NRCDose3

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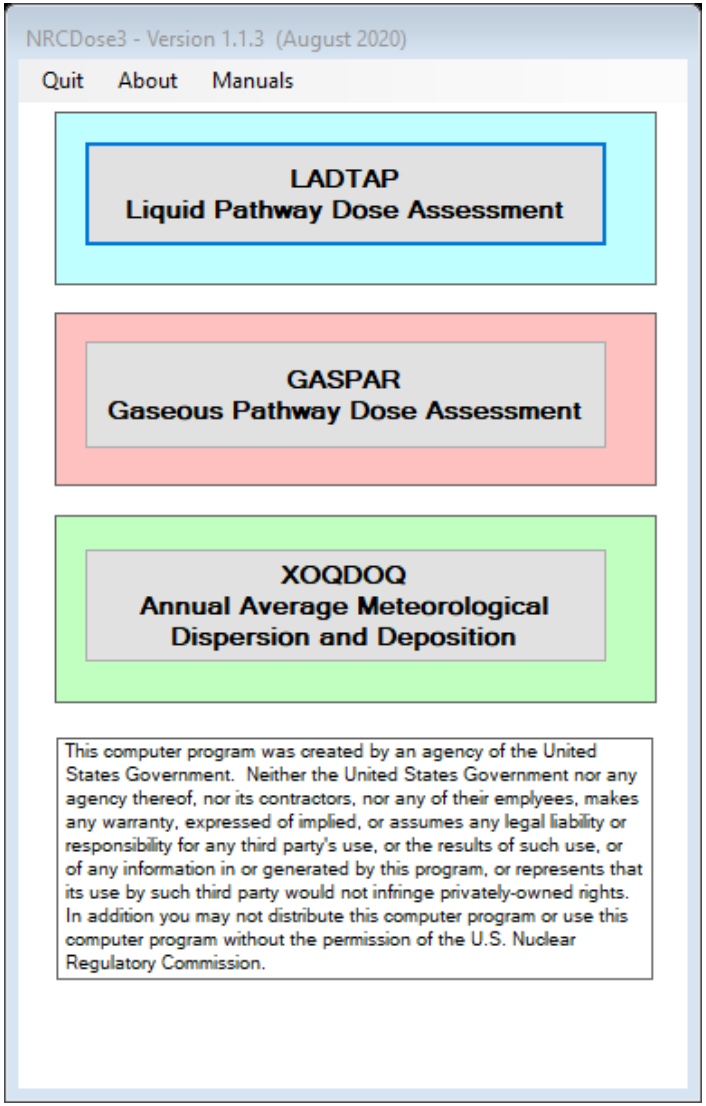
Topics

- NRCDose3 Overview
- Overview of Features
- XOQDOQ Modeling and Use/Screens
- GASPAR Modeling and Use/Screens
- LADTAP Modeling and Use/Screens
- NRCDose3 Code Discussions

NRCDOSE3 OVERVIEW



Purpose of Code

- Exposure pathway dose modeling, primarily developed for reactor effluents to demonstrate compliance with:
  - 10 CFR Part 20
  - Appendix I to 10 CFR Part 50
  - 40 CFR Part 190
  - 10 CFR Part 51
- Results used for reactor licensing (applicants, licensees, NRC staff) and inspection activities
- With expanded source term applicable to other fuel cycle facilities

NRC Guidance

- NRC guidance on reactor effluent dose calculations is contained in:
  - RG 1.109, *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I*
  - RG 1.111, *Methods of Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light Water Cooled Reactors*
  - RG 1.113, *Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purposes of Implementing Appendix I*

FORTRAN Codes

LADTAP II

- Liquid effluent doses
- NUREG/CR-4013, RSICC CCC-363

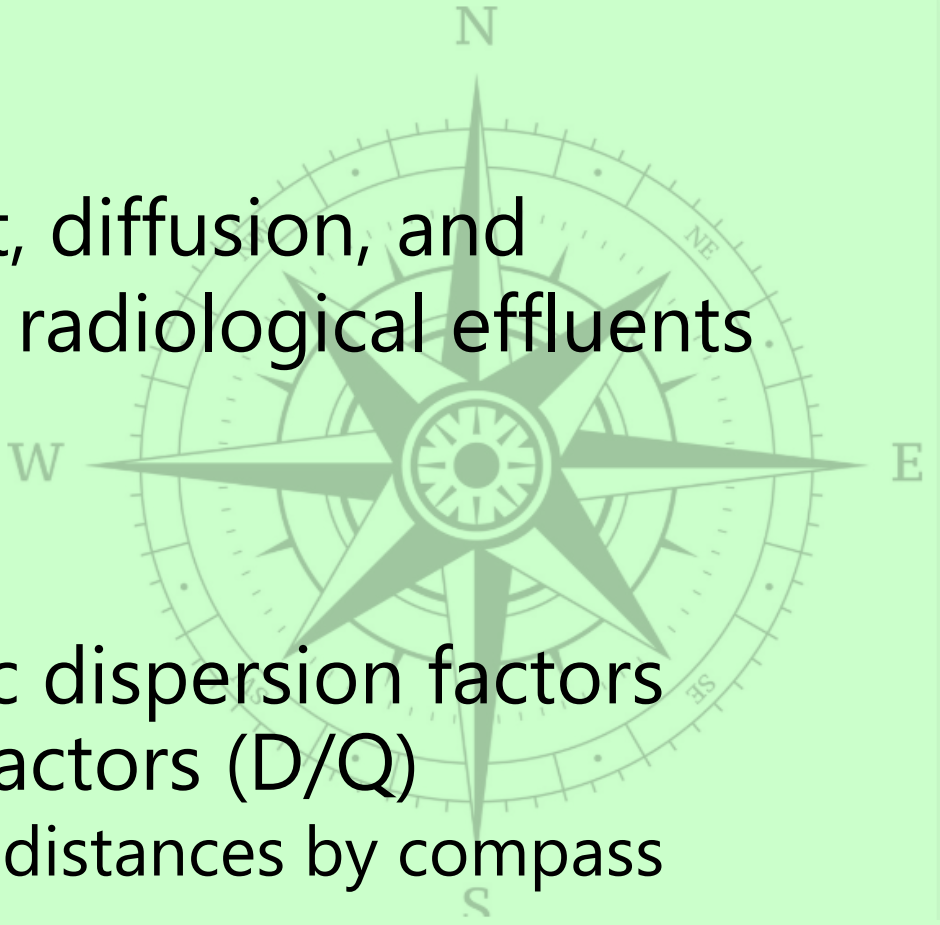
GASPAR II

- Gaseous effluent doses
- NUREG/CR-4653, RSICC CCC-463

XOQDOQ

- Atmospheric transport and diffusion
- NUREG/CR-2919, RSICC CCC-316

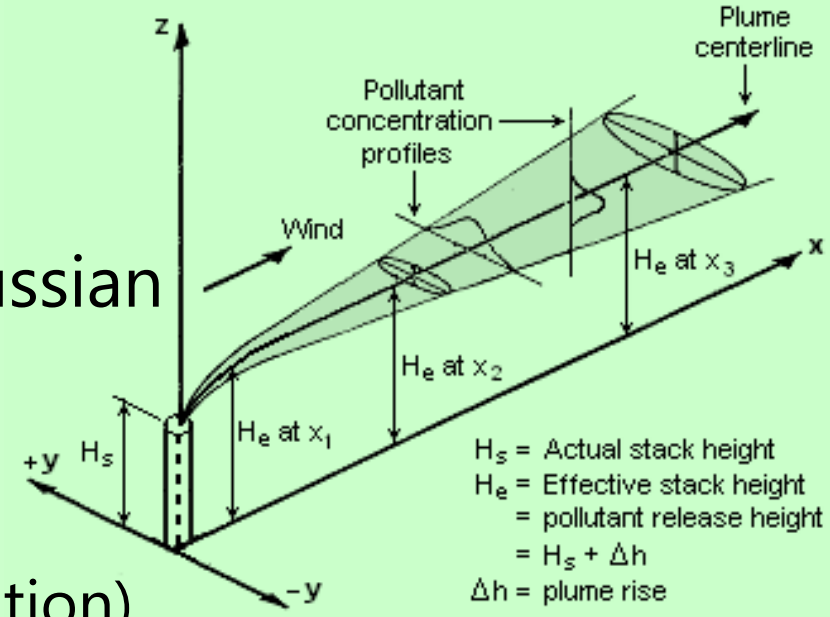
XOQDOQ



- Evaluation of transport, diffusion, and deposition of airborne radiological effluents
  - Routine releases
  - Intermittent releases
  - Non-emergency
- Calculates atmospheric dispersion factors (χ/Q) and deposition factors (D/Q)
  - Predefined segmented distances by compass sectors out to 50 miles
  - User defined points of interest

XOQDOQ

- Straight-line trajectory Gaussian plume model. Considers:
  - Dry deposition
  - Radioactive decay
  - Plume recirculation (stagnation)
- Calculates effective plume height
  - Physical release height
  - aerodynamic downwash
  - plume rise
  - terrain features



GASPAR II

- Estimates airborne effluent doses
  - Routine
  - Non-emergency
  - Individuals or populations
- Requires:
  - Source term released (Ci/yr)
  - Atmospheric dispersion (XOQDOQ)
  - Demographics

GASPAR II

- Internal Exposure Pathways
  - Inhalation (of plume)
  - Ingestion of contaminated food
    - leafy vegetables
    - vegetables and grains
    - meat
    - milk
- External Exposure Pathways
  - Plume
  - Ground Plane

LADTAP II

- Estimates liquid effluent doses
  - Routine
  - Non-emergency
  - Individuals, populations or biota
- Hydrologic model represents mixing in the effluent impoundment system and surface waters

LADTAP II

- Internal Exposure Pathways:
  - Drinking water (freshwater site)
  - Fish
  - Invertebrates
  - Aquatic plants
  - Irrigated crops
- External Exposure Pathways
  - Shoreline
  - Boating
  - Swimming

GASPAR II and LADTAP II

- ICRP-2 DCFs (1950s)
- Four (4) Age Groups
  - Infant
  - Child
  - Teen
  - Adult
- 7 Organs
  - Total Body
  - Bone
  - Liver
  - Thyroid
  - Kidneys
  - Lungs
  - GI-LLI

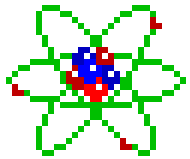
NRC and Industry End Uses

- NRC licensing reviews
  - Design Certification, Combined License, and Early Site Permit Applications
  - License Amendment Requests
- NRC health physics reactor inspections
  - Independent assessment of potential doses from effluent releases
  - Independent assessment of ODCM Dose Conversion Factors and effluent dose calculations

NRC and Industry End Uses (Cont.)

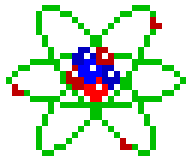
- Calculate doses at locations of interest
- Evaluate Land Use Census
  - Public interest
- Annual dose assessments
  - Actual receiving water body flows and dilutions
  - Meteorology with effluents for evaluated year
- ODCM Dose Conversion Factors

Why Update to NRCDose3



- Updates the NRCDose 2.3.20 (CCC-684) code
- Significant increase in flexibility and functionality

Why Update to NRCDose3



- Need for a licensing tool to support reactor application submittals
- Provides an acceptable method for evaluating exposure pathway doses from reactor effluents
- Improves efficiency in reactor licensing process, and NRC safety and environmental reviews

Overview of Updates

- Improved functionality
  - Updated Windows interface
- Option to select ICRP-2, ICRP-30, or ICRP-72 Dose Conversion Factors (DCFs)
  - Age range
  - Organs
- Expanded license application ready reports

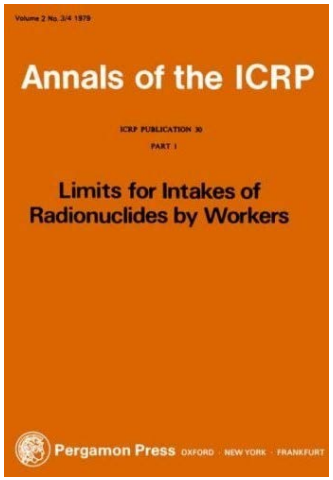
Overview of Updates

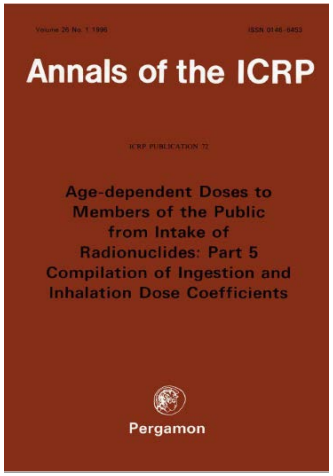
- User-modifiable parameter values
  - Bioaccumulation factors
  - Consumption rates
  - Usage factors
  - Other parameters

Previous versions of NRCDose (and FORTRAN codes) did not allow for edits to parameters

Updates (Cont.) – DCFs

- Expanded ICRP-2 DCFs
- ICRP-30 DCFs
- ICRP-72 DCFs
- Ingestion DCFs: Gastrointestinal Absorption Fractions (f1)
- Inhalation DCFs: Lung Clearance Classes for Chemical Compounds
  - ICRP-30: D/W/Y
  - ICRP-72: F/M/S





DCFs obtained from Radiological Toolbox, NRC RAMP at https://ramp.nrc-gateway.gov/

Updates (Cont.) – Biota Dose

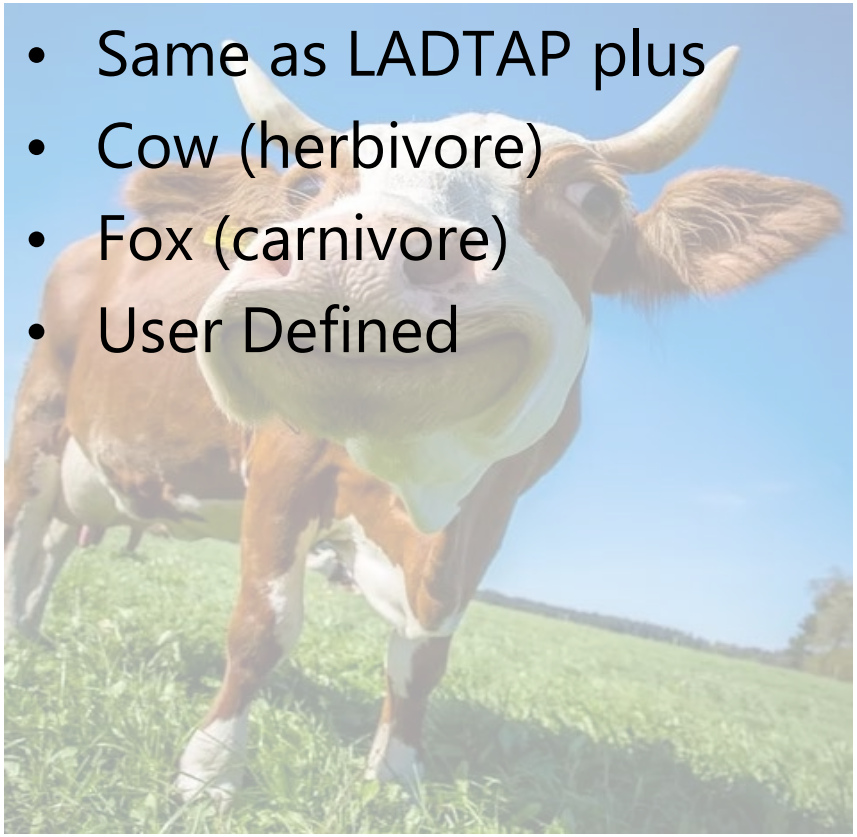
- Biota dose added to GASPAR and expanded in LADTAP
- Biota dose calculated at all user defined special location (GASPAR)
- Biota dose based on species mass, effective radius, primary food eaten (produce or meat) and consumption rate

Updates (Cont.) – Biota Dose

LADTAP

- Algae
- Muskrat
- Racoon
- Duck
- Heron
- User defined

GASPAR



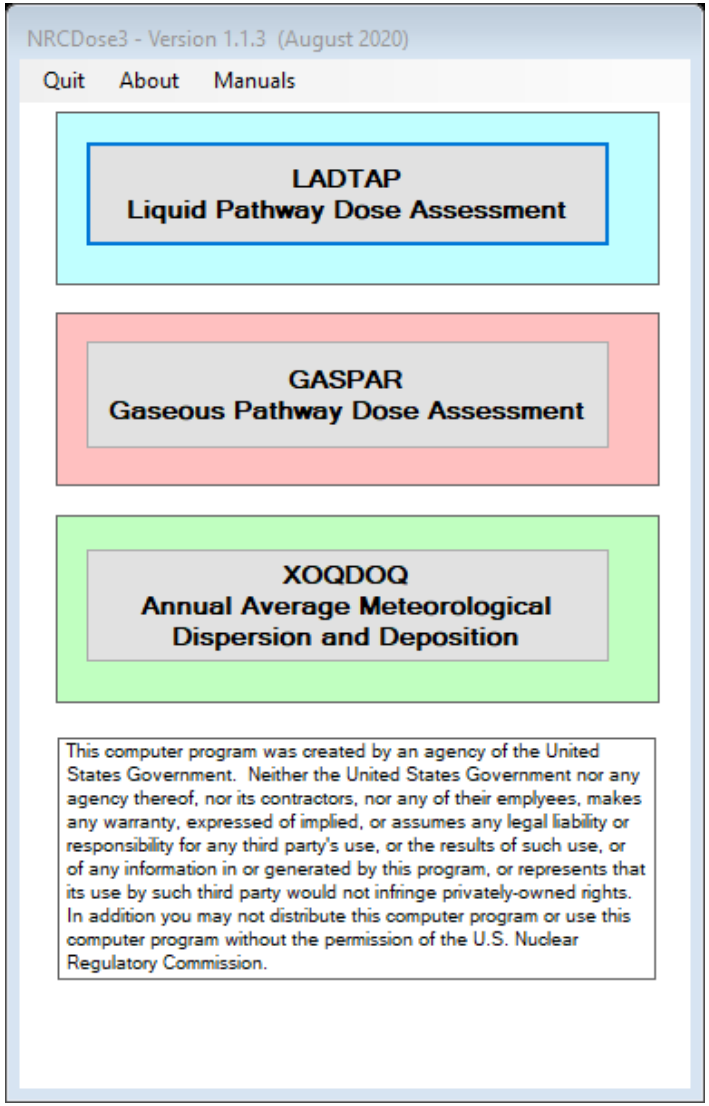
- Same as LADTAP plus
- Cow (herbivore)
- Fox (carnivore)
- User Defined

Documentation and Release

- NRCDose3 Quick Start Guide
  - How to install, run, and view output
- DRAFT NUREG on NRCDose3 Code: User Guide and Technical Manual
  - Technical basis
- Distribution by NRC RAMP

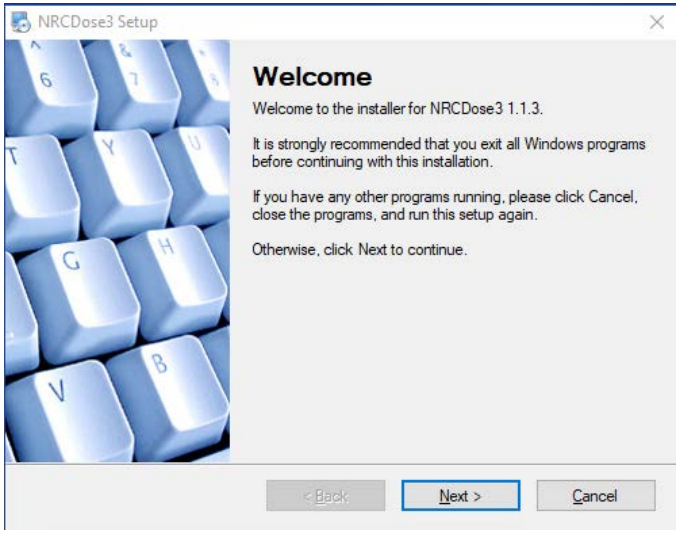
https://ramp.nrc-gateway.gov/

OVERVIEW OF FEATURES AND ENHANCEMENTS



Installation and Operation

- Double-click *NRCDose3_v113_Setup.exe*
- Follow prompts
- NRCDose3 will install in C:\directory (unless changed by the user)



File Types

.XN3

- XOQDOQ
- Case file saved by XOQDOQ

.GN3

- GASPAR
- Case file saved by GASPAR

.LN3

- LADTAP
- Case file saved by LADTAP

.DAT

- LADTAP and GASPAR
- Data file used in place of manually entered data
- Used to initially test the program (Older DAT files incompatible with NRCDose3)

File Structure

- When a code is opened, it will be loaded with the last case file from the database
  - When first opened, an example case file will be pre-loaded
- If a different case is desired, select *File->Open LN3 File* from the menu to load a saved case
  - Or "*Open GN3 File*" or "*Open XN3 File*" as applicable
- When saving a case, it will be saved to the database as well as a case file (.xn3, .gn3, .ln3 file type, as applicable)

Hard-Coded Parameters

- Previous versions of codes had many hard-coded parameters that are now user-editable
- Editing may be appropriate for site-specific conditions

CAUTION

Changing parameters from accepted methods (i.e., RGs) or licensing documentation may require evaluation or justification

XOQDOQ Expanded Editable Parameters

- Building wake constant
  - Though not recommended without a sound technical bases
- Essentially all other key modeling parameters (input values to the meteorological model) were already user defined or user controlled

LADTAP Expanded Editable Parameters

- Population age group fractions
- Food and water consumption rates
- Bioaccumulation and transfer factors
- Various environmental exposure times and produce production and storage times

GASPAR Editable Parameters

- Population age group fractions
- Human consumption and inhalation rates
- Bioaccumulation factors
- Various environmental exposure times and produce production and storage times
- Meat and milk animal consumption rates

Dose Conversion Factors

- Expanded ICRP-2 DCFs from:
  - RG 1.109, Revision 1, *Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I* (October 1977)
  - NUREG-0172, *Age Specific Radiation Dose Commitment Factors for One-Year Chronic Intake* (November 1977)
  - NUREG-0172, *Errata* (August 1983)
  - NUREG/CR-2384, *Age Specific Inhalation Radiation Dose Commitment Factors for Selected Radionuclides* (August 1982)
  - EMP-155, *Review and Expansion of USNRC Regulatory Guide 1.109 Models for Computing Dose Conversion Factors* (February 1983)

DCFs

- Some radionuclides in those sources were not included in LADTAP II/GASPAR II
- NRCDose3 includes ICRP-2 DCFs for ALL radionuclides contained in those sources
- NRCDose3 includes ICRP-30 and ICRP-60/72 DCFs for ALL radionuclides in those sources
- 203 radionuclides included in NRCDose3

Additional Radionuclides

S-35	Kr-88	Xe-138
Cl-36	Kr-89	Ba-133
Ar-39	Sr-85	Tm-170
Ar-41	Cd-109	Yb-169
Ca-45	Sn-113	Ta-182
Ga-67	I-125	Ir-192
Se-75	Xe-131m	Au-198
Kr-83m	Xe-133m	Tl-201
Kr-85m	Xe-133	Tl-204
Kr-85	Xe-135m	Rn-22
Kr-87	Xe-137	Pu-236

DCFs

- NRCDose3 allows only one chemical form, inhalation class or ingestion class for each radionuclide
- Multiple ingestion DCFs based on f1 value
- Multiple inhalation DCFs based on inhalation class
  - D/W/Y for ICRP-30
  - F/M/S for ICRP-72
- Nuclear power plant effluents are assumed to be oxides; other fuel cycle facilities may have different states

Age Ranges

ICRP-30

- Adult only
  - Occupational DCFs

ICRP-72

- Adult
- 15 year old
- 10 year old
- 5 year old
- 1 year old
- Newborn

Organs

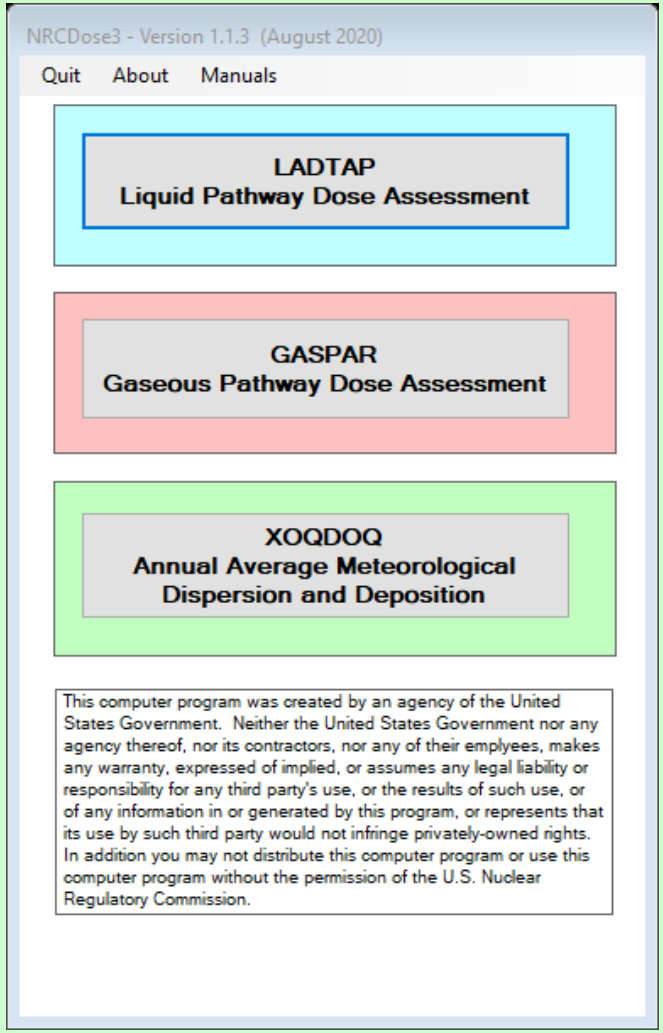
ICRP-30

- 24 organs, including remainder

ICRP-72

- 27 organs, including remainder
  - Colon, ETA, remainder

XOQDOQ MODELING AND USE



XOQDOQ – Atmospheric Transport and Dispersion

- Implements the straight-line Gaussian modeling of RG 1.111
- Calculates ground-level concentrations
- Accounts release points characteristics (height, plume rise)
- Additional plume dispersion due to building wakes
- Plume depletion via dry deposition and radioactive decay

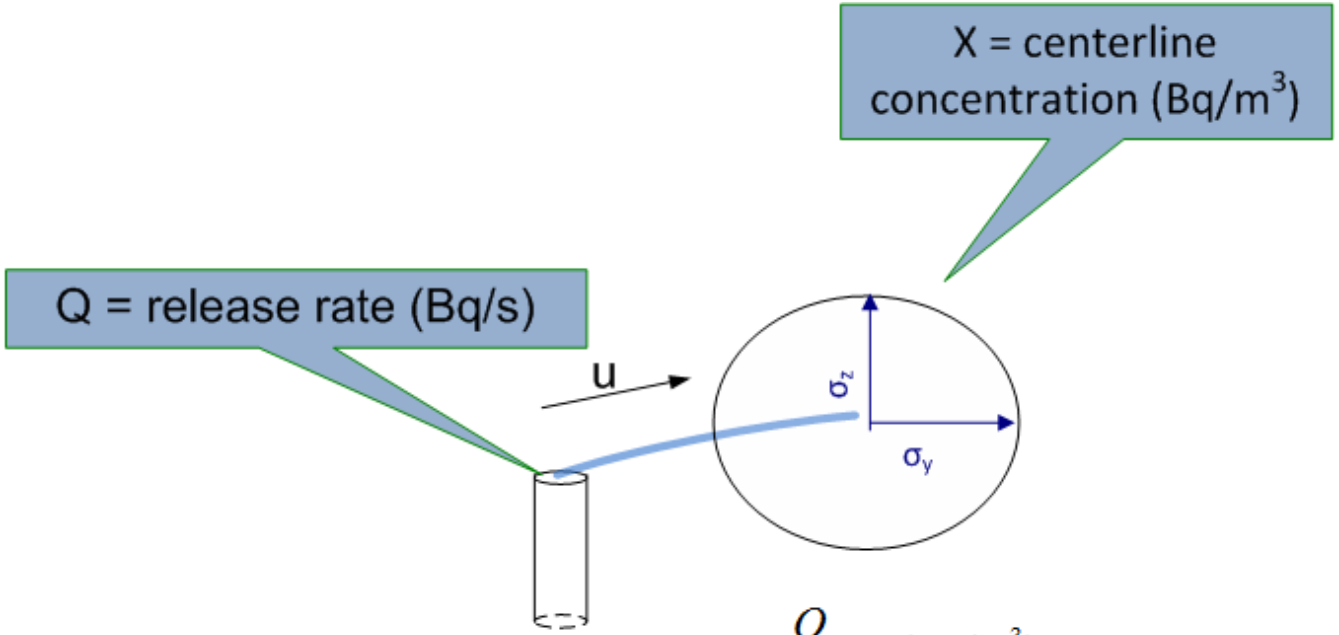
XOQDOQ – Atmospheric Transport and Dispersion

- Annual average relative dispersion (χ/Q) and deposition (D/Q) values at user specified locations (MEI doses) and standard radial distances and segments (population doses) for routine releases
- Intermittent releases (e.g., containment purge, waste gas tank)
- Elevated, ground level, or mixed mode releases
- Meteorological modeling considerations: building wake effects, plume depletion (dry deposition), and radioactive decay

XOQDOQ – Atmospheric Transport and Dispersion

- Wind direction in 16 compass directions (22.5° sectors), 14 wind speed classes, and 7 atmospheric stability classes (A-G)
- Three different dispersion χ/Q values; one deposition D/Q value
  - Undecayed, Undepleted χ/Q
  - Decayed, Undepleted χ/Q (2.26-day half-life)
  - Decayed, Depleted χ/Q (8-day half-life)
  - Deposition D/Q (2.26-day and 8-day half-lives)
- Output used as meteorological data input to GASPAR

