Identifying Priority Hazardous Air Pollutants of Potential Concern: A Comparison of Toxicity-Weighted Emissions and Ambient Risk Screening Results

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June 4, 2008

17th Annual International Inventory Conference – Portland, OR

Acknowledgements

- U.S. EPA – Anne Pope, Mike Jones, and James Hemby

- Other ERG staff:
  - Dave Dayton
  - Julie Swift
  - Jaime Hauser

Overview of Presentation

- Background on Urban Air Toxics Monitoring Program (UATMP) and Risk
- Toxicity-Weighted Calculations Approach
- Results
- Wrap-up

Background of the UATMP

- Sponsored by EPA; began in 1987
- Goal: Characterize the composition and magnitude of urban air pollution through ambient monitoring.
- EPA Regional/State/Local/Tribal agencies participate; number of sites varies by year
- Historically, data collected within the UATMP has been considered by EPA as the most representative data available for air toxics monitoring (Level 1 EPA QAPP).

Background of the UATMP

- Pollutants Measured:
  - Volatile Organic Compounds (VOCs)
  - Carbonyl Compounds
  - Metals/Hexavalent Chromium
  - Semi-VOCs
  - Speciated Non-Methane Organic Compounds

- Important non-HAPs: acetylene, ethylene, TAME, ETBE

- Potential of over 50 HAPs

- HAPs can be both cancer and noncancer

HAPs and Risk

- Theoretical Cancer Risk: likelihood of developing cancer as a result of exposure over a 70-year period
  - Presented as the number of people at risk for cancer per million people.
  - Pollutant cancer risk can be summed for overall cancer risk.

- Theoretical Noncancer Risk: presented as the Noncancer Hazard Quotient (HQ).
  - Noncancer health effects include targeted areas, such as respiratory, neurological, and kidney.
  - An HQ>1 indicates that developing a noncancerous health effect is possible from that pollutant.
  - Pollutant noncancer HQs can be summed only by target area to create a Hazard Index (HI).

HAPs and Risk

- EPA uses the National-scale Air Toxics Assessment (NATA) to evaluate risk.
  - Starting point is the National Emissions Inventory, but also incorporates ambient monitoring data, geographic information, and chemical/physical transformation to model ambient concentrations.
  - The modeled concentrations are then applied to cancer URE and noncancer RfC factors to yield cancer and noncancer risk.
  - The 2002 NATA is under state review currently.

HAPs and Risk

- 1999 NATA Results
  - National Drivers:
    - Cancer: Benzene
    - Noncancer: Acrolein
  - Regional Drivers - Cancer:
    - Arsenic compounds
    - Benzidine
    - 1,3-Butadiene
    - Cadmium compounds
    - Coke Oven Emissions
    - Ethylene Oxide
    - Hydrazine
    - Naphthalene
    - Perchloroethylene
    - POM

HAPs and Risk

- 1999 NATA Results
  - Regional Drivers - Noncancer:
    - Antimony
    - Arsenic compounds
    - 1,3-Butadiene
    - Cadmium compounds
    - Chlorine
    - Chrome VI
    - Diesel PM
    - Formaldehyde
    - Hexamethyl-1,6-Diisocyanate
    - Hydrazine
    - Hydrochloric Acid
    - Maleic Anhydride
    - Manganese compounds
    - Nickel compounds
    - 2,4-Toluene Diisocyanate
    - Triethylene

Toxicity-Weighted Emissions

- Question: From an emissions inventory standpoint, what pollutants are most toxic?

- Problem: difficult to assess toxicity by comparing mass emissions…a little dioxin (pounds) can hurt you…

- Solution: tox-weight (or relatively rank the toxicity of) the emissions inventory based on cancer and noncancer benchmarks.

- Further: How do the tox-weighted emissions ranking compare to the ambient monitoring data?

• Toxicity-Weighted Calculations Approach

- Methodology presented at the 2007 Emission Inventory Conference (http://www.epa.gov/ttn/chief/conference/ei16/session6/a.pope.pdf)

- Good approach for comparing emissions and concentrations from a toxicity standpoint.

- Good approach to “screen” and “identify” pollutants of concern

Toxicity-Weighted Calculations Approach

- For the 2006 Annual UATMP Report, the Top 10 pollutants based on toxicity-weighted emissions (cancer and noncancer) are calculated for each site's county.

- Compare the ranking of the cancer and noncancer risk to the ranking of the tox-weighted emissions.

