Introduction to FRMAC Dose Assessment Methodology and Turbo FRMAC Software

National Nuclear Security Administration

Sandia National Laboratories

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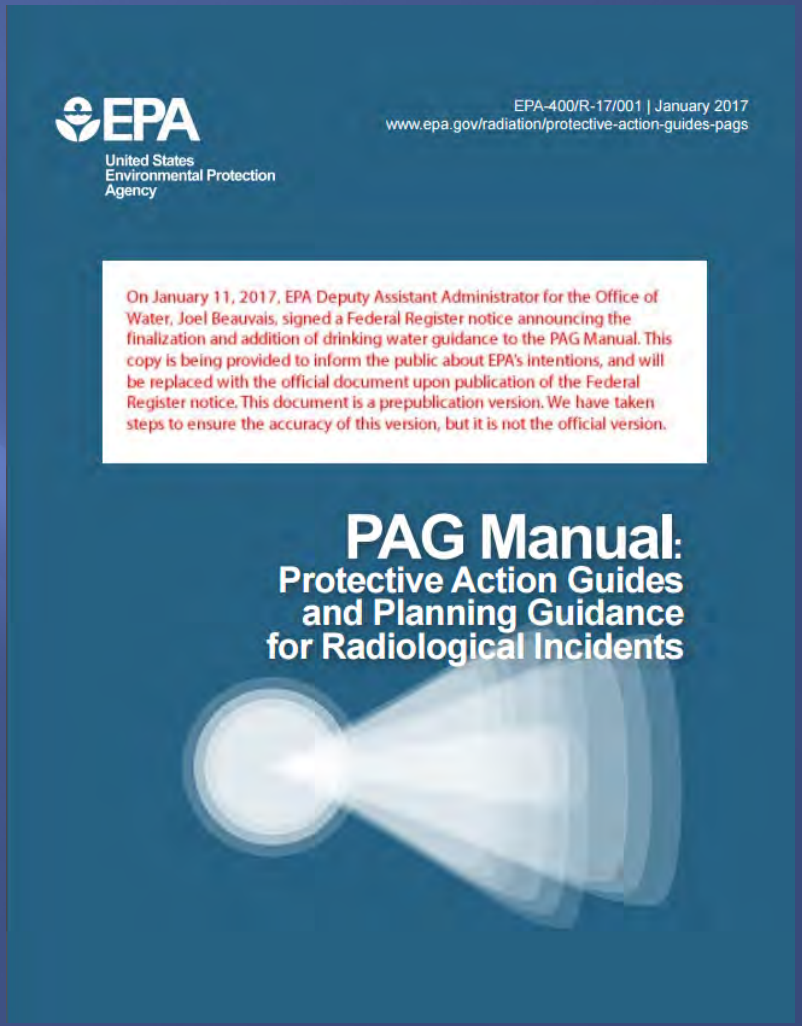
EPA Protective Action Guide (PAG) Manual

Final Approval, January 2017



https://www.epa.gov/radiation/protective-action-guides-pags

EPA PAG Manual Revision Key Changes

- Incorporates FDA's recommended PAG of 5 rem projected Child Thyroid Dose for administration of stable iodine (KI)
- Removes the 25 rem Adult Thyroid Dose and the 50 rem Skin Dose Evacuation PAGs
- Removes the 50-year, 5 rem Relocation PAG
- Provides guidance for reentry, late phase cleanup and waste disposal
- Adopts the FDA's 1998 Food PAGs

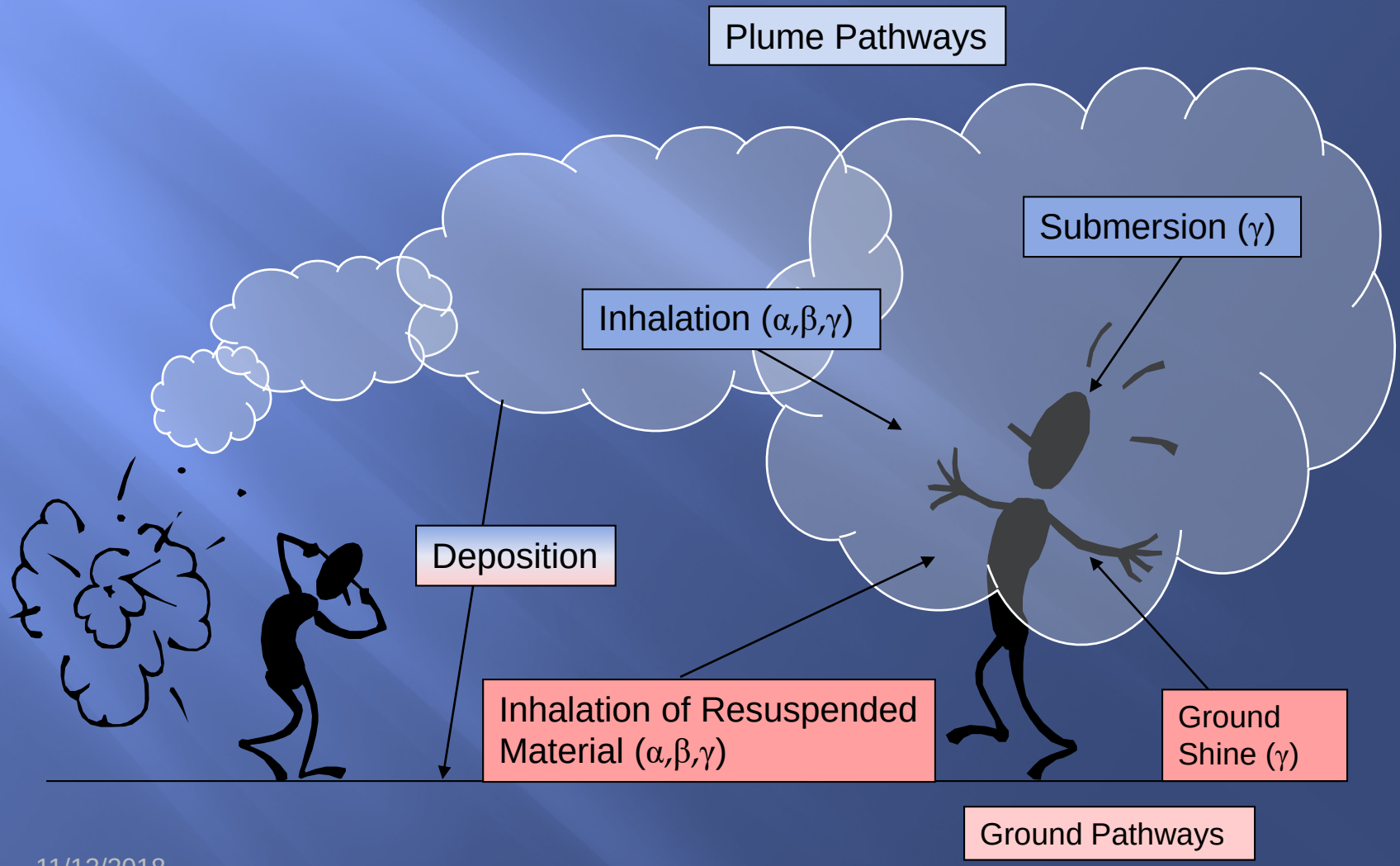
PAG Manual Guidance – Time Phases

Time Phase	Start	Duration	Protective Actions
Early	Begins with the radiological release	May last hours to days; Generally considered to last 4 days (~96 hours)	Evacuation and/or Shelter in Place
Intermediate	Release under control or terminated	1st Year 2nd & Subsequent Years	Relocation
Late	Transition from strategies driven by urgency, to strategies aimed at reducing longer-term exposures	Not Defined	Relocation