Basic Meteorology Dispersion – χ/Q

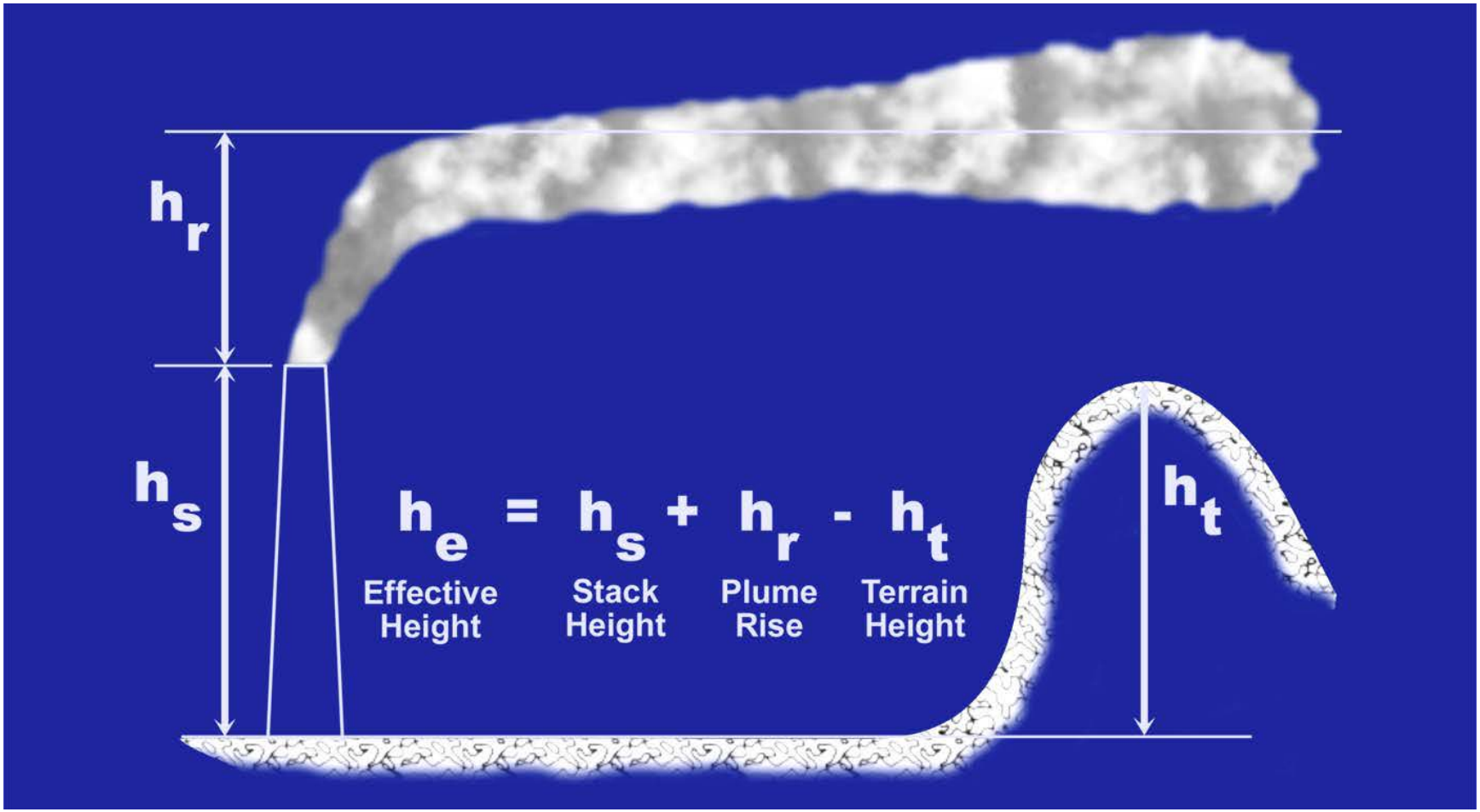


$$X = \frac{Q}{u\pi\sigma_y\sigma_z} \ (\mathrm{Bq/m^3})$$

then

$$\frac{X}{Q} = \frac{1}{u\pi\sigma_y\sigma_z} \ (\mathrm{s/m^3})$$

Dispersion – Release and Terrain Characteristics



Gaussian Model – Sector Average

- Dividing the area surrounding a point source into 16 segments gives 360°/16 = 22.5° per segment
- For averaging condition (over time), the plume is assumed to meander, spreading uniformly over the 22.5° sector

$$\frac{\chi}{Q} = \frac{2.032}{\sigma_z u x}$$

where

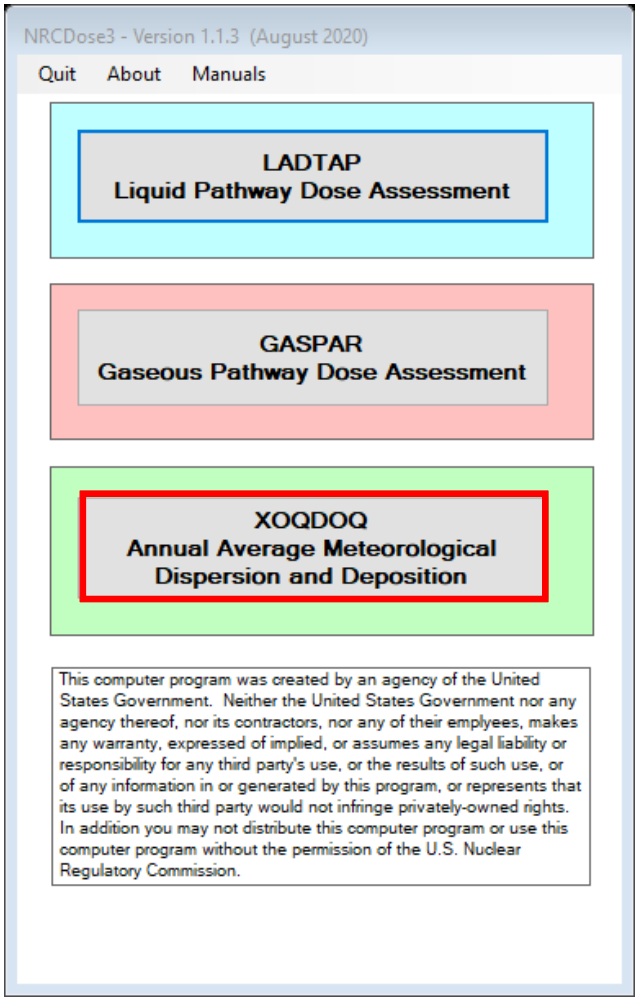
x = the distance from the point of release

u = the wind velocity

$2.032 = \sqrt{2/\pi}$ divided by the width of a 22.5° segment in radians

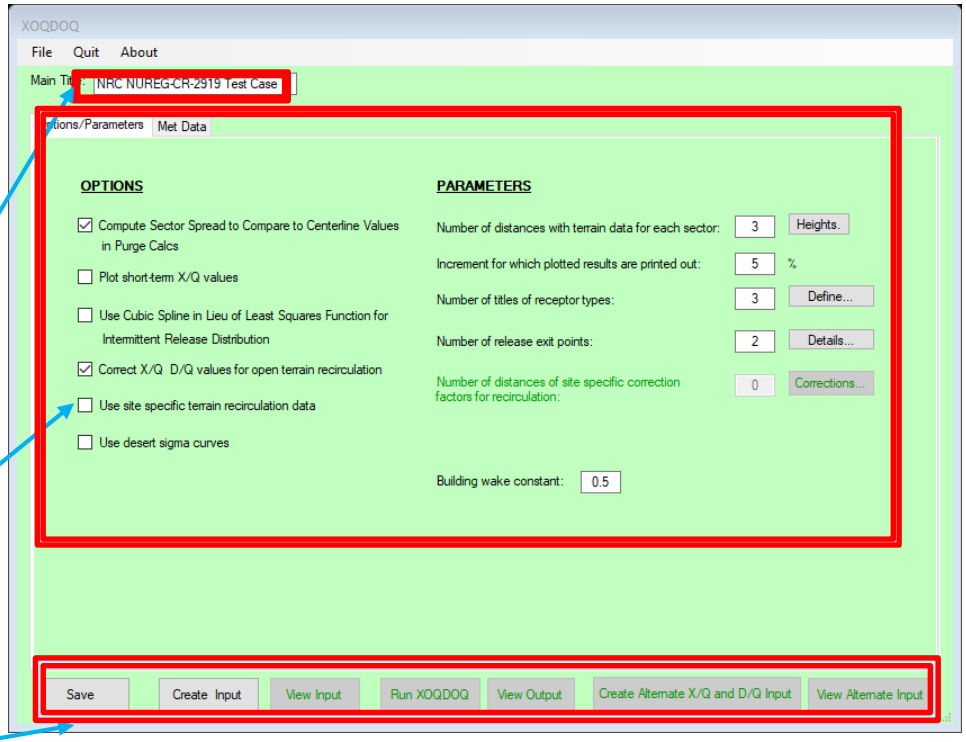
Starting and Running XOQDOQ

- Double click "XOQDOQ"



XOQDOQ Main Screen

- XOQDOQ Module Main Screen opens with case data that is saved in the database
- Contains three main functional areas:
  - toolbar and initial setup area,
  - data input tabs
  - code execution and reports



XOQDOQ – File Management

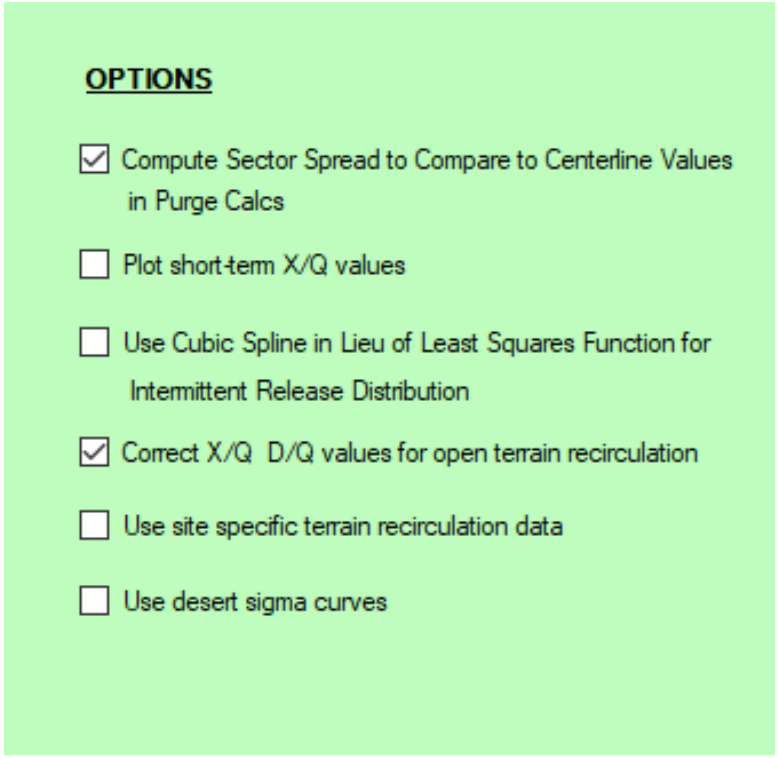
- New — New XOQDOQ case. Clears the databases.
- Open XN3 File — open an existing "*.XN3" file previously created with NRCDose3
- Open Legacy Input File — Opens Windows Explorer; navigate to "*.dat" file
  - Uses a file created with the original XOQDOQ
  - "Create input" not needed; select run XOQDOQ. Input screens and options cannot be used

XOQDOQ – File Management

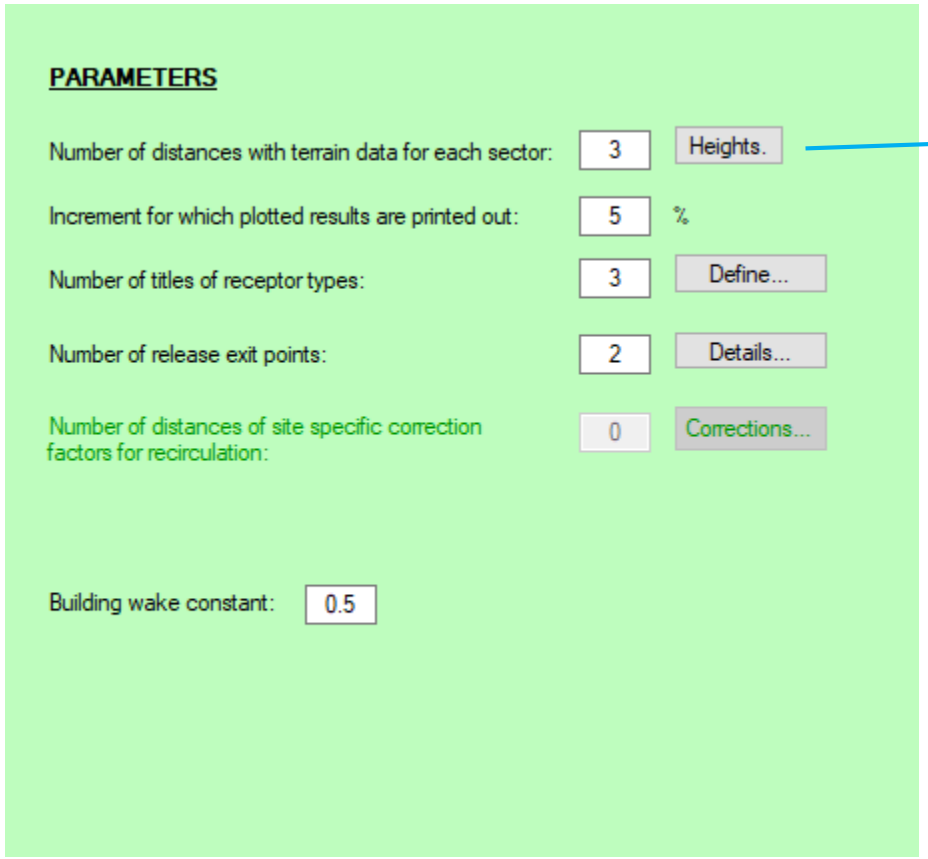
- Save to Database — Choose this option to save current case to the database. When XOQDOQ is opened with "Current Project" selected, the information in the database, as last saved before exiting, initially populates all XOQDOQ screens and windows.
- Save to XN3 File — Choose this option to save the completed case to a "*.XN3" file
- Delete — Choose this option to open an explorer window that will allow the user to delete any previously saved "*.XN3" files

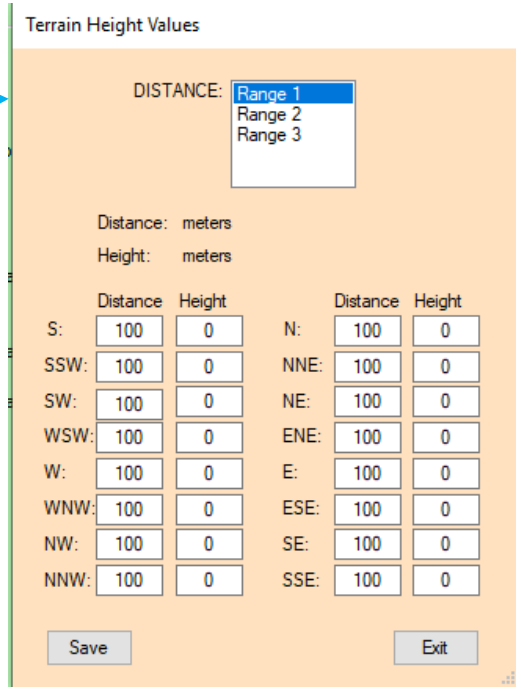
XOQDOQ Main Screen – Options

- Various options
  - Purge calc (short term releases) printout compares sector spread to centerline values
  - Printout plot of short-term X/Q values (not very useful)
  - Open terrain recirculation: correction is applied uniformly to all directional sectors out to 10 km (NUREG/CR-2919, Figure 3.2)
  - Use site-specific terrain recirc values (user input under Parameters)
  - Desert sigma curves (specialized dispersion values developed for desert environment)

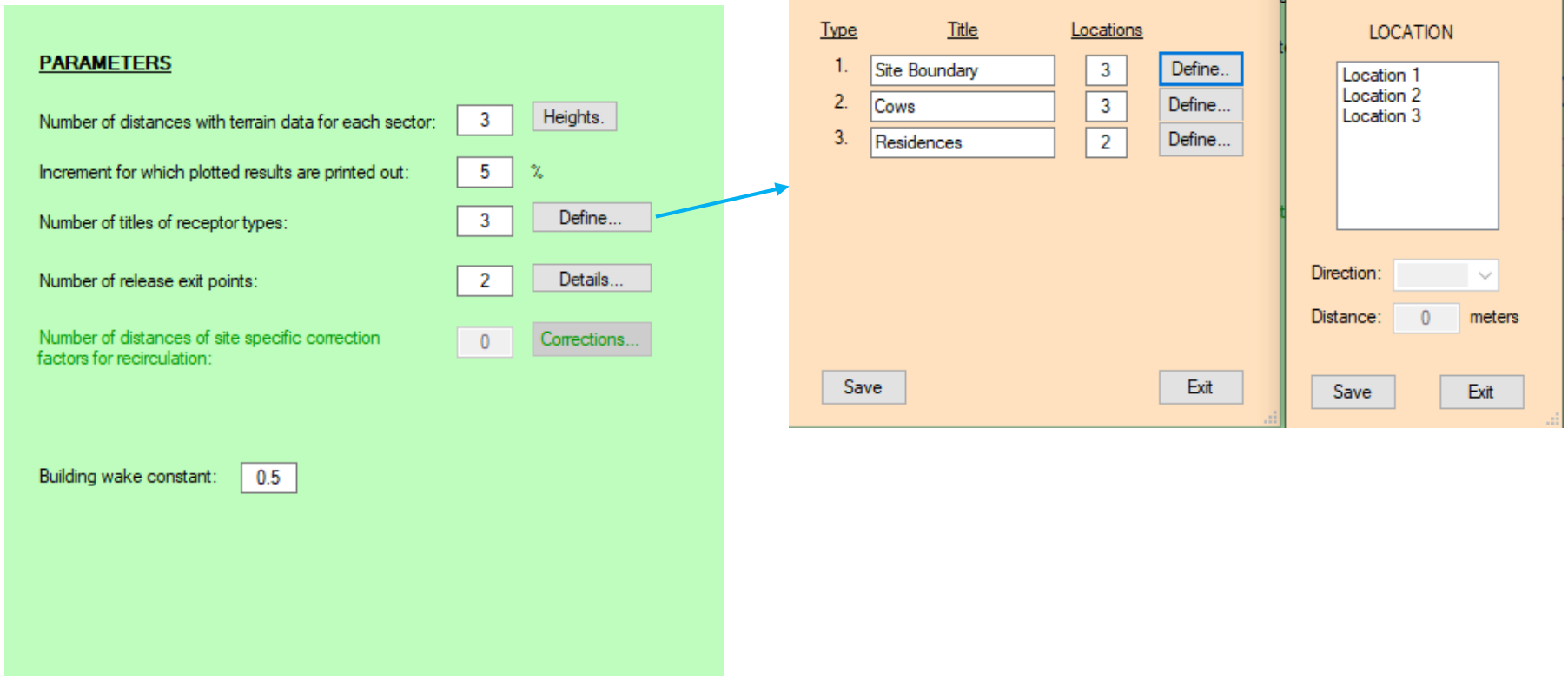


XOQDOQ Options/Parameters

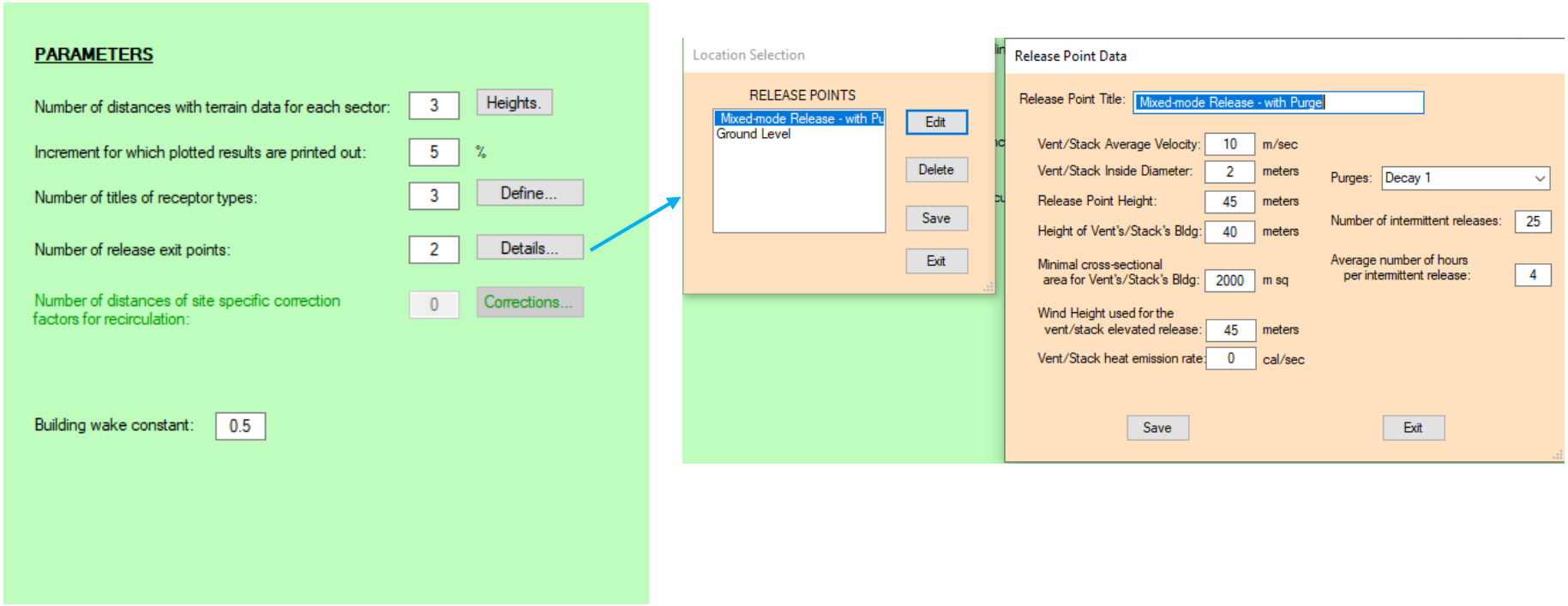




XOQDOQ Main Screen – Parameters

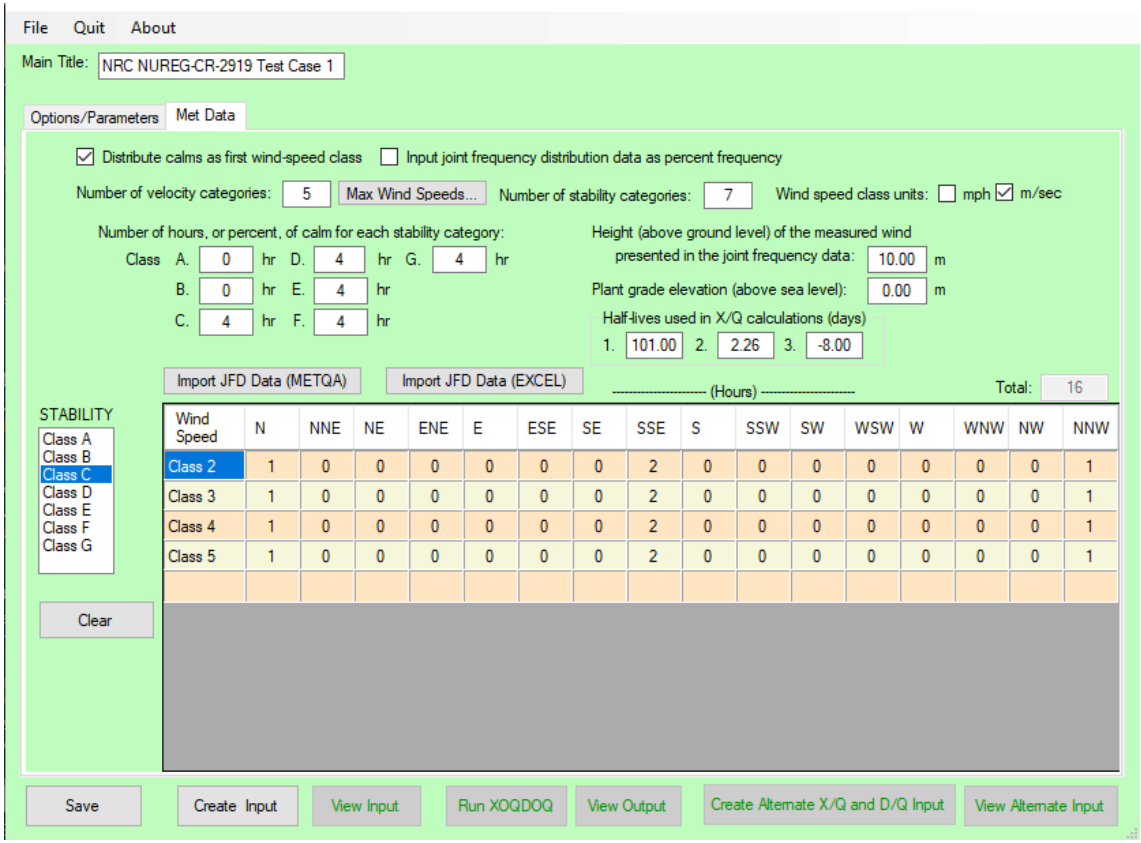


XOQDOQ Main Screen – Parameters



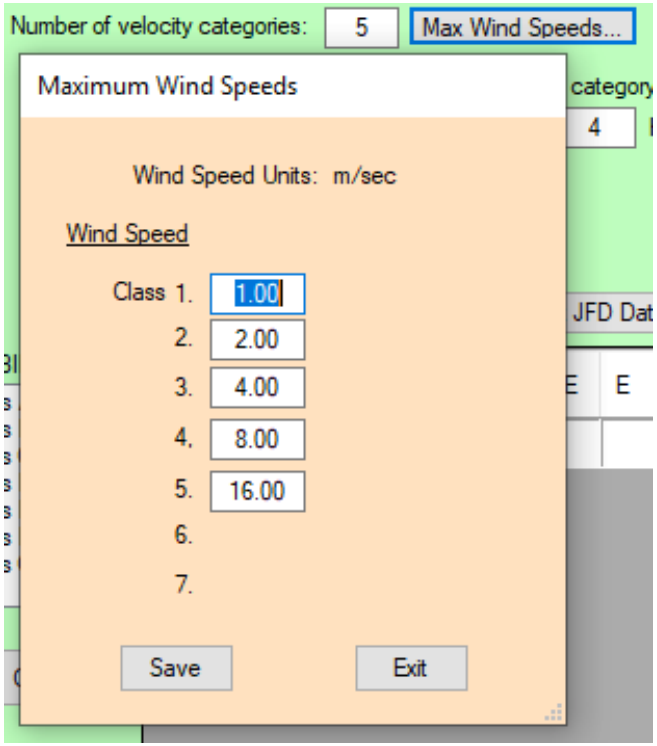
Met Data Input

- Calms
- Met data: hours or % frequency
- Height of measurement
- Plant grade
- Half-lives (do not change)
- Inputting joint frequency distribution (JFDs)
  - Line-by-line entering for each Stability Class



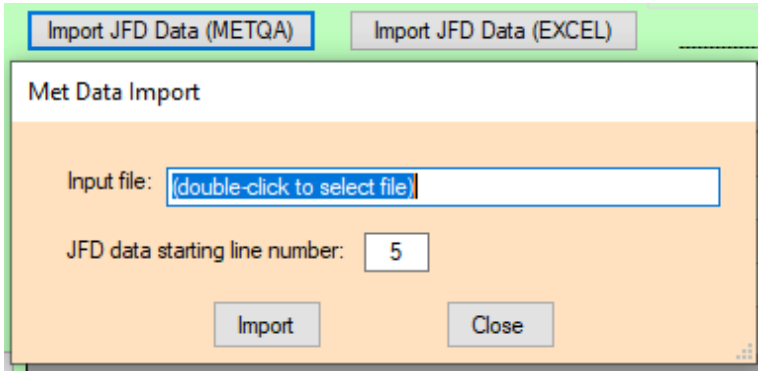
Windspeed Input

- Enter the “Number of velocity categories” (maximum 13), and then select “Max Wind Speeds…” to enter the maximum wind speed of each category



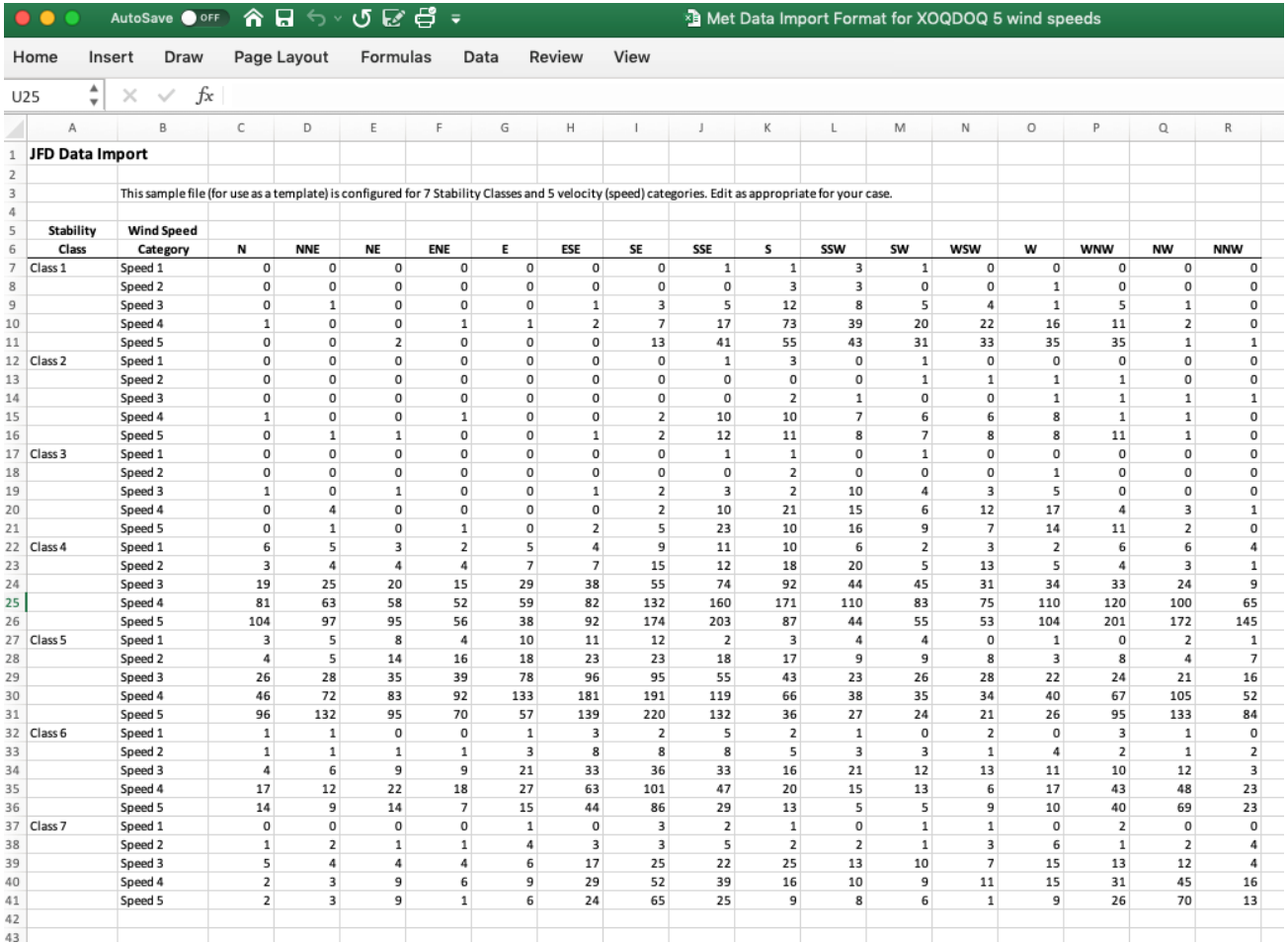
Import Met Data

- Met data (JFD) can be imported using 2 standard file formats
  - **MetQA**: file format generated by an internal (NRC) application MetQA (Version 2.0), which represents the NRC staff's implementation of NUREG-0917
  - **EXCEL**: specific data array by wind direction, wind speed range, and atmospheric stability classes ranging, in sequence, from extremely unstable (Class A) thru extremely stable (Class G)



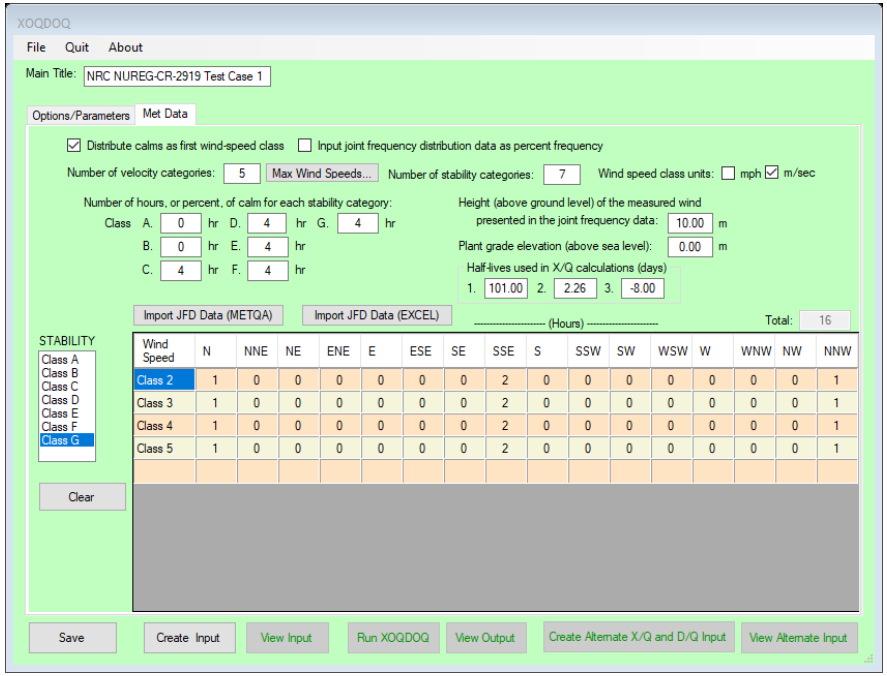
NOTE: Input file examples included in install

