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DandD Decommissioning Dose Modeling Code

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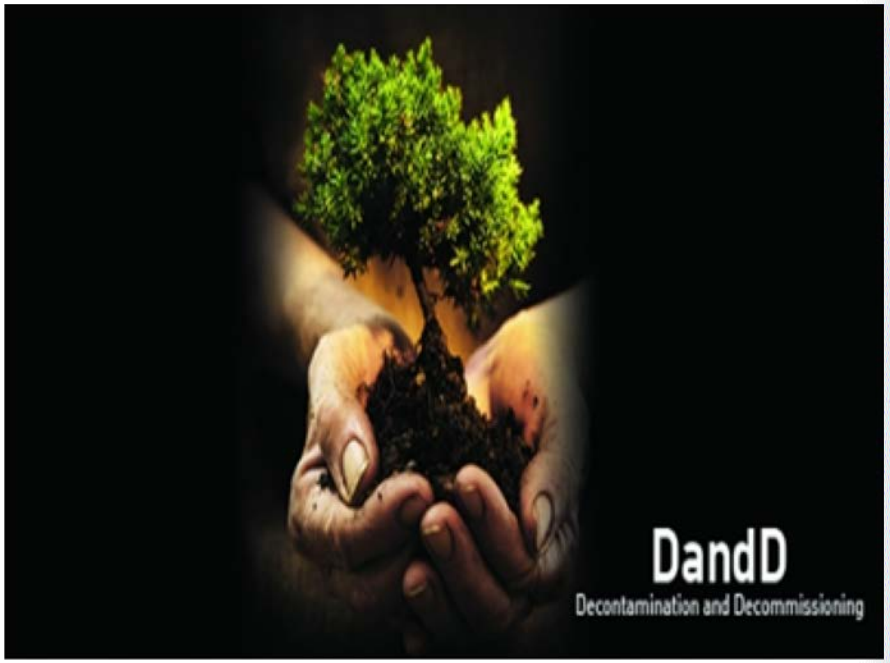
Outline

- Dose Assessment
- DandD
- How does DandD compare to RESRAD



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Release of a site

- A decommissioned site can be released for unrestricted use and the license terminated if the site meets the radiological criteria for license termination.
- A decommissioned site does not always have to be remediated to meet the radiological criteria.
- There are different ways to demonstrate compliance with the radiological criteria.
  - All approaches entail dose modeling

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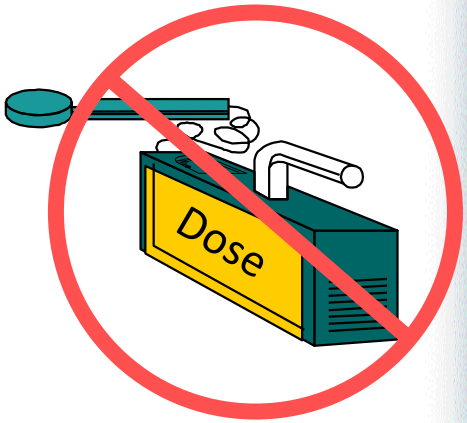
Why is dose modeling needed?

- There is no "dose meter" available to demonstrate compliance.
  - At the time of decommissioning
  - During the 1,000 year compliance period



- The compliance demonstration requires the use of mathematical models to estimate dose through various pathways.

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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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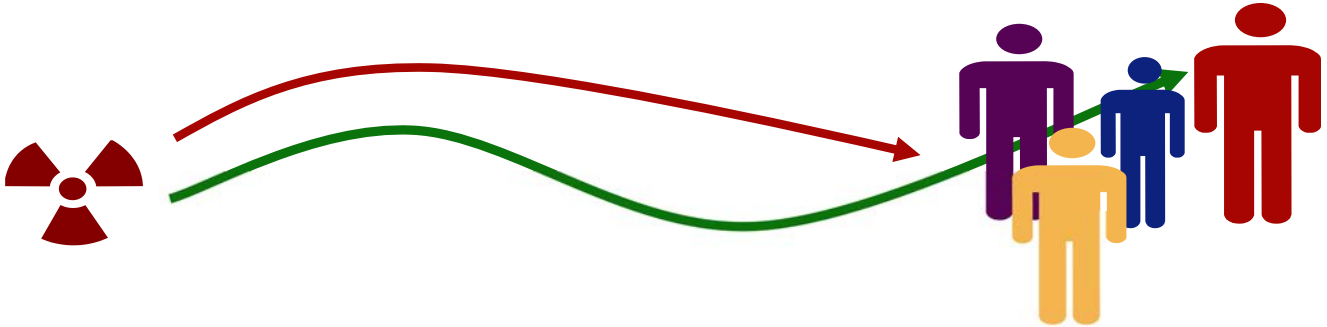
What is the critical group?

