



2015 Fall RAMP Meeting





Welcome to the 2015 Fall RAMP Meeting





2015 Fall RAMP Meeting



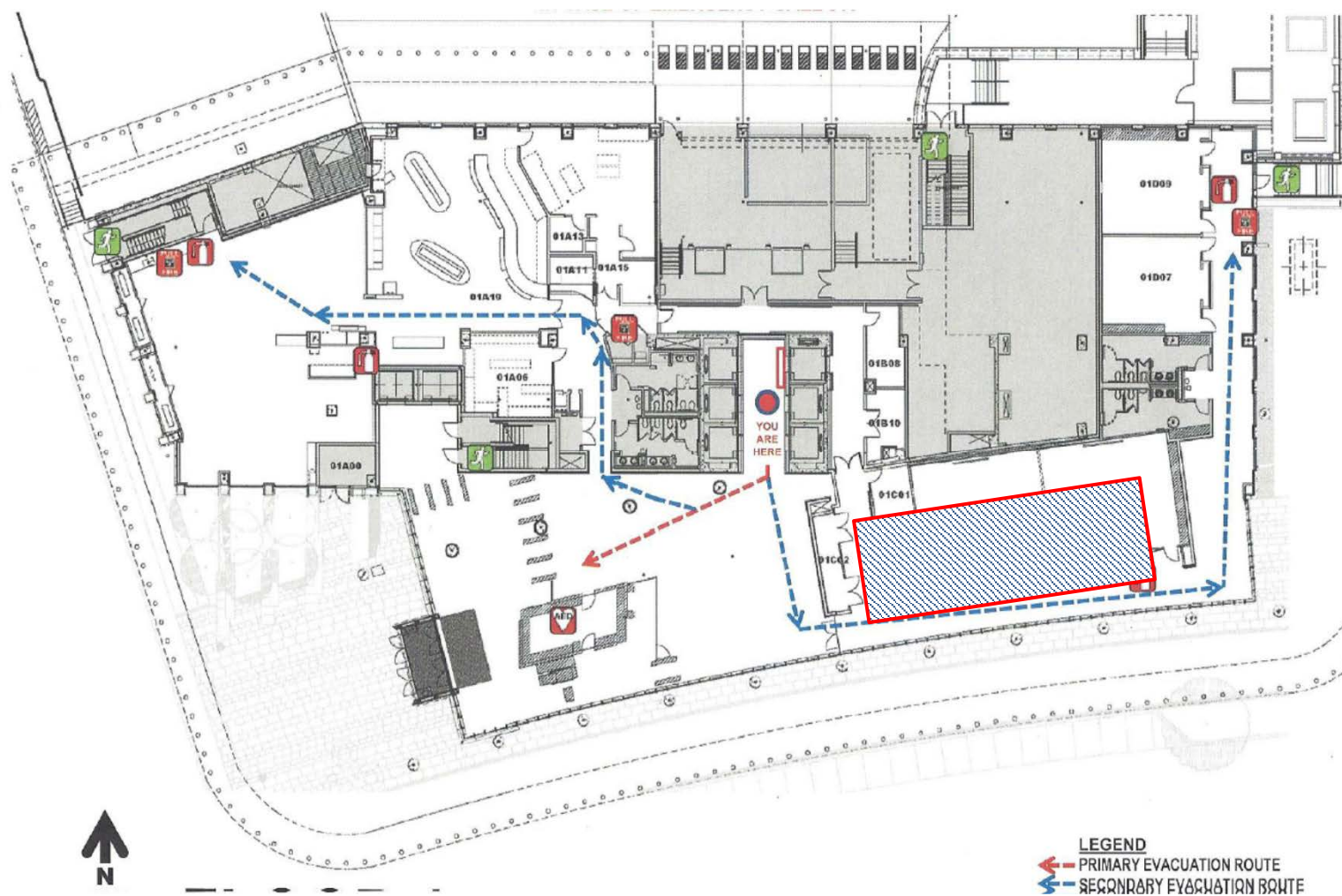
Stephanie Bush-Goddard, Ph. D.

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

October 7th, 2015

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



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



The Office of Nuclear Regulatory Research: Enhancing Radiation Protection Worldwide through Collaborative International Code Development



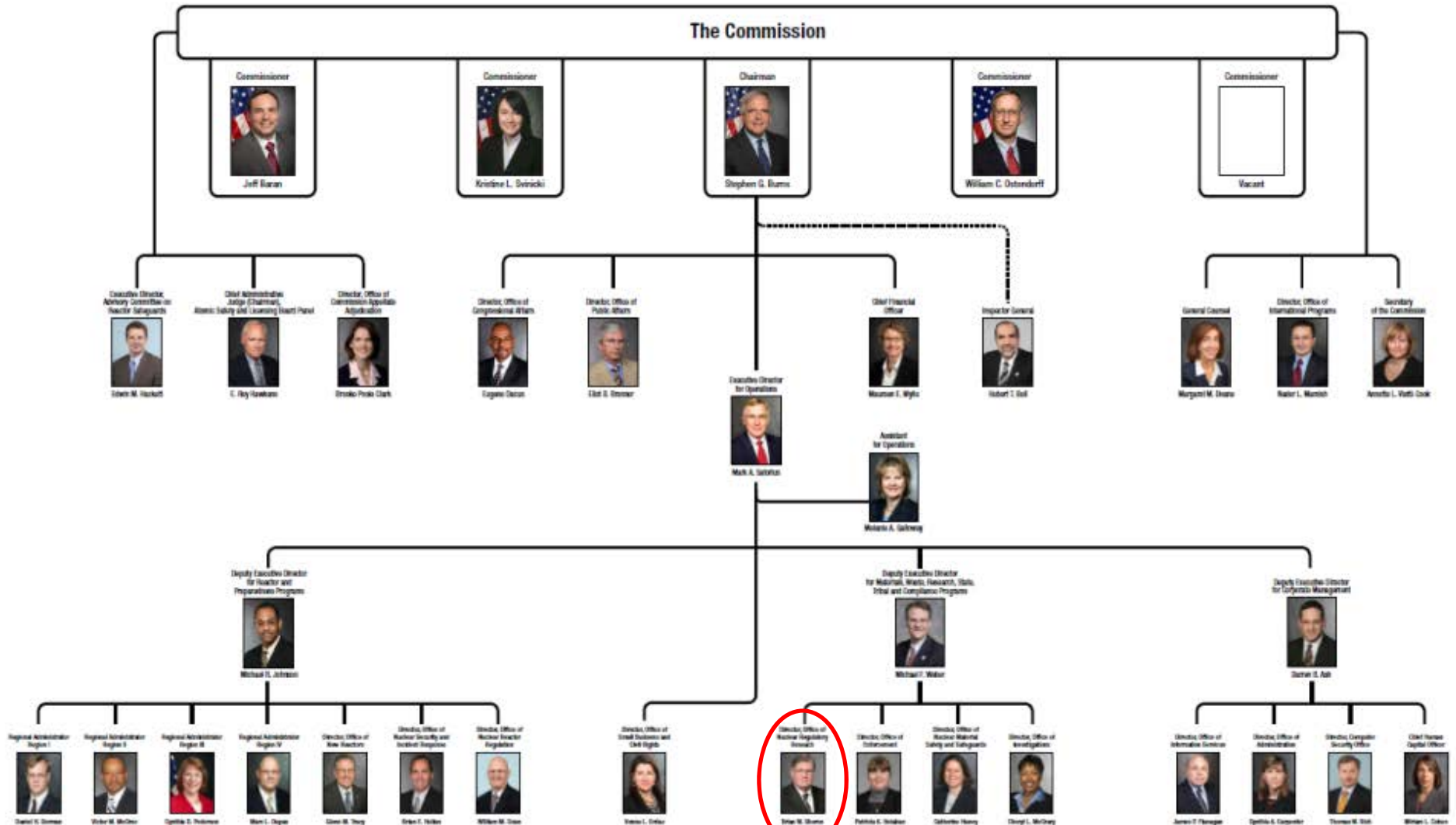
Dr. Brian Sheron
Office of Nuclear Regulatory Research

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

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



March 17, 2011

Nuclear Regulatory Research
(RES)

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





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.

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/>

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

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

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.

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

Again Welcome!

We are glad you are here!

THE RADIATION PROTECTION CODE ANALYSIS AND MAINTENANCE PROGRAM (RAMP)



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

AGENDA

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



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

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

WHO SHOULD JOIN RAMP

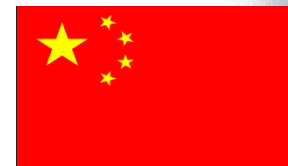
Who should Join RAMP?

- Regulators
- Licensees
- Licensee Vendor groups and etc.

Collaboration is Key

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



Program at a Glance

Monday, 10/5/2015 8am - 5pm	Tuesday, 10/6/2015 8am - 5pm	Wednesday, 10/7/15 8am - 5pm	Thursday, 10/8/15 8am - 5pm	Friday, 10/9/15 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	

Meet the RAMP Team



April Augustine, PMP
RAMP Project Manager
Pacific Northwest National Laboratory



RAMP Core Team



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

RAMP Users' Group Meeting 2015

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

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

RAMP Code Training

1st RAMP Users' Group Training:

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

RAMP Code Teams

RASCAL

- John Tomon, CHP U.S. NRC; COR
- Jeff Kowalczyk, 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

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.

RAMP Code Teams

VARSKIN

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

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

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

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

Networking Session

RASCAL

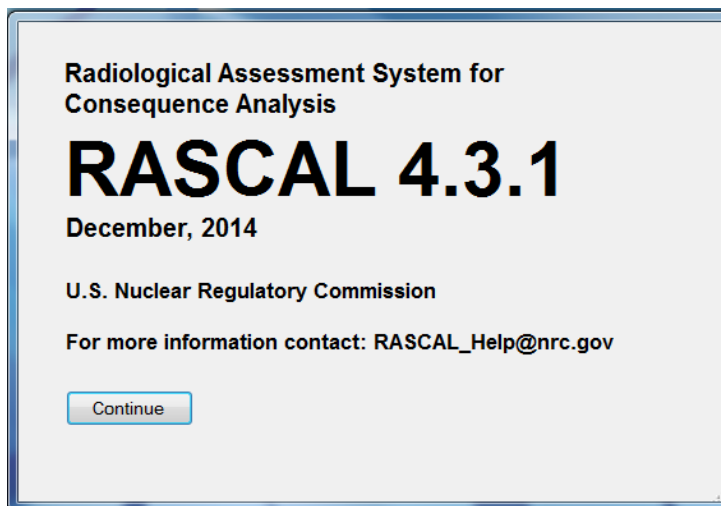


John Tomon, CHP
Radiation Protection Branch
Office of Nuclear Regulatory Research
The United States Nuclear Regulatory Commission

What is RASCAL?

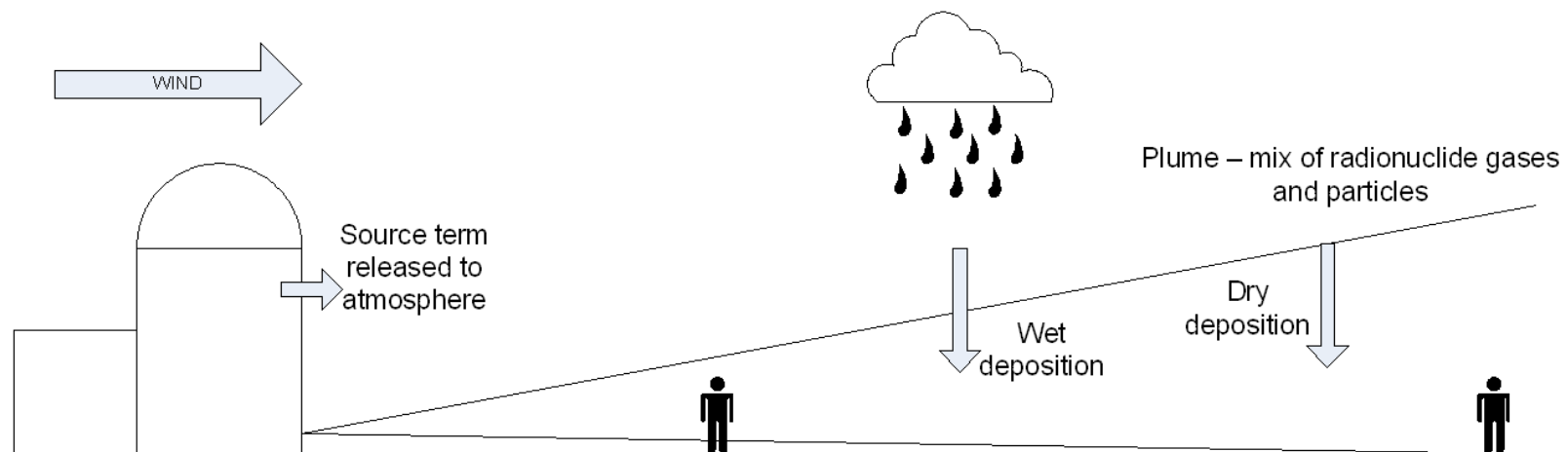
RASCAL

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

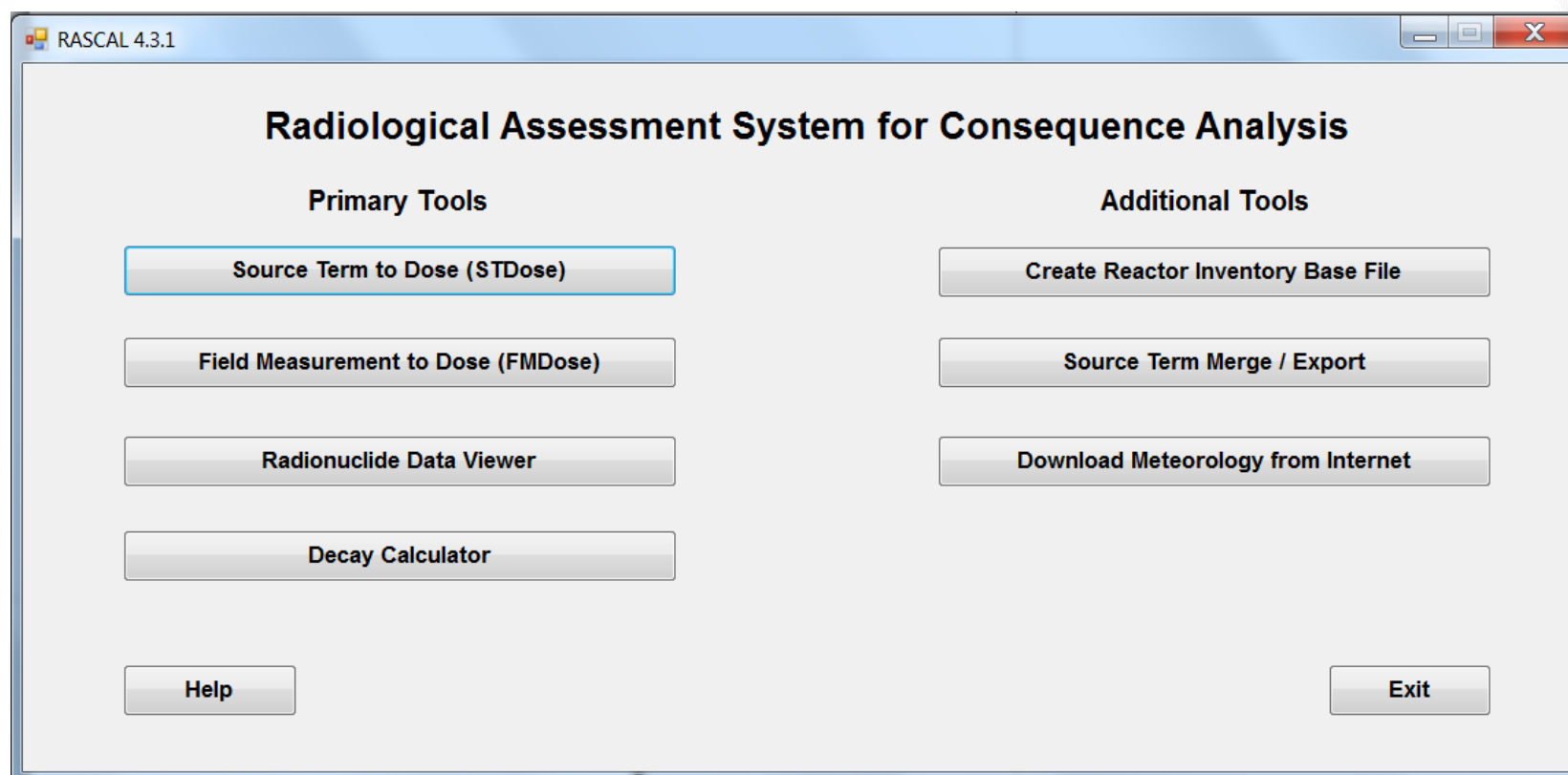


What does it do?

- RASCAL is an 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.



RASCAL Tools



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.

