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# 2015 Fall RAMP Meeting

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# Welcome to the 2015 Fall RAMP Meeting

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# 2015 Fall RAMP Meeting


**Stephanie Bush-Goddard, Ph. D.**

**RAMP Program Manager**
**Radiation Protection Branch**
**Division of Systems Analysis**
**Office of Nuclear Regulatory Research**


**October 7th, 2015**

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# Logistics

- **Photos** – not allowed in NRC-controlled spaces
- **Visitor Badge** – limited to 1st floor areas only (otherwise escort needed)
- **Exits** - emergency exit (out and toward metro station)
- **Restrooms –** out and to your left, pass break area, overflow use restrooms by the cafeteria sign
- **Hospitality Suite–** out and to your left

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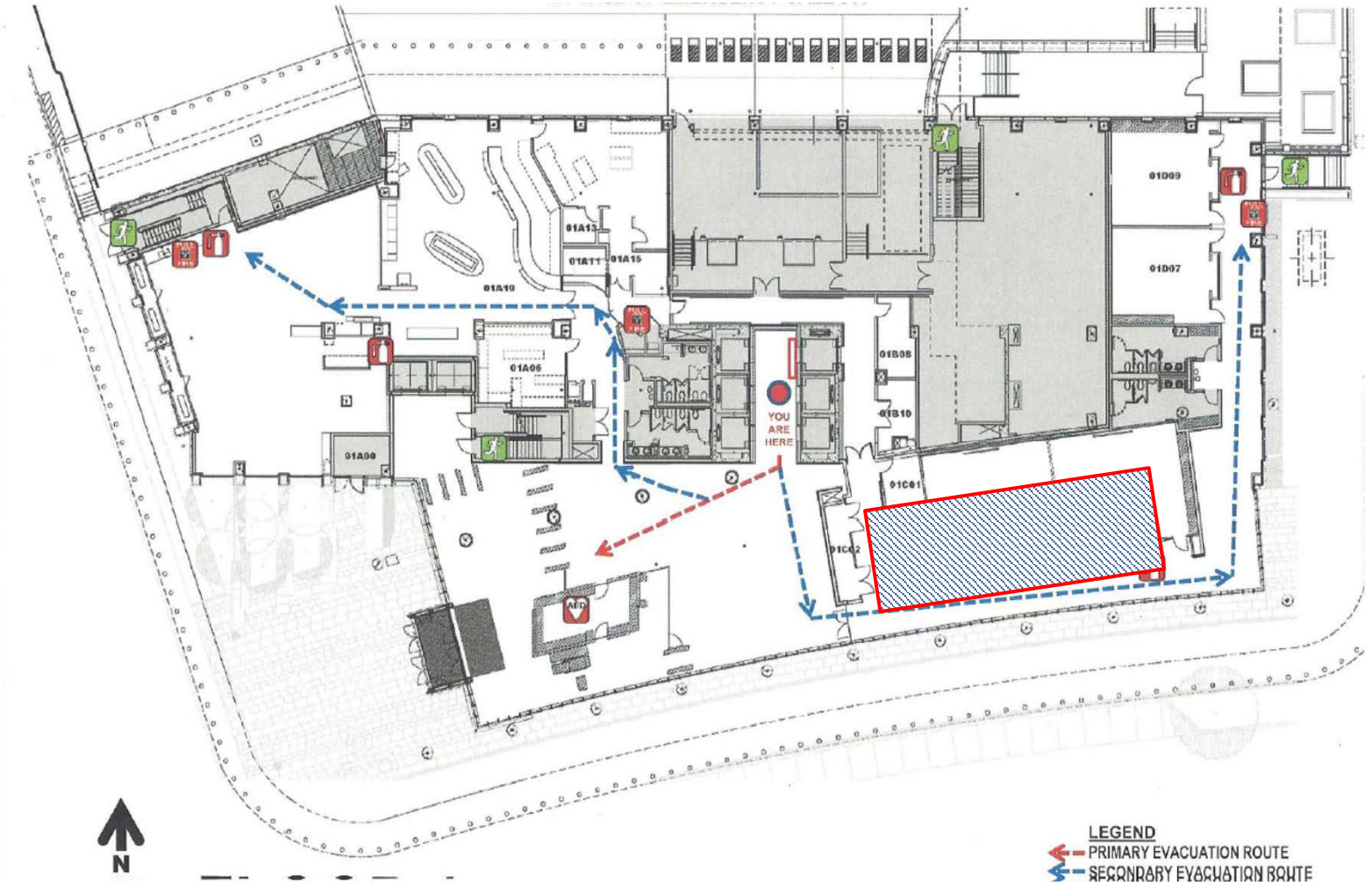

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# Our Next Speakers

- Welcome
  - Michael Weber, Deputy Executive Director of Operations
  - Brian Sheron, Ph. D.  Director, Office of Nuclear Regulatory Research
  - Stephanie Coffin, Deputy Division Director
- The RAMP Program Overview
  - Rebecca Tadesse, Chief Radiation Protection Branch
- Meet the RAMP Team
  - April Augustine, PMP,  RAMP  PNNL Program Manager
- Networking Session and Break
- Overview of RAMP Codes
  - John Tomon, CHP RAMP Program Manager
  - Code Program Managers and Developers
- Check in for Ops Tour and International Meeting

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# The Office of Nuclear Regulatory Research:

## Enhancing Radiation Protection Worldwide through Collaborative International Code Development

**Dr. Brian Sheron**
*Office of Nuclear Regulatory Research*

*Fall 2015 RAMP Meeting*
*Rockville, MD*
*October 5th-9th, 2015*

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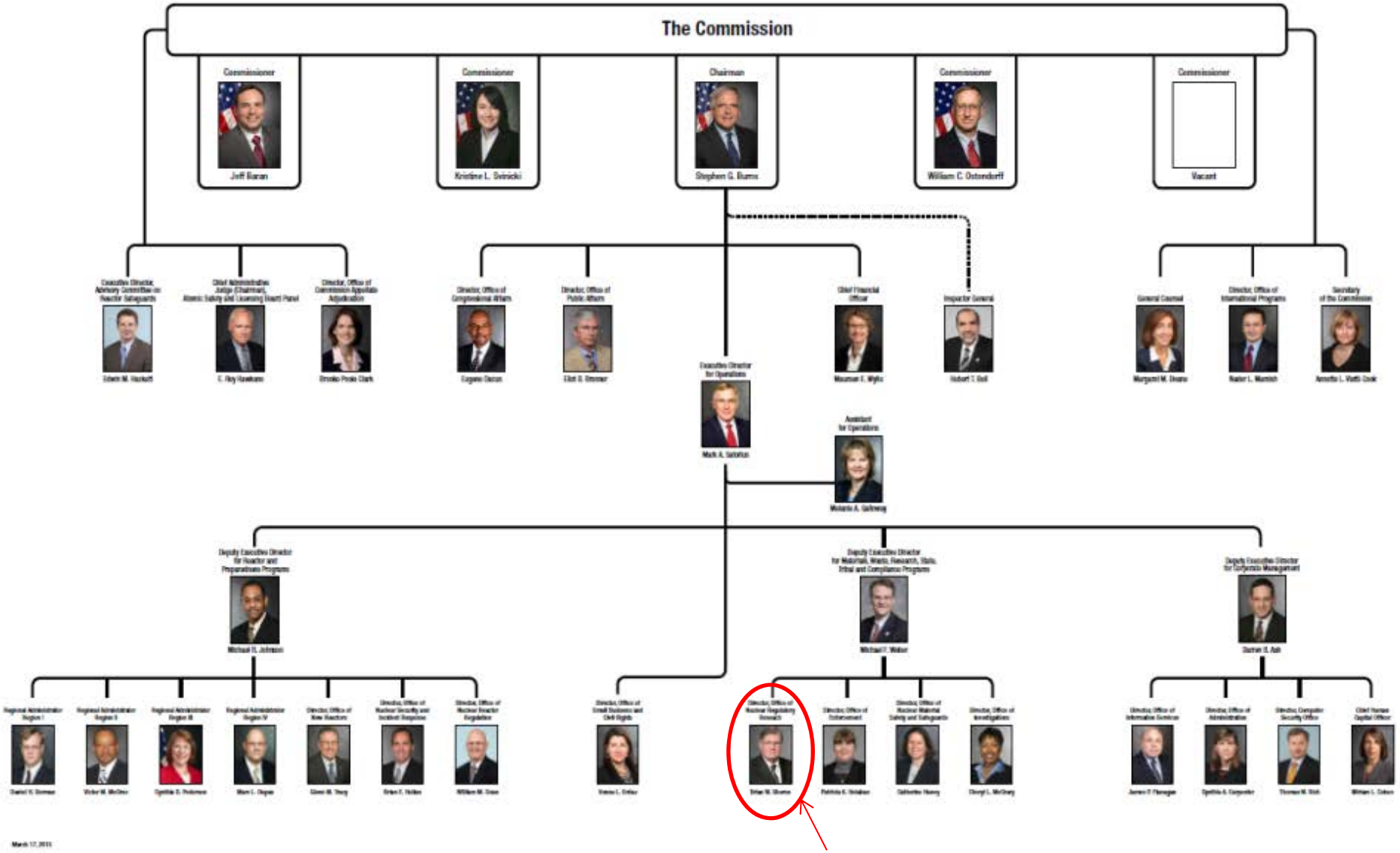
# *Welcome !*

- Welcome to the 1st RAMP Meeting
- Over 180 registered RAMP Users
- Over 70 participants at this RAMP Meeting
  - Representatives from 4 Countries
    - South Africa, Canada , South Korea and Japan
  - Government Agencies – NRC, EPA, NIST, DHS and DOE
  - National Laboratories
  - Agreement States
  - Universities and Industry

# U.S. Nuclear Regulatory Commission




Nuclear Regulatory Research
(RES)

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# RES: Who We Are

- Mandated by Congress
- Three technical divisions and a support organization:
  - Division of Engineering
  - Division of Risk Analysis
  - Division of Systems Analysis
  - Program Management, Policy Development & Analysis Staff
- About 220 engineers, scientists, analysts, and support staff.
  - ~ 30% M.S. and 30% Ph.D.
- About $58M funding

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# Technical Support Organization

- Develop technical bases to support regulatory decisions involving nuclear reactors, materials, and radioactive waste
- Conduct confirmatory research to verify licensee submittals
- Provide specialized technical expertise and tools to the regulatory and regional offices
- Conduct research programs with national labs, commercial contractors, universities, other government agencies, industry organizations, and international organizations
- Issue Commission and congressionally mandated reports
- Manage the Generic Issues Program
- Anticipate future research needs
- Support government-wide initiatives
- Agency lead for certain programs, e.g., CRGR and LLOB.

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# Key Research Areas

- Thermal-Hydraulics Research
- Fuel and Core Research
- Severe Accident and Accident Consequences Research
- **Radiation and Environmental Protection Research**
- Risk Analysis Research
- Human Reliability and Human Factors Research
- Fire Safety Research
- External Events Research
- Materials Performance Research
- Structural Performance Research
- Digital Instrumentation & Control and Electrical Research
- Robust International Program


http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1925/

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# NRC vs. Industry Research

- Licensees and applicants have the primary responsibility to develop data to support their safety analysis and applications
- NRC does not conduct development research designed to improve plant performance
- NRC does research to determine if a safety issue exists
- NRC conducts confirmatory research to independently verify licensee or applicant's data, determine safety margins, and explore uncertainties

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# International Research Collaboration

- International community rates NRC research very highly
- 100+ bilateral or multilateral agreements with over 20 countries
  - Cooperative Research Programs
- Shared financial responsibility
- Wide range of technical activities, including
  - Fukushima Activities
  - Halden Reactor Project
  - Zirconium Fire during Loss-of-coolant Accident Study
  - Fire Research

Halden Lab

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# Cooperative Research Programs

- **CSARP**: NRC and international partners have formed the Cooperative Severe Accident Research Program to exchange information on severe accident safety issues related to reactor, spent fuel pool, and plant systems. The group meets once a year.
- **CAMP**: NRC and international partners have formed the Code Applications and Maintenance Program to exchange information on thermal-hydraulic safety issues related to reactor and plant systems. The group meets twice a year.
- **SGTIP**: The cooperative Steam Generator Tube Integrity Program provides data and analysis for predicting the ability of degraded steam generator tubes to withstand normal operating and accident conditions.
- **RAMP**: NRC and international partners have formed the Radiation Protection Code Analysis and Maintenance Program to exchange information on radiation protection and dose assessment codes.

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# Importance of RAMP

- Venue to collaborate on NRC radiation protection, dose assessment and emergency response computer codes to promote worldwide radiation safety
- Promotes sharing of knowledge about radiation safety through training, code discussions and "in-kind" contributions
- Enhances feedback on code/model strengths and deficiencies from a wide and experienced user community

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# Again Welcome!

We are glad you are here!

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# THE **R**ADIATION PROTECTION CODE **A**NALYSIS AND **M**AINTENANCE **P**ROGRAM (RAMP)


Rebecca Tadesse, Chief
Radiation Protection Branch
Office of Nuclear Regulatory Research
The United States Nuclear Regulatory Commission

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# AGENDA

- What is RAMP?
- Benefits to Members
- Who should join RAMP?
- RAMP Partners
- Program at a Glance

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# What Is RAMP?

RAMP is a Computer Code Management Program that will support development and maintenance of radiation/dose assessment codes by:

- Sharing Expertise and experience
- Leveraging Resources among members
- Benchmarking Codes to Validate and Verify
- Incorporating lessons learned from events

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# BENEFITS TO ALL MEMBERS

## The Benefit to RAMP member include:

- Access to the most up-to-date version of the code
- Code maintenance, development, benchmarking, and uncertainty studies
- A Cooperative forum to resolve code errors and inefficiencies
- Technical basis documents and user guide
- Periodic meeting to share experience, discuss code development, and to be trained on the Codes
- Addressing other country specific needs

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# WHO SHOULD JOIN RAMP

## Who should Join RAMP?

- Regulators
- Licensees
- Licensee Vendor groups and etc.

**Collaboration is Key**

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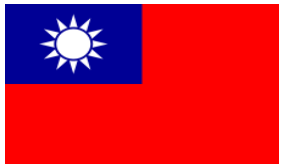
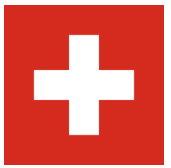
# Welcome to Our RAMP Partners

- Canada
- South Africa
- South Korea
- Japan (Mitsubishi)
- In discussion with:
  - American Institute of Taiwan
  - United Arab Emirates
  - China
- …and a host of other countries







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# Program at a Glance

| Monday, 10/5/2015<br>8am - 5pm | Tuesday, 10/6/2015<br>8am - 5pm | Wednesday, 10/7/15<br>8am - 5pm | Thursday, 10/8/15<br>8am - 5pm | Friday, 10/9/15<br>8am - 12pm |
|---|---|---|---|---|
| RASCAL Training | RASCAL Training | RAMP Formal Opening & Welcome | RASCAL Discussions | RASCAL Discussions |
| VARSKIN Training | VARSKIN Training | GENII / Atmospheric Code Discussions | GALE Training | GALE Training (AM) |
| HABIT Discussions | SNAP/RADTRAD Discussions | SNAP/RADTRAD Training (PM) | SNAP/RADTRAD Training | SNAP/RADTRAD Training (AM) |
| RAD Toolbox Discussions | | PIMAL Training (PM) | PIMAL Training | PIMAL Training (AM) |
| DandD Discussions | | NRC Operations Tour | NRC Operations Tour | |

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# Meet the RAMP Team


April Augustine, PMP
RAMP Project Manager
Pacific Northwest National Laboratory

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# RAMP Core Team

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Pacific Northwest
NATIONAL LABORATORY
*Proudly Operated by Battelle Since 1965*

LOCKHEED MARTIN

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# RAMP Team – U.S. NRC

Rebecca Tadesse, Chief
Protection Branch of System Analysis
Office of Nuclear Regulatory Research

**Stephanie Bush-Goddard, Ph.D.**
**RAMP Program Manager**

**John Tomon, CHP**
**RAMP Program Manager**

**Kimberly Gaskins**
**RAMP Administrator**

The United States Nuclear Regulatory Commission
North Bethesda, MD

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# RAMP Team - PNNL

**April Augustine, PMP**
**PNNL RAMP Project Manager**

**Abby Foster**
**PNNL RAMP Project Coordinator**

**Kenneth Geelhood**
**RAMP Co-Principle Investigator**

**Walter Luscher, Ph.D.**
**RAMP Co-Principle Investigator**

## Pacific Northwest National Laboratory
## Richland, WA

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# RAMP Team - LM

Poonam Sachdeva, PMP
Lockheed Martin RAMP Project Manager

Wendy Chinchilla
RAMP Operations/System Analyst

Raymond Aurdos
RAMP Website Developer

Lockheed Martin
Rockville, MD

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# RAMP Code Training

1st RAMP Users' Group Training:

- RASCAL
- SNAP/RADTRAD
- VARSKIN
- PiMAL
- GALE
- HABIT
- DandD
- Radiological Toolbox

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# RAMP Code Teams

## RASCAL

- John Tomon, CHP U.S. NRC;  COR
- Jeff Kowalczik, U.S. NRC; Technical Monitor
- Tony Huffert, CHP U.S. NRC; Technical Monitor
- George Athey, Athey Consulting, Inc.
- Jeremy Rishel, Pacific Northwest National Laboratory
- John Fulton, Sandia National Laboratory

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# RAMP Code Teams

## SNAP/RADTRAD

- John Tomon, U.S. NRC;  COR
- Mark Blumberg, U.S. NRC; Technical Monitor
- Bill Arcieri, Information Systems Laboratory, Inc.
- Diane Mlynarczyk, Information Systems Laboratory, Inc.

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# RAMP Code Teams

## VARSKIN

- Mohammad Saba, U.S. NRC;  COR
- David Hamby, Ph.D., Oregon State University

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# RAMP Code Teams

## PIMAL

- Mohammad Saba, U.S. NRC;  COR
- Dr. Sami Sherbini, U.S. NRC; Sr. Technical Advisor
- Dr. Shaheen Dewji, Oak Ridge National Laboratory
- Dr. Michael Bellamy, Oak Ridge National Laboratory
- Dr. Nolan Hertel, Oak Ridge National Laboratory
- Dr. Mauritius Hiller, Oak Ridge National Laboratory

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# RAMP Code Teams

## GALE

- Stephanie Bush-Goddard, Ph. D. U.S. NRC;  COR
- Luis Benevides, Ph. D. U.S. NRC; Technical Monitor
- Ken Geelhood, Pacific Northwest National Laboratory
- Walter Luscher, Ph.D., Pacific Northwest National Laboratory
- April Augustine, PMP, Pacific Northwest National Laboratory
- Abby Foster, Pacific Northwest National Laboratory

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# HABIT, RadToolbox, DandD

HABIT

- Casper Sun, Ph.D. U.S. NRC COR

Radiological Toolbox

- Casper Sun, Ph.D., U.S. NRC

DandD

- Stephanie Bush-Goddard, Ph. D. PM
- Adam Schwartzman, U.S. NRC
- Cynthia Barr, U.S. NRC

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# Networking Session

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# RASCAL



John Tomon, CHP
Radiation Protection Branch
Office of Nuclear Regulatory Research
The United States Nuclear Regulatory Commission

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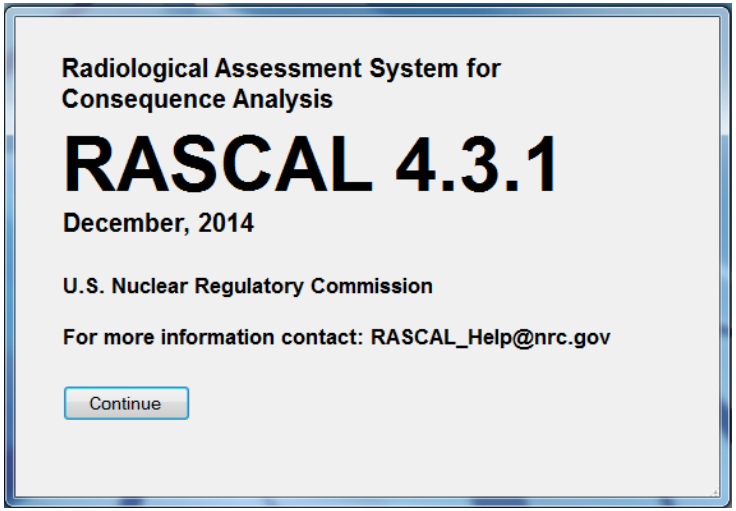
# What is RASCAL?

# RASCAL

**R**adiological **A**ssessment **S**ystem for **C**onsequence **A**na**L**ysis computer code.



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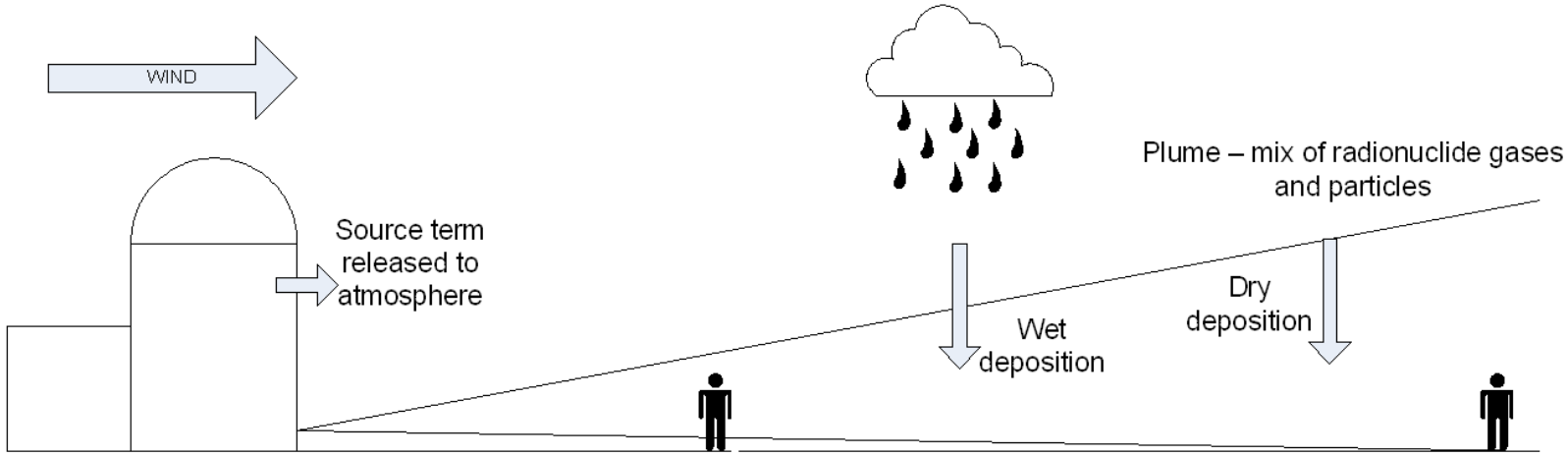
# What does it do?

- RASCAL is a emergency response code that calculates dose and consequence projections during radiological incidents and emergencies.
- Calculates a radiological source term, transports and deposits it, and then produces dose projections.



