An Air Toxics Assessment
The City of Philadelphia

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Outline

- Brief Overview of Study
- Description of Modeling/Risk Results
Purpose of Study

- **Primary:**
  - Refine 1996 NATA risk estimates
  - Estimate present & future day risk

- **Secondary:**
  - Develop regional capabilities
  - Examine importance of using link data
  - Examine importance of secondary impacts via CAMQ – including the effects of sub-grid scale variability
  - Examine culpability (primary & secondary) for effective control strategy development
  - Develop a template to transfer to other urban areas in the Region
Estimate Present Day & Future Risk

- Primary Impacts (ISCST3)
  - Hot Spot analysis: 500 m fine grid over city

- Secondary Impacts (CMAQ):
  - 36km to 12km to 4km nesting over Philadelphia
  - Population Risk: 2000 population centroids / HAPEM

- Emissions Inventories:
  - Refined 1999 NEI w/ link level on-road mobile
  - 2010: Grown from refined 1999 NEI

- Meteorology
  - 1999 – for comparisons with ’99 NATA
  - 2001 – present day and future (2010) risk predictions
Nine pollutants examined (based on NATA)

**Primary & Secondary**
- Formaldehyde
- Acetaldehyde
- Acrolein

**Primary Only**
- 1,3 butadiene
- Benzene
- Chromium
- Ethylene Dichloride
- POM
- Diesel PM
Emissions Modeling Grid & Urban/Rural Land Use

ISCST3 Urban (gray) and Rural (white) 1x1km Domain - Commercial/Industrial - threshold=25th percentile
2001 Acetaldehyde: Primary + Secondary

Maximum = 3.73 ug/m³
Mean = 2.79 ug/m³
2001 Acetaldehyde: Total Primary

Maximum = 2.28 ug/m³
Mean = 0.28 ug/m³
2001 Acetaldehyde: Non Road Only

Maximum = 2.23 ug/m³
Mean = 0.19 ug/m³
2010 Acetaldehyde: Primary + Secondary

Maximum = 3.73 ug/m³
Mean = 2.74 ug/m³
2001 Acrolein: Primary + Secondary

Maximum = 1.0 ug/m³
Mean = 0.08 ug/m³
2001 Acrolein: Non-Road Only

Maximum = 0.96 ug/m³
Mean = 0.03 ug/m³
2010 Acrolein: Primary + Secondary

Maximum = 0.39 ug/m³
Mean = 0.07 ug/m³
2001 Benzene: Total plus Background

- Maximum = 6.0 ug/m$^3$
- Mean = 1.4 ug/m$^3$
- Background = 0.5 ug/m$^3$
2001 Benzene: On-Road

Maximum = 1.7 ug/m³
Mean = 0.5 ug/m³
2001 Benzene: Major Point

Maximum = 4.7 ug/m³
Mean = 0.1 ug/m³
2010 Benzene: Total plus Background

Maximum = 3.14 ug/m³
Mean = 0.78 ug/m³
Background = 0.5 ug/m³
2001 1,3 Butadiene: Primary + Background

Maximum = 0.94 ug/m³
Mean = 0.22 ug/m³
2001 1,3 Butadiene: Non Road Only

Maximum = 0.80 ug/m³
Mean = 0.05 ug/m³
2010 1,3 Butadiene: Primary + Background

Maximum = 0.45 ug/m³
Mean = 0.16 ug/m³
2001 Ethylene Dichloride: Total including Background

Maximum = 0.26 ug/m³
Background = 0.055 ug/m³
Mean = 0.06 ug/m³
2001 Ethylene Dichloride: Total without Background

Maximum = 0.20 ug/m³
Mean = 0.006 ug/m³
2010 Ethylene Dichloride:
Total including Background

Maximum = 0.11 ug/m³
Background = 0.055 ug/m³
Mean = 0.10 ug/m³
2001 Formaldehyde: Primary + Secondary

Maximum = 9.1 ug/m³
Mean = 2.6 ug/m³
2001 Formaldehyde: Primary Only

Maximum = 7.1 ug/m³
Mean = 0.8 ug/m³
2001 Formaldehyde: Non-Road

Maximum = 6.9 ug/m³
Mean = 0.5 ug/m³
2010 Formaldehyde: Primary + Secondary

Maximum = 2.88 ug/m³
Mean = 0.70 ug/m³
2001 Diesel PM (Original Inventory): Total Including Background