"the **group of individuals** reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances" (10 CFR 20.1003)

Considers

- Habits (time fraction spent on site)
- Actions (worker or resident)
- Characteristics (e.g., inhalation rate, soil ingestion)



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Approaches to demonstrating compliance

There are two different approaches for demonstrating compliance with the dose-based decommissioning criteria:

- Dose modeling approach
- Derived concentration guideline level (DCGL) approach

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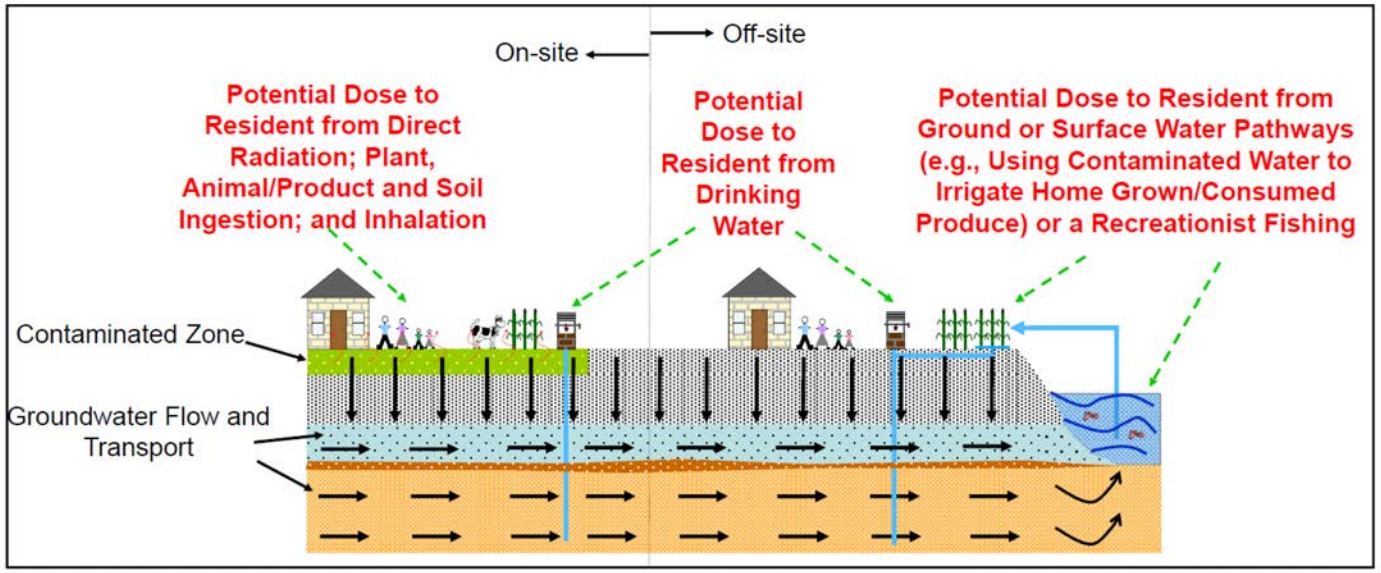
Dose modeling approach

The dose modeling approach uses actual measurements of residual radioactivity at a site following remediation (or estimated concentrations) to assess the potential dose to the average member of the critical group. Various pathways of exposure are considered.



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DCGL approach

- The DCGL approach allows a licensee to calculate, a priori, a concentration limit (DCGL) for each radionuclide based on the dose criteria, and then demonstrate that the residual radionuclide concentrations are below these DCGLs.
- Using this approach, the final status survey results using MARSSIM are compared to the DCGLs to demonstrate compliance.

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Implementation techniques

- Screening-level analyses
  - More restrictive due to “conservative” assumptions.
  - Generic analyses have built-in assumptions and conceptual models (e.g., only surface contamination in buildings and soil & no existing groundwater contamination).
  - DandD is used to support screening-level analyses.
- Site-specific analyses
  - Generally less restrictive for the majority of sites.
  - More flexibility in assumptions and conceptual models (e.g., can handle more complex sources and hydrogeological systems).
  - More resource intensive--parameters must be justified.
  - Can use modeling codes such as DandD, RESRAD, RESRAD-BUILD, RESRAD-OFFSITE, or other codes.

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Deterministic versus probabilistic

- Deterministic method
  - Iterative process
  - “Deterministic” or “Probabilistic” sensitivity analysis are used to identify important parameters
  - Single, “conservative” values are assigned to important parameters
- Probabilistic method
  - Straightforward to run
  - Parameter distributions are available to perform sensitivity analyses
  - May need to justify parameter distributions that have a significant impact on dose
  - Can use the “Peak of the Mean” or “Mean of the Peaks”

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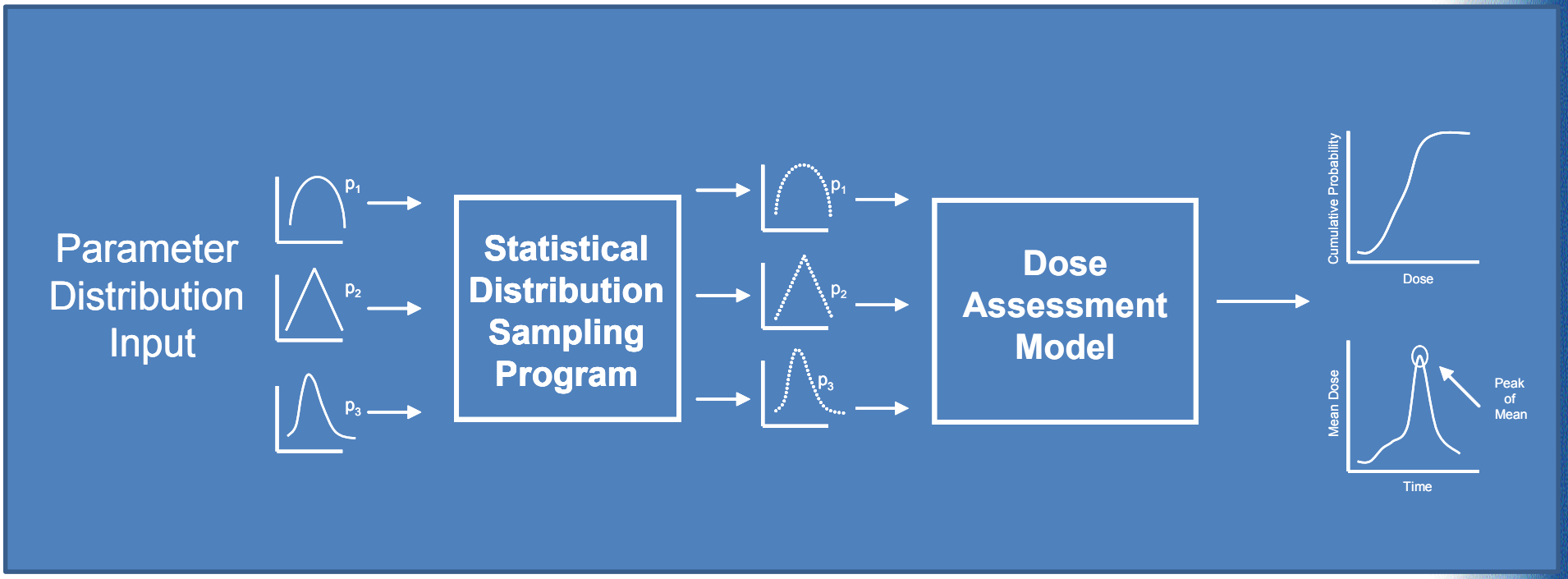
Probabilistic