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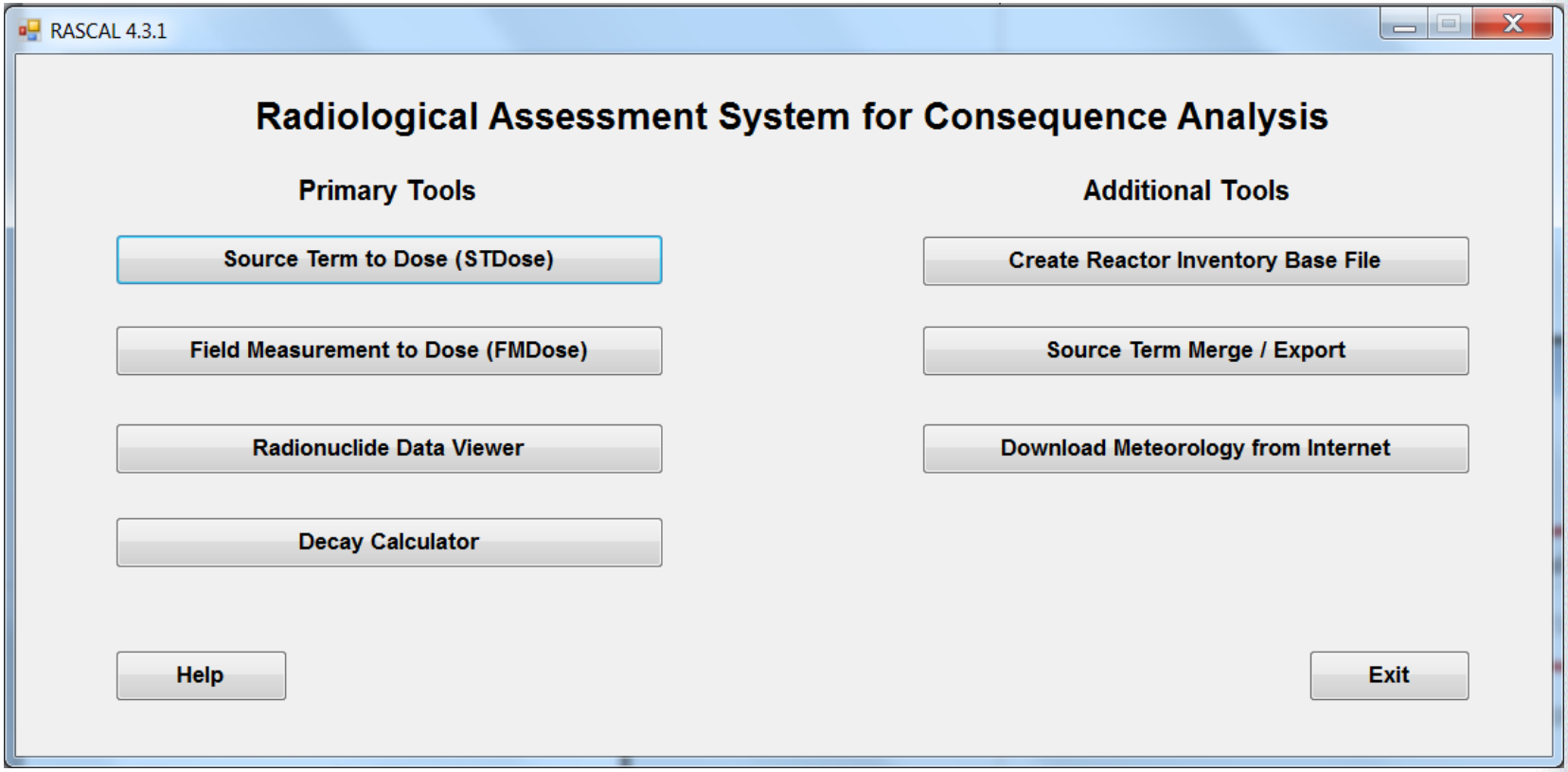
# RASCAL Tools



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# How is it used?

- RASCAL is one of the tools used by the Protective Measures Team (PMT) in the NRC's Headquarters Operations Center (HOC) and the NRC Regional Incident Response Centers (IRCs) making **independent** dose and consequence projections during radiological incidents and emergencies.
- RASCAL provides a tool for the rapid assessment of an incident or accident at an NRC-licensed facility and aid decision-making such as whether the public should evacuate or shelter in place.

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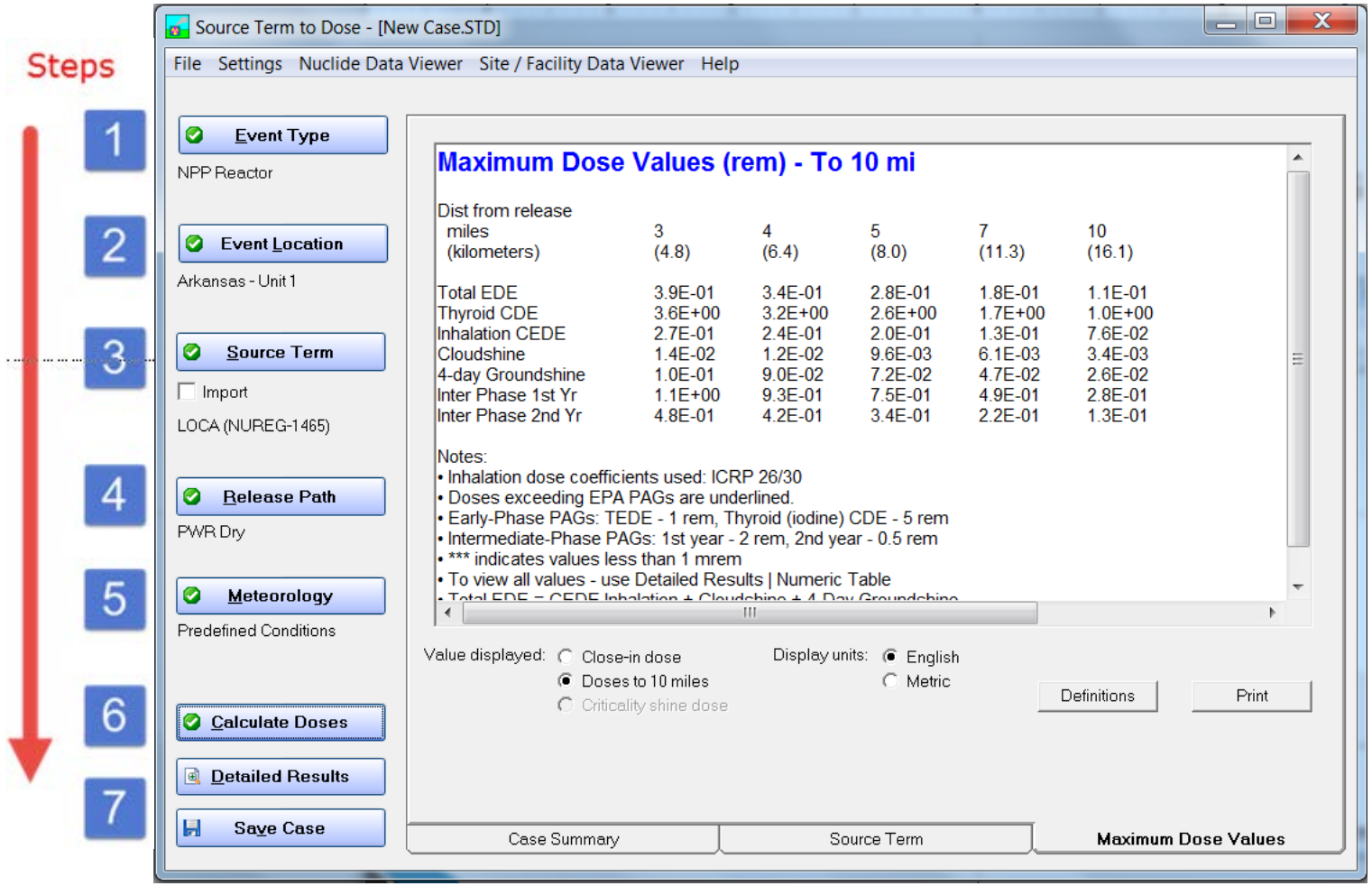
# RASCAL Sequence



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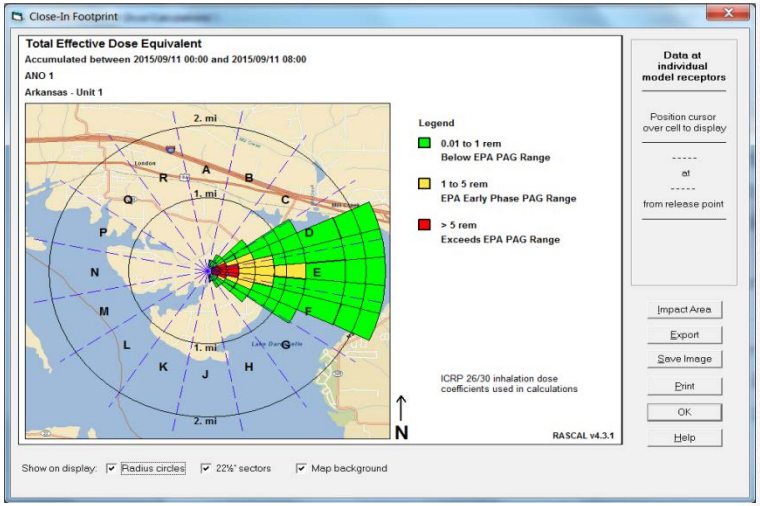
# RASCAL Outputs

- Plume Footprints
- Max Dose Values
- Case Summary



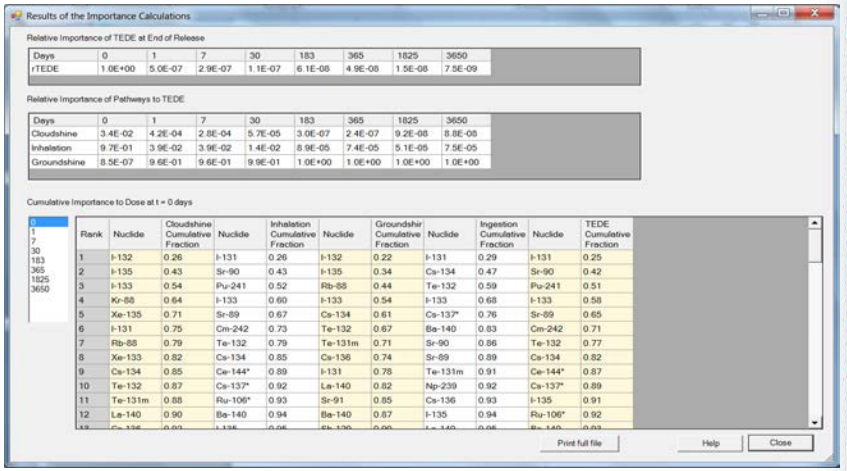

**Maximum Dose Values (rem) - Close-In**

| Dist from release miles (kilometers) | 0.1 (0.16) | 0.2 (0.32) | 0.3 (0.48) | 0.5 (0.8) | 0.7 (1.13) | 1. (1.61) | 1.5 (2.41) | 2. (3.22) |
|---|---|---|---|---|---|---|---|---|
| Total EDE | 5.1E+01 | 1.6E+01 | 8.7E+00 | 4.0E+00 | 2.4E+00 | 1.3E+00 | 7.7E-01 | 6.0E-01 |
| Thyroid CDE | 4.7E+02 | 1.5E+02 | 7.9E+01 | 3.6E+01 | 2.1E+01 | 1.2E+01 | 7.0E+00 | 5.4E+00 |
| Inhalation CEDE | 3.6E+01 | 1.1E+01 | 6.1E+00 | 2.8E+00 | 1.6E+00 | 9.2E-01 | 5.4E-01 | 4.1E-01 |
| Cloudshine | 4.7E-01 | 2.3E-01 | 1.6E-01 | 8.6E-02 | 5.6E-02 | 3.3E-02 | 2.3E-02 | 1.9E-02 |
| 4-day Groundshine | 1.5E+01 | 4.6E+00 | 2.5E+00 | 1.1E+00 | 6.6E-01 | 3.7E-01 | 2.2E-01 | 1.7E-01 |
| Inter Phase 1st Yr | 1.5E+02 | 4.7E+01 | 2.5E+01 | 1.1E+01 | 6.8E+00 | 3.8E+00 | 2.2E+00 | 1.7E+00 |
| Inter Phase 2nd Yr | 6.8E+01 | 2.1E+01 | 1.1E+01 | 5.2E+00 | 3.1E+00 | 1.7E+00 | 1.0E+00 | 7.8E-01 |

**Maximum Dose Values (rem) - To 10 mi**

| Dist from release miles (kilometers) | 3 (4.8) | 4 (6.4) | 5 (8.0) | 7 (11.3) | 10 (16.1) |
|---|---|---|---|---|---|
| Total EDE | 3.9E-01 | 3.4E-01 | 2.8E-01 | 1.8E-01 | 1.1E-01 |
| Thyroid CDE | 3.6E+00 | 3.2E+00 | 2.6E+00 | 1.7E+00 | 1.0E+00 |
| Inhalation CEDE | 2.7E-01 | 2.4E-01 | 2.0E-01 | 1.3E-01 | 7.6E-02 |
| Cloudshine | 1.4E-02 | 1.2E-02 | 9.6E-03 | 6.1E-03 | 3.4E-03 |
| 4-day Groundshine | 1.0E-01 | 9.0E-02 | 7.2E-02 | 4.7E-02 | 2.6E-02 |
| Inter Phase 1st Yr | 1.1E+00 | 9.3E-01 | 7.5E-01 | 4.9E-01 | 2.8E-01 |
| Inter Phase 2nd Yr | 4.8E-01 | 4.2E-01 | 3.4E-01 | 2.2E-01 | 1.3E-01 |

Notes:
- Inhalation dose coefficients used: ICRP 26/30
- Doses exceeding EPA PAGs are underlined.
- Early-Phase PAGs: TEDE - 1 rem, Thyroid (iodine) CDE - 5 rem
- Intermediate-Phase PAGs: 1st year - 2 rem, 2nd year - 0.5 rem
- *** indicates values less than 1 mrem
- To view all values - use Detailed Results | Numeric Table
- Total EDE = CEDE Inhalation + Cloudshine + 4-Day Groundshine



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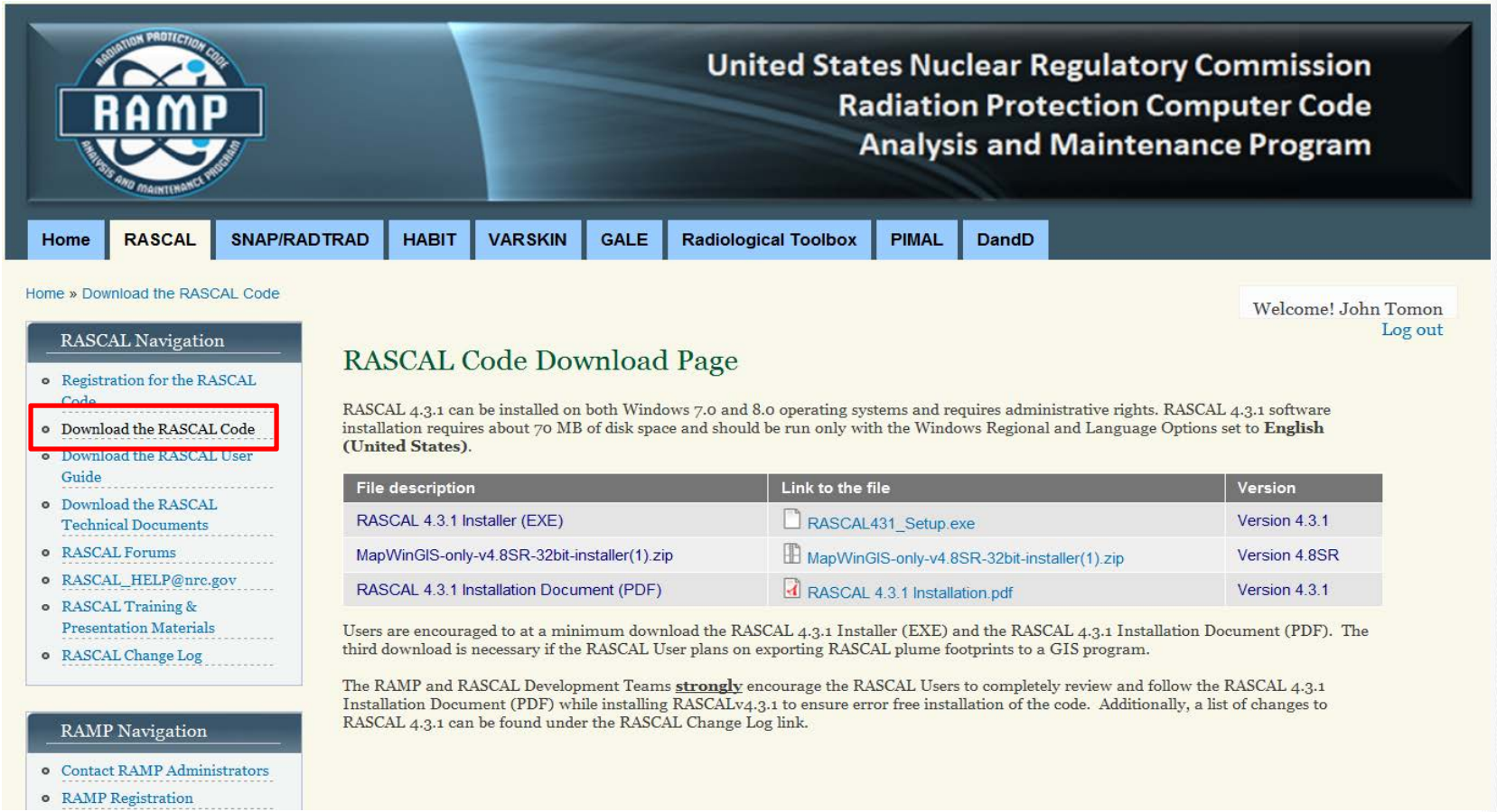
# Latest Version of the Code

- RASCAL (v 4.3.1)



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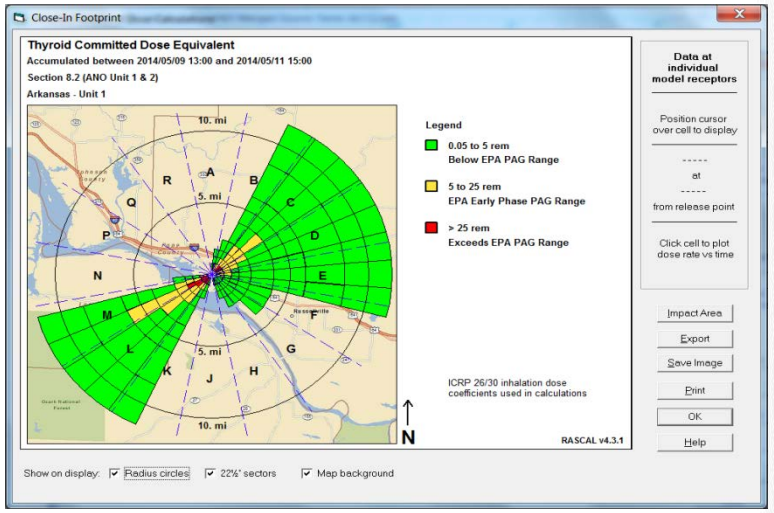
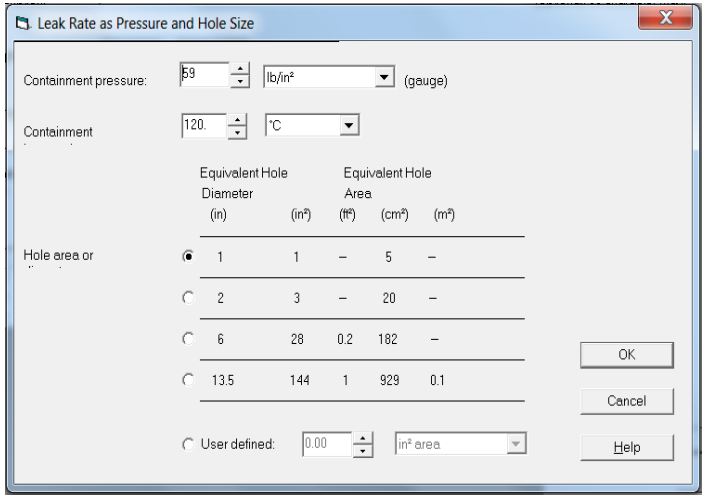
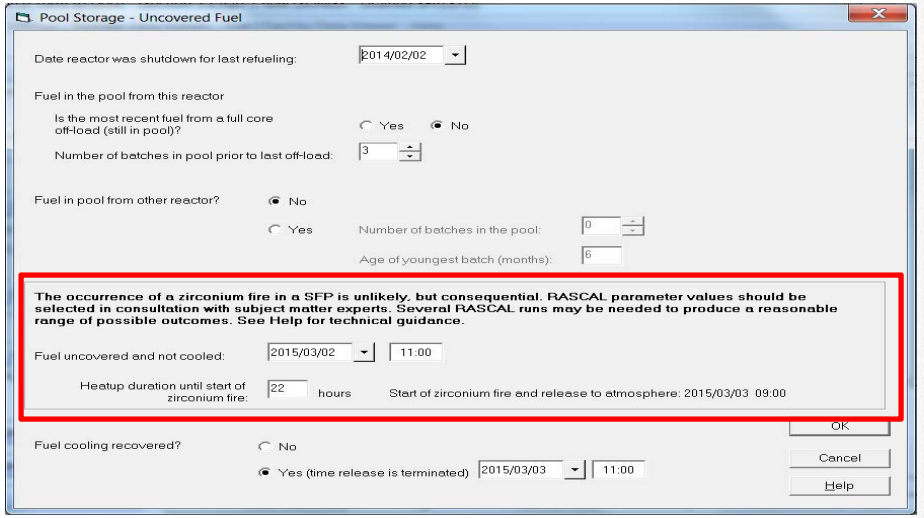
# New Features

- Reactor Source Term Changes
  - Long-term Station Blackout (LTSBO)
  - Updated LOCA (NUREG-1465)
  - Pressure/Hole size leak rate model
  - Spent Fuel Pool
  - Containment Radiation Monitor
- Multi-unit assessments



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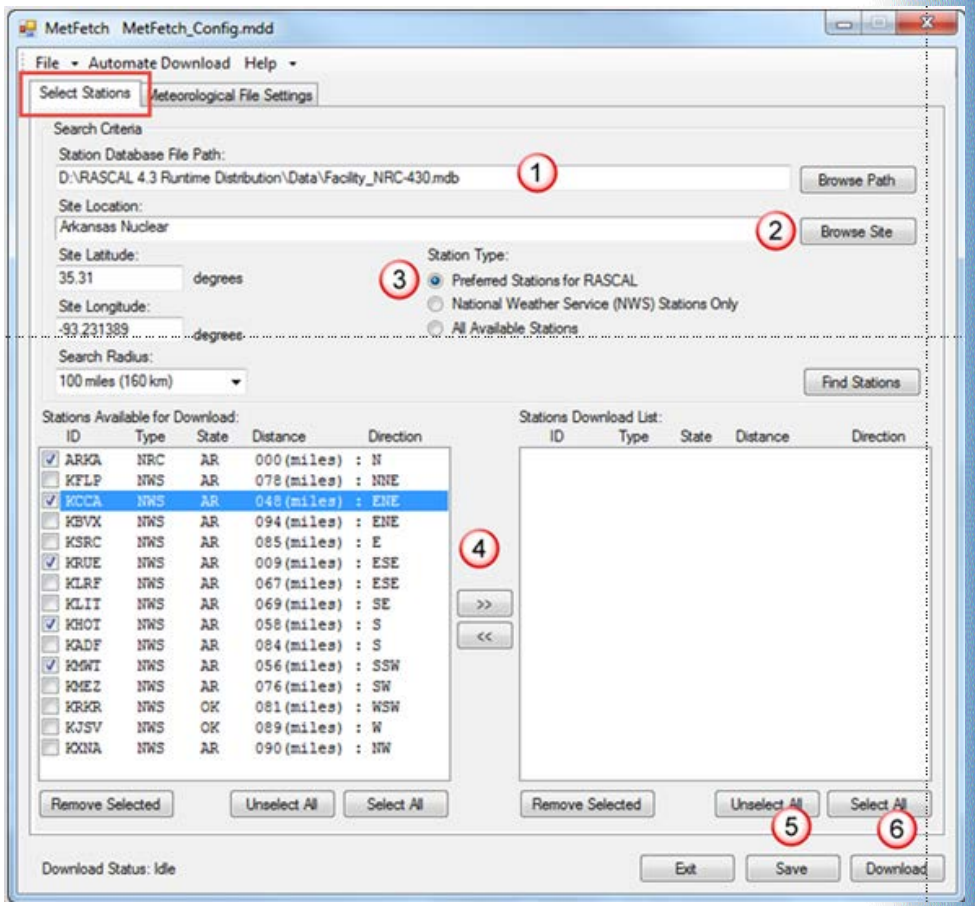
# New Features (cont)

- Automated meteorology data retrieval
- Child thyroid dose calculation
- Additional and improved file export format
- Custom inventories for reactors
- Extended calculation times and distances



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# Future Work

- Additional of the CANDU reactor source term options to the STDose module.
- Adding to the RASCAL Facility database file for RAMP member sites (Plant specific data, topography and surface roughness files).
- Add additional options for users to select DCFs based upon different dosimetry systems.
- Other options based upon the needs of the RASCAL user community (RAMP members).