- Note: 2006 is the first year where acrolein sampling occurred year-round.

Toxicity-Weighted Calculations Approach

- Approach:
  - Step 1 – Obtain the HAP data from the 2002 NEI (all sectors)
  - Step 2 – Except for two chromium species (pollcode = 7440473 and 136), apply the Metal_CN Speciation Factor to extract metal and cyanide mass.
  - Step 3 – Apply the chromium speciation factor to pollcodes 7440473 and 136 to determine Cr^{6+} and Cr^{3+} emissions

Toxicity-Weighted Calculations Approach

- Approach (cont.):
  - Step 4 – Calculate the tox-weighted emissions:
    - For cancer weighting, multiply the emissions from Steps 2 and 3 by the cancer URE.
    - For noncancer weighting, divide the emissions from Steps 2 and 3 by the noncancer RfC for each target organ

Toxicity-Weighted Calculations Approach

- Example Calcs

Benzene cancer toxicity = Benzene emissions * Speciation Factor * Cancer URE

Benzene cancer toxicity = 1000 tons * 1 * 7.8e-6 µg/m^3

Benzene cancer toxicity = **0.0078**

$$\text{Chrome VI noncancer toxicity} = \frac{\text{Chromium emissions} * \text{Chrome VI Speciation Factor}}{\text{Noncancer RfC}}$$

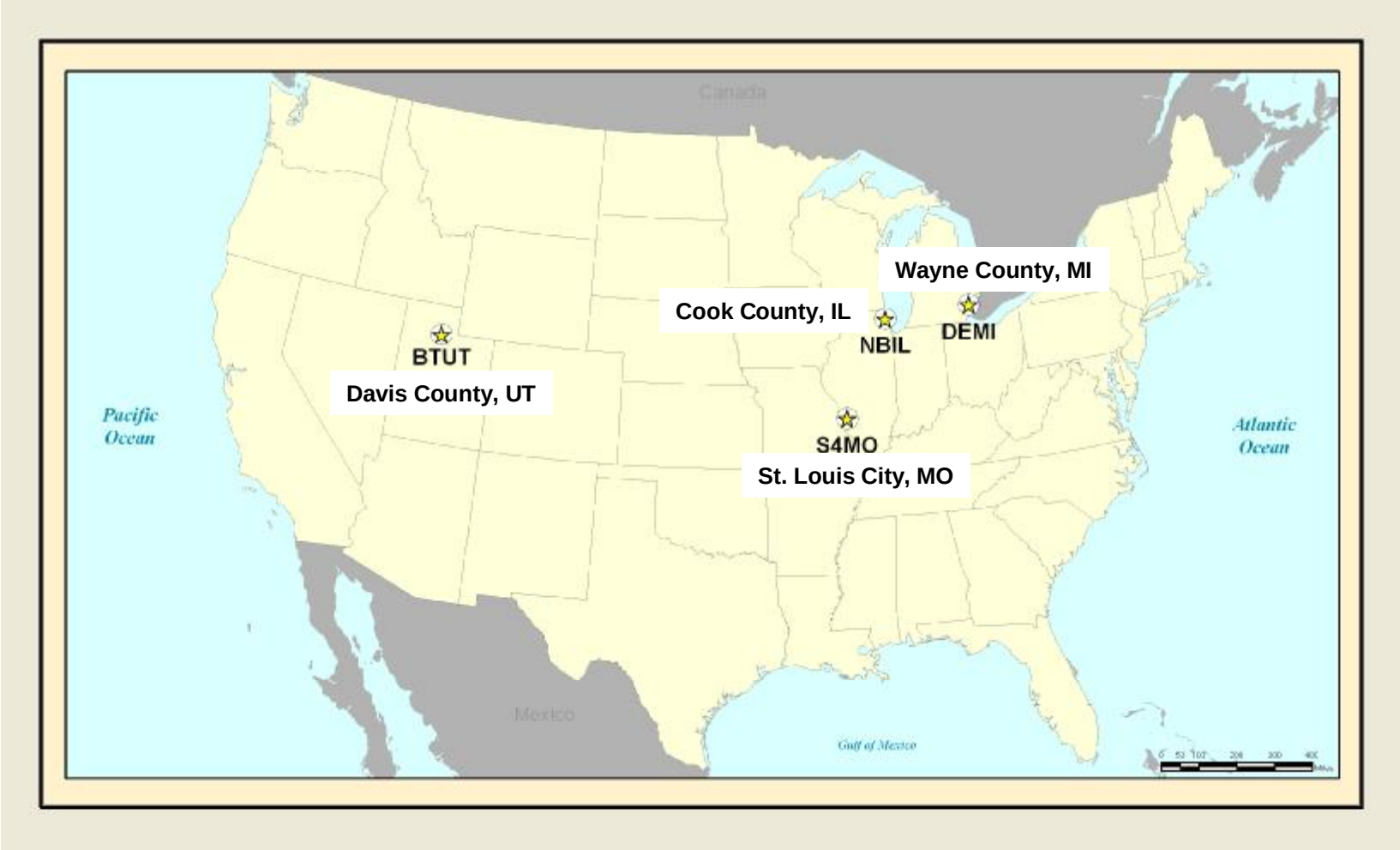
$$\text{Chrome VI noncancer toxicity} = \frac{3.0 \text{ tons} * 0.0334}{0.0001 \text{ } m^3/\mu g}$$

