Preliminary Overview of the 2006 Urban Air Toxics Monitoring Program

Regi Oommen, Jaime Hauser, Susan McClutchey, Julie Swift, and Dave Dayton
Eastern Research Group, Inc.
Morrisville, NC
regi.oommen@erg.com

Air Toxics Data Analysis Workshop
Chicago, IL
October 4, 2007

Overview of Presentation

- **Background on Urban Air Toxics Monitoring Program (UATMP)**
- **Data Analysis Products**
- **Toxicity-Weighted Calculations**
- **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 National Monitoring Programs

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

- **Potential of over 50 HAPs**

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

Urban Air Toxic Monitoring Program: 2006

- **For the 2006 Program:**
  - **59 sites in 38 locations**
  - **33 in MSAs**
  - **182,288 valid concentrations**

- **By EPA Region:**
  - **Region 1 = 3**
  - **Region 2 = 6**
  - **Region 3 = 1**
  - **Region 4 = 20**
  - **Region 5 = 11**
  - **Region 6 = 10**
  - **Region 7 = 1**
  - **Region 8 = 4**
  - **Region 9 = 1**
  - **Region 10 = 2**

UATMP: 2006 Locations

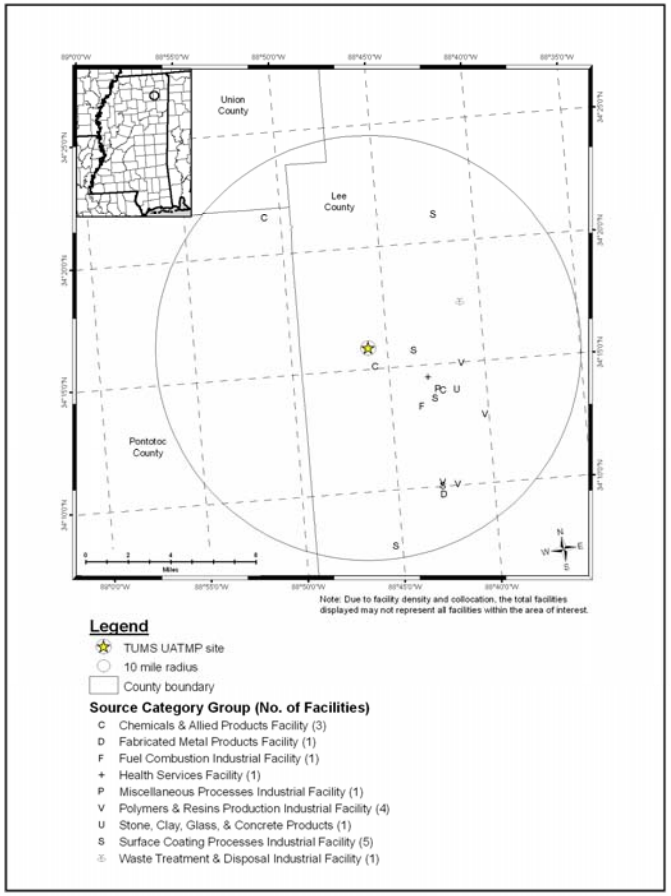
Urban Air Toxic Monitoring Program: 2006

- **By Location Setting**
  - **Rural = 12**
  - **Suburban = 26**
  - **Urban = 21**

- **By Land Use**
  - **Agricultural = 4**
  - **Commercial = 12**
  - **Forest = 3**
  - **Industrial = 7**
  - **Military = 1**
  - **Mobile = 1**
  - **Residential = 31**