PAGs

Early Phase		
Protective Action Recommendation	**PAG (Projected Dose)**	**Comments**
Sheltering-in-Place or Evacuation	1-5 rem	Evacuation (or, for some situations, sheltering-in-place) should be initiated when projected dose is 1 rem
Administration of prophylactic drugs – KI	5 rem to child thyroid from iodine exposure	May require approval of state medical officials (or in accordance with established emergency plans)
Intermediate Phase		
Relocate the general population	2 rem	1st year following the event
Relocate the general population	0.5 rem	In the 2nd and subsequent years
Late Phase		
Relocate the general population	NA	PAGs will not be used to guide restoration and recovery

Release Exposure Pathways



Public Protection Exposure Pathways

Early Phase

1. Inhalation of radioactive materials in the plume
2. Direct exposure from radioactive materials in the plume
3. Inhalation of ground-deposited radionuclides resuspended into the breathing zone
4. Direct exposure from "groundshine" from deposited radioiodines and particulates

Intermediate & Late Phases

1. Inhalation of ground-deposited radionuclides resuspended into the breathing zone
2. Direct exposure from "groundshine" from deposited radioiodines and particulates

FDA Ingestion PAG Manual

ACCIDENTAL RADIOACTIVE CONTAMINATION
OF HUMAN FOOD AND ANIMAL FEEDS:
RECOMMENDATIONS FOR STATE AND LOCAL AGENCIES

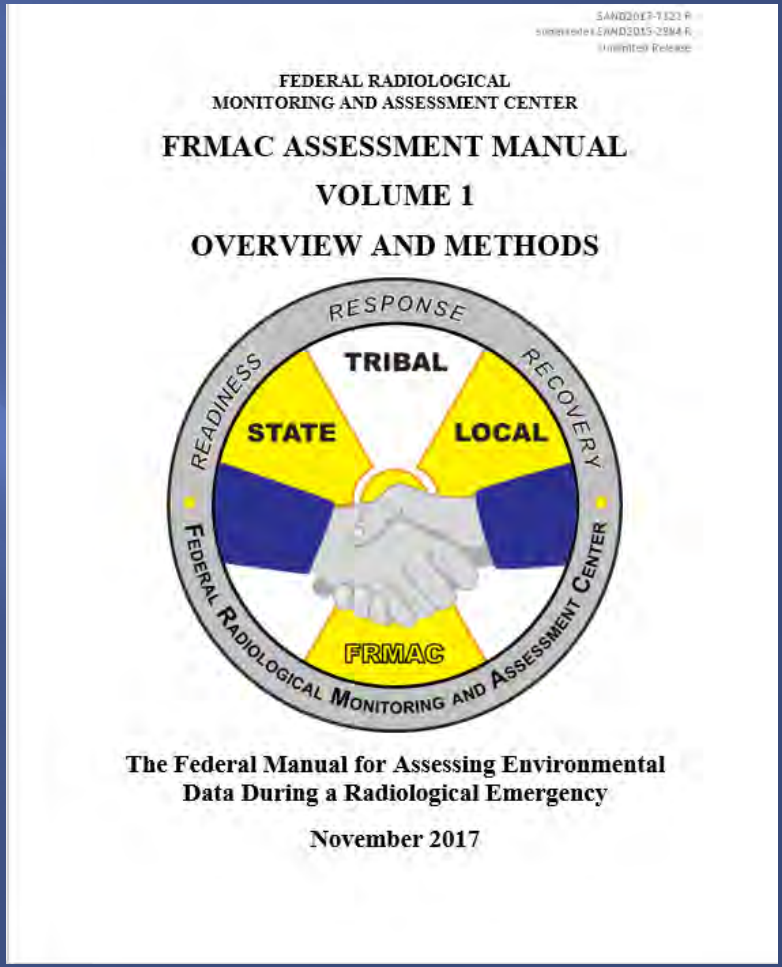
FDA Ingestion PAGs

Protective Action Recommendation	PAG (Projected Dose)	Comments
See Below	0.5 rem (E_{50}) 5 rem (H_T)	Whichever is more limiting (Whole Body or Organ) from ingestion of contaminated food in 1st year

Ingestion Protective Action Recommendations	
All foods	Isolate by temporary embargo until survey and initial sampling is completed Determine whether condemnation or other disposition is appropriate
Milk	Hold for decay or divert to other products involving adequate decay during processing (e.g., cheese, butter, dry milk solids, or evaporated milk)
Fruits and Vegetables	Wash, brush, scrub or peel to remove surface contamination Preserve by canning, freezing, dehydration, or storage to permit decay
Grains	Process by milling and polishing to remove surface contamination
Animals	Move to shelter and/or corral; provide protected feed and water

FRMAC Assessment Manual

- Latest Revision
  November 2017
- Available on
  Nevada National Security Site



FEDERAL RADIOLOGICAL
MONITORING AND ASSESSMENT CENTER

FRMAC ASSESSMENT MANUAL

VOLUME 1

OVERVIEW AND METHODS

The Federal Manual for Assessing Environmental Data During a Radiological Emergency

November 2017

http://www.nnss.gov/pages/programs/frmac/frmac_documentsmanuals.html

FRMAC Assessment Manual

- Provides the technical basis for FRMAC Dose Assessments
- Provides the technical basis for the Turbo FRMAC© Software Package
- Provides updated tabulated reference data for default assessment conditions (e.g., Time Phases, PAGs, likely nuclides of concern)

NOTE: The FRMAC Assessment Division strives to implement the best technical health physics, however these may differ from other agencies due to a difference in alternate assumptions

FRMAC Assessment Methods

FRMAC Assessment Working Group (AWG) develops and implements consistent, defensible and state-of-the-art radiological assessment methods across all the represented agencies/organizations

$$CED = DFIR_{age,f} * \sum_{i}^{n} \left(FFC_i * FC_i * IngDC_{organ,i,age} * \left(\frac{1 - e^{-(\lambda_i * t)}}{\lambda_i} \right) \right)$$

What is Turbo FRMAC?

