Consequence Sensitivity Analyses for a Risk-Informed Review of a Preclosure Safety Analysis

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Outline

- Introduction
- Risk-Informed Review
- Consequence Sensitivity Analyses
- Results
- Conclusions
- Acknowledgment

Introduction

- U.S. Department of Energy (DOE) — Repository Developer
- U.S. Nuclear Regulatory Commission (NRC) — Regulator
- Center for Nuclear Waste Regulatory Analyses (CNWRA) — Federally Funded Research and Development Center

Introduction (cont'd)

- Preclosure — Operations Prior to Permanent Closure of the Potential Repository
- DOE Preclosure Safety Analysis
- NRC "PCSA Tool" Software

Risk-Informed Review

- Preclosure Safety Analysis Identifies Structures, Systems, and Components Important to Safety
- Review Focus
  - SSCs Important to Safety
  - Risk-Significant Technical Areas and Uncertainties
- Risk = Probability x Consequence

Phases of Consequence Sensitivity Analyses

- Consequence Estimates
  - Offsite Members of the Public
  - Onsite Workers
  - Different Potential Hazards

X

Probability of Potential Hazards

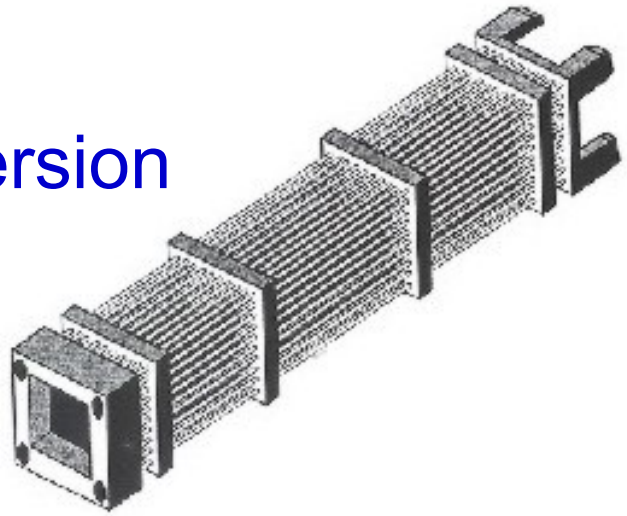
Risk Insights

Consequence Sensitivity Analyses Objectives

- Identify Individual Parameters with the Greatest Potential to Significantly Influence the Consequence Results
- Quantify the Sensitivity of Consequence Results to Variations in Individual Parameters

Release Scenario

- Hypothetical Drop and Breach of a Spent Nuclear Fuel Assembly in the Hot Cell
- Filtered Atmospheric Release of Airborne Radioactive Material
- Plume Migration and Dispersion
- Exposure to an Offsite Member of the Public Located Downwind



Independent Modeling

- PCSA Tool Version 3.0.0
- Probabilistic Consequence Analyses
  - 60 Input Parameters
  - Latin Hypercube Sampling
  - Default Probability Distributions

Sensitivity Analysis Approach

- Parameter Input Range
  - Reasonable High Constant Value
  - Reasonable Low Constant Value
- Absolute Sensitivity Analysis
  - Adjust Input Parameters One at a Time to Constant High or Low Values
  - Record Mean Total Dose Consequence
  - Rank Results Based on Largest Increase and Largest Decrease from Baseline

Sensitivity Analysis Approach (cont'd)

- Relative Change Score

$$\frac{d_{x,i} - d_{\text{baseline}}}{d_{\text{baseline}}} \frac{x_{\text{nominal}}}{x_i - x_{\text{nominal}}}$$

