Comparison of Two Equivalency Factor Approaches with Simplified Risk Assessment for LCIA of Toxicity Impact Potential

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Comparisons Between 3 LCIA Approaches

- Compare effort for data collection and analysis
- Compare number of LCI toxic emissions that can be evaluated and ability to aggregate into category indicators
- Correlate rank order of toxicity impact potential scores by chemical within a category indicator
- Compare advantages and limitations

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Toxicity Impact Potential Approaches for LCIA Characterization

- Equivalency Factor Approaches
  - **Persistence, Bioaccumulation, and Toxicity (PBT)** (modified from UT chemical hazard approach)
  - **Multimedia Fate Modeling (MFM)** (Level III Mackay model; 1 km^2 unit world)
- Simplified Risk Assessment (SRA) (site-specific dispersion modeling; excluded emissions if release concentration below safe threshold)

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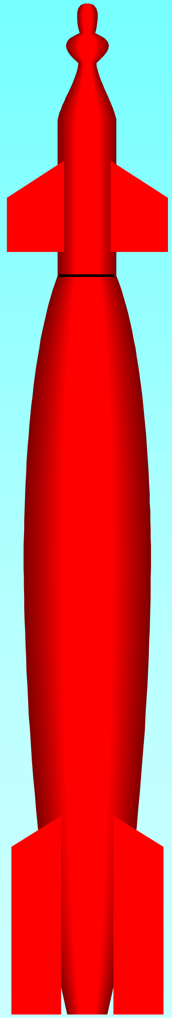
GBU-24 Case Study

- LCI data from GBU-24 munition
- Selected life cycle stage with detailed data and variety of toxic emissions
- Evaluated toxic emissions from RDX manufacture at Holston Army Ammunition Plant (HSAAP)
- HSAAP located in Kingsport, Tennessee along Holston River



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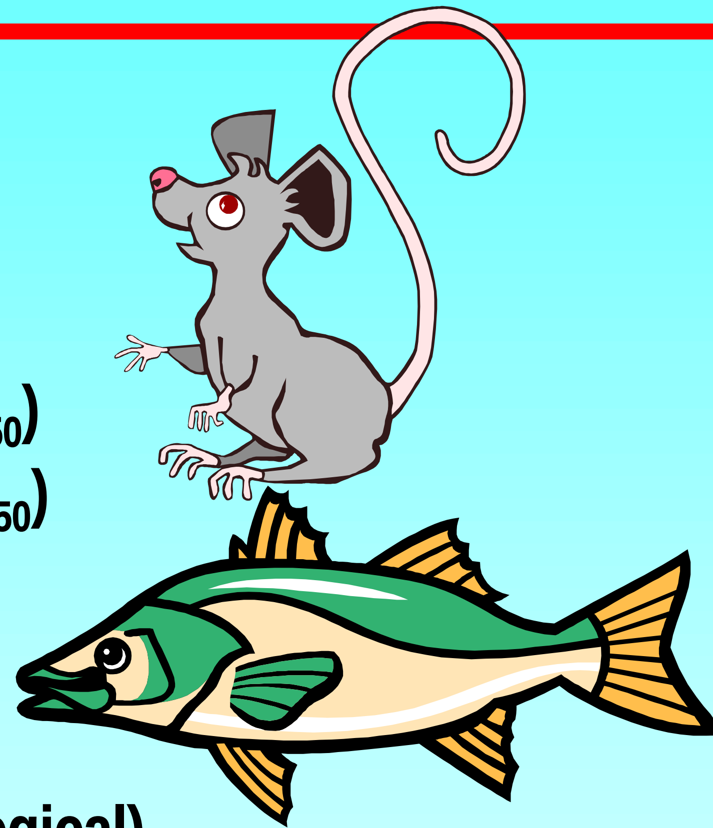
Non-Cancer Toxicity Benchmarks (human & ecological)

- PBT & MFM Equivalency Approaches - acute toxicity benchmarks
  - Inhalation Toxicity (rodent LC_{50})
  - Terrestrial Toxicity (rodent LD_{50})
  - Aquatic Toxicity (fish LC_{50})
- SRA Approach
  - Chronic Toxicity Threshold Concentration (human & ecological)



