALL NEWS

Related Codes

- RASCAL**
Radiological Assessment System for Consequence...

VIEW ALL CODES

Turbo FRMAC

Assess radiological hazards during an emergency response

The Turbo FRMAC analysis tool performs complex calculations to quickly evaluate radiological hazards during an emergency response by assessing impacts to the public, workers, and the food supply. Turbo FRMAC can be used to evaluate the hazard from a wide variety of radiological incidents, such as:

- Radiological Dispersal Devices (RDDs)
- Nuclear Power Plant Emergencies
- Fuel Handling Accidents
- Transportation Accidents
- Nuclear Detonations

Turbo FRMAC

Accessing Turbo FRMAC



- Software may be issued to response organizations/individuals with justification
- Registration required via the following site: <https://nirp.sandia.gov>

Sandia National Laboratories

Search Sandia.gov | All Sandia Websites

[Log In]

NUCLEAR INCIDENT RESPONSE PROGRAM

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News and Updates
Latest Software Releases

- SHARC 2021
- Turbo FRMAC 2021 11.0

Our Mission
The NIRP program provides research and technical solutions, expert analysis, and highly trained emergency response professionals to support the federal government's response to an accident or act of terrorism involving radiological, chemical, or biological material. This site provides access to software developed by NIRP's [Software Development Team](#) which is used in emergency response.

Registration Page

<https://nirp.sandia.gov/register>

- Once you create an account, check your email for an email verification link
- Once your email has been verified, you can then start requesting access to software


Search Sandia.gov | All Sandia Websites


NUCLEAR INCIDENT RESPONSE PROGRAM

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Create a New Account

Use the form below to create a new user account.

[Click here for help and instructions on how to create an account.](#)

Contact and Licensee Information

First Name:

Last Name:

Note: We strongly recommend that you enter your work/organization email address to register for software access.

Email:

Confirm Email:

Work Phone:

Company/Organization Name:

Company/Organization Address:

Title/Position:

Are you a U.S. Person (e.g. U.S. citizen or legal permanent resident)?

Yes No

The company/organization listed is a(n):

Small U.S. business

Large U.S. business (500 or more employees)

Non-profit organization or business under the U.S. Internal Revenue Code

U.S. state or local government entity

U.S. federal government agency

U.S. institution of higher education

Department of Energy National Laboratory

Foreign company / Foreign government entity / Foreign institution of higher education

Other

Why do you need this software access?

Explanation of Need:

Will there be any **non**-U.S. Persons using any of nirp.sandia.gov software?
(Green card holders are considered U.S. Persons.)

Turbo FRMAC Page

<https://nirp.sandia.gov/Software/TurboFRMAC/>

- After logging in, request access to Turbo FRMAC at bottom of software page
- Once access is approved, page will list available installers for download

What's New

A complete list of improvements and bug fixes for the latest versions of Turbo FRMAC is available by viewing the Release Notes.

[View Release Notes](#)

Software & Downloads

Turbo FRMAC Downloads

All recent installers are expected to function properly on Windows 11, however the applications have not yet been tested on Windows 11. Please report any issues to nirp-fogbugz@sandia.gov.

[View System Requirements & Troubleshooting](#)

Windows Downloads

Runs on: Windows 10, 8, 7, Vista

* The Single Installer installs only the Turbo FRMAC application to your computer. [Mixture Manager](#) and [Radionuclide Viewer](#) can be launched from within Turbo FRMAC.

* For information on silent, noninteractive installation of Turbo FRMAC, please refer to documentation on [running an installer silently](#) and [creating an installation properties file](#).

Turbo FRMAC - Version 11.2 | Released 10/18/2022

Download Link	Description
Download 64-bit	Single Installer Windows 64-bit Turbo FRMAC Version 11.2 SHA1 checksum value : b963015fb2262ea0feb2d3ac260968890e4eac38

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NUCLEAR INCIDENT RESPONSE PROGRAM

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Overview
What's New
Features
Software & Downloads

Overview

The Turbo FRMAC (TF) software automates the calculations described in Volume 1 of "The Federal Manual for Assessing Environmental Data During a Radiological Emergency". The manual upon which the software is based is unclassified and freely available by [clicking here](#).

Using values generated by field samples, instrument readings, or computer dispersion models, TF assesses the generated results into values that are meaningful and actionable for a decision maker at a radiological emergency. TF provides calculated results to answer questions such as:

- Do radiation values exceed city, state, or federal limits?
- Should crops be destroyed or can they be utilized?
- Do residents need to be evacuated, sheltered in place, or should another action be taken?
- How long can emergency workers work in a given area?

The software uses formulas generated by the Environmental Protection Agency (EPA), Food and Drug Administration (FDA), and other federal agencies to generate field-observable values specific to the radiological event that can be used to determine where regulatory limit values are exceeded. TF calculates values that indicate:

- How long an emergency worker can work in the contaminated area during a radiological emergency?
- The dose received from drinking contaminated water or milk.
- The dose from eating contaminated food.
- The dose expected down or upwind of a given field sample.
- Other similar radiological health values.

TF is designed to help the decision maker in a radiological emergency understand the significance of the field sample results and modeling information, so that proper response actions can be implemented. The software provides information about the impacts a radiological emergency will have on people affected by the event. It is intended to aid the leadership in identifying the proper action needed in order to protect the public without causing widespread panic.