Import Met Data – Example File Format



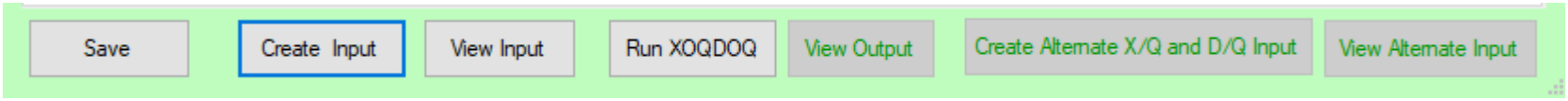
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	**JFD Data Import**																	
2																		
3		This sample file (for use as a template) is configured for 7 Stability Classes and 5 velocity (speed) categories. Edit as appropriate for your case.																
4																		
5	**Stability**	**Wind Speed**																
6	**Class**	**Category**	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**
7	Class 1	Speed 1	0	0	0	0	0	0	0	1	1	3	1	0	0	0	0	0
8		Speed 2	0	0	0	0	0	0	0	0	3	3	0	0	1	0	0	0
9		Speed 3	0	1	0	0	0	1	3	5	12	8	5	4	1	5	1	0
10		Speed 4	1	0	0	1	1	2	7	17	73	39	20	22	16	11	2	0
11		Speed 5	0	0	2	0	0	0	13	41	55	43	31	33	35	35	1	1
12	Class 2	Speed 1	0	0	0	0	0	0	0	1	3	0	1	0	0	0	0	0
13		Speed 2	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
14		Speed 3	0	0	0	0	0	0	0	0	2	1	0	0	1	1	1	1
15		Speed 4	1	0	0	1	0	0	2	10	10	7	6	6	8	1	1	0
16		Speed 5	0	1	1	0	0	1	2	12	11	8	7	8	8	11	1	0
17	Class 3	Speed 1	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0
18		Speed 2	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0
19		Speed 3	1	0	1	0	0	1	2	3	2	10	4	3	5	0	0	0
20		Speed 4	0	4	0	0	0	0	2	10	21	15	6	12	17	4	3	1
21		Speed 5	0	1	0	1	0	2	5	23	10	16	9	7	14	11	2	0
22	Class 4	Speed 1	6	5	3	2	5	4	9	11	10	6	2	3	2	6	6	4
23		Speed 2	3	4	4	4	7	7	15	12	18	20	5	13	5	4	3	1
24		Speed 3	19	25	20	15	29	38	55	74	92	44	45	31	34	33	24	9
25		Speed 4	81	63	58	52	59	82	132	160	171	110	83	75	110	120	100	65
26		Speed 5	104	97	95	56	38	92	174	203	87	44	55	53	104	201	172	145
27	Class 5	Speed 1	3	5	8	4	10	11	12	2	3	4	4	0	1	0	2	1
28		Speed 2	4	5	14	16	18	23	23	18	17	9	9	8	3	8	4	7
29		Speed 3	26	28	35	39	78	96	95	55	43	23	26	28	22	24	21	16
30		Speed 4	46	72	83	92	133	181	191	119	66	38	35	34	40	67	105	52
31		Speed 5	96	132	95	70	57	139	220	132	36	27	24	21	26	95	133	84
32	Class 6	Speed 1	1	1	0	0	1	3	2	5	2	1	0	2	0	3	1	0
33		Speed 2	1	1	1	1	3	8	8	8	5	3	3	1	4	2	1	2
34		Speed 3	4	6	9	9	21	33	36	33	16	21	12	13	11	10	12	3
35		Speed 4	17	12	22	18	27	63	101	47	20	15	13	6	17	43	48	23
36		Speed 5	14	9	14	7	15	44	86	29	13	5	5	9	10	40	69	23
37	Class 7	Speed 1	0	0	0	0	1	0	3	2	1	0	1	1	0	2	0	0
38		Speed 2	1	2	1	1	4	3	3	5	2	2	1	3	6	1	2	4
39		Speed 3	5	4	4	4	6	17	25	22	25	13	10	7	15	13	12	4
40		Speed 4	2	3	9	6	9	29	52	39	16	10	9	11	15	31	45	16
41		Speed 5	2	3	9	1	6	24	65	25	9	8	6	1	9	26	70	13
42																		
43																		

XOQDOQ – Save, Create Input and Run



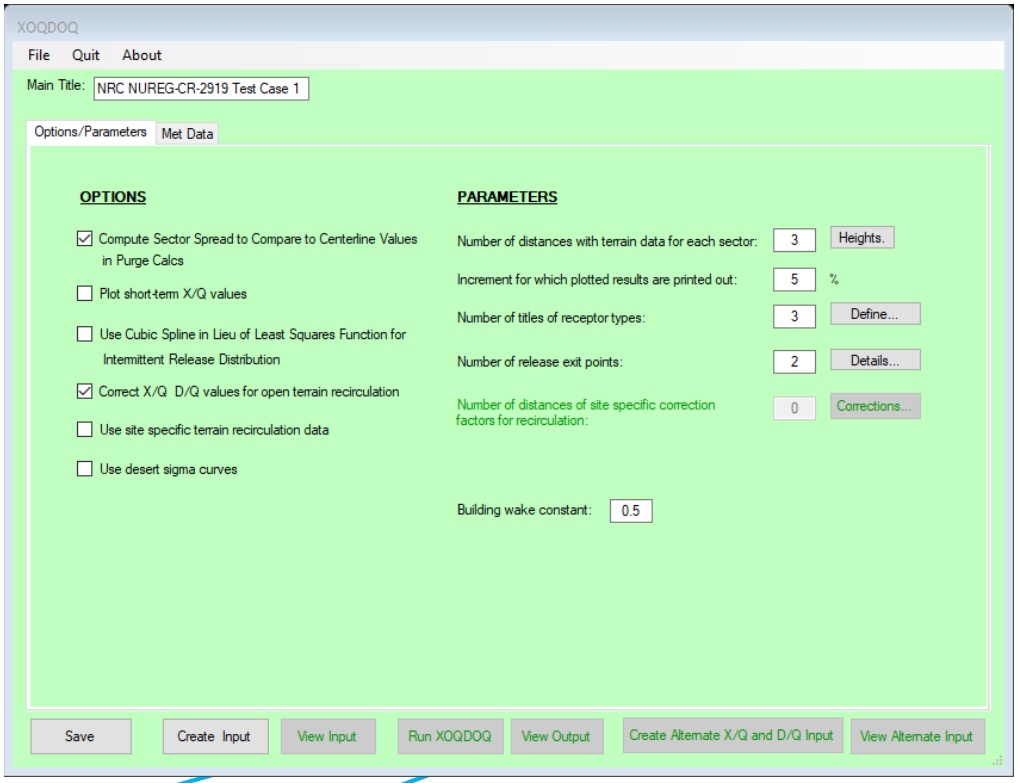
After inputting JDFs,

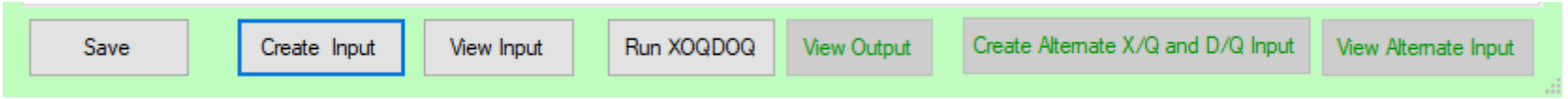
- Save
  - This will save to the dataset as well as to any file name as being used.
- Create Input
  - This creates the dataset in the format required by the FORTRAN code
- View Input
  - Allows user to view he created input file
- Run XOQDOQ



XOQDOQ – Save, Create, Input and Run

- **Save** to save the dataset to any file name as being used.
- **Create Input** to create the dataset in the format required by the FORTRAN code
- **View Input** to view created input file
- **Run XOQDOQ**





View Input

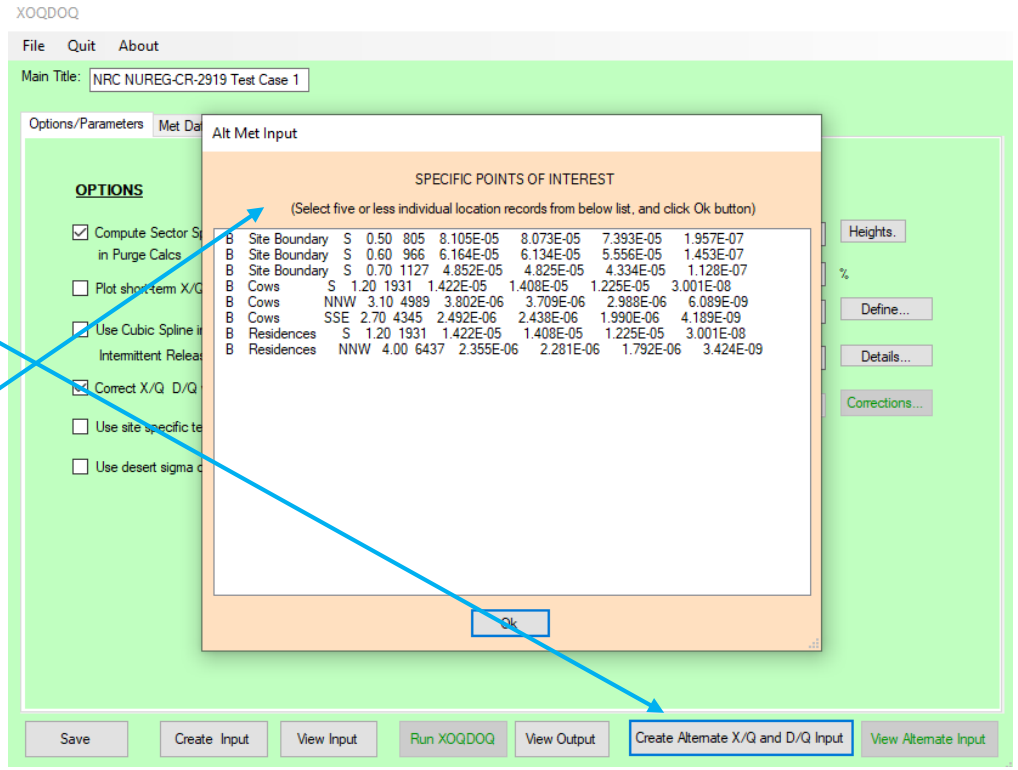
- Shows the input deck as used by the FORTRAN code
- Follows the card format as described in NUREG/CR-2919

```
1010011100
NRC NUREG-CR-2919 Test Case 1
    5    7    3    5    3    2    0
   10  101 2.26   -8    0
    0    0    4    4    4    4    4
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
    1    0    0    0    0    0    0    2    0    0    0    0    0    0    0    1
  0.5 -100    1    2    4    8   16
  100  100  100  100  100  100  100  100  100  100  100  100  100  100  100  100
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
  800  800  800  800  800  800  800  800  800  800  800  800  800  800  800  800
   16   16   16   16   16   16   16   16   16   16   16   16   16   16   16   16
10000100001000010000100001000010000100001000010000100001000010000100001000010000
  200  200  200  200  200  200  200  200  200  200  200  200  200  200  200  200
    3    3    2
Site Boundary
    1  805    1  966    1 1127
Cows
    1 1931    8 4989   16 4345
Residences
    1 1931    8 6437
 Mixed-mode Release - with Purge
   10    2   45   40 2000   45    0
A   1   25    4
Ground Level
    0    0   30   25  900   10    0
B   0    0    0
```

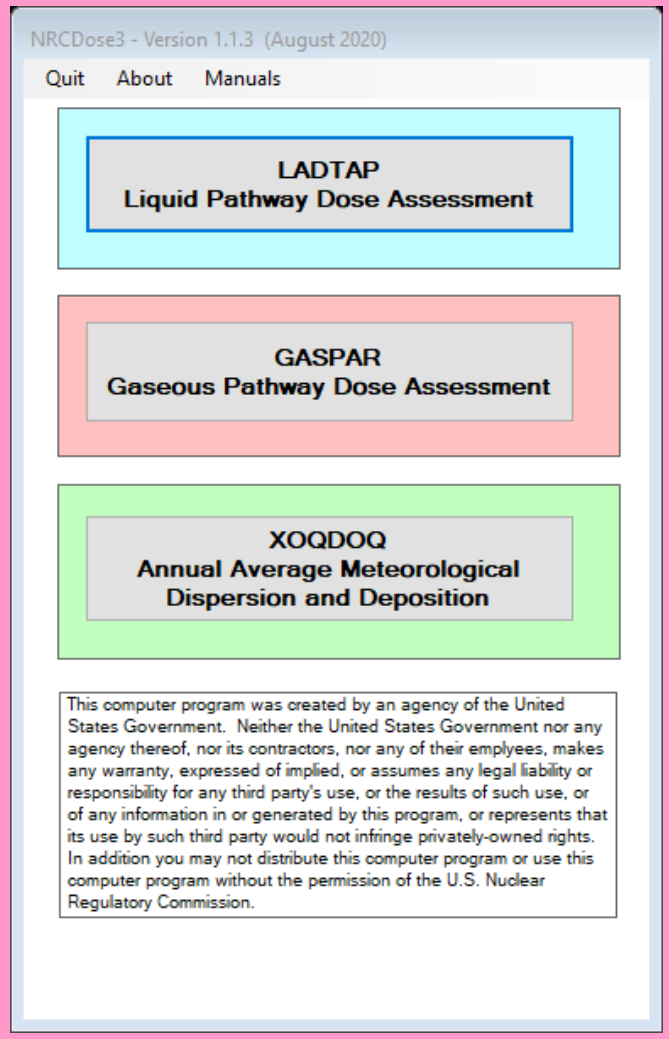
Chesapeake Nuclear Services

Create Alt. Input – For GASPAR

- A meteorological dataset suitable for import by GASPAR can be created
  - Select **Create Alternate X/Q and D/Q Input**
- Pop-up screen to select up to 5 locations
- An input file will be created internal which may be referenced during the GASPAR run
- Only applicable to XOQDOQ for single release point runs



GASPAR MODELING AND USE



GASPAR

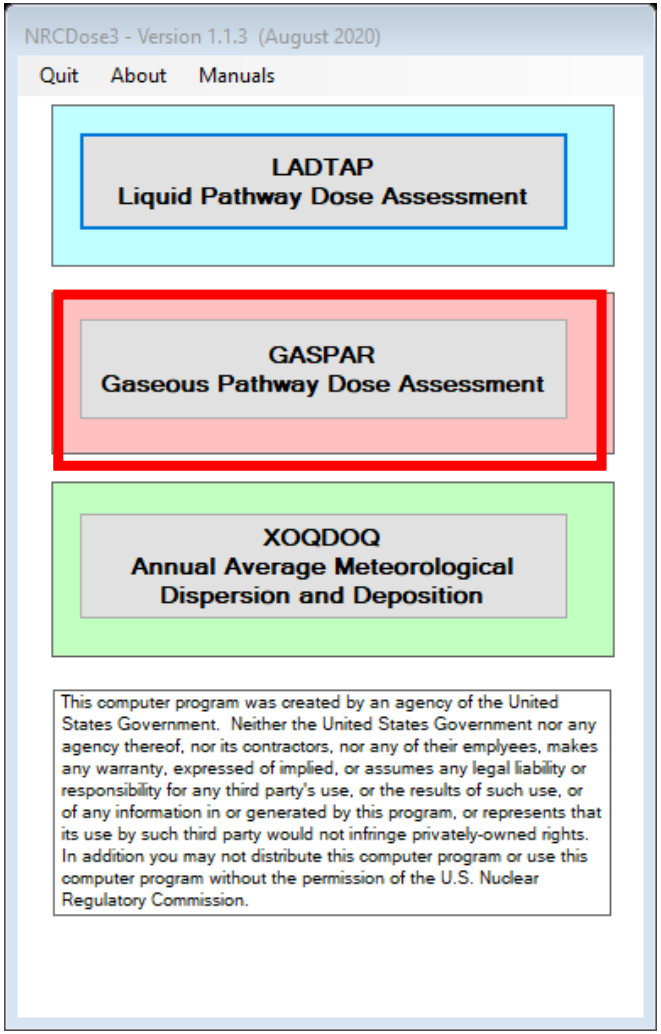
- Performs dose assessments for gaseous radioactive effluents released into the atmosphere
- Implements dose assessment methods described in RG 1.109
- Calculates the radiation dose to individuals, population groups, and biota from:
  - inhalation of contaminated air,
  - direct exposure from contaminated ground and
  - consumption of contaminated foods
- Basic calculation methods are described in NUREG/CR-4653

GASPAR

- Calculated doses support
  - NEPA evaluations
  - Compliance with the NRC public dose limits in 10 CFR Part 20
  - EPA public dose limits in 40 CFR Part 190
  - NRC ALARA design objectives and numerical guides in 10 CFR Part 50, Appendix I

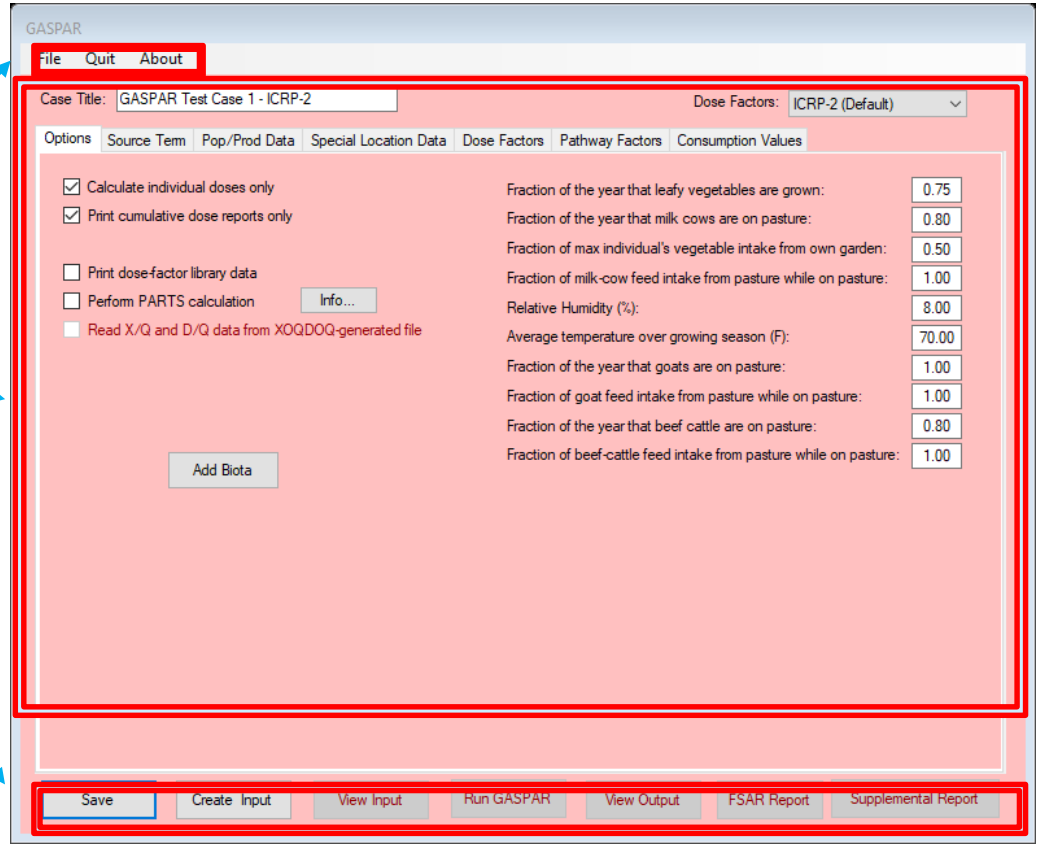
Starting and Running GASPAR

- Double click "GASPAR"



GASPAR Main Screen

- Contains three main functional areas:
  - the toolbar and initial setup area,
  - data input tabs area and
  - code execution and reports area



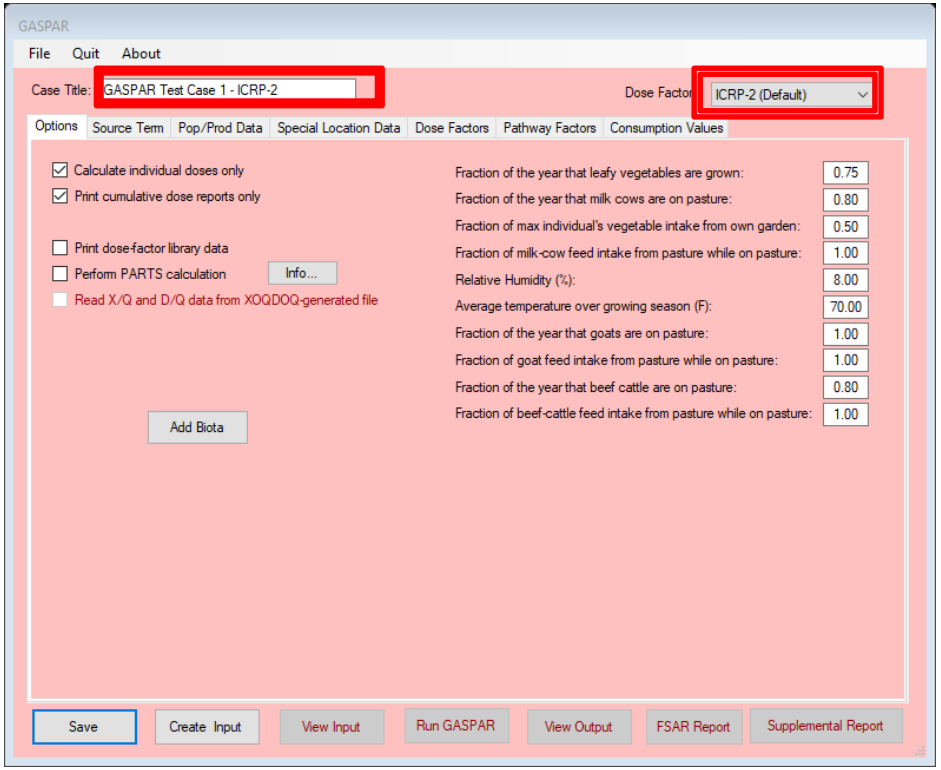
NOTE: GASPAR opens with the last saved database

GASPAR Start-up

- New — Select this option to begin a new GASPAR case. This will clear the database from any previously input information.
- Open GN3 File — Select this option to access and open a "*.GN3" file that was previously created with NRCDose3.
- Save to Database — Choose this option to save the current case to the database. When GASPAR starts, it loads the data that was last saved (typically from the last, previous run), populating all GASPAR screens and windows.
- Save to GN3 File — Choose this option to save the completed case to a "*.GN3" file. This allows the file to be saved for later use, or for sharing with others.
- Delete — Choose this option to open an explorer window that will allow the user to delete any previously saved "*.GN3" files.

GASPAR – Options

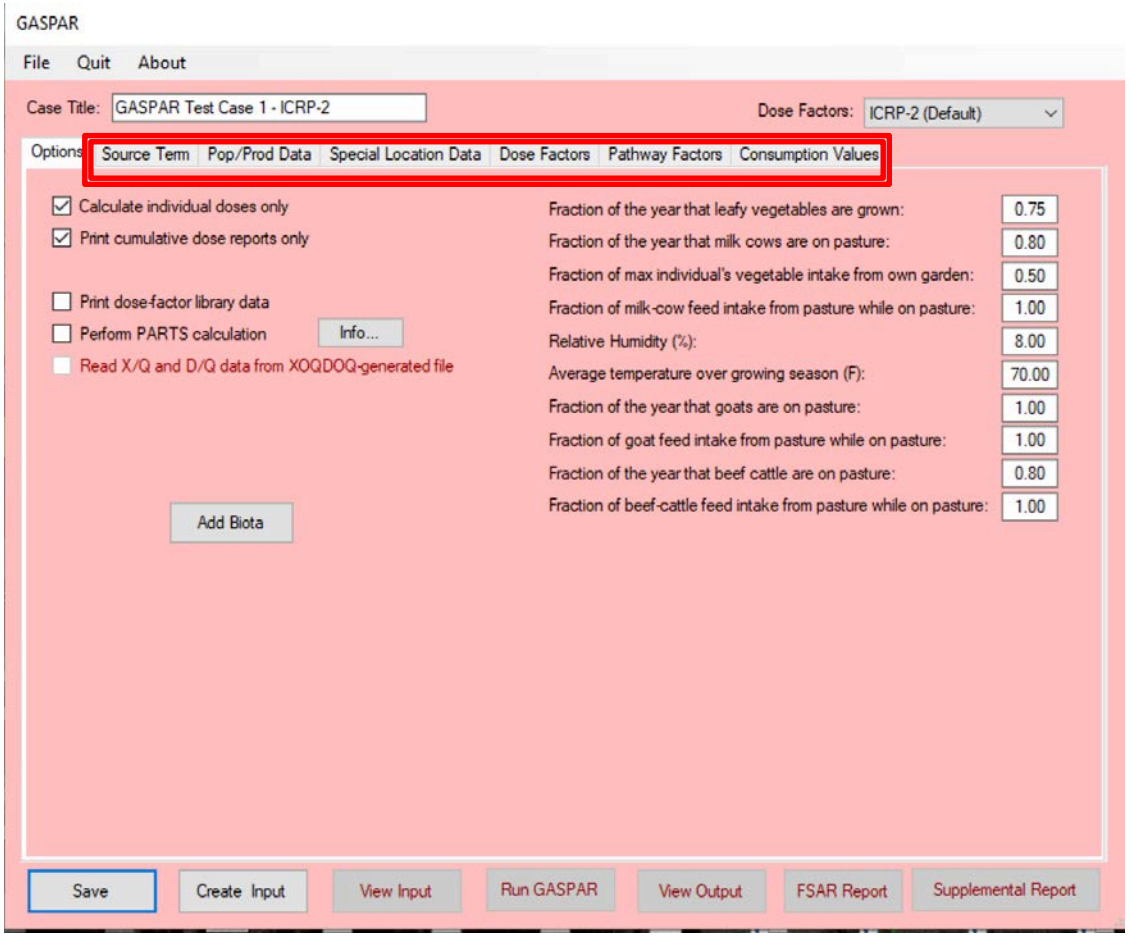
- Enter a Case Title
- Select dose factors to be used:
  - ICRP-2 (Default)
  - ICRP-30
  - ICRP-72
- Option for individual doses only
- Printing cumulative or detailed dose reports
- Printing dose factor library (don't select unless want many pages of DCFs for all 203 radionuclides)
- PARTS calculations (calculates dose conversion factors incorporating site-specific dose modeling; used in ODCM)



NOTE: Changing DCFs will re-initialize the source term

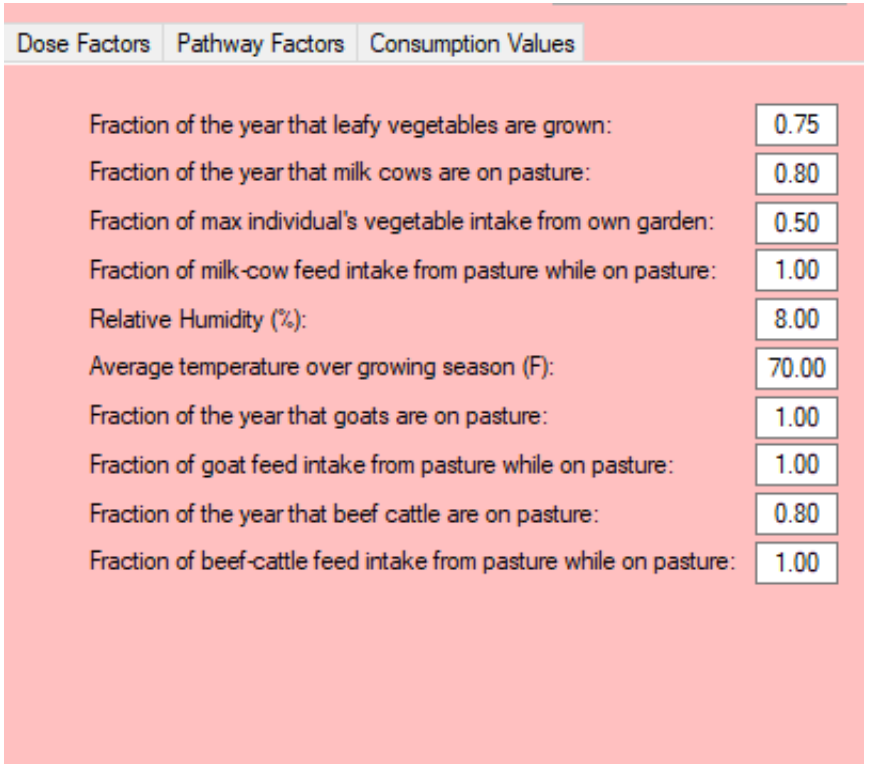
GASPAR Main Screen

- The seven GASPAR Data Input Tabs:
  - Options
  - Source Term
  - Pop/Prod Data
  - Special Locations
  - Dose Factors
  - Pathway Factors
  - Consumption Values



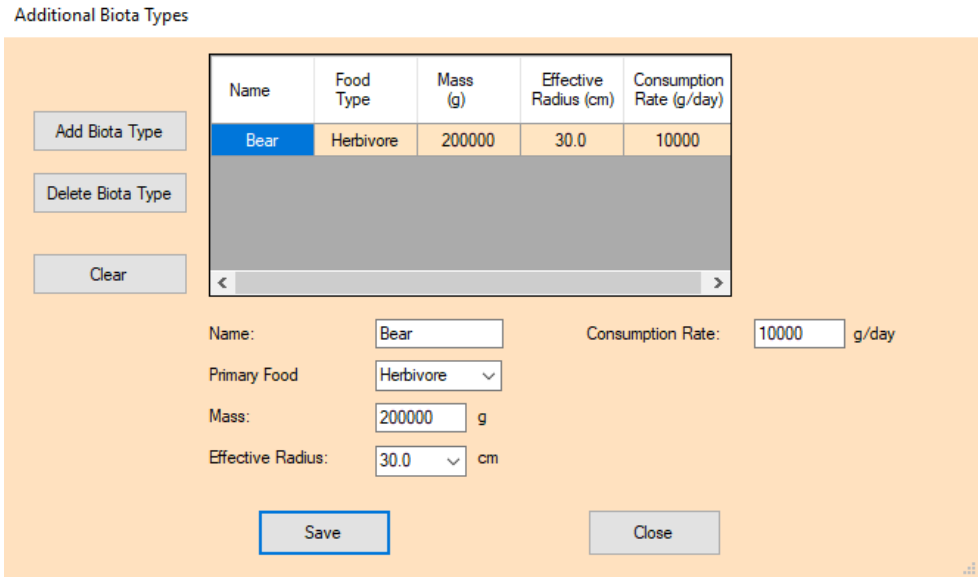
GASPAR – Options

- Input site-specific for pathway modeling assumptions
  - Fraction of foods taken from local garden
  - Fraction of year animals on pasture