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PBT Approach

- **Toxicity hazard values (HV) range from 0-5**
- **Fate hazard values (HV) range from 1-2.5**
- **EF = (toxicity HV) (BOD HV + hydrolysis HV + BCF HV)**
- **PBT Score = (EF) (LCI emission in lbs.)**
  - Inhalation Toxicity applied to air emissions
  - Aquatic Toxicity applied to water emissions
  - Terrestrial Toxicity applied to solid wastes

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MFM Approach

- Emission inventory assumed to be continuous based on production of 2,200 munitions/yr.
- Model estimates fate to five compartments: air, surface water, sediment, soil, & biota
- State-specific analysis used 7 unit world parameters specific to Tennessee
- Used 11 physical/chemical properties of emissions (e.g., vapor pressure and Henry's Law constant)

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SRA Approach

- Collect Emission & Environmental Data
  - Water emissions from PCS for IWTP
  - Air emissions from Title V air permit
  - Environmental data from installation EA
- Select Endpoints
  - Humans exposed to air pollutants above threshold
  - Maintain aquatic biota in Holston River
  - No increase in cancer rate from well water
- Evaluate Exposure Routes and Models
  - Primary emissions released to air or Holston River

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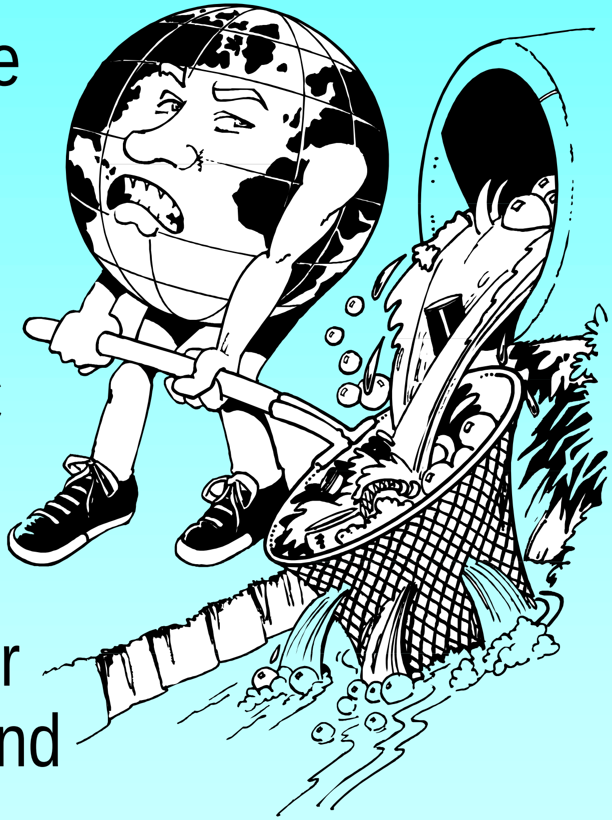
Screen Water Emissions Against Benchmarks



- Maximum emission concentration in Holston River based on 10th percentile flow
- Diluted concentrations of toxic chemicals from IWTP are all far below freshwater acute and chronic NAWQC and LOEL
- Maximum (untreated) drinking water concentration of carcinogens are all far below IRIS risk level of 1 in 1 million and carcinogenic potency for chronic dose-rate

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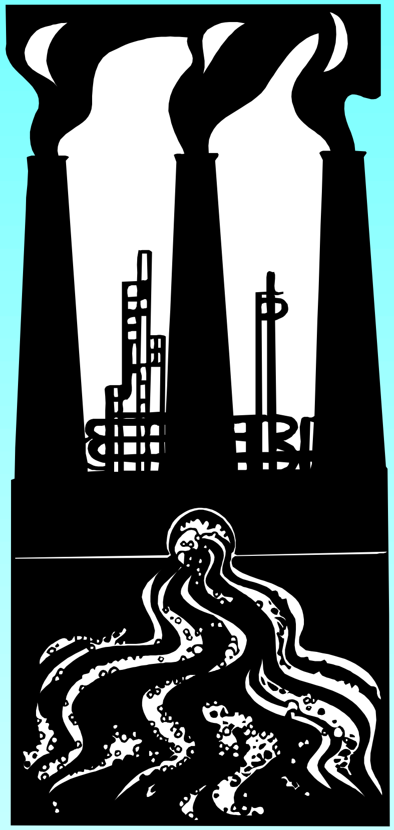
Air Dispersion Modeling