Turbo FRMAC is a member of RAMP. The purpose of the [Radiation Protection Computer Code Analysis and Maintenance Program \(RAMP\)](#) is to develop, maintain, improve, distribute and provide training on NRC-sponsored radiation protection and dose assessment computer codes. Training for Turbo FRMAC is available to RAMP members.

Turbo FRMAC Factsheet

View

FRMAC Assessment Manual

View

Features

- Formulas located in Volume 1 of the FRMAC Assessment Manual.
- Includes DCFPAK 2015, containing six different vintages of data with published coefficients ranging from years 1983 to 2015.
- A radionuclide viewer for viewing nuclide information, such as decay modes, and radionuclide decay chains.
- Integration with Radionuclide Mixture Manager which allows for importation of existing mixtures, ability to create and reuse mixtures, import mixtures from RASCAL, etc.
- Complex Particle Size Distribution that allows for calculation of values under realistic complex particle distribution scenarios.
- ICRP 60 with both true Monodispersed Dose Coefficients and Lognormal based coefficients.
- ICRP 107 radiation decay data.
- ICRP 56 (FDA) data for calculation of FDA DILs.
- Instrument Thresholds: allows indication of what energy levels field instruments can register to dynamically changes values to be consistent with instruments in use.
- Decay Curve Export: exports the decay curve of a mixture for importation into other software tools for further analysis. Charts allow for analysis of the decay curve inside TF.
- Ability to export table data to Microsoft Excel™.
- Ability to share calculations via email. Import and export calculations to TFV files.

Approval Process



- The software licensing process may take up to 10 business days to complete for a U.S. person and up to 30 days to complete for international users
- If a license agreement is not in place for your organization, you will be asked to complete a Participant Data Sheet
- If a license agreement is already in place for your organization, the process is faster
- If you have not heard anything after 10 business days, contact NIRP-support-fogbugz@sandia.gov

Computer Requirements



- Turbo FRMAC has been designed for Windows 10 and is compatible with Windows Vista, 7, 8, and 10
- Compatible with Mac OS 10.6 or newer
- Minimum 2 GHz Pentium 4 Processor
 - Recommended: Dual- or Quad-Core or higher
- Minimum 2 GB RAM Memory
 - Recommended: 4 GB RAM or higher
- Minimum 15 GB Free Disk Space
 - Recommended: 25 GB Free or higher
- Minimum 1024 x 768 Screen Resolution
 - Recommended: 1280 x 1024 or higher
- Other Software
 - MS Excel 2007 or newer (for special data export capabilities)
 - MS Outlook 2007 or newer (for built-in email attachment support)
 - MS PowerPoint 2007 or newer (for briefing products)
 - MS Word 2007 or newer (for report generation)
 - Adobe Acrobat Reader (for viewing related documents)



- Tool that comes with Turbo FRMAC
- Displays full radionuclide decay chain
- Displays basic radionuclide data (half life, decay mode)
- Provides access to dose coefficients for each radionuclide

Radionuclide Viewer

View the decay chain, dose coefficients, and other properties of Radionuclides.

Decay Properties: Cs-137

Radionuclide	Half-Life	Decay Mode	Decay Constant	Branch Factor	Specific Activity	Fire Release Fraction	Total Emitted Alpha Energy	Total Emitted Beta Energy	Total Emitted Photon Energy
¹³⁷ Cs	1.10E4 B-		6.33E-5	N/A	8.71E10	1.00E-2	0.0	1.87E2	0.0
^{137m} Ba	1.77E-3 IT		3.91E2	0.946	5.38E17	1.00E-2	0.0	65.1	0.596

Radionuclides

View Options

ICRP Guidance: ICRP 60...

Age: Adult

Commitment Period: Chronic

Instrument Threshold: 70 keV...

Select Radionuclide

Filter: Show All

Search: CS

Cs-125
Cs-126
Cs-127
Cs-128
Cs-129
Cs-130
Cs-131
Cs-132
Cs-134
Cs-134m
Cs-135
Cs-135m
Cs-136
Cs-137
Cs-138

Dose Coefficients

Cs-137 Stochastic Inhalation Dose Coefficients

Organ	Dose Coefficient
Adrenal	17.6
Bone Surface	17.3
Brain	14.8
Breasts	14.1
Kidneys	16.9
Liver	17.1
Lower Large Intestine	20.9
Lung	16.0
Muscle	15.8
Ovaries	18.0
Pancreas	18.1
Red Marrow	16.5
Skin	13.5
Small Intestine	17.6
Spleen	16.9
Stomach	16.5
Testes	15.8
Committed Effective Dose	17.3

ICRP Guidance: ICRP 60
Age: Adult
Commitment Period: Chronic

View Particle Sizes for:
 Compound Distribution
 Vapor or Gas

Compound Distribution
View/Edit Distributions...