Chrome VI noncancer toxicity = **1002**

*** Note: calculated values are meaningless; useful for ranking/comparison**

Toxicity-Weighted Calculations - Results

- Sites of Interest



Toxicity-Weighted Calculations - Results

St. Louis City, MO (FIPS=29-510) Cancer Toxicity-Weighted Emissions

Rank	Cancer Pollutant	Emissions (tpy)
1	Benzene	252.4
2	Formaldehyde	160.1
3	Acetaldehyde	62.9
4	1,3-Butdiene	30.0
5	Trichloroethylene	27.6
6	Tetrachloroethylene	18.3
7	Methylene Chloride	13.2
8	Naphthalene	7.8
9	POM as 15-PAH	1.2
10	Nickel	0.7

Rank	Pollutant	Cancer Toxicity Weight	Relative Weight (to Cr^{6+})
1	**Benzene**	0.00197	21.0
2	*1,3-Butadiene*	0.00090	9.6
3	*Arsenic**	0.00037	4.0
4	*Hydrazine*	0.00032	3.4
5	*Naphthalene*	0.00026	2.8
6	Acetaldehyde	0.00014	1.5
7	Nickel	0.00011	1.2
8	*Tetrachloroethylene*	0.00011	1.2
9	*POM as 7-PAH*	0.00009	1.0
10	*Chromium (VI)*	0.00009	1.0

* Arsenic emission = 0.09 tpy (Rank=17)

BOLD = National Driver, Italics = Regional Driver

Toxicity-Weighted Calculations - Results

S4MO Cancer Risk

Rank	Pollutant	Ambient Monitoring Cancer Screening (in-a-million)	Cancer Toxicity Weight Rank
1	Carbon Tetrachloride	9.38	NR
2	Benzene	7.09	1
3	Acetaldehyde	6.49	6
4	Arsenic	4.53	3
5	Acrylonitrile	4.48	NR
6	1,3-Butadiene	2.88	2
7	1,1,2,2-Tetrachloroethane	2.66	NR
8	*p*-Dichlorobenzene	2.48	NR
9	Hexachloro-1,3-butadiene	1.92	NR
10	Cadmium	1.18	NR

NR = not ranked in Top 10

Toxicity-Weighted Calculations - Results

St. Louis City, MO (FIPS=29-510) Noncancer Toxicity-Weighted Emissions

Rank	Noncancer Pollutant	Emissions (tpy)
1	Toluene	688.5
2	Xylenes (total)	453.8
3	Methanol	445.4
4	HCl	348.7
5	MTBE	307.8
6	MEK (delisted)	278.8
7	Ethylene Glycol	254.9
8	Benzene	252.4
9	Formaldehyde	160.1
10	Methyl Isobutyl Ketone	143.0

Rank	Pollutant	Noncancer Toxicity Weight
1	**Acrolein**	386,409.4
2	*Chlorine**	23,771.3
3	*HCl*	17,433.4
4	*Formaldehyde*	16,333.6
5	*1,3-Butadiene*	14,995.1
6	*Nickel*	10,815.4
7	*Maleic Anhydride*	9,645.6
8	Benzene	8,414.8
9	Acetaldehyde	6,987.5
10	*Manganese*	5,315.5

* Chlorine emission = 4.75 tpy (Rank=27)