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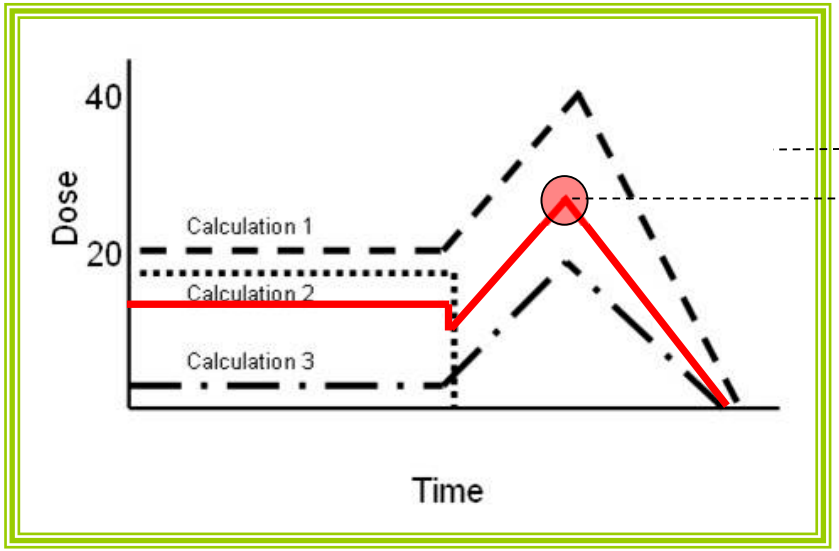
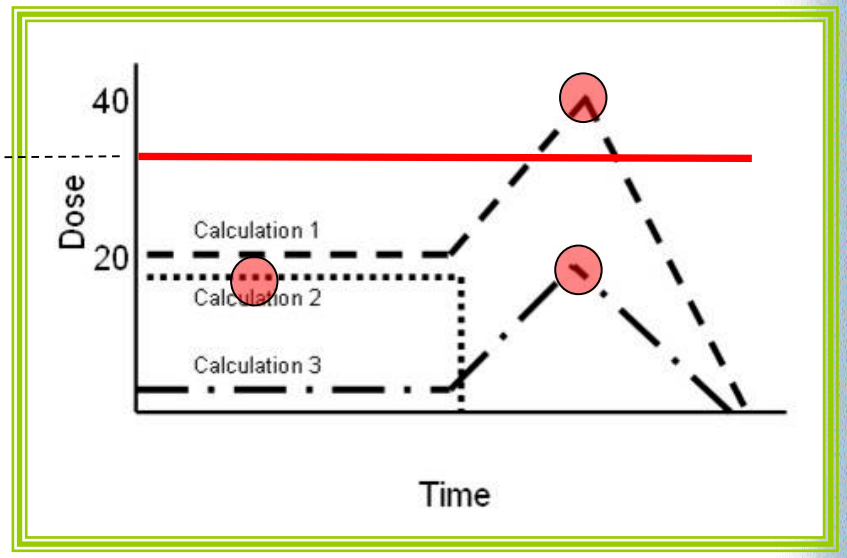
How does a licensee demonstrate compliance?