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# SNAP/RADTRAD



John Tomon, CHP
Radiation Protection Branch
Office of Nuclear Regulatory Research
The United States Nuclear Regulatory Commission

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# What is RADTRAD?

# RADTRAD

**RAD**ionuclide **T**ransport, **R**emoval **A**nd **D**ose Estimation computer code.

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# What does it do?

RADTRAD uses a combination of tables and numerical models of source term reduction phenomena to determine the time-dependent occupational radiation exposures in the control room (CR) (or emergency offsite facility) and to estimate site boundary doses at the exclusion area boundary (EAB) and low population zone (LPZ) for design basis accidents (DBAs).

- User can specify models for filtration and deposition within a flow pathway.
- Removal mechanisms (e.g. decay, natural deposition and sprays) can be modeled within a compartment.
- Modeling of daughter product buildup possible.

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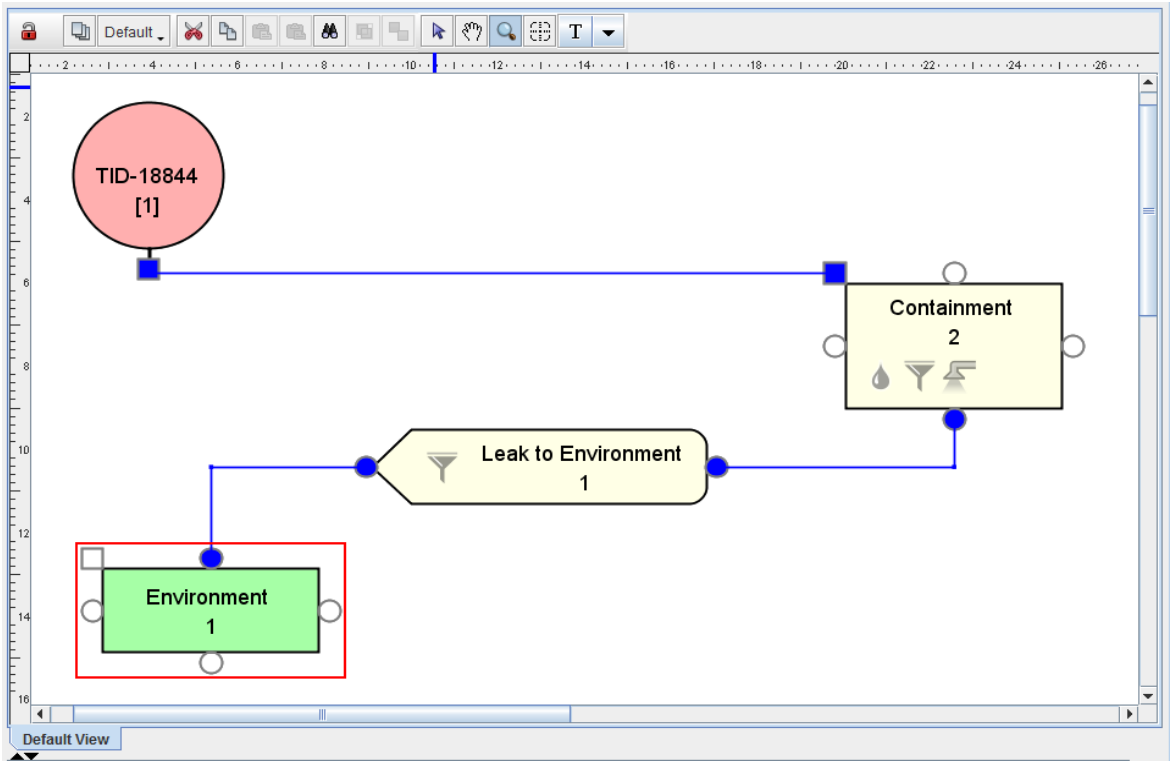
# RADTRAD Sequence

Source → Compartments → Pathways → Environment EAB & LPZ

Pathways → Control Room




**Symbolic Nuclear Analysis Package (SNAP)**

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# How is it used?

- The NRC uses RADTRAD as licensing analysis code to verify that the plant's design and the licensee's offsite and control room dose calculations following a DBA meet the following criteria:
  - 10 CFR Part 100, "Reactor Site Criteria"
  - 10 CFR 50.67, "Accident Source Term"
  - 10 CFR 50.34, "Contents of applications; technical information"
  - 10 CFR 50, Appendix A, GDC 19, "Control Room"

# Latest Version of the Code

- RADTRAD analytical code (RADTRAD-AC) (v 4.5)
- Symbolic Nuclear Analysis Package (SNAP) GUI (v 2.4.1)
- SNAP/RADTRAD Plugin (v 4.10.1)
- Applied Programming Technology Plotting Package (AptPlot) (v 6.6.0)

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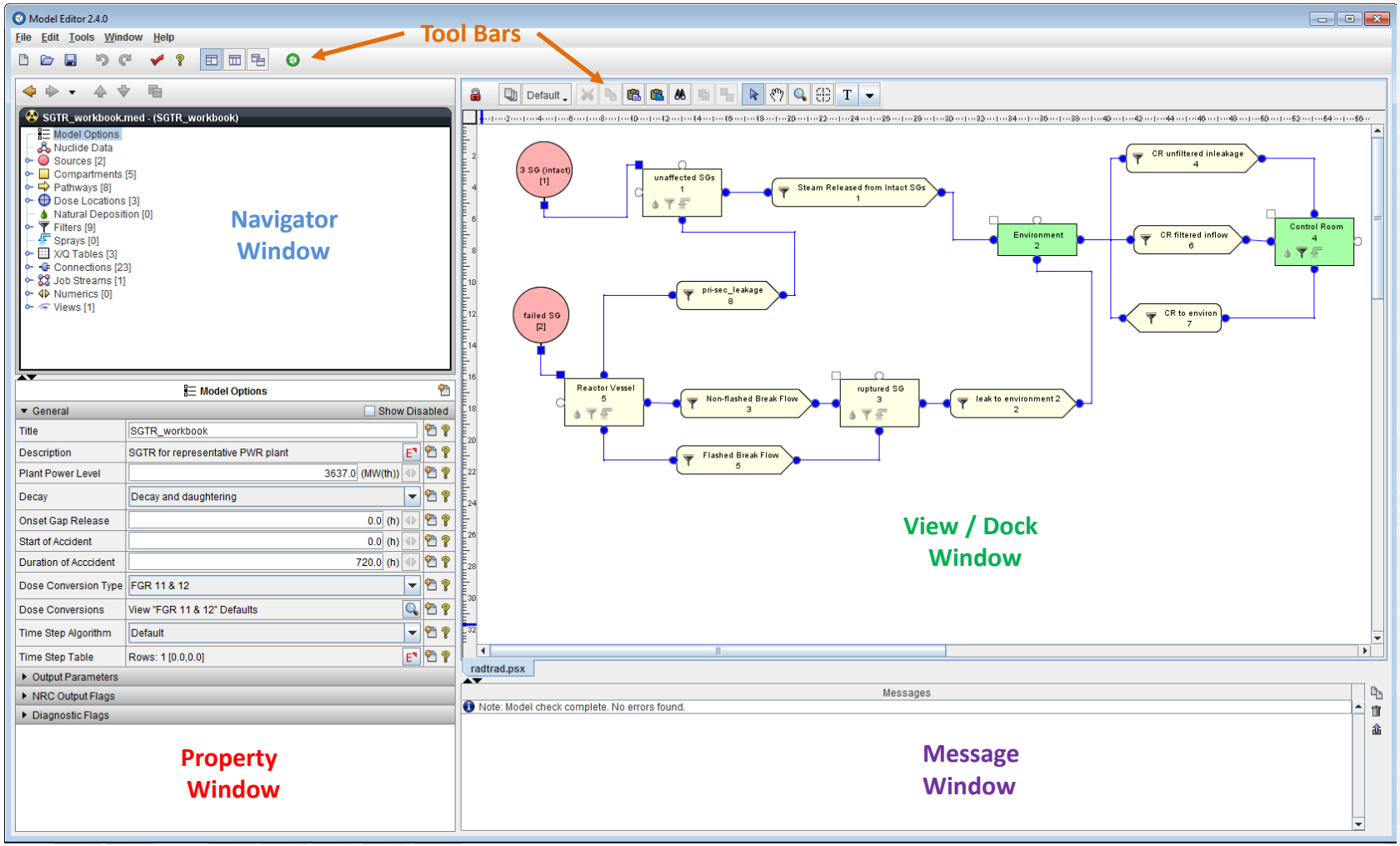
# SNAP/RADTRAD Model Editor



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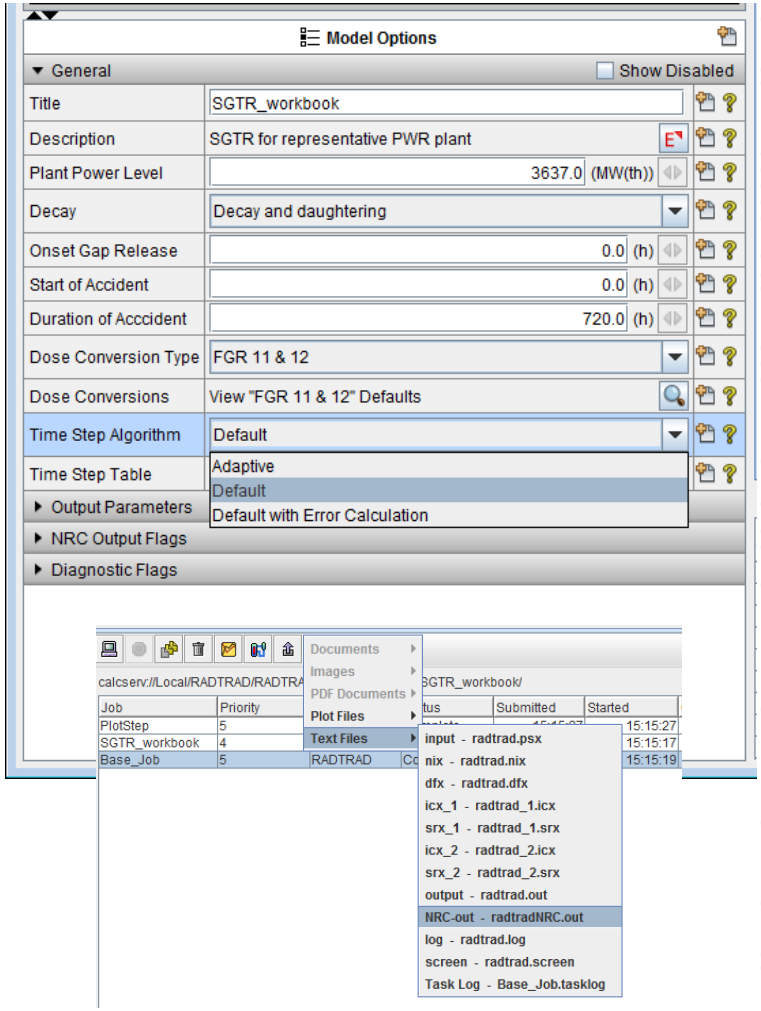
# New Features

- Time Step Algorithm Options
  - Adaptive
  - Default
  - Default with Error Calculation
- Updated DCFs (748 DCFs)
- Updated the radionuclide database (ICRP-38)
- Changes to the RATRAD output text files
  - output – radtrad.out
  - NRC-out - radtradNRC.out



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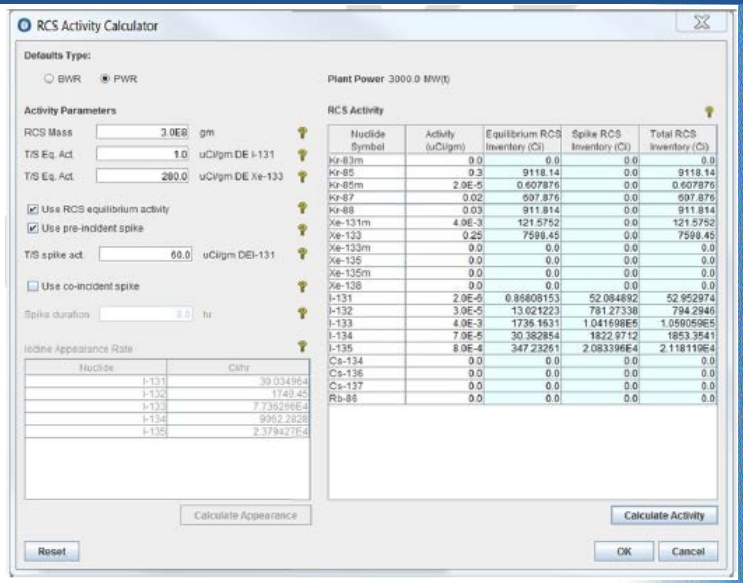
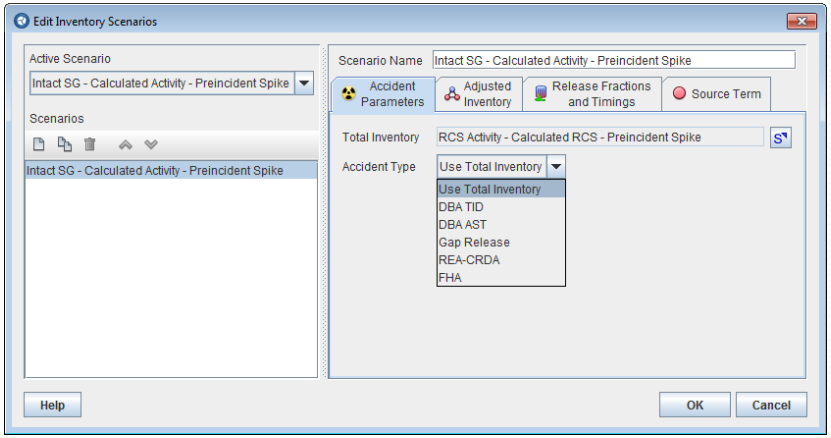
# New Features (cont)

- Reactor Coolant System (RCS) activity calculator
  - Pre-incident and co-incident iodine spiking
  - Dose Equivalent (DE) I-131 and Xe-133




- Ability to model alternative source term (AST) non-LOCA DBAs (RG 1.183):
  - Fuel Handling Accident (FHA)
  - Rod Ejection Accident (REA)
  - Control Rod Drop Accident (CRDA)
  - Gap Release (RG 1.25 or RG 1.183)



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# Future Work

- Final publication of the "SNAP/RADTRAD: Description of Models and Methods" (NUREG/CR) – December 2015.
- Final publication of the "Test Report for the RADTRAD Analytical Code and the SNAP Graphical User Interface" (NUREG/CR Supplement 1) – February 2016.
- Add additional options for users to select DCFs based upon different dosimetry systems.
- Other options based upon the needs of the SNAP/RADTRAD user community (RAMP members).

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# QUICK OVERVIEW OF VARSKIN



Mohammad Saba
Radiation Protection Branch
Office of Nuclear Regulatory Research
The United States Nuclear Regulatory Commission

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# VARSKIN 5

## A Software Package to Estimate Ionizing Radiation Dose to the Skin Resulting from Radioactive Material Exposure

Mohammad Saba, Office of Nuclear Regulatory Research

U.S.NRC
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# Background

- The NRC oversees licensee compliance with regulatory requirements specified in 10 CFR 20.1201(c)
- VARSKIN was originally developed in 1987 to allow the NRC independent confirmation of skin dose estimates submitted by licensees
  - the code is intended to be used as a tool for calculating tissue dose at depth resulting from radiological contamination of skin
- The current version that was developd by Oregon State University is VARSKIN 5.2.

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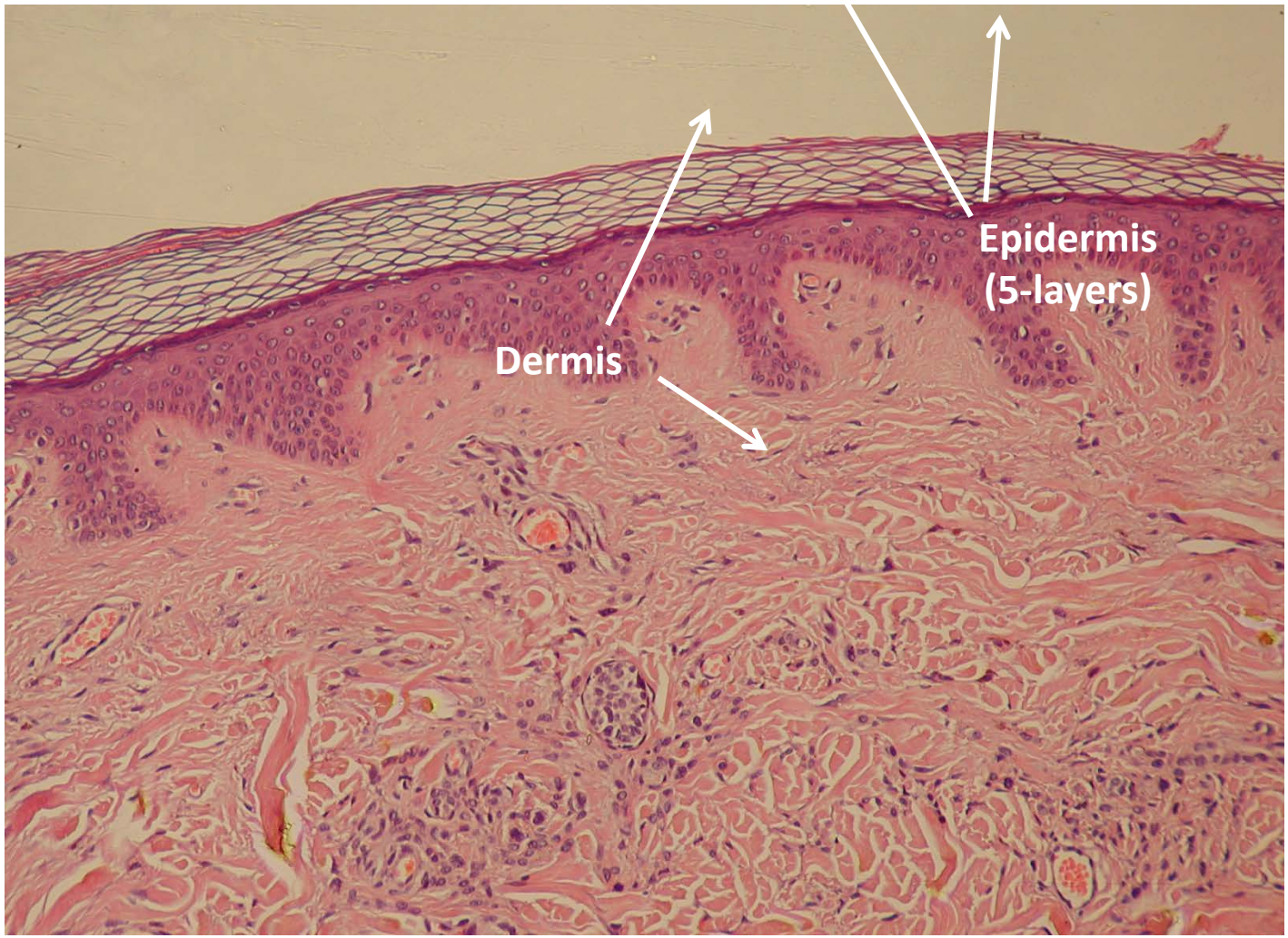
# Skin layers



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# VARSKIN Photon Model

- Photon dosimetry considers:
  - point-kernel methodology
    - with secondary charge buildup, attenuation, and off-axis scatter
    - convergence-maximized numerical integration
  - multiple source geometries
    - point, disk, cylinder, sphere, slab
  - skin dose is calculated for an infinitely thin disk at a user-specified depth
    - averaging areas between 0.01 and 100 $cm^2$
  - variable dose averaging techniques
    - 2D averaging areas (regulatory compliance)
    - 3D averaging volumes (detector simulation)

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# VARSKIN Electron Model

- Electron dosimetry constructs energy absorption distributions from the original beta emission spectrum
  - including conversion electrons and Auger electrons at their proper energy
  - but, not use the “dummy” tritium distribution
  - resulting in a more appropriate electron energy spectrum incident on the skin
- Kinetic energy loss is better estimated through new:
  - energy scaling
  - range/depth scaling
- A new backscatter correction model is applied