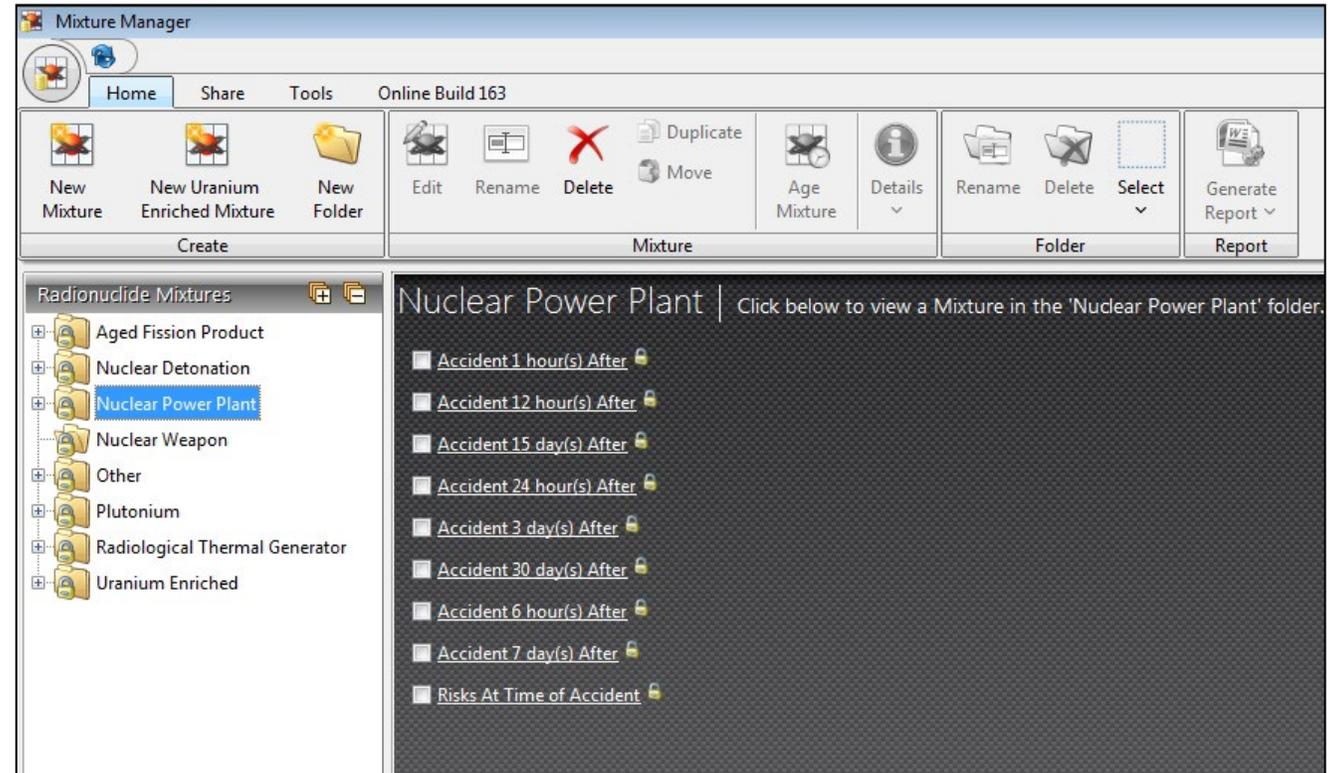
Distribution Summary:
1 Monodispersed

Lung Clearance Type
Maximum
Fast (F) - ICRP Recommended
Medium (M)
Slow (S)

Mixture Manager



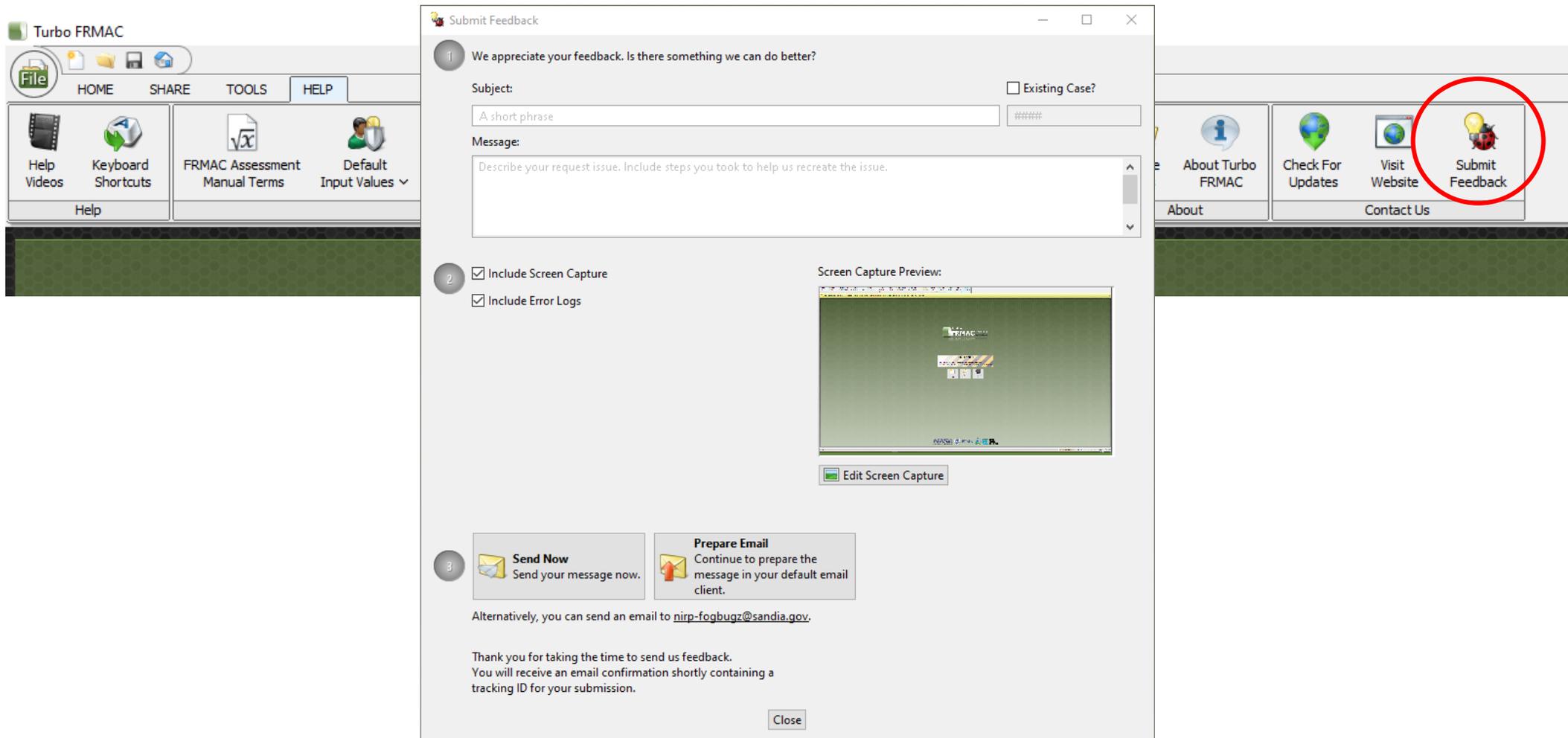
- Tool that comes with Turbo FRMAC
- Allows user to create, save, export, and import custom radionuclide mixtures
- Pre-determined radionuclide mixtures are also provided