- Peak of the Mean



- Find mean at each time
- Find peak of this mean

- Mean of the Peaks



- Find peak of each run
- Find mean of these peaks

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DandD

- Developed by Sandia National Laboratory
- Supports Table H.1 and H.2 in NUREG-1757, Volume 2, that provide screening tables to demonstrate 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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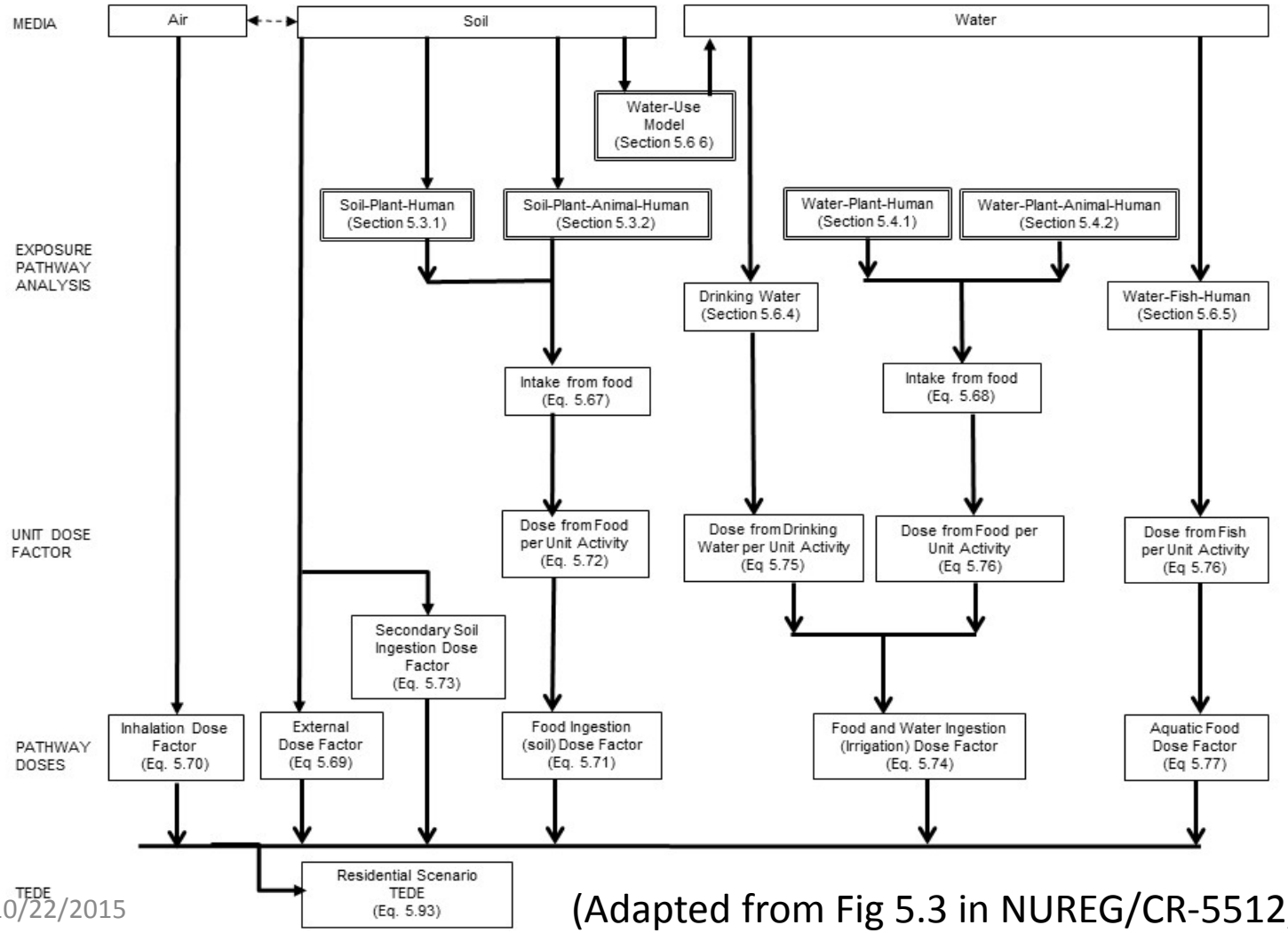
DandD Pathways Model



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

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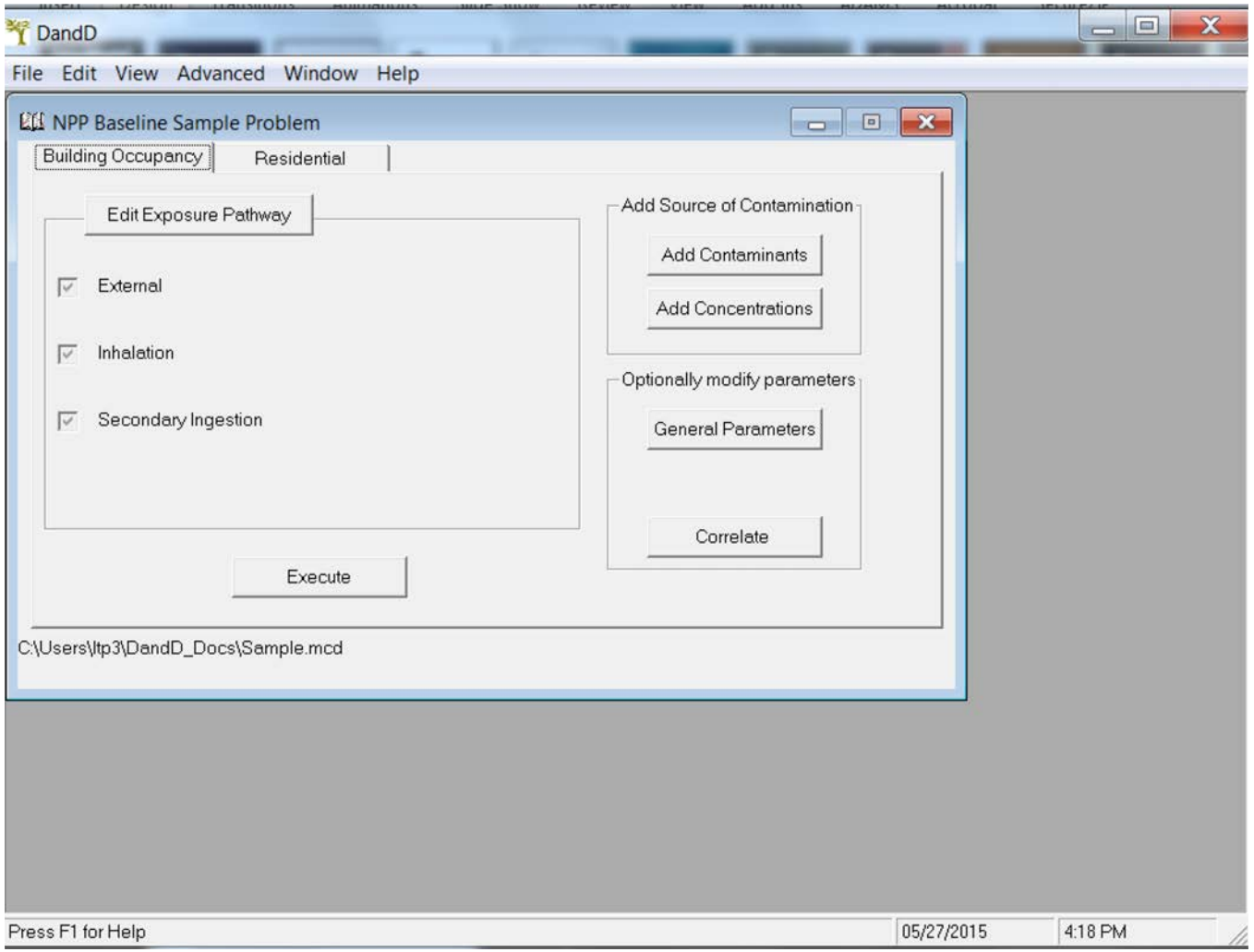
Interface