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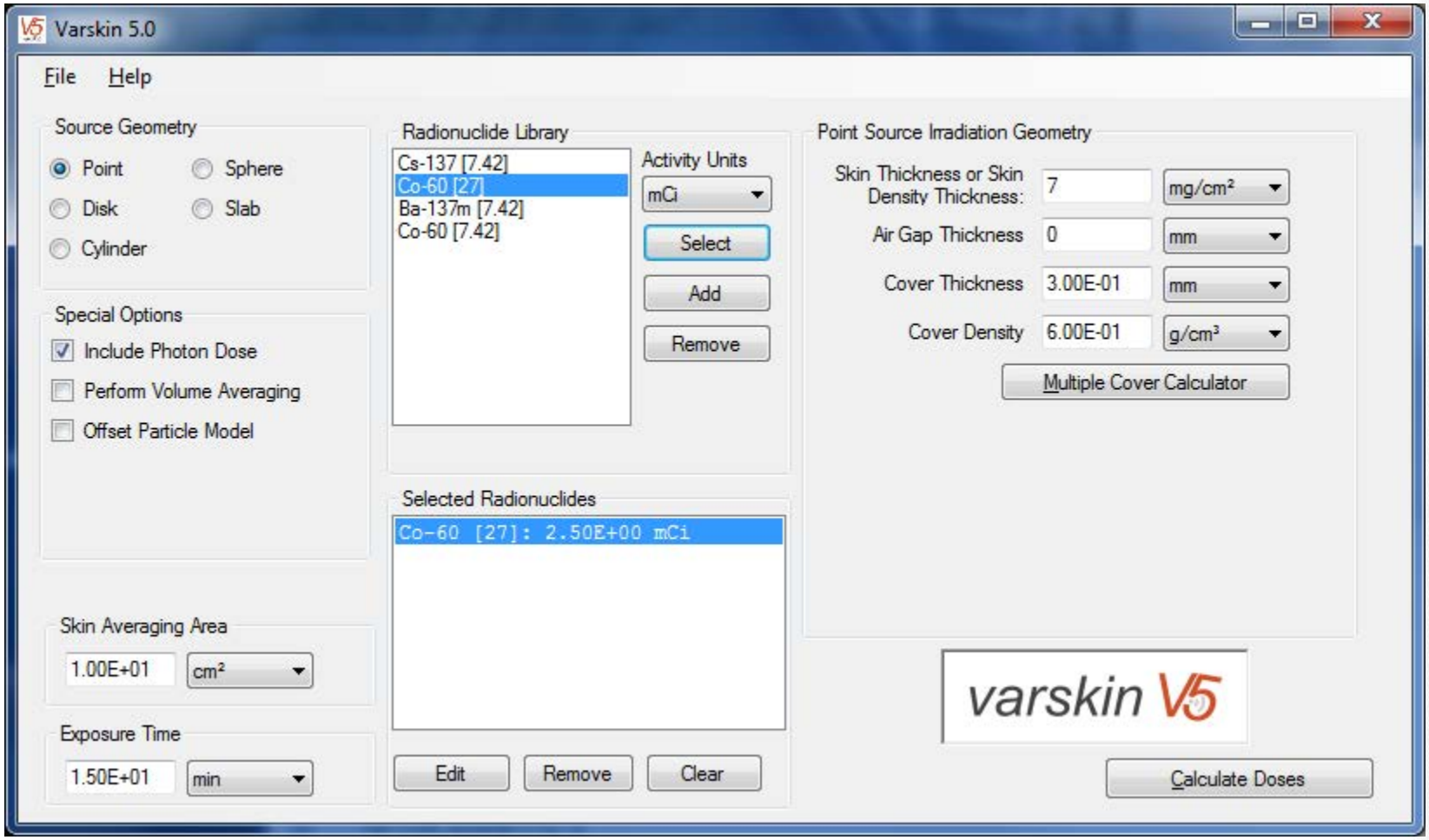
# Input



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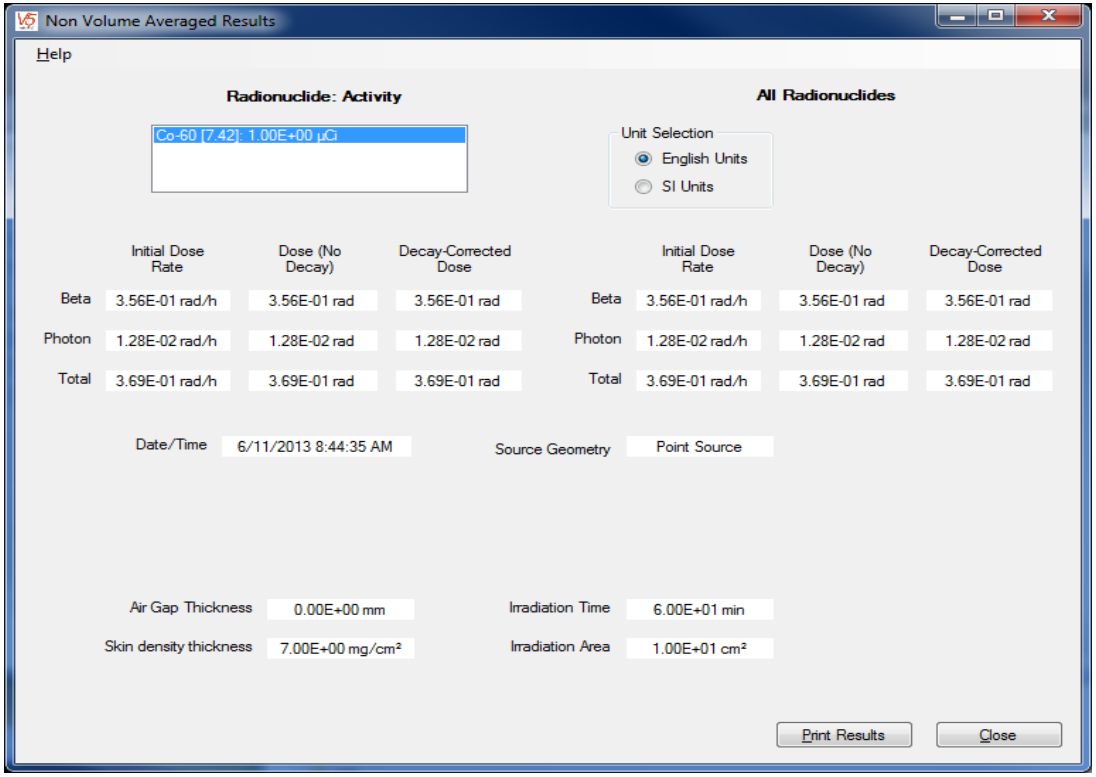
# Output



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# QUICK OVERVIEW OF PHANTOM WITH MOVING ARMS AND LEGS(PIMAL 4)



Mohammad Saba
Radiation Protection Branch
Office of Nuclear Regulatory Research
The United States Nuclear Regulatory Commission

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# Background

In order to model scenarios of radiation exposure to the human body either from internal or external sources. NRC partnered with Oak Ridge National Laboratory to develop the PIMAL(Phantom with Moving Arms and Legs) phantom utilizing a graphical user interface (GUI).

Phantom development with a GUI is considered an efficient and accurate tool for rapidly developing exposure models and performing dosimetry calculations for human exposure scenarios.

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# Background

- The GUI is used to graphically set the arms and legs to the desired orientation, develop the Monte Carlo N Particle Transport Code (MCNP) input file, and display a table of organ doses and effective dose at the end of the run.

- PIMAL 4 will be release in Winter of this year.

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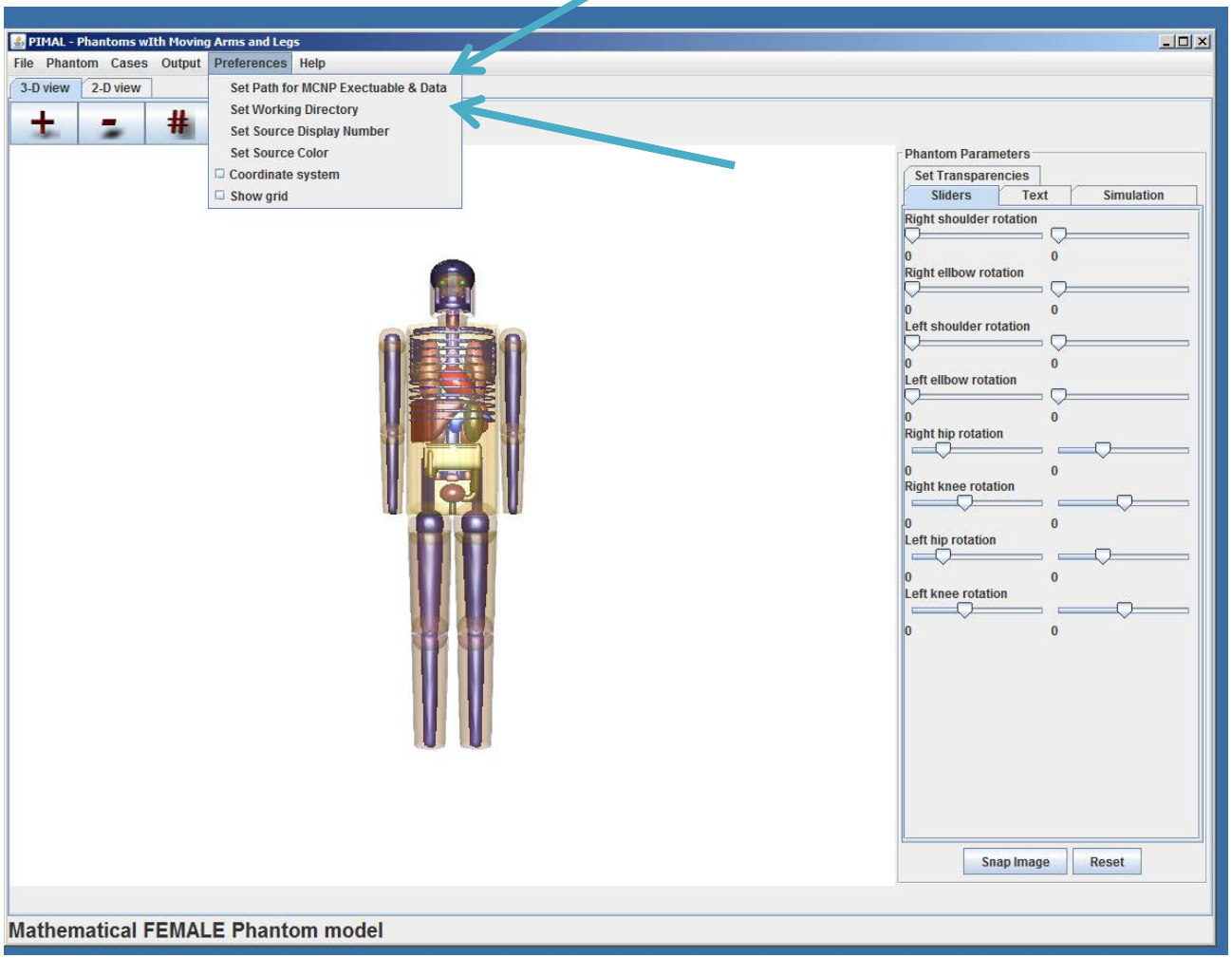
# Basic settings



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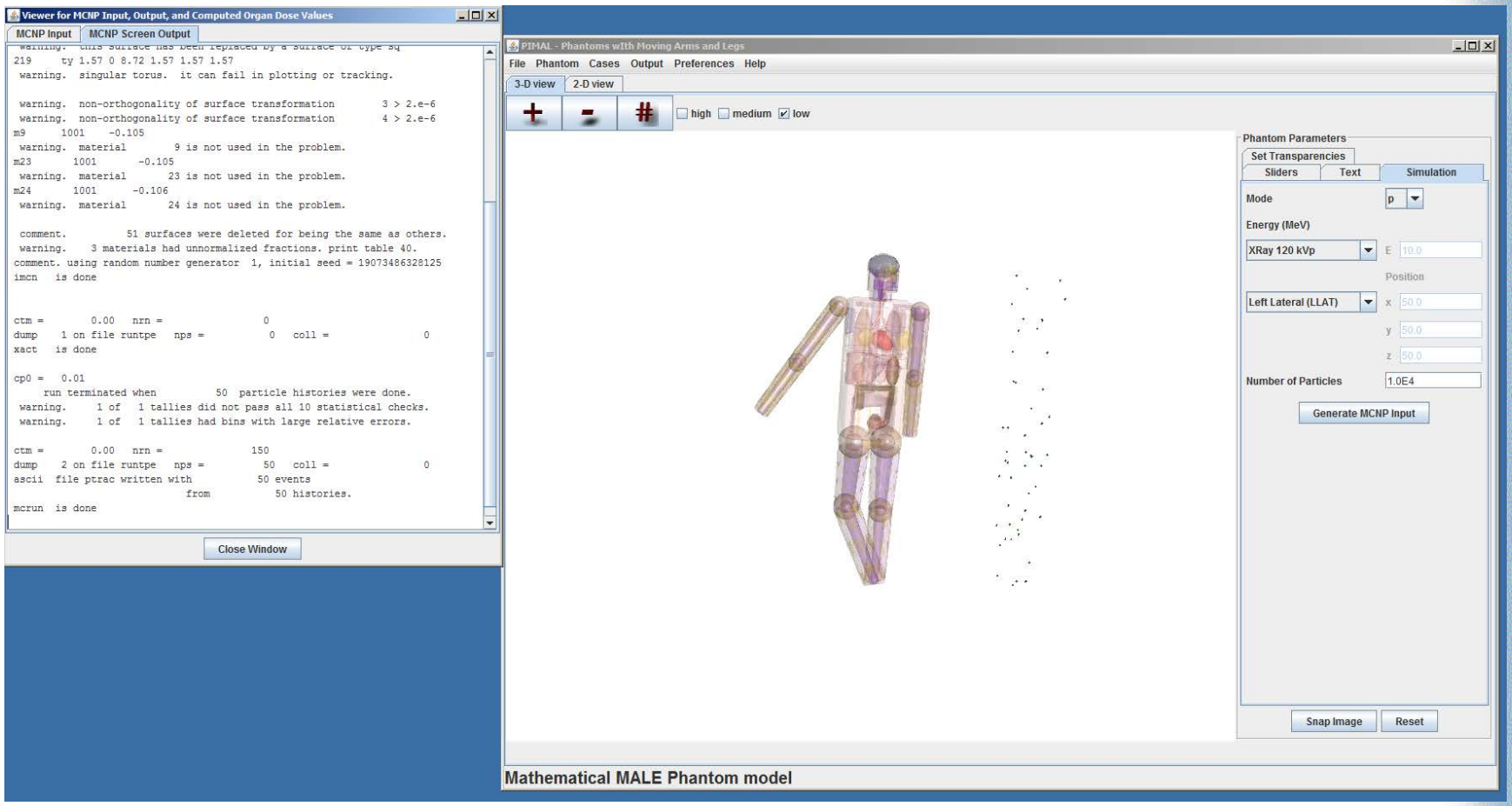
# Features –MCNP simulation inside PIMAL




Users may choose to run basic calculations from inside PIMAL.

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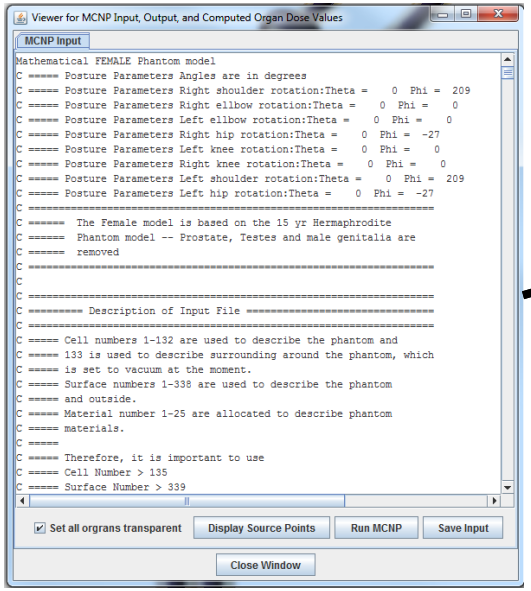
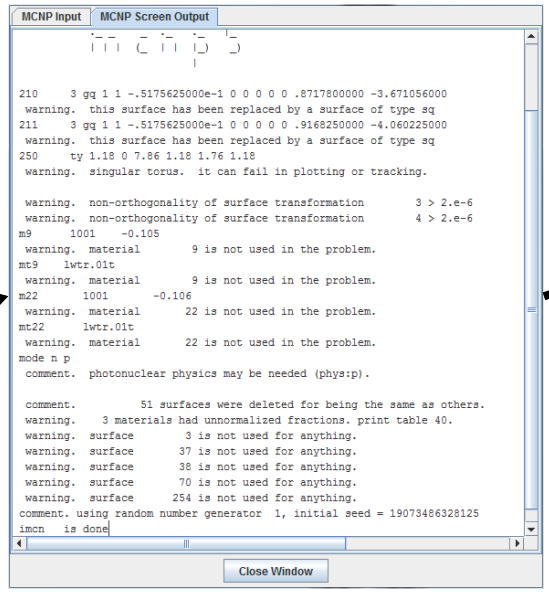
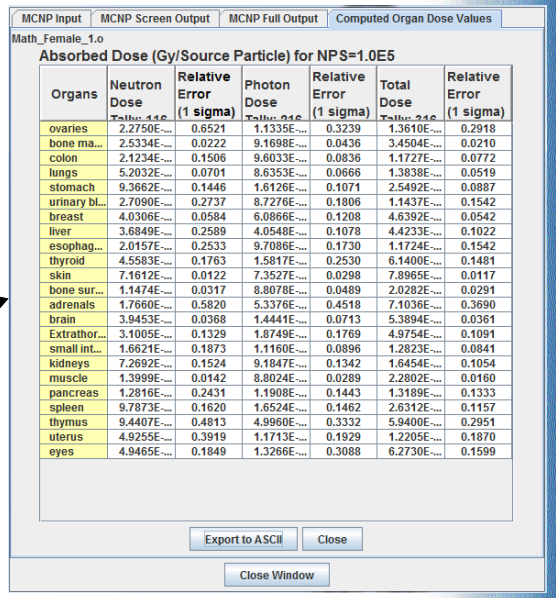
# Features – Basic MCNP Workflow




Step 1.
Generate MCNP Input




Step 2.
Run MCNP inside PIMAL




Step 3.
View organ absorbed dose

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# Features – Organ Dose Values

MCNP Input | MCNP Screen Output | MCNP Full Output | Computed Organ Dose Values

Math_Female_1.o

**Absorbed Dose (Gy/Source Particle) for NPS=1.0E5**

| Organs | Neutron Dose Tally: 116 | Relative Error (1 sigma) | Photon Dose Tally: 216 | Relative Error (1 sigma) | Total Dose Tally: 216 | Relative Error (1 sigma) |
|---|---|---|---|---|---|---|
| ovaries | 2.2750E-... | 0.6521 | 1.1335E-... | 0.3239 | 1.3610E-... | 0.2918 |
| bone ma... | 2.5334E-... | 0.0222 | 9.1698E-... | 0.0436 | 3.4504E-... | 0.0210 |
| colon | 2.1234E-... | 0.1506 | 9.6033E-... | 0.0836 | 1.1727E-... | 0.0772 |
| lungs | 5.2032E-... | 0.0701 | 8.6353E-... | 0.0666 | 1.3838E-... | 0.0519 |
| stomach | 9.3662E-... | 0.1446 | 1.6126E-... | 0.1071 | 2.5492E-... | 0.0887 |
| urinary bl... | 2.7090E-... | 0.2737 | 8.7276E-... | 0.1806 | 1.1437E-... | 0.1542 |
| breast | 4.0306E-... | 0.0584 | 6.0866E-... | 0.1208 | 4.6392E-... | 0.0542 |
| liver | 3.6849E-... | 0.2589 | 4.0548E-... | 0.1078 | 4.4233E-... | 0.1022 |
| esophag... | 2.0157E-... | 0.2533 | 9.7086E-... | 0.1730 | 1.1724E-... | 0.1542 |
| thyroid | 4.5583E-... | 0.1763 | 1.5817E-... | 0.2530 | 6.1400E-... | 0.1481 |
| skin | 7.1612E-... | 0.0122 | 7.3527E-... | 0.0298 | 7.8965E-... | 0.0117 |
| bone sur... | 1.1474E-... | 0.0317 | 8.8078E-... | 0.0489 | 2.0282E-... | 0.0291 |
| adrenals | 1.7660E-... | 0.5820 | 5.3376E-... | 0.4518 | 7.1036E-... | 0.3690 |
| brain | 3.9453E-... | 0.0368 | 1.4441E-... | 0.0713 | 5.3894E-... | 0.0361 |
| Extrathor... | 3.1005E-... | 0.1329 | 1.8749E-... | 0.1769 | 4.9754E-... | 0.1091 |
| small int... | 1.6621E-... | 0.1873 | 1.1160E-... | 0.0896 | 1.2823E-... | 0.0841 |
| kidneys | 7.2692E-... | 0.1524 | 9.1847E-... | 0.1342 | 1.6454E-... | 0.1054 |
| muscle | 1.3999E-... | 0.0142 | 8.8024E-... | 0.0289 | 2.2802E-... | 0.0160 |
| pancreas | 1.2816E-... | 0.2431 | 1.1908E-... | 0.1443 | 1.3189E-... | 0.1333 |
| spleen | 9.7873E-... | 0.1620 | 1.6524E-... | 0.1462 | 2.6312E-... | 0.1157 |
| thymus | 9.4407E-... | 0.4813 | 4.9960E-... | 0.3332 | 5.9400E-... | 0.2951 |
| uterus | 4.9255E-... | 0.3919 | 1.1713E-... | 0.1929 | 1.2205E-... | 0.1870 |
| eyes | 4.9465E-... | 0.1849 | 1.3266E-... | 0.3088 | 6.2730E-... | 0.1599 |

Export to ASCII | Close

Close Window

PIMAL computes all dose to organs in the ICRP103 definition of effective dose.