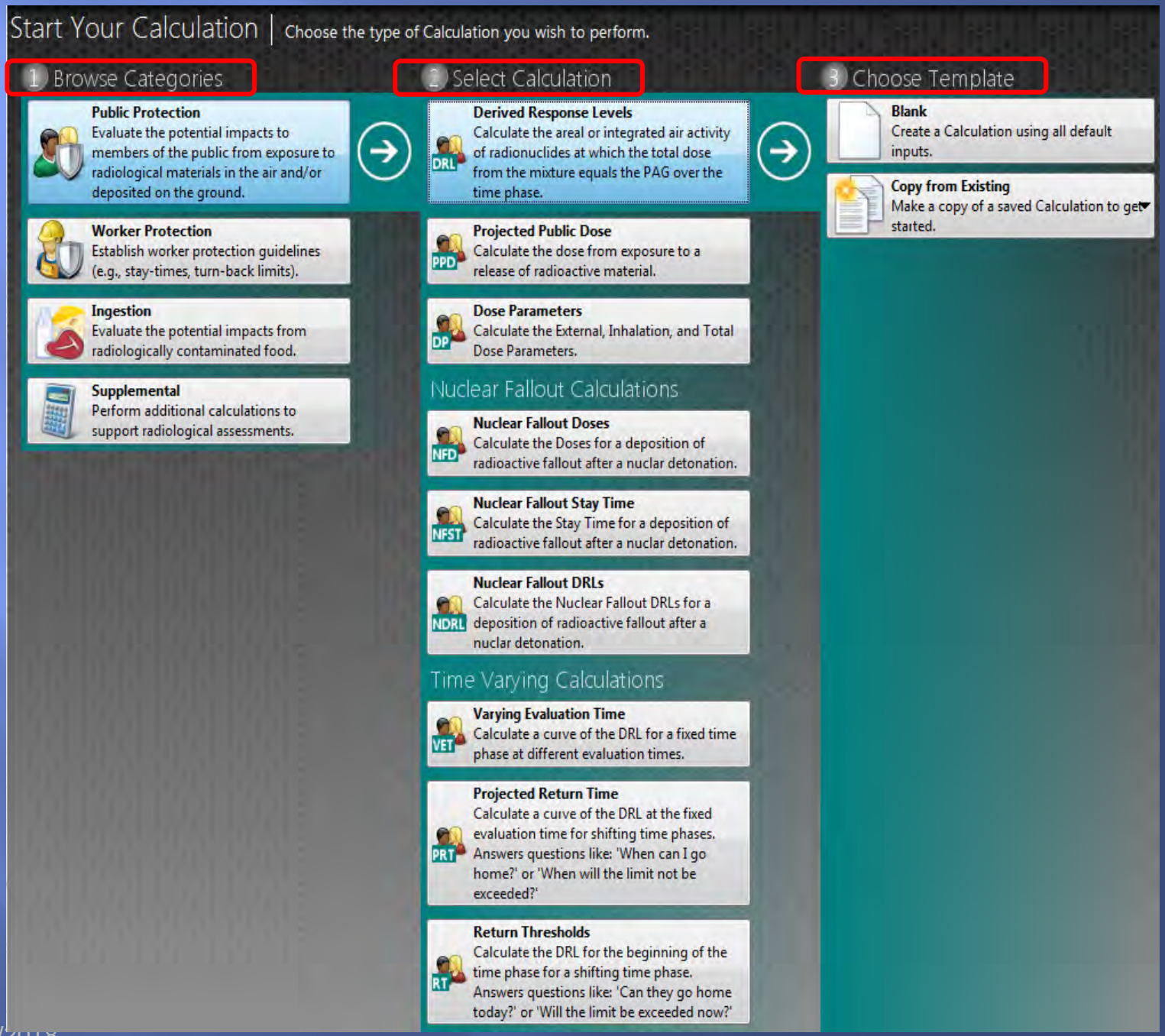
- Turbo FRMAC automates FRMAC Assessment Manual methods
- Turbo FRMAC eliminates most human errors
- Turbo FRMAC is a deployable software application
- Turbo FRMAC is not a replacement for Health Physics knowledge and experience

Accessing Turbo FRMAC

- Software may only be issued to Federal, State, Tribal, Local responders with Justification
- Registration required via the following site:

https://nirp.sandia.gov/

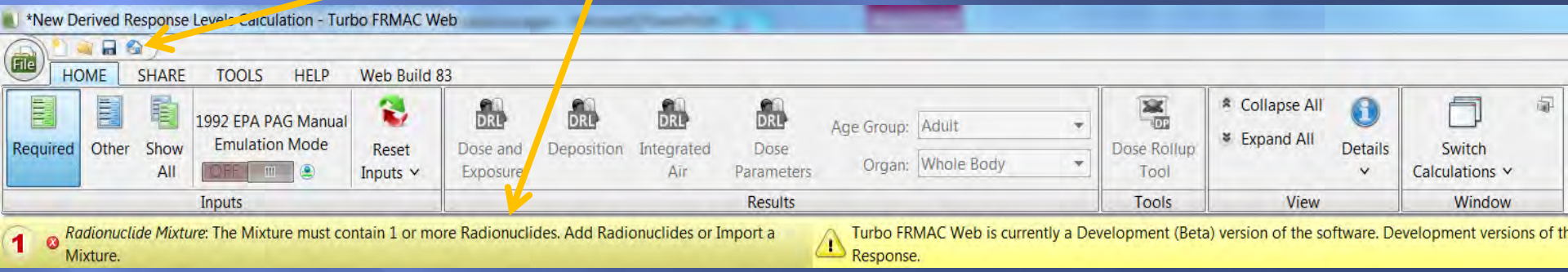

Turbo
FRMAC 2018
New Calculation
Open Calculation
Watch Help Videos
National Nuclear Security Administration
FEMA
Sandia National Laboratories
PUBLICLY AVAILABLE


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 nuclar detonation.
Nuclear Fallout Stay Time
Calculate the Stay Time for a deposition of radioactive fallout after a nuclar detonation.
Nuclear Fallout DRLs
Calculate the Nuclear Fallout DRLs for a deposition of radioactive fallout after a nuclar 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?'
Blank
Create a Calculation using all default inputs.
Copy from Existing
Make a copy of a saved Calculation to get started.