Additional Site Characteristics Information

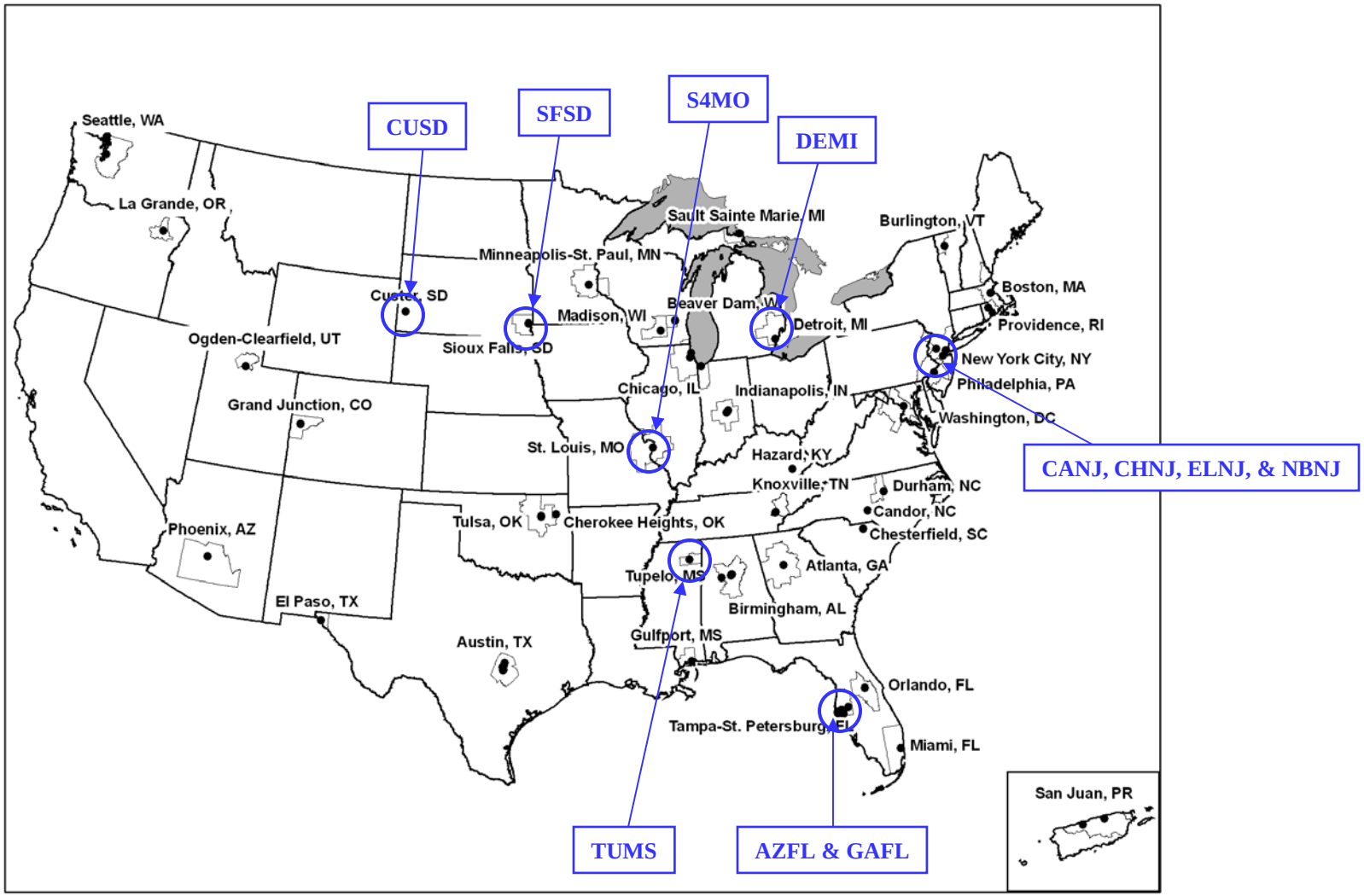
- Daily traffic passing by the monitor
- Description of the immediate surroundings
- AQS Site Codes
- County-level stationary and mobile source emissions
- 10-mile map of point sources from the NEI