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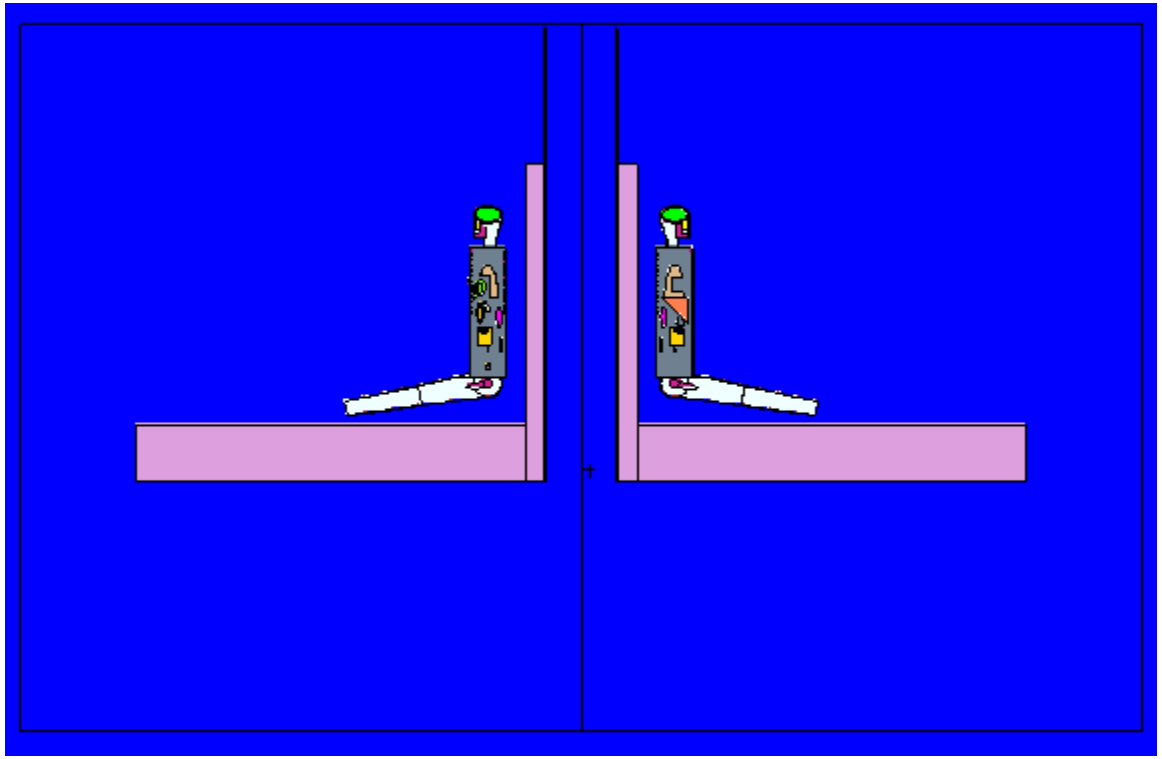
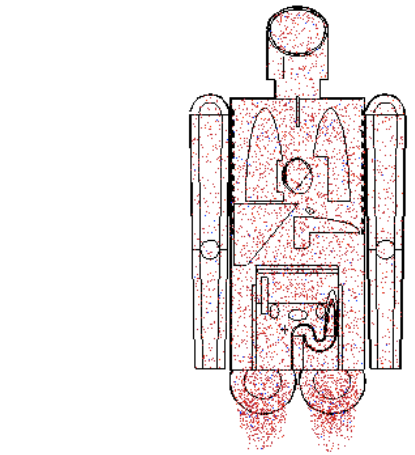
# (Dewji et al.) Hotel: Back-to-Back Seated in Bed





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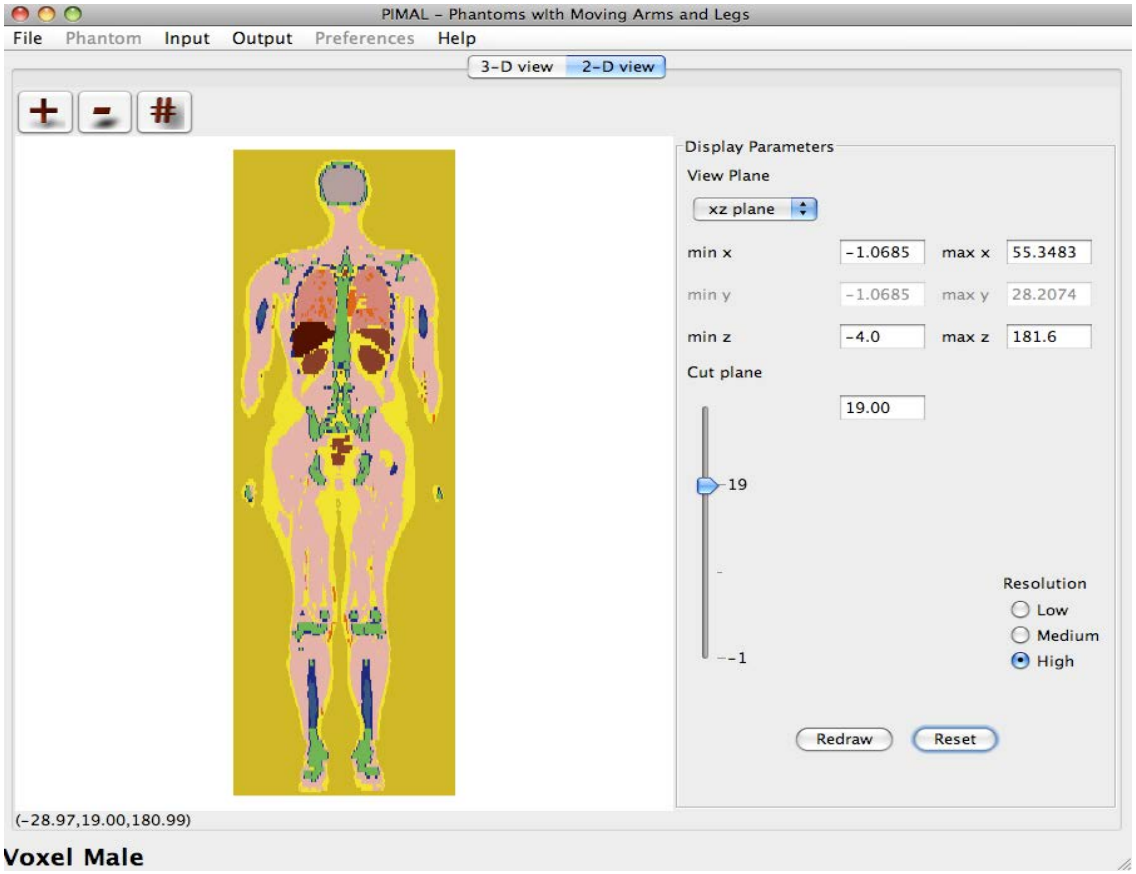
# Features - Two dimensional cross section view




Two dimensional cross section views are available both for voxel and the stylized phantoms

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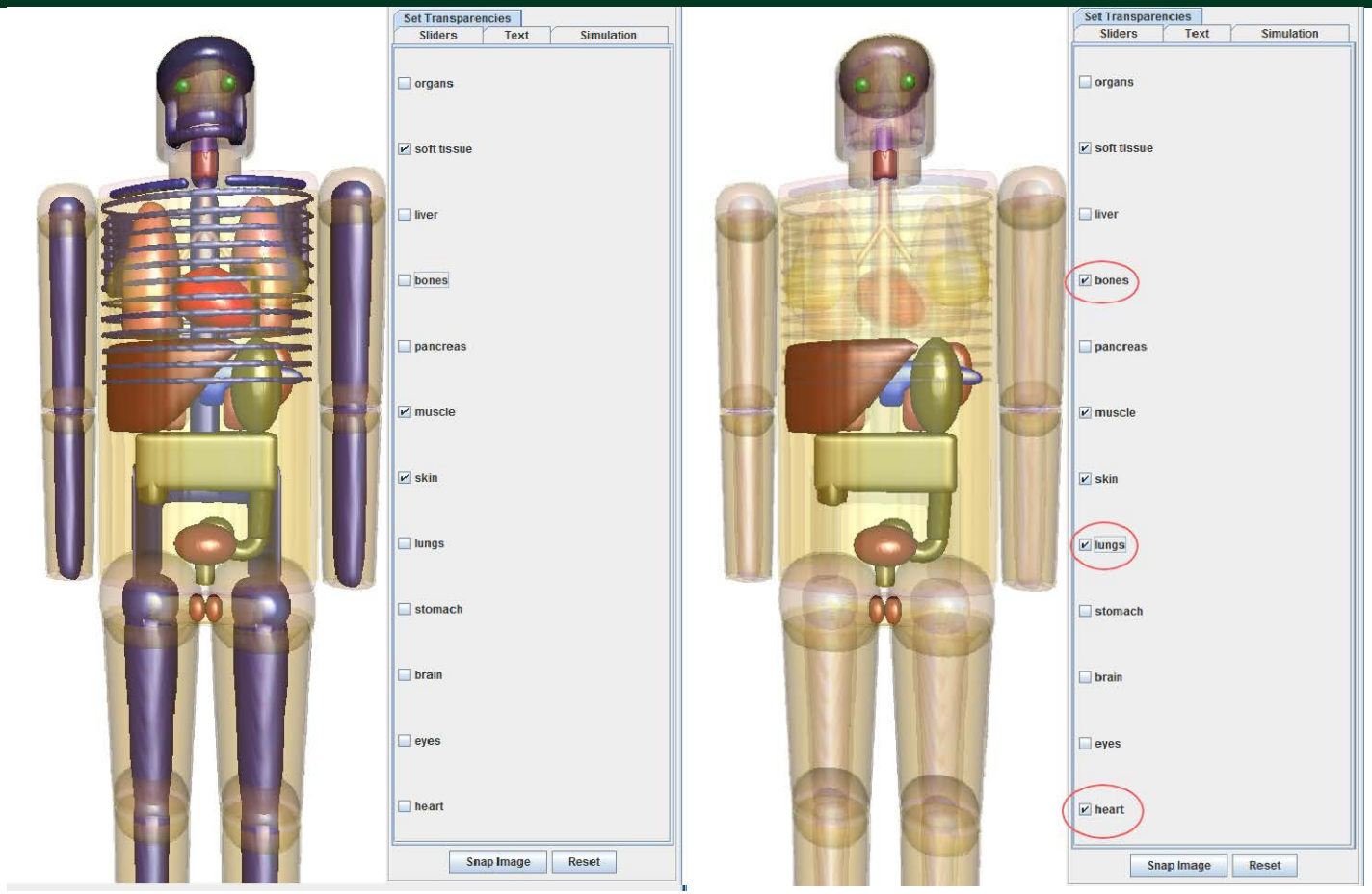
# Features –Organ Visualizations




PIMAL users may toggle organ transparencies to highlight important tissues.

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# PIMAL Version 4.0 –Features

- Added ability to save and load configurations **(new)**
- Expanded range of phantom motion **(new)**
- Added user's guide **(new)**
- Validated PIMAL against the EPA FGR12/15 Reports **(new)**
- Real-time Java3D interface for adjusting Phantom posture
- ICRP's reference voxel phantoms
- 2D cross sectional view
- Automatic generation of valid MCNP files
- MCNP output file reader to display organ doses
- MCNP source visualization

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# COMPUTER CODES IN RAMP



# HABIT

## CODE FOR ASSESSING CONTROL ROOM HABITABILITY

Casper Sun, PhD, CHP, FHPS, MCP
Radiation Protection Branch
Office of Nuclear Regulatory Research
The United States Nuclear Regulatory Commission

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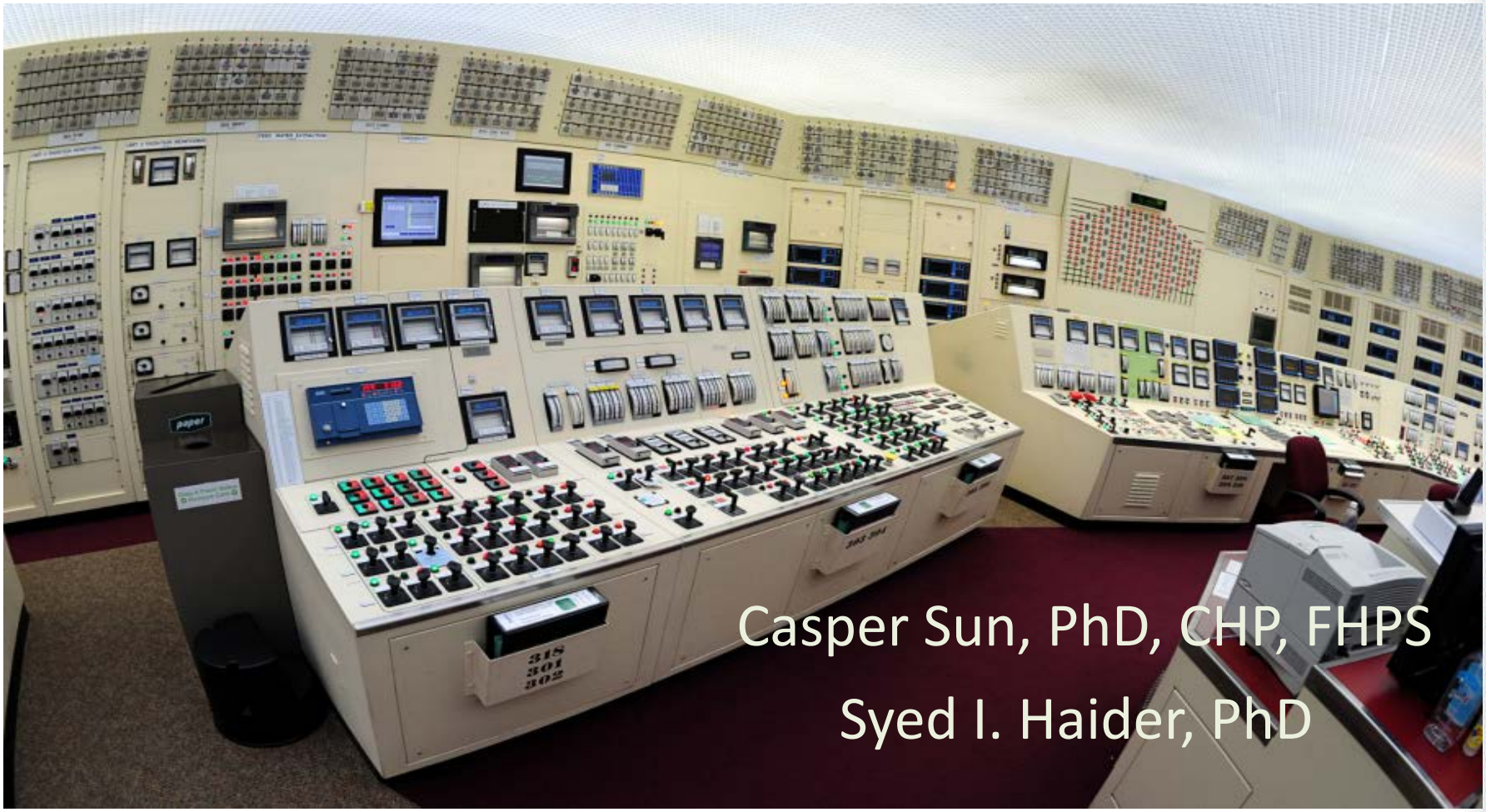
# CONTROL ROOM



Casper Sun, PhD, CHP, FHPS
Syed I. Haider, PhD

*2015 RAMP first annual meeting, Rockville, MD 20852*
*October 7th, 2015*

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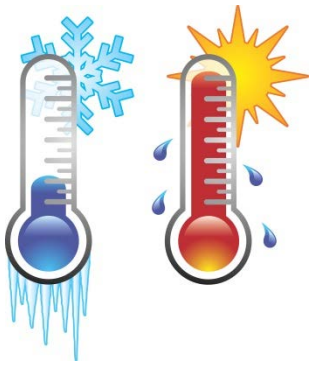
# Habitability Issues at NRC

## Radiological

## Non-radiological

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# Request for Additional Information (RAI) No. 6158

"…the staff posits that since chlorine and sulfuric acid clearly fit the definition of a heavy gas that **ALOHA modeling is the more appropriate program (i.e. as opposed to HABIT) to use for determining main control room habitability.** More specifically, the use of the HABIT Gaussian model may be producing non-conservative results for these two heavy gases. The staff requests that the applicant re-evaluate their findings of FSAR 6.4.4.2 and address the fact that chlorine and sulfuric acid are heavy gases and provide **a comprehensive justification for why the results are appropriate and conservative.**" (November 2011)

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# Project Overview

- **Phase I** (June 2014 – Feb. 2015):
  - Repair **HABIT v1.1** FORTRAN source code
  - Develop User Manual and interactive pop-up help screens.
  - Comply Section 508 requirements
  - TRM for **HABIT v1.2** (download and install)
- **Phase II** (April 2015 – Sept. 2016):
  - Integrate DEGADIS and SLAB (D&S) dense gas models
  - GUI and programing completed by April 2016
  - **HABIT v2.0** and revise NUREG/CR-6210 (9/30/16)
  - ATD benchmark and revise RG 1.78 (on the horizon)

**RG 1.78: Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release (2001)**

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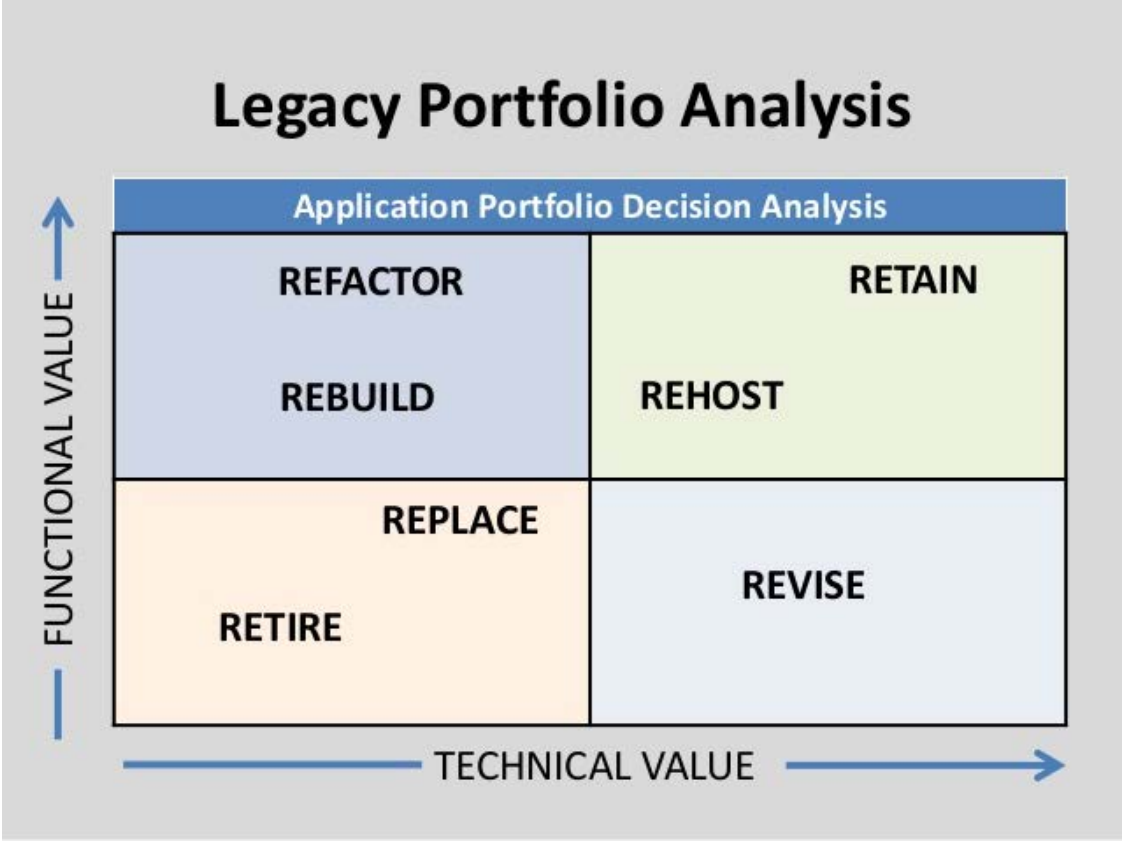
# HABIT PHASE-I

**June 1, 2014 – February 14, 2015**

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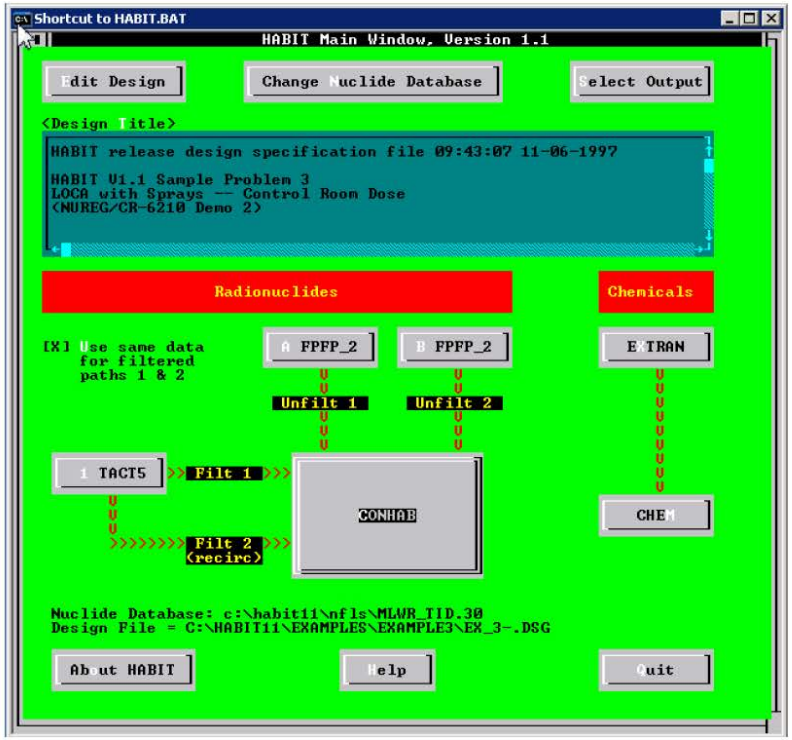
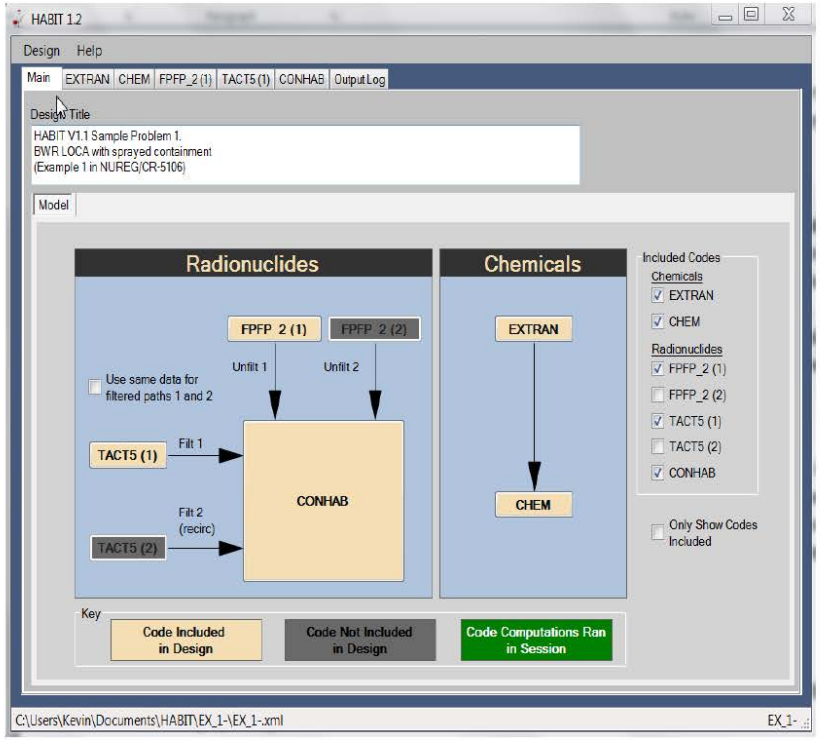
# HABIT MAKEOVER

## from v1.1 to v1.2

| Original | New |
| --- | --- |
|  |  |

Have we built the software right?

# Verification and Validation

Have we built the right software?