BOLD = National Driver, Italics = Regional Driver

Toxicity-Weighted Calculations - Results

S4MO Noncancer Risk

Rank	Pollutant	Ambient Monitoring Noncancer Screening (HQ)	Noncancer Toxicity Weight Rank
1	Acrolein	28.83	1
2	Manganese	0.33	10
3	Acetaldehyde	0.33	9
4	Formaldehyde	0.33	4
5	1,3-Butadiene	0.05	5
6	Arsenic	0.04	NR
7	Acrylonitrile	0.03	NR
8	Cadmium	0.03	NR
9	Benzene	0.03	8
10	Nickel	0.02	6

NR = not ranked in Top 10

Toxicity-Weighted Calculations - Results

Wayne County, MI (FIPS=26-163) Cancer Toxicity-Weighted Emissions

Rank	Cancer Pollutant	Emissions (tpy)
1	Benzene	1,901.8
2	Formaldehyde	740.6
3	Tetrachloroethylene	388.1
4	Dichloromethane	290.4
5	Acetaldehyde	272.6
6	1,3-Butadiene	192.1
7	1,3-Dichloropropene	147.7
8	Naphthalene	113.2
9	p-Dichlorobenzene	76.6
10	Trichloroethylene	47.8

Rank	Pollutant	Cancer Toxicity Weight	Relative Weight (to POM as 15-PAH)
1	*Coke Oven Emissions**	0.0250	25.0
2	**Benzene**	0.0148	14.8
3	*1,3-Butadiene*	0.0058	5.8
4	Quinoline	0.0048	4.8
5	*POM as 7-PAH*	0.0043	4.3
6	*Naphthalene*	0.0039	3.9
7	*Cadmium*	0.0032	3.2
8	*Tetrachloroethylene*	0.0023	2.3
9	Lead	0.0022	2.2
10	*POM as 15-PAH*	0.0010	1.0

* Coke Oven Emissions = 40.3 tpy (Rank=11)

BOLD = National Driver, Italics = Regional Driver

Toxicity-Weighted Calculations - Results

DEMI Cancer Risk

Rank	Pollutant	Ambient Monitoring Cancer Screening (in-a-million)	Cancer Toxicity Weight Rank
1	Carbon Tetrachloride	10.04	NR
2	Benzene	9.77	2
3	Tetrachloroethylene	5.05	8
4	Acrylonitrile	4.80	NR
5	1,3-Butadiene	3.71	3
6	Acetaldehyde	3.63	NR
7	1,2-Dichloroethane	2.40	NR
8	Hexachloro-1,3-butadiene	1.92	NR
9	p-Dichlorobenzene	1.10	NR
10	Chromium (VI)	0.82	NR

NR = not ranked in Top 10

Toxicity-Weighted Calculations - Results

Wayne County, MI (FIPS=26-163) Noncancer Toxicity-Weighted Emissions

Rank	Noncancer Pollutant	Emissions (tpy)
1	Toluene	4,966.6
2	Xylenes (total)	3,339.7
3	Benzene	1,901.8
4	HCl	1,627.8
5	Methanol	907.6
6	Ethylbenzene	748.3
7	Formaldehyde	740.6
8	Hexane	720.4
9	MEK (delisted)	575.0
10	Glycol Ethers	476.5

Rank	Pollutant	Noncancer Toxicity Weight
1	**Acrolein***	2,046,078.6
2	*Manganese**	330,598.3
3	*1,3-Butadiene*	96,059.9
4	*Cadmium*	87,737.4
5	*HCl*	81,389.7
6	*Formaldehyde*	75,575.6
7	Benzene	63,391.9
8	Bromomethane	41,215.9
9	*Nickel*	40,571.1
10	Naphthalene	37,730.6

BOLD = National Driver, Italics = Regional Driver

* Acrolein emission = 40.9 (Rank = 27); Manganese emission = 16.5 tpy (Rank=30)

Toxicity-Weighted Calculations - Results

DEMI Noncancer Risk

Rank	Pollutant	Ambient Monitoring Noncancer Screening (HQ)	Noncancer Toxicity Weight Rank
1	Acrolein	22.68	1
2	Formaldehyde	0.30	6
3	Acetaldehyde	0.18	NR
4	1,3-Butadiene	0.06	3
5	Benzene	0.04	7
6	Acrylonitrile	0.04	NR
7	Xylenes (total)	0.03	NR
8	Carbon Tetrachloride	0.02	NR
9	Tetrachloroethylene	<0.01	NR
10	Hexachloro-1,3-butadiene	<0.01	NR