Submitting Feedback



- Find a bug? Have a good idea for an improvement or new feature?



Nuclear Incident Response Self-Paced Learning Opportunities



AS-100: Introduction to Assessment Science

24 ABHP CECs

- 22 module course covering FRMAC Assessment methods for public protection, worker protection, and ingestion pathway **PNNS-KDXC**

Turbo FRMAC Advanced Methods

1 ABHP CEC each

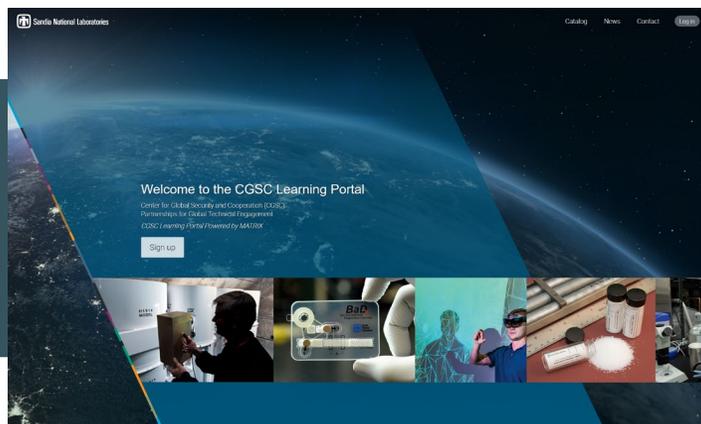
- Administration of Potassium Iodide
Derived Response Level Calculation **OMXL-NMBV**
- Analytical Action Level Calculation **HZAK-EWAX**

LA-050: Support Laboratory Briefing (Coming soon!)

- What labs should expect when called to help FRMAC

Gamma Spectroscopy (Coming soon!)

- Detector Calibration Methods
- Sample Analysis
- Software Functions
- Mathematical Instrument Calibration
- True Coincidence Summing Corrections
- In-Situ Gamma Spectrometry



Sandia and partners have developed *free, online* training!

Learn more: <https://snl.matrixlms.com/>

AS-100: Introduction to Assessment Science



Course Objectives

- Understand the basis of the EPA and FDA Protective Action Guides
- Understand the basis of the FRMAC Assessment Manual and how it is organized
- Understand the FRMAC Assessment methods for public protection, worker protection, and ingestion pathway
- Demonstrate ability to calculate values using Turbo FRMAC