## FORTRAN modules and I/O data

- Impacts from identified "BUGS" and modifications made in HABIT 1.2
- Precision of reproduced identical results

## Compilation and operational steps in the new "User Manual"

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# HABIT Phase-II Milestone & Schedule

**Program Schedule: April 20, 2015 – April 04, 2016**

**Kickoff: April 20, 2015**

| Task | Main Objective | Duration (days) | Finish Date |
|---|---|---|---|
| 1 | Re-host D&S | 109 | June 22 |
| 2 | Integrate D&S | 113 | Oct. 16 |
| 3 | V&V HABIT v 2.0 | 73 | Jan. 26, 16 |
| 4 | Update NUREG/CR-6210 | 85 | April 4, 16 |

**D&S: DEGADIS and SLAB**

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# DRY ICE SMOKE

$$C(x,y,z,t) = \frac{Q}{2\pi u \sigma_y \sigma_z} \cdot \exp\left(-\frac{y^2}{2\sigma_y^2}\right)\left[\exp\left(-\frac{(z-H_{eff})^2}{2\sigma_z^2}\right) + \exp\left(-\frac{(z+H_{eff})^2}{2\sigma_z^2}\right)\right]$$

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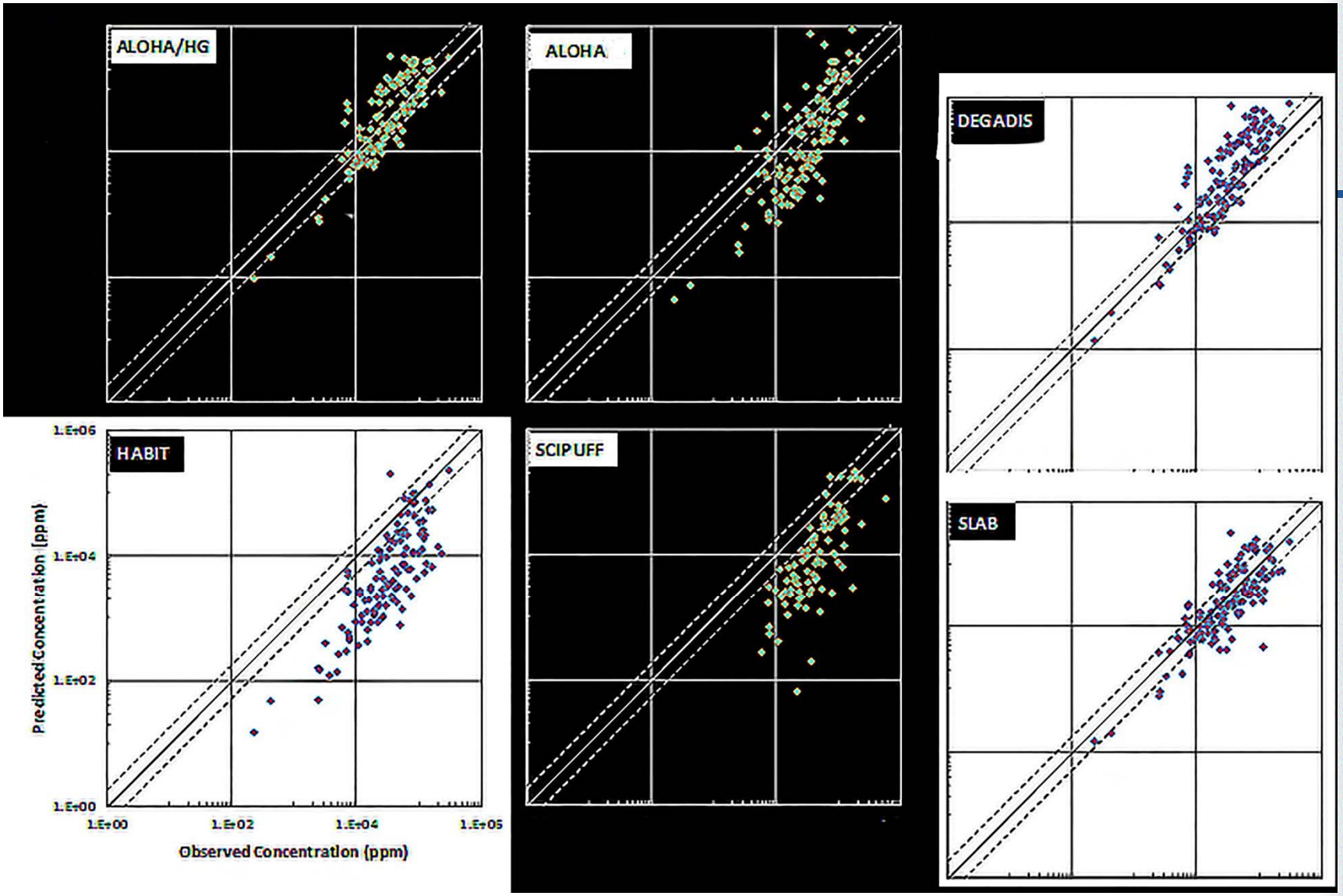
# Dense Gases Models Validation

| Model | Developer | Purpose | Scenarios | Type |
|---|---|---|---|---|
| ALOHA 5.4.3 | EPA/NOAA | Dense gas and neutrally buoyant gas dispersions | Leak from pipeline or tank, evaporating puddle, direct open source | Source-term model |
| DEGADIS 2.1 | University of Arkansas | Dense gas and neutrally buoyant gas dispersions | Elevated or ground-level area source, vertical jet leak | Non-source-term model |
| HABIT 1.1 | **PNNL** | **Neutrally buoyant gas dispersions** | **Liquid or gas tank burst and leak** | **Source-term model** |
| SCIPUFF 2.2 | Titan Research and Technology | Dense gas and neutrally buoyant gas dispersions | Moving and stack sources, gaseous and particulate materials | Non-source-term model |
| SLAB | LLNL | Dense gas and neutrally buoyant gas dispersions | Open evaporating pool, horizontal and vertical jet/stack, instantaneous volume liqiud sources | Non-source-term model |

**Table E.1: Performed by ANL (ANL/EVS/TM-13.3: April 2013)**




# Comparison of Observed and the Predicted Concentrations (ppm)

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# HABIT V2.0

- **DEGADIS (Thomas Spicer)** solves the gas concentrations by gravity-driven, over flat terrain, then into the entrainment layers.
- **SLAB (Donald Ermak)** solves gas concentrations by mass, energy, and momentum balances at downwind locations.
- **HABIT Version 2.0 available in April 2016**

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# On-Going Enhancements


Photo taken by Dr. Jay MacLellan (9/28/15)

- Adding chemicals
- Adding graphic analysis
- Adding ICRP 60/103 dose coefficients
- Supporting RAMP
- Benchmark ATD Models

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# COMPUTER CODES IN RAMP



# Radiological Toolbox Version 3.0

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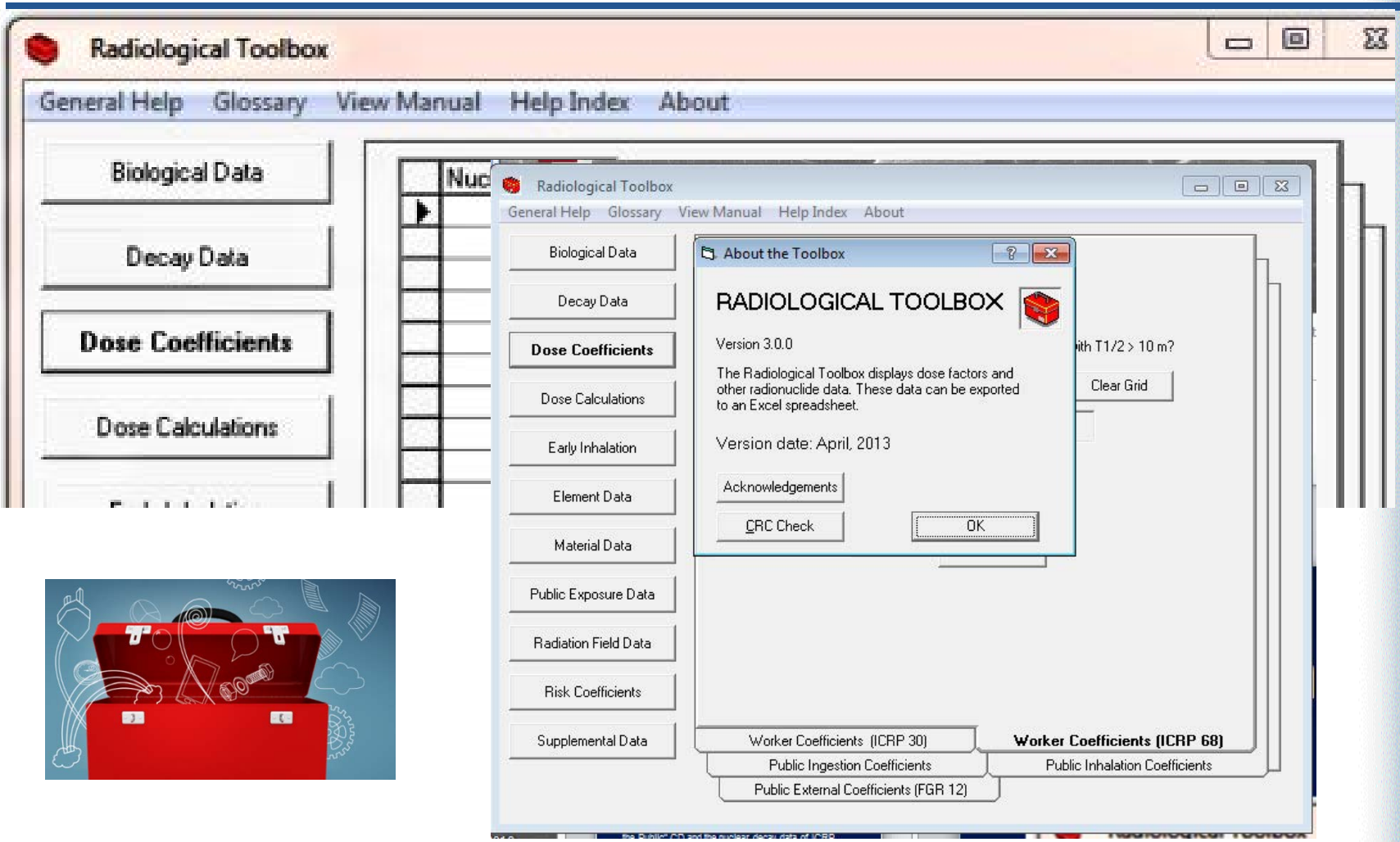
# Menu Bar (About)



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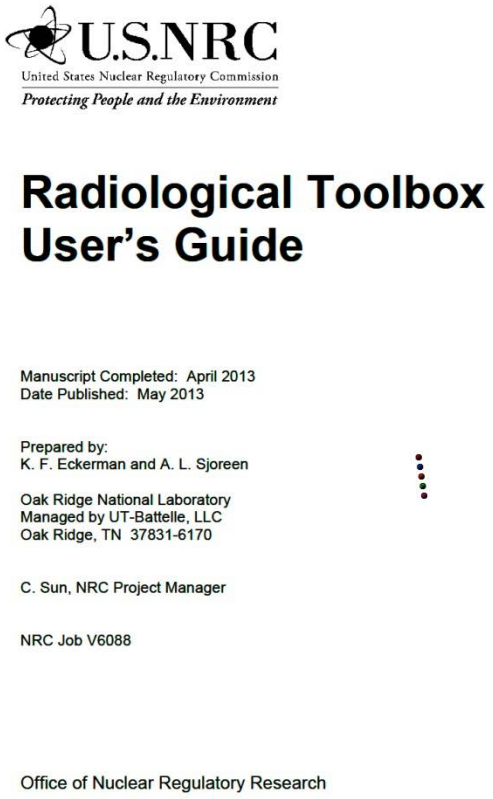
# What's in The Latest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**Radiological Toolbox User's Guide**

NUREG/CR-7166
ORNL/TM-2013/16

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Date Published: May 2013

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NRC Job V6088

Office of Nuclear Regulatory Research

- **Rad-Toolbox V3.0 (April 2013)**
  - Windows 7 and OS 64-bit compatible
  - Code is 27 MB in size and one click to install.
  - TRM certified for NRC workstations
  - ***Forum: Look for your feedback***
- **User's Manual (May 2013)**
  - In color and PDF searchable
  - References are up to date
  - Built-in under "View-Manual" tab

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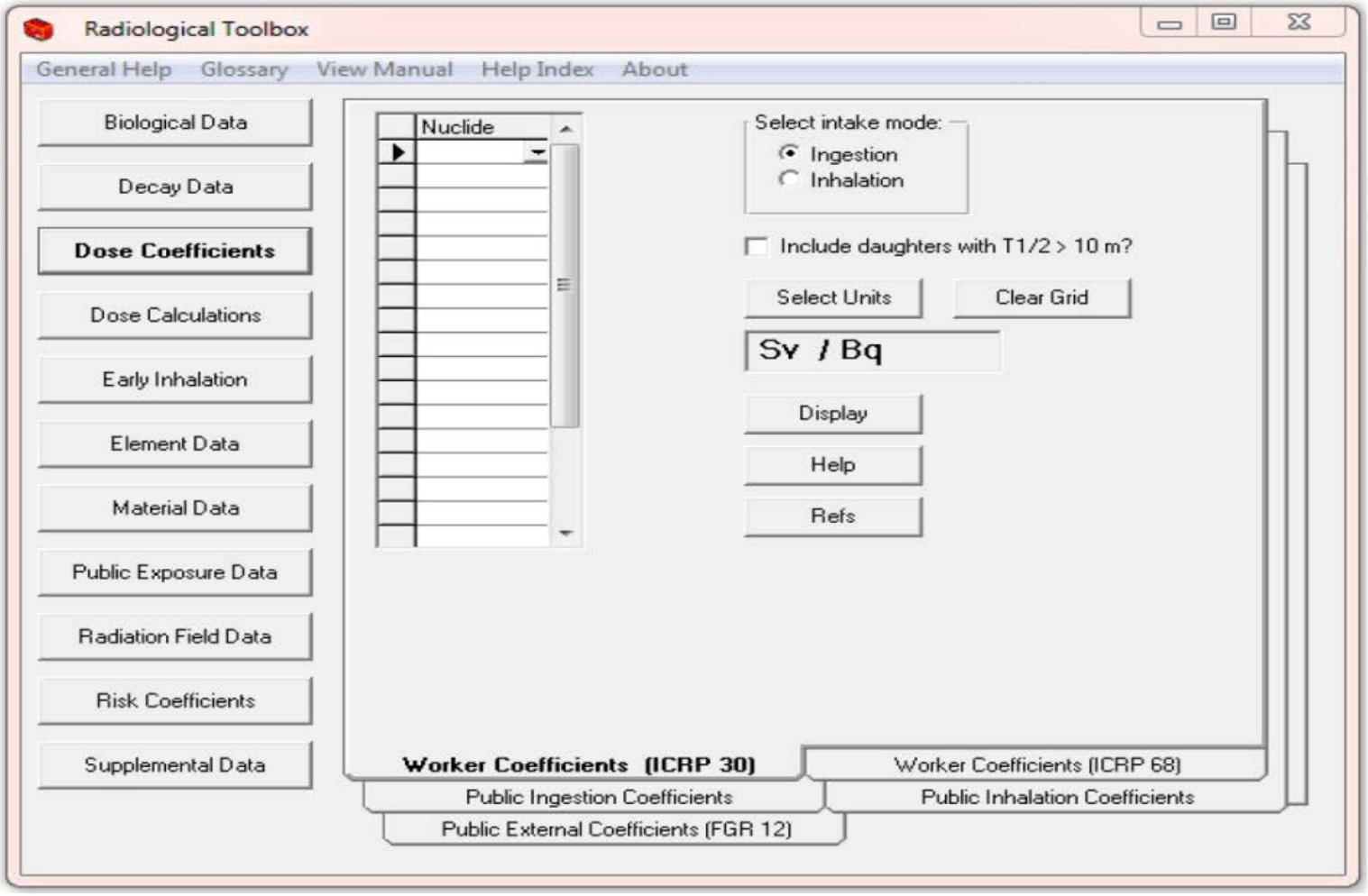
# Rad-Toolbox 11 Database



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# HP Constants

**Useful Constants and Conversions**

| | |
|---|---|
| Avogadro's number | $6.023 \times 10^{23}$ mol$^{-1}$ |
| Planck's constant | $6.625 \times 10^{-34}$ J s |
| volume of ideal gas (STP) | 22.4 L mol$^{-1}$ |
| charge ($e^{-1}$) | $1.602 \times 10^{-19}$ C |
| roentgen (STP) | $2.58 \times 10^{-4}$ C kg$^{-1}$ |
| 1 MeV | $1.602 \times 10^{-13}$ J |
| 1 atm | 760 mm Hg |
| w | 33.7 eV ion pair$^{-1}$ |
| rad | $6.242 \times 10^{7}$ MeV g$^{-1}$ |
| 1 m$^3$ | 1000 L |
| 1 ft$^3$ | 28.32 L |
| universal gas constant (R) | $8.32 \times 10^{7}$ erg °C$^{-1}$ g$^{-1}$ mol$^{-1}$ |
| standard temperature | 0°C |
| standard pressure | 1 atm |
| 1 barn (b) | $10^{-24}$ cm$^2$ |

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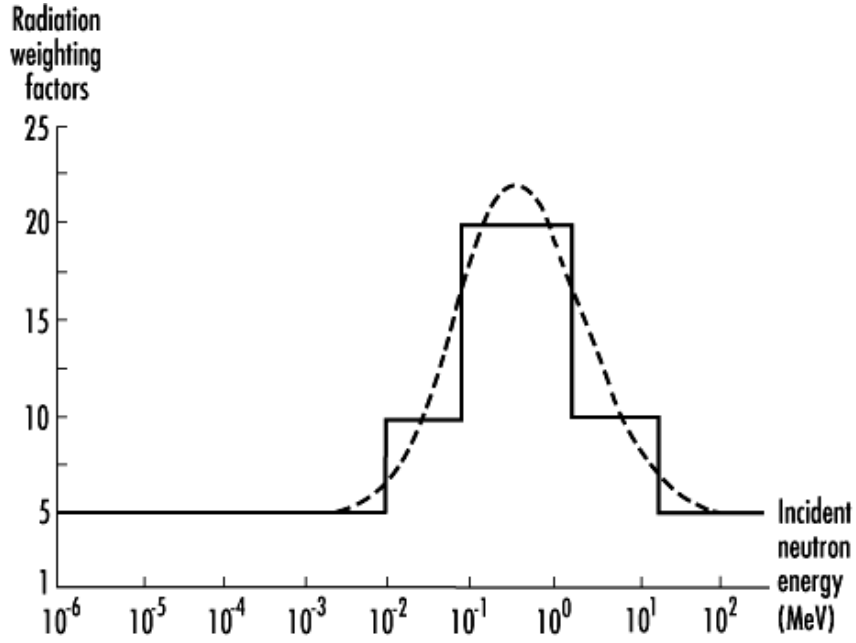
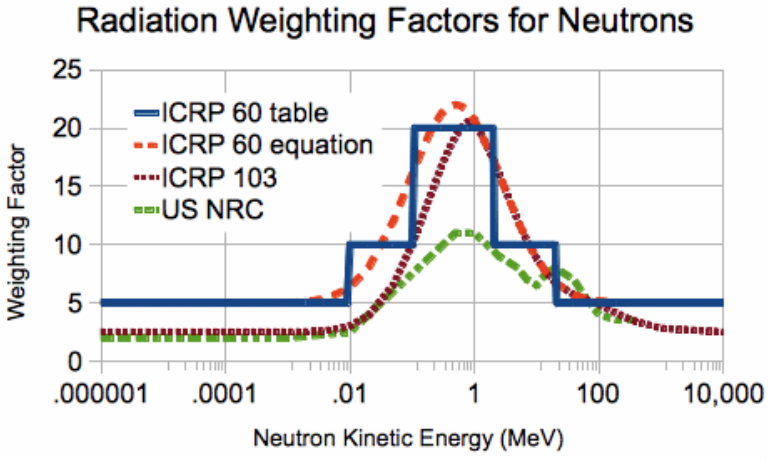
# (7) Neutron "$w_R$"




$$w_R = \begin{cases} 2.5 + 18.2e^{-[\ln (E_n)]^2/6}, & E_n < 1 \text{ MeV} \\ 5.0 + 17.0e^{-[\ln (2E_n)]^2/6}, & 1 \text{ MeV} \leqslant E_n \leqslant 50 \text{ MeV} \\ 2.5 + 3.25e^{-[\ln (0.04E_n)]^2/6}, & E_n > 50 \text{ MeV} \end{cases}$$

**ICRP 60 Radiation Weighting Factors**

| Radiation type and energy | Weighting Factor $w_R$ |
|---|---|
| Photons, all energies | 1 |
| Electrons, all energies | 1 |
| Neutrons, energy < 10 keV | 5 |
| 10 - 100 keV | 10 |
| 100 - 2000 keV | 20 |
| 2 - 20 MeV | 10 |
| > 20 MeV | 5 |
| Protons, energy > 2 MeV | 5 |
| Alpha, fission fragments | 20 |



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# (8) Medical Exposures

| Dose from Medical Diagnostic Procedures | | |
|---|---|---|
| **Procedure** | **Dose (rem)** | **Dose (mSv)** |
| Chest x-ray (1 film) | 0.01 | 0.1 |
| Dental x-ray | 0.16 | 1.6 |
| Mammogram | 0.25 | 2.5 |
| Lumbosacral spine | 0.32 | 3.2 |
| Bone scan (Tc-99m) | 0.44 | 4.4 |
| Cardiac (Tc-99m) | 0.75 | 7.5 |
| Cranial CT | 5 | 50 |
| GI fluoroscopy (barium) | 8.5 | 85 |
| Spiral CT | 3-10 | 30 - 100 |

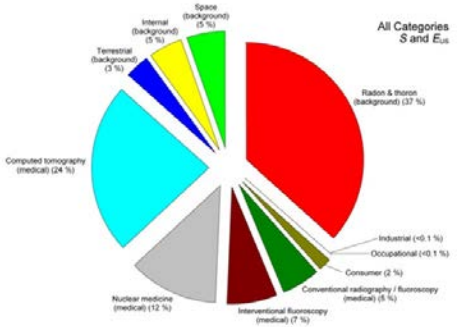


**Fig. 1.1.** Percent contribution of various sources of exposure to the total collective effective dose (1,870,000 person-Sv) and the total effective dose per individual in the U.S. population (6.2 mSv) for 2006. Percent values have been rounded to the nearest 1 %, except for those <1 % [see Table 1.1 for the values of $S$ (person-sievert) and $E_{US}$ (millisievert)].