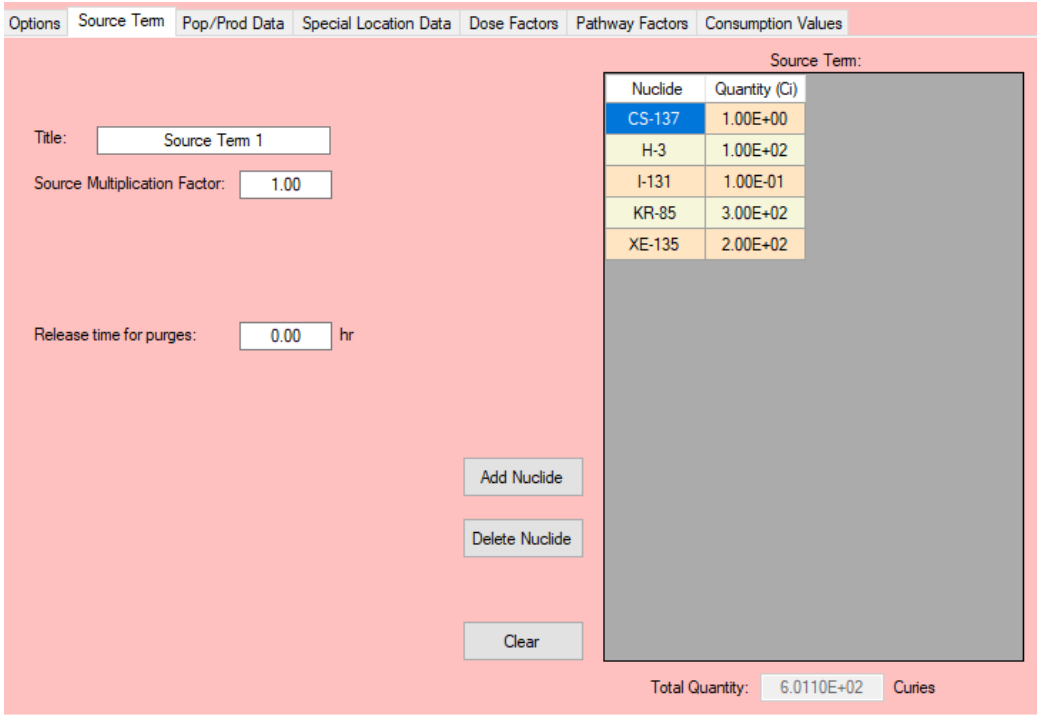
GASPAR – Biota

- Modeling based on BNWL-1754 (same as LADTAP)
- Six (6) biota types automatically included
  - muskrat, racoon, duck, heron, cow, and fox
- Option for User defined biota
  - Food type (limited to either herbivore or carnivore)



GASPAR – Source Term

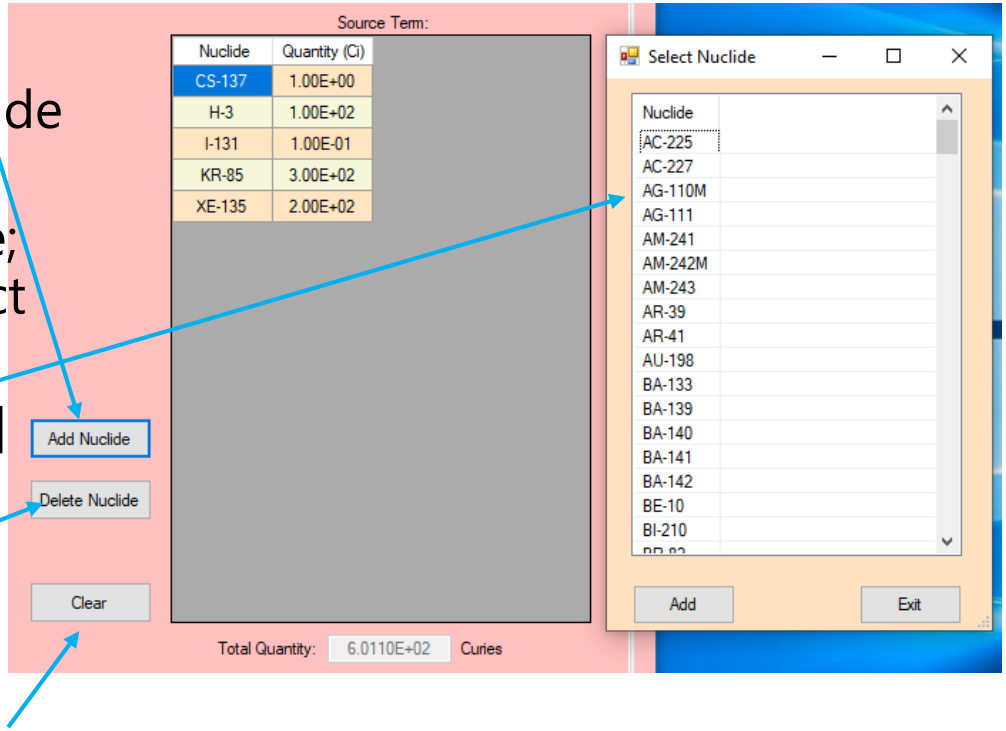
- Title
- Source term multiplication
- Add, delete or clear options



NOTE: Only a single source term may be used for each case

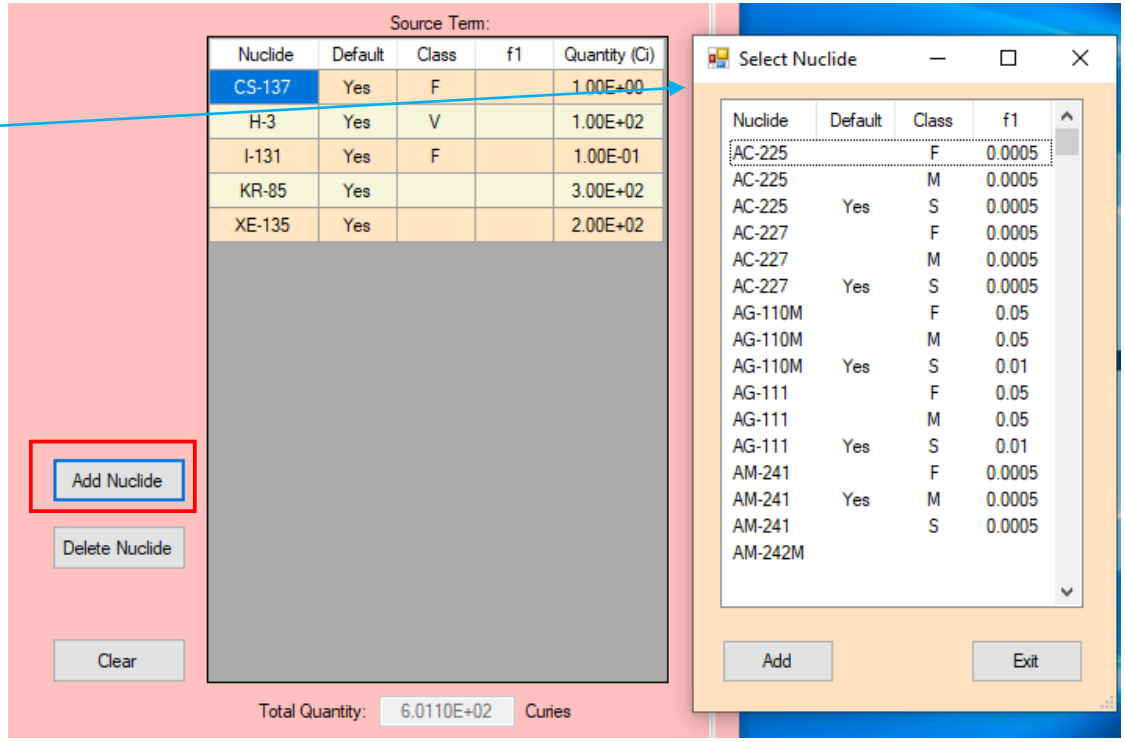
GASPAR – Source Term

- Select: Add Nuclide
  - Pop-up menus with nuclide list
  - Highlight desired nuclide; use "control" key to select multiple nuclides
- Selecting "Add" will add them to list
- "Delete Nuclide" will delete selected nuclide
- "Clear" will clear all nuclides in the source term



GASPAR – Source Term – ICRP-30 and ICRP-72 DCFs

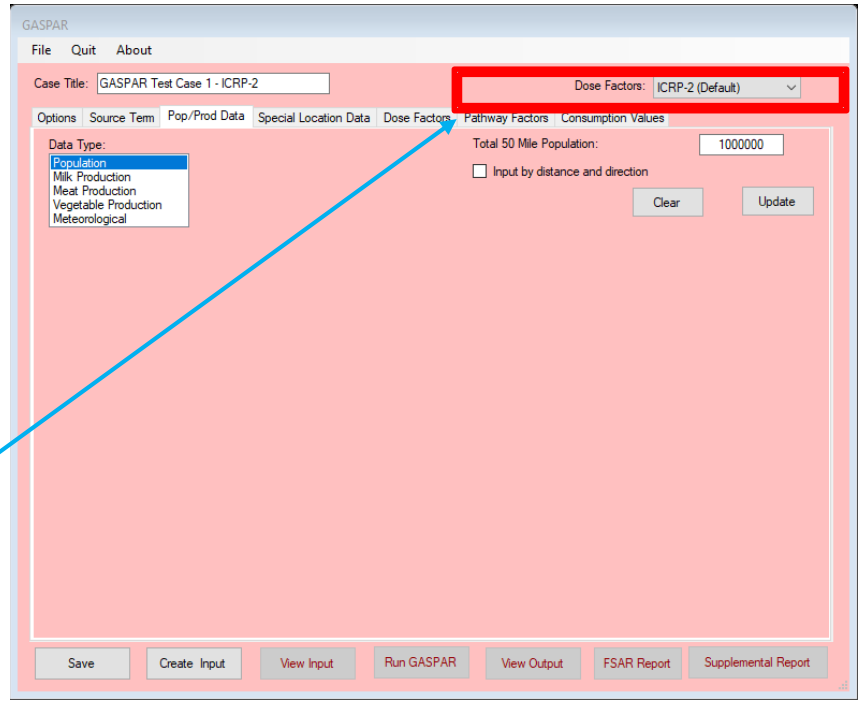
- ICRP-30 and ICRP-72 DCFs, select the applicable solubility (f1) or lung clearance type (F, M, S) for each radionuclide



NOTE: Only one solubility or inhalation class allowed per radionuclide

GASPAR – Population/Production Data

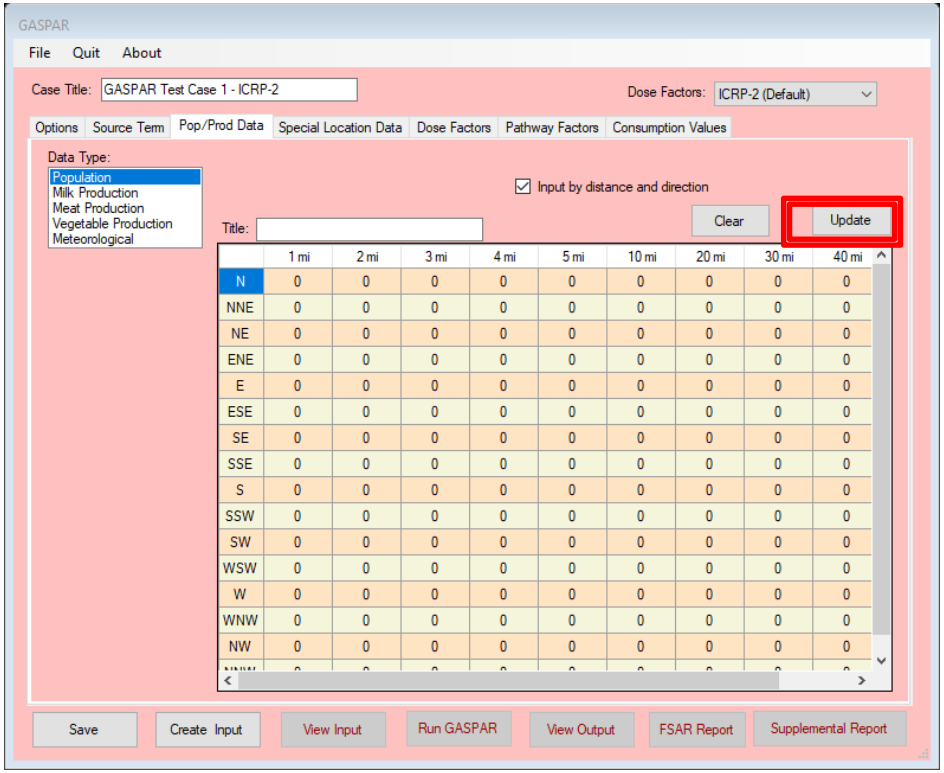
- Used for population dose calculations only
- Dropdown menu for data type
  - Population
  - Milk
  - Meat
  - Vegetable
  - Meteorology
- Except for meteorology, 50 mile data may be entered rather than sector segmented data



GASPAR – Input Population/Production Data

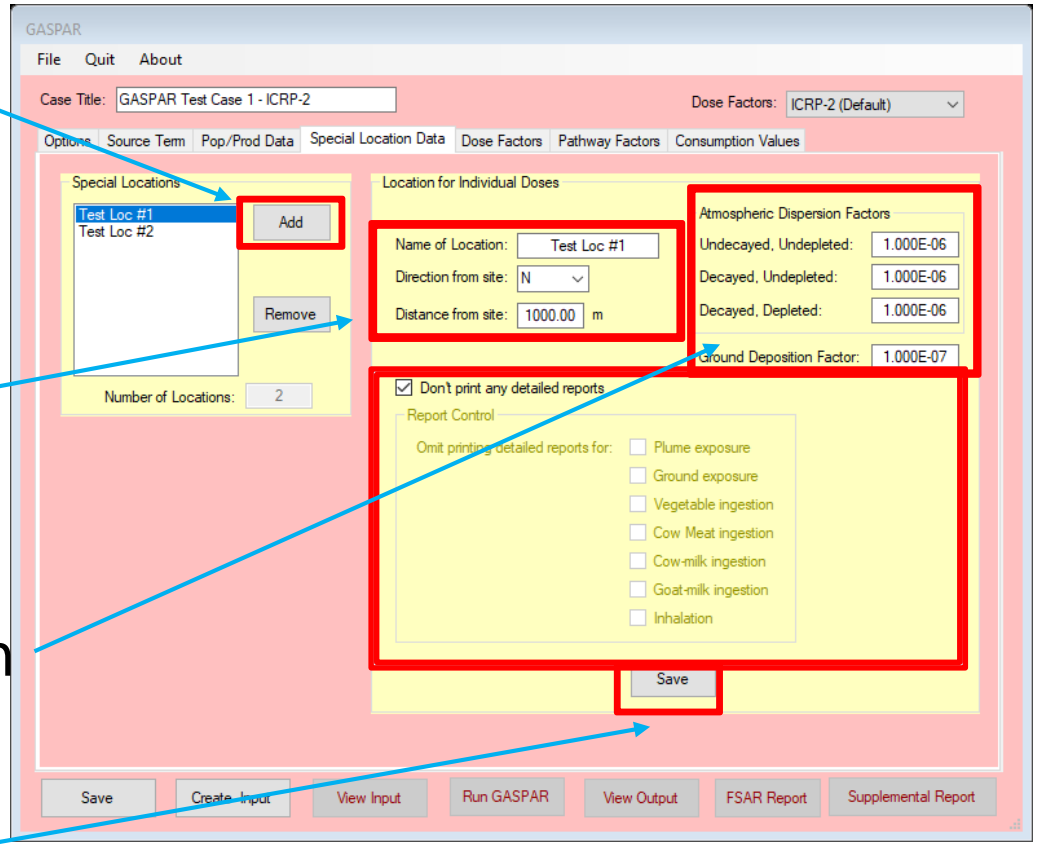
- Applies for population, milk, meat, and vegetable production
- Input population or production data by meteorological sector and distance (data typically found in applicant's FSAR or ER)

NOTE: Select "UPDATE" before exiting input



GASPAR – Special Location Data

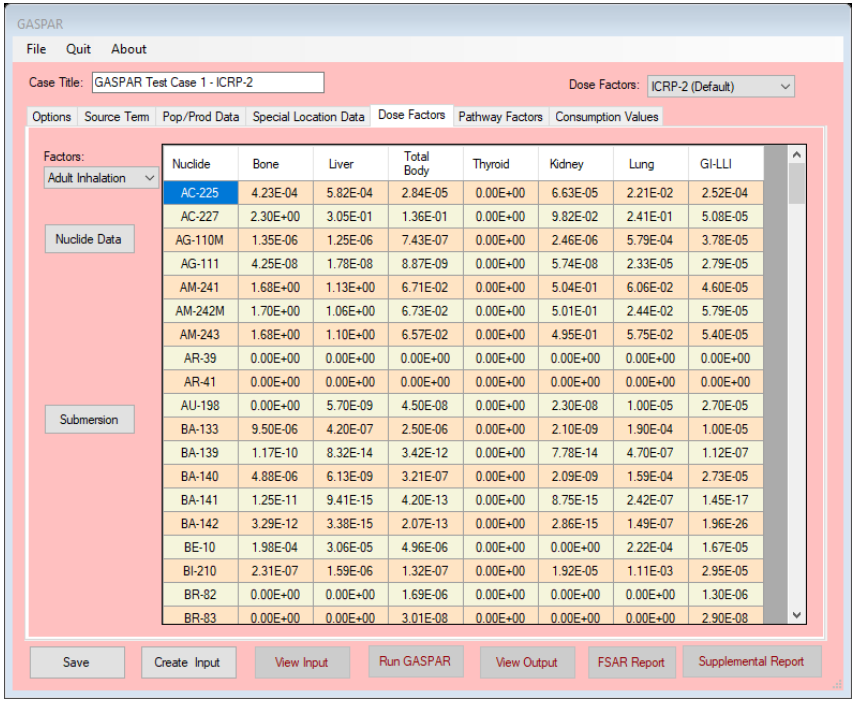
- Select Add to add new location (will clear fields)
  - Identified the location where individual doses will be calculated
- Location data
  - Name
  - Distance/Direction (information use only)
- Atmospheric dispersion factors
- Detailed Reports
- Save



GASPAR – Dose Factors

- Dropdown menu for displaying dose factors
  - Inhalation
  - Ingestion
  - By age group
- Values for the Dose Factors being used

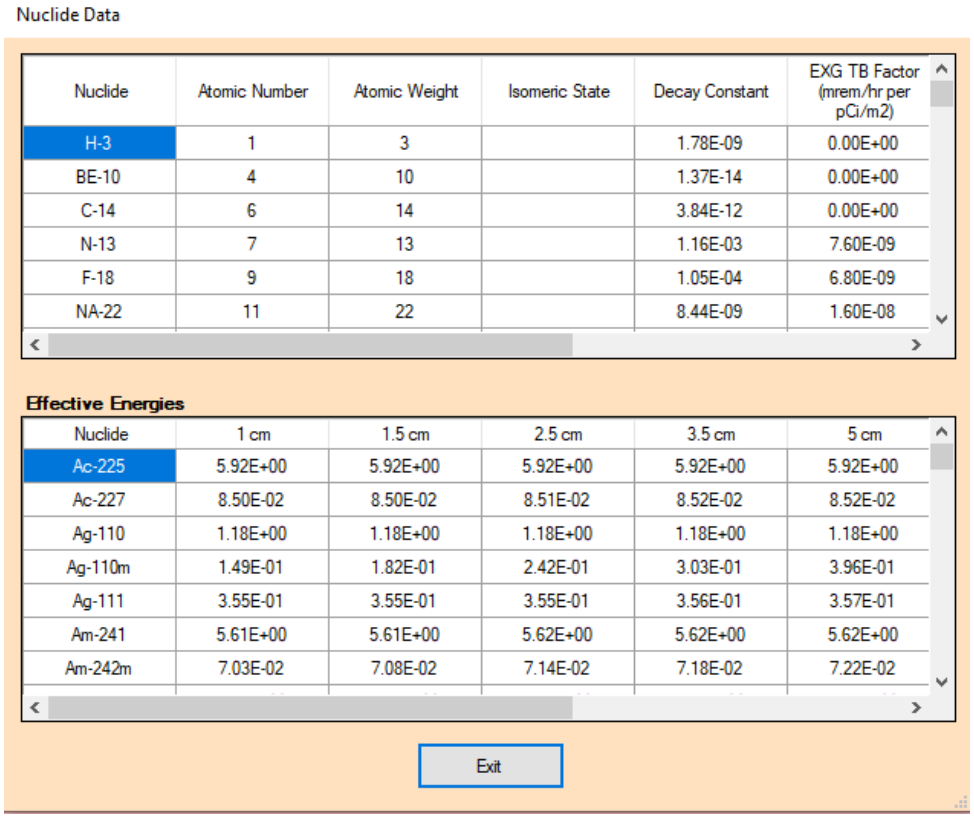
NOTE: Dose factor data is not editable



Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
AC-225	4.23E-04	5.82E-04	2.84E-05	0.00E+00	6.63E-05	2.21E-02	2.52E-04
AC-227	2.30E+00	3.05E-01	1.36E-01	0.00E+00	9.82E-02	2.41E-01	5.08E-05
AG-110M	1.35E-06	1.25E-06	7.43E-07	0.00E+00	2.46E-06	5.79E-04	3.78E-05
AG-111	4.25E-08	1.78E-08	8.87E-09	0.00E+00	5.74E-08	2.33E-05	2.79E-05
AM-241	1.68E+00	1.13E+00	6.71E-02	0.00E+00	5.04E-01	6.06E-02	4.60E-05
AM-242M	1.70E+00	1.06E+00	6.73E-02	0.00E+00	5.01E-01	2.44E-02	5.79E-05
AM-243	1.68E+00	1.10E+00	6.57E-02	0.00E+00	4.95E-01	5.75E-02	5.40E-05
AR-39	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AR-41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU-198	0.00E+00	5.70E-09	4.50E-08	0.00E+00	2.30E-08	1.00E-05	2.70E-05
BA-133	9.50E-06	4.20E-07	2.50E-06	0.00E+00	2.10E-09	1.90E-04	1.00E-05
BA-139	1.17E-10	8.32E-14	3.42E-12	0.00E+00	7.78E-14	4.70E-07	1.12E-07
BA-140	4.88E-06	6.13E-09	3.21E-07	0.00E+00	2.09E-09	1.59E-04	2.73E-05
BA-141	1.25E-11	9.41E-15	4.20E-13	0.00E+00	8.75E-15	2.42E-07	1.45E-17
BA-142	3.29E-12	3.38E-15	2.07E-13	0.00E+00	2.86E-15	1.49E-07	1.96E-26
BE-10	1.98E-04	3.06E-05	4.96E-06	0.00E+00	0.00E+00	2.22E-04	1.67E-05
BI-210	2.31E-07	1.59E-06	1.32E-07	0.00E+00	1.92E-05	1.11E-03	2.95E-05
BR-82	0.00E+00	0.00E+00	1.69E-06	0.00E+00	0.00E+00	0.00E+00	1.30E-06
BR-83	0.00E+00	0.00E+00	3.01E-08	0.00E+00	0.00E+00	0.00E+00	2.90E-08

GASPAR – Dose Factors – Nuclide Data

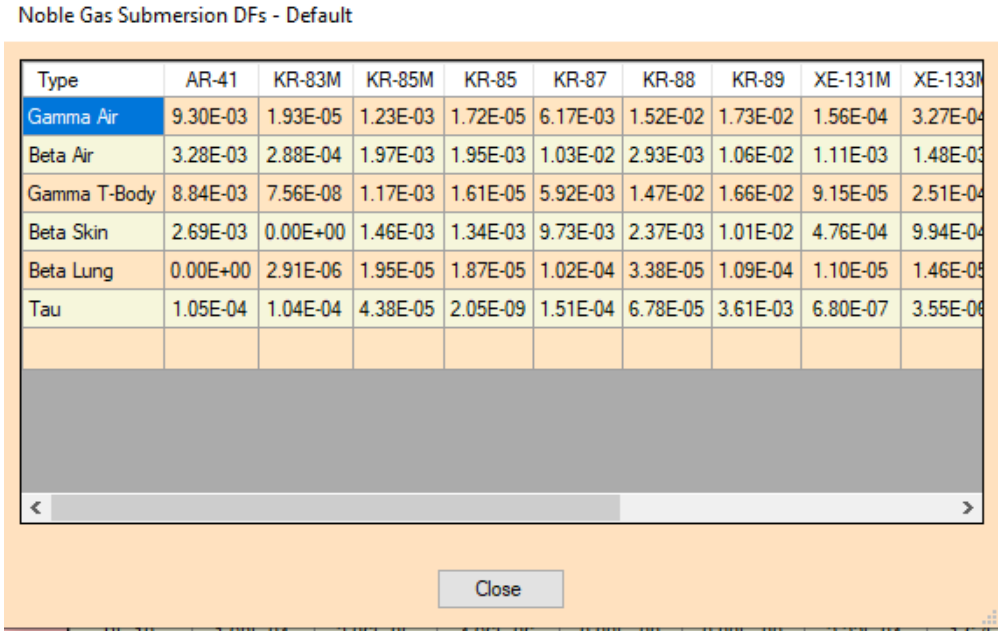
- Nuclide decay data
- External dose factors
- Absorbed Energies
  - For biota calculations
  - Effective radii



NOTE: Dose factor data is not editable

GASPAR – Dose Factors Submersion

- Submersion (semi-infinite plume) dose factors for noble gases


Noble Gas Submersion DFs - Default

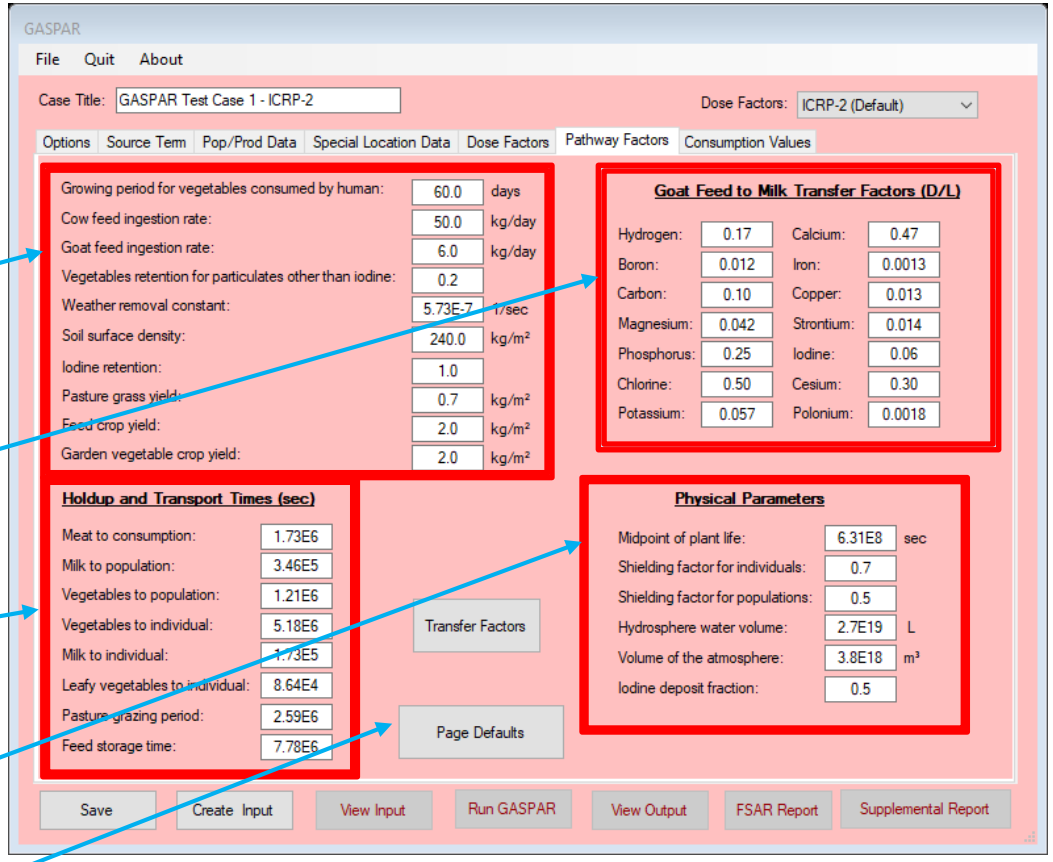
Type	AR-41	KR-83M	KR-85M	KR-85	KR-87	KR-88	KR-89	XE-131M	XE-133M
Gamma Air	9.30E-03	1.93E-05	1.23E-03	1.72E-05	6.17E-03	1.52E-02	1.73E-02	1.56E-04	3.27E-04
Beta Air	3.28E-03	2.88E-04	1.97E-03	1.95E-03	1.03E-02	2.93E-03	1.06E-02	1.11E-03	1.48E-03
Gamma T-Body	8.84E-03	7.56E-08	1.17E-03	1.61E-05	5.92E-03	1.47E-02	1.66E-02	9.15E-05	2.51E-04
Beta Skin	2.69E-03	0.00E+00	1.46E-03	1.34E-03	9.73E-03	2.37E-03	1.01E-02	4.76E-04	9.94E-04
Beta Lung	0.00E+00	2.91E-06	1.95E-05	1.87E-05	1.02E-04	3.38E-05	1.09E-04	1.10E-05	1.46E-05
Tau	1.05E-04	1.04E-04	4.38E-05	2.05E-09	1.51E-04	6.78E-05	3.61E-03	6.80E-07	3.55E-06

Close

NOTE: GASPAR calculates airborne submersion dose only from noble gas

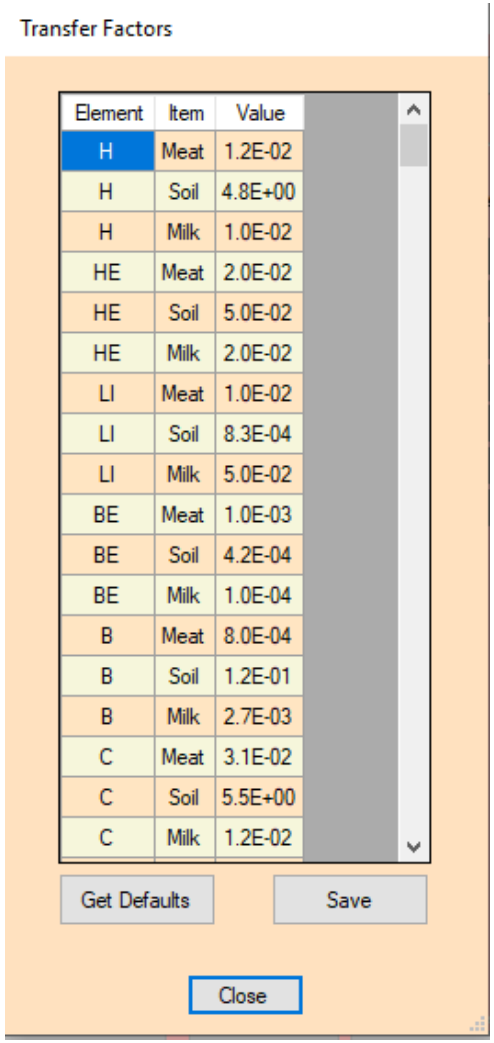
GASPAR – Pathway Factors

- Default values included for various environmental pathway modeling parameters
- Goat milk transfer factors
- Hold-up and Transport Times
- Physical parameters
- Option to reset to default values