Course Organization

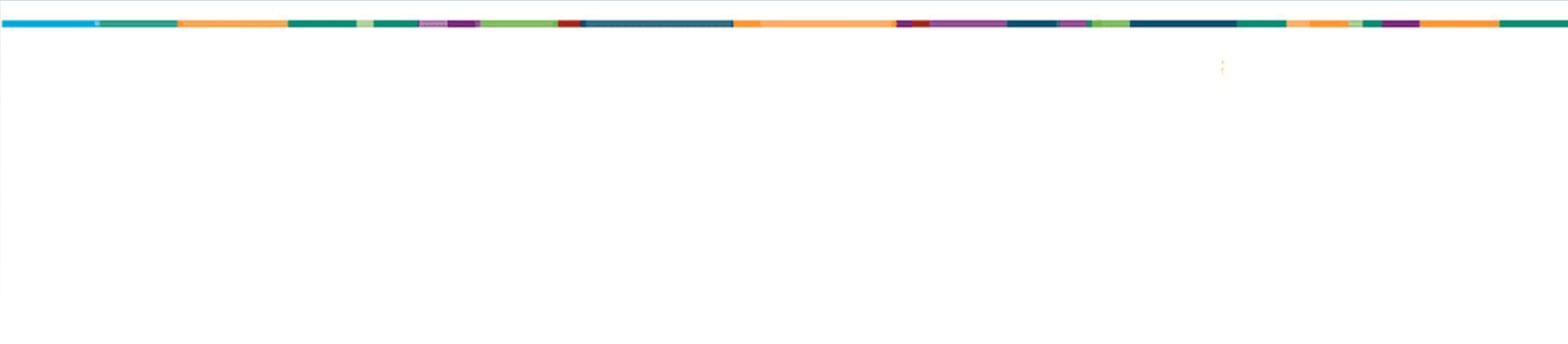
- 24 hours of self-paced content
- Each topic structured by:
 - Part 1: Topic overview
 - Part 2: Method discussion
 - Part 3: Turbo FRMAC demonstration

Prerequisites

- A working knowledge of health physics
- Turbo FRMAC software installed



Demonstration



Using Field Measurements for Projected Public Dose



- In the Intermediate phase of a response, questions about protective actions such as relocation for specific areas or populations might arise requiring calculation of projected doses based on measurement data
- **Example:** A field team was dispatched to an area where models indicate material from a nuclear power plant release has deposited. Should the population in this area be relocated? The field team measured the following:

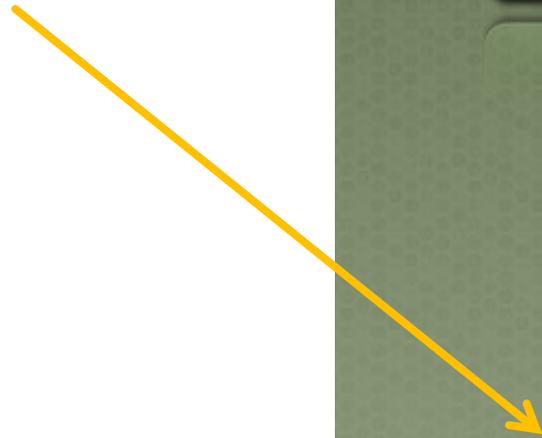
Radionuclide	Measured Deposition ($\mu\text{Ci}/\text{m}^2$)
Ba-140	1.4
Cs-134	0.6
Cs-137	0.35
I-131	1.7
I-132	1.3
La-140	1.3
Sr-89	1.0
Te-132	1.2

We will use Turbo FRMAC to calculate a **projected public dose** and compare it to the appropriate PAG for relocation