Turbo FRMAC General Layout

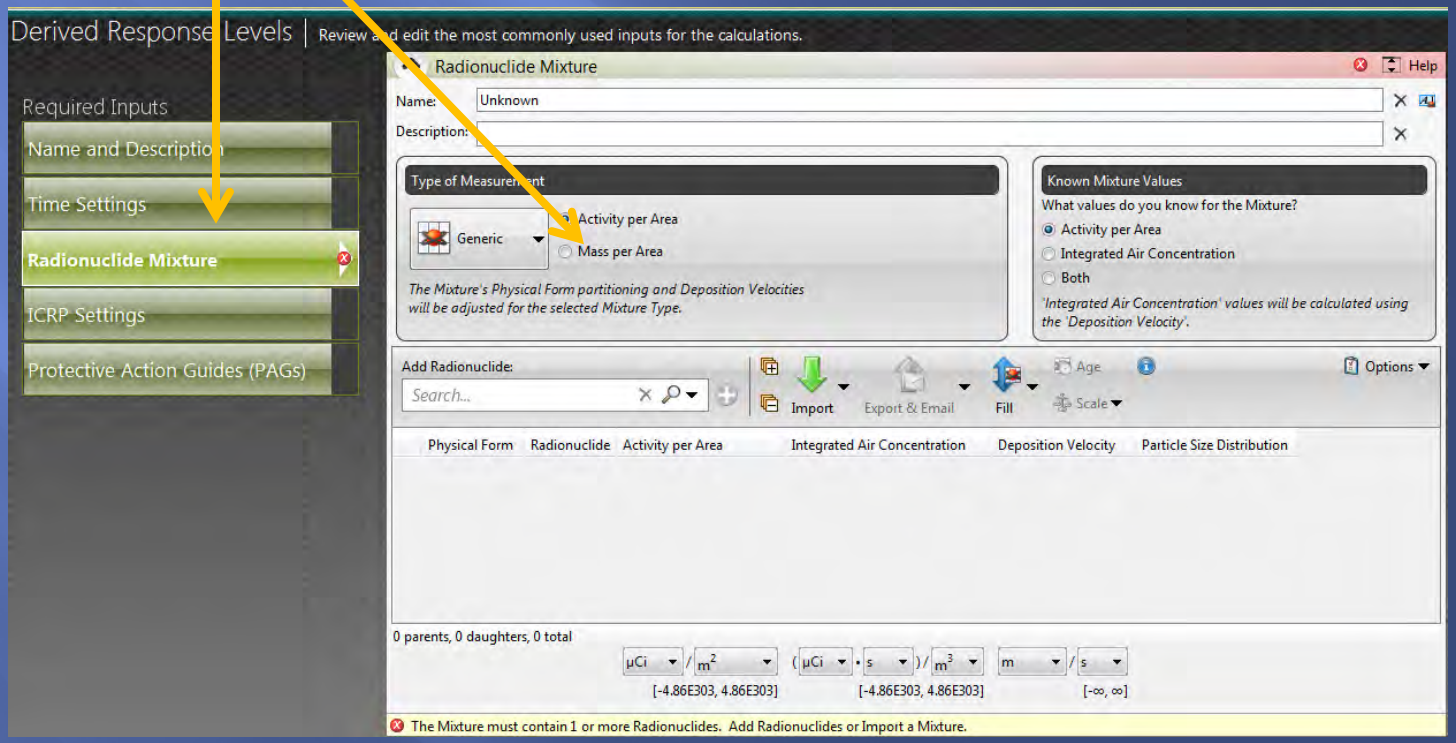
Ribbons and Tabs

- Controls calculations
- Allows movement to other work options
- Provides any error messages