**Computed tomography examinations**

| Effective dose per CT scans | |
|---|---|
| **Examination** | **Dose (mSv)** |
| Head | 2 |
| Chest | 7 |
| Abdomen/pelvis | 10 |
| Extremity | 0.1 |
| CT angiography: heart | 20 |
| CT angiography: head | 5 |
| Spine | 10 |
| Interventional | 0.1 |
| Whole-body screening | 10 |
| Calcium scoring | 2 |
| Cardiac | 20 |
| Virtual colonography | 10 |
| Miscellaneous | 5 |

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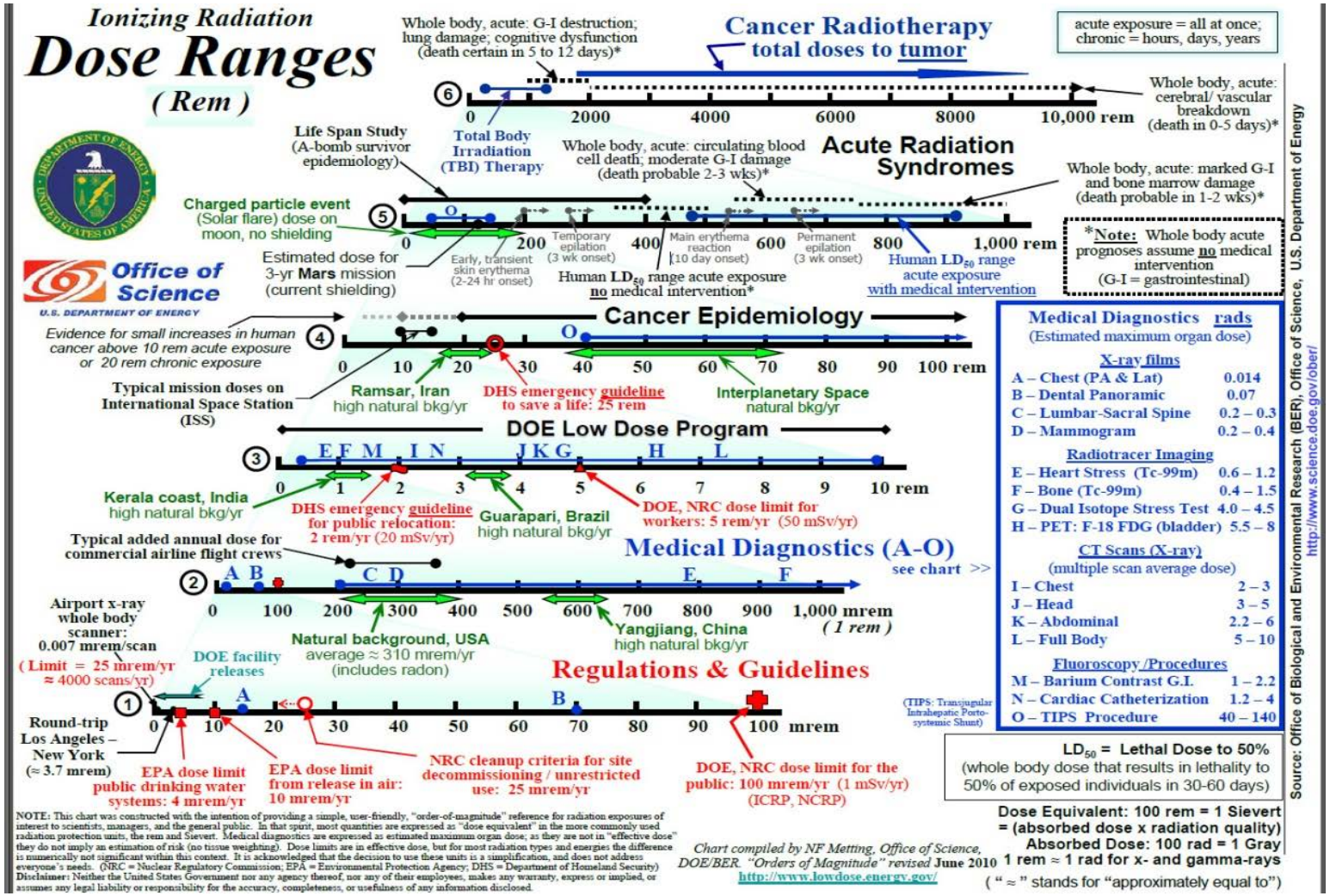
# (11) Supplemental Data



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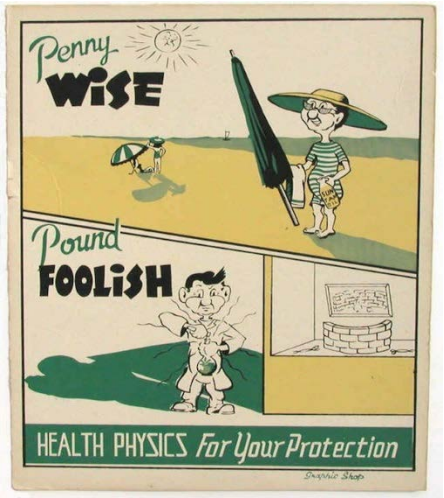
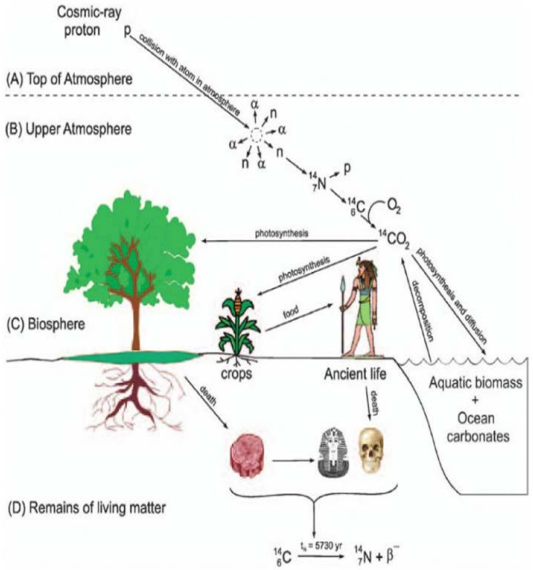
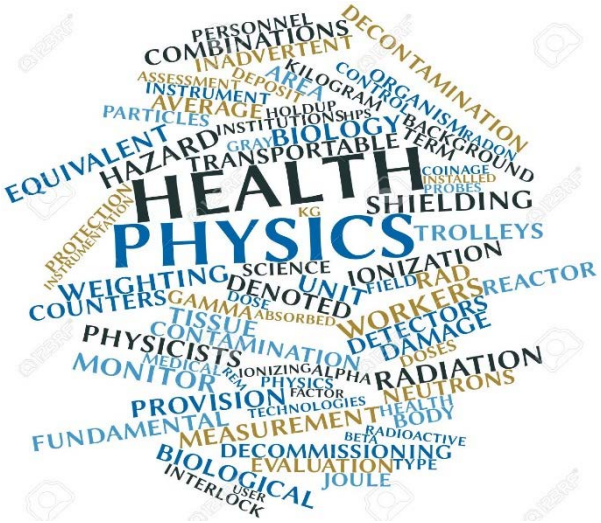
# More Database?




$$C(x,y,z,t) = \frac{Q}{2\pi u \sigma_y \sigma_z} \cdot \exp\left(-\frac{y^2}{2\sigma_y^2}\right)\left[\exp\left(-\frac{(z-H_e)^2}{2\sigma_z^2}\right) + \exp\left(-\frac{(z+H_e)^2}{2\sigma_z^2}\right)\right]$$

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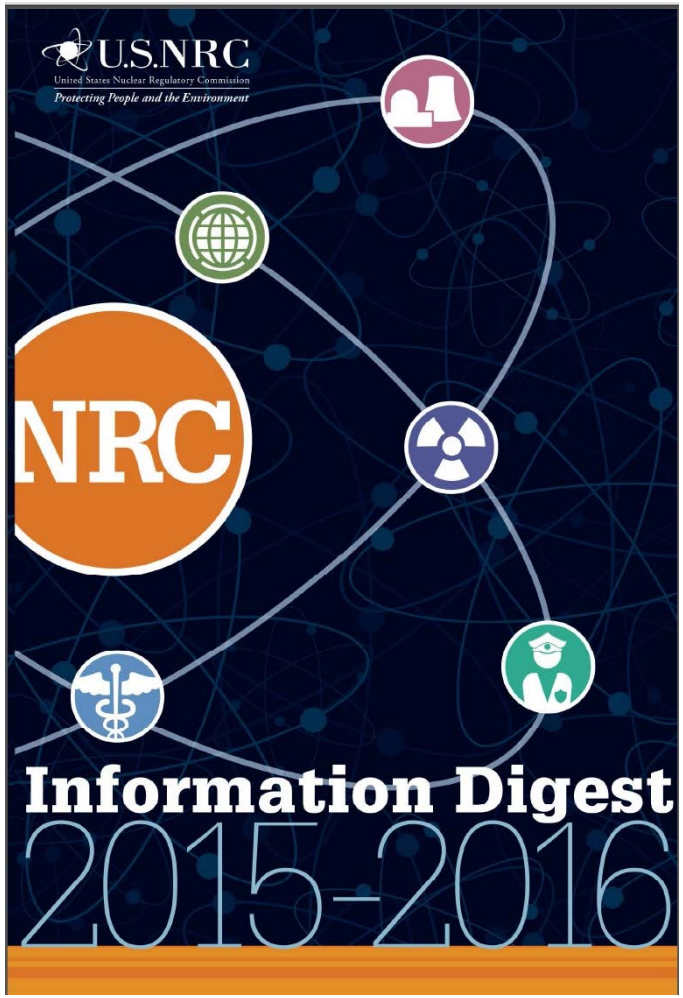
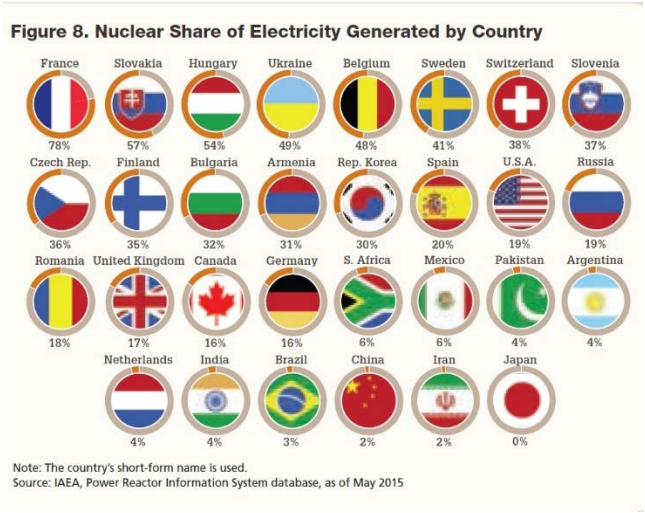
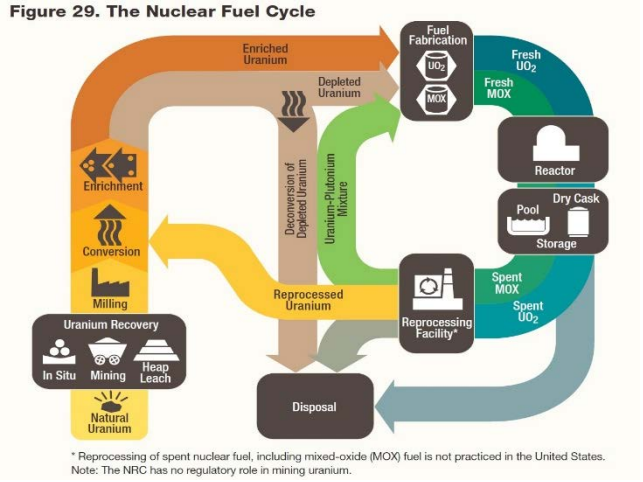
# Freebie:

## NUREG-1350: ML15254A321.pdf



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# DandD Decommissioning Dose Modeling Code



Adam Schwartzman and Cynthia Barr
Division of Decommissioning, Uranium Recovery, and Waste Programs
Office of Nuclear Materials Safety and Safeguards
United States Nuclear Regulatory Commission

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# Radiological Criteria

"A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TEDE to an *average member of the critical group* that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and that the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA)." **10 CFR 20.1402**

*Radiological criteria for unrestricted use*

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# DandD

- Decontamination and Decommissioning
- Developed by Sandia National Laboratory
- Supports Table H.1 and H.2 in NUREG-1757, Volume 2 → screening tables for demonstrating compliance with the radiological criteria for license termination with no restrictions
- Considers residual radioactivity associated with
  - Building surfaces (Table H.1) and
  - Surface soils (Table H.2)
- Current version is DandD v 2.4 and is compatible with Windows 8 operating systems

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# Screening Tables

**Table H.1 Acceptable Licens Radionuclides for**

| Radionuclide | Symbol |
|---|---|
| Hydrogen-3 (Tritium) | $^{3}H$ |
| Carbon-14 | $^{14}C$ |
| Sodium-22 | $^{22}Na$ |
| Sulfur-35 | $^{35}S$ |
| Chlorine-36 | $^{36}Cl$ |
| Manganese-54 | $^{54}Mn$ |
| Iron-55 | $^{55}Fe$ |
| Cobalt-60 | $^{60}Co$ |
| Nickel-63 | $^{63}Ni$ |
| Strontium-90 | $^{90}Sr$ |
| Technetium-99 | $^{99}Tc$ |
| Iodine-129 | $^{129}I$ |
| Cesium-137 | $^{137}Cs$ |
| Iridium-192 | $^{192}Ir$ |

Notes:

a Screening levels are based on the assu is equal to 0.1. For cases when the fra than 0.1, users may assume for screen removable, and therefore the screenin calculate site-specific levels using ava DandD Version 2.

**Table H.2 Screening Values[a] (pCi/g) of Common Radionuclides for Soil Surface Contamination Levels**

| Radionuclide | Symbol | Surface Soil Screening Values[b] |
|---|---|---|
| Hydrogen-3 | $^{3}H$ | 110 |
| Carbon-14 | $^{14}C$ | 12 |
| Sodium-22 | $^{22}Na$ | 4.3 |
| Sulfur-35 | $^{35}S$ | 270 |
| Chlorine-36 | $^{36}Cl$ | 0.36 |
| Calcium-45 | $^{45}Ca$ | 57 |
| Scandium-46 | $^{46}Sc$ | 15 |
| Manganese-54 | $^{54}Mn$ | 15 |
| Iron-55 | $^{55}Fe$ | 10000 |
| Cobalt-57 | $^{57}Co$ | 150 |
| Cobalt-60 | $^{60}Co$ | 3.8 |
| Nickel-59 | $^{59}Ni$ | 5500 |
| Nickel-63 | $^{63}Ni$ | 2100 |
| Strontium-90 | $^{90}Sr$ | 1.7 |
| Niobium-94 | $^{94}Nb$ | 5.8 |
| Technetium-99 | $^{99}Tc$ | 19 |
| Iodine-129 | $^{129}I$ | 0.5 |
| Cesium-134 | $^{134}Cs$ | 5.7 |
| Cesium-137 | $^{137}Cs$ | 11 |

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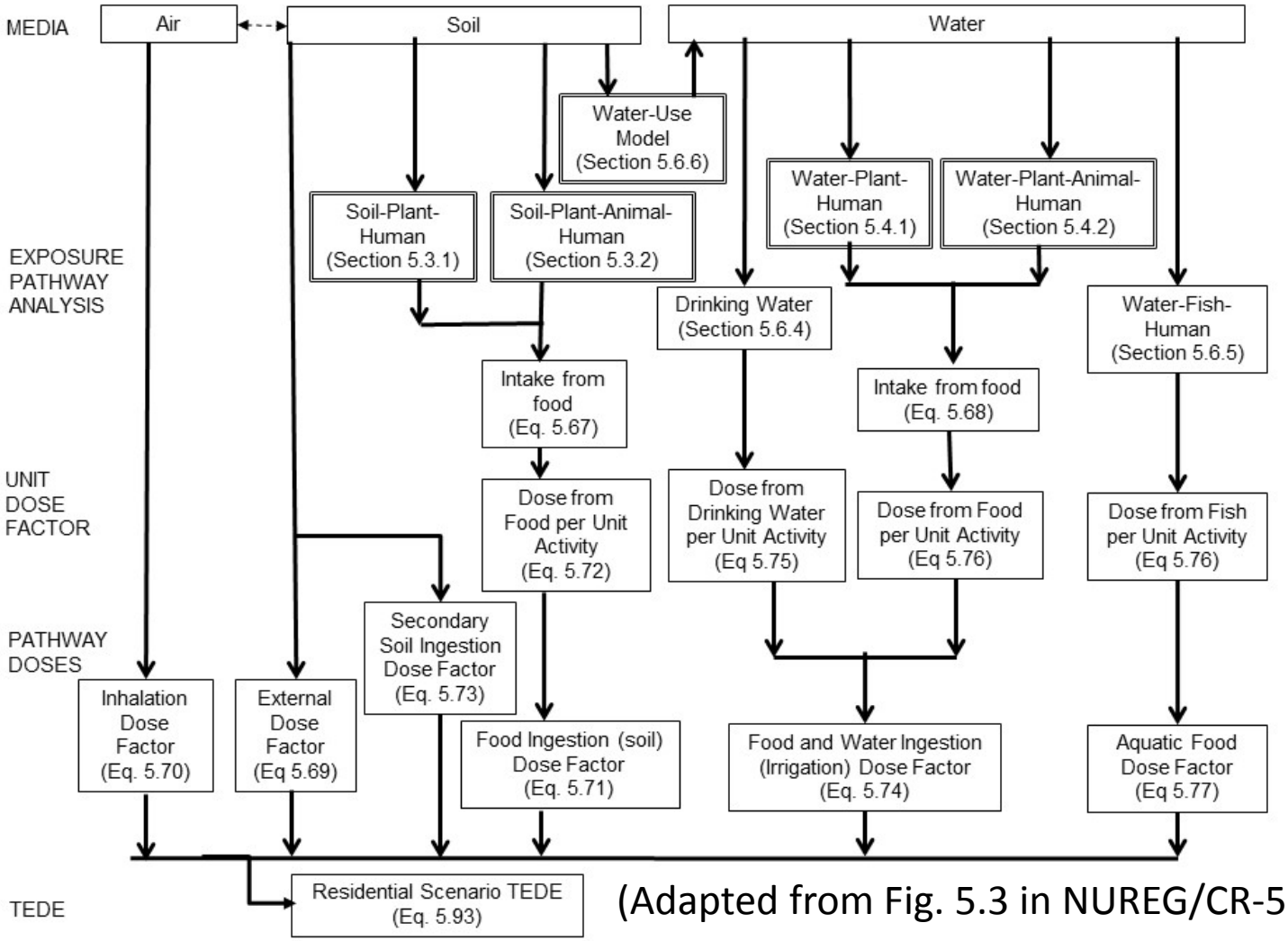
# DandD Pathways Model




(Adapted from Fig. 5.3 in NUREG/CR-5512, Vol. 1)

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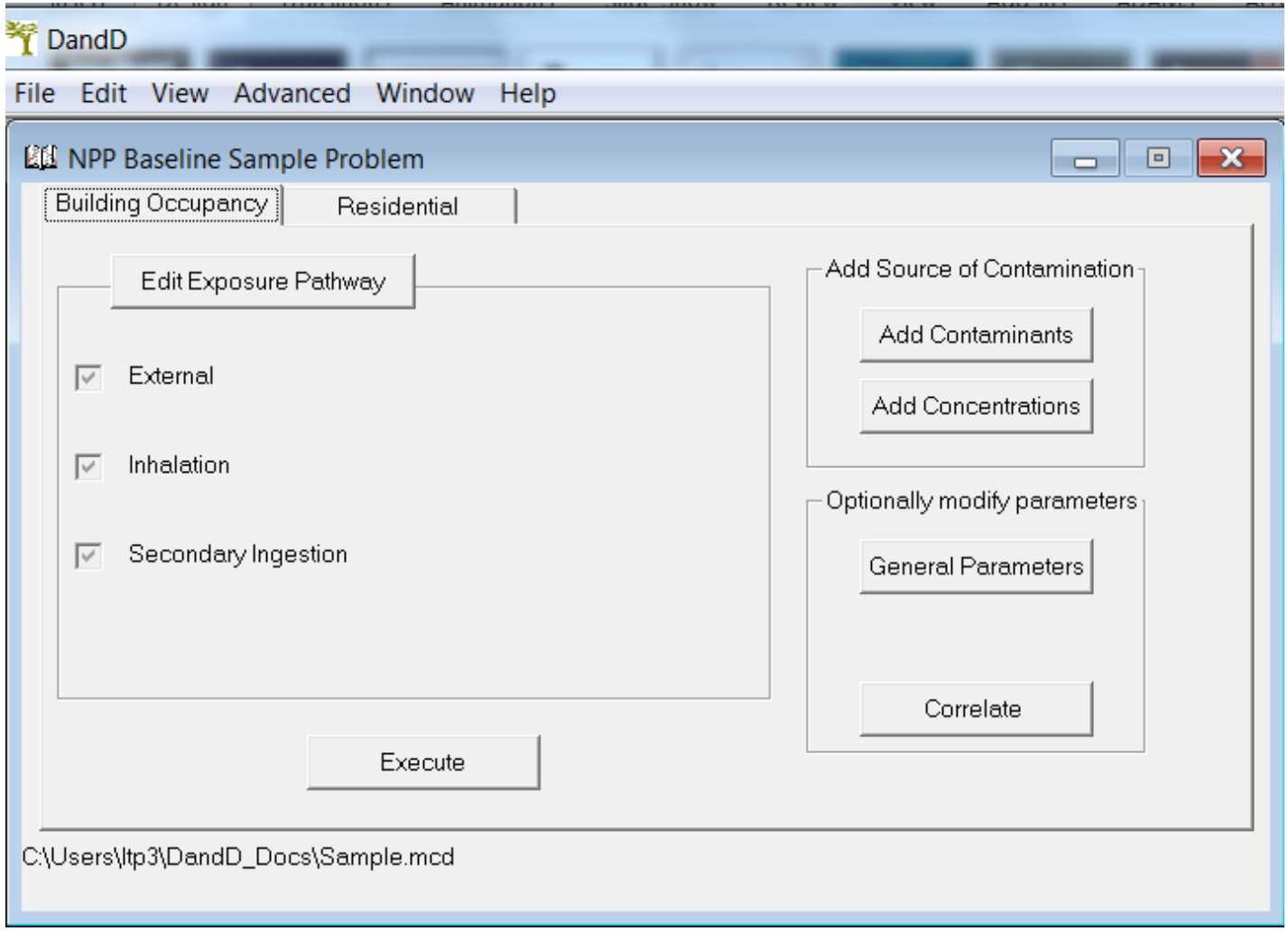
# Interface (Building Occupancy)



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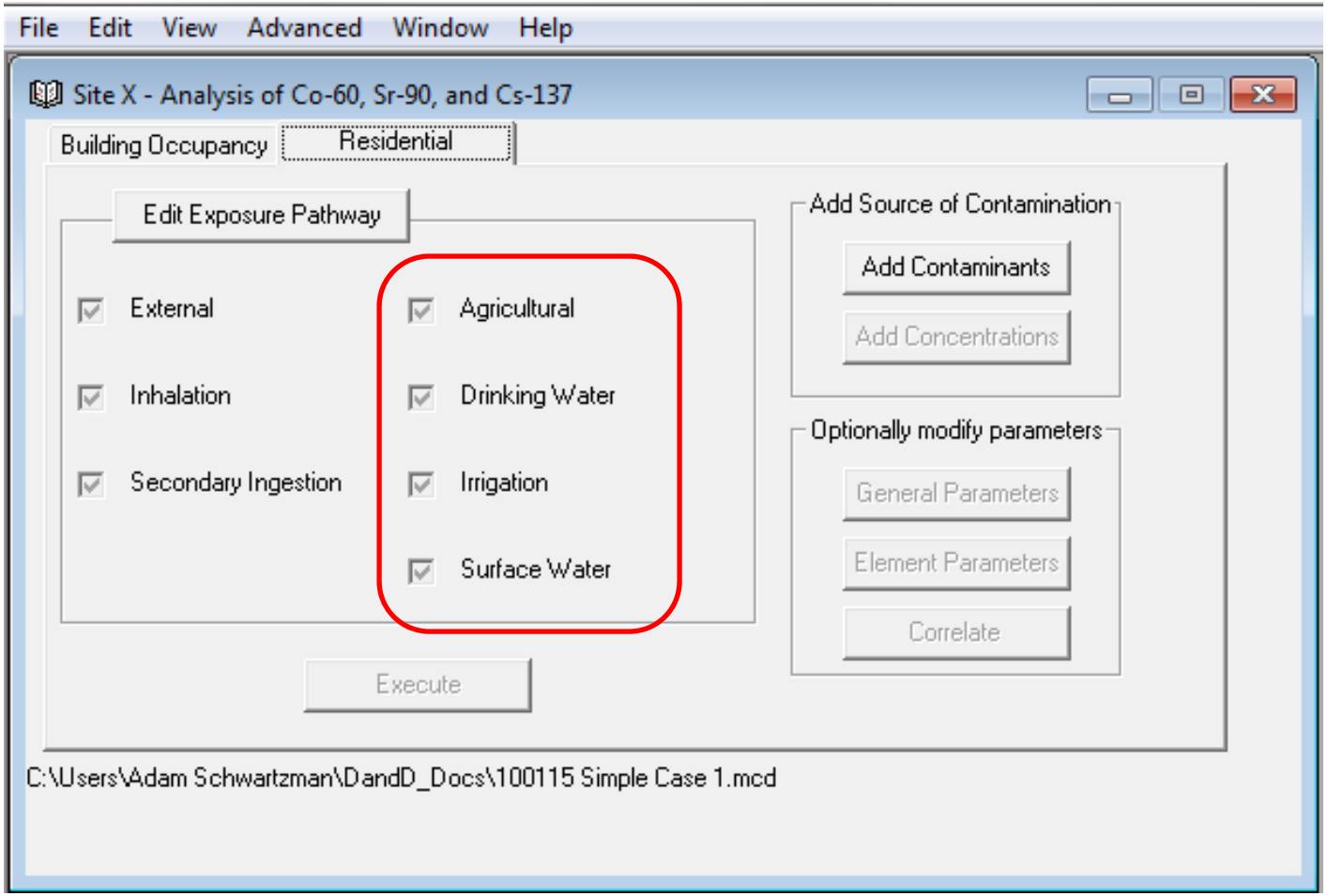
# Interface (Residential)



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# DandD Parameters

- Parameter information is provided in NUREG/CR-5512, Volume 3
- Probabilistic capabilities are available since version 2
- Sensitivity Analyses
- Online parameter help is available through the code