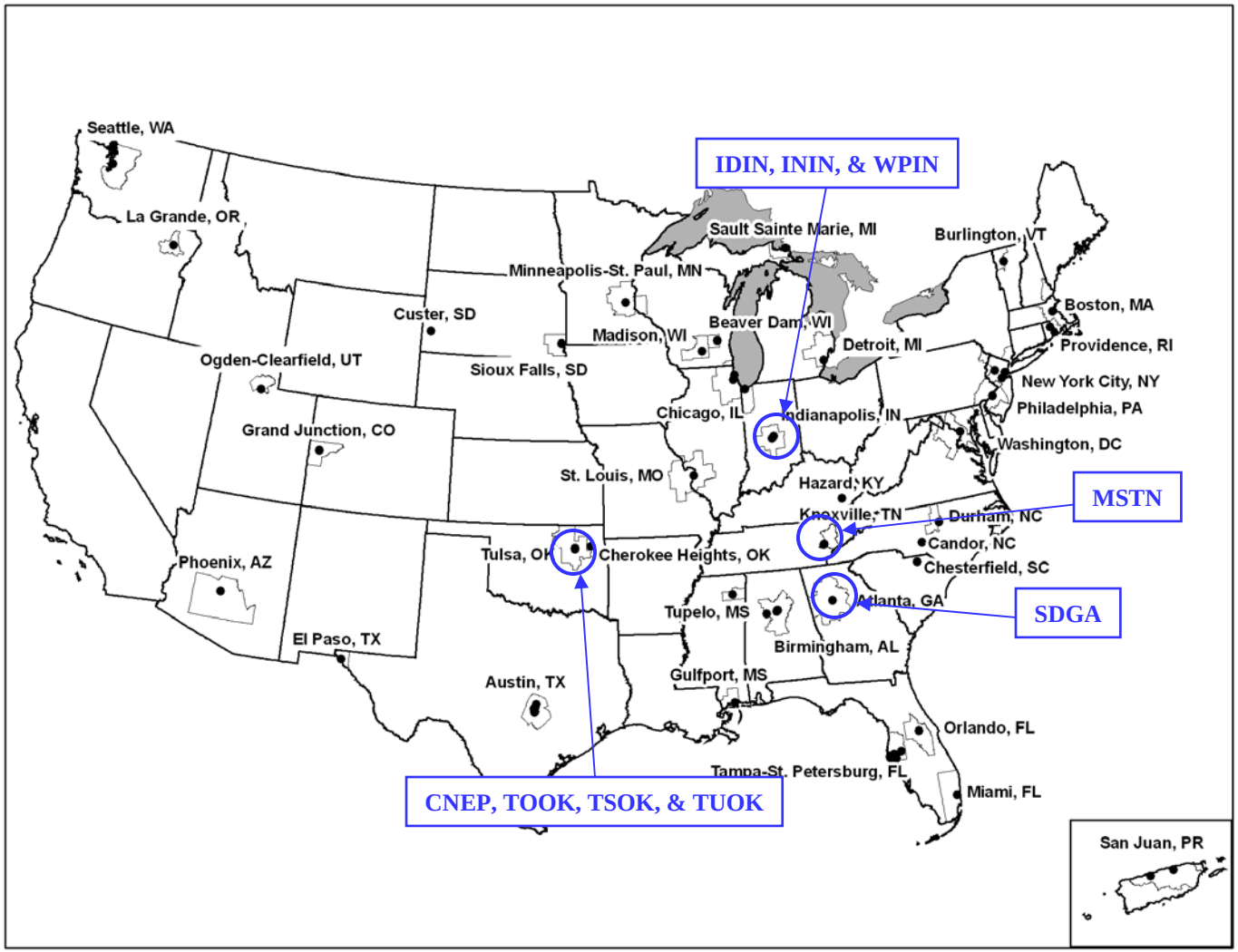
Additional Site Characteristics Information

- **Population residing within 10 miles of the site**
- **Closest National Weather Service Station**
- **County motor vehicle registration totals**
- **Topographic map showing each site**