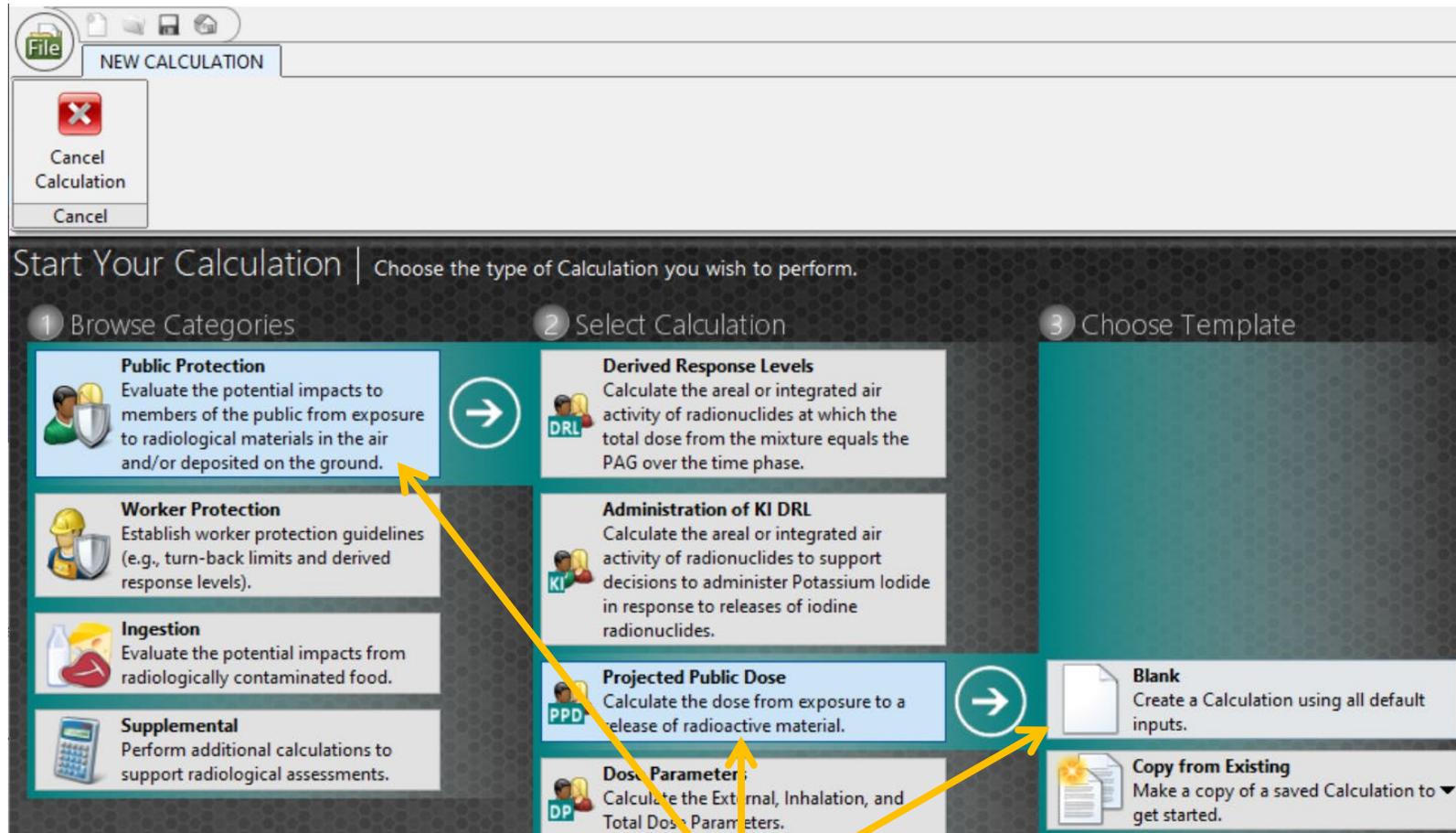
Open Turbo FRMAC



Select New Calculation



Select New Calculation



Select Public Protection, then Projected Public Dose, then Blank

Verify Time Phases



Click on Time Settings Button

Edit default time phases as needed for the question being asked

Projected Public Dose | Review and edit the most commonly used inputs for the calculations.

Required Inputs

- Name and Description
- Time Settings
- Radionuclide Mixture
- ICRP Guidance

Name and Description

Name: Projected Public Dose Example
29 characters entered

Description: For Fall 2022 RAMP Users' Meeting
33 characters entered

Time Settings

Release Date & Time: 10/17/2022 11:40 CST/MDT (UTC-06:00)

Date/Time Mode: Date & Time Time After Release

+ Add - Delete... Reset

Time Phase	Start Time	Duration	End Time	Plume Inhalation	Plume Submersion	Resuspension Inhalation	Group
Early Phase (TD)	0.0	96.0	96.0	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Early Phase (AD)	12.0	96.0	1.08E2	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
First Year	12.0	8.76E3	8.77E3	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Second Year	8.76E3	8.76E3	1.75E4	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Fifty Year	12.0	4.38E5	4.38E5	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	

hr hr hr
[0.0, 8.77E5] [1.67E-2, 8.77E5] [0.0, 8.77E5]

The PAGs for relocation apply to first and subsequent (second) years following the release, so additional default time phases can be removed

Build Radionuclide Mixture



Click on Radionuclide Mixture Button

Projected Public Dose | Review and edit the most commonly used inputs for the calculations.

Required Inputs

- Name and Description
- Time Settings
- Radionuclide Mixture
- ICRP Guidance

Radionuclide Mixture

Name: Field measurement

Description: Based on RASCAL 4.3 workbook example

Mixture and Measurement Type

Activity per Area Mass per Area

What Values are Known for the Mixture?

Activity per Area *Integrated Air Concentration values will be calculated using the Deposition Velocity.*

Integrated Air Concentration

Both

Add Radionuclide: Search... Import Export & Email Manage Daughters Age Scale View 2015 ICRP 60

Form	Radionuclide	Activity per Area	Integrated Air Concentration	Deposition Velocity	Plume Particle Size Distribution	Resuspension
------	--------------	-------------------	------------------------------	---------------------	----------------------------------	--------------

0 parents, 0 daughters, 0 total radionuclides, 0 total forms

Truncation: ON Equilibrium: ON

$\mu\text{Ci} / \text{m}^2$ ($\mu\text{Ci} \cdot \text{s}$) / m^3 m / s

[-∞, ∞] [-∞, ∞] [-∞, ∞]

Daughters are assigned the Deposition Velocity of their parent.

The Mixture must contain 1 or more Radionuclides. Add Radionuclides or Import a Mixture.

Build Radionuclide Mixture



Click on Search and begin to populate radionuclides

Projected Public Dose | Review and edit the most commonly used inputs for the calculations. PPD

Required Inputs

- Name and Description
- Time Settings
- Radionuclide Mixture
- ICRP Guidance

Radionuclide Mixture

Name: field measurement

Description: Based on RASCAL 4.3 workbook example

Mixture and Measurement Type

Generic Activity per Area Mass per Area

What Values are Known for the Mixture?

Activity per Area *Integrated Air Concentration values will be calculated using the Deposition Velocity.*

Integrated Air Concentration

Both

Add Radionuclide:

ba-

Searching All Radionuclides

Form	Area	Integrated Air Concentration	Deposition Velocity	Plume Particle Size Distribution	Resuspension
Ba-124					
Ba-126					
Ba-127					
Ba-128					
Ba-129					
Ba-129m					
Ba-131					
Ba-131m					
Ba-133					
Ra-133m					

0 parents, 0 daughters, 0 total radionuclides, 0 total forms

Truncation: ON Equilibrium: ON

$\mu\text{Ci} / \text{m}^2$ ($\mu\text{Ci} \cdot \text{s}$) / m^3 m / s

[-∞, ∞] [-∞, ∞] [-∞, ∞]

Daughters are assigned the Deposition Velocity of their parent.