RASCAL Sequence

Steps

1

2

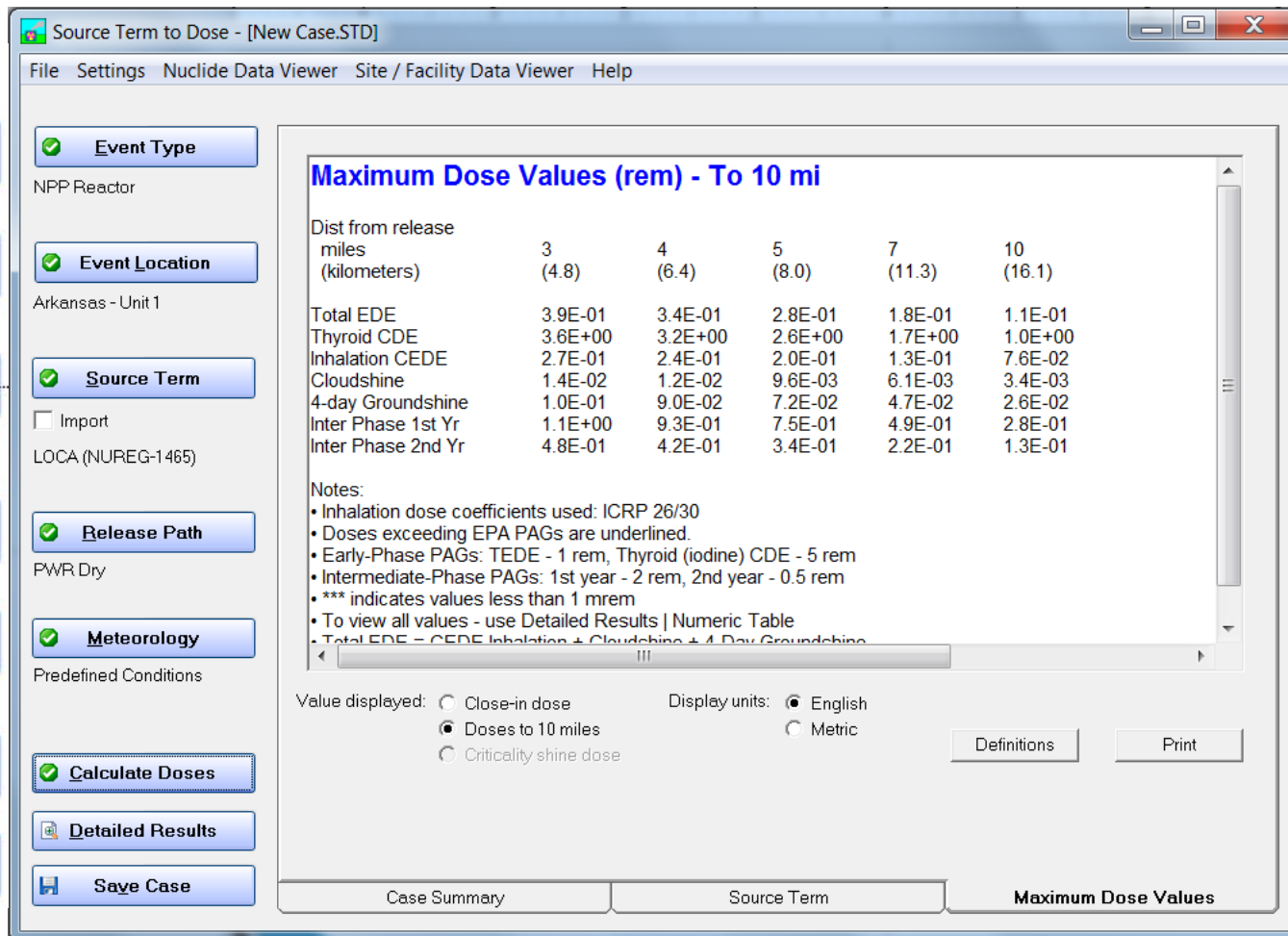
3

4

5

6

7



Source Term to Dose - [New Case.STD]

File Settings Nuclide Data Viewer Site / Facility Data Viewer Help

Event Type
NPP Reactor

Event Location
Arkansas - Unit 1

Source Term
☐ Import
LOCA (NUREG-1465)

Release Path
PWR Dry

Meteorology
Predefined Conditions

Calculate Doses

Detailed Results

Save Case

Maximum Dose Values (rem) - To 10 mi

Dist from release	3	4	5	7	10
miles					
(kilometers)	(4.8)	(6.4)	(8.0)	(11.3)	(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

Value displayed: ☐ Close-in dose ☒ Doses to 10 miles ☐ Criticality shine dose

Display units: ☒ English ☐ Metric

Definitions Print

Case Summary Source Term **Maximum Dose Values**

RASCAL Outputs

- Plume Footprints
- Max Dose Values
- Case Summary

Maximum Dose Values (rem) - Close-In

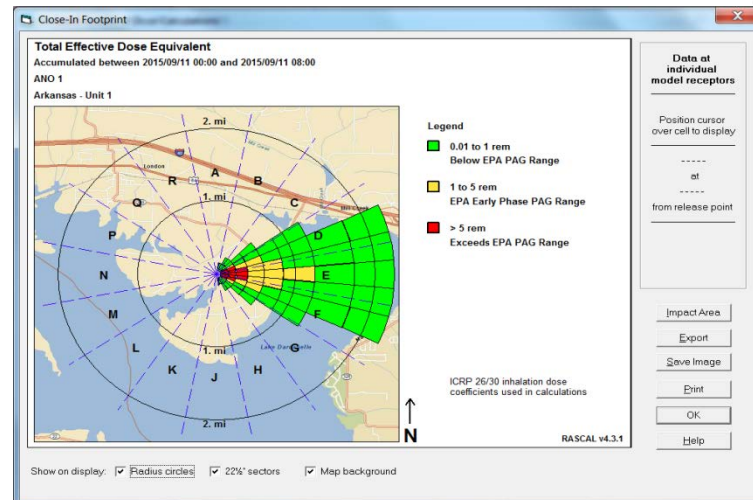
Dist from release miles (kilometers)	0.1 (0.16)	0.2 (0.32)	0.3 (0.48)	0.5 (0.8)	0.7 (1.13)	1. (1.61)	1.5 (2.41)	2. (3.22)
Total EDE	5.1E+01	1.6E+01	8.7E+00	4.0E+00	2.4E+00	1.3E+00	7.7E-01	6.0E-01
Thyroid CDE	4.7E+02	1.5E+02	7.9E+01	3.6E+01	2.1E+01	1.2E+01	7.0E+00	5.4E+00
Inhalation CEDE	3.6E+01	1.1E+01	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:

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- 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



Results of the Importance Calculations

Relative Importance of TEDE at End of Release

Days	0	1	7	30	183	365	1825	3650
TEDE	1.0E+00	5.0E-07	2.9E-07	1.1E-07	6.1E-08	4.9E-08	1.5E-08	7.5E-09

Relative Importance of Pathways to TEDE

Days	0	1	7	30	183	365	1825	3650
Cloudshine	3.4E-02	4.2E-04	2.8E-04	5.7E-05	3.0E-07	2.4E-07	9.2E-08	8.8E-08
Inhalation	9.7E-01	3.9E-02	3.9E-02	1.4E-02	8.9E-05	7.4E-05	5.1E-05	7.5E-05
Groundshine	5.5E-07	9.6E-01	9.6E-01	9.9E-01	1.0E+00	1.0E+00	1.0E+00	1.0E+00

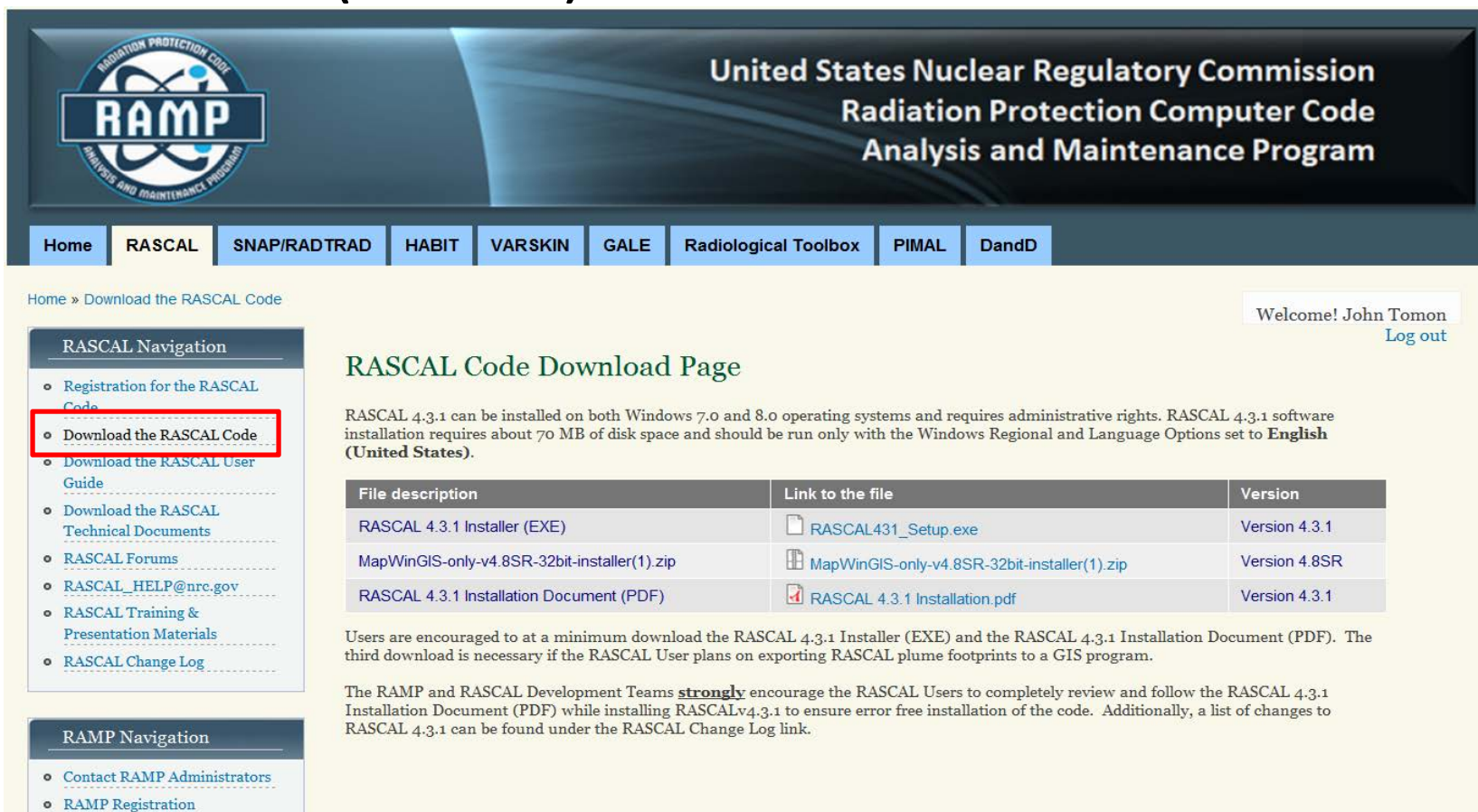
Cumulative Importance to Dose at t = 0 days

Rank	Nuclide	Cloudshine Cumulative Fraction	Nuclide	Inhalation Cumulative Fraction	Nuclide	Groundshine Cumulative Fraction	Nuclide	Ingestion Cumulative Fraction	Nuclide	TEDE Cumulative Fraction
1	I-132	0.26	I-131	0.26	I-132	0.22	I-131	0.29	I-131	0.25
2	I-135	0.43	Sr-90	0.43	I-135	0.34	Ce-134	0.47	Sr-90	0.42
3	I-133	0.54	Pu-241	0.52	Rb-88	0.44	Te-132	0.59	Pu-241	0.51
4	Kr-88	0.64	I-133	0.60	I-133	0.54	I-133	0.68	I-133	0.58
5	Xe-135	0.71	Sr-89	0.67	Ce-134	0.61	Ce-137m	0.76	Sr-89	0.65
6	I-131	0.75	Cm-242	0.73	Te-132	0.67	Ba-140	0.83	Cm-242	0.71
7	Rb-88	0.79	Te-132	0.79	Te-131m	0.71	Sr-90	0.86	Te-132	0.77
8	Xe-133	0.82	Ce-134	0.85	Ce-136	0.74	Sr-89	0.89	Ce-134	0.82
9	Ce-134	0.85	Ce-144*	0.89	I-131	0.78	Te-131m	0.91	Ce-144*	0.87
10	Te-132	0.87	Ce-137m	0.92	La-140	0.82	Np-239	0.92	Ce-137m	0.89
11	Te-131m	0.88	Ru-106*	0.93	Sr-91	0.85	Ce-136	0.93	I-135	0.91
12	La-140	0.90	Ba-140	0.94	Ba-140	0.87	I-135	0.94	Ru-106*	0.92
13	Ce-136	0.90	I-135	0.94	Pa-233	0.90	La-140	0.96	Ba-140	0.93

Print full file Help Close

Latest Version of the Code

- RASCAL (v 4.3.1)



The screenshot shows the RASCAL Code Download Page on the United States Nuclear Regulatory Commission website. The page features a header with the RAMP logo and the text "United States Nuclear Regulatory Commission Radiation Protection Computer Code Analysis and Maintenance Program". Below the header is a navigation bar with links to Home, RASCAL, SNAP/RADTRAD, HABIT, VARSKIN, GALE, Radiological Toolbox, PIMAL, and DandD. The main content area is titled "RASCAL Code Download Page" and includes a welcome message for John Tomon. A sidebar on the left contains a "RASCAL Navigation" menu with links to Registration, Download the RASCAL Code (highlighted with a red box), Download the RASCAL User Guide, Download the RASCAL Technical Documents, RASCAL Forums, RASCAL_HELP@nrc.gov, RASCAL Training & Presentation Materials, and RASCAL Change Log. Below this is a "RAMP Navigation" menu with links to Contact RAMP Administrators and RAMP Registration. The main content area also includes a table of download links and a paragraph of instructions.

Home » Download the RASCAL Code

Welcome! John Tomon
[Log out](#)

RASCAL Code Download Page

RASCAL 4.3.1 can be installed on both Windows 7.0 and 8.0 operating systems and requires administrative rights. RASCAL 4.3.1 software installation requires about 70 MB of disk space and should be run only with the Windows Regional and Language Options set to **English (United States)**.

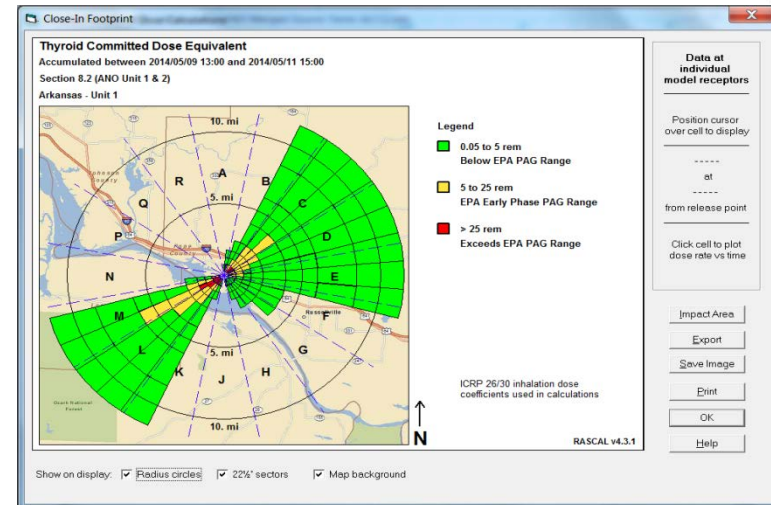
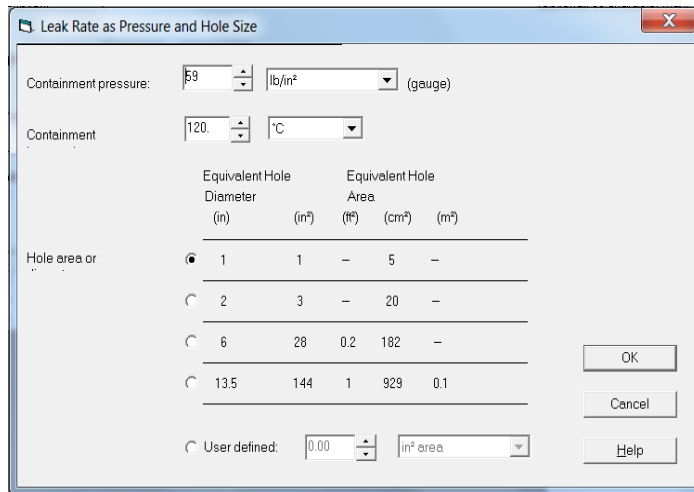
File description	Link to the file	Version
RASCAL 4.3.1 Installer (EXE)	RASCAL431_Setup.exe	Version 4.3.1
MapWinGIS-only-v4.8SR-32bit-installer(1).zip	MapWinGIS-only-v4.8SR-32bit-installer(1).zip	Version 4.8SR
RASCAL 4.3.1 Installation Document (PDF)	RASCAL 4.3.1 Installation.pdf	Version 4.3.1

Users are encouraged to at a minimum download the RASCAL 4.3.1 Installer (EXE) and the RASCAL 4.3.1 Installation Document (PDF). The third download is necessary if the RASCAL User plans on exporting RASCAL plume footprints to a GIS program.

The RAMP and RASCAL Development Teams **strongly** encourage the RASCAL Users to completely review and follow the RASCAL 4.3.1 Installation Document (PDF) while installing RASCALv4.3.1 to ensure error free installation of the code. Additionally, a list of changes to RASCAL 4.3.1 can be found under the RASCAL Change Log link.

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

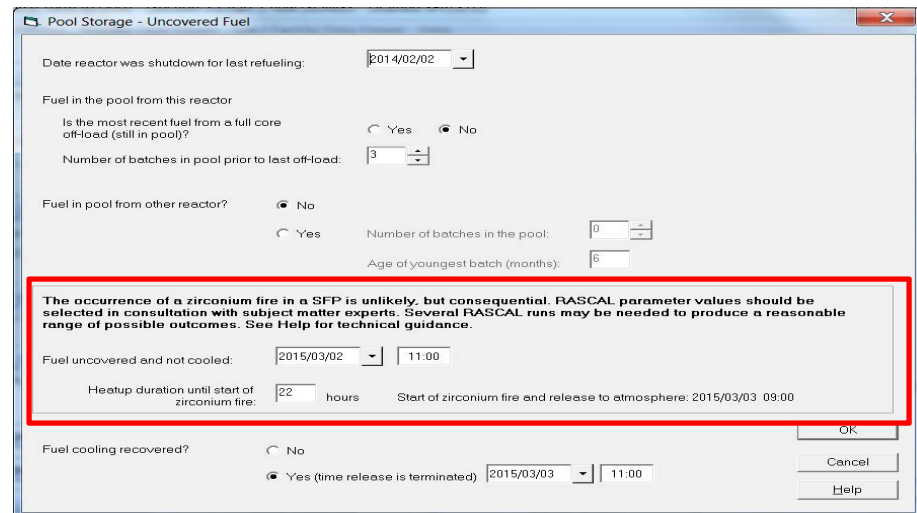
Leak Rate as Pressure and Hole Size

Containment pressure: 59 lb/in² (gauge)

Containment temperature: 120 °C

Equivalent Hole Diameter (in)	Equivalent Hole Area (in²)	Equivalent Hole Diameter (in)	Equivalent Hole Area (cm²)
1	1	5	-
2	3	20	-
6	28	0.2	182
13.5	144	1	929

User defined: 0.00 in² area



Pool Storage - Uncovered Fuel

Date reactor was shutdown for last refueling: 2014/02/02

Fuel in the pool from this reactor
Is the most recent fuel from a full core off-load (still in pool)? ☐ Yes ☒ No

Number of batches in pool prior to last off-load: 3

Fuel in pool from other reactor? ☒ No ☐ Yes

Number of batches in the pool: 0

Age of youngest batch (months): 6

The occurrence of a zirconium fire in a SFP is unlikely, but consequential. RASCAL parameter values should be selected in consultation with subject matter experts. Several RASCAL runs may be needed to produce a reasonable range of possible outcomes. See Help for technical guidance.

Fuel uncovered and not cooled: 2015/03/02 11:00

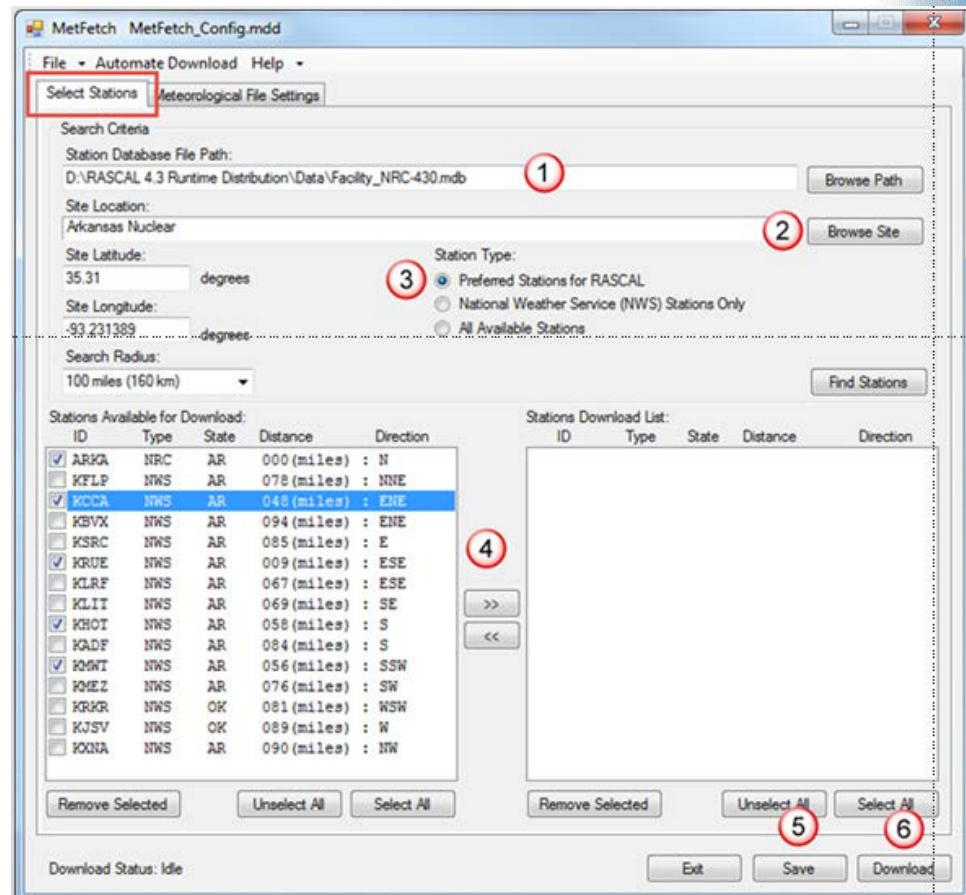
Heatup duration until start of zirconium fire: 22 hours

Start of zirconium fire and release to atmosphere: 2015/03/03 09:00

Fuel cooling recovered? ☐ No ☒ Yes (time release is terminated) 2015/03/03 11:00

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



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).