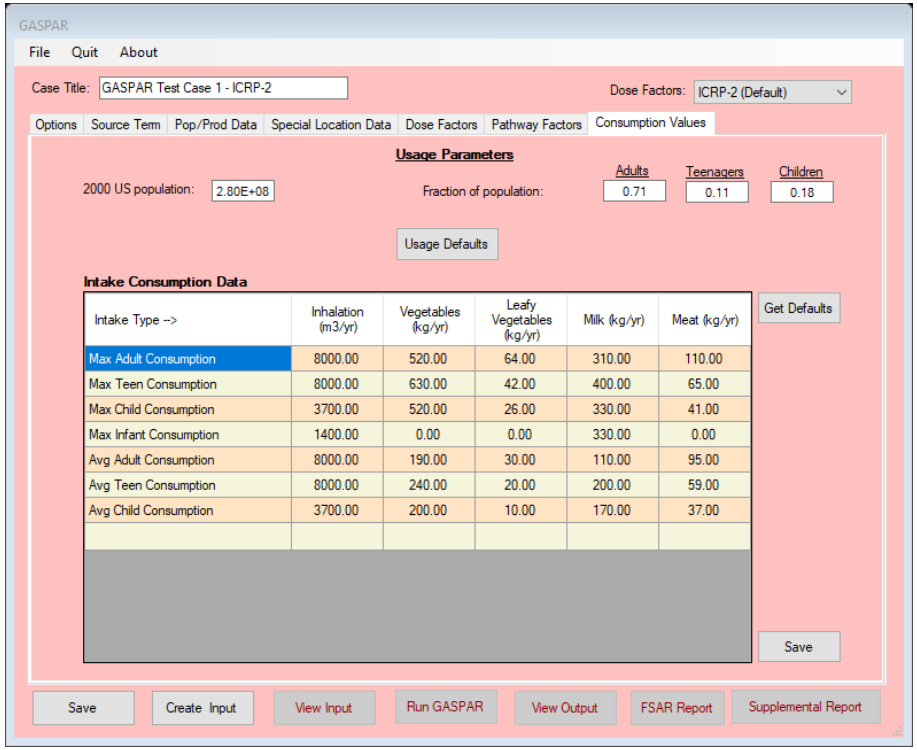
GASPAR – Transfer Factors

- By element
  - Feed-to-meat (cow)
  - Soil-to-vegetation
  - Grass-to-milk (cow)
- Can be edited to address site-characteristic data
- Tab to reset to Default values
- Save – any changed



GASPAR – Consumption Values

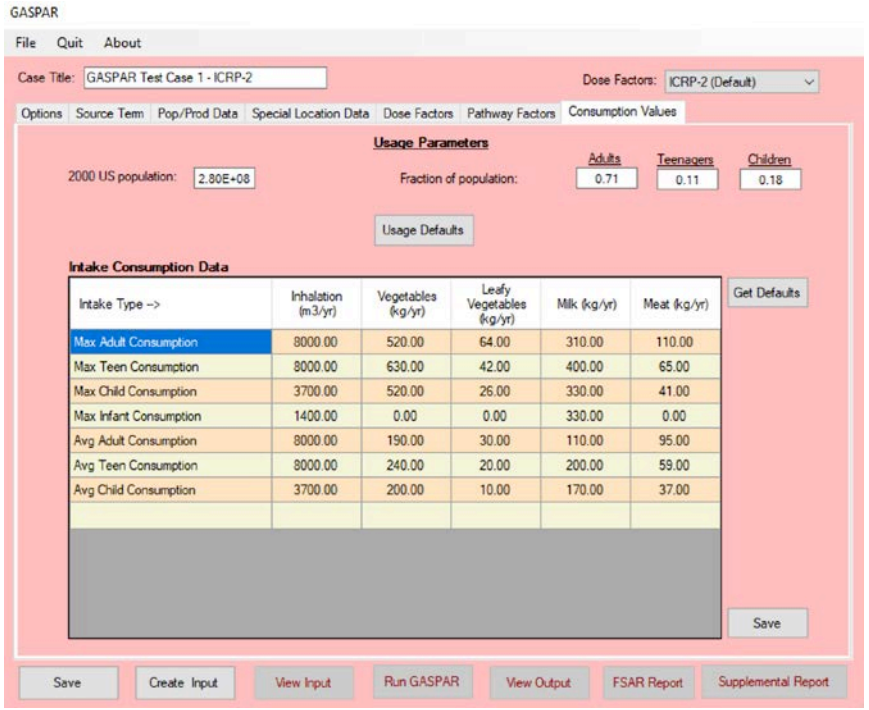
- U.S. (country) population
  - used for total population H-3 and C-14 dose calcs
- Population fractions
- Maximum and average individual consumption values; by age group
- Get Defaults to reset
- Save changes



Intake Type -->	Inhalation (m3/yr)	Vegetables (kg/yr)	Leafy Vegetables (kg/yr)	Milk (kg/yr)	Meat (kg/yr)
Max Adult Consumption	8000.00	520.00	64.00	310.00	110.00
Max Teen Consumption	8000.00	630.00	42.00	400.00	65.00
Max Child Consumption	3700.00	520.00	26.00	330.00	41.00
Max Infant Consumption	1400.00	0.00	0.00	330.00	0.00
Avg Adult Consumption	8000.00	190.00	30.00	110.00	95.00
Avg Teen Consumption	8000.00	240.00	20.00	200.00	59.00
Avg Child Consumption	3700.00	200.00	10.00	170.00	37.00

Running GASPAR – Viewing Outputs/Reports

- Can be Saved and Run from any screen
  - Save
  - Create Input
  - View Input
  - Run GASPAR
  - View Output
  - FSAR Report
  - Supplemental Report



View Input

- Input follows the format of the “card deck” as described in NUREG/CR-4653
- The datasets reflect modeling under the “Pathway factors” tab, such as transfer factors, exposure and transfer assumptions.
- The bottom section is the standard format for GASPAR input (individual doses only), containing the Selections inputs, source term, Special Location assumptions
- If population doses performed, would also include the population, production and meteorological data

```
|1.20E-2 2.00E-2 1.00E-2 1.00E-3 8.00E-4 3.10E-2 7.70E-2 1.60E-2 1.50E-1 2.00E-2 3.00E-2 5.00E-3
1.50E-3 4.00E-5 4.60E-2 1.00E-1 8.00E-2 2.00E-2 1.20E-2 4.00E-3 1.60E-2 3.10E-2 2.30E-3 2.40E-3
8.00E-4 4.00E-2 1.30E-2 5.30E-3 8.00E-3 3.00E-2 1.30E+0 2.00E+1 2.00E-3 1.50E-2 2.60E-2 2.00E-2
3.10E-2 6.00E-4 4.60E-3 3.40E-2 2.80E-1 8.00E-3 4.00E-1 4.00E-1 1.50E-3 4.00E-3 1.70E-2 5.30E-4
8.00E-3 8.00E-2 4.00E-3 7.70E-2 2.90E-3 2.00E-2 4.00E-3 3.20E-3 2.00E-4 1.20E-3 4.70E-3 3.30E-3
4.80E-3 5.00E-3 4.80E-3 3.60E-3 4.40E-3 5.30E-3 4.40E-3 4.00E-3 4.40E-3 4.00E-3 4.40E-3 4.00E-1
1.60E+0 1.30E-3 8.00E-3 4.00E-1 1.50E-3 4.00E-3 8.00E-3 2.60E-1 4.00E-2 2.90E-4 1.30E-2 1.20E-2
8.00E+0 2.00E-2 2.00E-2 3.40E-2 6.00E-2 2.00E-4 8.00E+2 3.40E-4 2.00E-4 1.40E-5 2.00E-4 2.00E-4
2.00E-4 2.00E-4 2.00E-4 2.00E-4
 4.80E+0 5.00E-2 8.30E-4 4.20E-4 1.20E-1 5.50E+0 7.50E+0 1.60E+0 6.50E-4 1.40E-1 5.20E-2 1.30E-1
1.80E-4 1.50E-4 1.10E+0 5.90E-1 5.00E+0 6.00E-1 3.70E-1 3.60E-2 1.10E-3 5.40E-5 1.30E-3 2.50E-4
2.90E-2 6.60E-4 9.40E-3 1.90E-2 1.20E-1 4.00E-1 2.50E-4 1.00E-1 1.00E-2 1.30E+0 7.60E-1 3.00E+0
1.30E-1 1.70E-2 2.60E-3 1.70E-4 9.40E-3 1.20E-1 2.50E-1 5.00E-2 1.30E+1 5.00E+0 1.50E-1 3.00E-1
2.50E-1 2.50E-3 1.10E-2 1.30E+0 2.00E-2 1.00E+1 1.00E-2 5.00E-3 2.50E-3 2.50E-3 2.50E-3 2.40E-3
2.50E-3 2.50E-3 2.50E-3 2.60E-3 2.60E-3 2.50E-3 2.60E-3 2.50E-3 2.60E-3 2.50E-3 2.60E-3 1.70E-4
6.30E-3 1.80E-2 2.50E-1 5.00E-2 1.30E+1 5.00E-1 2.50E-3 3.80E-1 2.50E-1 6.80E-2 1.50E-1 1.50E-1
2.50E-1 3.50E+0 1.00E-2 3.10E-4 2.50E-3 4.20E-3 2.50E-3 2.50E-3 2.50E-4 2.50E-4 2.50E-3
2.50E-3 2.50E-3 2.50E-3 2.50E-3
 1.00E-2 2.00E-2 5.00E-2 1.00E-4 2.70E-3 1.20E-2 2.20E-2 2.00E-2 1.40E-2 2.00E-2 4.00E-2 1.00E-2
5.00E-4 1.00E-4 2.50E-2 1.80E-2 5.00E-2 2.00E-2 1.00E-2 8.00E-3 5.00E-6 5.00E-6 1.00E-3 2.20E-3
2.50E-4 1.20E-3 1.00E-3 6.70E-3 1.40E-2 3.90E-2 5.00E-5 5.00E-4 6.00E-3 4.50E-2 5.00E-2 2.00E-2
3.00E-2 8.00E-4 1.00E-5 5.00E-6 2.50E-3 7.50E-3 2.50E-2 1.00E-6 1.00E-2 1.00E-2 5.00E-2 1.20E-4
1.00E-4 2.50E-3 1.50E-3 1.00E-3 6.00E-3 2.00E-2 1.20E-2 4.00E-4 5.00E-6 1.00E-4 5.00E-6 5.00E-6
5.00E-6 5.00E-6 5.00E-6 5.00E-6 5.00E-6 5.00E-6 5.00E-6 5.00E-6 5.00E-6 5.00E-6 5.00E-6 5.00E-6
2.50E-2 5.00E-4 2.50E-2 5.00E-3 5.00E-3 5.00E-3 5.00E-3 3.80E-2 2.20E-2 6.20E-4 5.00E-4 3.00E-4
5.00E-2 2.00E-2 5.00E-2 8.00E-3 5.00E-6 5.00E-6 5.00E-6 5.00E-4 5.00E-6 2.00E-6 5.00E-6 5.00E-6
5.00E-6 5.00E-6 5.00E-6 5.00E-6
    2.80E+08         3
 9.30E-03 1.93E-05 1.23E-03 1.72E-05 6.17E-03 1.52E-02 1.73E-02 1.56E-04 3.27E-04 3.53E-04 3.36E-03
1.92E-03 1.51E-03 9.21E-03
 3.28E-03 2.88E-04 1.97E-03 1.95E-03 1.03E-02 2.93E-03 1.06E-02 1.11E-03 1.48E-03 1.05E-03 7.39E-04
2.46E-03 1.27E-02 4.75E-03
 7.18E-03 1.40E-07 8.03E-04 2.81E-05 4.64E-03 1.13E-02 1.12E-02 4.08E-05 1.50E-04 1.55E-04 2.22E-03
1.29E-03 1.21E-03 6.41E-03
 1.18E-02 4.16E-06 2.62E-03 1.54E-03 1.60E-02 1.58E-02 2.43E-02 5.63E-04 1.22E-03 5.81E-04 3.47E-03
3.65E-03 1.58E-02 1.25E-02
 0.00E+00 2.91E-06 1.95E-05 1.87E-05 1.02E-04 3.38E-05 1.09E-04 1.10E-05 1.46E-05 1.05E-05 8.79E-06
2.46E-05 1.23E-04 4.93E-05
 1.05E-04 1.04E-04 4.38E-05 2.05E-09 1.51E-04 6.78E-05 3.61E-03 6.80E-07 3.55E-06 1.53E-06 7.41E-04
2.12E-05 2.96E-03 8.15E-04
     60.0      50.0       6.0       0.2   5.73E-7
    240.0       1.0       0.7       2.0       2.0
  1.73E+06  3.46E+05  1.21E+06  5.18E+06  1.73E+05  8.64E+04  2.59E+06  7.78E+06
  1.70E-01  1.20E-02  1.00E-01  4.20E-02  2.50E-01  5.00E-01  5.70E-02  4.70E-01  1.30E-03  1.30E-02
1.40E-02  6.00E-02  3.00E-01  1.80E-03
     0.18      0.11      0.71
   3760.0    5548.0    5950.0
    111.0     120.0     175.0
      4.8       8.1      17.0
    141.0      83.0      70.0
     22.0      35.0      47.0
   3360.0    5000.0    5040.0    6060.0    8000.0    8980.0
    182.0     249.0     269.0     323.0     296.0     429.0
      4.8      10.1      11.5      14.6      19.9      42.2
    150.0     477.0     347.0     369.0     340.0     301.0
     27.0      51.0      58.0      74.0      97.0     120.0
      0.7       0.5       0.5       5.0
   6.31E8    2.7E19    3.8E18
0
 GASPAR Test Case 1 - ICRP-72
1 1 1 0 1 0 0
   1000    0.75     0.8     0.5       1       8      70     1     1   0.8     1
Source Term 1
       1         1         0             0
 CS-137   1.000E+00
 H -3     1.000E+02
 I -131   1.000E-01
 KR-85    3.000E+02
 XE-135   2.000E+02

1Test Loc #1        N   1000 1.000E-06 1.000E-06 1.000E-06 1.000E-070000000
1Test Loc #2       NE   1200 2.200E-07 2.100E-07 2.000E-07 3.400E-090000000
```

Run GASPAR – View Output

- Basic assumptions used for calculations
- Lists the Source Term
- Followed by Doses
  - Population (if performed)
  - Individual by Special Locations
- If selected "Print Dose Factor Library," output will include all nuclides

```
      ********************************************************************************************************
      *                                                                                                      *
      *                                                                                                      *
      *                                          NRCDose3                                                    *
      *                                                                                                      *
      *                                                                                                      *
      *                                      GASPAR Test Case 1 - ICRP-2                                     *
      *                                                                                                      *
      *                                                                                                      *
      *                                 U.S. NUCLEAR REGULATORY COMMISSION                                   *
      *                                       WASHINGTON, D.C. 20555                                         *
      *                                                                                                      *
      *                                       DATE OF RUN:10-23-2019                                         *
      *                                                                                                      *
      *                                                                                                      *
      *                                CALCULATIONS PERFORMED USING THE ICRP-2                               *
      *                                     BASED DOSE CONVERSION FACTORS                                    *
      *                                                                                                      *
      *                                                                                                      *
      ********************************************************************************************************


GASPAR Test Case 1 - ICRP-2


 JOB CONTROL PARAMETERS

      JC(1) =  1  :POPULATION/INDIVIDUAL DOSE SELECTION
      JC(2) =  1  :NUMBER OF SOURCE RELEASE POINTS
      JC(3) =  1  :PRINT CONTROL FOR DOSE ACCUMULATION
      JC(4) =  0  :READ CONTROL FOR BLOCK DATA CHANGE RECORDS
      JC(5) =  0  :PRINT CONTROL FOR DOSE FACTOR TABLE
      JC(6) =  0  :CALCULATION CONTROL FOR UNIT DOSE FACTORS
      JC(7) =  0  :READ CONTROL FOR DISPERSION DATA INPUT FILE
      JC(8) =  0
      JC(9) =  0
      JC(10)=  0


 EXPOSURE PATHWAY FRACTIONS

      PARAMETER DESCRIPTION(FRACTION)    VALUE
      ---------------------------------------
      FV   LEAFY VEGETABLE FROM GARDEN    0.75
      FG   OTHER EDIBLES FROM GARDEN      0.50
      FP   TIME MILK COWS ON PASTURE      0.80
      FB   TIME BEEF ON PASTURE           0.80
      FGT  TIME MILK GOATS ON PASTURE     1.00
      FPF  MILK COW INTAKE FROM PASTURE   1.00
      FBF  BEEF INTAKE FROM PASTURE       1.00
      FPG  MILK GOAT INTAKE FROM PASTURE  1.00

      HUMIDITY(G/M**3)   1.42


 SOURCE TERM RELEASE NUMBER  1

      RELEASE POINT     Source Term 1
      UML =  1.00E+00   SOURCE TERM MULTIPLICATION FACTOR
      JC1 =  0          NEW OR PREVIOUS MET DATA PARAMETER
      JC2 =  0          NEW OR PREVIOUS SOURCE TERM RELEASE DATA 'PARAMETER

        NUCLIDE     CI/YR
        -------     -----
        55CS137   1.00E+00
         1H   3   1.00E+02
        53I 131   1.00E-01
        36KR 85   3.00E+02
        54XE135   2.00E+02

                6.011E+02 TOTAL CURIES FOR   5 RADIONUCLIDES
```

GASPAR FSAR Report

- Provides a summary report of assumptions and doses
- Suitable for use in creating input for safety analyses and licensing support

FSAR Input Report - GASPAR Test Case 1 - ICRP-2 - 22-Oct-2019 18:07

Input Parameters for the GASPAR Code

X/Q (sec/m3)	
For maximum individual dose calculation	
Undecayed, Undepleted:	1.00E-06
Decayed, Undepleted:	1.00E-06
Decayed, Depleted:	1.00E-06
D/Q (1/m2)	
For maximum individual dose calculation	1.00E-07
Distance to residence (mi)	0.62
Midpoint of plant life (yr)	20.0
Fraction of the year that leafy vegetables are grown:	0.75
Fraction of the year that milk cows are on pasture:	0.80
Fraction of milk-cow feed intake that is from pasture while on pasture:	1.00
Fraction of the year that goats are on pasture:	1.00
Fraction of goat feed intake that is from pasture while on pasture:	1.00
Fraction of the maximum individual's vegetable intake that is from garden:	0.50
Average absolute humidity over the growing season (g/m3):	1.00
Fraction of the year that beef cattle cows are on pasture:	0.80
Fraction of beef-cattle feed intake that is from pasture while on pasture:	1.00
Animal considered for milk pathway	Cow and Goat
Annual milk production for all distances and directions within 50 miles (L)	1000
Annual meat production for all distances and directions within 50 miles (kg)	1000
Annual vegetable production for all distances and directions within 50 miles (kg)	1000

Gaseous Source Term for the GASPAR Code

Isotope	Release Rate (Ci/yr)
CS-137	1.00E+00
H-3	1.00E+02
I-131	1.00E-01
KR-85	3.00E+02
XE-135	2.00E+02

Calculated Doses from Gaseous Effluents
(Plume Exposure due to Noble Gases)

Type of Dose	Dose
Gamma dose in air (mrad/yr)	1.23E-02
Beta dose in air (mrad/yr)	3.41E-02
Dose to total body (mrem/yr)	8.14E-03
Dose to skin (mrem/yr)	3.41E-02

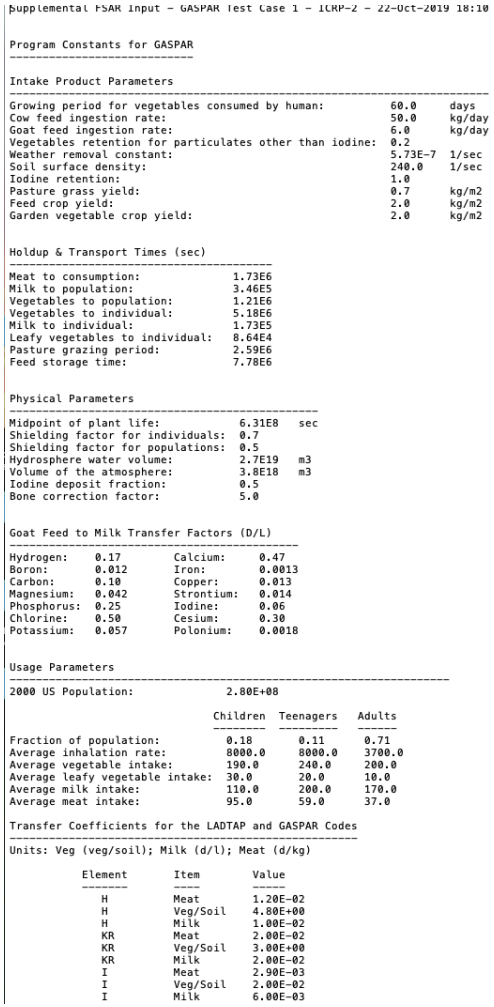
Note:
1. Doses due to noble gases, including AR-41

Calculated Doses from Gaseous Effluents
(mrem/yr)

Age Group	Effective	GI-LLI	Bone	Liver	Kidney	Thyroid	Lung
Ground							
	4.13E+01	4.13E+01	4.13E+01	4.13E+01	4.13E+01	4.13E+01	4.13E+01
Vegetable							
Adult	1.30E+01	4.09E-01	1.45E+01	1.99E+01	6.81E+00	1.20E+01	2.25E+00
Teen	1.07E+01	4.62E-01	2.30E+01	3.06E+01	1.05E+01	1.49E+01	4.05E+00
Child	7.70E+00	3.58E-01	5.41E+01	5.18E+01	1.70E+01	2.76E+01	6.09E+00
Meat							
Adult	1.81E+00	5.71E-02	2.01E+00	2.76E+00	9.40E-01	6.30E-01	3.14E-01
Teen	7.76E-01	3.39E-02	1.67E+00	2.22E+00	7.60E-01	4.56E-01	2.96E-01
Child	4.38E-01	2.10E-02	3.08E+00	2.95E+00	9.65E-01	6.88E-01	3.47E-01
Cow Milk							
Adult	1.53E+01	4.72E-01	1.71E+01	2.33E+01	8.00E+00	1.73E+01	2.63E+00
Teen	1.44E+01	6.13E-01	3.09E+01	4.12E+01	1.41E+01	2.74E+01	5.44E+00
Child	1.06E+01	4.76E-01	7.45E+01	7.13E+01	2.35E+01	5.40E+01	8.36E+00
Infant	1.00E+01	4.73E-01	1.19E+02	1.30E+02	3.78E+01	1.31E+02	1.51E+01

GASPAR Supplemental Report

- Provides additional information that may not be included in the GASPAR output or the FSAR



Supplemental FSAR Input - GASPAR Test Case 1 - ICRP-2 - 22-Oct-2019 18:10

Program Constants for GASPAR

Intake Product Parameters

Growing period for vegetables consumed by human:	60.0	days
Cow feed ingestion rate:	50.0	kg/day
Goat feed ingestion rate:	6.0	kg/day
Vegetables retention for particulates other than iodine:	0.2	
Weather removal constant:	5.73E-7	1/sec
Soil surface density:	240.0	1/sec
Iodine retention:	1.0	
Pasture grass yield:	0.7	kg/m2
Feed crop yield:	2.0	kg/m2
Garden vegetable crop yield:	2.0	kg/m2

Holdup & Transport Times (sec)

Meat to consumption:	1.73E6
Milk to population:	3.46E5
Vegetables to population:	1.21E6
Vegetables to individual:	5.18E6
Milk to individual:	1.73E5
Leafy vegetables to individual:	8.64E4
Pasture grazing period:	2.59E6
Feed storage time:	7.78E6

Physical Parameters

Midpoint of plant life:	6.31E8	sec
Shielding factor for individuals:	0.7	
Shielding factor for populations:	0.5	
Hydrosphere water volume:	2.7E19	m3
Volume of the atmosphere:	3.8E18	m3
Iodine deposit fraction:	0.5	
Bone correction factor:	5.0	

Goat Feed to Milk Transfer Factors (D/L)

Hydrogen:	0.17	Calcium:	0.47
Boron:	0.012	Iron:	0.0013
Carbon:	0.10	Copper:	0.013
Magnesium:	0.042	Strontium:	0.014
Phosphorus:	0.25	Iodine:	0.06
Chlorine:	0.50	Cesium:	0.30
Potassium:	0.057	Polonium:	0.0018

Usage Parameters

2000 US Population: 2.80E+08

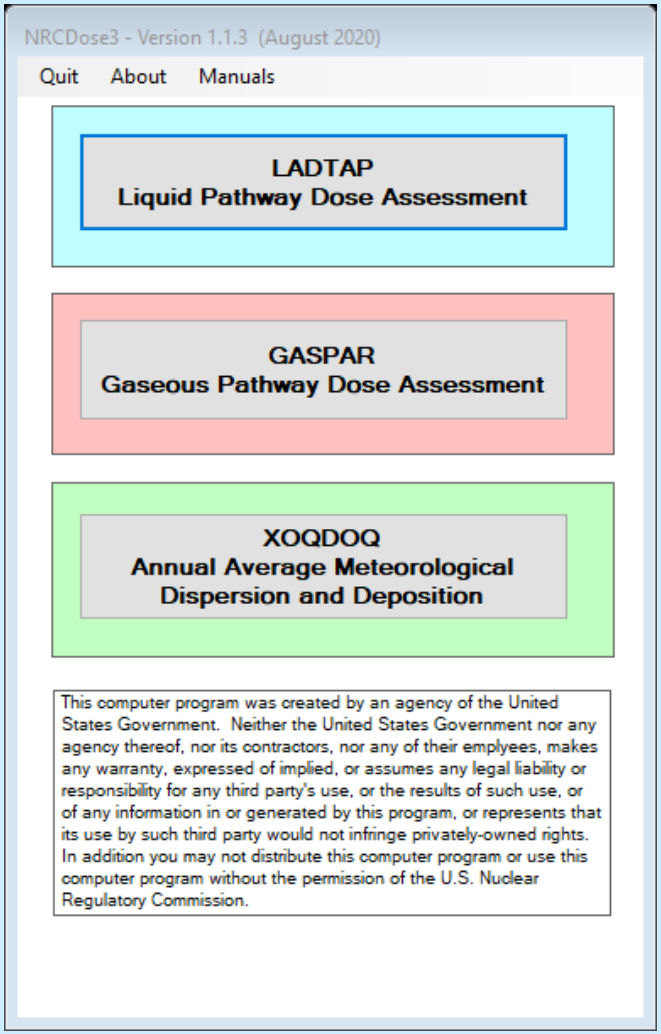
	Children	Teenagers	Adults
Fraction of population:	0.18	0.11	0.71
Average inhalation rate:	8000.0	8000.0	3700.0
Average vegetable intake:	190.0	240.0	200.0
Average leafy vegetable intake:	30.0	20.0	10.0
Average milk intake:	110.0	200.0	170.0
Average meat intake:	95.0	59.0	37.0

Transfer Coefficients for the LADTAP and GASPAR Codes

Units: Veg (veg/soil); Milk (d/l); Meat (d/kg)

Element	Item	Value
H	Meat	1.20E-02
H	Veg/Soil	4.80E+00
H	Milk	1.00E-02
KR	Meat	2.00E-02
KR	Veg/Soil	3.00E+00
KR	Milk	2.00E-02
I	Meat	2.90E-03
I	Veg/Soil	2.00E-02
I	Milk	6.00E-03

LADTAP MODELING AND USE



LADTAP Dose Modeling

- Routine liquid effluent releases – not for short-term accident
- Modeling assumes annual average conditions
  - Average dispersion in receiving water body
  - Average radioactive effluents over time
- RG 1.109, Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, Rev. 1, October 1977

LADTAP Dose Modeling

- Exposure pathways to man: potable water, aquatic foods, shoreline deposits, swimming, boating, and irrigated foods; and to non-human biota (7 surrogate species)
- Pathway (age groups, organs) doses to maximum exposed individual (MEI) and population

LADTAP

- Exposure pathways – MEI and Populations:
  - Surface water transport (dilution and transport times) to downstream water supplies
  - Aquatic foods: fresh and saltwater water fish, invertebrate (crustacea and shellfish), and aquatic plants (seaweed)
  - Shoreline deposition: direct exposure from shoreline deposits; build-up to mid-point of plant life (assumed 40 year life)
  - Swimming and boating: direct exposure
  - Irrigated foods; and to non-human biota (7 surrogate species)

LADTAP – Reconcentration models

- Models from RG 1.113:
  - Plug-Flow Model - uniform, constant flow through pond; negligible evaporation
  - Partially Mixed Model - applicable where blowdown and plant pumping significant
  - Completely Mixed Model - estimates effluent concentration at midpoint of plant life
- Refer to NUREG/CR-4013, Section 3.1.1 for more detail

LADTAP – Reconcentration models

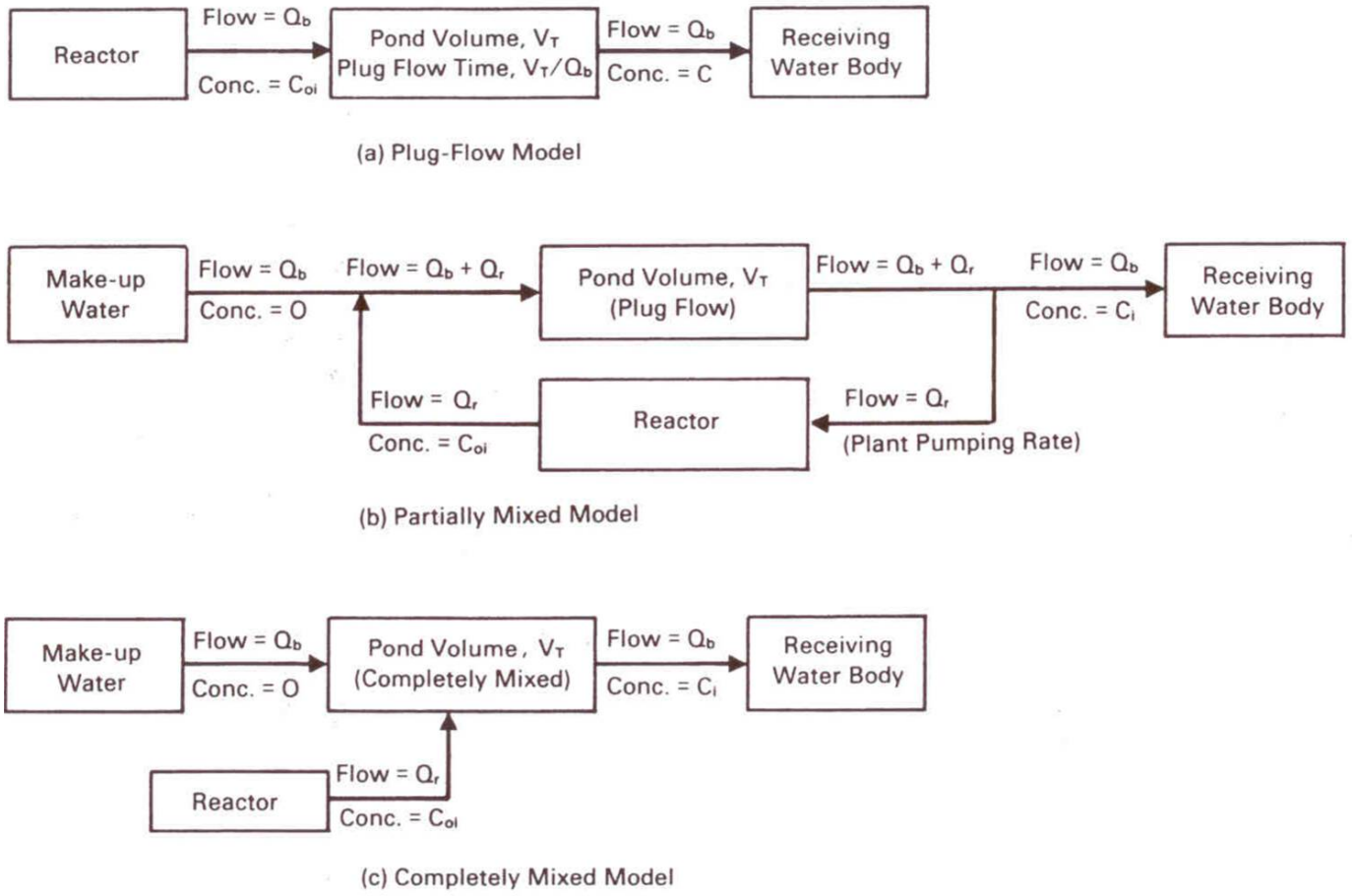
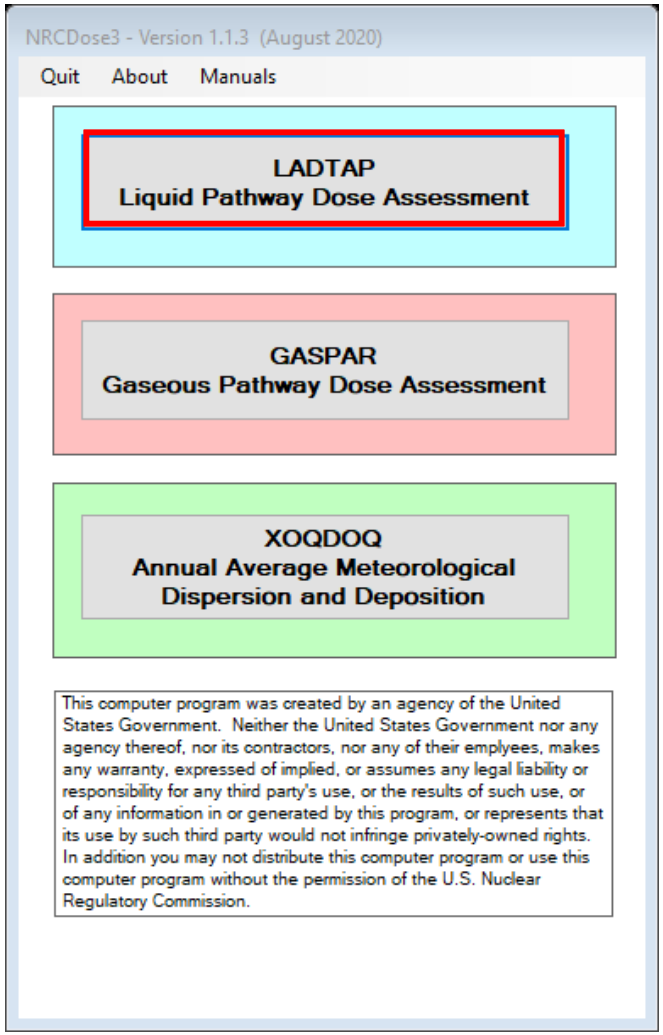