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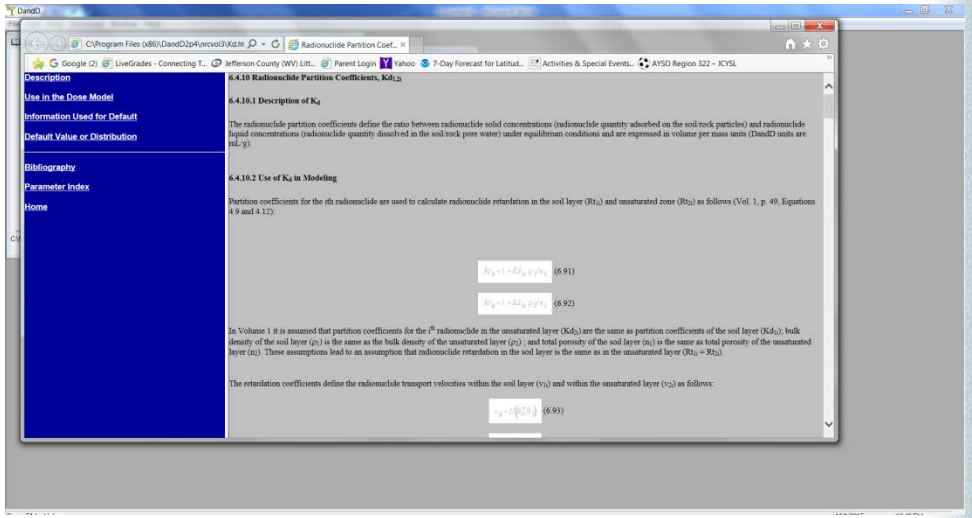
DandD Parameters

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



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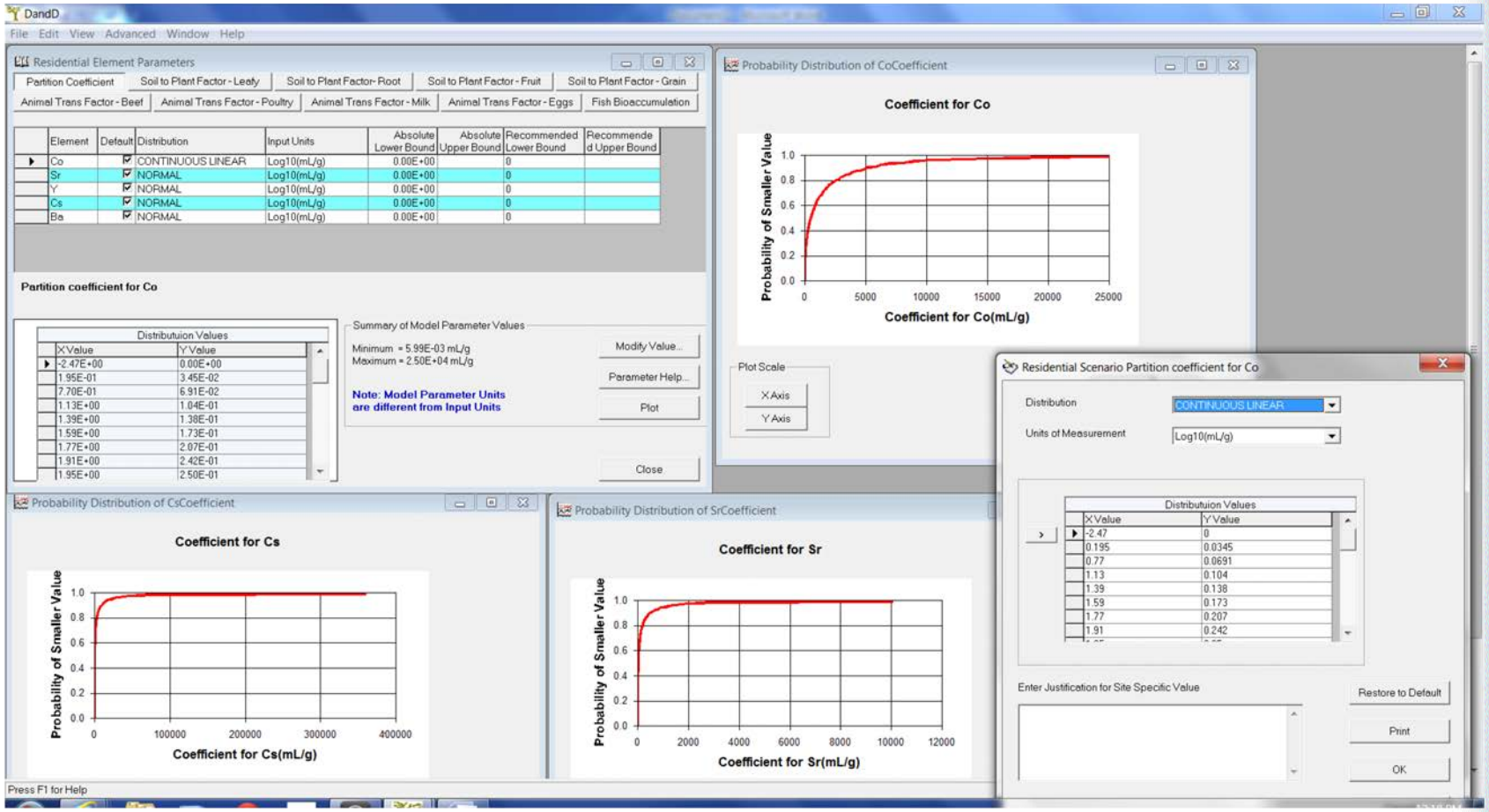
DandD Parameters (cont)



