

Integrated Multimedia Decision- Making for Human and Ecological Risk Assessment: A National-Scale Study of Land Application of Arsenic-Bearing Wastes

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Presentation Outline

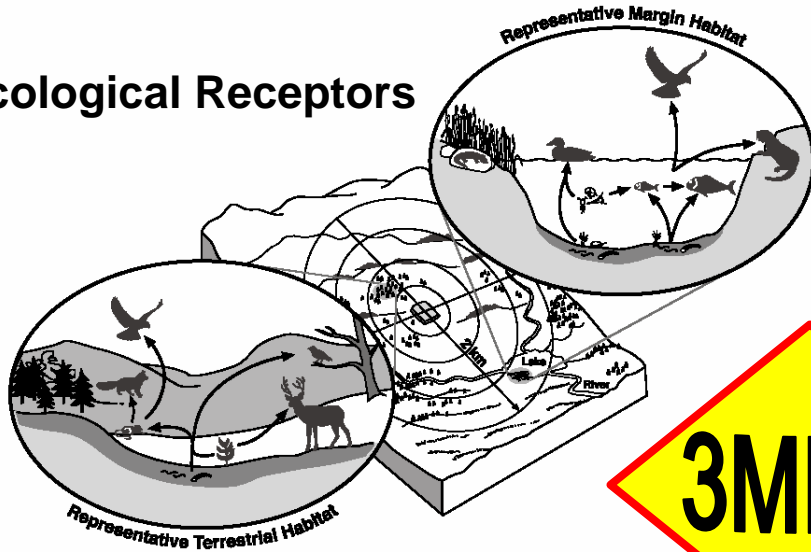
- **FRAMES 3MRA**
 - **Overview of FRAMES 3MRA Version 1.0/1.x**
- **Human and Ecological Risk Assessment of Land Application of Arsenic Bearing Wastes**
- **Results**
- **Conclusions**

Disclaimer:

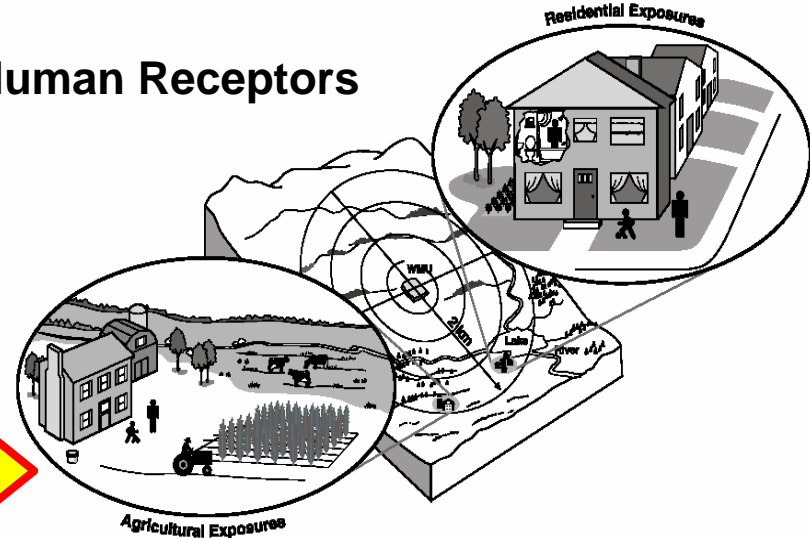
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Multimedia, Multipathway, Multireceptor Risk Assessment