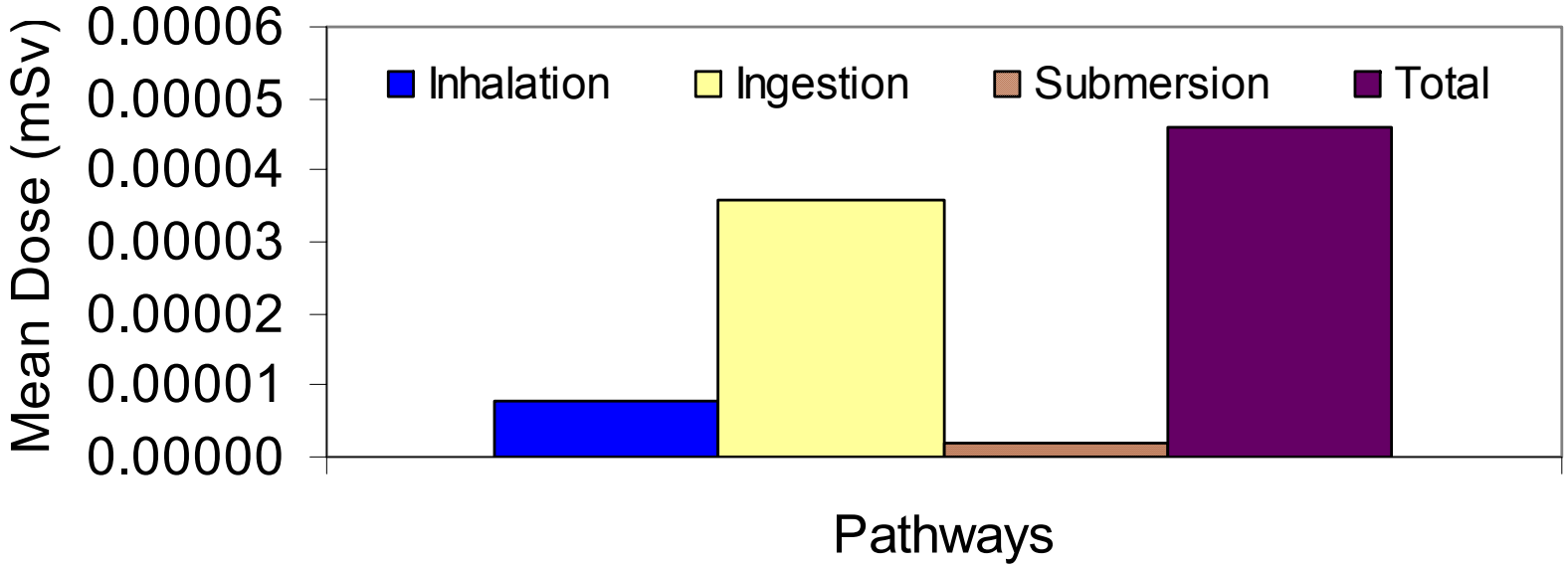
$d_{x,i}$ – mean total dose corresponding to the sensitivity calculation for input parameter *x*, where *i* represents either high or low

d_{baseline} – mean total dose corresponding to the baseline calculation with all input parameters set at their default distributions and values

x_i – sensitivity value for input parameter *x*, where *i* represents either high or low

x_{nominal} – nominal value for input parameter *x* in the baseline calculation

Baseline Results



- Ingestion and Inhalation Are Dominant Pathways
- Hydrogen-3 and Iodine-129 Are Primary Radionuclides

Absolute Sensitivity Results: Largest Increases From Baseline

Parameter	High or Low Constant Value	Constant Sensitivity Value	Effect on Mean Total Dose
Iodine Release Fraction	High	0.3	7.2 x baseline
Absolute Humidity	Low	0.739 g/m^3	4.3 x baseline
Vegetable Vegetation Yield	Low	0.17 kg/m^2	3.8 x baseline
Crop Exposure Time During Growing Season	Low	1 day	3.0 x baseline
Consumption Rate of Other Vegetables, Fruits, & Grains	High	140 wet kg/yr	3.0 x baseline
Wind Speed	Low	0.9 m/sec	2.4 x baseline
Consumption Rate of Leafy Vegetables	High	60 wet kg/yr	2.1 x baseline

Absolute Sensitivity Results: Largest Decreases From Baseline

Parameter	High or Low Constant Value	Constant Sensitivity Value	Effect on Mean Total Dose
Wet Deposition Scavenging Coefficient	High	0.00126/sec	baseline / 1500
Weather Class	Low	1 = Class A	baseline / 17
Wind Speed	High	12.25 m/sec	baseline / 4.7
Tritium Release Fraction	Low	0.01	baseline / 3.5

Relative Sensitivity Results: Largest Relative Change Score

Parameter	High or Low Constant Value	Constant Sensitivity Value	Relative Change Score
Absolute Humidity	Low	0.739 g/m^3	-3.9
Vegetable Vegetation Yield	Low	0.17 kg/m^2	-2.9
Crop Exposure Time During Growing Season	Low	1 day	-2.4
Wind Speed	Low	0.9 m/sec	-1.8
Tritium Release Fraction	High	0.3	+0.80
Tritium Release Fraction	Low	0.01	+0.76

Conclusions

- Initial Sensitivity Analyses for a Single Baseline Scenario Identified
  - Potentially Significant Radiological Dose Pathways
  - Primary Radionuclide Contributors
  - Influential Parameters and Uncertainties
- Absolute and Relative Sensitivity Approaches Yielded Similar Results
- In General, No Order-Of-Magnitude Sensitivities to Individual Parameters (2 Exceptions)
- Results Can Be Used to Further Risk Inform the Regulatory Review

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