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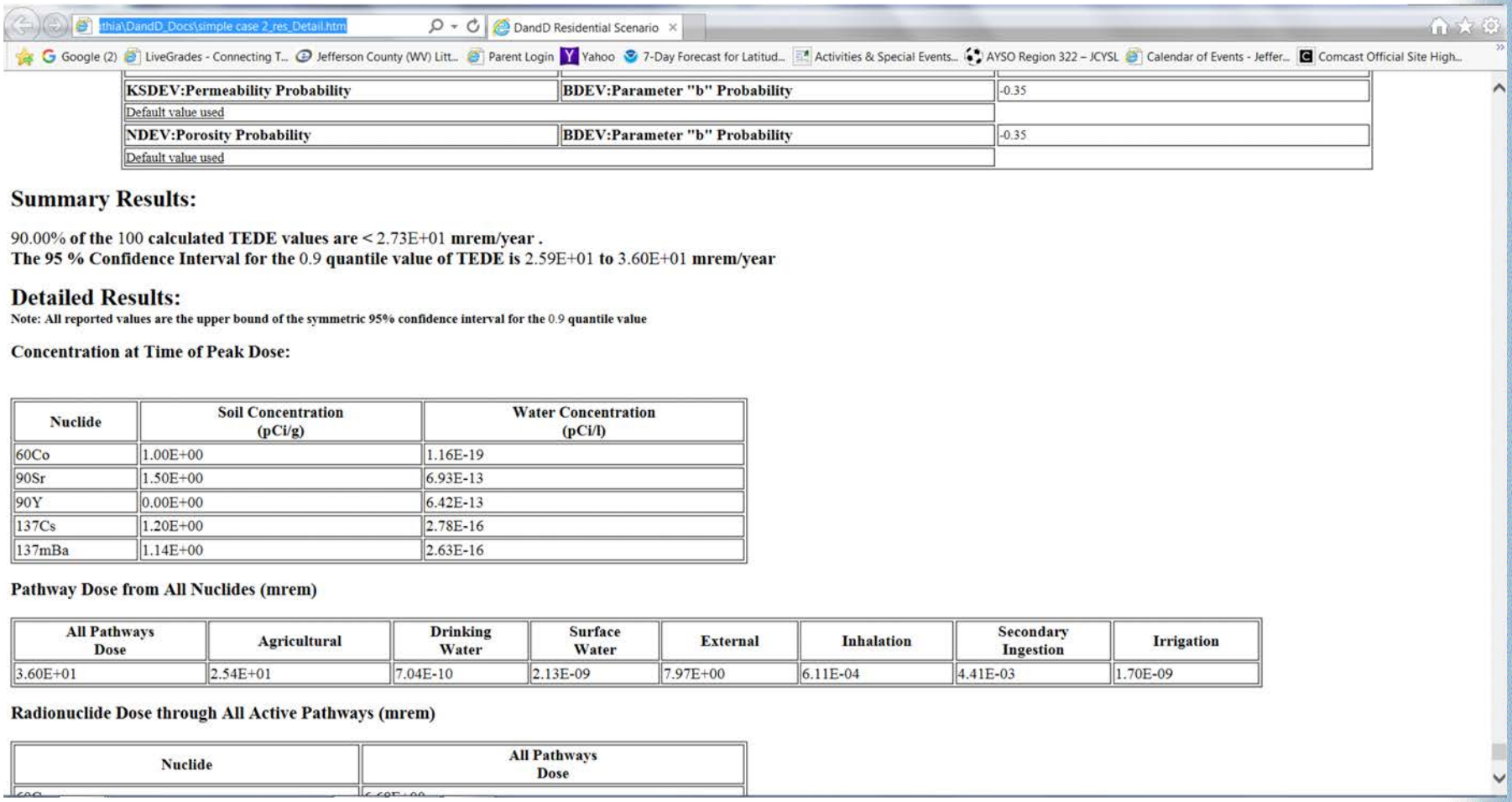
DandD Outputs



thia\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		
NDEV:Porosity 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**