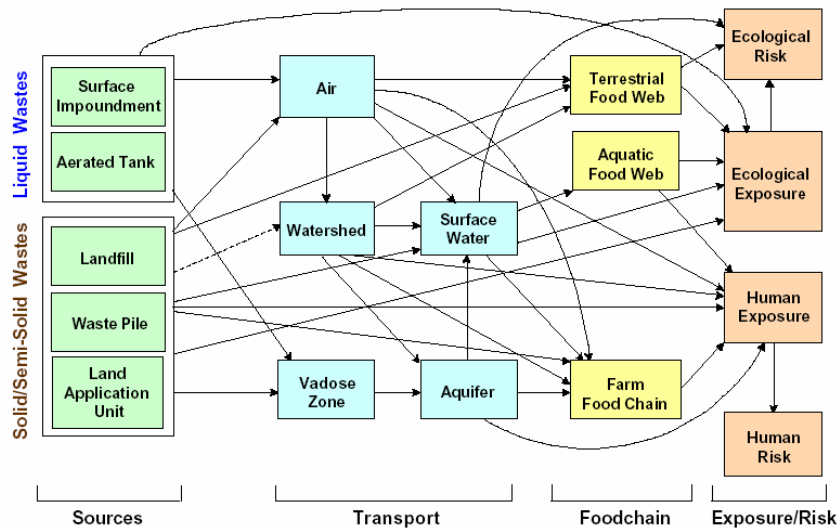
Ecological Receptors



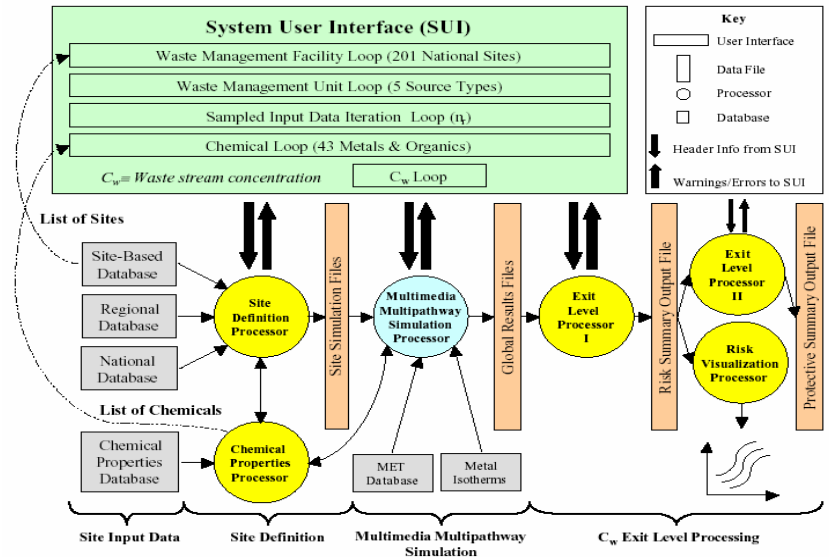
Human Receptors



Science Models and Connectivity



Integrated Modeling System



What is FRAMES-3MRA ?

A State-of-the-Art Human/Ecological Exposure and Risk Assessment Technology Encompassing:

- **Multimedia** (*Air, Water, Soil, Sediments, Biota*)
- **Multipathway** (*Food Ingestion, Water Ingestion, Soil Ingestion, Air Inhalation, etc*)
- **Multireceptor** (*Resident, Farmer, Gardener, Fisher, Ecological Populations, etc*)
- **Risk** (*Human Cancer Risk & Non-cancer Effects, Ecological Population and Community Effects*)
- **Assessment** (*Strategy to inform environmental decisions; addresses uncertainty & variability*)

FRAMES 3MRA 1.0/1.x User Interface

The screenshot displays the 'FRAMES 3MRA - Multimedia Multipathway Multireceptor Risk Assessment' application window. The interface includes a menu bar with 'File', a tabbed navigation system with 'System Configuration', 'System Management', 'System Status', and 'Post Processing', and a main content area with 'Selections' and 'Options' tabs. The 'Selections' tab is active, showing three columns of data: Site, Chemical, and Source. A 'Waste level' section is also present.