The Mixture must contain 1 or more Radionuclides. Add Radionuclides or Import a Mixture.

Build Radionuclide Mixture



Enter each radionuclide in the mix and enter the measured Activity per Area

Turbo FRMAC will autopopulate concentrations for daughters present in equilibrium

Projected Public Dose | Review and edit the most commonly used inputs for the calculations.

Required Inputs

- Name and Description
- Time Settings
- Radionuclide Mixture
- ICRP Guidance

Radionuclide Mixture

Name:

Description:

Mixture and Measurement Type

Activity per Area Mass per Area

What Values are Known for the Mixture?

Activity per Area *Integrated Air Concentration values will be calculated using the Deposition Velocity.*

Integrated Air Concentration

Both

Add Radionuclide:

2015 ICRP 60

Form	Radionuclide	Activity per Area	Integrated Air Concentration	Deposition Velocity	Plume Particle Size Distribution	Resu
<input type="checkbox"/> P	¹⁴⁰ Ba	1.4	4.67E2	3.00E-3	Mono 100%	M
	¹⁴⁰ La	1.61	5.37E2	3.00E-3	Mono 100%	M
<input type="checkbox"/> P	¹³⁴ Cs	0.6	2.00E2	3.00E-3	Mono 100%	M
<input type="checkbox"/> P	¹³⁷ Cs	0.35	1.17E2	3.00E-3	Mono 100%	M
	^{137m} Ba	0.33	1.10E2	3.00E-3	Mono 100%	M
<input type="checkbox"/> Multiple	¹³¹ I	1.7	2.62E2	6.50E-3	Mono 100%	M

8 parents, 4 daughters, 12 total radionuclides, 20 total forms

Truncation: ON Equilibrium: ON

/ () / /

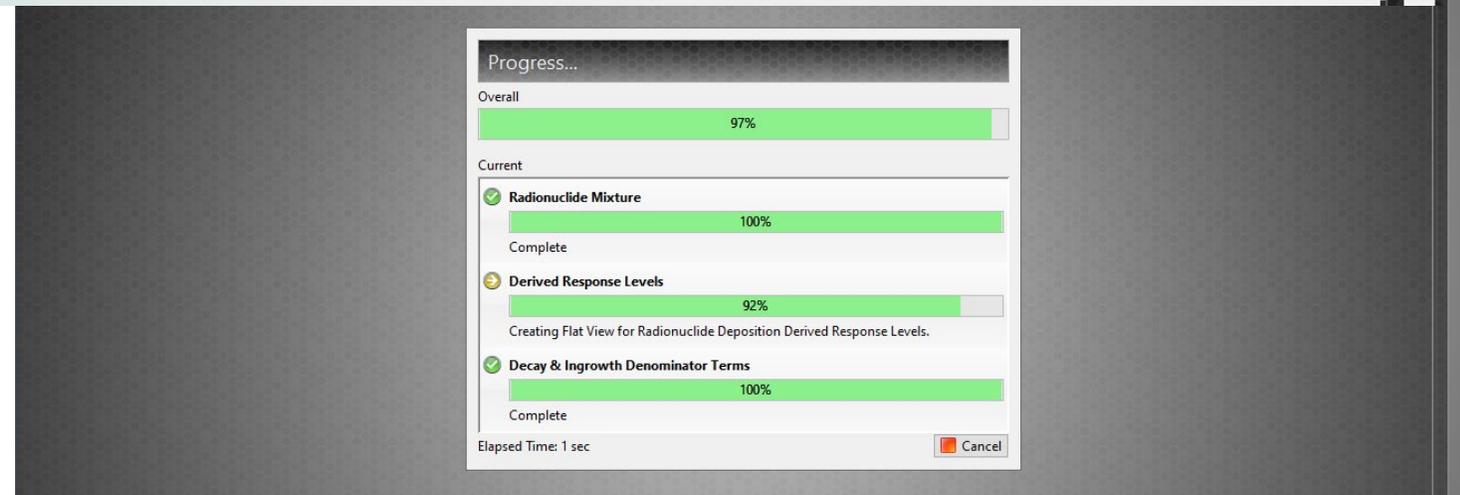
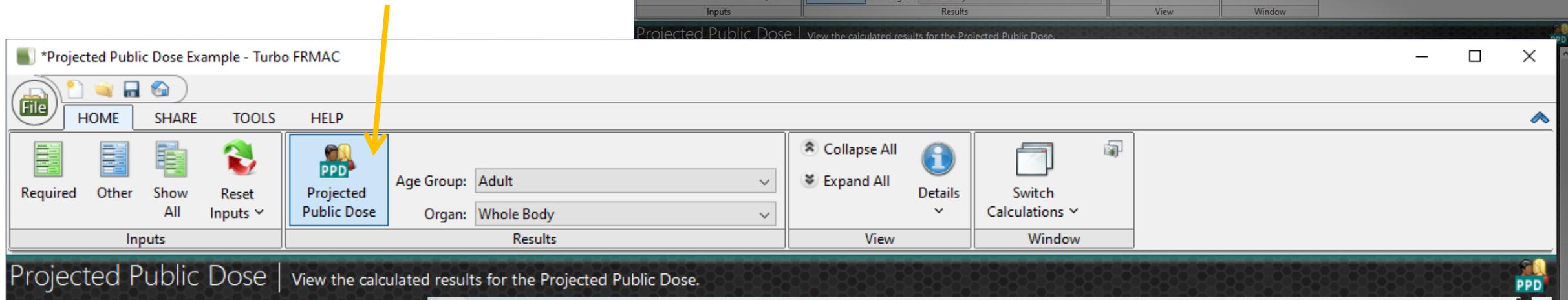
[0.0, 1.75E29]
[0.0, 1.75E29]
[0.0, 100.0]