NR = not ranked in Top 10

Toxicity-Weighted Calculations - Results

Cook County, IL (FIPS=17-031) Cancer Toxicity-Weighted Emissions

Rank	Cancer Pollutant	Emissions (tpy)
1	Benzene	1,923.9
2	Formaldehyde	1,311.5
3	Tetrachloroethylene	1,167.2
4	Acetaldehyde	635.0
5	p-Dichlorobenzene	523.4
6	Trichloroethylene	420.9
7	Dichloromethane	316.8
8	1,3-Butadiene	236.7
9	Naphthalene	219.0
10	1,3-Dichloropropene	89.8

* Arsenic emission = 2.9 tpy (Rank=20)

Rank	Pollutant	Cancer Toxicity Weight	Relative Weight (to Lead)
1	**Benzene**	0.0150	6.8
2	*Arsenic**	0.0125	5.7
3	*Coke Oven Emissions*	0.0104	4.7
4	*Naphthalene*	0.0075	3.4
5	*1,3-Butadiene*	0.0071	3.2
6	*Tetrachloroethylene*	0.0069	3.1
7	p-Dichlorobenzene	0.0058	2.6
8	*Chromium (VI)*	0.0057	2.6
9	*Cadmium*	0.0025	1.1
10	Lead	0.0022	1.0

BOLD = National Driver, Italics = Regional Driver

Toxicity-Weighted Calculations - Results

NBIL Cancer Risk

Rank	Pollutant	Ambient Monitoring Cancer Screening (in-a-million)	Cancer Toxicity Weight Rank
1	Carbon Tetrachloride	10.58	NR
2	Benzene	4.58	1
3	Acrylonitrile	4.39	NR
4	Arsenic	3.68	2
5	1,1,2,2-Tetrachloroethane	2.69	NR
6	Hexachloro-1,3-butadiene	2.21	NR
7	Acetaldehyde	2.16	NR
8	Tetrachloroethylene	2.00	6
9	1,3-Butadiene	1.68	5
10	p-Dichlorobenzene	1.20	7

NR = not ranked in Top 10

Toxicity-Weighted Calculations - Results

Cook County, IL (FIPS=17-031) Noncancer Toxicity-Weighted Emissions

Rank	Noncancer Pollutant	Emissions (tpy)
1	Toluene	7,837.7
2	Xylenes (total)	5,082.6
3	Methanol	3,404.0
4	MEK (delisted)	3,215.9
5	Benzene	1,923.9
6	Methyl Isobutyl Ketone	1,483.8
7	Hexane	1,332.5
8	Formaldehyde	1,311.5
9	Tetrachloroethylene	1,167.2
10	1,1,1-Trichloroethane	1,137.3

Rank	Pollutant	Noncancer Toxicity Weight
1	**Acrolein**	3,193,594.1
2	*Manganese*	153,628.0
3	*Formaldehyde*	133,828.1
4	*1,3-Butadiene*	118,344.3
5	Bromomethane*	113,356.0
6	*Nickel*	100,856.6
7	*Arsenic*	96,523.6
8	Naphthalene	73,005.5
9	Acetaldehyde	70,553.2
10	*Cadmium*	69,789.8

BOLD = National Driver, Italics = Regional Driver

* Bromomethane emission = 566.8 tpy (Rank=15)

Toxicity-Weighted Calculations - Results

NBIL Noncancer Risk

Rank	Pollutant	Ambient Monitoring Noncancer Screening (HQ)	Noncancer Toxicity Weight Rank
1	Acrolein	12.46	1
2	Bromomethane	0.41	5
3	Formaldehyde	0.28	3
4	Manganese	0.12	2
5	Acetaldehyde	0.11	9
6	Acrylonitrile	0.03	NR
7	Arsenic	0.03	7
8	1,3-Butadiene	0.03	4
9	Benzene	0.02	NR
10	Nickel	0.02	6

NR = not ranked in Top 10

Toxicity-Weighted Calculations - Results

Davis County, UT (FIPS=49-011) Cancer Toxicity-Weighted Emissions

Rank	Cancer Pollutant	Emissions (tpy)
1	Benzene	227.1
2	Formaldehyde	71.1
3	Dichloromethane	29.2
4	Acetaldehyde	27.7
5	1,3-Butadiene	20.9
6	Tetrachloroethylene	13.5
7	p-Dichlorobenzene	5.4
8	Naphthalene	4.5
9	Trichloroethylene	2.9
10	POM as 15-PAH	1.1