Site	Chemical	Source
0223504	1,1,1-Trichloroethane [Meth	LAU
0224002	2,3,7,8-Tetrachlorodibenzo-p	WP
0231002	2,4-D [2,4-Dichlorophenoxy	SI
0231106	Acetonitrile [Methyl cyanide]	AT
0231407	Acrylonitrile [2-Propenenitri	LF
0231610	Aniline	
0231911	Benzene	
0231914	Benzo(a)pyrene	
0232305	Bis-(2-ethylhexyl) phthalate [
0232313	Carbon disulfide	
0232402	Chlorobenzene	
0232415	Chloroform	
0232501	Dibenz[a,h]anthracene	
0232705	Ethylene dibromide [1,2-Dib	
0233601	Hexachloro-1,3-butadiene [L	

Waste level

5
4
3
2
1

FRAMES 3MRA 1.x Post-Processing (HH)

3MRA - Multimedia Multipathway Multireceptor Risk Assessment

File

System Configuration | System Management | System Status | **Post Processing**

Human | Ecological | Data Structure

Distance

- 500
- 1000
- 2000

Cohort

- Infants
- 1-12 Years Old
- 13 Years and Older
- All Cohorts

Critical Year Method

- Maximum

Receptor

- Resident
- Gardener
- Beef/Dairy Farmer
- Fisher
- All Receptors

Exposure Pathway

- Air Inhalation
- Soil Ingestion
- Water Ingestion
- Crop Ingestion
- Beef Ingestion
- Milk Ingestion
- Fish Ingestion
- Shower Inhalation
- Breast Milk
- Summation of All Inhalation Pathways
- Summation of all Ingestion Pathways
- Summation of Inhalation and Ingestion Pathways
- Ground Water Total All Pathways

FRAMES 3MRA 1.x Post-Processing (Eco)

3MRA - Multimedia Multipathway Multireceptor Risk Assessment

File

System Configuration | System Management | System Status | Post Processing

Human | Ecological | Data Structure

Rollup Option

- By Ring and Habitat Group
- By Ring and Habitat Type
- By Ring and Receptor Group
- By Ring and Trophic Level
- Habitat Group and Receptor Group
- Habitat Group and Trophic Level

Trophic Level

- Producers
- T1
- T2
- T3
- Communities

Radius Ring Distance

- <1000m
- 1000m - 2000m
- <2000m

Habitat Group

- Aquatic
- Terrestrial
- Wetland

Habitat Type

- Grasslands
- Shrub Scrub
- Forest
- Crops
- Residential
- Stream
- Pond
- Lake
- PermFloodGrassForB
- PermFloodShrubScrub
- PermFloodForest
- No Habitat

Receptor Group

- Mammal
- Bird
- Amphibian
- Reptile
- Soil Biota
- Terrestrial Plant
- Aquatic Biota
- Sediment Biota
- Aquatic Plant

National-Scale ABW Problem Statement

At what waste stream concentration ($C_{w\text{safe}}$) will ABWs, when placed in land application units over the unit's life, result in:

1. **(Human)** Greater than **A%** of the people living within **B** distance of the facility with a risk/hazard of **C** or less, and
2. **(Ecological)** Greater than **D%** of the habitats within **E** distance of the facility with an ecological hazard less than **F**,
3. **(National)** At **G%** of facilities nationwide,
4. **(Uncertainty)** With confidence **H%** accounting for subjective input uncertainty (i.e., accuracy), and confidence **I%** accounting for output sampling error (i.e., precision).