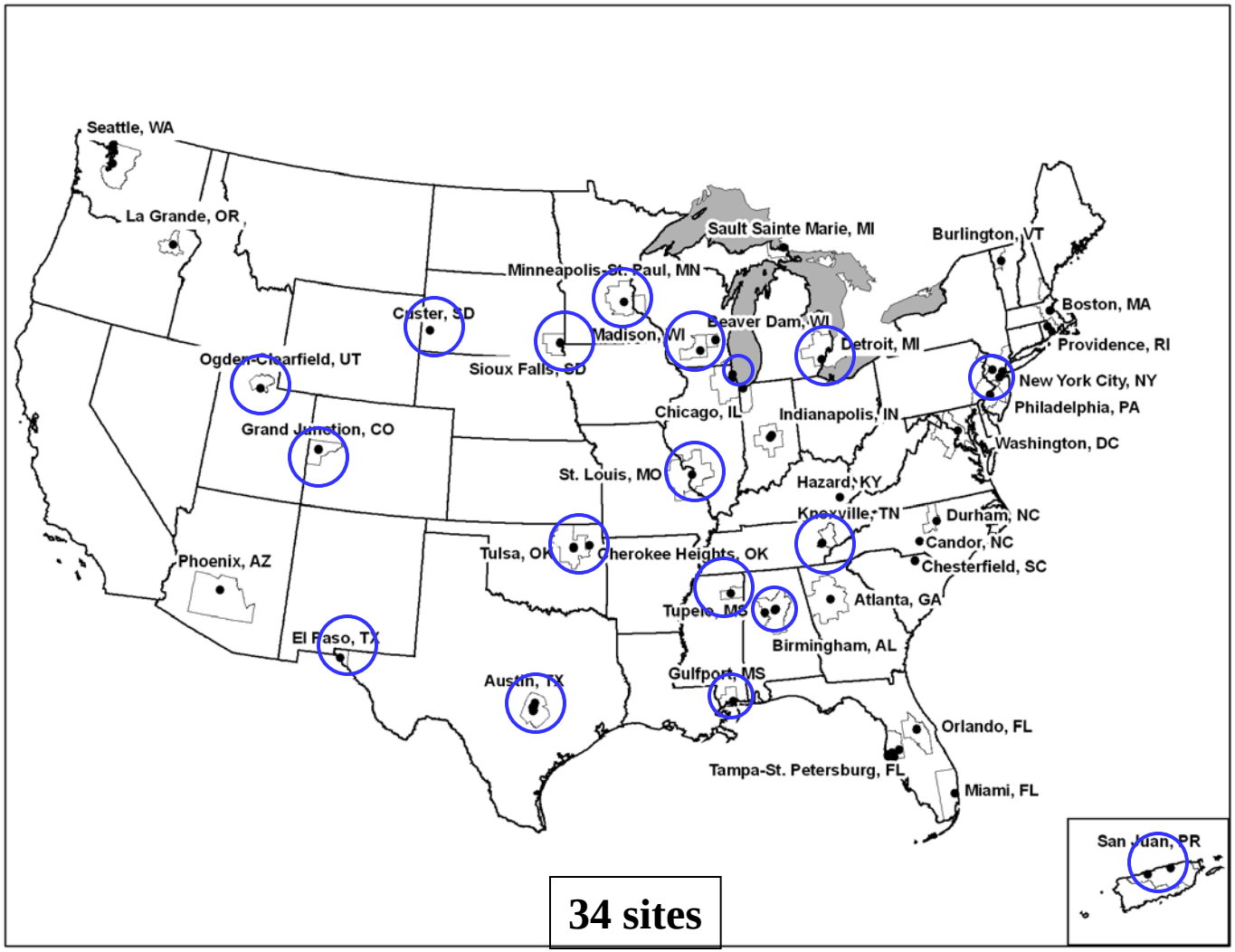
2006 Sites with 5 Consecutive Years in UATMP