SNAP/RADTRAD



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

What is RADTRAD?

RADTRAD

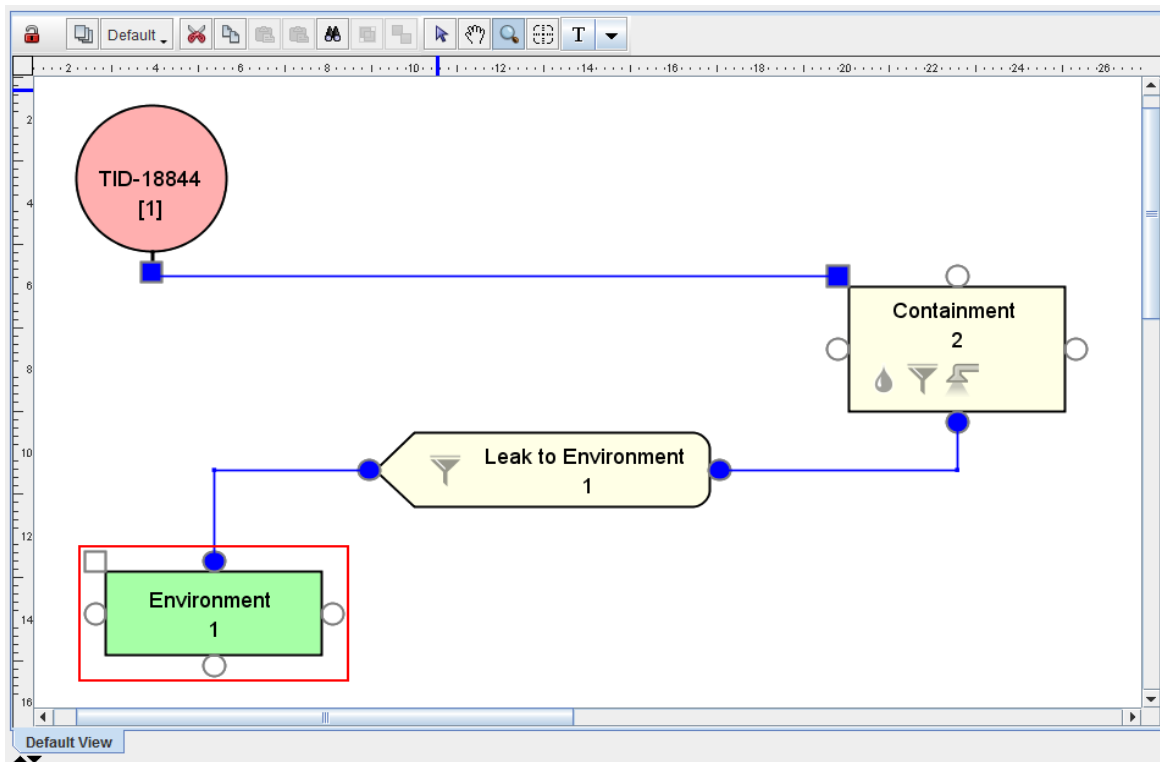
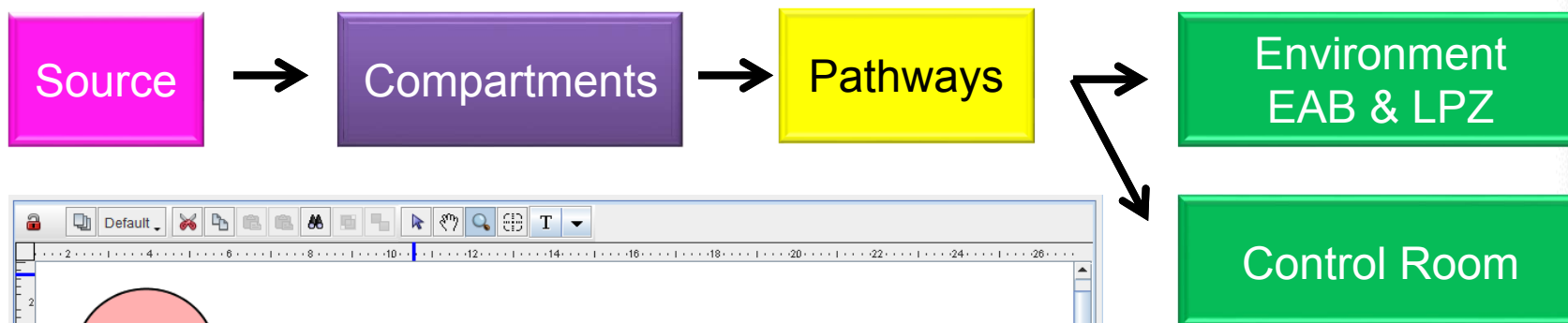
RADionuclide **T**ransport, **R**emoval **A**nd **D**ose Estimation
computer code.

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.

RADTRAD Sequence



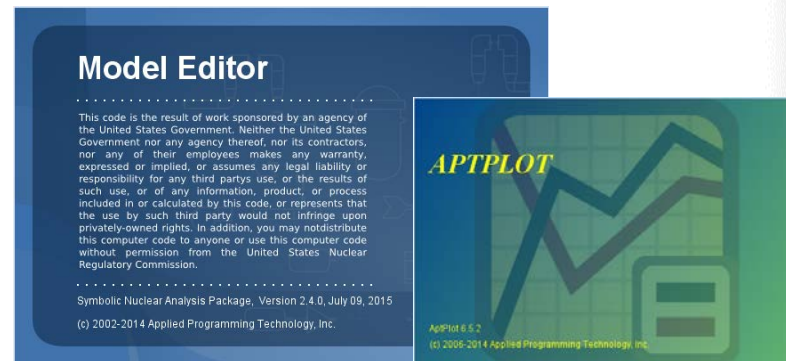

**Symbolic
Nuclear Analysis
Package (SNAP)**

How is it used?

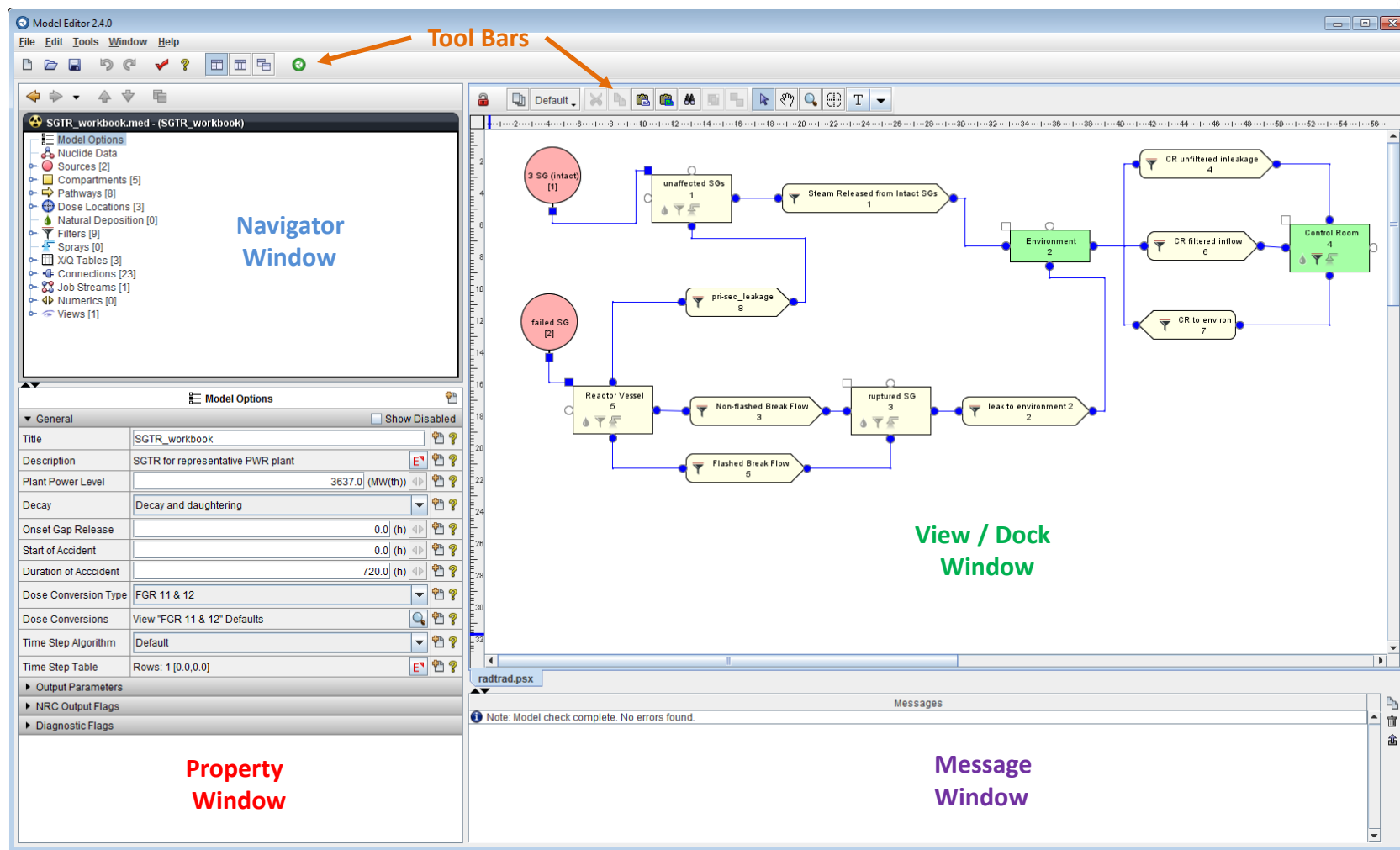
- The NRC uses RADTRAD as licensing analysis code to verify that the plant's design and the licensee's offsite and control room dose calculations following a DBA meet the following criteria:
 - 10 CFR Part 100, "Reactor Site Criteria"
 - 10 CFR 50.67, "Accident Source Term"
 - 10 CFR 50.34, "Contents 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)

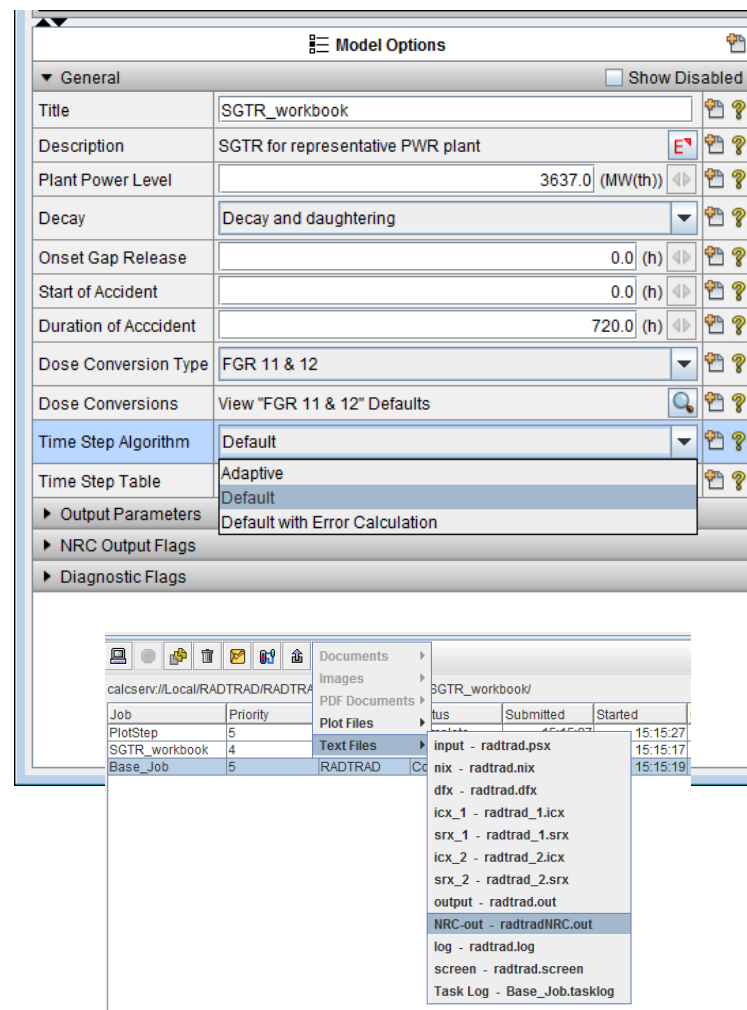


SNAP/RADTRAD Model Editor



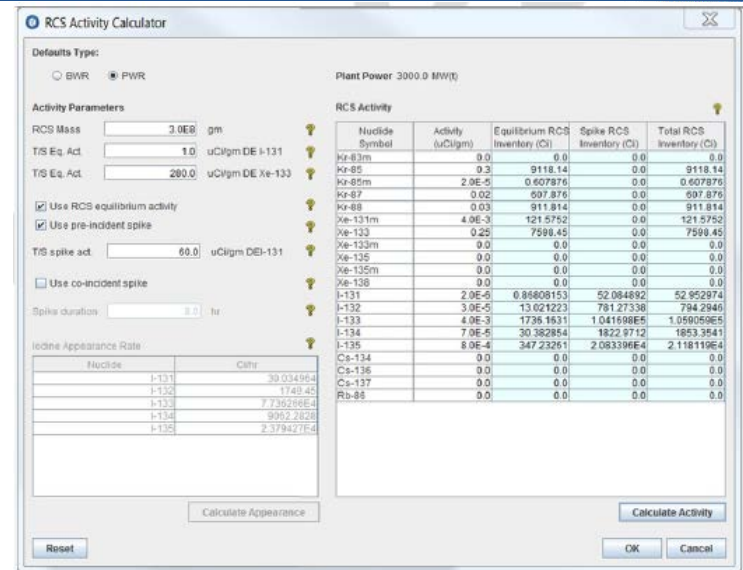
New Features

- 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



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)



RCS Activity Calculator

Defaults Type: ☐ BWR ☒ PWR

Plant Power: 3000.0 MW(t)

Activity Parameters

RCS Mass: 2.0E8 gm

T/S Eq. Act: 1.0 uCi/gm DE I-131

T/S Eq. Act: 200.0 uCi/gm DE Xe-133

☒ Use RCS equilibrium activity

☒ Use pre-incident spike

T/S spike act: 60.0 uCi/gm DE I-131

☐ Use co-incident spike

Spike duration: 2.0 hr

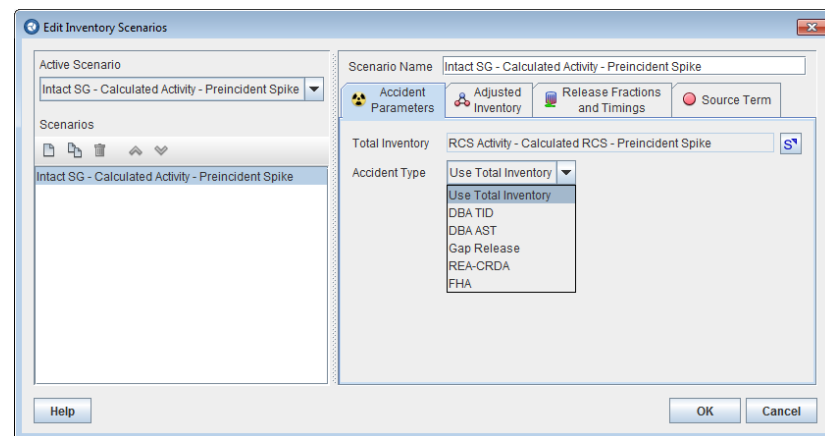
Iodine Appearance Rate

Nuclide	Ci/hr
I-131	39.034954
I-132	1749.45
I-133	7.735296E-4
I-134	9052.2828
I-135	2.379427E-4

RCS Activity

Nuclide Symbol	Activity (uCi/gm)	Equilibrium RCS Inventory (Ci)	Spike RCS Inventory (Ci)	Total RCS Inventory (Ci)
Kr-83m	0.0	0.0	0.0	0.0
Kr-85	0.3	9118.14	0.0	9118.14
Kr-85m	2.0E-5	0.607876	0.0	0.607876
Kr-87	0.02	697.876	0.0	697.876
Kr-88	0.03	911.814	0.0	911.814
Xe-131m	4.0E-3	121.5752	0.0	121.5752
Xe-133	0.25	7598.45	0.0	7598.45
Xe-133m	0.0	0.0	0.0	0.0
Xe-135	0.0	0.0	0.0	0.0
Xe-135m	0.0	0.0	0.0	0.0
Xe-138	0.0	0.0	0.0	0.0
I-131	2.0E-6	0.84608153	52.084862	52.952974
I-132	3.0E-5	13.021223	781.27338	794.2946
I-133	4.0E-3	1736.1631	1.041698E5	1.050059E5
I-134	7.0E-5	30.382854	1822.9712	1853.3541
I-135	8.0E-4	347.23261	2.083398E4	2.118119E4
Cs-134	0.0	0.0	0.0	0.0
Cs-136	0.0	0.0	0.0	0.0
Cs-137	0.0	0.0	0.0	0.0
Rb-88	0.0	0.0	0.0	0.0

Buttons: Calculate Appearance, Calculate Activity, Reset, OK, Cancel



Edit Inventory Scenarios

Active Scenario: Intact SG - Calculated Activity - Preincident Spike

Scenarios: Intact SG - Calculated Activity - Preincident Spike

Scenario Name: Intact SG - Calculated Activity - Preincident Spike

Accident Parameters | Adjusted Inventory | Release Fractions and Timings | Source Term

Total Inventory: RCS Activity - Calculated RCS - Preincident Spike

Accident Type: Use Total Inventory

Buttons: Help, OK, Cancel

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).