Example 3MRA Decision Variables in Red

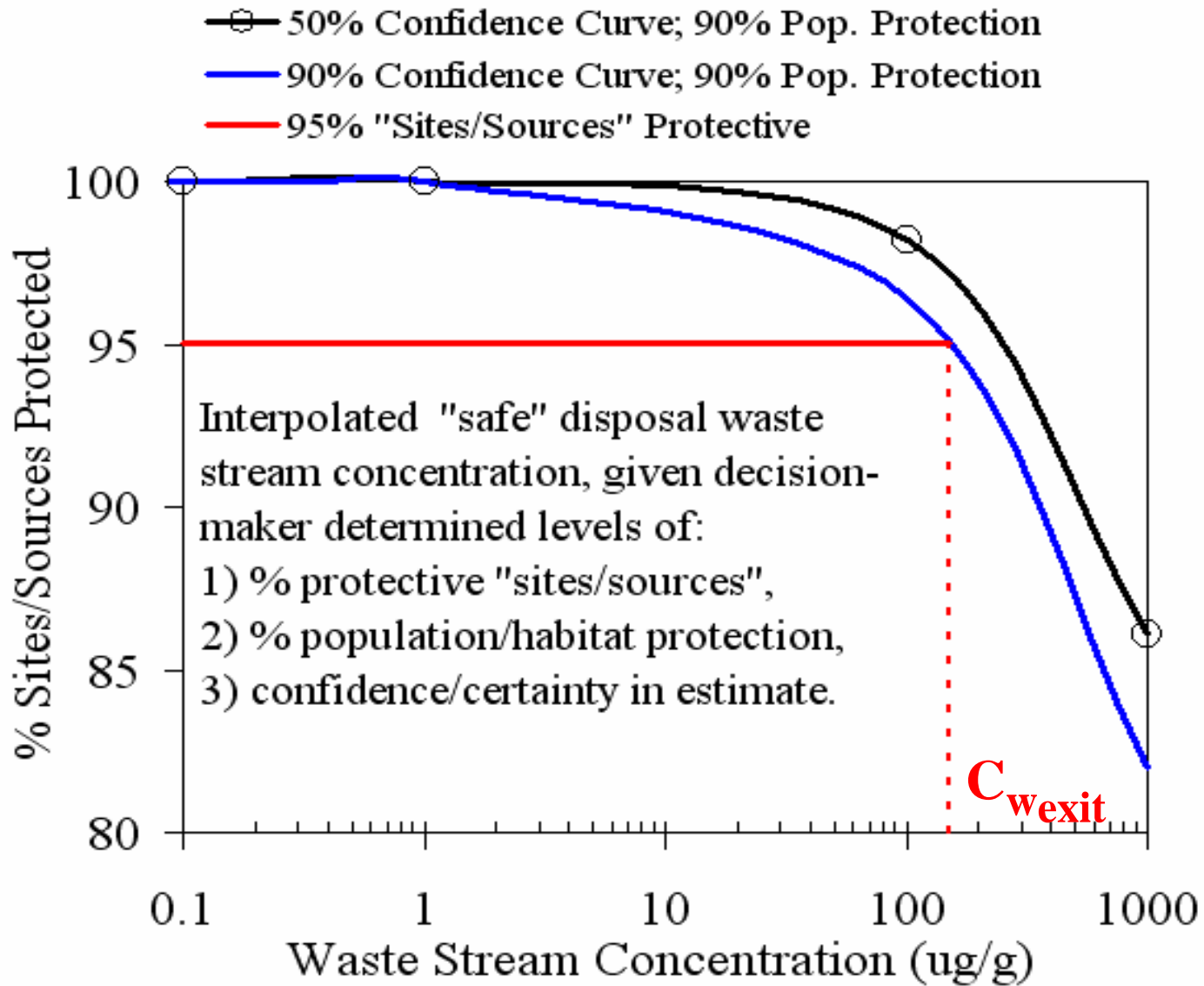
$C_{w\text{safe}} \equiv$ safe level

About “Exit” Levels

- A fundamental capability of 3MRA is **the ability to quantify “safe” waste/wastestream concentration levels** for treatment, storage, disposal, and/or reuse management practices.
- **This “safe” level can take on many forms (e.g., exit level, entry level, cleanup level, reuse level)**
- **Safe levels depend on** decision variables selected by **decision-maker**

Example 3MDA Output: Risk Curve Calculation

*Can also evaluate
by distance, risk level, etc.*



Similar graphic for each (post-processing) exposure profile combination.....