FIGURE 3.2. Schematic Representations of Impoundment Models

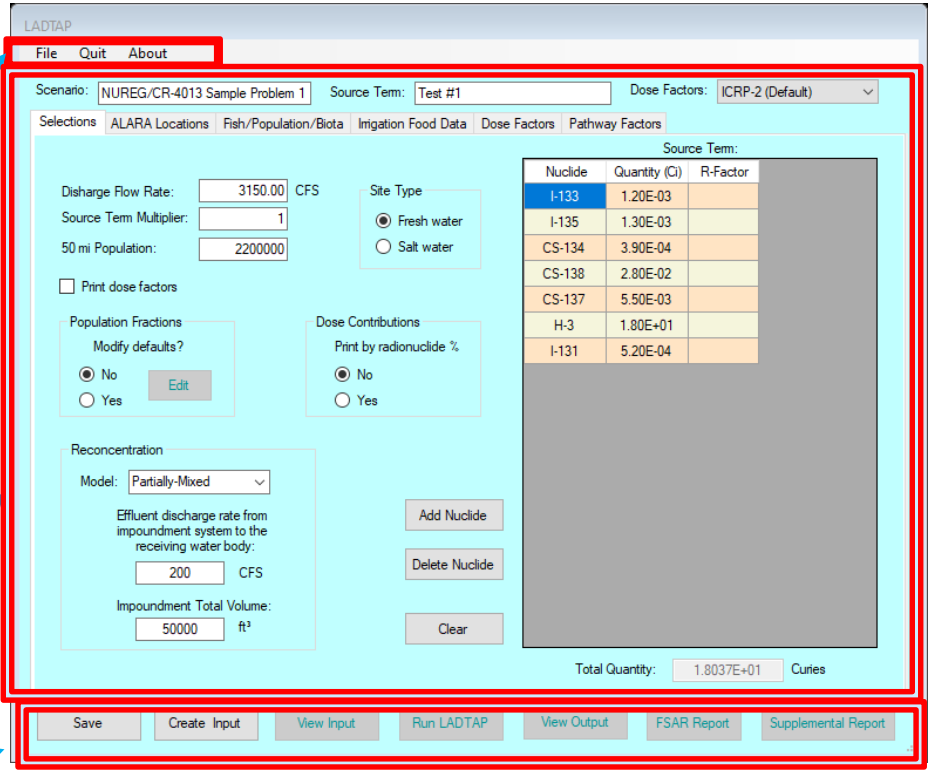
Starting and Running LADTAP

- Double click “LADTAP”



LADTAP Main Screen

- LADTAP Module Main Screen opens with case data that is saved in the database
- Contains three main functional areas:
  - the toolbar and initial setup area,
  - data input tabs area and
  - code execution and reports area



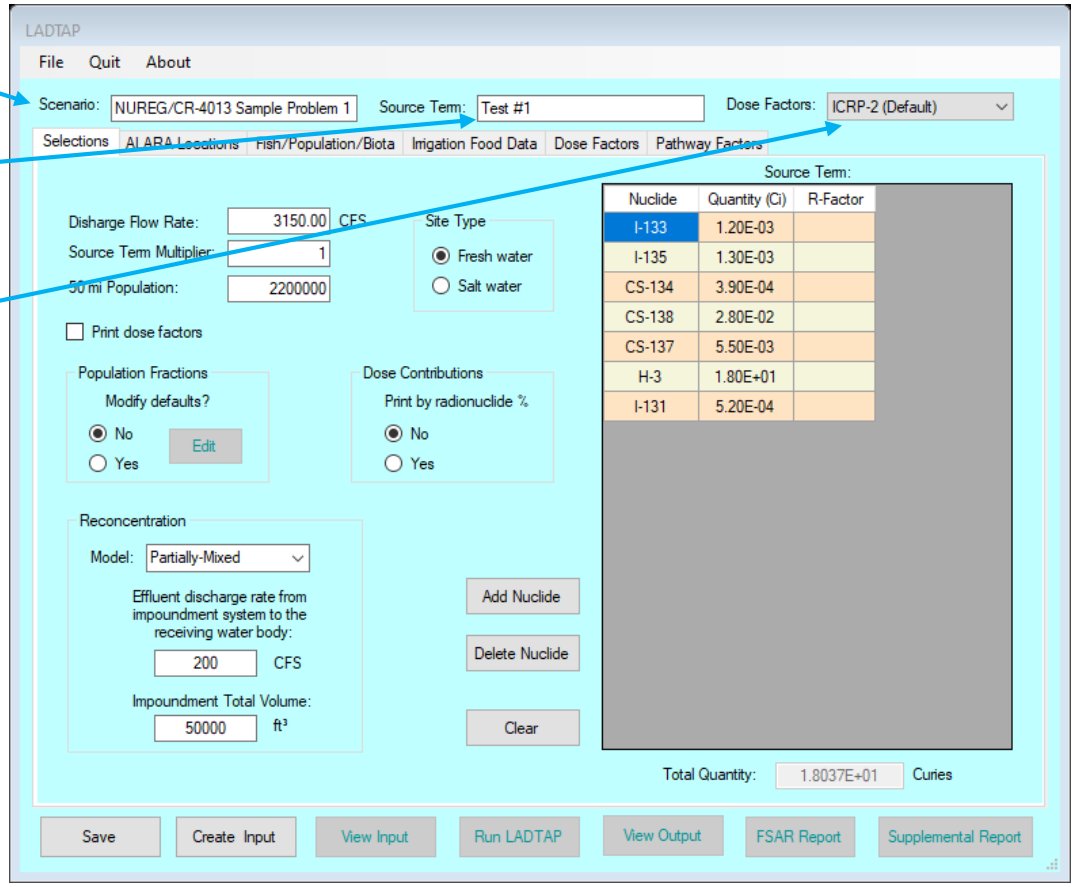
LADTAP Start-up

- New — Select this option to begin a new LADTAP case. This will clear the database from any previously input information.
- Open LN3 File — Select this option to access and open a "*.LN3" file that was previously created with NRCDose3.
- Save to Database — Choose this option to save the current case to the database. When LADTAP starts, it loads the data that was last saved (typically from the last, previous run), populating all LADTAP screens and windows.
- Save to LN3 File — Choose this option to save the completed case to a "*.LN3" file. This allows the file to be saved for later use, or for sharing with others.
- Delete — Choose this option to open an explorer window that will allow the user to delete any previously saved "*.LN3" files.

LADTAP – Basic Information

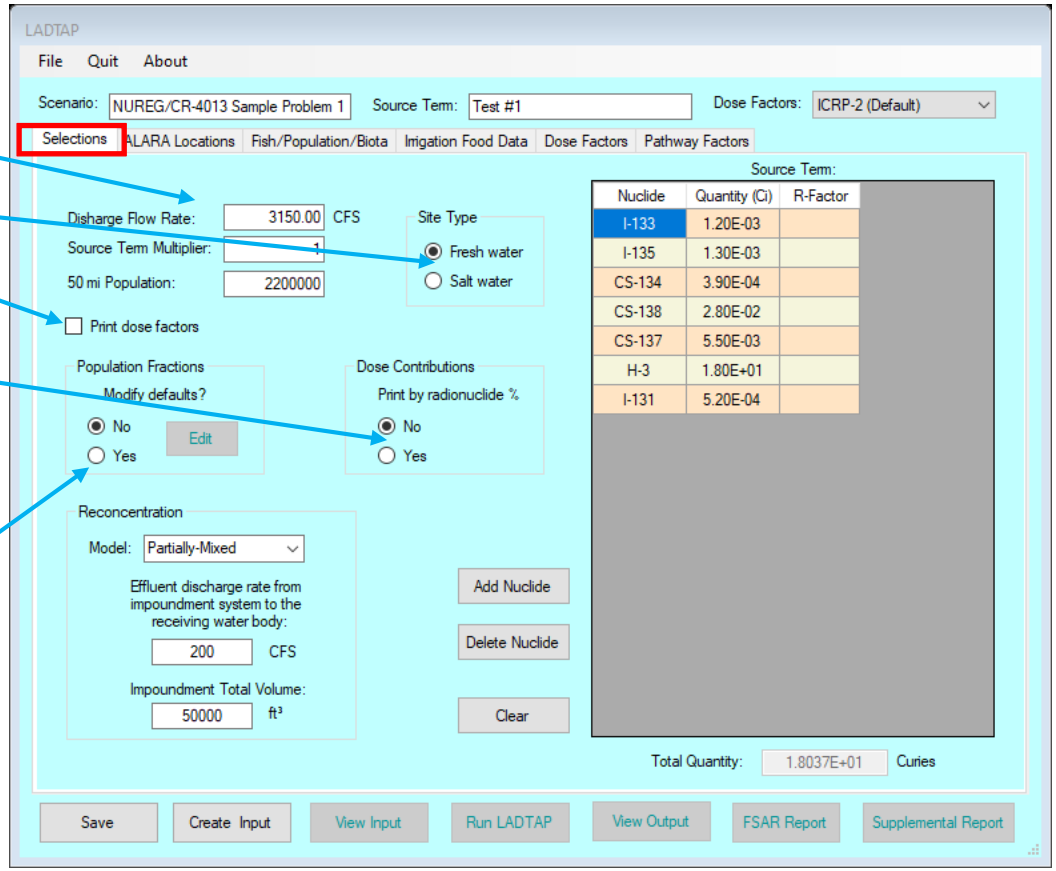
- Scenario Name
- Source Term Identifier
- Dose Factor Library
  - ICRP-2 (Default)
  - ICRP-30
  - ICRP-72

NOTE: Changing DCF Library will cause other entries to reset



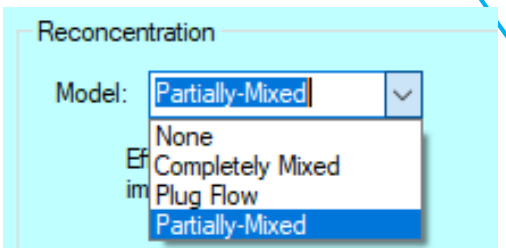
LADTAP – Selections

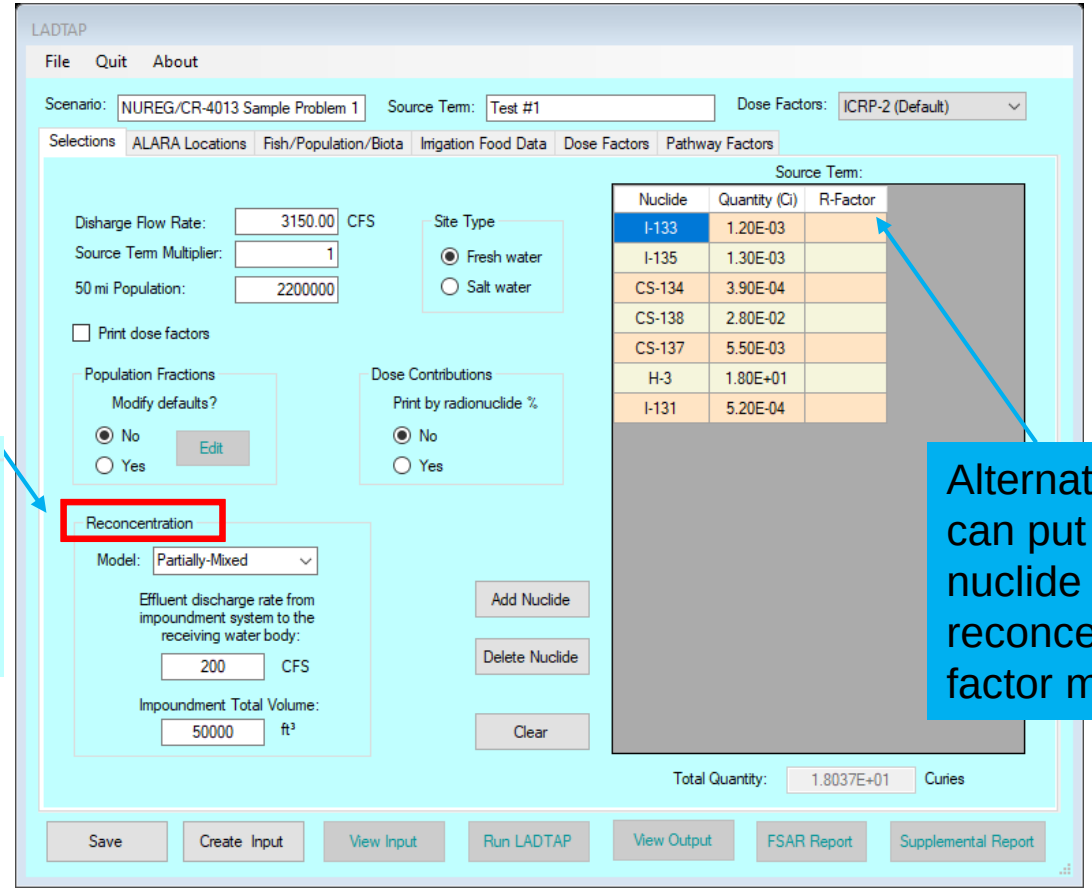
- Release/site information
- Fresh or Saltwater
- Print Dose Factors
- Dose contribution by nuclide
- Modify Population Fractions
  - (ICRP-2/ICRP-72)
    - Adult (71%)
    - Teen (11%)
    - Child (18%)
  - ICRP-30
    - Adult (100%)



LADTAP – Reconcentration

- Drop down menus for the three (3) models





Alternatively, user can put in a nuclide specific reconcentration factor manually.

LADTAP – Reconcentration models

- Plug-Flow Model

$$C_i = C_{0i} * \exp[-2.788X10^{-4}\,\lambda_i\, V_T / Q_B]$$

- Partially Mixed Model

$$C_i = C_0 * \frac{R}{(R+1) * \exp[\frac{V_T * \lambda_i}{3600 * Q_r (R+1)} - 1]}$$

where:

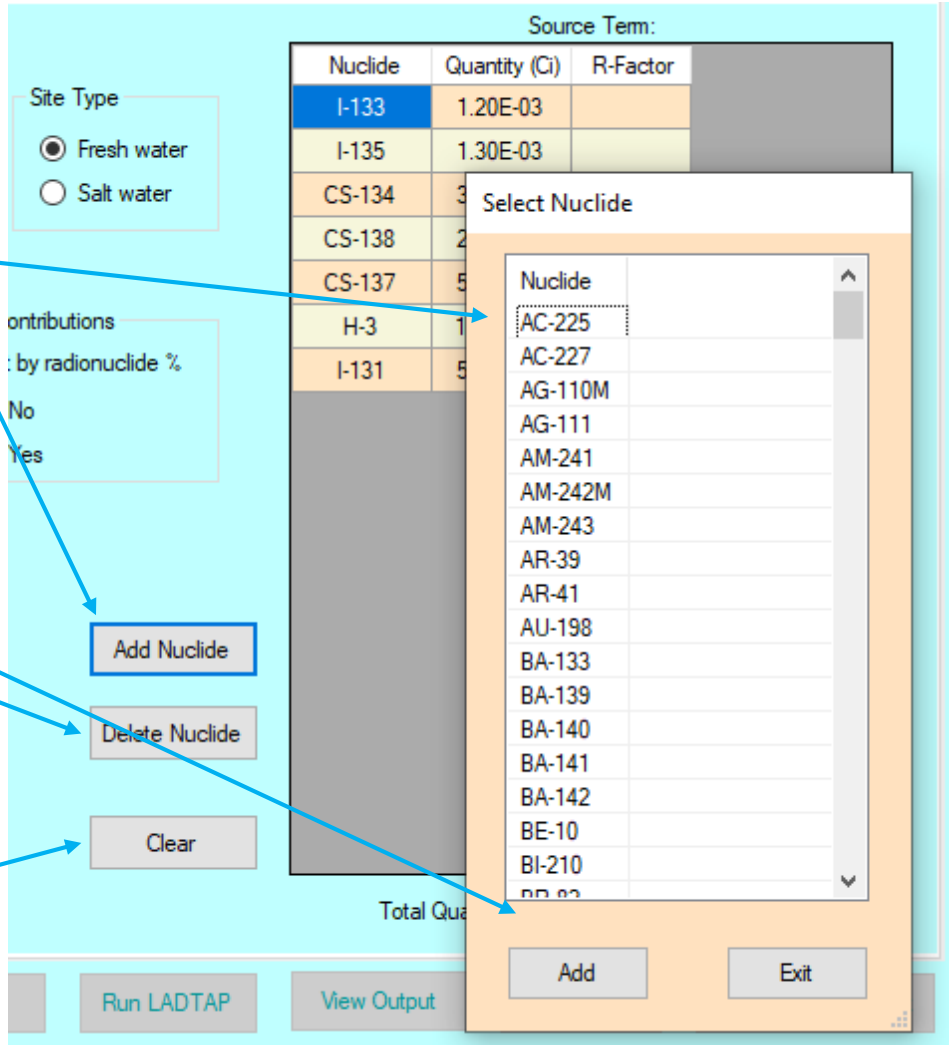
$$R = \frac{\text{reactor effluent discharge rate}}{\text{pond flow-through rate}}$$

- Completely Mixed Model

$$C_i = C_0 * \frac{Q_b}{(Q_b + V_T * \lambda_i / 3600)\left\{1 - \exp\left[-3.15X10^7 (Q_b + \frac{\lambda_i V_T}{3600})(\frac{T_{PL}}{V_T})\right]\right\}}$$

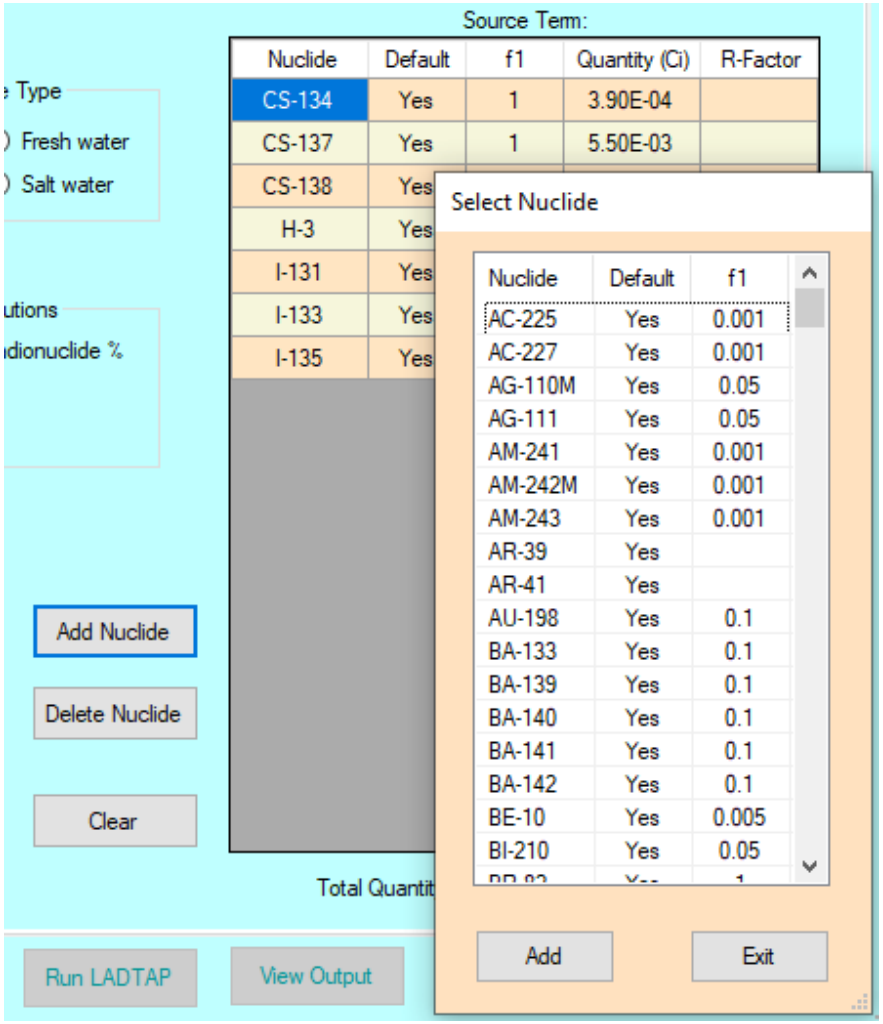
LADTAP – Source Term

- Select: Add Nuclide
- Pop-up menus with nuclide list
- Highlight desired nuclide; use "control" key to select multiple nuclides
  - Select "Add" to add to list
- "Delete Nuclide" will delete selected nuclide
- "Clear" will clear all nuclides in the Source Term



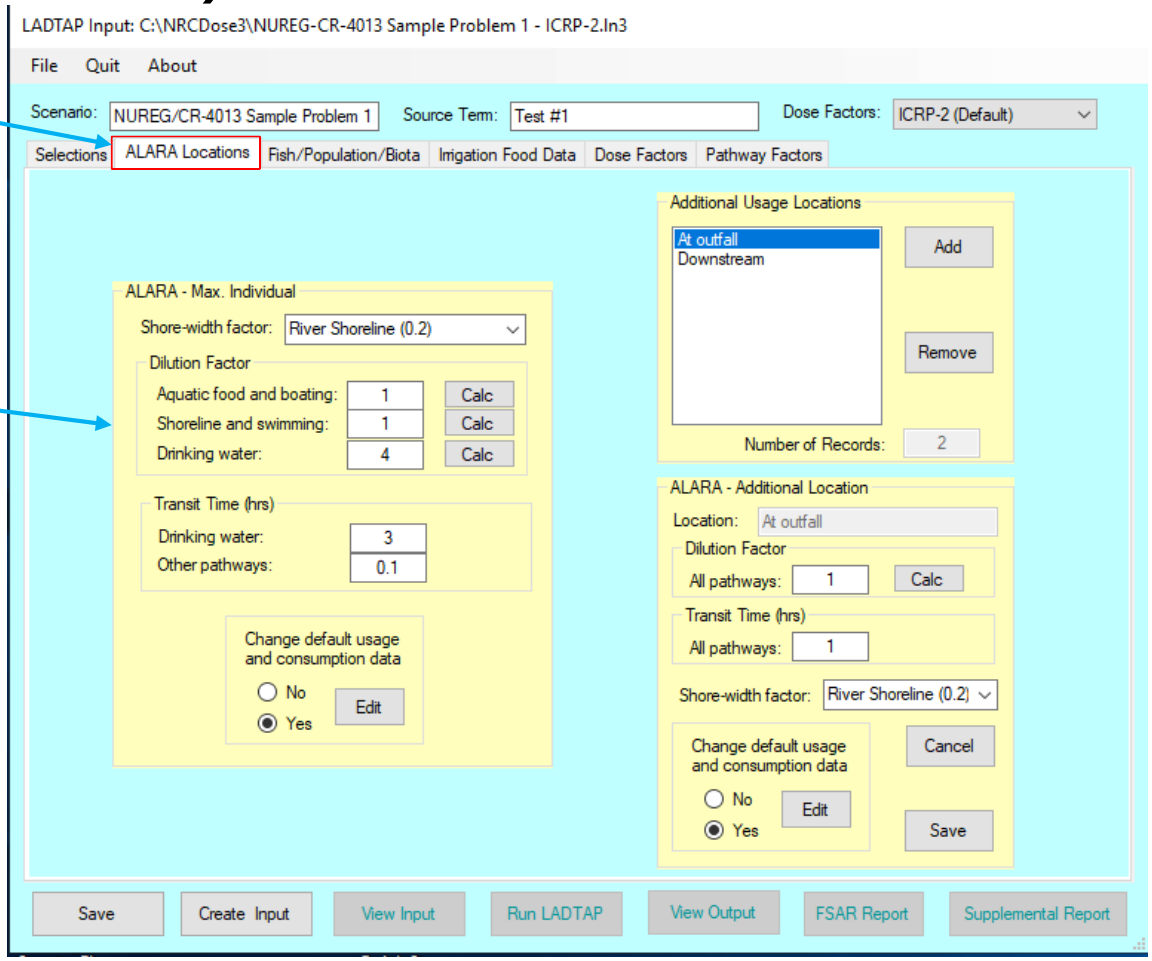
LADTAP – Source Term

- ICRP-30 and ICRP-72 DCFs
  - For radionuclides with more than one solubility class, select the applicable one
  - The same nuclide with more than one solubility class is not allowed



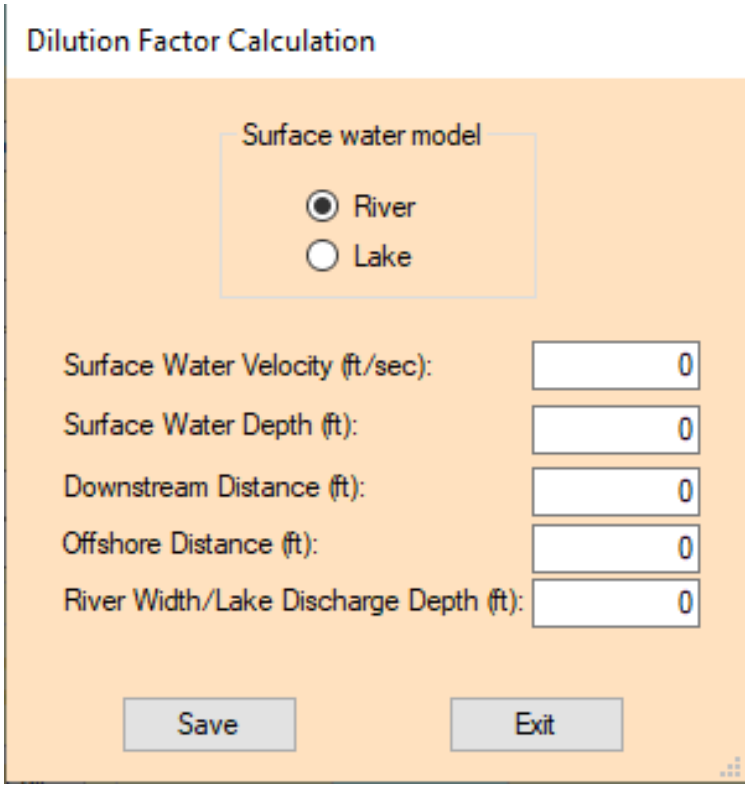
LADTAP – ALARA Locations (Individual Doses)

- Defines the exposure assumptions for individual dose calculations
- Enter data
  - Shore width factor defines the geometry for the shoreline exposure
  - Dilution factors by pathway
  - Transit time by pathways



LADTAP – Dilution Factor Calculation

- Using the "Calc" options, a dilution factor will be calculated based on receiving water body parameters
  - Based on RG 1.113
  - For nontidal uniform flow and steady-state conditions, diffusive transport in the flow direction negligible compared with advective transport

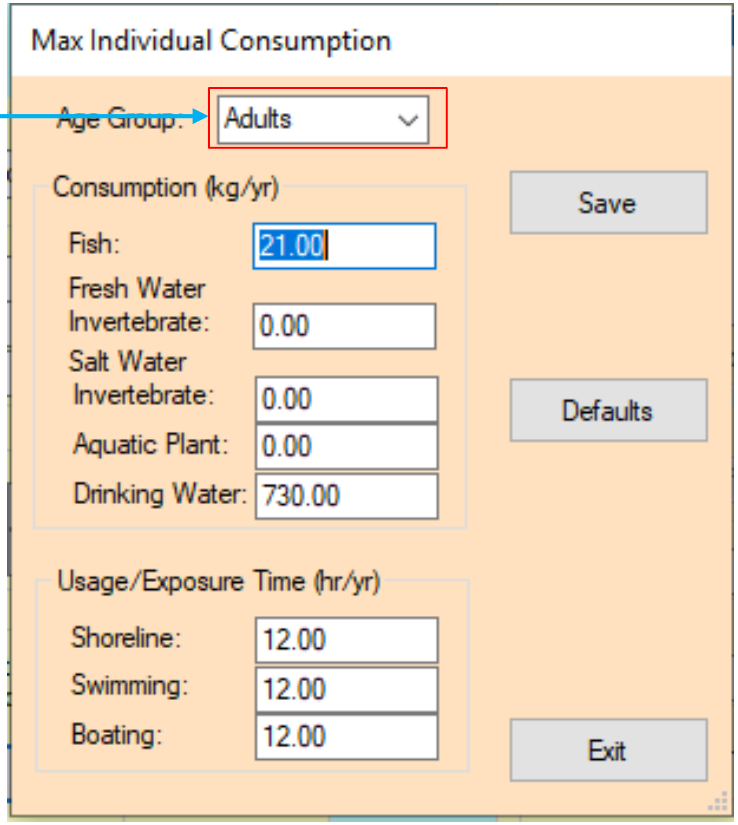


LADTAP Dilution Calculation

- Surface Water Model — Select the appropriate hydrological model by clicking on either River or Lake model option
- Surface Water Velocity — surface water velocity in units of feet per second (ft/s)
- Surface Water Depth — surface water depth in units of ft
- Downstream Distance — downstream distance in units of ft
- Offshore Distance — offshore distance in units of ft
- River Width/Lake Discharge Depth — either the river width or lake discharge depth depending on the model selected in units of ft