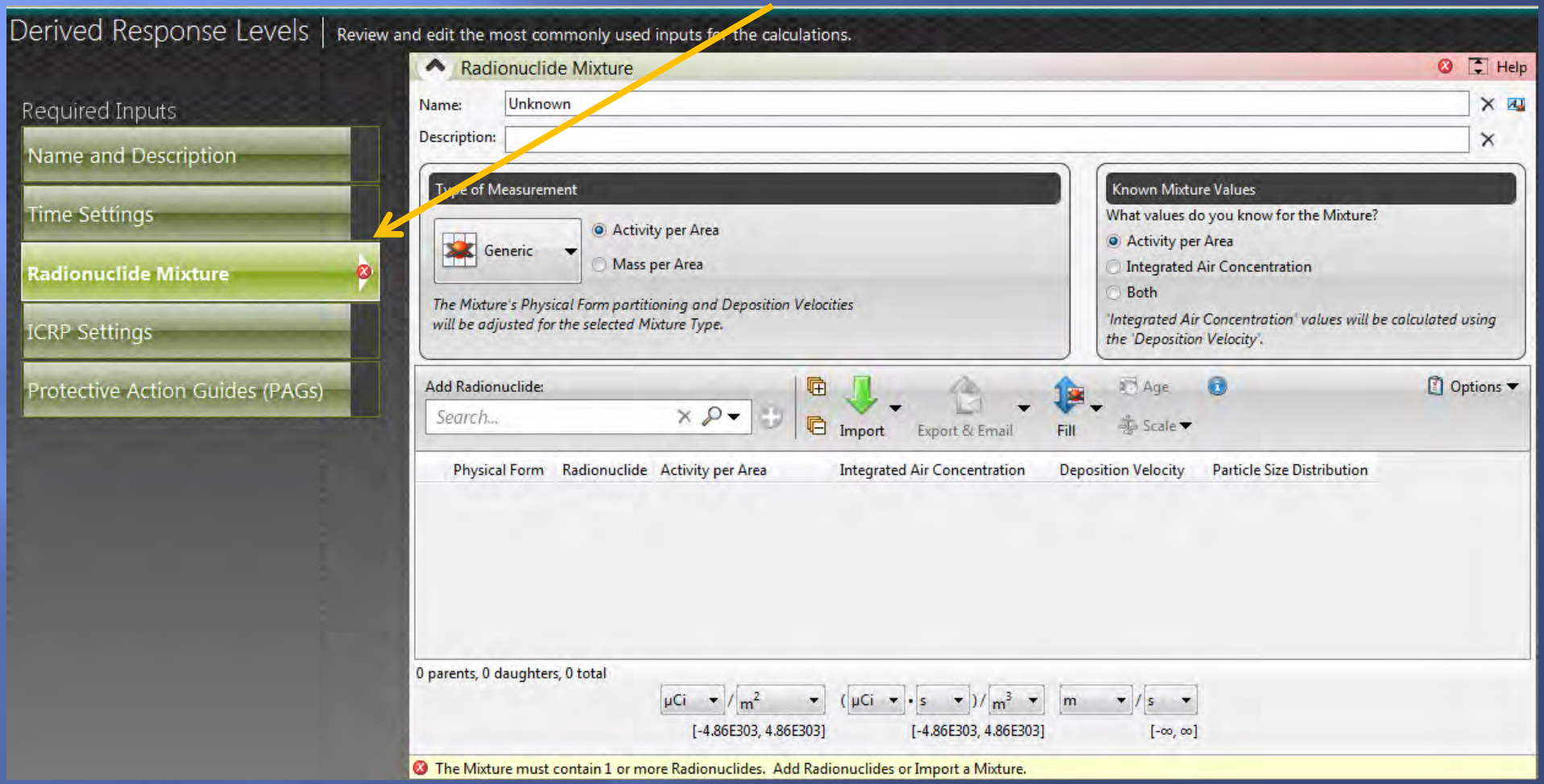
Turbo FRMAC General Layout

- Buttons
  - Required Inputs
  - Other Inputs
- Panels
  - Individual data



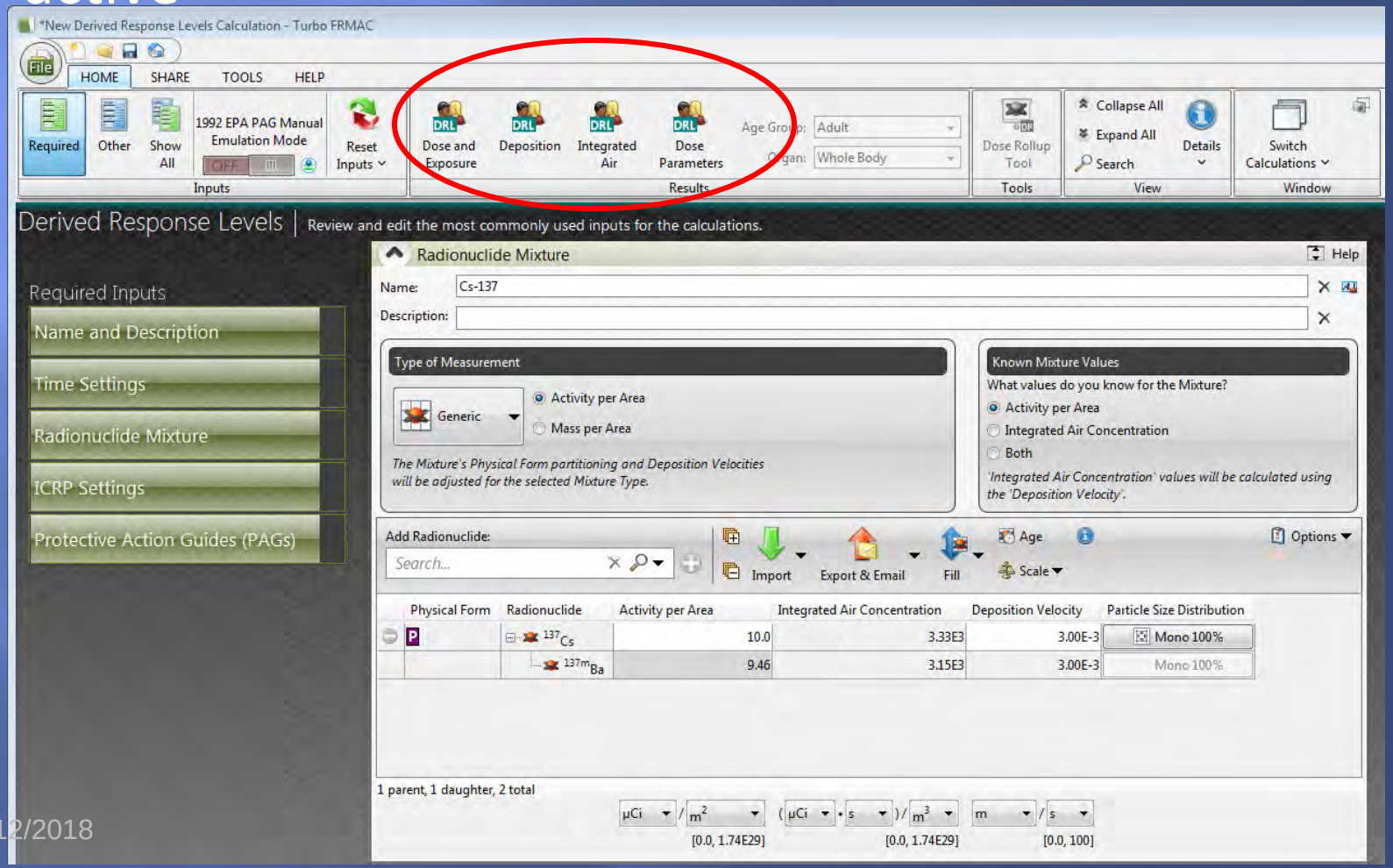
Features → Main Window

Clicking the button brings the panel into viewing area



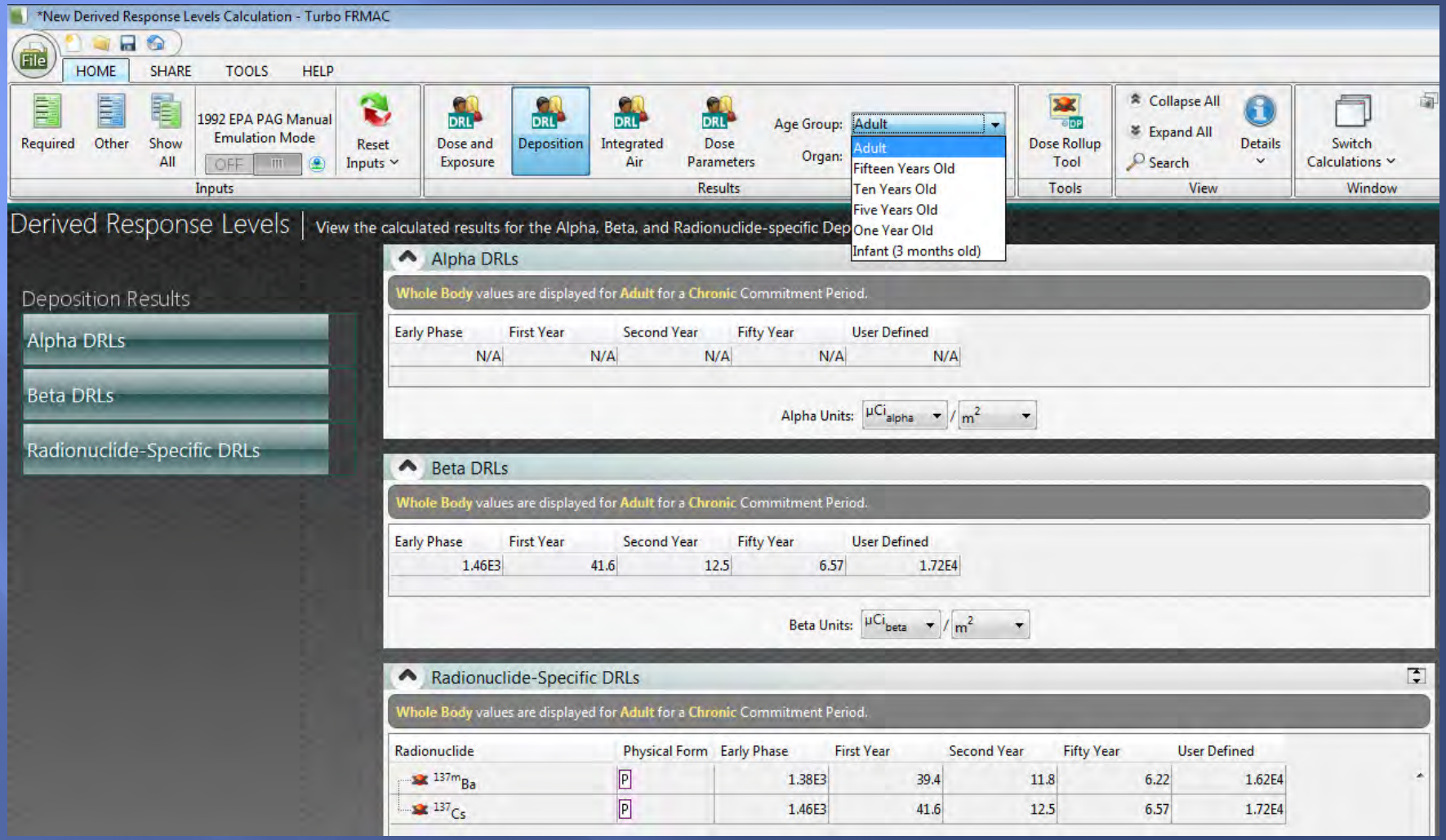
Features → Main Window

Once the user provides required data, calculation buttons are “active”