QUICK OVERVIEW OF VARSKIN



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

VARSKIN 5

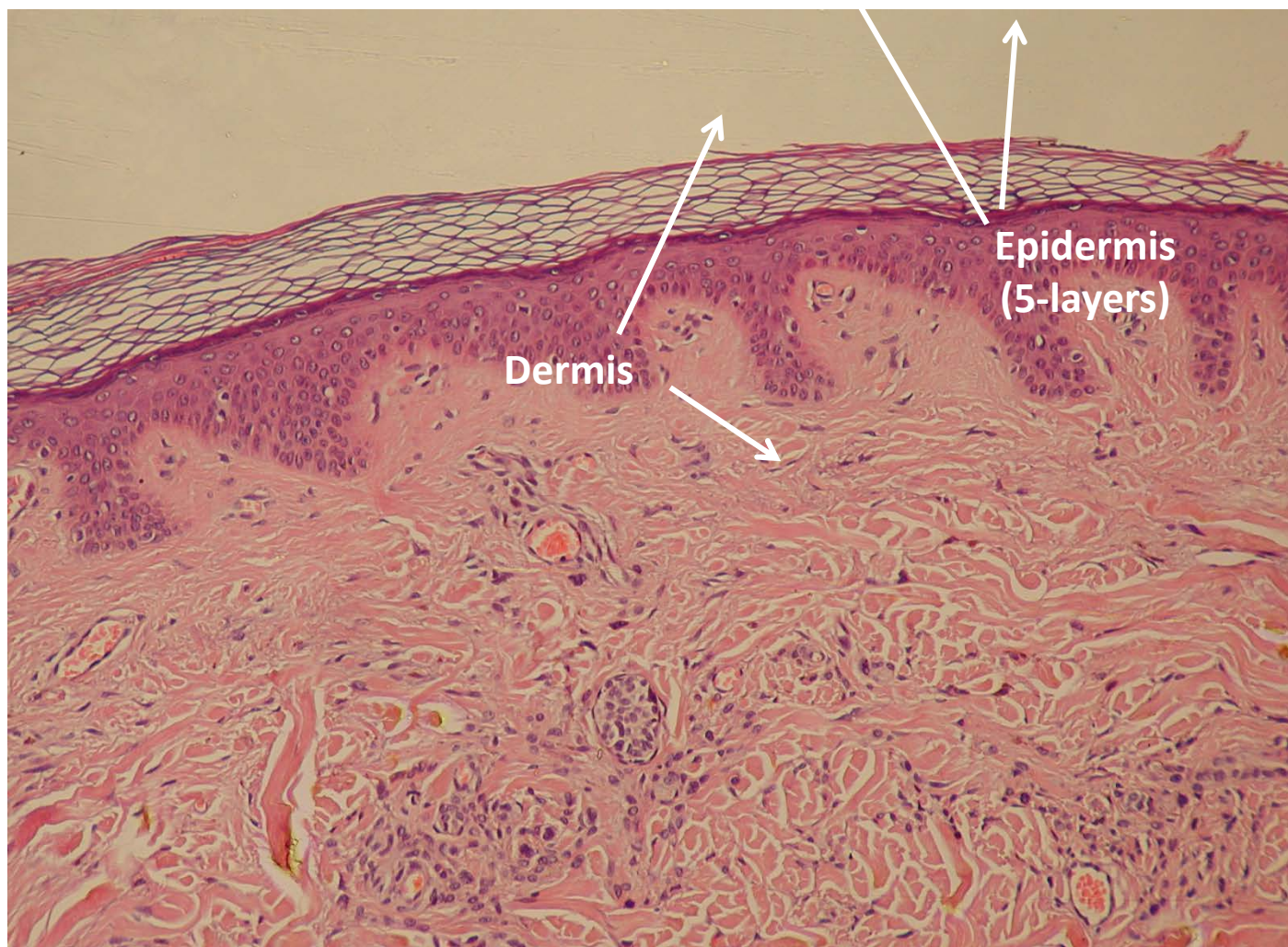
A Software Package to Estimate Ionizing Radiation Dose to the Skin Resulting from Radioactive Material Exposure

Mohammad Saba, Office of Nuclear Regulatory Research

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 developed by Oregon State University is VARSKIN 5.2.

Skin layers



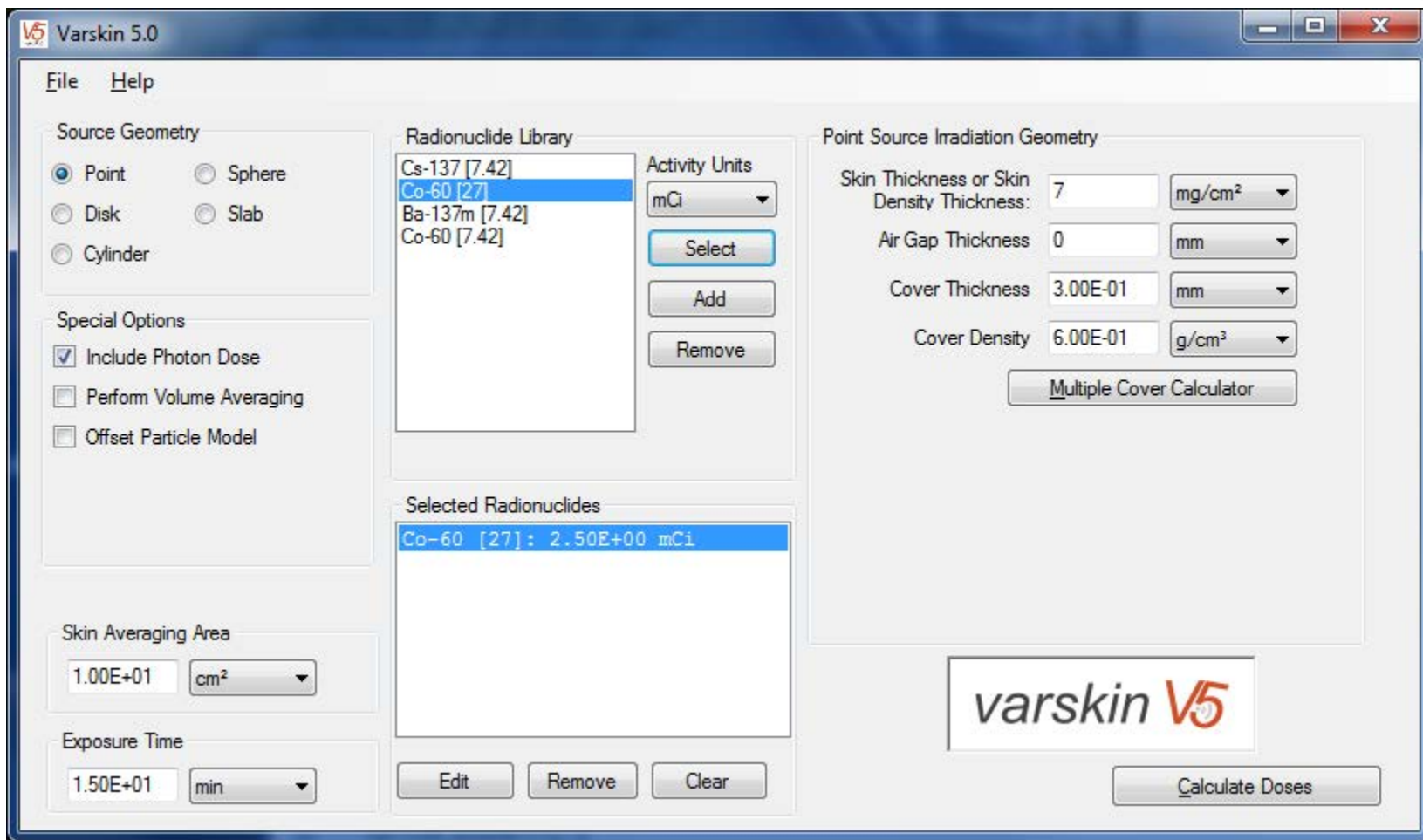
VARSKIN Photon Model

- 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 cm²
 - variable dose averaging techniques
 - 2D averaging areas (regulatory compliance)
 - 3D averaging volumes (detector simulation)

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

Input



The image shows the Varskin 5.0 software interface, which is used for calculating skin doses from radionuclides. The interface is divided into several sections:

- File Help**: Menu bar.
- Source Geometry**: Radio buttons for Point (selected), Sphere, Disk, Slab, and Cylinder.
- Special Options**: Checkboxes for Include Photon Dose (checked), Perform Volume Averaging, and Offset Particle Model.
- Skin Averaging Area**: Input field for 1.00E+01 cm².
- Exposure Time**: Input field for 1.50E+01 min.
- Radionuclide Library**: List of radionuclides: Cs-137 [7.42], Co-60 [27] (selected), Ba-137m [7.42], and Co-60 [7.42]. Activity Units are set to mCi. Buttons: Select, Add, Remove.
- Selected Radionuclides**: List showing Co-60 [27]: 2.50E+00 mCi. Buttons: Edit, Remove, Clear.
- Point Source Irradiation Geometry**: Input fields for Skin Thickness or Skin Density Thickness (7 mg/cm²), Air Gap Thickness (0 mm), Cover Thickness (3.00E-01 mm), and Cover Density (6.00E-01 g/cm³). A button for Multiple Cover Calculator is also present.
- Calculate Doses**: Button at the bottom right.

The Varskin V5 logo is displayed in the bottom right corner of the main window.

Output

Non Volume Averaged Results

Help

Radionuclide: Activity

Co-60 (7.42): 1.00E+00 µCi

All Radionuclides

Unit Selection
☒ English Units
☐ SI Units

	Initial Dose Rate	Dose (No Decay)	Decay-Corrected Dose		Initial Dose Rate	Dose (No Decay)	Decay-Corrected Dose
Beta	3.56E-01 rad/h	3.56E-01 rad	3.56E-01 rad	Beta	3.56E-01 rad/h	3.56E-01 rad	3.56E-01 rad
Photon	1.28E-02 rad/h	1.28E-02 rad	1.28E-02 rad	Photon	1.28E-02 rad/h	1.28E-02 rad	1.28E-02 rad
Total	3.69E-01 rad/h	3.69E-01 rad	3.69E-01 rad	Total	3.69E-01 rad/h	3.69E-01 rad	3.69E-01 rad

Date/Time: 6/11/2013 8:44:35 AM Source Geometry: Point Source

Air Gap Thickness: 0.00E+00 mm Irradiation Time: 6.00E+01 min

Skin density thickness: 7.00E+00 mg/cm² Irradiation Area: 1.00E+01 cm²

Print Results Close

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

Background

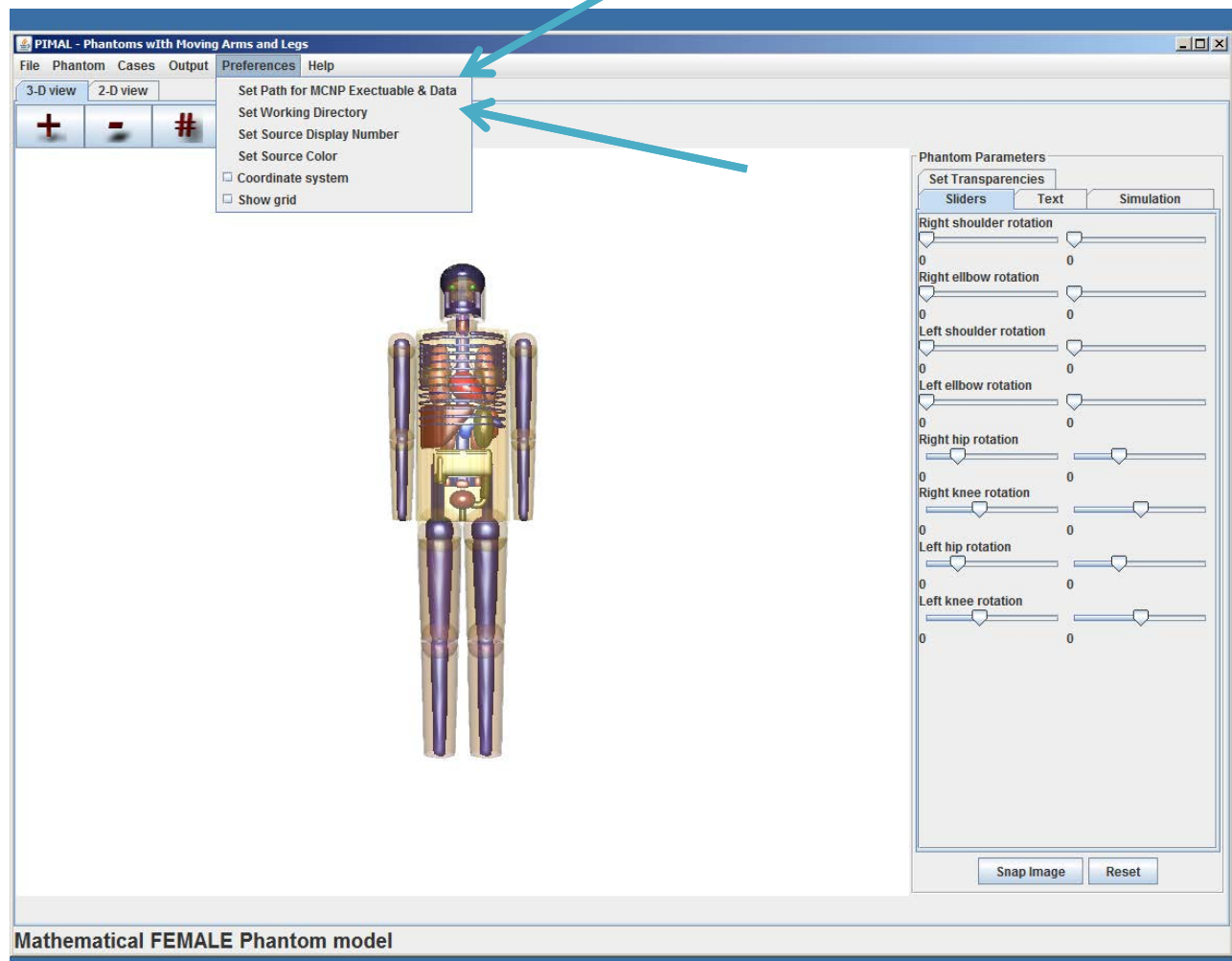
In order to model scenarios of radiation exposure to the human body either from internal or external sources. NRC partnered with Oak Ridge National Laboratory to develop the PIMAL(Phantom with Moving Arms and Legs) phantom utilizing a graphical user interface (GUI).

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.

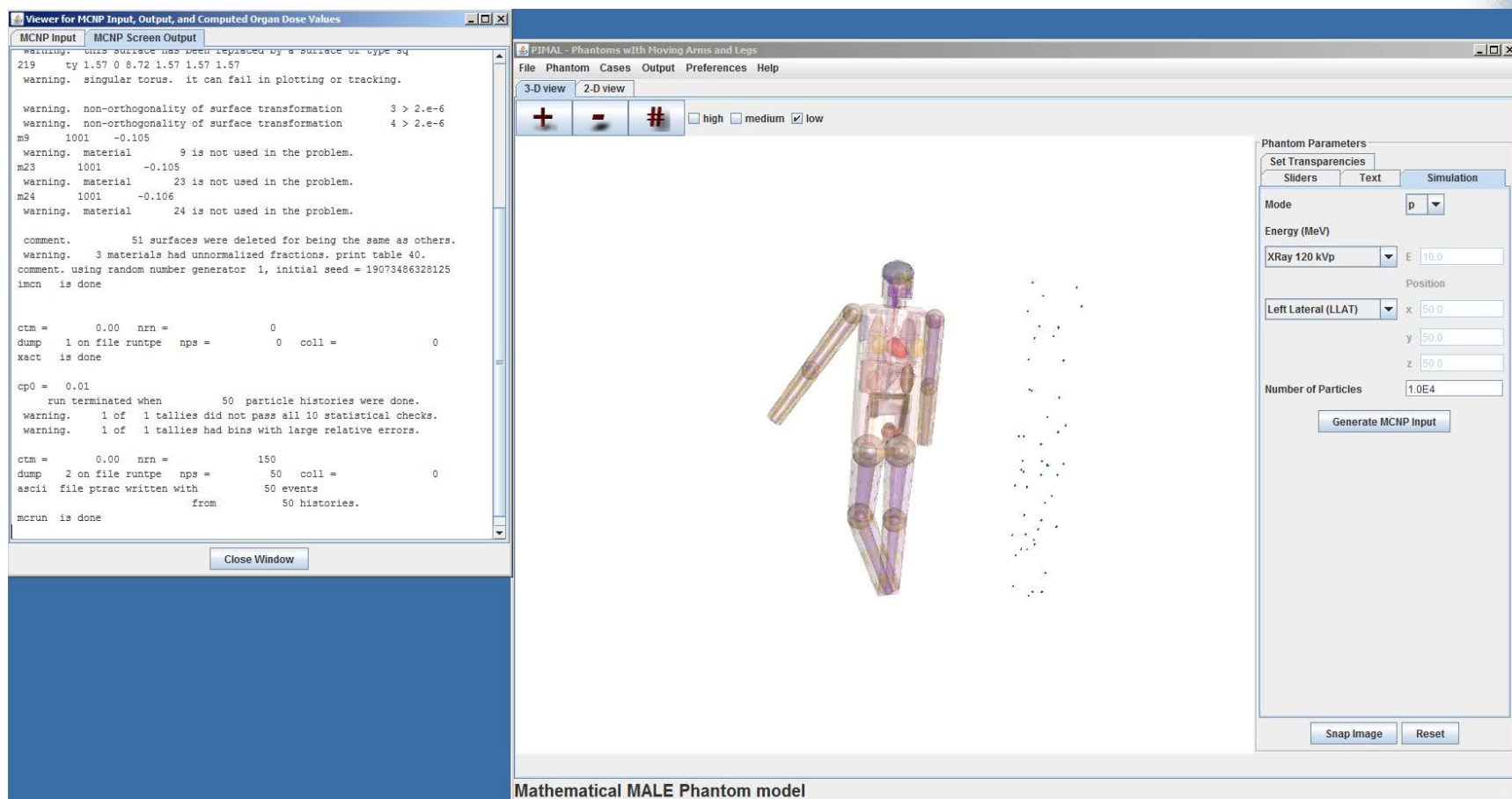
Background

- 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.

Basic settings

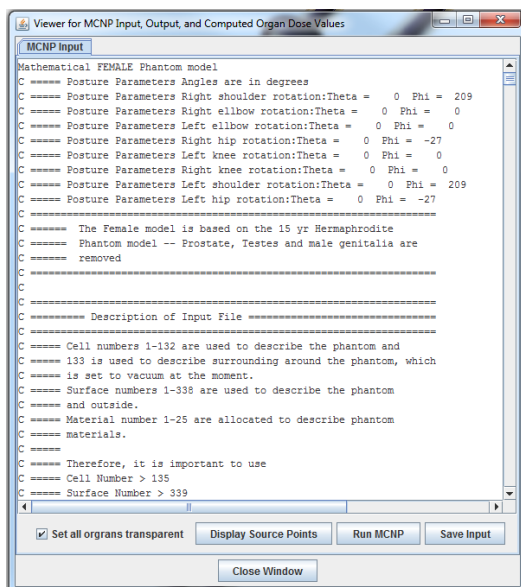


Features – MCNP simulation inside PIMAL

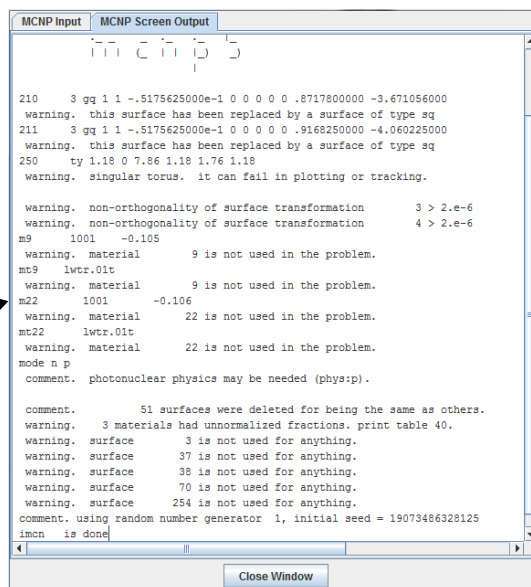


Users may choose to run basic calculations from inside PIMAL.