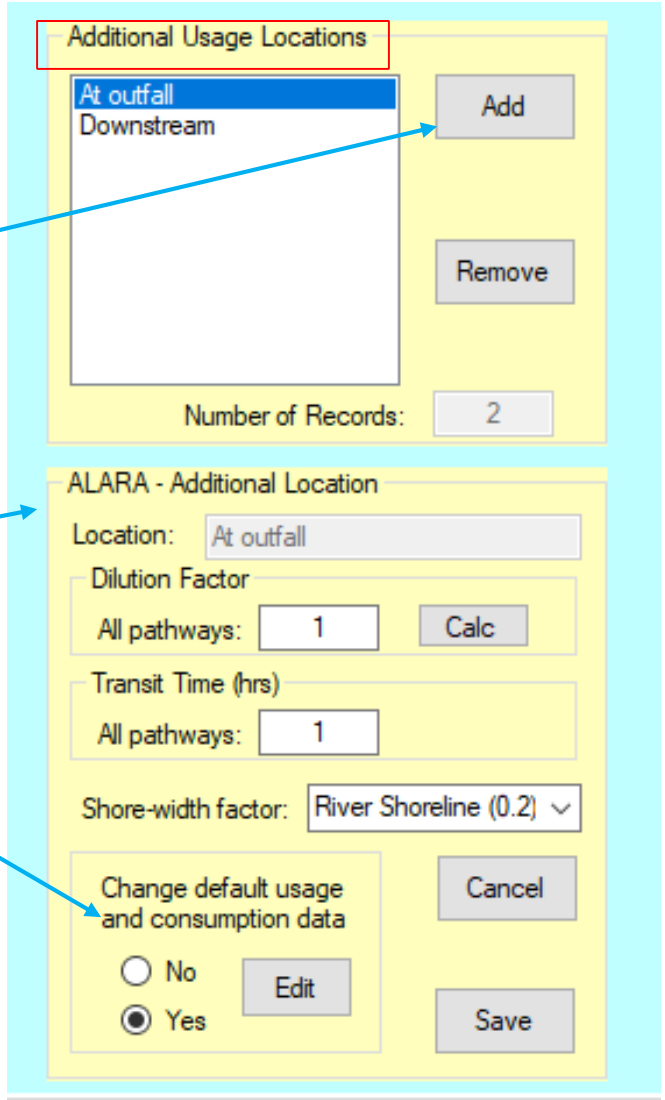
LADTAP – Individual Age Group Exposure Assumptions

- Drop down menu to select age group
  - ICRP-2 DCFs: four age groups: Adult, Teen, Child, Infant
  - ICRP-30 DCFs: Adult age group only
  - ICRP-72 DCFs: Adult, 15-year, 10-year, 5-year, 1-year and newborn
- Remember to Save before Exit



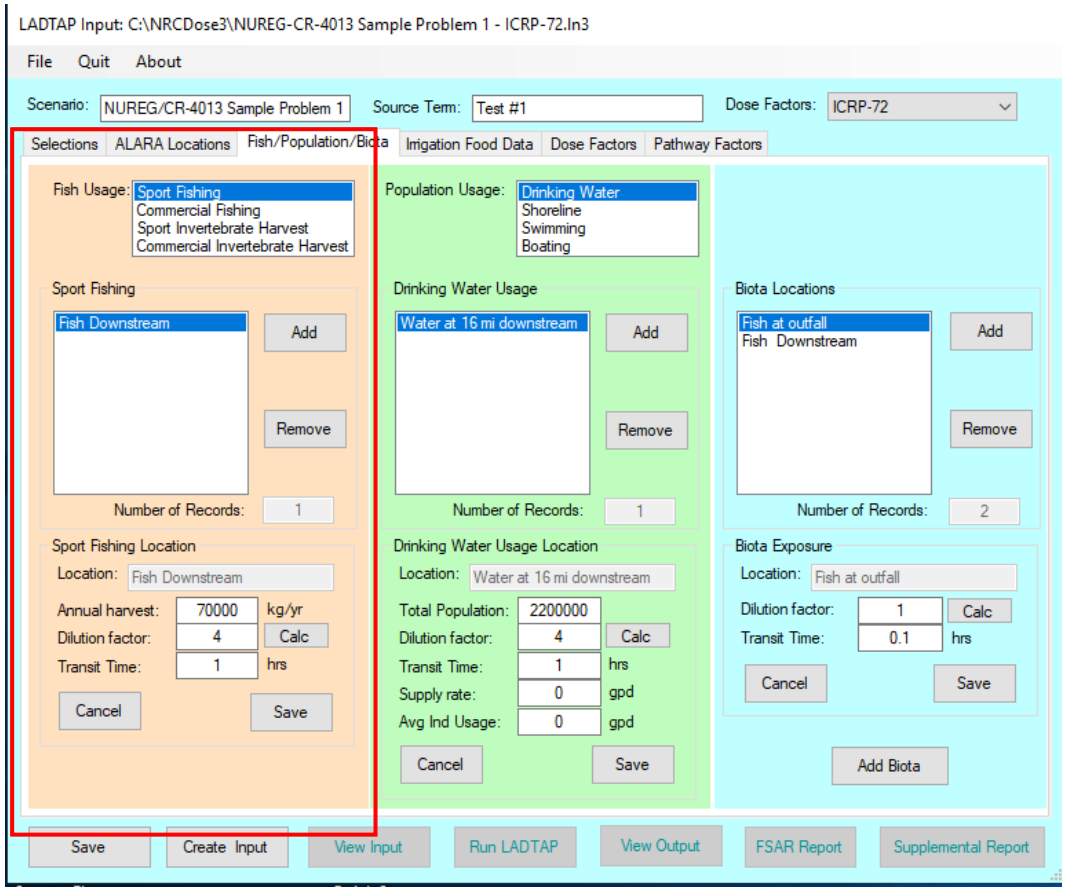
LADTAP – Additional Locations (Individual Doses)

- Add/remove additional locations of interest – by name
- Define exposure assumptions
  - Dilution
  - Transit time
  - Shore width factor
- Ability to change exposure times and consumption rates



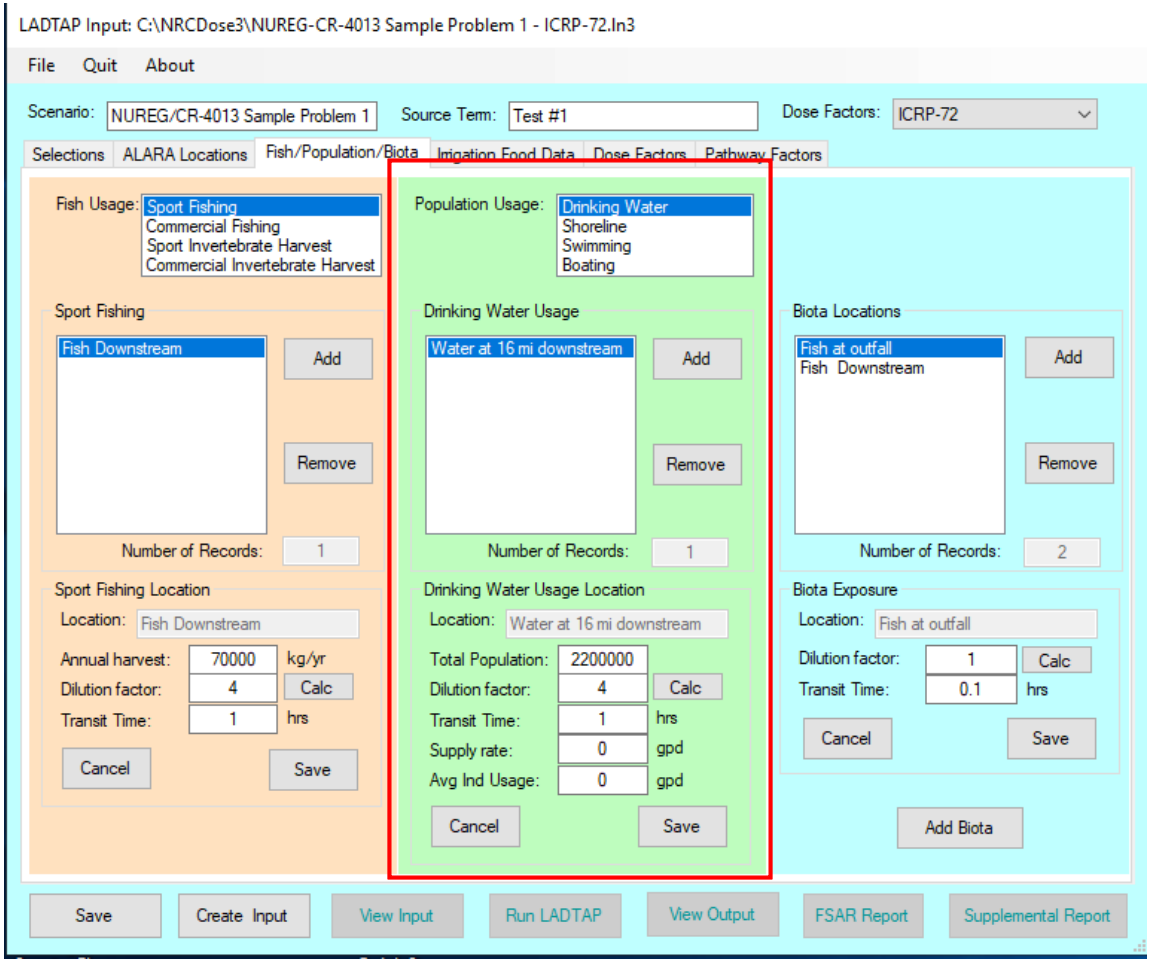
LADTAP Population Doses: Fish and Shellfish

- Select pathway from dropdown menu
- Add location
- Define harvest, dilution and transit time



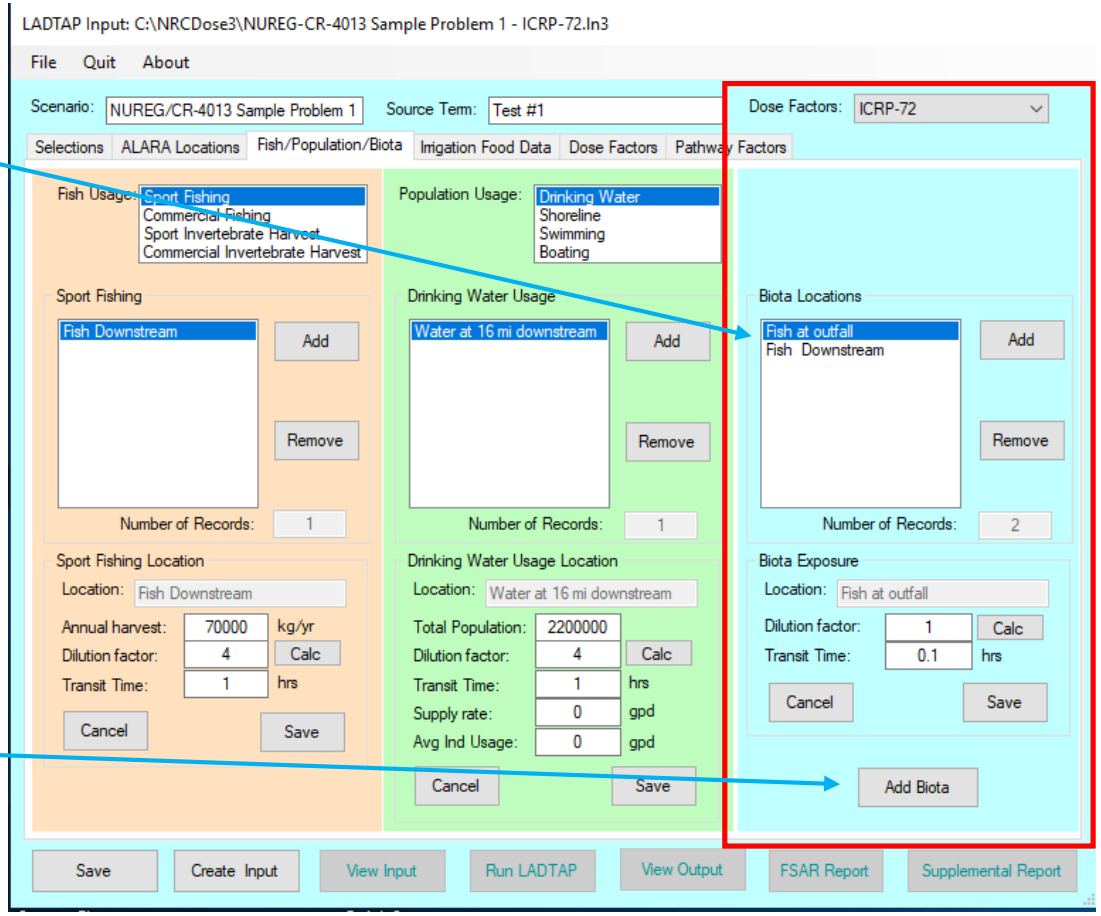
LADTAP Population Usages

- From drop down, select population usage: drinking water, shoreline, swimming or boating
- Add location
- For drinking water, define the population served or the supply rate
- For others, define person-hours annual usage
- Define dilution and transit time
- Add additional locations as needed



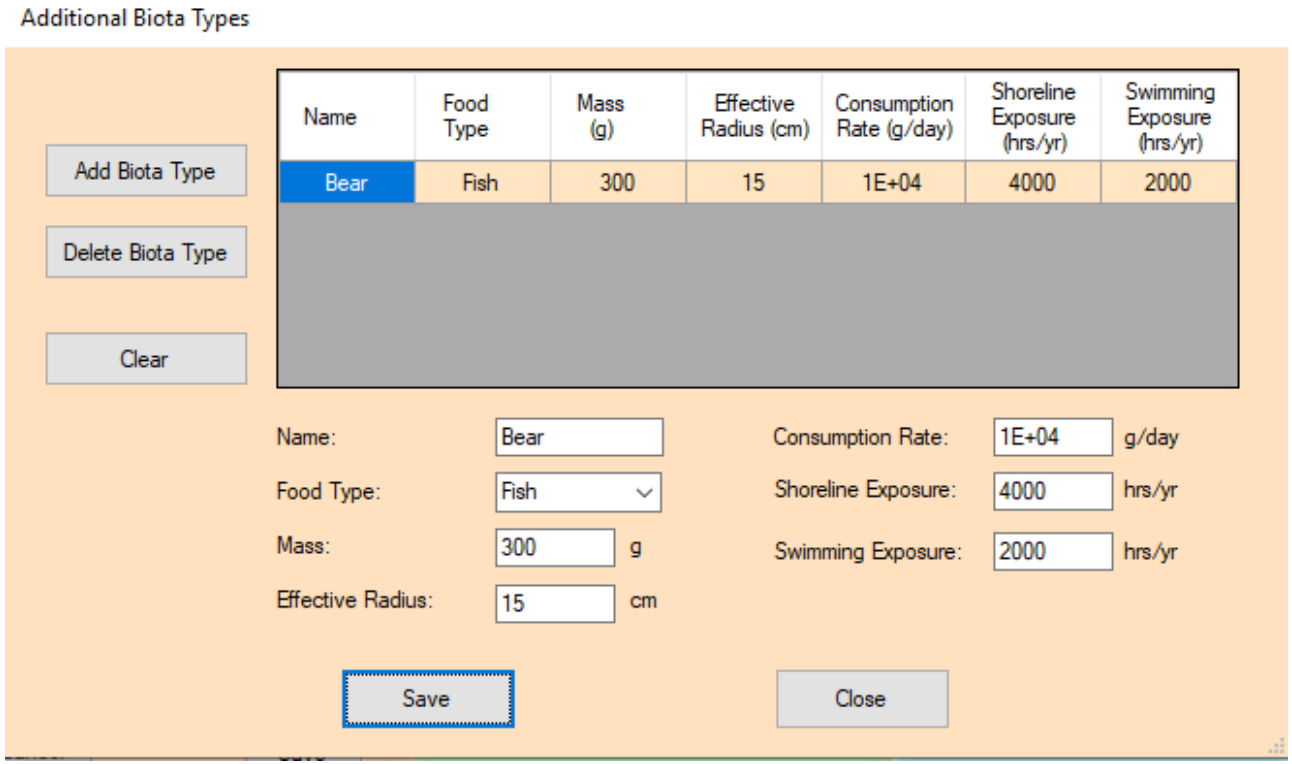
LADTAP – Biota Doses

- Add locations for calculating doses to biota
- Define dilution and transit time
- Add additional locations as needed
- A "new" biota can be defined and added

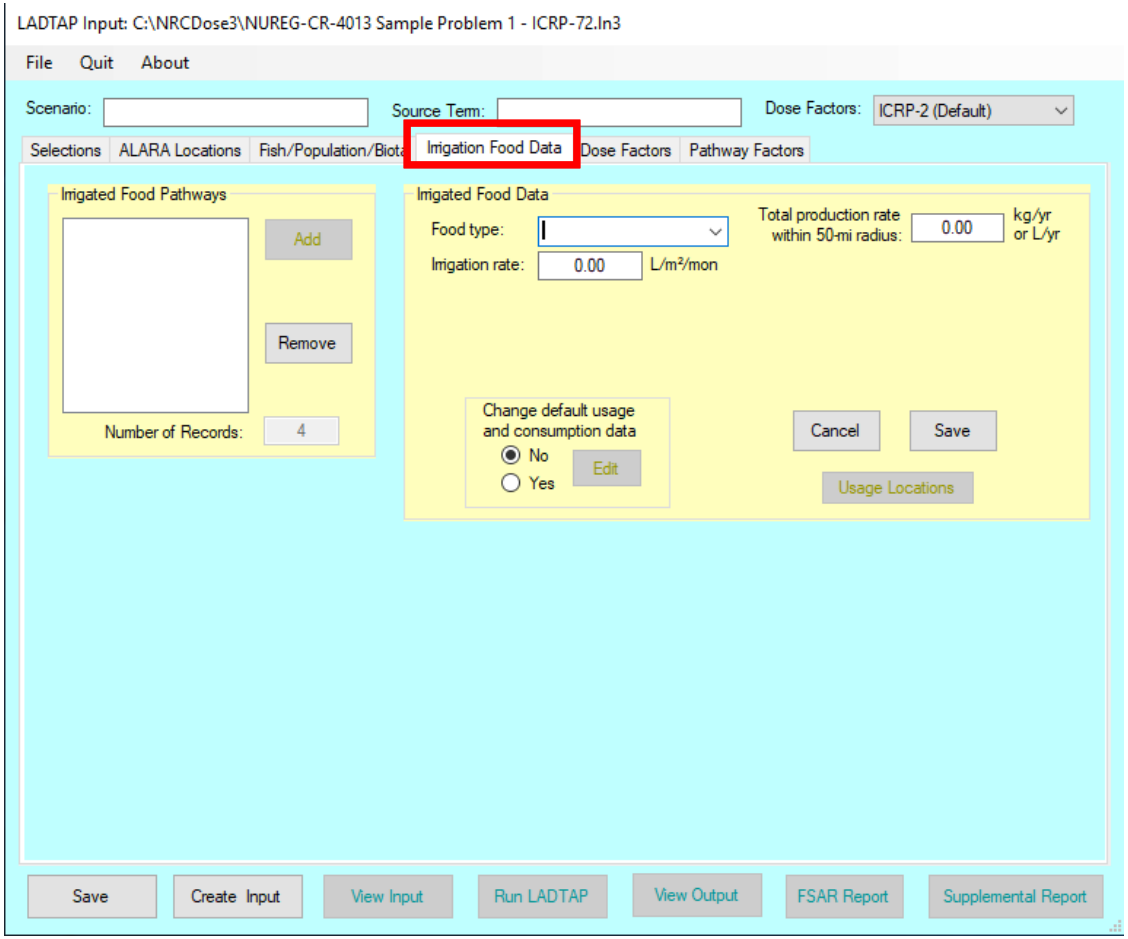


LADTAP – Biota Doses

- Select the "Add Biota" button
- Enter the name and exposure assumptions for the new biota type.
- Select the "Save" button
- Up to five (5) new biota may be added

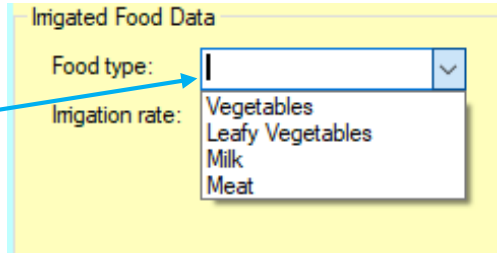


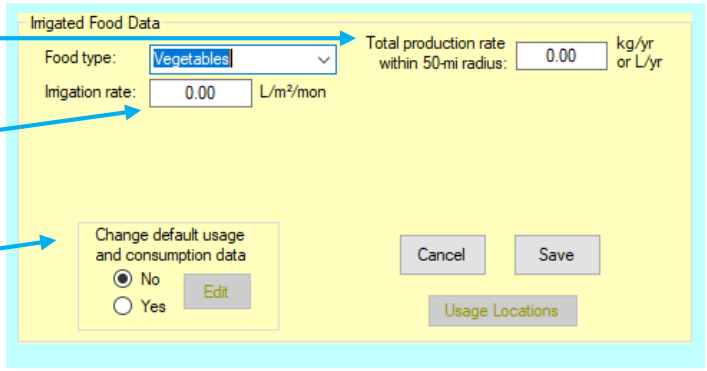
LADTAP – Irrigated Foods

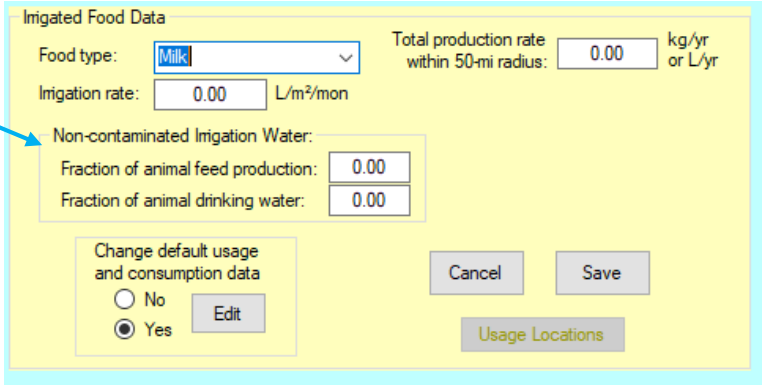


LADTAP – Irrigated Foods

- From dropdown menu select food type
- Total production within 50 miles
- Add irrigation rate
- Option to change default consumption rates
- For milk and meat, add non-contaminated water fractions
- Save: adds Food type to list.

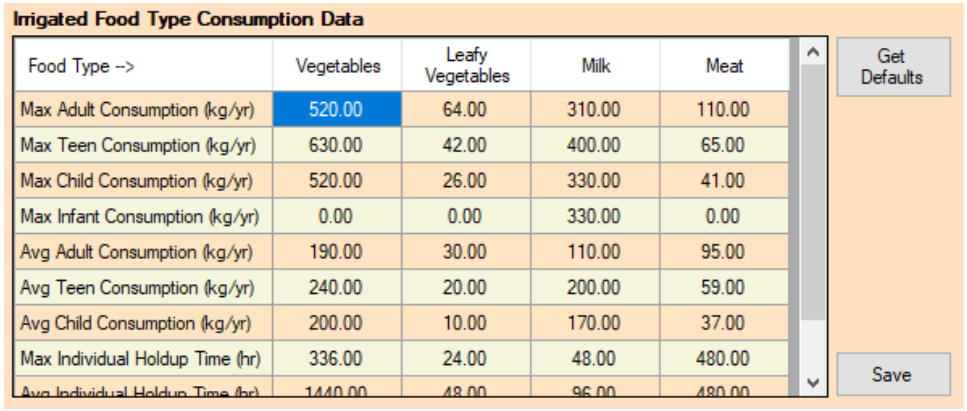




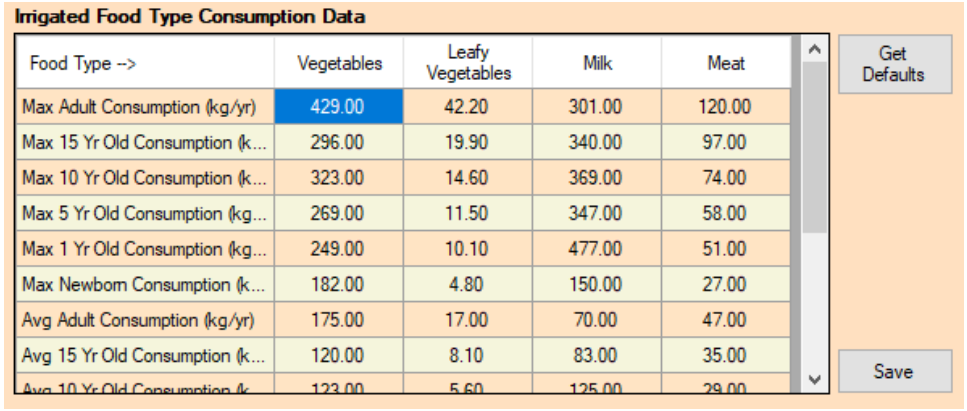


LADTAP – Irrigated Foods

ICRP-2

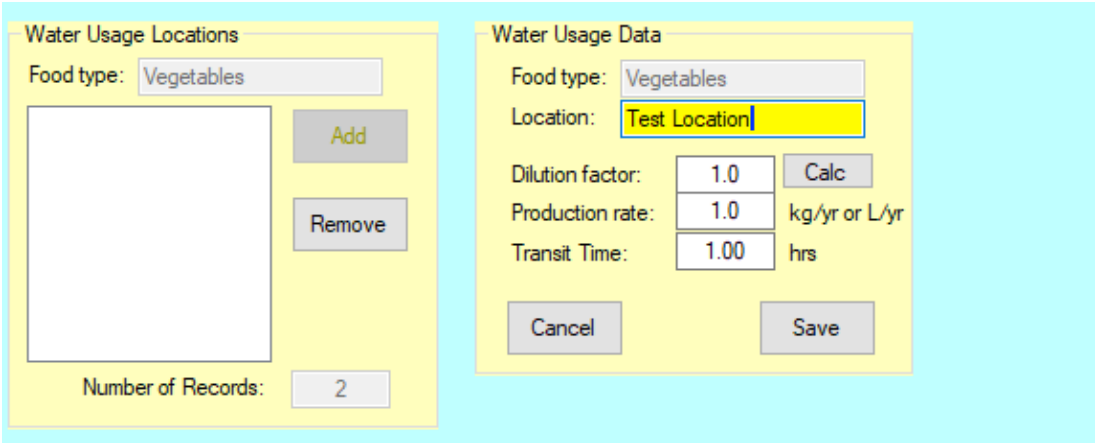


ICRP-72



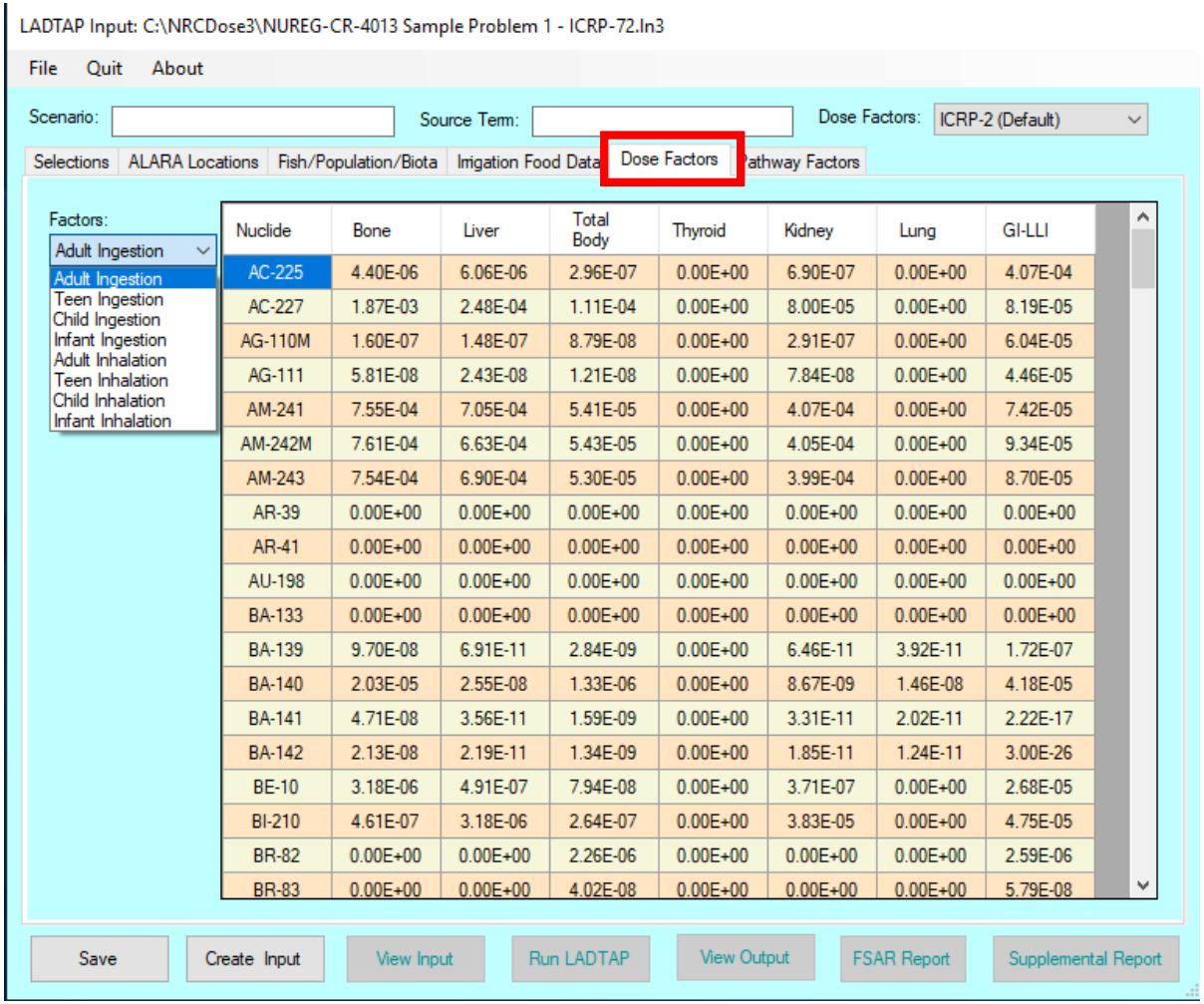
LADTAP – Irrigated Foods, Farm Data

- For each farm location, add:
  - Dilution
  - Production
  - Transit time



- Save: adds Food type to list
- Add locations for selected farms for production
- Option to change default consumption rates