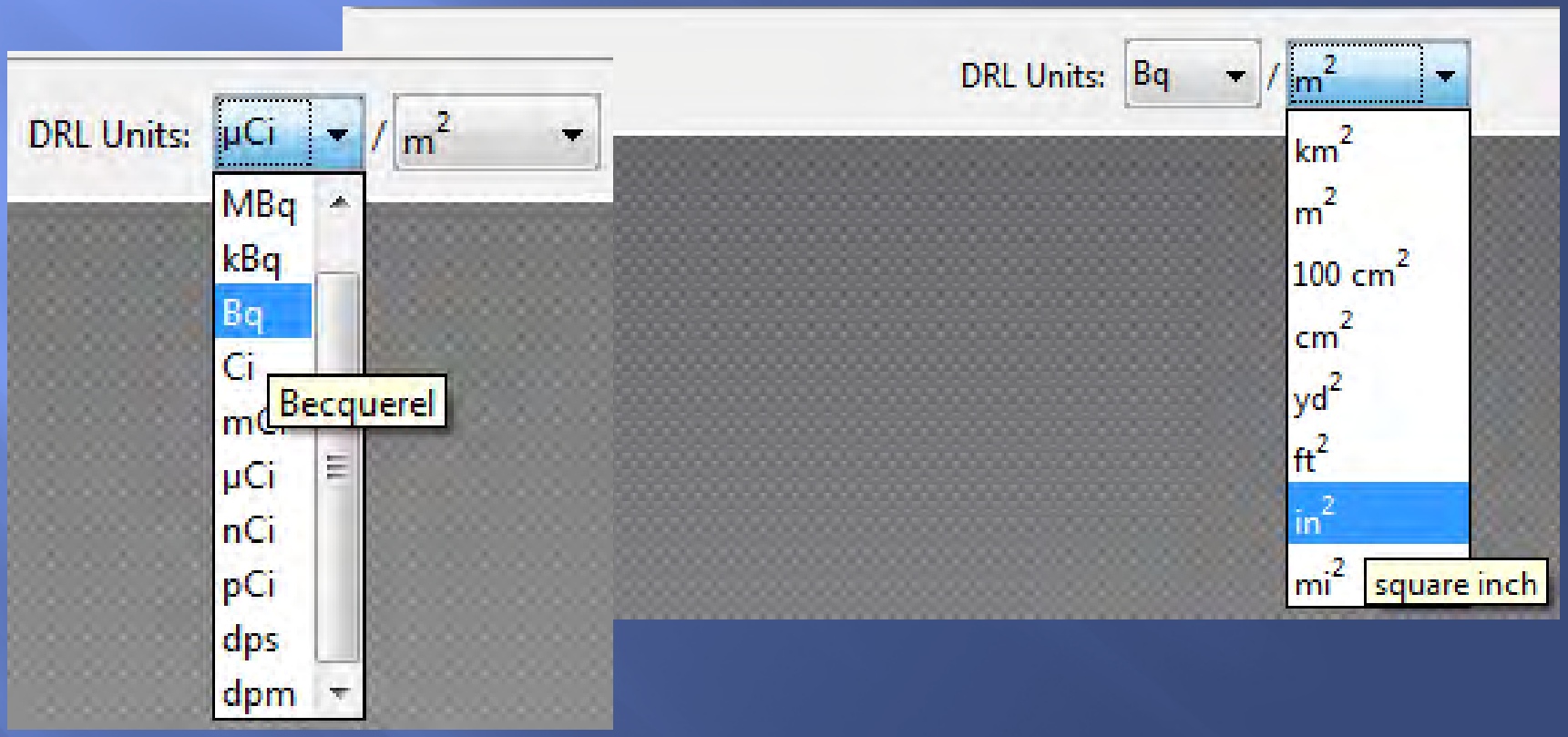
Features → Results

Calculation completed for all radionuclides and for all age groups



Features → Results

Units can be converted as needed



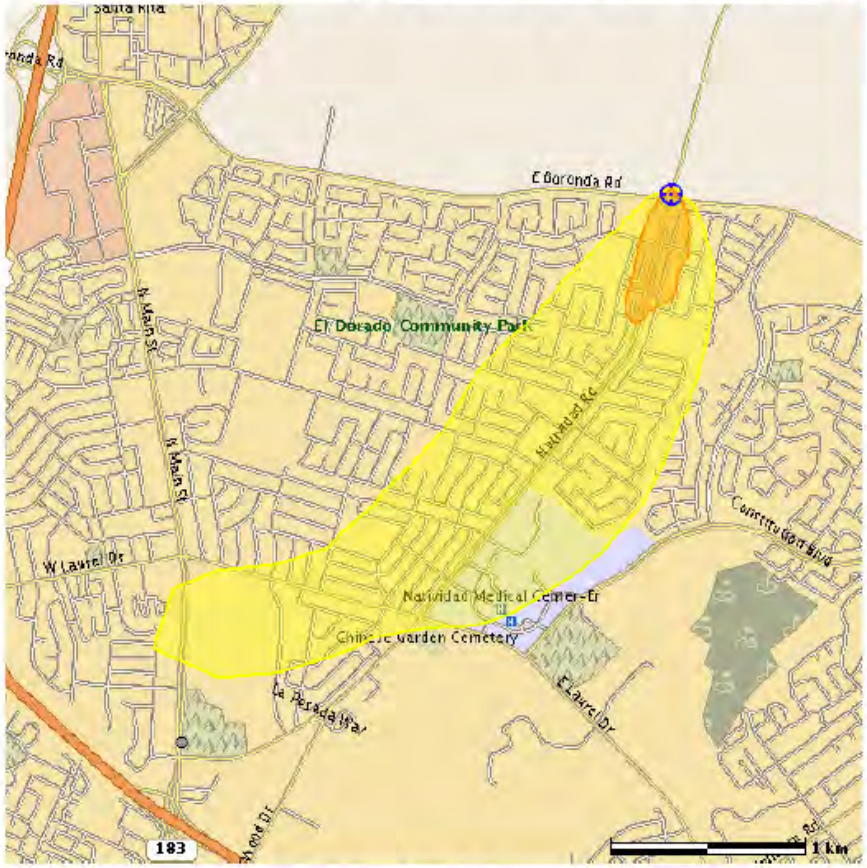
Example for Demonstration Only

Automated Report: Testing
(36.7158,-121.623)
RDD Release at 30 Jun 2011 13:00 UTC

Predicted Evacuation and Sheltering Areas - Most Limiting Criteria

The Whole Body Dose is the most limiting of the EPA Guide criteria

Avoidable Dose - Applicable 12 hr after start of release



Shelter of entire population warranted, often followed by a delayed, deliberate evacuation. Those already outdoors should be removed from the area (exceeds 5 rem). Estimated Population: 360 Area: 0.1 km2 Extent: 0.7 km

Evacuation or sheltering normally initiated (1 to 5 rem). Estimated Population: 10,300 Area: 2.7 km2 Extent: 3.6 km

Notes:

- EPA's Early Phase Guides provide separate criteria to limit dose to both the whole body and the thyroid. Separate predictions of the affected area were compared based on each criteria.
- The Whole Body Dose criterion is the most limiting in this case.
- Protective actions are normally based on the most limiting case.
- Prompt evacuation and/or sheltering reduces radiation dose and cancer risk. Sheltering-in-place may be more protective than evacuation while the radioactive cloud is present.
- Protective actions are only based on dose that can be avoided.
- Prediction excludes dose received before 01 Jul 2011 01:00 UTC.