Rank	Pollutant	Cancer Toxicity Weight	Relative Weight (to POM as non-15-PAH)
1	**Benzene**	0.00177	88.5
2	*1,3-Butadiene*	0.00063	31.5
3	*Naphthalene*	0.00015	7.5
4	*Tetrachloroethylene*	0.00008	4.0
5	Acetaldehyde	0.00006	3.0
6	*POM as 15-PAH*	0.00006	3.0
7	p-Dichlorobenzene	0.00006	3.0
8	*POM as 7-PAH**	0.00005	2.5
9	Acrylonitrile	0.00003	1.5
10	*POM as non-15-PAH*	0.00002	1.0

BOLD = National Driver, Italics = Regional Driver

* POM as 7-PAH emission = 0.24 tpy (Rank=14)

Toxicity-Weighted Calculations - Results

BTUT Cancer Risk

Rank	Pollutant	Ambient Monitoring Cancer Screening (in-a-million)	Cancer Toxicity Weight Rank
1	Benzene	9.09	1
2	Carbon Tetrachloride	9.08	NR
3	Acetaldehyde	7.41	5
4	Acrylonitrile	4.88	NR
5	1,3-Butadiene	3.21	2
6	Arsenic	3.07	NR
7	Hexachloro-1,3-butadiene	1.63	NR
8	Cadmium	1.41	NR
9	Tetrachloroethylene	1.05	4
10	1,2-Dichloroethane	0.83	NR

NR = not ranked in Top 10

Toxicity-Weighted Calculations - Results

Davis County (FIPS=49-011) Noncancer Toxicity-Weighted Emissions

Rank	Noncancer Pollutant	Emissions (tpy)
1	Toluene	681.5
2	Xylenes (total)	489.2
3	Benzene	227.1
4	n-Hexane	113.9
5	Ethylbenzene	106.1
6	Methanol	93.7
7	MEK (delisted)	89.9
8	Methyl Isobutyl Ketone	87.1
9	Formaldehyde	71.1
10	1,1,1-Trichloroethane	51.8

Rank	Pollutant	Noncancer Toxicity Weight
1	**Acrolein**	231,458.8
2	*Hexamethylene Diisocyanate**	12,645.0
3	*1,3-Butadiene*	10,436.7
4	*Manganese*	9,087.7
5	Benzene	7,570.4
6	*Formaldehyde*	7,258.2
7	Xylenes (total)	4,891.6
8	*Chlorine*	4,710.0
9	Cyanide	3,915.0
10	Acetaldehyde	3,082.1

BOLD = National Driver, Italics = Regional Driver

* Hexamethylene Diisocyanate emission = 0.13 tpy (Rank=39)

Toxicity-Weighted Calculations - Results

BTUT Noncancer Risk

Rank	Pollutant	Ambient Monitoring Noncancer Screening (HQ)	Noncancer Toxicity Weight Rank
1	Acrolein	28.77	1
2	Formaldehyde	0.57	6
3	Acetaldehyde	0.37	10
4	Manganese	0.16	4
5	1,3-Butadiene	0.05	3
6	Cadmium	0.04	NR
7	Benzene	0.04	5
8	Acrylonitrile	0.04	NR
9	Xylenes (total)	0.03	7
10	Arsenic	0.02	NR

NR = not ranked in Top 10

Wrap-Up

- Toxicity-weighting data from an emissions inventory can be useful in prioritizing pollutants based on risk potential.

- Fairly good agreement between mass emissions and cancer tox-weighting in Davis County, UT (7 polls in common among Top 10)

- Very little agreement between mass emissions and cancer tox-weighting in Wayne County, MI (4 polls in common among Top 10)

- For noncancer toxicity, few Top 10 polls in common:
  - Davis County, UT = 3 common Top 10 pollutants
  - Cook County, IL = 1 common Top 10 pollutant

Wrap-Up

- OK agreement between cancer tox-weighting in Cook County, IL and NBIL (5 common pollutants among Top 10)

- Weak agreement between cancer tox-weighting in Wayne County, MI and DEMI (3 common pollutants among Top 10)

- Very good agreement between noncancer tox-weighting:
  - Cook County, IL and NBIL (8 common Top 10 pollutants)
  - St. Louis City, MO and S4MO (7)
  - Davis County, UT and BTUT (7)

- Weak agreement between noncancer tox-weighting:
  - Wayne County, MI and DEMI (4 common Top 10 pollutants)

Questions?

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