LADTAP – Dose Factors

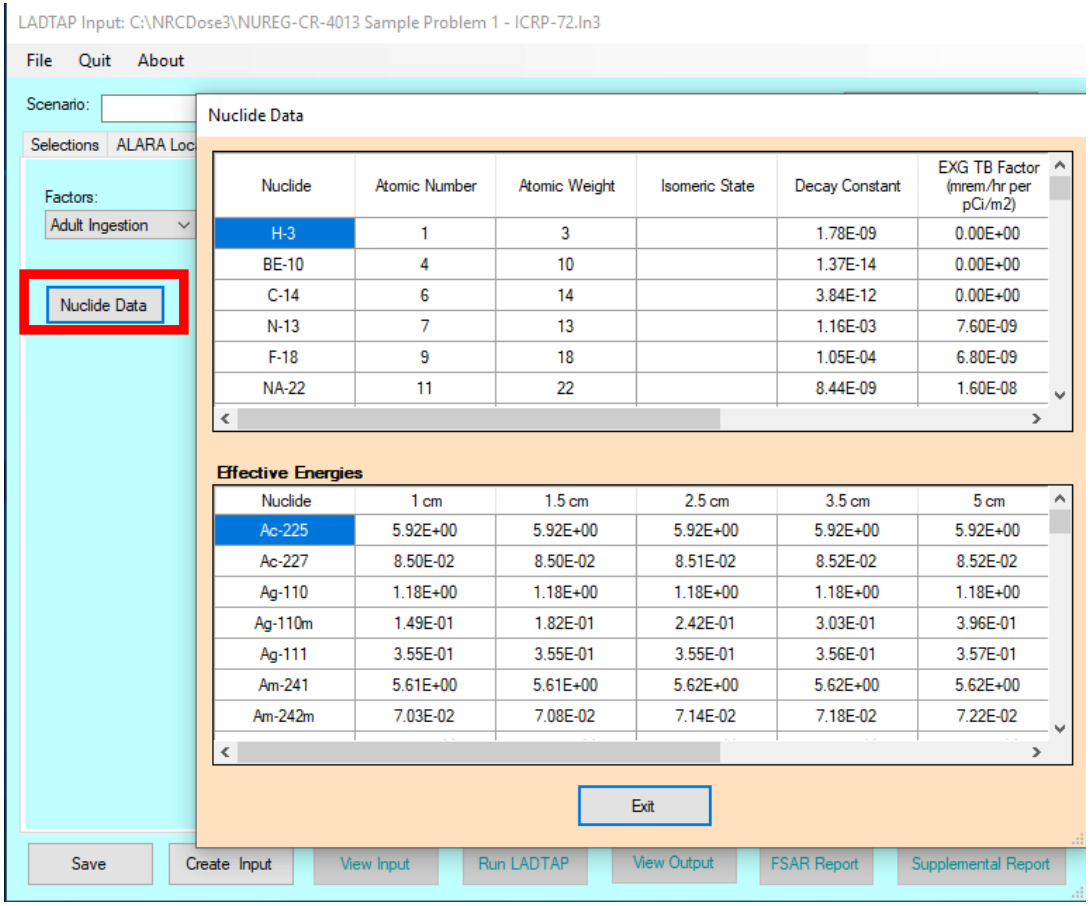


Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
AC-225	4.40E-06	6.06E-06	2.96E-07	0.00E+00	6.90E-07	0.00E+00	4.07E-04
AC-227	1.87E-03	2.48E-04	1.11E-04	0.00E+00	8.00E-05	0.00E+00	8.19E-05
AG-110M	1.60E-07	1.48E-07	8.79E-08	0.00E+00	2.91E-07	0.00E+00	6.04E-05
AG-111	5.81E-08	2.43E-08	1.21E-08	0.00E+00	7.84E-08	0.00E+00	4.46E-05
AM-241	7.55E-04	7.05E-04	5.41E-05	0.00E+00	4.07E-04	0.00E+00	7.42E-05
AM-242M	7.61E-04	6.63E-04	5.43E-05	0.00E+00	4.05E-04	0.00E+00	9.34E-05
AM-243	7.54E-04	6.90E-04	5.30E-05	0.00E+00	3.99E-04	0.00E+00	8.70E-05
AR-39	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AR-41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AU-198	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BA-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BA-139	9.70E-08	6.91E-11	2.84E-09	0.00E+00	6.46E-11	3.92E-11	1.72E-07
BA-140	2.03E-05	2.55E-08	1.33E-06	0.00E+00	8.67E-09	1.46E-08	4.18E-05
BA-141	4.71E-08	3.56E-11	1.59E-09	0.00E+00	3.31E-11	2.02E-11	2.22E-17
BA-142	2.13E-08	2.19E-11	1.34E-09	0.00E+00	1.85E-11	1.24E-11	3.00E-26
BE-10	3.18E-06	4.91E-07	7.94E-08	0.00E+00	3.71E-07	0.00E+00	2.68E-05
BI-210	4.61E-07	3.18E-06	2.64E-07	0.00E+00	3.83E-05	0.00E+00	4.75E-05
BR-82	0.00E+00	0.00E+00	2.26E-06	0.00E+00	0.00E+00	0.00E+00	2.59E-06
BR-83	0.00E+00	0.00E+00	4.02E-08	0.00E+00	0.00E+00	0.00E+00	5.79E-08

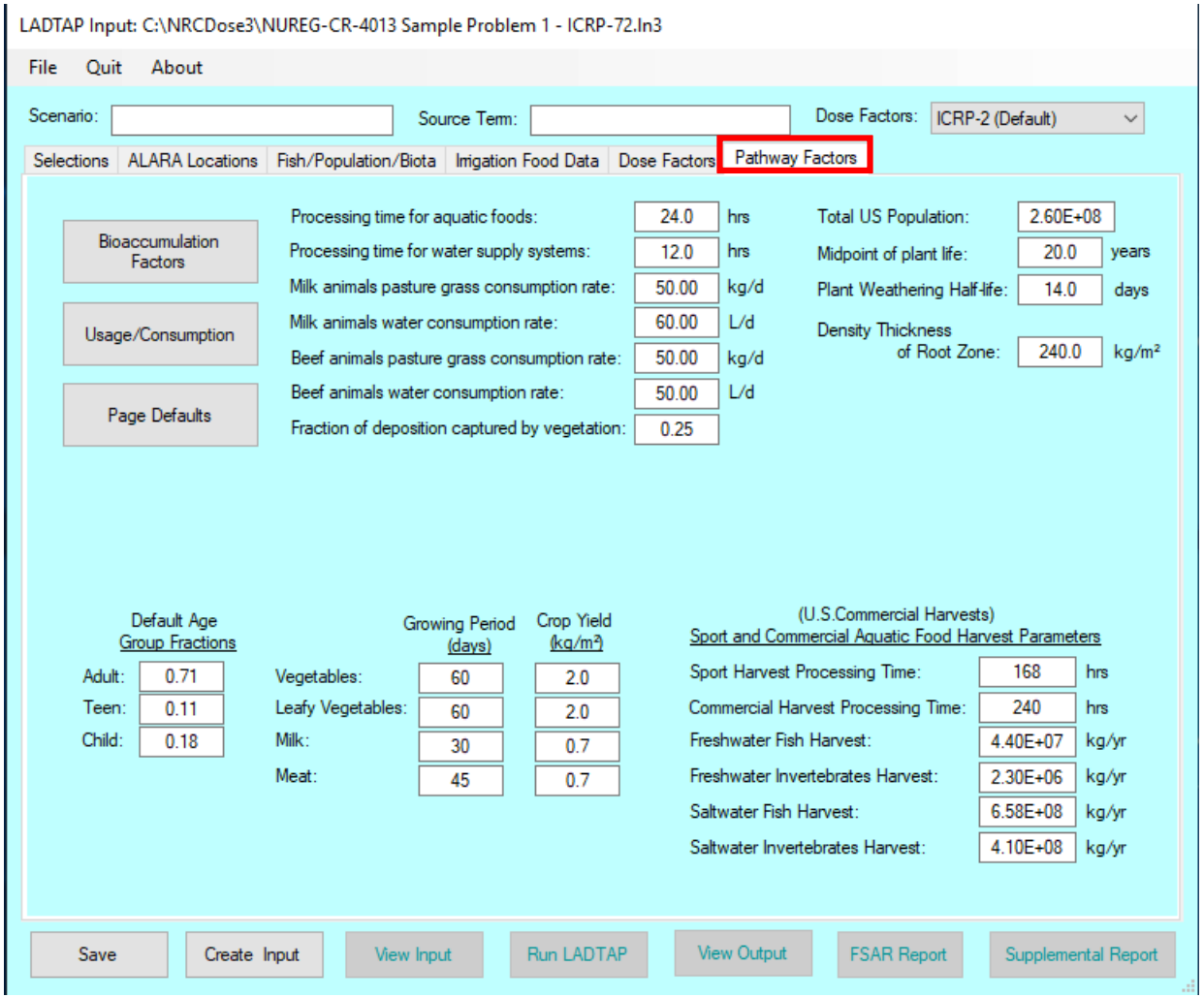
LADTAP – Dose Factors

- Nuclide Data
  - External TB and skin DFs from
  - Ground Surface
  - Water Submersion
  - Absorbed Energies
  - For biota calculations
  - Effective radii

NOTE: Nuclide Data is non-editable



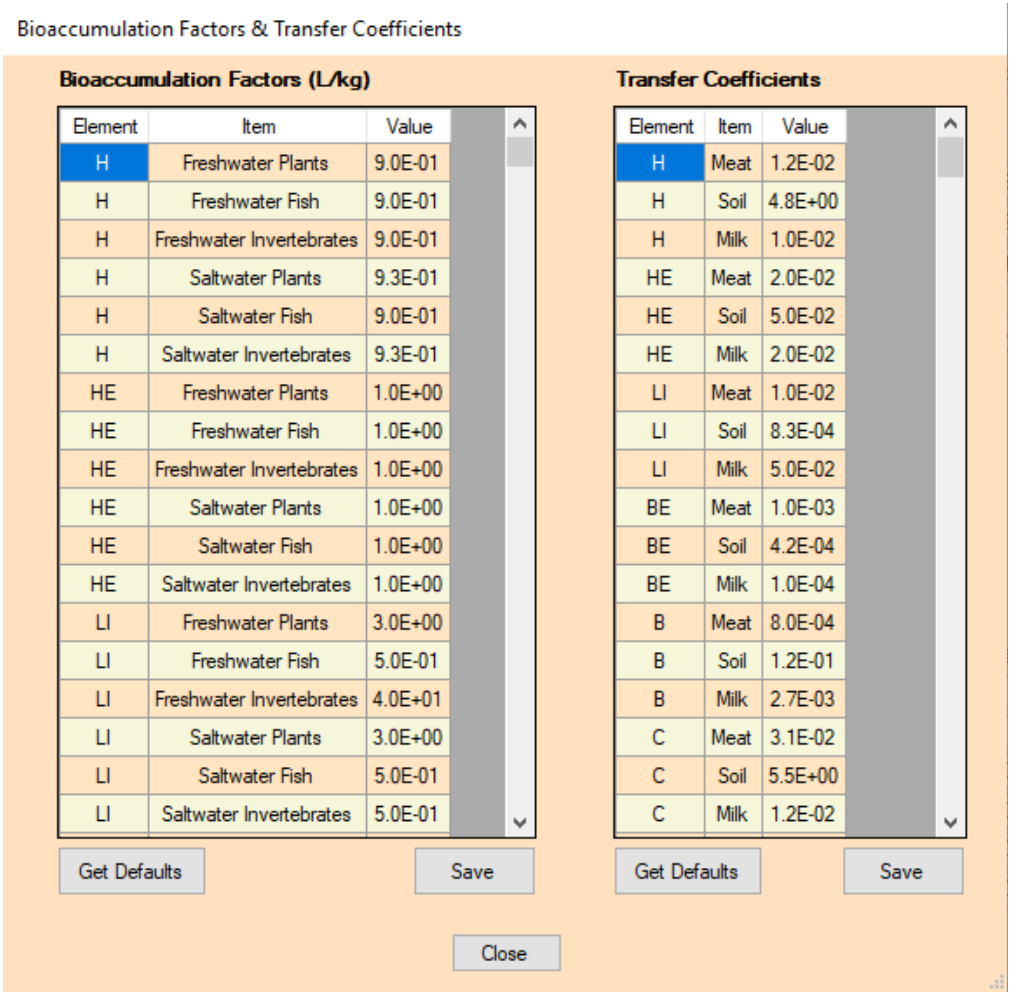
LADTAP Pathway Factors



LADTAP Pathway Factors – Bioaccumulation Factors

- Bioaccumulation factors (fresh and saltwater):
  - Fish
  - Invertebrate
  - Plants
- Transfer factors:
  - Soil-to-vegetables
  - Grass-to-meat
  - Grass-to-milk

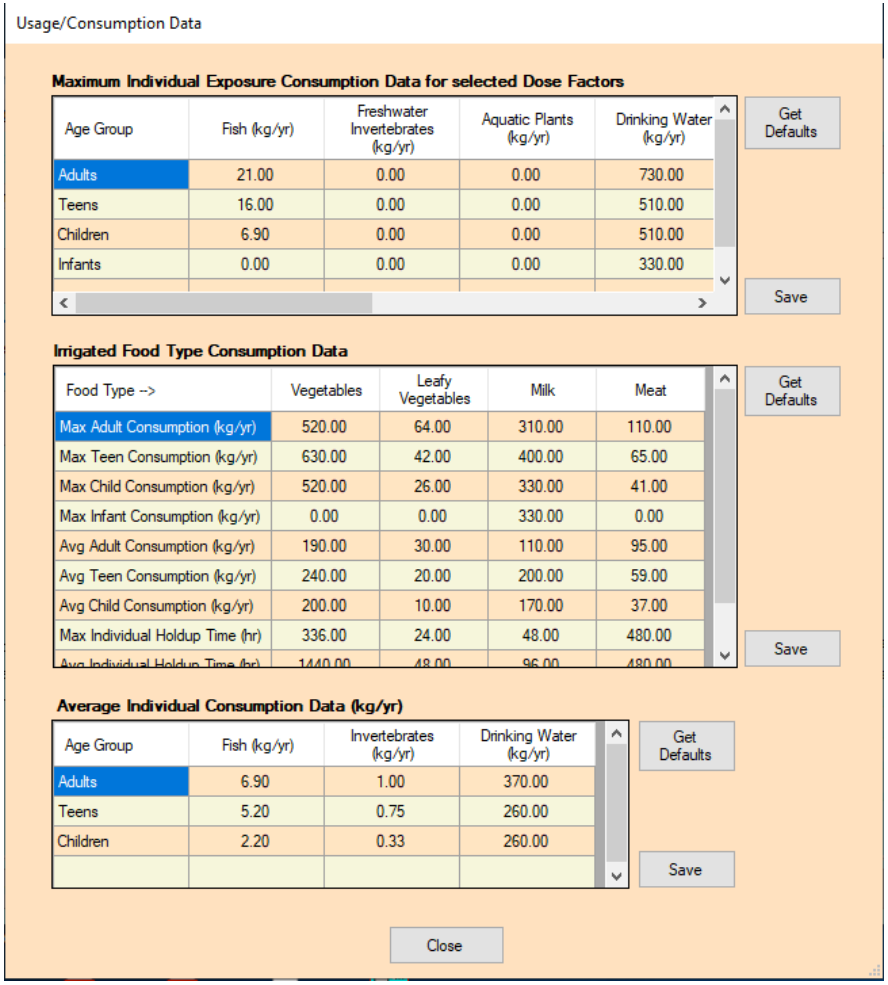
NOTE: All bioaccumulation factors are editable for site-specific data



LADTAP Pathway Factors – Usage/Consumption

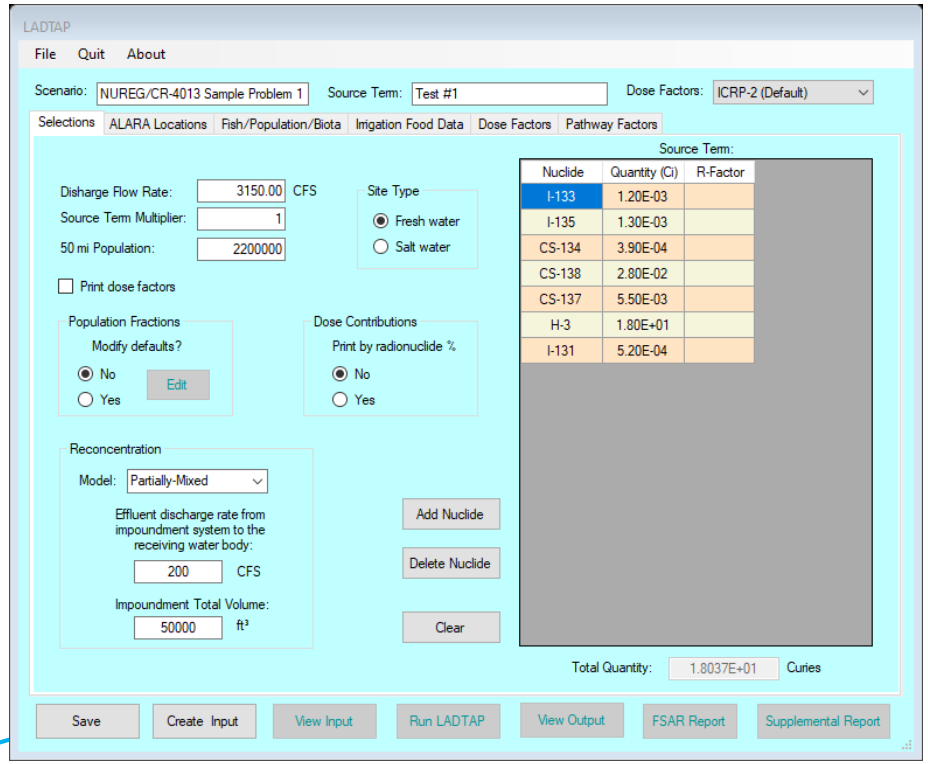
- Consumption Rates
  - Fish
  - Invertebrate
  - Plants
  - Drinking water
  - Shoreline
  - Swimming
  - Boating
- Irrigated Food Consumption:
  - Vegetables
  - Leafy vegetables
  - Milk
  - Meat
  - Transit and hold-up times

NOTE: All consumption rates are editable for site-specific data



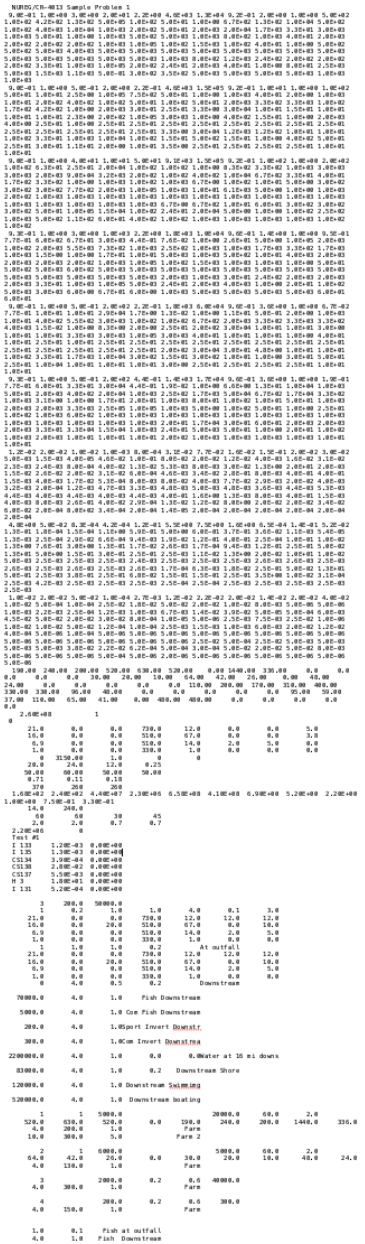
Running LADTAP – Viewing Outputs/Reports

- Save
- Create Input
- View Input
- Run LADTAP
- View Output
- FSAR Report
- Supplemental Report



View Input

- Input follows the format of the “card deck” as described in NUREG/CR-4013
- The datasets at beginning reflect assumptions that could have been changed under the “Pathway factors” tab.
- The bottom section is standard LADTAP input
  - Selections inputs
  - Source Term
  - ALARA Location assumptions
  - Fish/population/biota inputs
  - irrigated foods



Run LADTAP/View Output

```
*******************************************************************************
*                                                                             *
*                                   NRCDose3                                  *
*                                                                             *
*                                                                             *
*          EVALUATION OF RADIATION DOSES FROM RELEASES OF RADIOACTIVITY       *
*                                                                             *
*                    IN NUCLEAR POWER PLANTS LIQUID EFFLUENTS                 *
*                                                                             *
*                                                                             *
*                      U. S. NUCLEAR REGULATORY COMMISSION                    *
*                             WASHINGTON, D. C.                               *
*                                                                             *
*                                                                             *
*                       NUREG/CR-4013 Sample Problem 1                        *
*                                                                             *
*                           DATE OF RUN: 10-22-2019                           *
*                                                                             *
*                    CALCULATIONS PERFORMED USING THE ICRP-2                  *
*                        BASED DOSE CONVERSION FACTORS                        *
*                                                                             *
*******************************************************************************


NUREG/CR-4013 Sample Problem 1

 DISCHARGE = 3.15E+03 CFS          SOURCE TERM MULTIPLIER = 1.00E+00

 50-MILE POPULATION = 2.20E+06     FRACTION ---     ADULT = 0.71
                                                 TEENAGER = 0.11
                                                    CHILD = 0.18

 FRESHWATER SITE


Test #1
PARTIALLY MIXED MODEL-- POND BLOWDOWN (CFS) - 2.00E+02   PLANT FLOW RATE (CFS) - 3.15E+03   POND VOLUME (CF) - 5.00E+04

                          *  *  *  ADULT DOSE FACTORS  *  *  *

                  _________________INGESTION DOSE FACTORS_____________________________ _____SHORELINE______
                                          (MREM/PCI INTAKE)                           (MREM/HR)/(PCI/M**2)
 NUCLIDE   CURIE/YEAR  BONE     LIVER  TOT BODY THYROID   KIDNEY    LUNG    GI-LLI    SKIN   TOT BODY  RECON
          ------------------------------------------------------------------------------------------------
 53I  133   1.20E-03 1.42E-06 2.47E-06 7.53E-07 3.63E-04 4.31E-06 0.00E+00 2.22E-06 4.50E-09 3.70E-09 1.57E+01
 53I  135   1.30E-03 4.43E-07 1.16E-06 4.28E-07 7.65E-05 1.86E-06 0.00E+00 1.31E-06 1.40E-08 1.20E-08 1.56E+01
 55CS 134   3.90E-04 6.22E-05 1.48E-04 1.21E-04 0.00E+00 4.79E-05 1.59E-05 2.59E-06 1.40E-08 1.20E-08 1.57E+01
 55CS 138   2.80E-02 5.52E-08 1.09E-07 5.40E-08 0.00E+00 8.01E-08 7.91E-09 4.65E-13 2.40E-08 2.10E-08 1.45E+01
 55CS 137   5.50E-03 7.97E-05 1.09E-04 7.14E-05 0.00E+00 3.70E-05 1.23E-05 2.11E-06 4.90E-09 4.20E-09 1.57E+01
  1H    3   1.80E+01 0.00E+00 5.99E-08 5.99E-08 5.99E-08 5.99E-08 5.99E-08 5.99E-08 0.00E+00 0.00E+00 1.57E+01
 53I  131   5.20E-04 4.16E-06 5.95E-06 3.41E-06 1.95E-03 1.02E-05 0.00E+00 1.57E-06 3.40E-09 2.80E-09 1.57E+01
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LADTAP FSAR Report

- Provides a summary report of assumptions and doses
- Suitable for use in creating input for safety analyses and licensing support

FSAR Input Report - NUREG/CR-4013 Sample Problem 1 - 22-Oct-2019 06:48

Parameters:

Midpoint of Plant Life (yr):	20.00
Circulating Water System discharge rate (cfs):	3150.00
Water type selection:	Freshwater
Reconcentration model index:	3 Partially-Mixed
Discharge rate to receiving water (ft3/sec):	200
Total impoundment volume (ft3):	50000
Shore-width factor:	0.2 River Shoreline
Dilution factor for aquatic foods and boating:	1.00
Dilution factor for shoreline and swimming exposure:	1.00
Dilution factor for drinking water:	4.00
Transit time for drinking water (hr):	3.00
Transit time for other pathways (hr):	0.10
Source term multiplier:	1.00
50-mile population:	2200000
Total shoreline usage time (person-hr/yr):	83000
Total swimming usage time (person-hr/yr):	120000
Total boating usage time (person-hr/yr):	520000

Irrigated Foods

Food Type	Irrigation Rate (L/m2-month)	Fraction not contaminated Animal Feed	Animal Water	Total Production within 50-miles (kg/yr,L/yr)
Vegetables	5000	0.00	0.00	20000
Leafy Vegetables	6000	0.00	0.00	5000
Milk	2000	0.20	0.60	40000
Meat	200	0.20	0.60	300

Population using water-supply system:	2200000
Annual local harvest for sports fishing (kg/yr):	70000
Annual local harvest for commercial fishing (kg/yr):	5000
Annual local harvest for sports invertebrates (kg/yr):	200
Annual local harvest for commercial invertebrates (kg/yr):	300

Liquid Source Term for the LADTAP Code

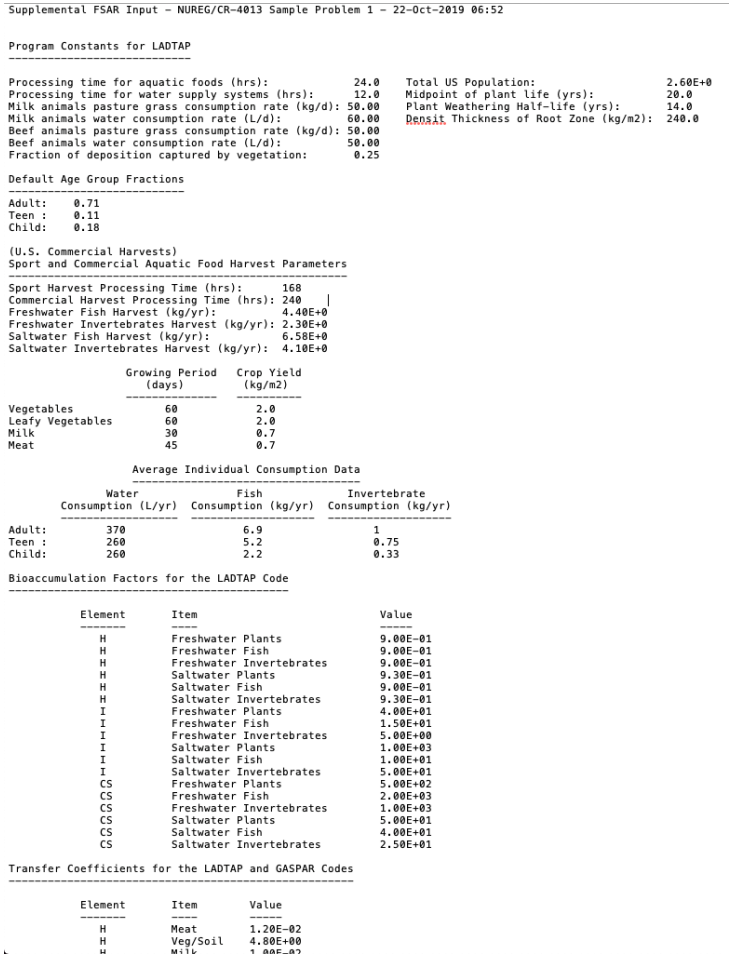
Isotope	Release Rate (CI/yr)
CS-134	3.90E-04
CS-137	5.50E-03
CS-138	2.80E-02
H-3	1.80E+01
I-131	5.20E-04
I-133	1.20E-03
I-135	1.30E-03

Individual ALARA Doses (mrem/yr)

Age Group	Skin	Bone	Liver	TBody	Thyroid	Kidney	Lung	GI-LLI
Fish								
Adult	0.00E+00	1.09E-01	1.55E-01	1.03E-01	2.11E-03	5.23E-02	1.75E-02	3.08E-03
Teen	0.00E+00	1.16E-01	1.61E-01	5.76E-02	1.97E-03	5.44E-02	2.12E-02	2.35E-03
Child	0.00E+00	1.46E-01	1.45E-01	2.21E-02	2.09E-03	4.70E-02	1.69E-02	9.69E-04
Infant	0.00E+00	3.38E-02	4.07E-02	2.99E-03	7.27E-04	1.09E-02	4.43E-03	1.42E-04
Plant								
Teen	0.00E+00	3.63E-02	5.03E-02	1.81E-02	6.40E-03	1.71E-02	6.69E-03	8.26E-04
Drinking								
Adult	0.00E+00	4.76E-04	1.78E-03	1.55E-03	2.37E-03	1.34E-03	1.18E-03	1.12E-03
Teen	0.00E+00	4.66E-04	1.42E-03	1.01E-03	1.88E-03	1.00E-03	8.59E-04	7.87E-04
Child	0.00E+00	1.36E-03	2.83E-03	1.70E-03	4.26E-03	1.94E-03	1.65E-03	1.50E-03
Infant	0.00E+00	1.41E-03	3.16E-03	1.59E-03	5.81E-03	1.93E-03	1.64E-03	1.47E-03
Shoreline								
Adult	1.52E-04	1.31E-04	1.31E-04	1.31E-04	1.31E-04	1.31E-04	1.31E-04	1.31E-04
Teen	8.50E-04	7.29E-04	7.29E-04	7.29E-04	7.29E-04	7.29E-04	7.29E-04	7.29E-04
Child	1.78E-04	1.52E-04	1.52E-04	1.52E-04	1.52E-04	1.52E-04	1.52E-04	1.52E-04
Infant	1.27E-05	1.09E-05	1.09E-05	1.09E-05	1.09E-05	1.09E-05	1.09E-05	1.09E-05
Swimming								
Adult	9.90E-06	6.90E-06	6.90E-06	6.90E-06	6.90E-06	6.90E-06	6.90E-06	6.90E-06
Child	1.65E-06	1.15E-06	1.15E-06	1.15E-06	1.15E-06	1.15E-06	1.15E-06	1.15E-06
Boating								
Adult	4.95E-06	3.45E-06	3.45E-06	3.45E-06	3.45E-06	3.45E-06	3.45E-06	3.45E-06
Teen	4.12E-06	2.87E-06	2.87E-06	2.87E-06	2.87E-06	2.87E-06	2.87E-06	2.87E-06

LADTAP Supplemental Report

- Provides additional information on inputs and exposure assumptions that may not be included in the LADTAP output or the FSAR



Supplemental FSAR Input - NUREG/CR-4013 Sample Problem 1 - 22-Oct-2019 06:52

Program Constants for LADTAP

Processing time for aquatic foods (hrs):	24.0	Total US Population:	2.60E+0
Processing time for water supply systems (hrs):	12.0	Midpoint of plant life (yrs):	20.0
Milk animals pasture grass consumption rate (kg/d):	50.00	Plant Weathering Half-life (yrs):	14.0
Milk animals water consumption rate (L/d):	60.00	Densit Thickness of Root Zone (kg/m2):	240.0
Beef animals pasture grass consumption rate (kg/d):	50.00		
Beef animals water consumption rate (L/d):	50.00		
Fraction of deposition captured by vegetation:	0.25		

Default Age Group Fractions

Adult:	0.71
Teen :	0.11
Child:	0.18

(U.S. Commercial Harvests)
Sport and Commercial Aquatic Food Harvest Parameters

Sport Harvest Processing Time (hrs):	168
Commercial Harvest Processing Time (hrs):	240
Freshwater Fish Harvest (kg/yr):	4.40E+0
Freshwater Invertebrates Harvest (kg/yr):	2.30E+0
Saltwater Fish Harvest (kg/yr):	6.58E+0
Saltwater Invertebrates Harvest (kg/yr):	4.10E+0

	Growing Period (days)	Crop Yield (kg/m2)
Vegetables	60	2.0
Leafy Vegetables	60	2.0
Milk	30	0.7
Meat	45	0.7

Average Individual Consumption Data

	Water Consumption (L/yr)	Fish Consumption (kg/yr)	Invertebrate Consumption (kg/yr)
Adult:	370	6.9	1
Teen :	260	5.2	0.75
Child:	260	2.2	0.33

Bioaccumulation Factors for the LADTAP Code

Element	Item	Value
H	Freshwater Plants	9.00E-01
H	Freshwater Fish	9.00E-01
H	Freshwater Invertebrates	9.00E-01
H	Saltwater Plants	9.30E-01
H	Saltwater Fish	9.00E-01
H	Saltwater Invertebrates	9.30E-01
I	Freshwater Plants	4.00E+01
I	Freshwater Fish	1.50E+01
I	Freshwater Invertebrates	5.00E+00
I	Saltwater Plants	1.00E+03
I	Saltwater Fish	1.00E+01
I	Saltwater Invertebrates	5.00E+01
CS	Freshwater Plants	5.00E+02
CS	Freshwater Fish	2.00E+03
CS	Freshwater Invertebrates	1.00E+03
CS	Saltwater Plants	5.00E+01
CS	Saltwater Fish	4.00E+01
CS	Saltwater Invertebrates	2.50E+01

Transfer Coefficients for the LADTAP and GASPAR Codes

Element	Item	Value
H	Meat	1.20E-02
H	Veg/Soil	4.80E+00
H	Milk	1.00E-02

Questions?