Detailed Results:

Note: All reported values are the upper bound of the symmetric 95% confidence interval for the 0.9 **quantile value**

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

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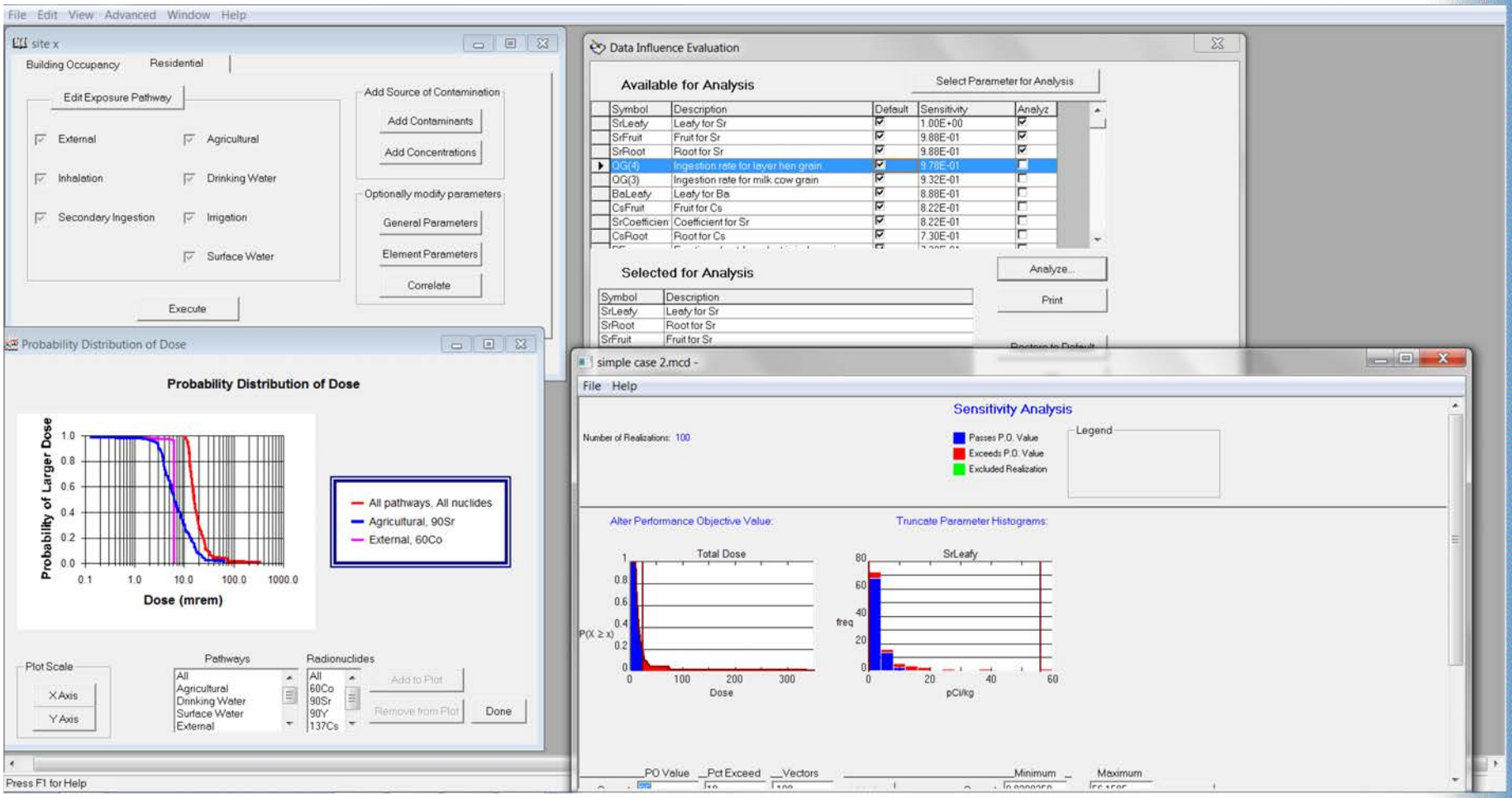
DandD Graphics