- **Selection of ISCST Air Dispersion Model**
  - Model input format compatible with source term data
  - Adaptable to hilly topography & variable meteorology
  - Considers averaging periods for toxicity benchmarks
- **Modeling Results**
  - Determined maximum offsite exposure concentration
  - Determined number of individuals living in areas above benchmark concentrations



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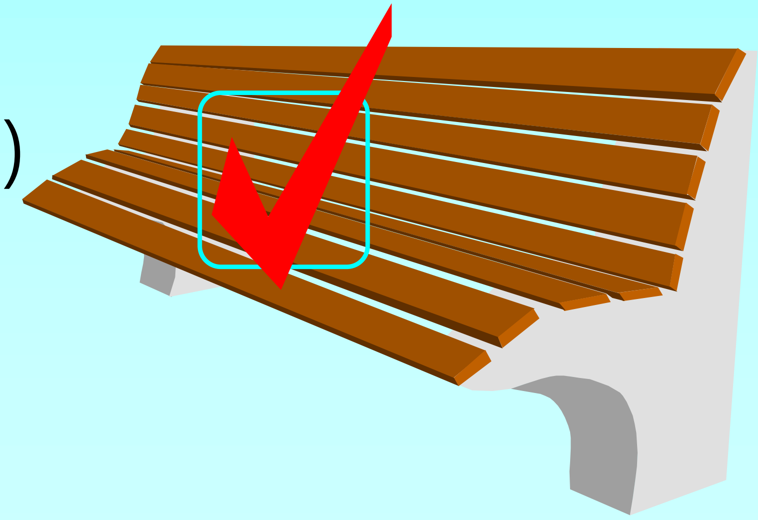
Maximum Offsite Exposures Compared to Inhalation Benchmarks

- Benchmarks for 6 criteria pollutants - NAAQS
- Used ozone benchmark as conservative surrogate for unspecified total VOCs
- Benchmarks for 4 other air pollutants - IRIS RfC, ATSDR MRL, or ACGIH TWA/uncertainty factor
- For 10 chemicals from 16 sources, only 3 emissions (SOx, total VOCs & acetic acid) exceeded benchmarks