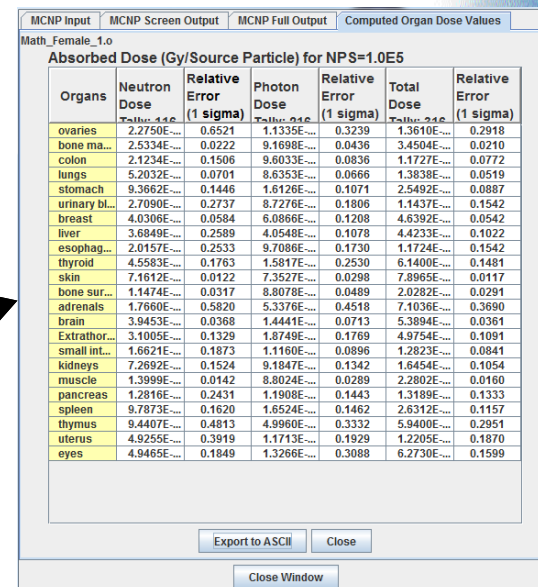
Features – Basic MCNP Workflow



Step 1.
Generate MCNP
Input



Step 2.
Run MCNP inside
PIMAL



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 Table 446	Relative Error (1 sigma)	Photon Dose Table 916	Relative Error (1 sigma)	Total Dose Table 246	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...	0.0038	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

Step 3.
View organ
absorbed dose

Features – Organ Dose Values

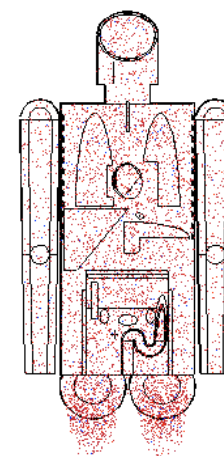
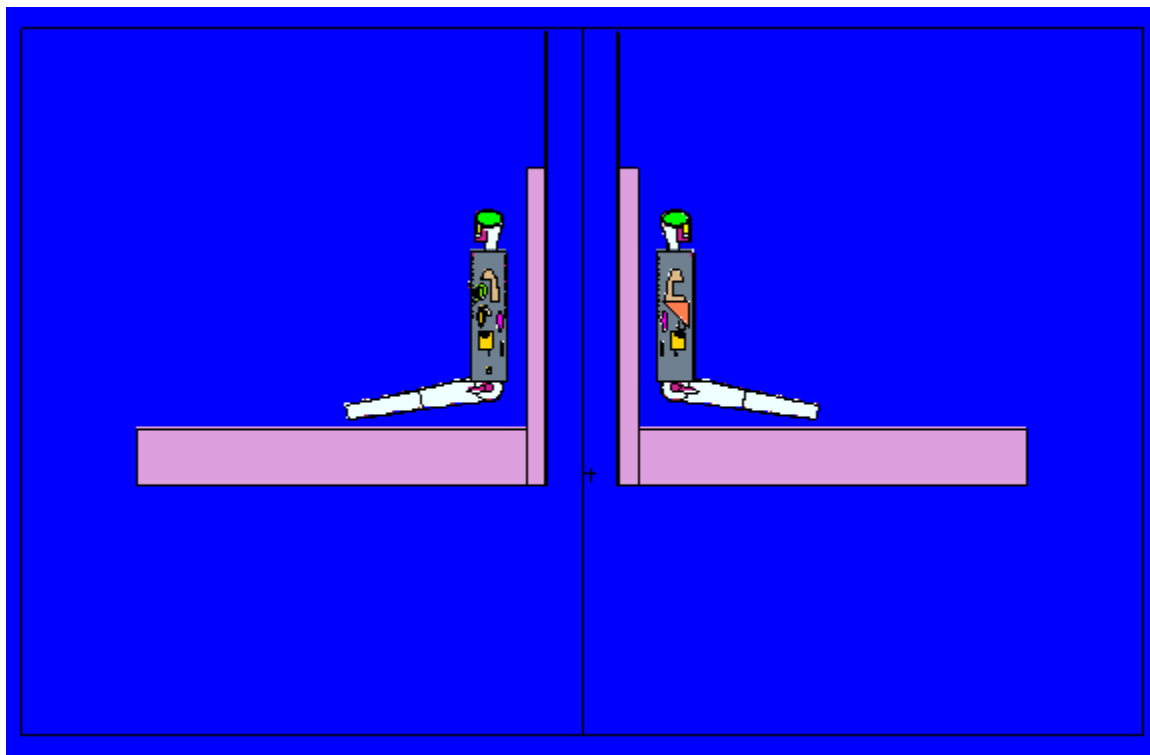
MCNP Input MCNP Screen Output MCNP Full Output Computed Organ Dose Values						
Math_Female_1.0						
Absorbed Dose (Gy/Source Particle) for NPS=1.0E5						
Organs	Neutron Dose <small>Tally 116</small>	Relative Error (1 sigma)	Photon Dose <small>Tally 216</small>	Relative Error (1 sigma)	Total Dose <small>Tally 216</small>	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

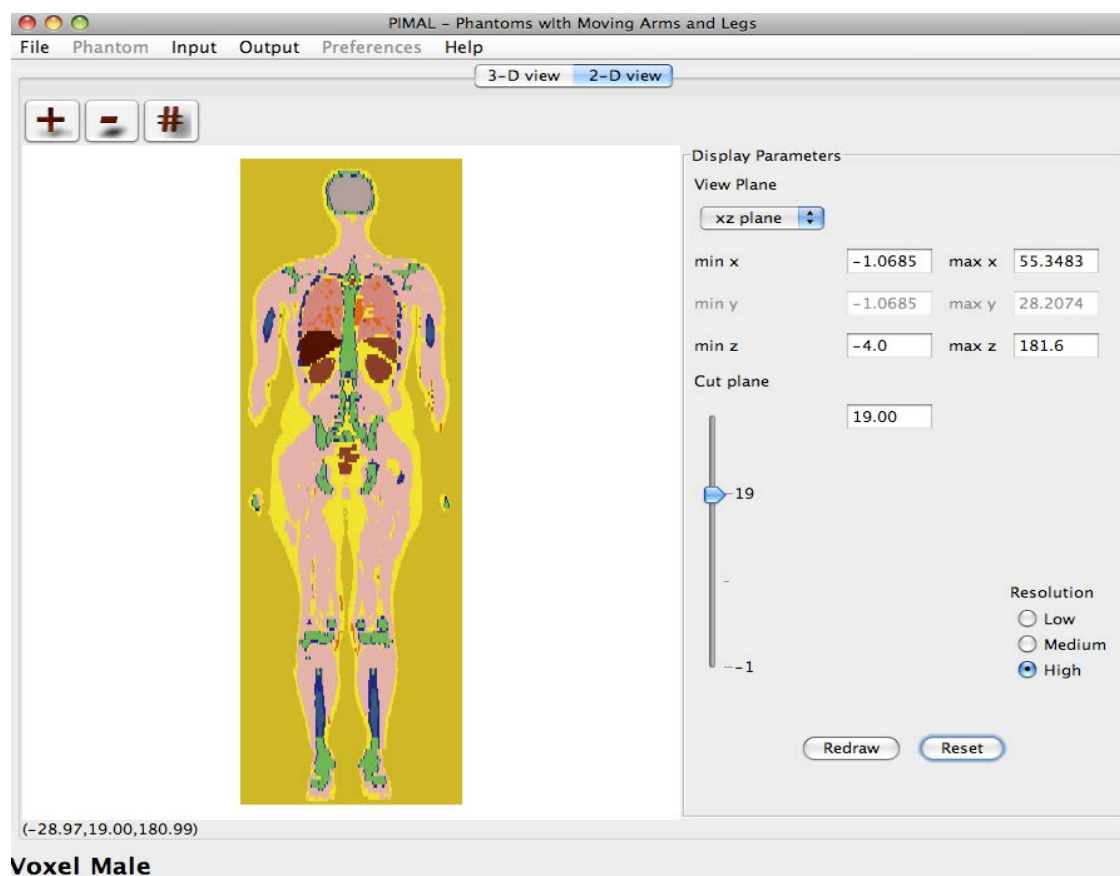
Close Window

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

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

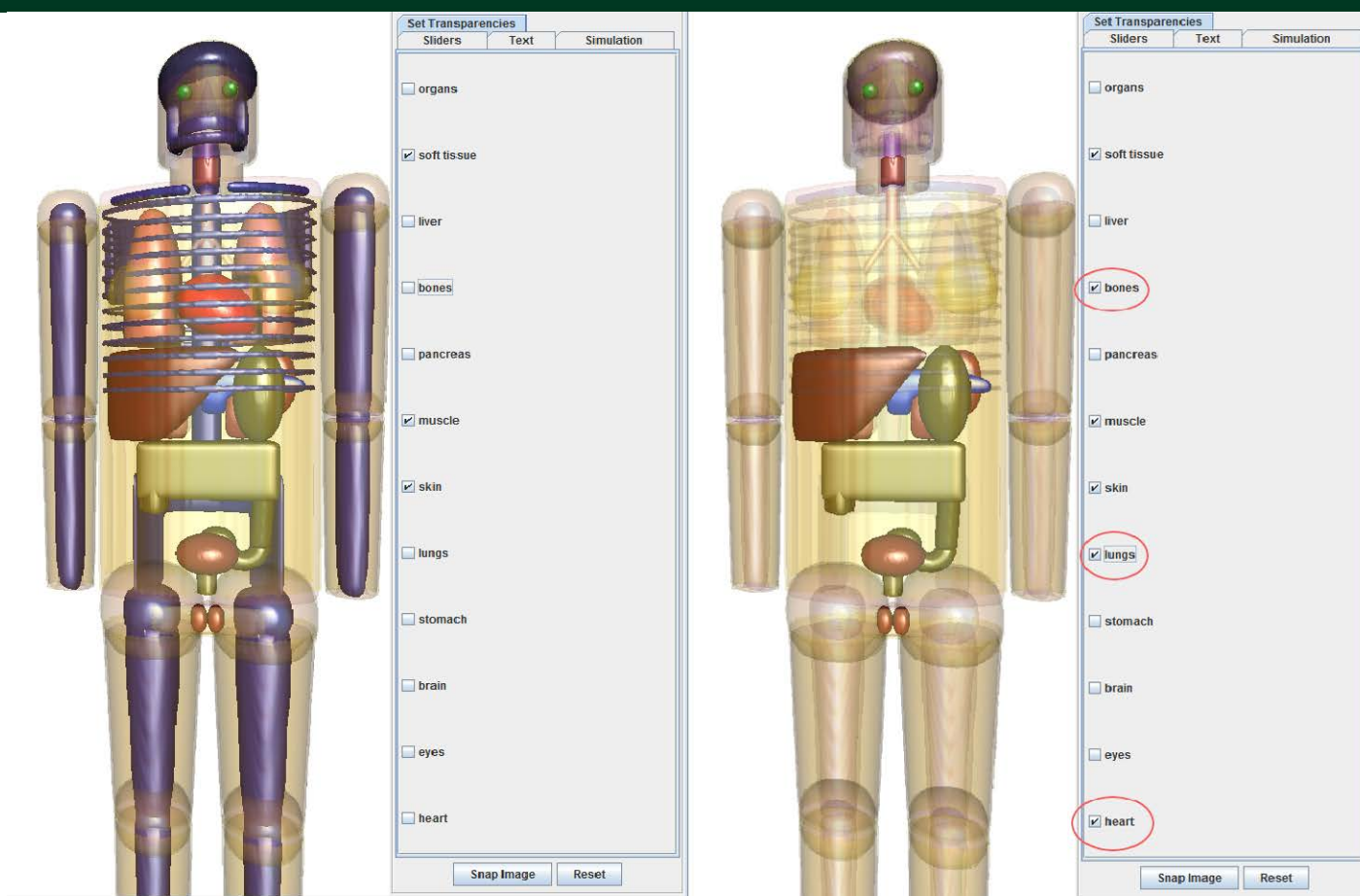


Features - Two dimensional cross section view



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

Features –Organ Visualizations



PIMAL users may toggle organ transparencies to highlight important tissues.

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

COMPUTER CODES IN RAMP



HABIT

CODE FOR ASSESSING CONTROL ROOM HABITABILITY

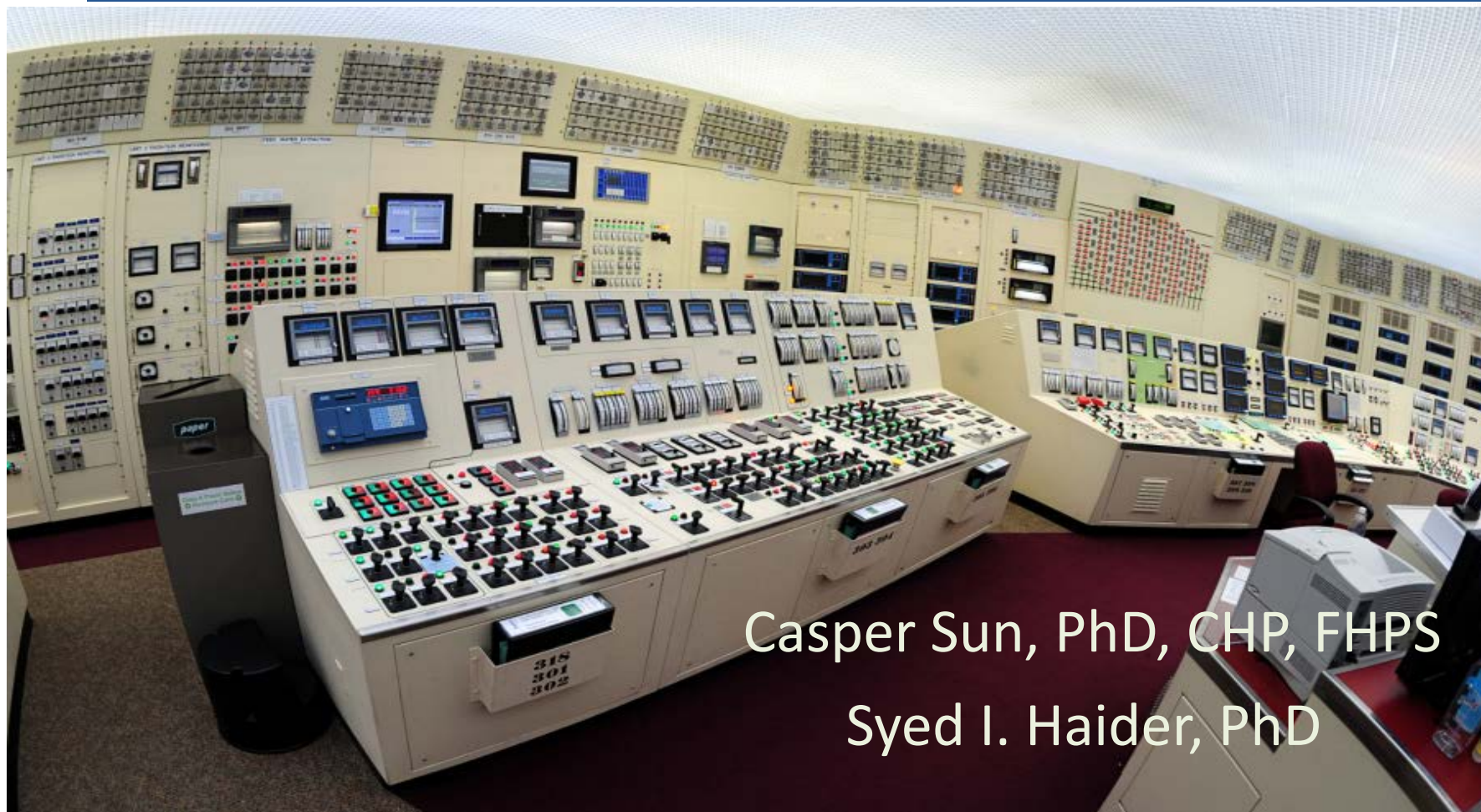
Casper Sun, PhD, CHP, FHPS, MCP

Radiation Protection Branch

Office of Nuclear Regulatory Research

The United States Nuclear Regulatory Commission

CONTROL ROOM



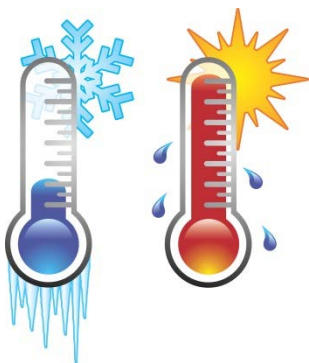
Casper Sun, PhD, CHP, FHPS

Syed I. Haider, PhD

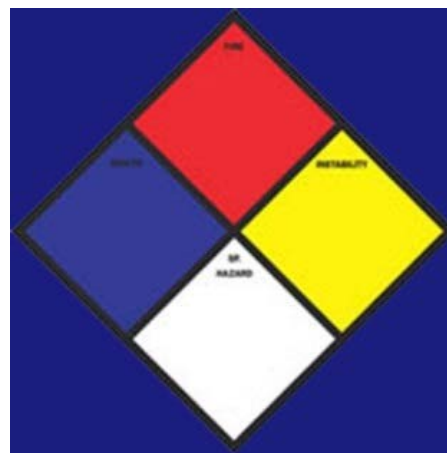
*2015 RAMP first annual meeting, Rockville, MD 20852
October 7th, 2015*

Habitability Issues at NRC

Radiological



Non-radiological



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)

Project Overview

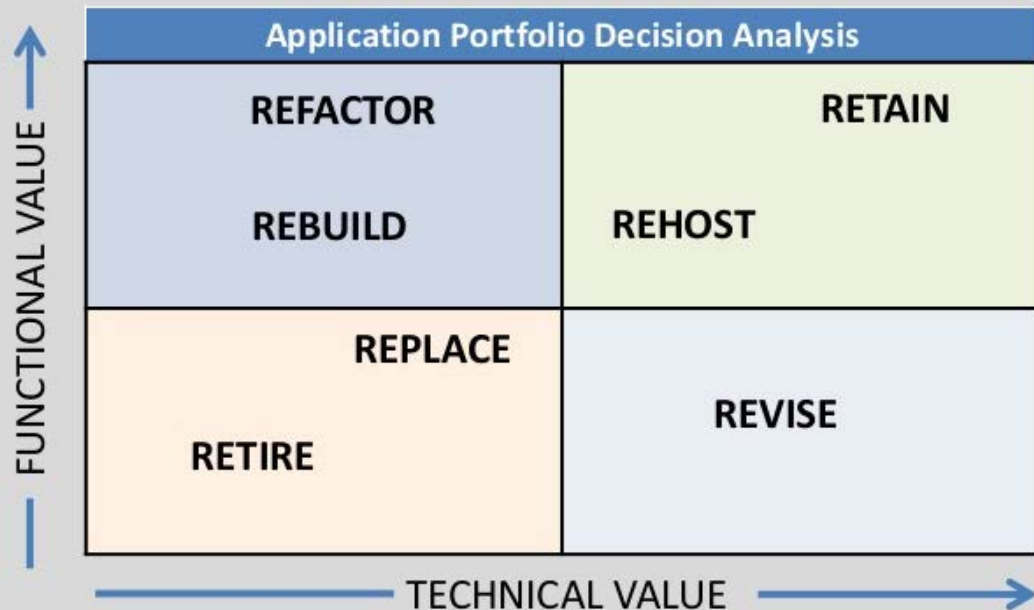
- **Phase I** (June 2014 – Feb. 2015):
 - Repair **HABIT v1.1** FORTRAN source code
 - Develop User Manual and interactive pop-up help screens.
 - Comply Section 508 requirements
 - TRM for **HABIT v1.2** (download and install)
- **Phase II** (April 2015 – Sept. 2016):
 - Integrate DEGADIS and SLAB (D&S) 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)