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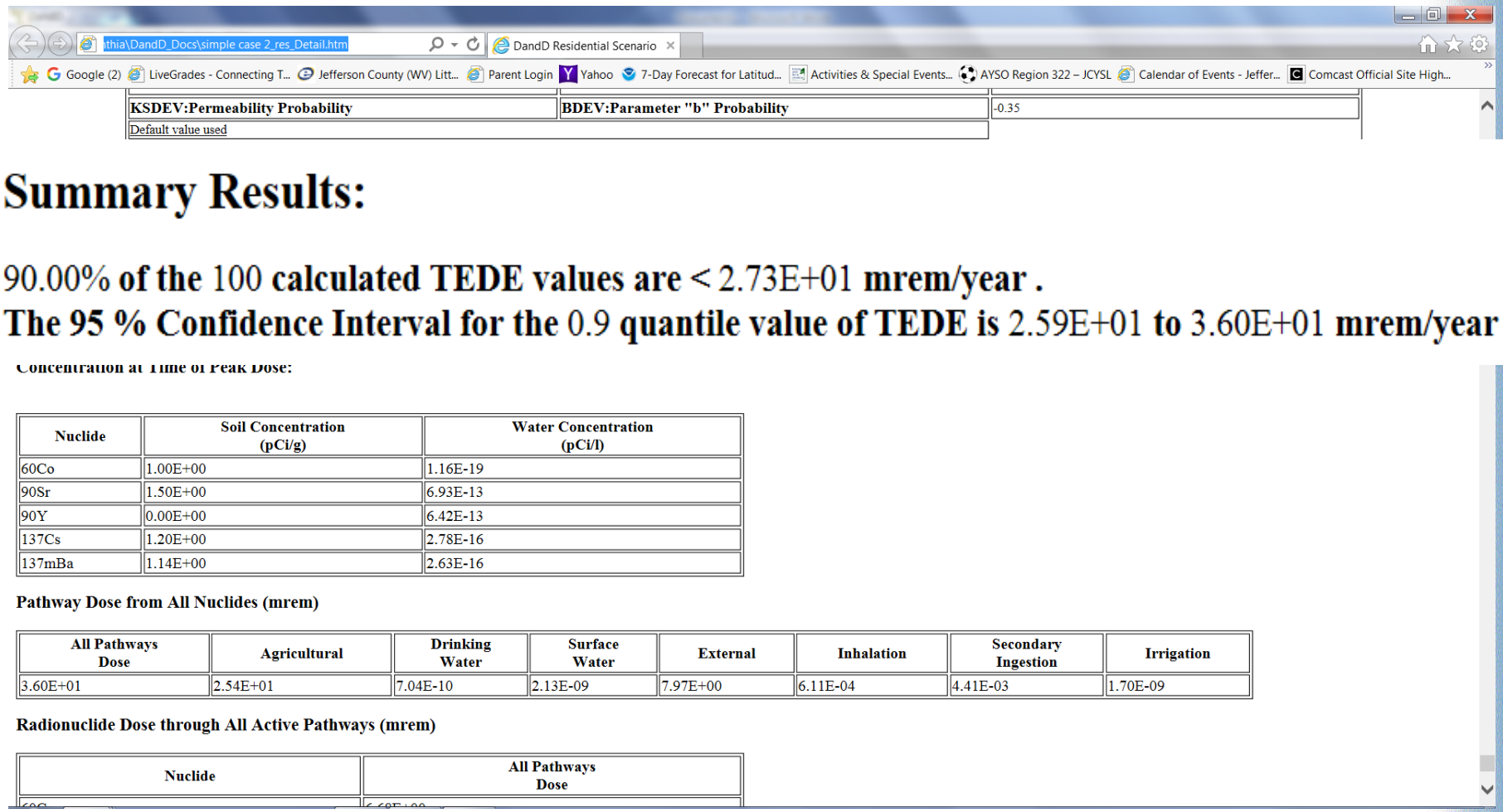
# DandD Outputs



ithia\DandD_Docs\simple case 2_res_Detail.htm — DandD Residential Scenario

Google (2) | LiveGrades - Connecting T... | Jefferson County (WV) Litt... | Parent Login | Yahoo | 7-Day Forecast for Latitud... | Activities & Special Events... | AYSO Region 322 – JCYSL | Calendar of Events - Jeffer... | Comcast Official Site High...

| | | |
|---|---|---|
| **KSDEV:Permeability Probability** | **BDEV:Parameter "b" Probability** | -0.35 |
| Default value used | | |

## Summary Results:

**90.00% of the 100 calculated TEDE values are < 2.73E+01 mrem/year .**
**The 95 % Confidence Interval for the 0.9 quantile value of TEDE is 2.59E+01 to 3.60E+01 mrem/year**

**Concentration at Time of Peak Dose:**

| Nuclide | Soil Concentration (pCi/g) | Water Concentration (pCi/l) |
|---|---|---|
| 60Co | 1.00E+00 | 1.16E-19 |
| 90Sr | 1.50E+00 | 6.93E-13 |
| 90Y | 0.00E+00 | 6.42E-13 |
| 137Cs | 1.20E+00 | 2.78E-16 |
| 137mBa | 1.14E+00 | 2.63E-16 |

**Pathway Dose from All Nuclides (mrem)**

| All Pathways Dose | Agricultural | Drinking Water | Surface Water | External | Inhalation | Secondary Ingestion | Irrigation |
|---|---|---|---|---|---|---|---|
| 3.60E+01 | 2.54E+01 | 7.04E-10 | 2.13E-09 | 7.97E+00 | 6.11E-04 | 4.41E-03 | 1.70E-09 |

**Radionuclide Dose through All Active Pathways (mrem)**

| Nuclide | All Pathways Dose |
|---|---|
| 60Co | 6.68E+00 |

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# Limitations

- Resuspension factor may overestimate inhalation dose for building surface contamination
- NUREG-1720 provides additional information regarding the resuspension factor
- The default parameter distribution recommended in NUREG-1720 can be used if consistent with underlying assumptions

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# Limitations (cont)

- DandD has limited ability to consider “hot spots” or elevated areas of contamination
  - Detailed analysis of area impact on pathway doses are not considered (e.g., RESRAD considers pathway-specific area impacts)
- DandD does not consider inhalation dose from release of H-3 and C-14 to the gas or vapor phase

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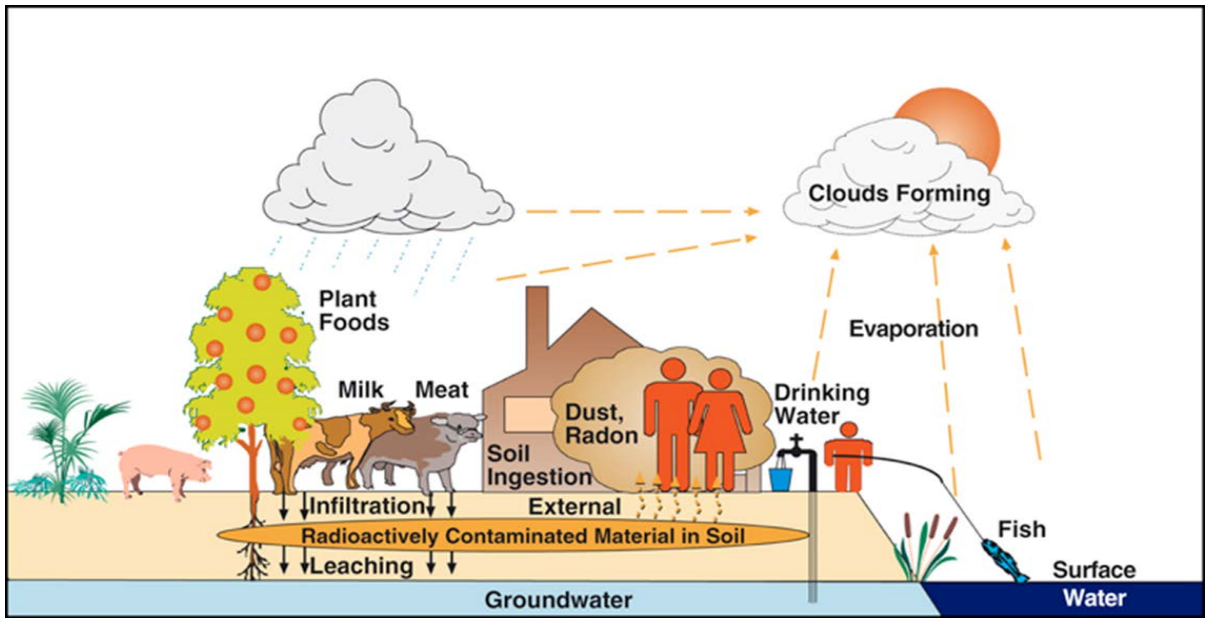
# RESRAD

- RESRAD is a computer code developed by Argonne National Lab to calculate radiation dose and lifetime cancer risk to an individual who is exposed to residual radioactivity in soil.



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# Differences Between DandD and RESRAD

- DandD:
  - Can be used for simple sites
    - Surface soil contamination
    - Building surface contamination
  - Limited ability to change default exposure scenarios
- RESRAD:
  - Can be used for more complex sites
    - Considers subsurface contamination
    - Considers clean cover
  - Greater number & more detailed exposure pathways
  - Has two options to consider dilution in the aquifer
  - Has special models for H-3, C-14, and radon

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# Conclusions

- DandD supports the screening tables in Appendix H of NUREG-1757, Volume 2, Revision 1
- Certain assumptions are inherent in screening level analyses
- Site-specific analyses may be necessary for sites with complex source terms, hydrogeology, etc.; or if screening analyses are too restrictive.
- NUREG/CR-5512, Vol. 2 User's Manual

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See
https://www.usnrc-ramp.com/DandD
for code support and download

Pacific Northwest
NATIONAL LABORATORY
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# RAMP Meeting: Overview of GALE

KEN GEELHOOD

Pacific Northwest National Laboratory

Richland, WA

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- GALE Code is a computerized mathematical model for calculating the releases of radioactive material in gaseous and liquid effluents (i.e., the gaseous and liquid source terms).
- The U.S. Nuclear Regulatory Commission uses the GALE Code to determine conformance with the requirements of Appendix I to 10 of 10 Code of Federal Regulations (CFR) Part 50.
- The current version of GALE-2.0 is posted as a Beta version under validation and verification under the US NRC contract with PNNL

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- Input
  - Plant data
  - Liquid waste cleanup system data
  - Gaseous effluent cleanup system data
- Ouptut
  - Liquid release of radionuclides from various buildings and the total release
  - Gaseous release of radionuclides from various buildings and the total release

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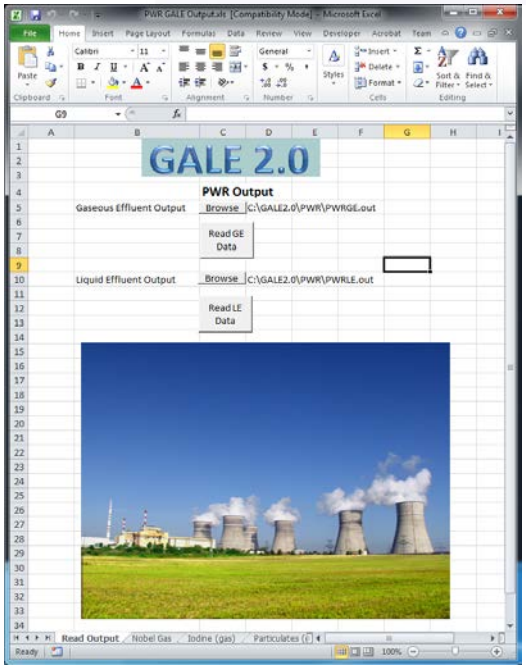
- Code runs on Microsoft Windows PCs
  - Graphical user interface uses standard Windows dialog boxes
- Code output is via text file
- Microsoft Excel worksheet has been included to visualize output and to facilitate use of output data in other calculations

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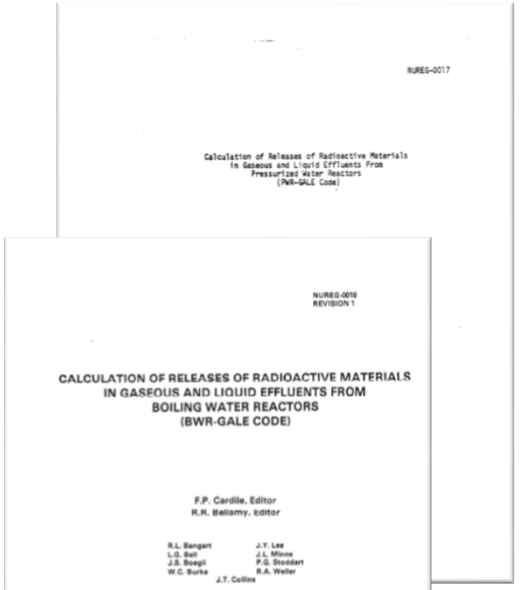
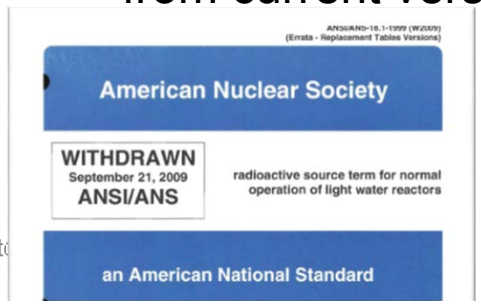
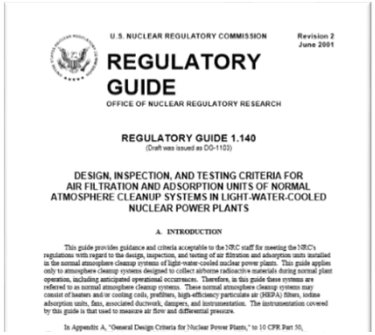
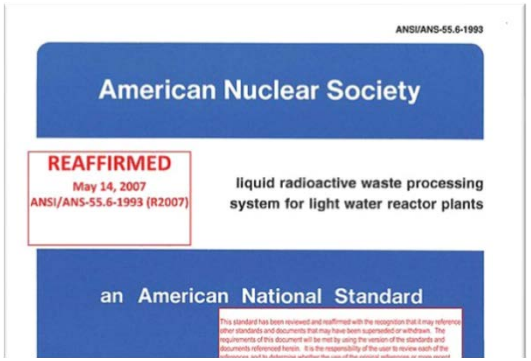
- Code originally developed by NRC staff
  - GALE-86
  - Documented by NUREG-0016 (BWR) and NUREG-0017 (PWR)
- Code Development moved to PNNL in 2008
- Several internal versions were released with no NUREG-series documentation
- GALE-08
  - Built-in nuclide concentrations from ANS-18.1 were updated to those in latest (1999) standard
  - Recommended parameters from ANS-55.6 and Regulatory Guide 1.140 were updated to values from current versions



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- GALE-09
  - A review of recent reactor operational experience was performed and recommendations for updates to the GALE source codes and their user guidance were made.
- Official GALE release with NUREG/CR documentation was made in 2015
- GALE-2.0 (beta version)
  - Code results are identical to GALE-09
  - Graphical user interface was added to facilitate user interaction
  - Excel worksheet was included to help visualize results
  - Code benchmarking was performed to validate GALE-2.0 (beta) results to recent reactor experience

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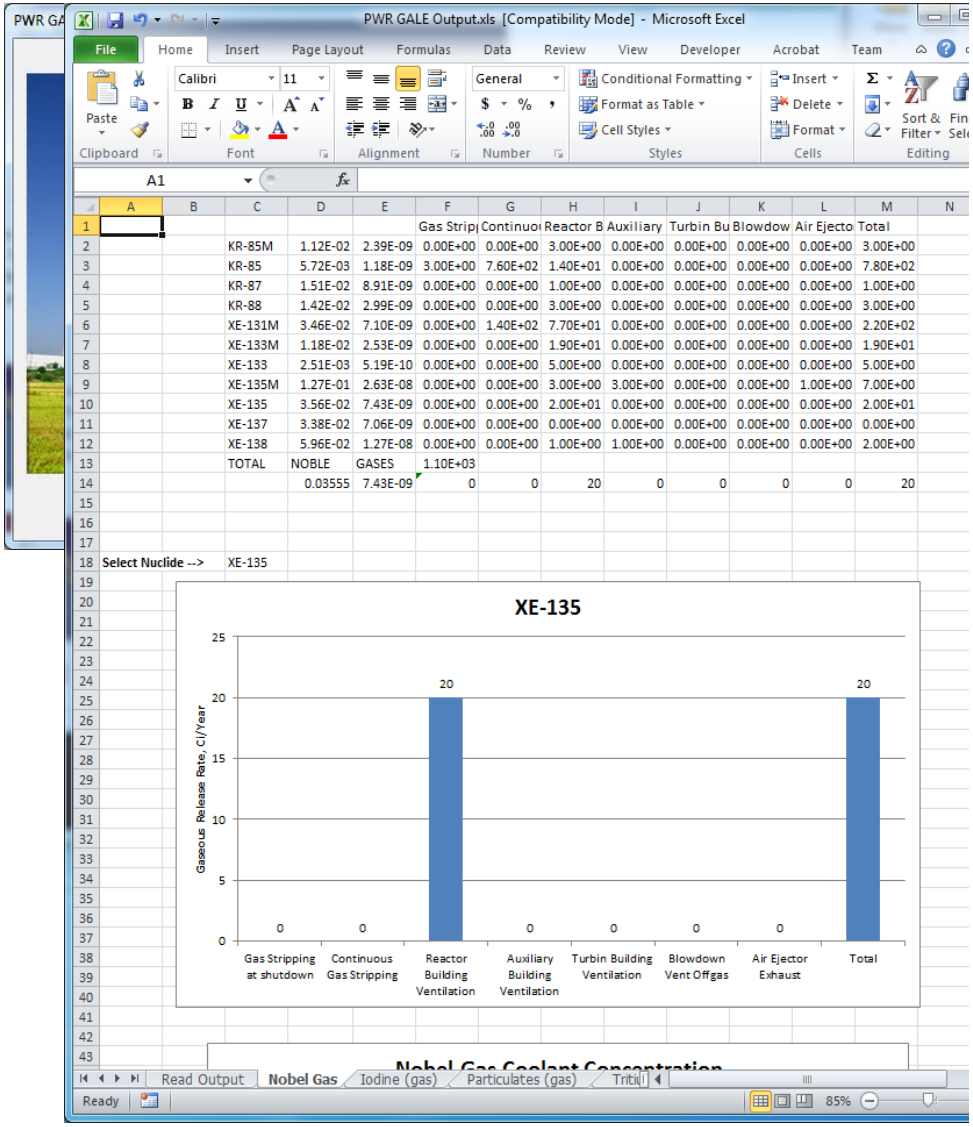
- Graphical User Interface
  - Uses standard Windows Dialog Boxes
- Specific Features
  - Ability to save input information and read previously set up input
  - Ability to read legacy input files from GALE
  - Built-in calculators to combine liquid waste from various sources
  - Built-in calculators to calculate liquid waste collection, processing, and discharge times
- Microsoft Excel worksheet has been included to visualize output and to facilitate use of output data in other calculations



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## Thursday

- GALE Overview
  - Purpose of Code
  - Code Requirements
  - History of Code Development
- GALE-2.0 (beta): Features and Validation
- Basics of Reactor Cleanup
- Code Demonstration
- Participants Set Up and Run GALE
- Q&A with GALE developers

## Friday

- GALE User's Group
  - Website
  - Training
  - Member Presentations
  - Technical Support
- Updates to ANS-18.1
- Activities Associated with GALE and SMRs
- Q&A and Wrap Up

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# 2015 Fall RAMP Meeting
# Welcome Wrap Up

**Stephanie Bush-Goddard, Ph. D.,**
**RAMP Program Manager**

**October 7th, 2015**

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# Goals of RAMP

- Venue to collaborate on radiation safety analysis codes to enhance safety worldwide
- Enhancements to codes/models from an experienced global user community
- Sharing of knowledge about radiation safety through “in-kind” contributions

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# Future of RAMP

- FY 2016 - Computer Codes add to RAMP
  - GENII
  - Atmospheric Codes
    - PAVAN
    - ARGON 96
    - XOQDOQ
- Cradle to Grave Nuclear Fuel Cycle Radiation Dose Computer Codes
  - Milling, Nuclear Operations, Emergency Response,
  - Accident, Environmental, Decommissioning
- Combining codes for efficiencies
- Country specific data

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# HTTPS://WWW.USNRC-RAMP.COM/


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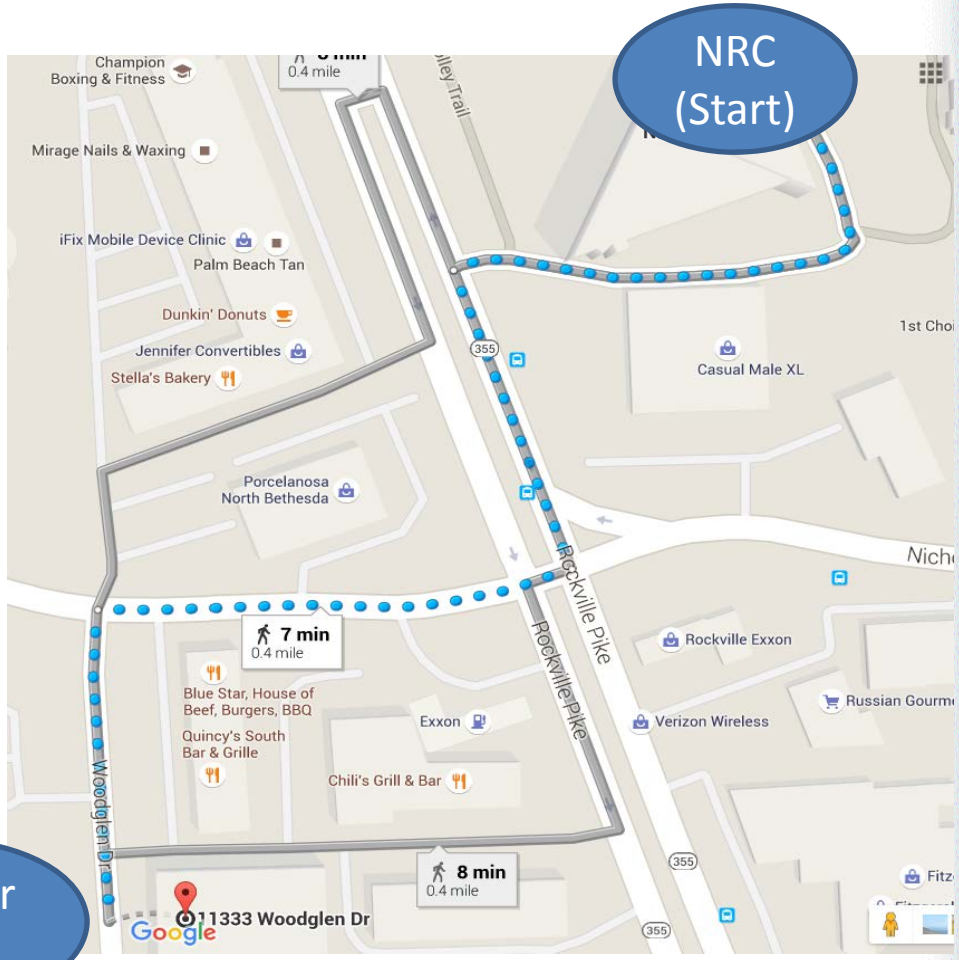
# TONIGHT: No Host Social Hour
# Wednesday, October 7th
# 5pm to 7pm

- Paladar Latin Kitchen and Rum Bar
- 11333 Woodglen Dr, Rockville, MD 20852
  Phone 301-816-1100
- 7 min walk from NRC



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# Thank You

- Your feedback is important to us.
- Please fill out a RAMP Evaluation

# QUESTIONS?