Assumptions:

- Areas shown are model predictions based on an estimated release of airborne radioactivity, but no measurements yet available.
- Avoidable dose predicted from 12 hr to 108 hr after release start.
- Dose predicted for maximally exposed adult externally exposed to radiation from contamination on the ground and inhalation of resuspended contaminated dust. Also includes dose due to external exposure from and inhalation of the radioactive cloud, if present.

Briefing Product for Public Officials
Produced: 17 May 2013 21:56 UTC
Check for updates

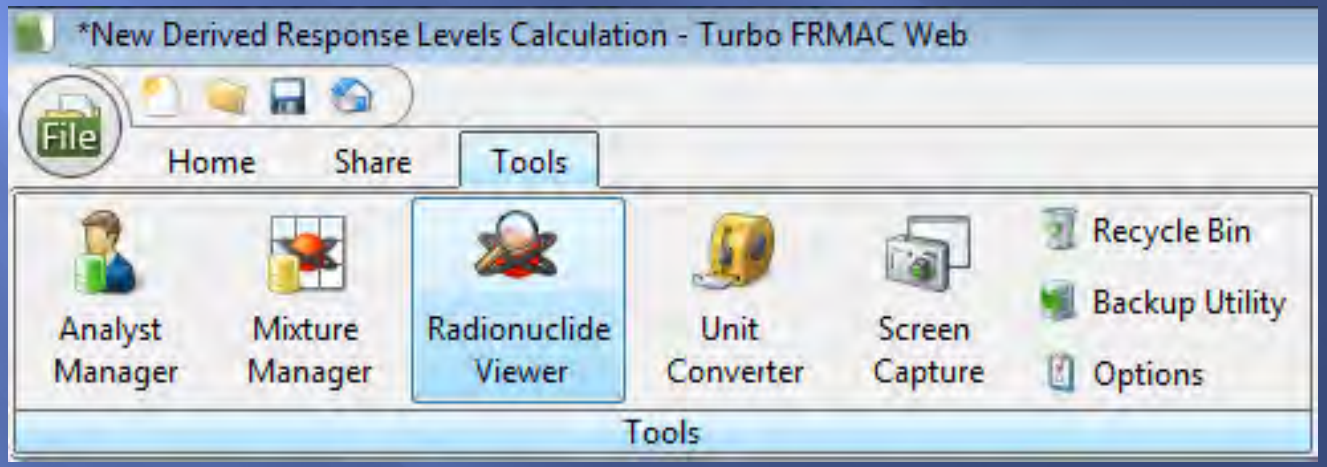
Technical Details: CMHT
Advice & Recommendations: A-Team