HABIT PHASE-I

June 1, 2014 – February 14, 2015

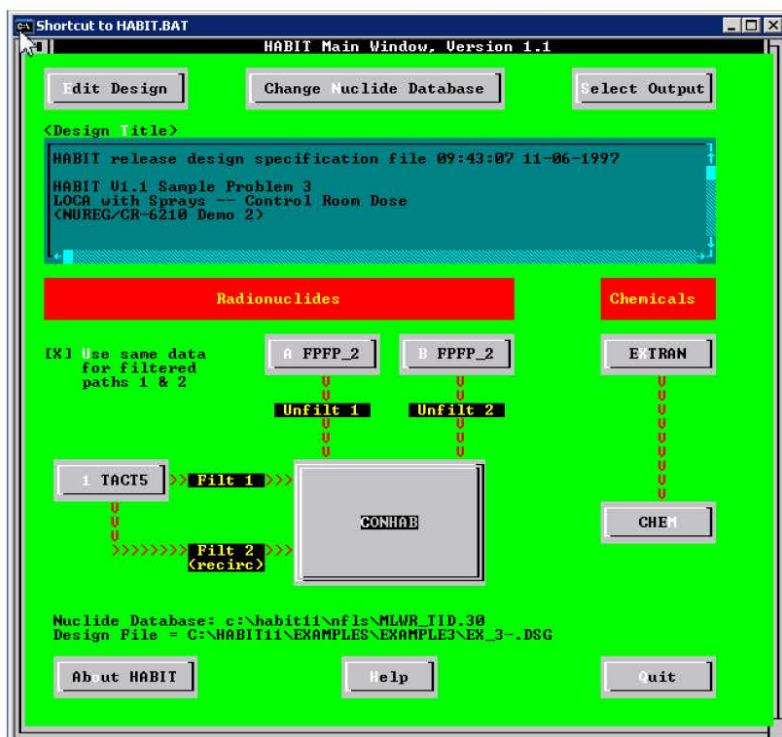
Legacy Portfolio Analysis



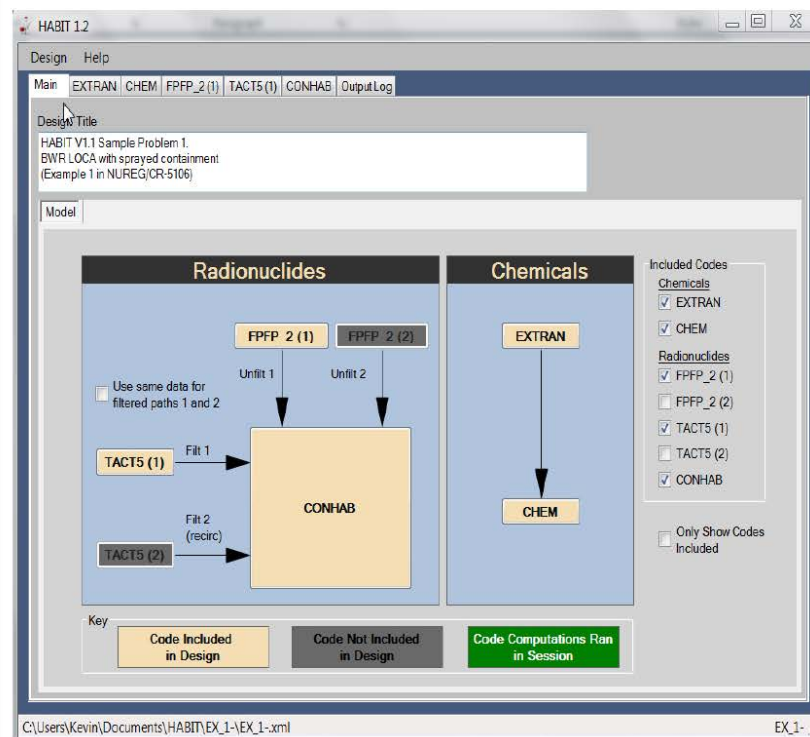
HABIT MAKEOVER

from v1.1 to v1.2

Original



New





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”

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

DRY ICE SMOKE

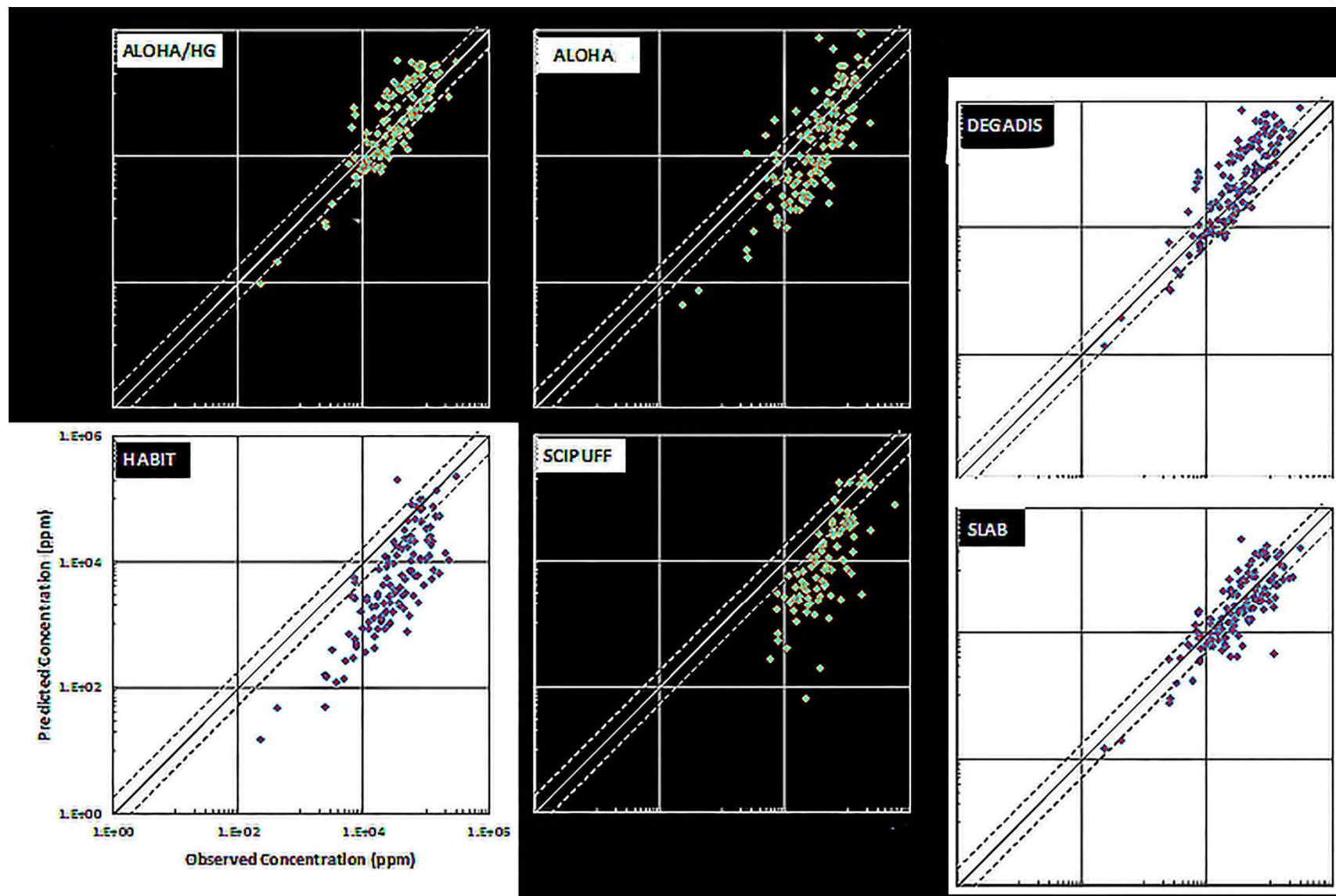
$$C(x, y, z, t) = \frac{Q}{2\pi u \sigma_y \sigma_z} \cdot \exp\left(-\frac{y^2}{2\sigma_y^2}\right) \left[\exp\left(-\frac{(z-H_{eff})^2}{2\sigma_z^2}\right) + \exp\left(-\frac{(z+H_{eff})^2}{2\sigma_z^2}\right) \right]$$




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 liquid 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)

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**

On-Going Enhancements



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

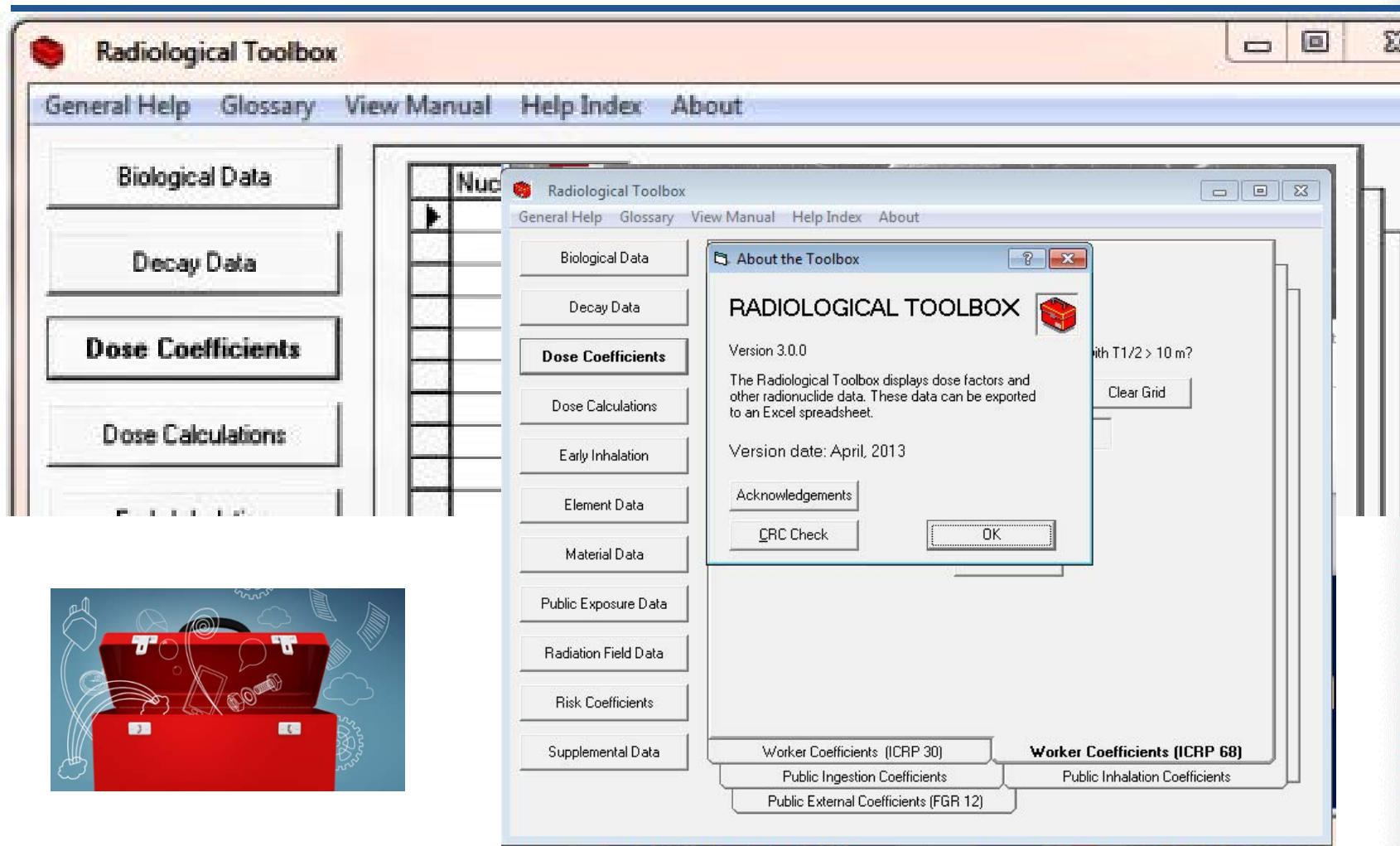
- Adding chemicals
- Adding graphic analysis
- Adding ICRP 60/103 dose coefficients
- Supporting RAMP
- Benchmark ATD Models

COMPUTER CODES IN RAMP



Radiological Toolbox Version 3.0

Menu Bar (About)



What's in The Latest



Radiological Toolbox User's Guide

Manuscript Completed: April 2013
Date Published: May 2013

Prepared by:
K. F. Eckerman and A. L. Sjoreen

Oak Ridge National Laboratory
Managed by UT-Battelle, LLC
Oak Ridge, TN 37831-6170

C. Sun, NRC Project Manager

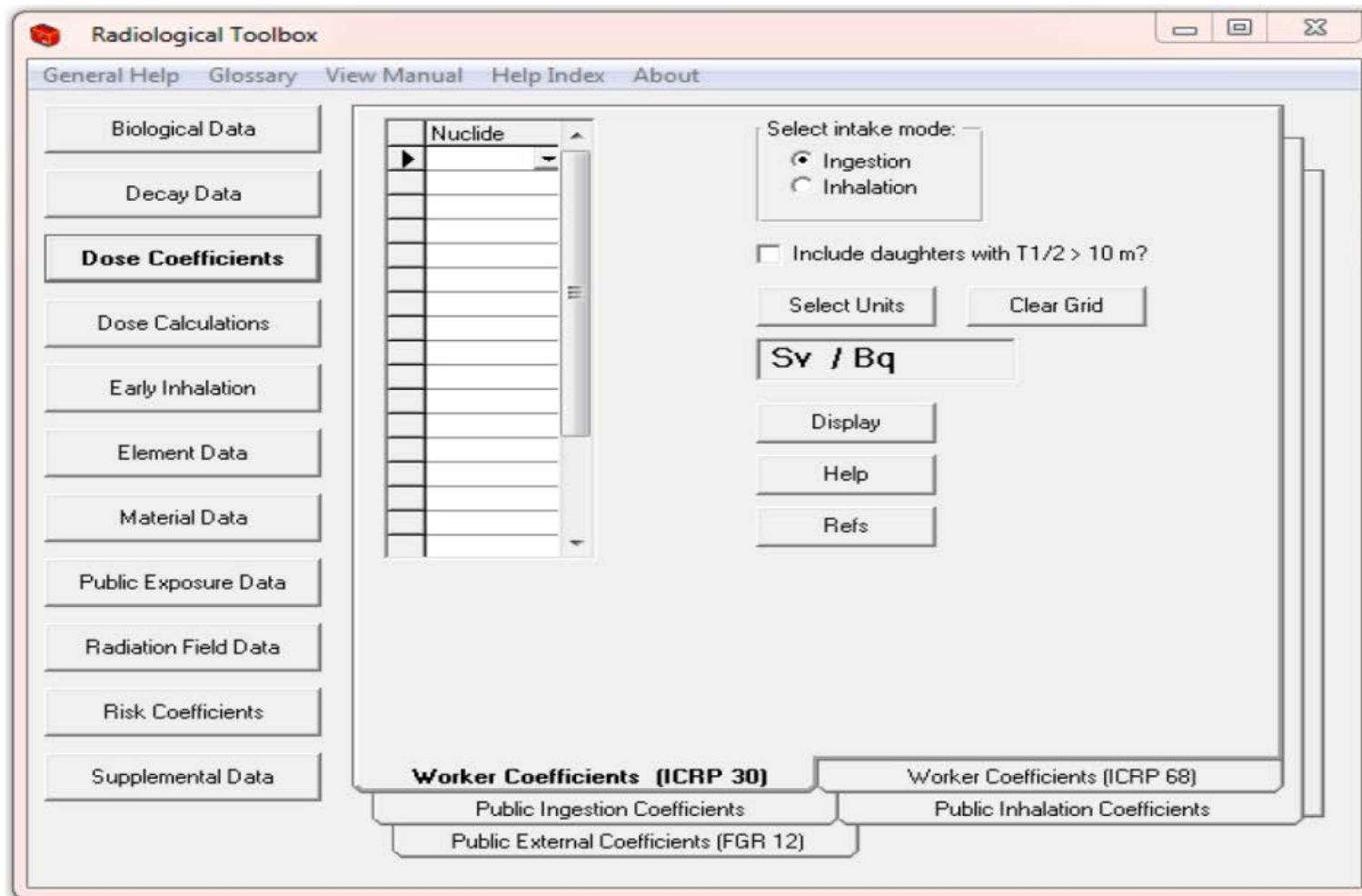
NRC Job V6088

Office of Nuclear Regulatory Research

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

- **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

Rad-Toolbox 11 Database



Radiological Toolbox

General Help Glossary View Manual Help Index About

Biological Data

Decay Data

Dose Coefficients

Dose Calculations

Early Inhalation

Element Data

Material Data

Public Exposure Data

Radiation Field Data

Risk Coefficients

Supplemental Data

Nuclide

Select intake mode:

☒ Ingestion

☐ Inhalation

☐ Include daughters with T1/2 > 10 m?

Select Units Clear Grid

Sv / Bq

Display

Help

Refs

Worker Coefficients (ICRP 30)

Public Ingestion Coefficients

Public External Coefficients (FGR 12)

Worker Coefficients (ICRP 68)

Public Inhalation Coefficients

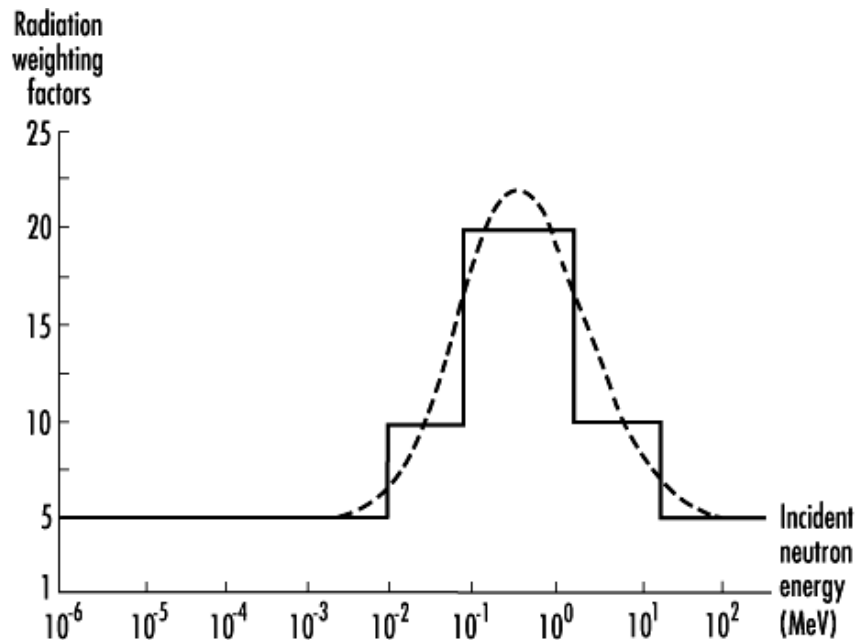
HP Constants

Useful Constants and Conversions

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

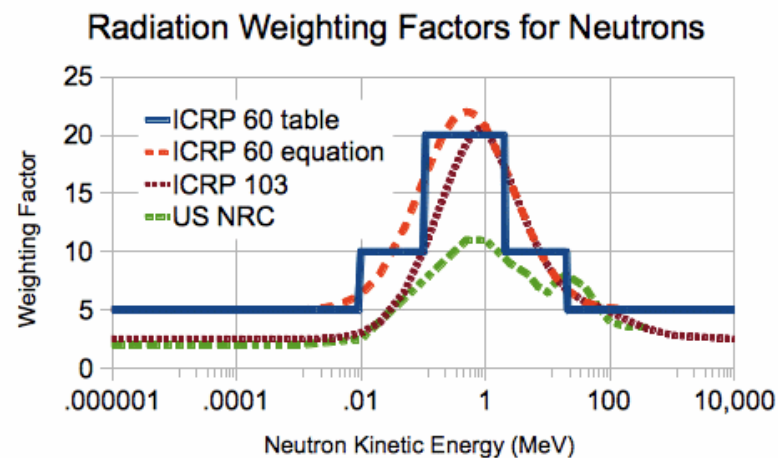


(7) Neutron “ w_R ”