Basic Description of Scenarios Evaluated

Exit Level Description	Scenario	
Scenario ID	1	2
Protection Levels		
% Population Protected	99%	95%
% Sites Protected	95%	95%
Protective?	More	Less
Human		
Distance (m)	500	2000
Cancer Risk	10^{-6}	10^{-5}
Hazard Risk	0.1	1
Exposure Pathway ¹	Sum Ingestion & Inhalation	
Receptor Group	All Receptors	
Cohort Group	All Cohorts	
¹ For Arsenic, cancer risks are non-additive, hazard only for ingestion.		
Ecological		
Ring Distance (m)	2000	2000
Hazard Risk	1	1
Roll-up by Habitat Group ²	Terrestrial, Aquatic, Wetland	
Simulation Design		
Sources/Chemicals/Cws	1/1/5	
Sites/sources	28	
# National Realizations	369	
# Modeling System Runs	51,660	

Scenario Identification for Joint Human and Ecological Risk Assessment		
² To evaluate ecological roll-ups jointly with human concerns, scenarios are further broken down by habitat group.		
Scenario 1		
Scenario 1a	Human	Terrestrial
Scenario 1b	Human	Aquatic
Scenario 1c	Human	Wetland
Scenario 2		
Scenario 2a	Human	Terrestrial
Scenario 2b	Human	Aquatic
Scenario 2c	Human	Wetland

Summary Results Comparing Two Scenarios

National Risk Assessment Exit Level Analysis						
Scenario # >>>>		1	1a	2	2b	
Dominant Risk Summary	Receptor Class	Human	Eco	Human	Eco	
	Eco Habitat Group		Ter.		Aquatic	
	Risk Category	Cancer	Hazard	Cancer	Hazard	
Exit Level (ppm) Uncertainty Analysis	Confidence Level		Accuracy and Precision in 3MRA Exit Levels for the Dominant Receptor Class/Risk Category/Pathway of Concern			
	Accuracy	Precision				
	%H	%I				
	95	0	0.0027	0.13	0.50	0.20
	80	0	0.0033	0.14	1.6	0.20
	Mean	0	0.0041	0.18	3.7	0.61
	95	95	0.0027	0.13	0.50	0.20
	80	95	0.0033	0.14	1.6	0.20
Mean	95	0.0040	0.17	3.3	0.56	

Arsenic LAU; Waste Stream Concentration Exit Level Analysis for 95% Sites Protection; Sum of Ing. and Inh., All Receptors, All Cohorts & Eco Roll-up by Habitat Group

Conclusions

- **Safe levels** and the dominant receptor class of concern **are sensitive to**, among other variables, **risk levels** typically assigned and **radial distance**
- Lacking an integrated approach for assessment of human and ecological receptors, a decision-maker cannot readily discriminate the greatest impacts.
- **Integrated 3M assessments** allow for explicit consideration of a broad suite of decision options, and associated levels of risks avoided and risks incurred by both human and ecological receptors.

3MRA Related Web Sites

- <http://www.epa.gov/ceampubl/mmedia/3mra/index.htm>
 - Modeling System Files
 - Source Code
 - Documentation
 - Installation procedures
 - Example Uncertainty Analysis of Seven Chemicals
- <http://www.epa.gov/epaoswer/hazwaste/id/hwirwste/risk.htm>
 - Documentation
 - USEPA Science Advisory Board peer review materials
 - Original 3MRA Model Development Plan
 - Detailed Descriptions of Science Modules
 - Reports, Feasibility Studies, Presentations, etc.
- <http://www.epa.gov/athens/research/modeling/supermuse/supermuse.html>
 - SuperMUSE: Supercomputer for Model Uncertainty and Sensitivity Evaluation