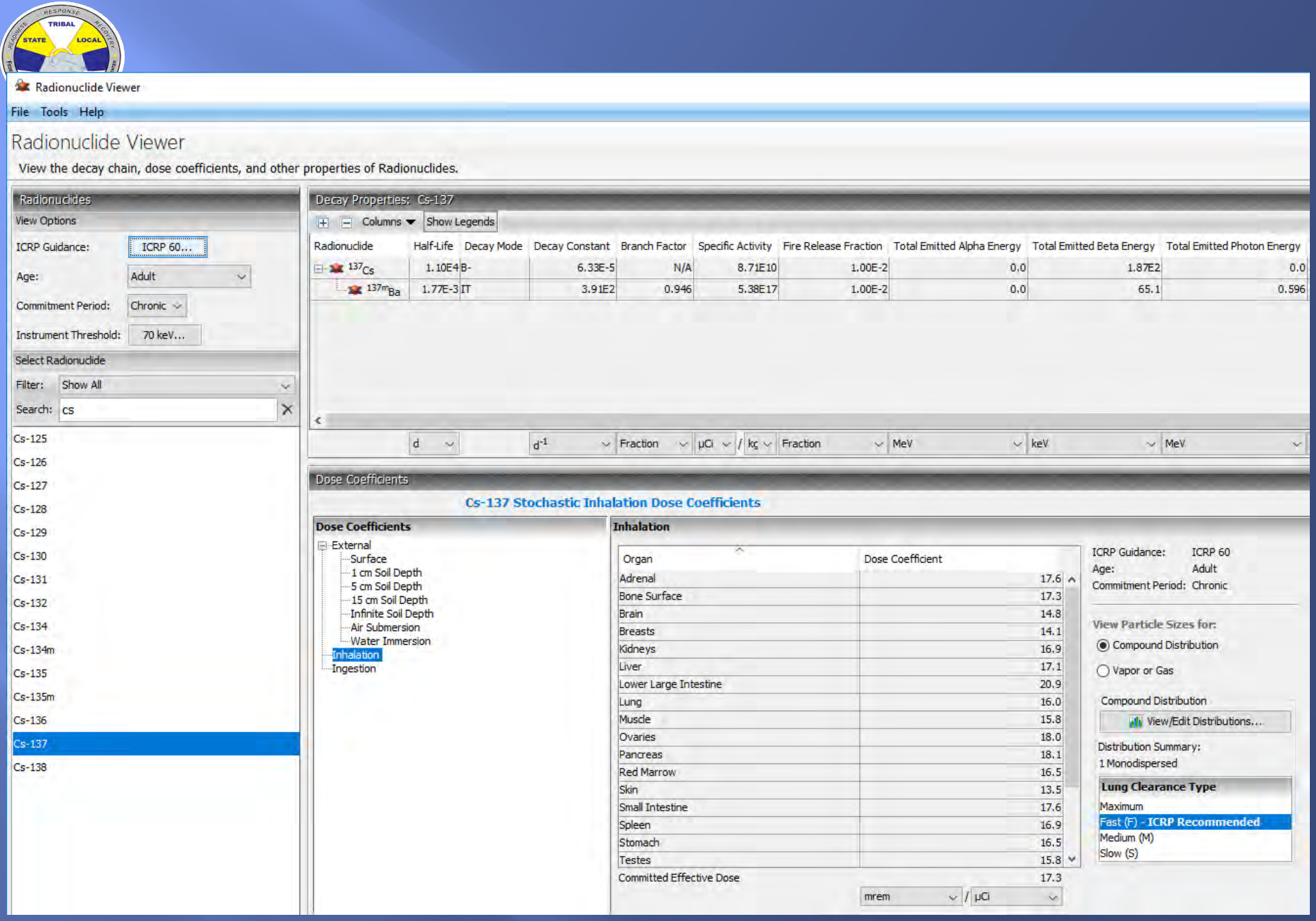
Production.rcE21475.rcC1

Example for Demonstration Only

Radionuclide Viewer

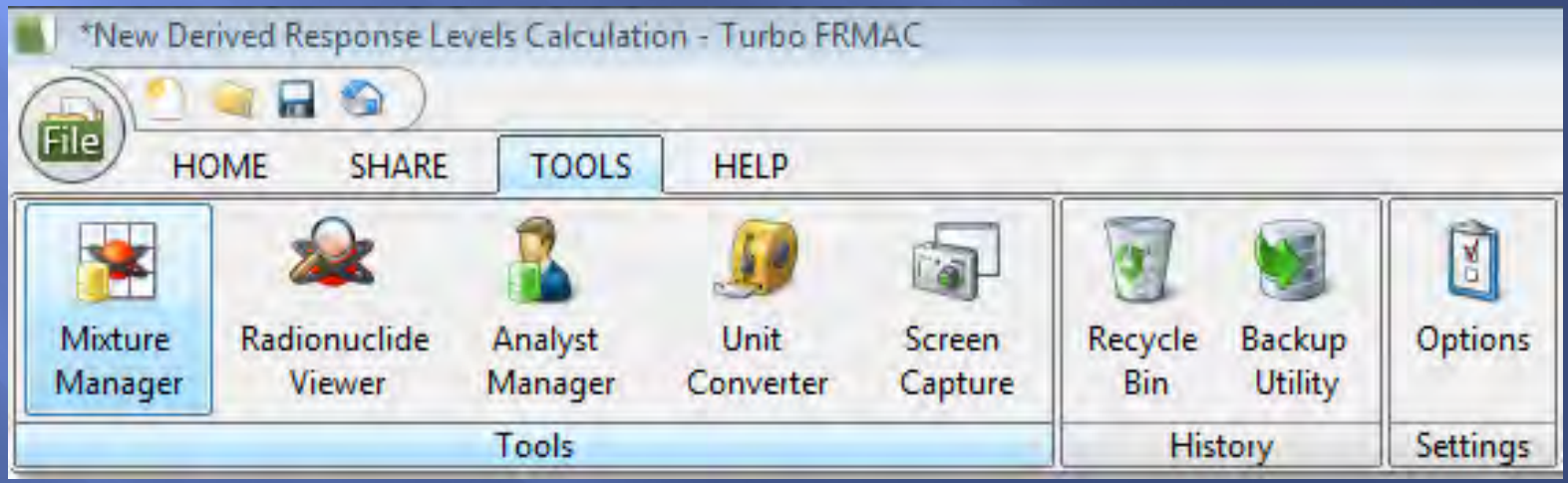
- Displays Full Radionuclide Decay Chain
- Displays basic nuclide data
  - Half Life
  - Decay mode
- Provides access to Dose Coefficients for each nuclide



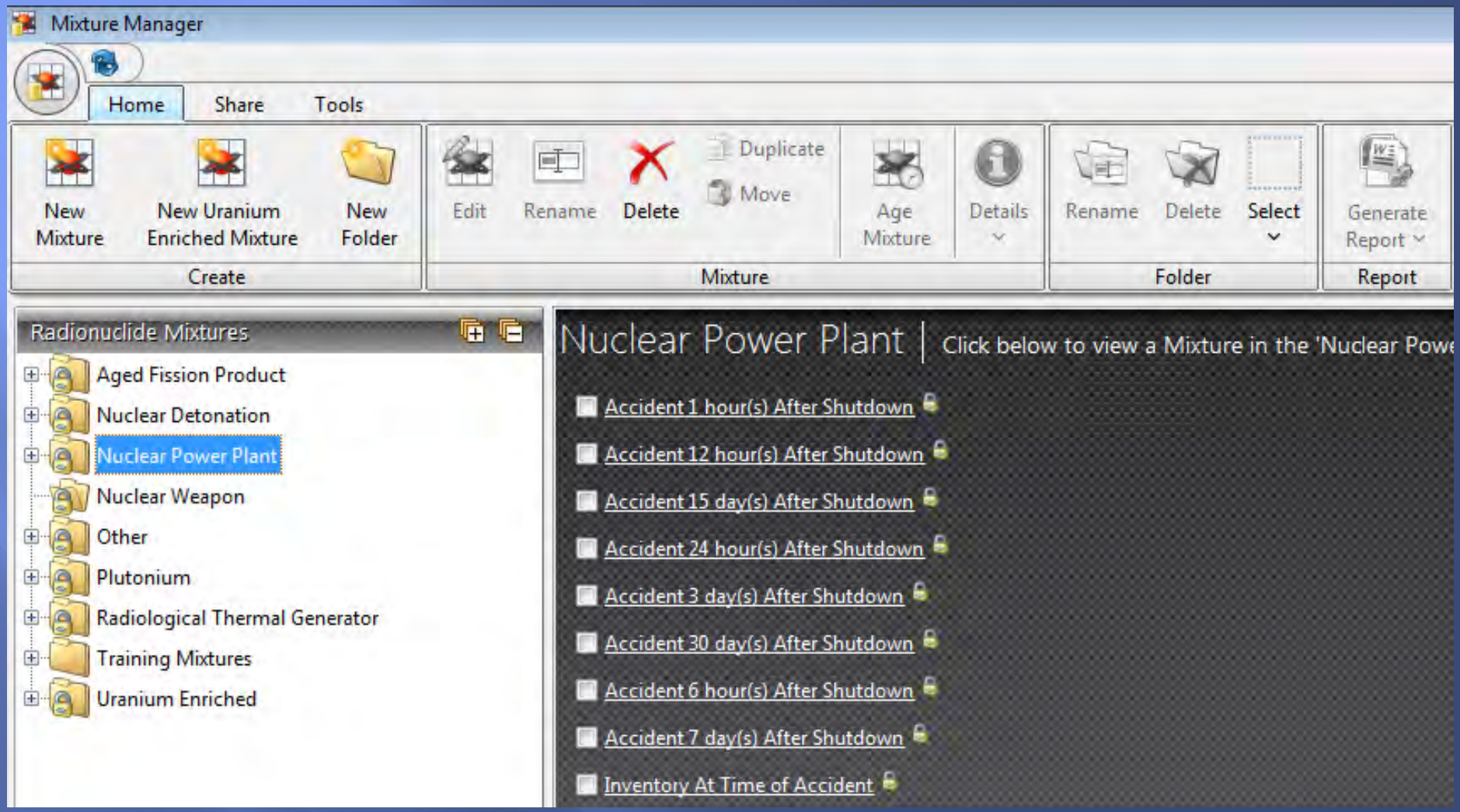

Radionuclide Viewer
File Tools Help
Radionuclide Viewer
View the decay chain, dose coefficients, and other properties of Radionuclides.
Radionuclides
View Options
ICRP Guidance: ICRP 60...
Age: Adult
Commitment Period: Chronic
Instrument Threshold: 70 keV...
Select Radionuclide
Filter: Show All
Search: 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
Decay Properties: Cs-137
Columns
Show Legends
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
137Cs | 1.10E4 | B- | 6.33E-5 | N/A | 8.71E10 | 1.00E-2 | 0.0 | 1.87E2 | 0.0
137mBa | 1.77E-3 | IT | 3.91E2 | 0.946 | 5.38E17 | 1.00E-2 | 0.0 | 65.1 | 0.596
d | d-1 | Fraction | µCi / kg | Fraction | MeV | keV | MeV
Dose Coefficients
Cs-137 Stochastic Inhalation Dose Coefficients
Dose Coefficients
External
Surface
1 cm Soil Depth
5 cm Soil Depth
15 cm Soil Depth
Infinite Soil Depth
Air Submersion
Water Immersion
Inhalation
Ingestion
Inhalation
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
mrem / µCi
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)

Radionuclide Mixture Manager

- Allows User to Create/Save/Export/Import Custom Mixtures
- User may select Pre-determined Mixtures



Radionuclide Mixture Manager



Turbo FRMAC

- Turbo FRMAC has been designed for Windows 7 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)

Questions?

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