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

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



(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

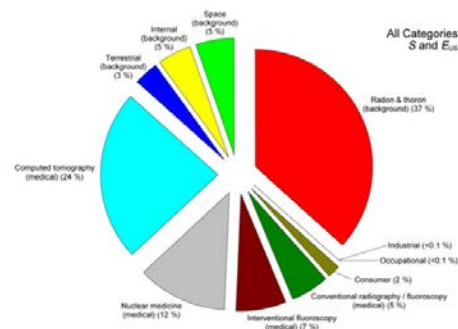
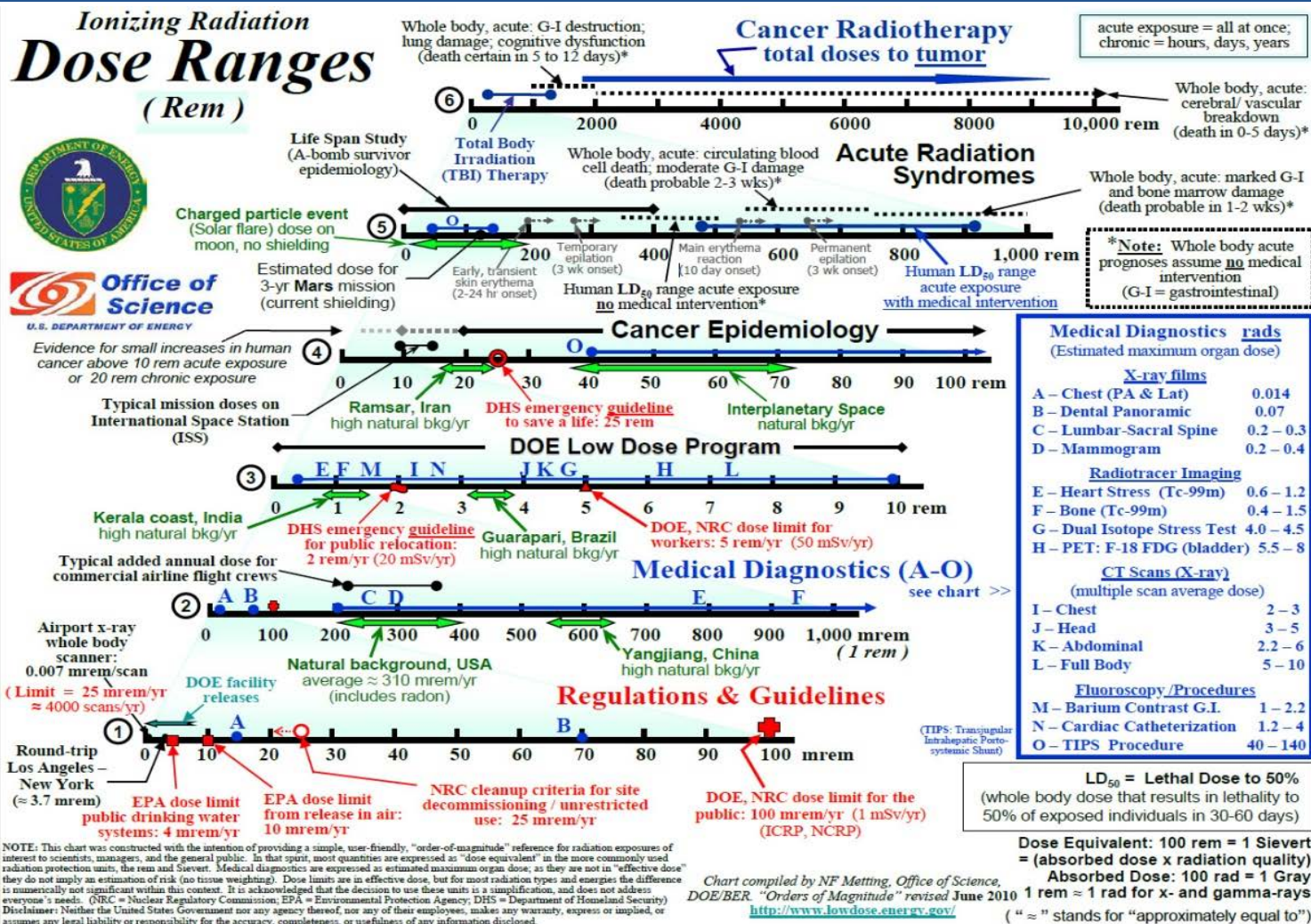


Fig. 1.1. Percent contribution of various sources of exposure to the total collective effective dose (1,870,000 person-Sv) and the total effective dose per individual in the U.S. population (6.2 mSv) for 2006. Percent values have been rounded to the nearest 1%, except for those <1% [see Table 1.1 for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

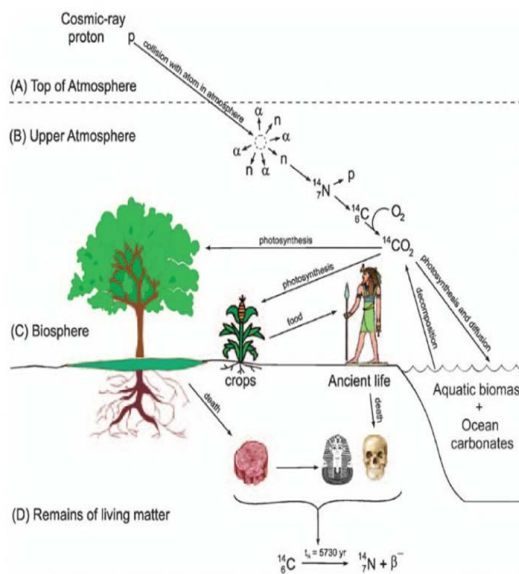
Computed tomography examinations

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

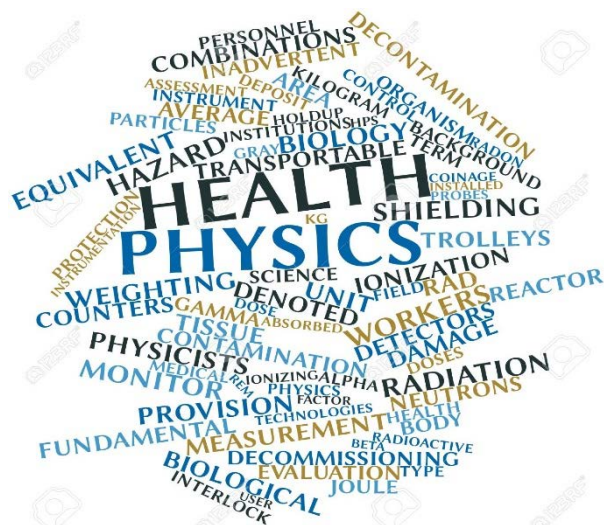
(11) Supplemental Data



More Database?



$$C(x, y, z, t) = \frac{Q}{2\pi u \sigma \sigma_z} \cdot \exp\left(-\frac{y^2}{2\sigma_y^2}\right) \left[\exp\left(-\frac{(z-H_0)^2}{2\sigma_z^2}\right) + \exp\left(-\frac{(z+H_0)^2}{2\sigma_z^2}\right) \right]$$



Freebie:

NUREG-1350: ML15254A321.pdf

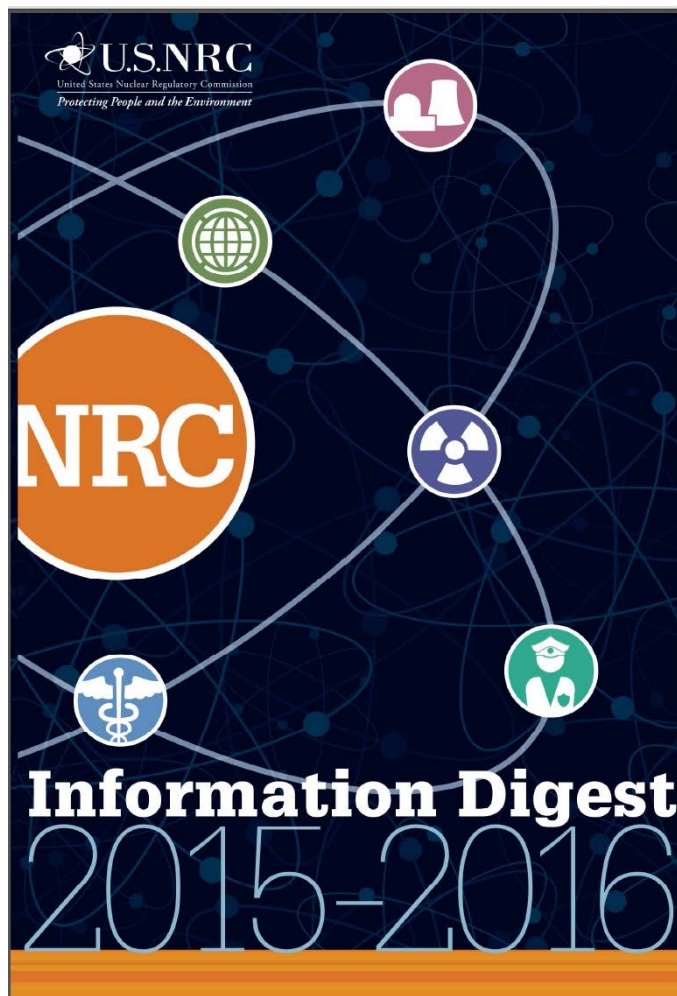
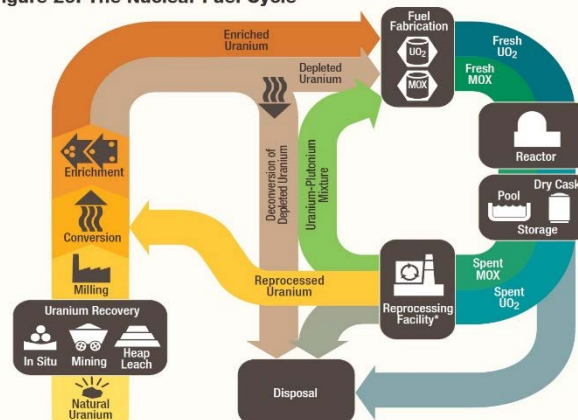


Figure 8. Nuclear Share of Electricity Generated by Country



Note: The country's short-form name is used.
Source: IAEA, Power Reactor Information System database, as of May 2015

Figure 29. The Nuclear Fuel Cycle



* Reprocessing of spent nuclear fuel, including mixed-oxide (MOX) fuel is not practiced in the United States.
Note: The NRC has no regulatory role in mining uranium.

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

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

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



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

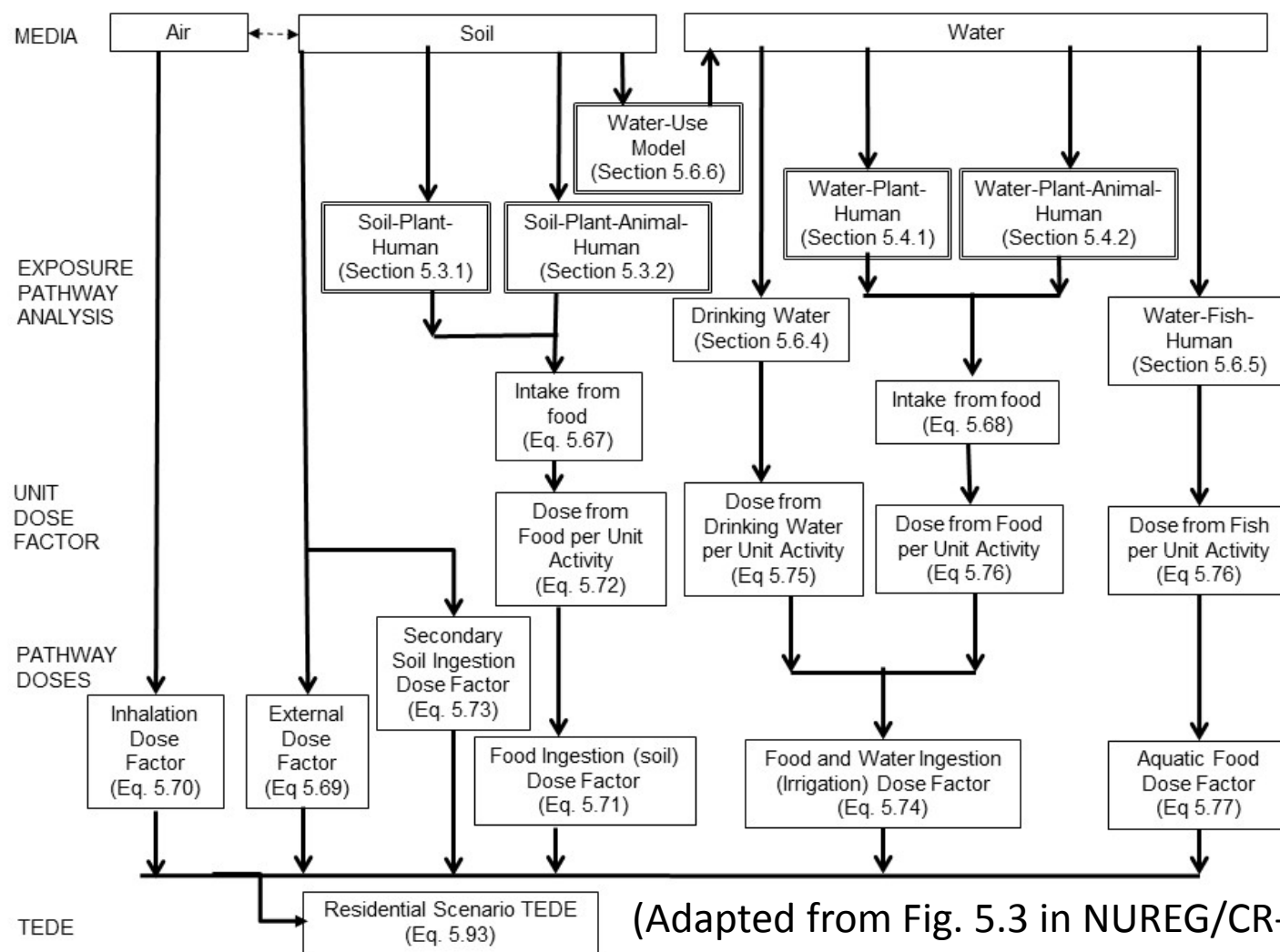
Radionuclide	Symbol	Surface Soil Screening Values ^b
Hydrogen-3	³ H	110
Carbon-14	¹⁴ C	12
Sodium-22	²² Na	4.3
Sulfur-35	³⁵ S	270
Chlorine-36	³⁶ Cl	0.36
Calcium-45	⁴⁵ Ca	57
Scandium-46	⁴⁶ Sc	15
Manganese-54	⁵⁴ Mn	15
Iron-55	⁵⁵ Fe	10000
Cobalt-57	⁵⁷ Co	150
Cobalt-60	⁶⁰ Co	3.8
Nickel-59	⁵⁹ Ni	5500
Nickel-63	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

a Screening levels are based on the assumption that the probability of a site being contaminated is equal to 0.1. For cases when the probability is less than 0.1, users may assume for screening purposes that the probability is 0.1. If the probability is greater than 0.1, users may assume for screening purposes that the probability is 0.1. Therefore the screening levels are calculated using a value of 0.1. To calculate site-specific levels using available data, users may use the following formula:

$$SL = \frac{C_{max} \times P}{D}$$

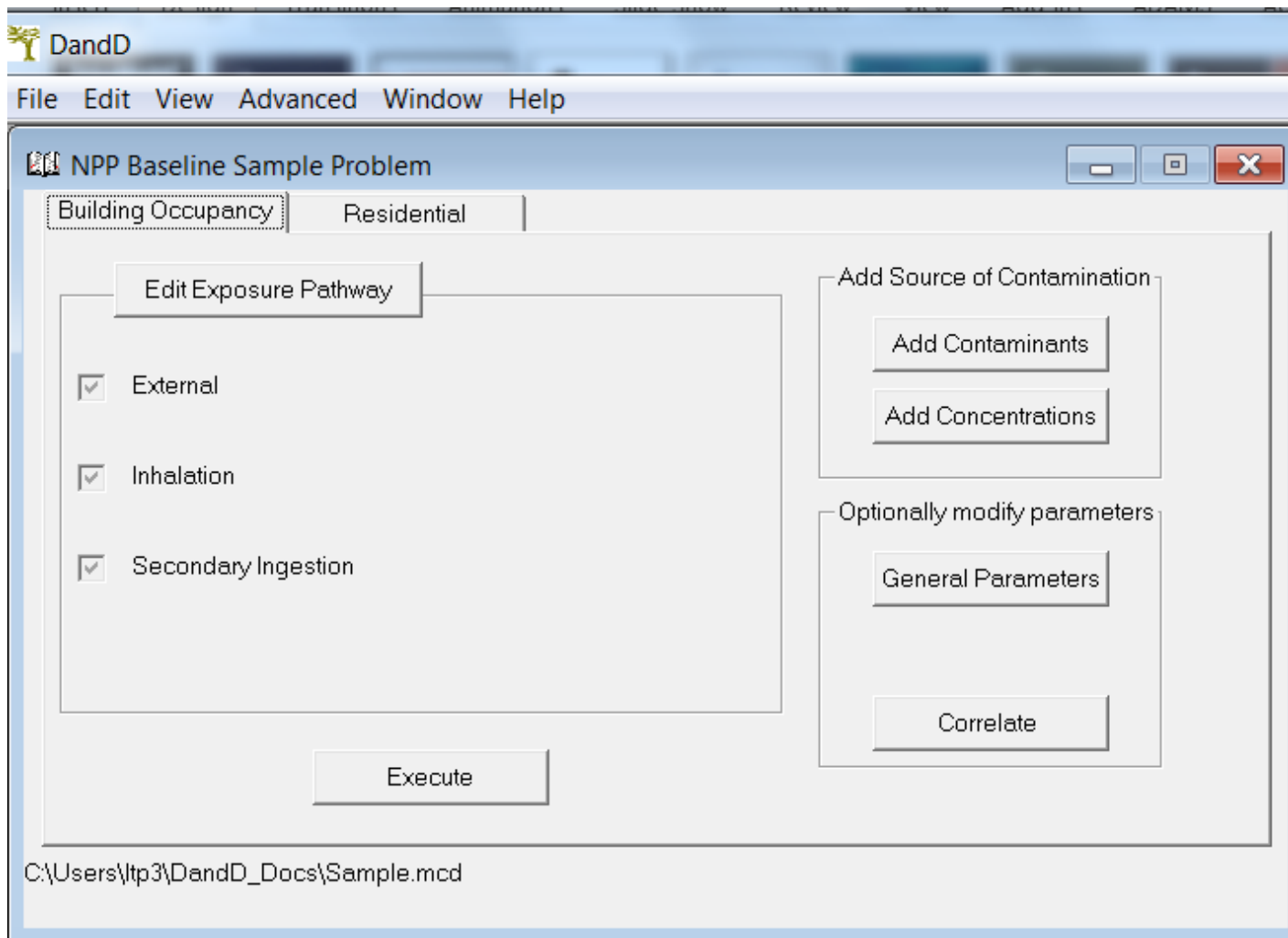
DandD Version 2.

DandD Pathways Model



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

Interface (Building Occupancy)



The screenshot shows a software window titled "DandD" with a menu bar (File, Edit, View, Advanced, Window, Help) and a toolbar. The main window is titled "NPP Baseline Sample Problem" and contains a tabbed interface. The "Building Occupancy" tab is selected, showing a "Residential" occupancy type. The interface includes a section for "Edit Exposure Pathway" with three checked options: External, Inhalation, and Secondary Ingestion. To the right, there is a section for "Add Source of Contamination" with buttons for "Add Contaminants" and "Add Concentrations". Below this is a section for "Optionally modify parameters" with a "General Parameters" button and a "Correlate" button. An "Execute" button is located at the bottom center. The status bar at the bottom shows the file path: C:\Users\ltp3\DandD_Docs\Sample.mcd.