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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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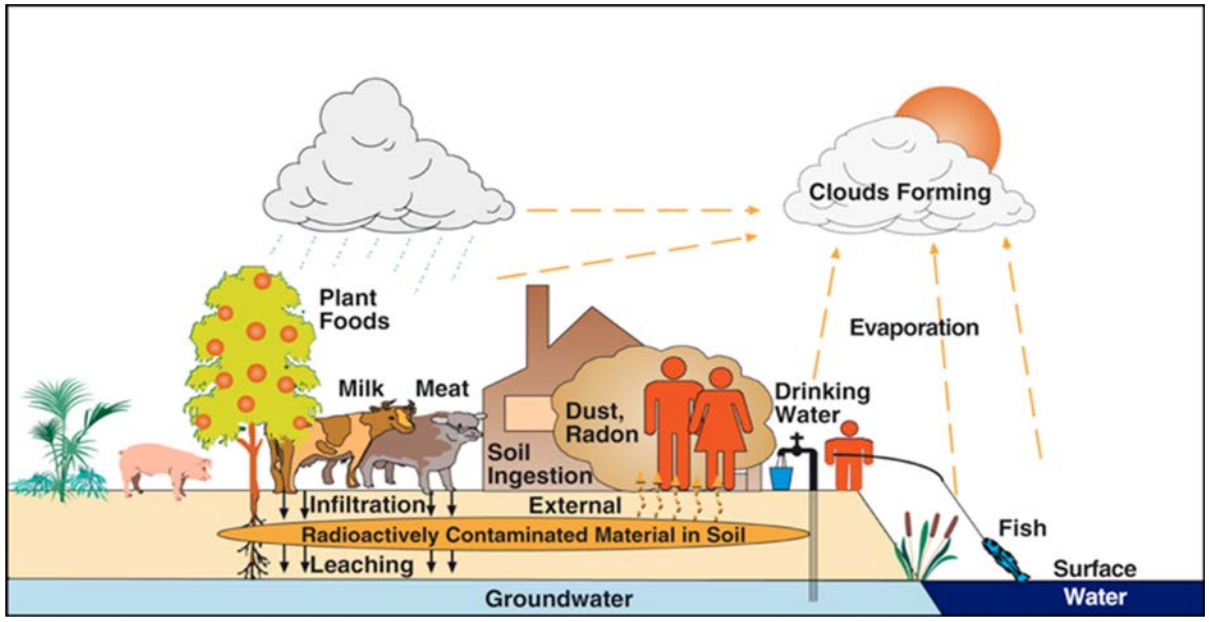
RESRAD

- 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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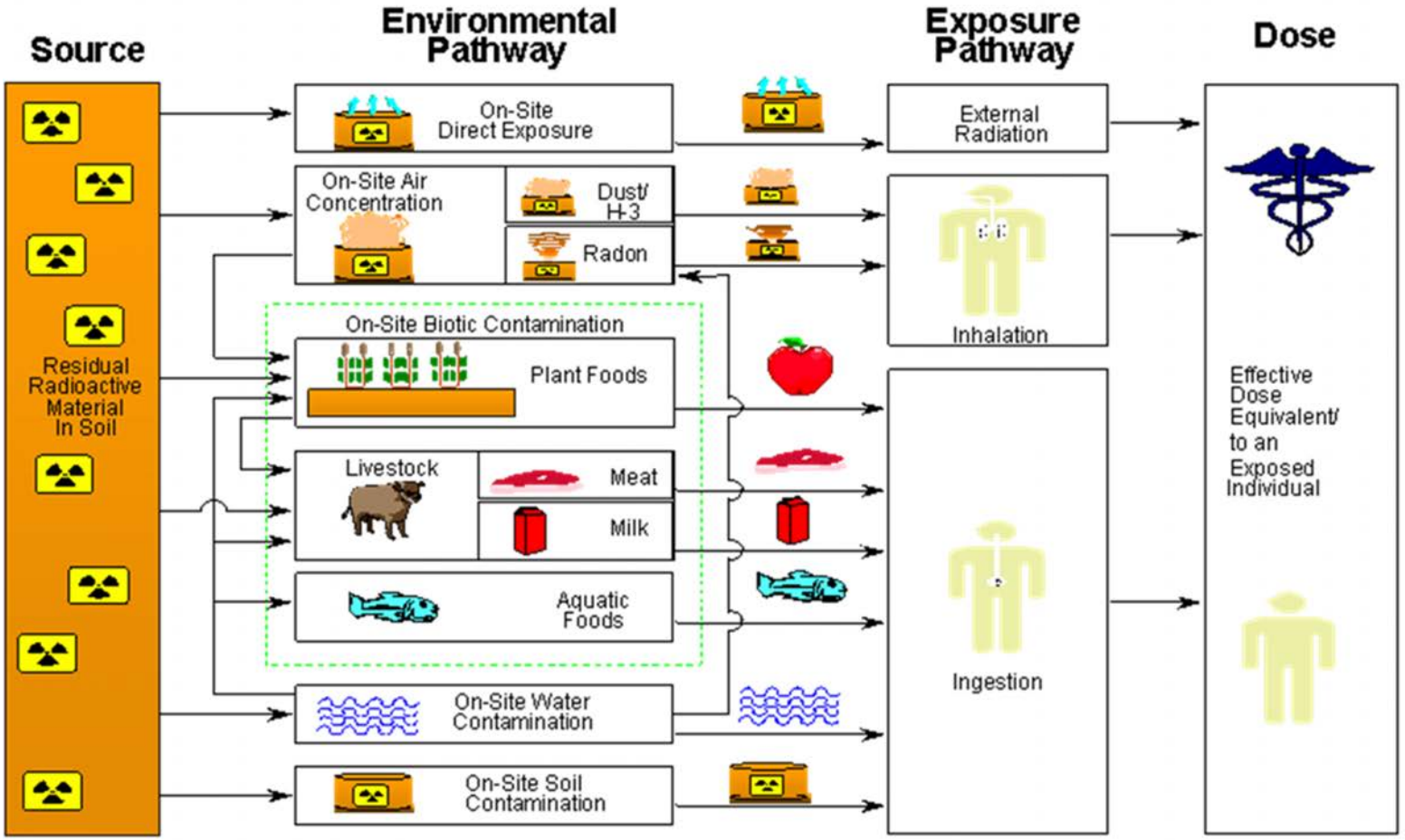
RESRAD pathways



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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
    - Consider “hot spots” or elevated areas of contamination
  - 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
- The screening tables can assist licensees with demonstrating compliance with radiological criteria for license termination
- 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.

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

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THANK YOU