Daughters are assigned the Deposition Velocity of their parent.

Run Calculation



Click the Projected Public Dose button



What do the results mean?



Time Phase	Projected Public Dose (rem)	EPA PAG (rem)
First Year	0.11	2
Second Year	5.5E-02	0.5

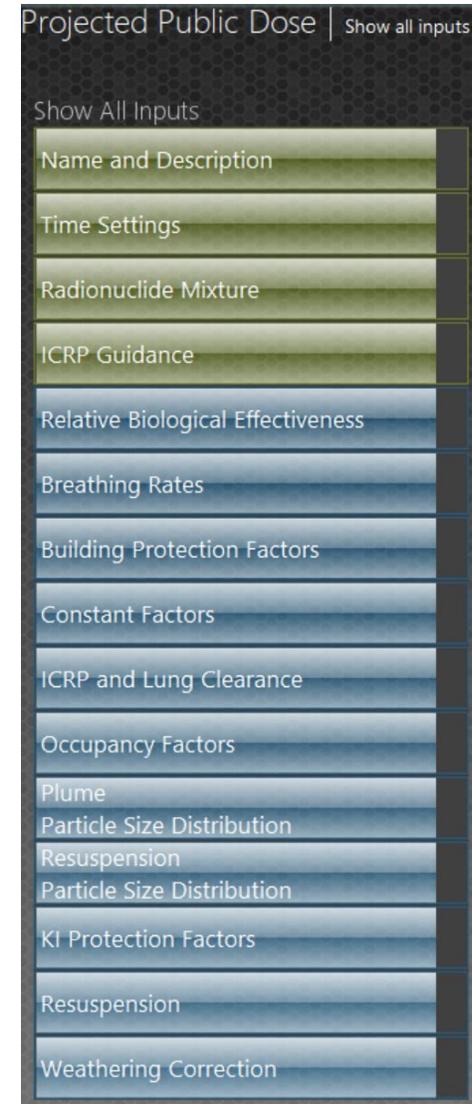
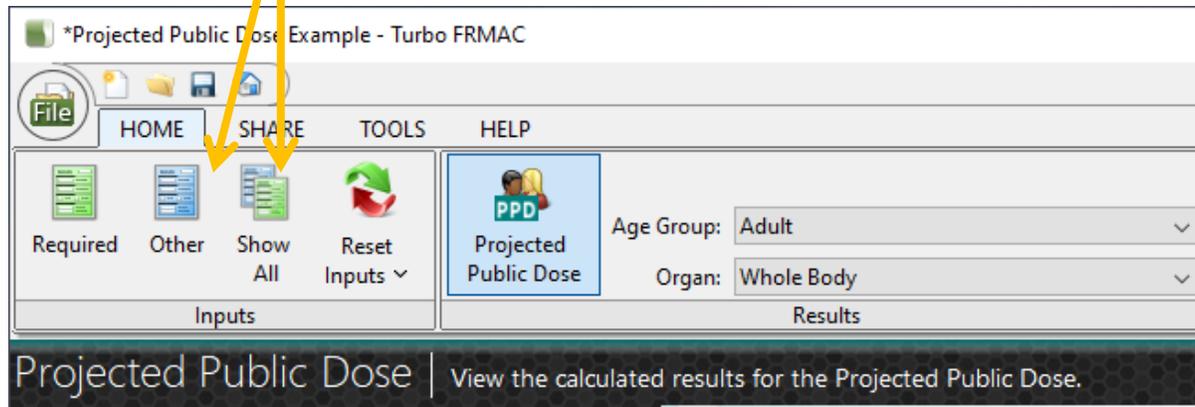
- Results are far below the PAGs for the intermediate phase
- Note, this is a conservative assessment based on a single measurement and might not be enough basis for a decision to relocate a population
- If results were close to the PAG, Assessment Scientist should consider acquiring more information about the population (e.g., time spent outdoors in the contaminated area) and tailor the calculation accordingly

Other Inputs



Only the radionuclide mixture was required to run this calculation

Selecting “Other” or “Show All” reveals the blue button inputs for advanced customization of the inputs



Required Inputs

Other Inputs



Thursday October 27, 2022

DAY 4-Virtual

8:00 AM-8:50 AM

Morning Primer – Code Consolidation

9:00 AM-12:00 PM

RASCAL Intermediate

1:30 PM-4:00 PM

RASCAL Advanced/Turbo FRMAC Discussion





Thank You

Lainy Cochran

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