DandD

File Edit View Advanced Window Help

NPP Baseline Sample Problem

Building Occupancy Residential

Edit Exposure Pathway

- ☒ External
- ☒ Inhalation
- ☒ Secondary Ingestion

Execute

Add Source of Contamination

Add Contaminants

Add Concentrations

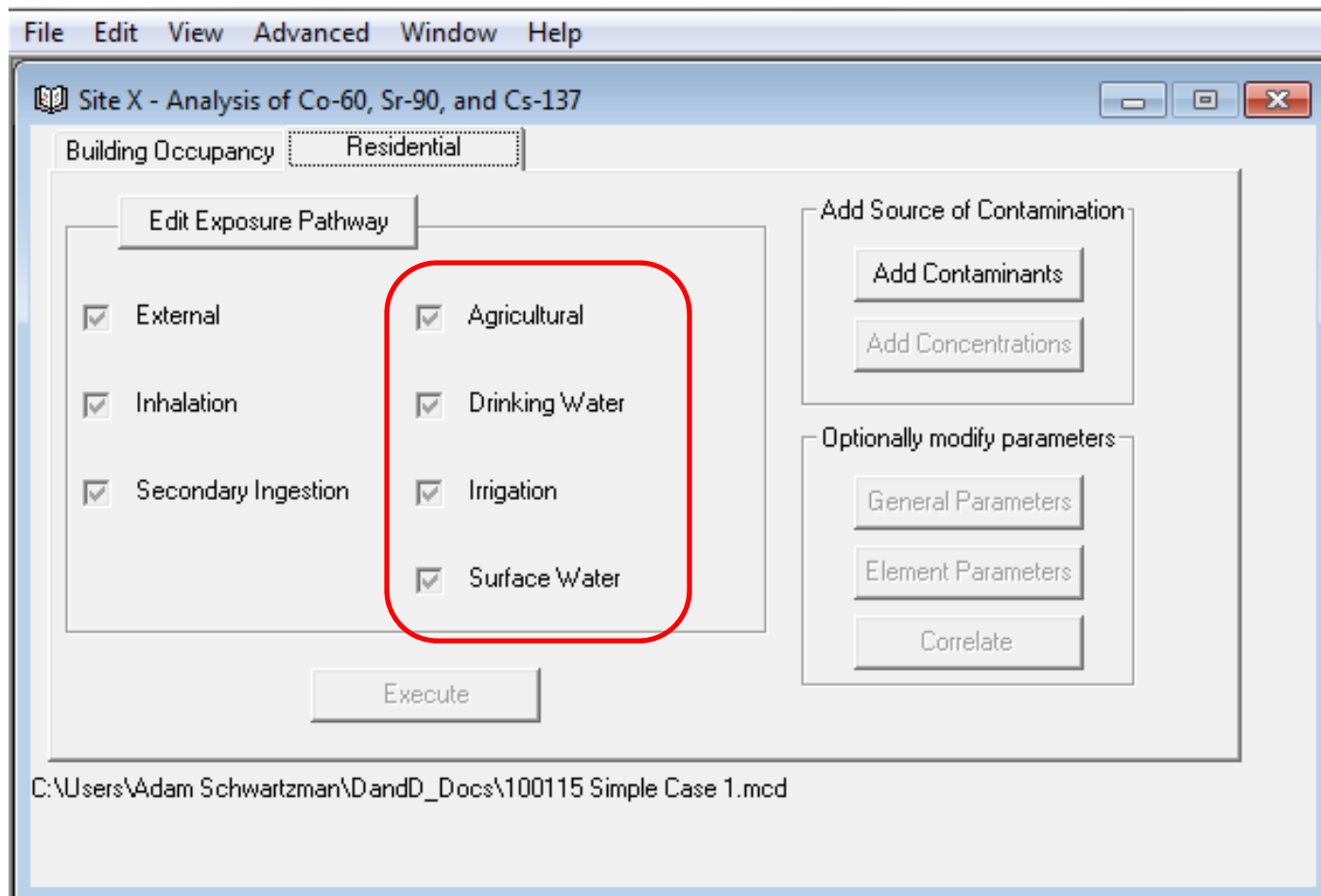
Optionally modify parameters

General Parameters

Correlate

C:\Users\ltp3\DandD_Docs\Sample.mcd

Interface (Residential)



File Edit View Advanced Window Help

Site X - Analysis of Co-60, Sr-90, and Cs-137

Building Occupancy Residential

Edit Exposure Pathway

- ☒ External
- ☒ Inhalation
- ☒ Secondary Ingestion
- ☒ Agricultural
- ☒ Drinking Water
- ☒ Irrigation
- ☒ Surface Water

Execute

Add Source of Contamination

Add Contaminants

Add Concentrations

Optionally modify parameters

General Parameters

Element Parameters

Correlate

C:\Users\Adam Schwartzman\DandD_Docs\100115 Simple Case 1.mcd

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

DandD Outputs

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

Summary Results:

90.00% of the 100 calculated TEDE values are $< 2.73\text{E}+01$ mrem/year .

The 95 % Confidence Interval for the 0.9 quantile value of TEDE is $2.59\text{E}+01$ to $3.60\text{E}+01$ 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	1.16E-19

Limitations

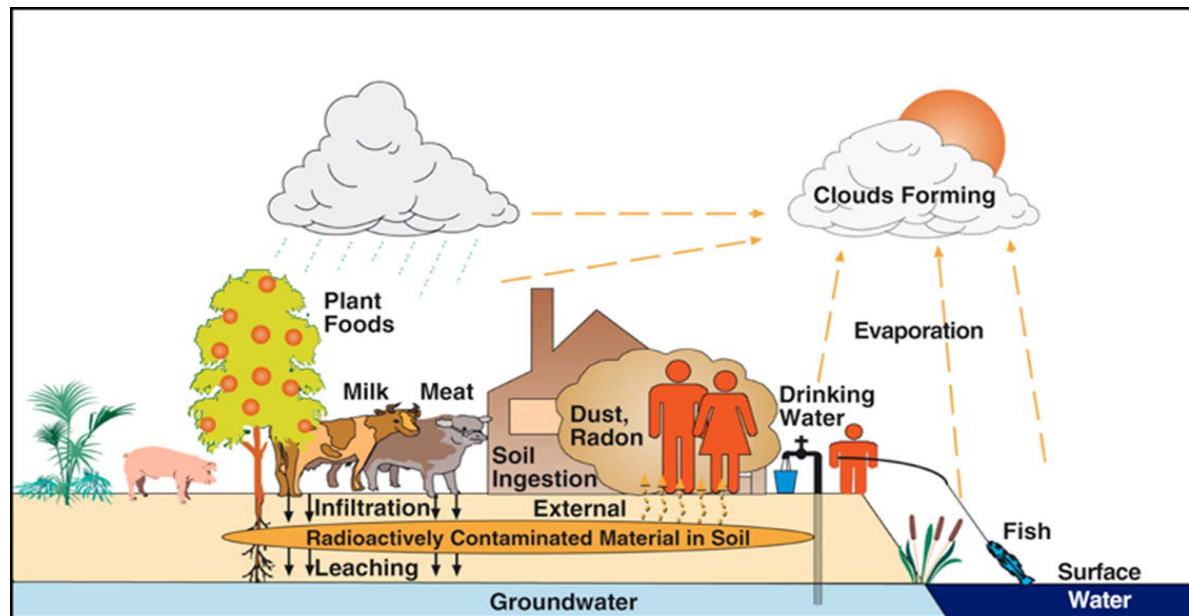
- Resuspension factor may overestimate inhalation dose for building surface contamination
- NUREG-1720 provides additional information regarding the resuspension factor
- The default parameter distribution recommended in NUREG-1720 can be used if consistent with underlying assumptions

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

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.



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

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

See

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



The screenshot shows the website for the DandD software, which is part of the RAMP (Radiation Protection Computer Code Analysis and Maintenance Program) suite. The website has a dark blue header with the RAMP logo and the text "United States Nuclear Regulatory Commission Radiation Protection Computer Code Analysis and Maintenance Program". Below the header is a navigation bar with links to Home, RASCAL, SNAP/RADTRAD, HABIT, VARSKIN, GALE, Radiological Toolbox, PIMAL, and DandD. The main content area is divided into three sections: "DandD Navigation" on the left, "DandD Overview" in the center, and "User login" on the right. The "DandD Navigation" section includes links for registration, user guides, technical documents, and contact information. The "DandD Overview" section provides a description of the software and its purpose, along with contact information for the development team and project manager. The "User login" section includes fields for username and password, a "Log in" button, and a link to request a new password.

Home » DandD

DandD Navigation

- Registration for the DandD Code
- Download the DandD User Guide
- Download the DandD Technical Documents
- DandD_HELP@nrc.gov

RAMP Navigation

- Contact RAMP Administrators
- RAMP Registration
- FAQs
- RAMP Information Policy Paper (SECY-14-0117)
- RAMP Newsletter
- Related Links
- Contact Us

DandD Overview

The Decontamination and Decommissioning (DandD) software package, developed by NRC, assesses compliance with the dose criteria of 10 CFR Part 20, Subpart E. Specifically, DandD embodies NRC's guidance on screening dose assessments to allow licensees to perform simple estimates of the annual dose from residual radioactivity in soils and on building surfaces. For a screening assessment with DandD, NRC has predefined conceptual models for the scenarios along with default parameter distributions (based on NUREG/CR-5512, Volumes 1 and 3).

DandD Contacts:
The DandD Development Team
DandD_HELP@nrc.gov

The RAMP Project Manager
RAMP@nrc.gov

User login

Username *

Password *

[Request new password](#)

Log in



RAMP Meeting: Overview of GALE

KEN GEELHOOD

Pacific Northwest National Laboratory

Richland, WA

October 9, 2015

PNNL-SA-113371

117



- ▶ 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





► Input

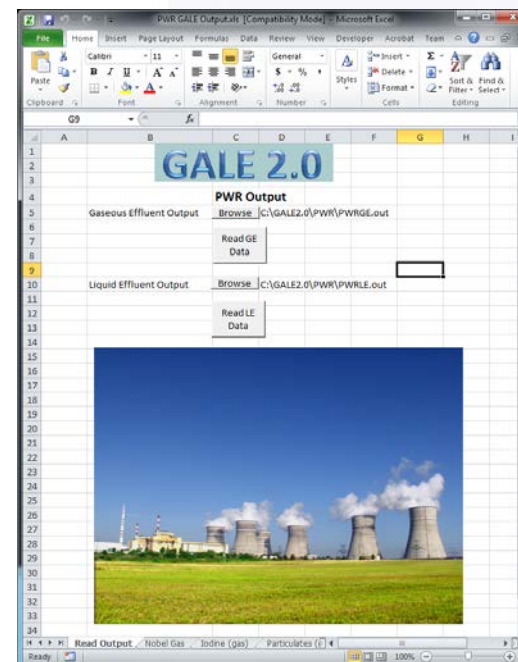
- Plant data
- Liquid waste cleanup system data
- Gaseous effluent cleanup system data

► Output

- Liquid release of radionuclides from various buildings and the total release
- Gaseous release of radionuclides from various buildings and the total release

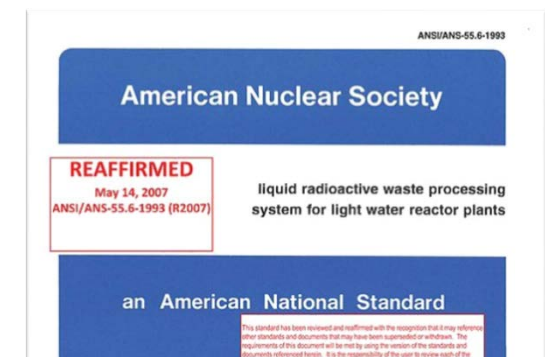
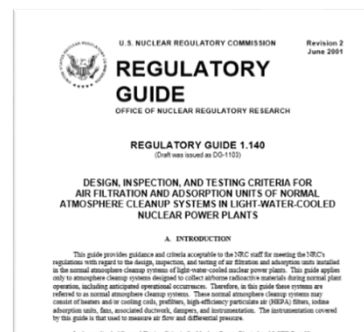
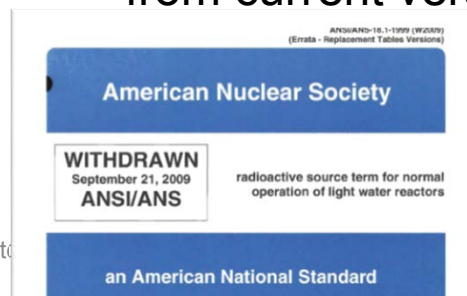


- ▶ Code runs on Microsoft Windows PCs
 - Graphical user interface uses standard Windows dialog boxes
- ▶ Code output is via text file
- ▶ Microsoft Excel worksheet has been included to visualize output and to facilitate use of output data in other calculations





- ▶ 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





- ▶ **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



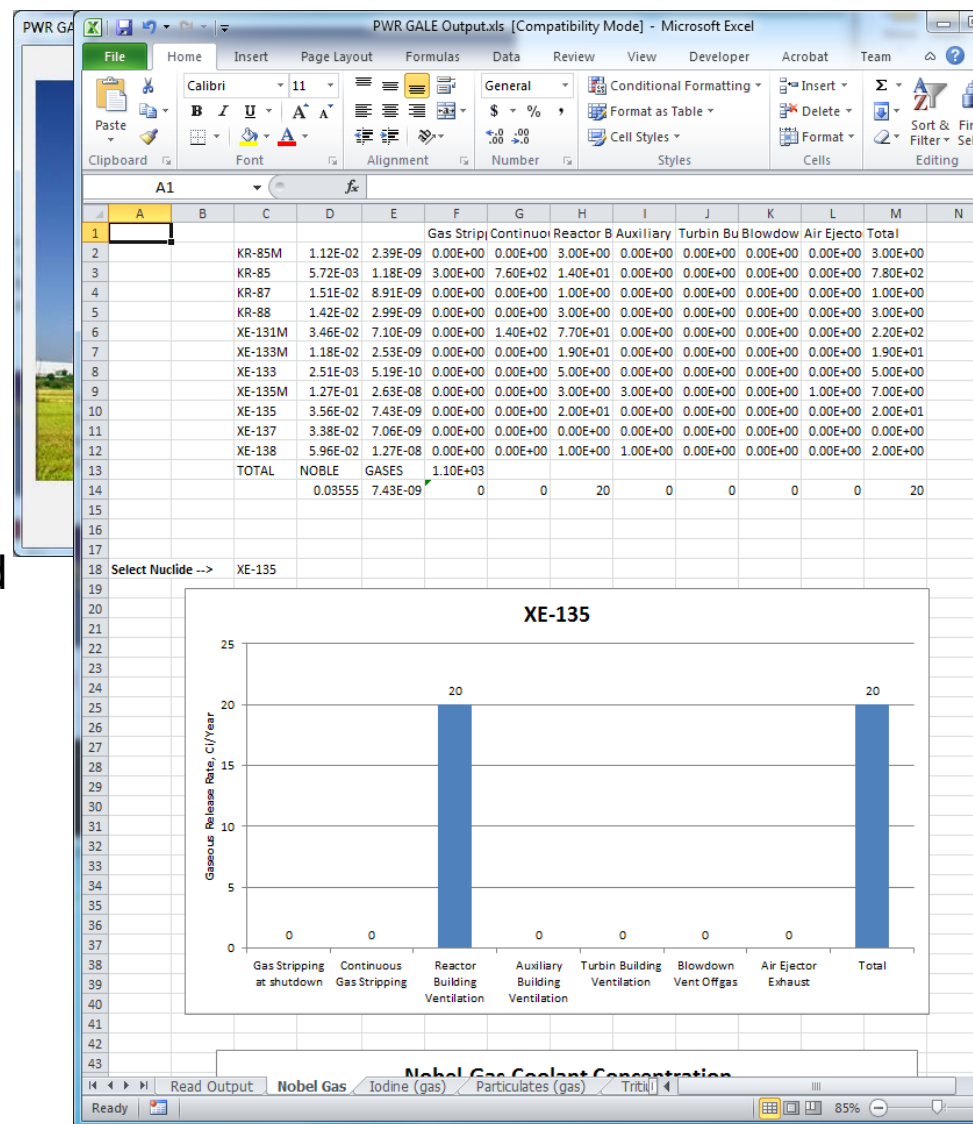
► Graphical User Interface

- 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





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





2015 Fall RAMP Meeting Welcome Wrap Up



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

October 7th, 2015

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

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



The screenshot shows the U.S. Nuclear Regulatory Commission (NRC) website. The header includes the NRC logo and navigation links. The main content area features a large image of a reactor core, a 'Facility Locator' section, and a 'Spotlight' section highlighting the '2015 Fuel Cycle Information Exchange (FCIX)'. The right sidebar contains links to 'Event Reports', 'ADAMS Public Documents', and 'Open Government'. The footer includes a 'STAY CONNECTED' section with social media links and a 'FOIA' section with links to various documents.



The screenshot shows the RAMP (Radiation Protection Computer Code Analysis and Maintenance Program) website. The header includes the RAMP logo and the title 'United States Nuclear Regulatory Commission Radiation Protection Computer Code Analysis and Maintenance Program'. The main content area features a 'Welcome to the US NRC RAMP Website' message, a 'RASCAL' logo, and sections for 'Goals of RAMP' and 'Benefits of RAMP'. The right sidebar contains a 'STAY CONNECTED' section with social media links and a 'FOIA' section with links to various documents.

TONIGHT: No Host Social Hour

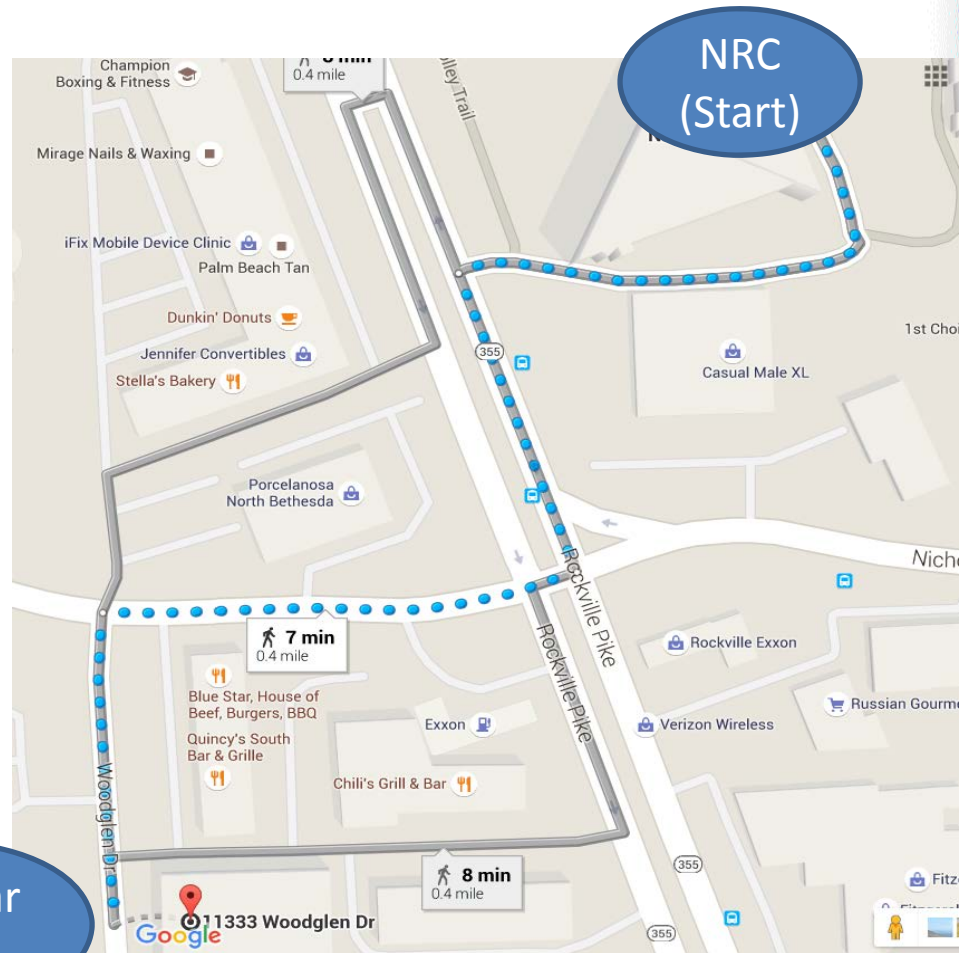
Wednesday, October 7th

5pm to 7pm

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



Paladar
(End)



Thank You

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

QUESTIONS?