Maximum = 19.1 ug/m$^3$
Mean = 3.3 ug/m$^3$
Background = 0.7 ug/m$^3$
2001 Diesel PM (Original Inventory): Marine Component

- Maximum = 17.2 ug/m³
- Mean = 1.3 ug/m³
2001 Diesel PM (Revised Inventory): Marine Component

Maximum = 4.42 ug/m³
Mean = 0.2 ug/m³
2001 Diesel PM (Revised Inventory): Total Including Background

Maximum = 6.7 ug/m³
Mean = 2.0 ug/m³
Background = 0.7 ug/m³
Cancer Risk

- **Incremental Cancer Risk (ICR)**
- **Expressed as a probability**
- **Calculated:**
  - $ICR = \text{dose} \times \text{cancer slope factor}$
- **Interpretation**
  - Example, $ICR = 3 \times 10^{-5}$: 3 excess cancers are expected out of 10 thousand exposed individuals.
Relevant Cancer Risk Ranges

Ample Margin of Safety Met

Ample Margin of Safety with consideration of costs, technical feasibility and other factors

Unacceptable Risk

1 in a million  100 in a million

Risk
Non-Cancer Risk

- Hazard Quotient (HQ)
- Not a probability
- Comparison of dose to safe dose
- RfC = Safe dose.
  - An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.
Relevant Noncancer Hazard Ranges

Ample Margin of Safety Met

Ample Margin of Safety with consideration of costs, technical feasibility and toxicity

Unacceptable Risk

1.0

???

Hazard Index
Exposure Assessment - HAPEM

- Average long-term exposures
- Census track scale (2,000 - 8,000 people)
- Tracks 10 demographic groups
- 37 microenvironments
- 3 hour increments
2001 Formaldehyde Cancer Risk (ICR) Primary + Secondary

Mean = 27.8 x 10^{-6}
Maximum = 47.8 x 10^{-6}
2001 Benzene Cancer Risk (ICR)
Total + Background

Mean = $9.79 \times 10^{-6}$
Maximum = $17.94 \times 10^{-6}$
2001 1,3 Butadiene Cancer Risk (ICR)
Total + Background

Mean = 5.47 x 10^{-6}
Maximum = 10.12 x 10^{-6}
2001 Acetaldehyde Cancer Risk (ICR)
Total + Secondary

Mean = 4.38 x 10^{-6}
Maximum = 6.21 x 10^{-6}
2001 Ethylene Dichloride Cancer Risk (ICR) Total + Background

Mean = $1.17 \times 10^{-6}$
Maximum = $2.95 \times 10^{-6}$
2001 Acrolein Hazard Index (HI)
Total + Secondary

Mean = 3.07
Maximum = 13.31
2001 Acetaldehyde Hazard Index (HI)  
Total + Secondary

Mean = 2.21
Maximum = 3.14
Conclusions – 2001/2010 Runs

- Formaldehyde, benzene, 1,3 butadiene and acetaldehyde appear to present the greatest cancer risk but all except acetaldehyde are expected to decline significantly by 2010.
- Acetaldehyde and Acrolein appear to present the greatest non-cancer risk
- Diesel PM appears to present some risk but is difficult to characterize
- The photochemically formed fractions are very significant
- Benzene background is as large as its on-road component
- Major impacts from Diesel PM due to marine activity
- Acrolein is the only pollutant examined who’s impact is above its hazard index
- Secondary acrolein impacts are much less significant than originally thought (about 25%) – major impact due to airport
- The Philadelphia airport stands out as a significant non-road source for many toxics (based on existing emissions inventory)
- Modeling crucial to evaluating toxics because of complexity and localized effects
Next Steps: Control Strategy Analysis

- Funding through a RARE
- Identify the importance of specific VOCs to each secondary pollutant
- Identify the sources that emit the important precursor VOCs
- Perform culpability analysis for primary pollutant emitters
- Develop a set of potential control scenarios
- For each control scenario estimate the ambient concentrations of the important toxic pollutants plus Ozone and PM 2.5
- Establish criteria for deciding on most effective control strategy
  - Environmental: Based on pollutant impacts and risk indicators
  - Social-Economic: e.g., control costs, ease of enforcement, etc.
Questions / copies

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