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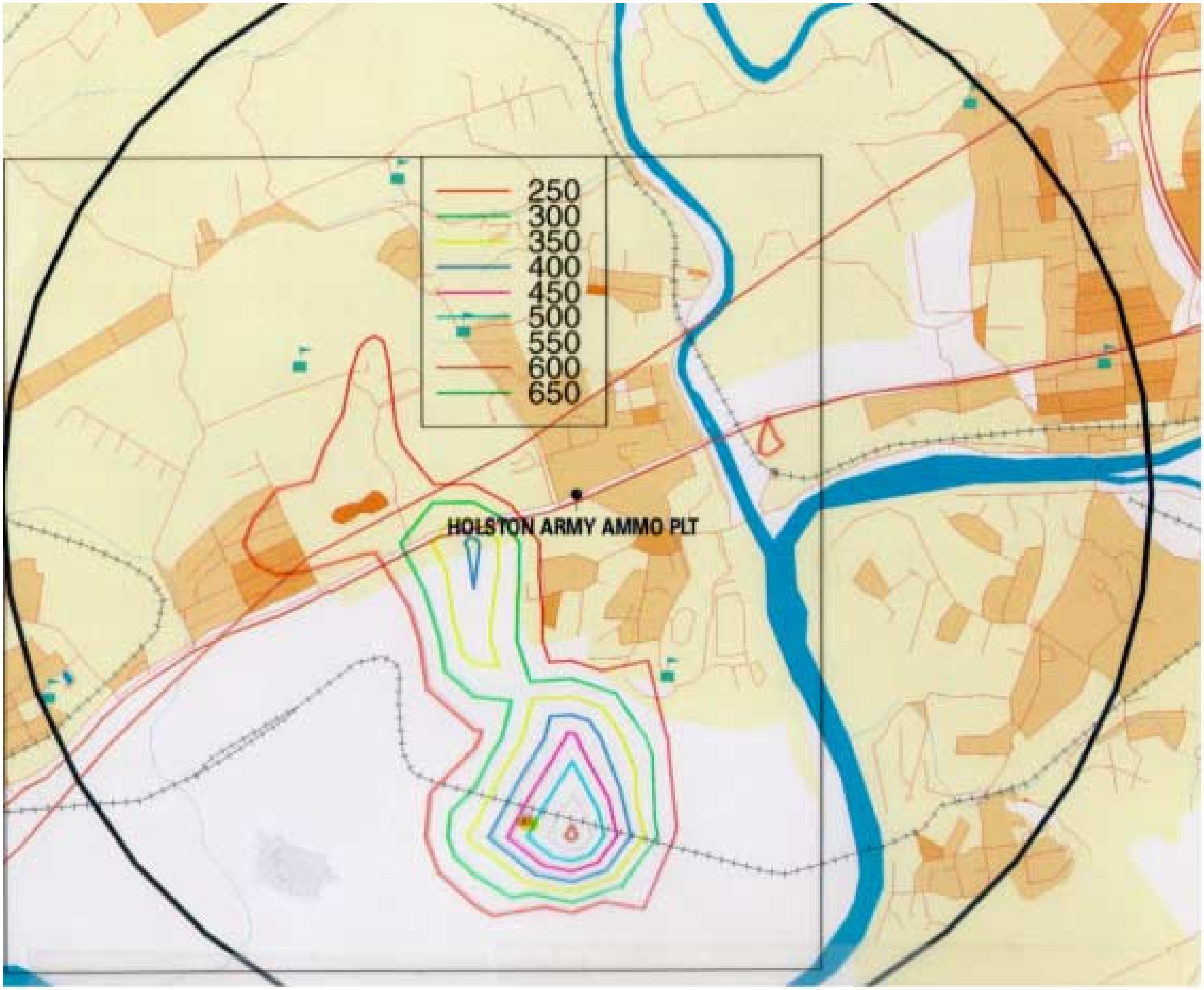
Acetic Acid Release Concentration Levels (exposure contours in units of µg/m³)



Emissions Compared Between 3 Toxicity Approaches

- Of the 17 chemical-specific emissions to all media, only 9 inhalation toxicity scores could be compared between approaches
- Water emissions were not modeled, because initial dilution in river was below benchmark
- Information on solid waste releases was insufficient for modeling

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Correlation of Rank Order on Inhalation Toxicity Potential Scores for 3 Approaches

Chemical Emissions	PBT	MFM	SRA
SO_X (as Sulfur Dioxide)	2	1	1
Acetic Acid (AcOH)	4	2	2
NO_X (as Nitrogen Dioxide)	1	3	3
Cyclohexanone	5	4	4
CO (Carbon Monoxide)	3	6	5
Acetone	6	5	6
Ammonia	7	7	7
Phenol	7	8	7
Sulfuric Acid	7	9	7
Correlation Coefficient of MFM and SRA Ranks = 0.96			
Correlation Coefficient of PBT and SRA Ranks = 0.83			
Correlation Coefficient of PBT and MFM Ranks = 0.78			

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Case Study Conclusions

- The SRA method (for 9 chemicals) took about 24X the effort for the PBT method and about 6X the effort for the MFM method
- PBT useful for initial screening for large LCIAs with many sites and many chemical emissions
- MFM considers transfers to other media, but not other two approaches
- Additional accuracy of MFM is worth the extra effort for comparative assertions or governmental policy decisions

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Case Study Conclusions (cont.)

- Site-specific environmental and chemical emission data needed for SRA are almost never included in LCIs and require substantial effort to collect/model
- Although SRA is assumed to be the most accurate, the substantial effort is not justified for LCIA unless there are very few sites
- Additional case studies are needed to confirm the tentative conclusions from this limited analysis

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