New 2006 Sites

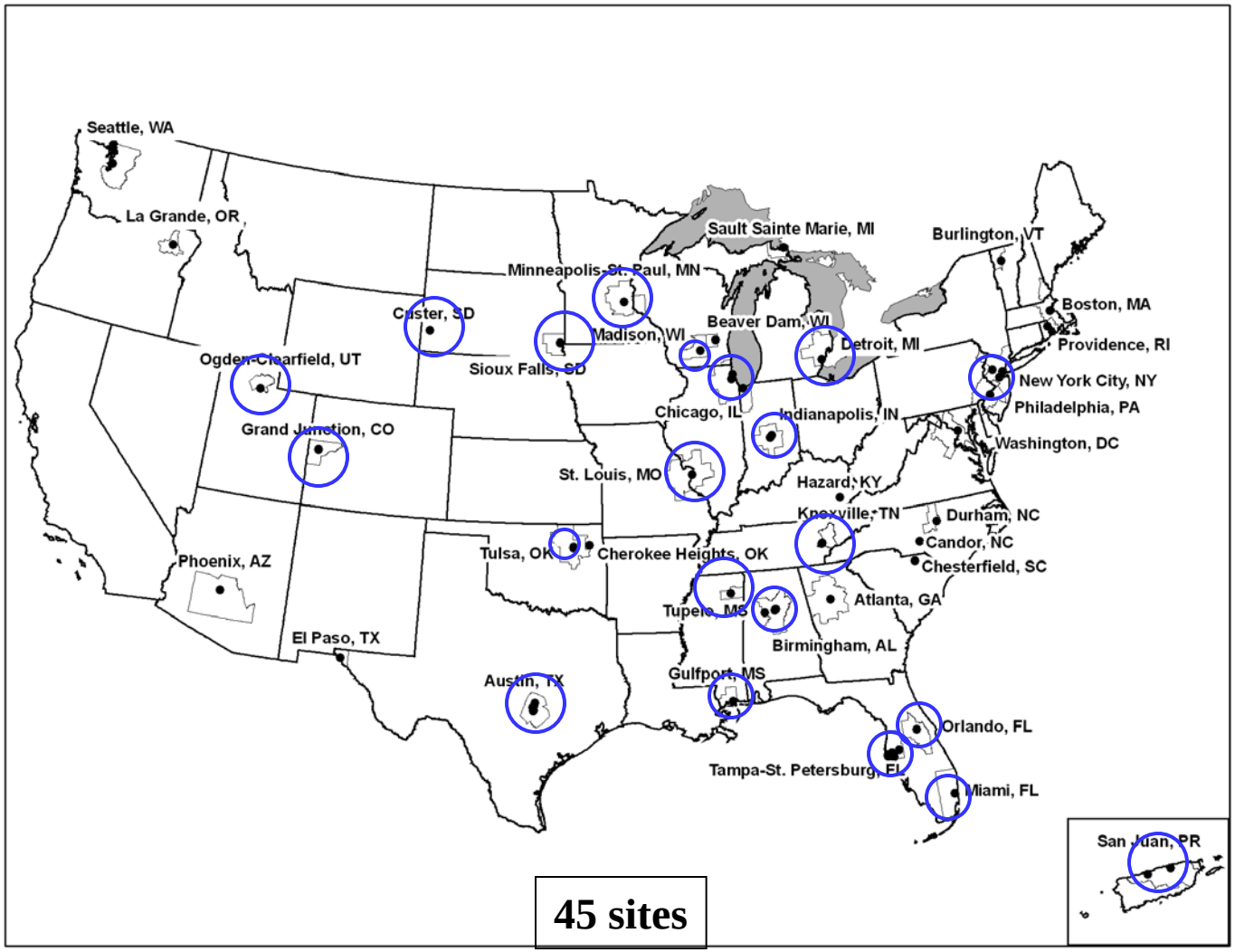


VOC Monitoring Sites (TO-15)

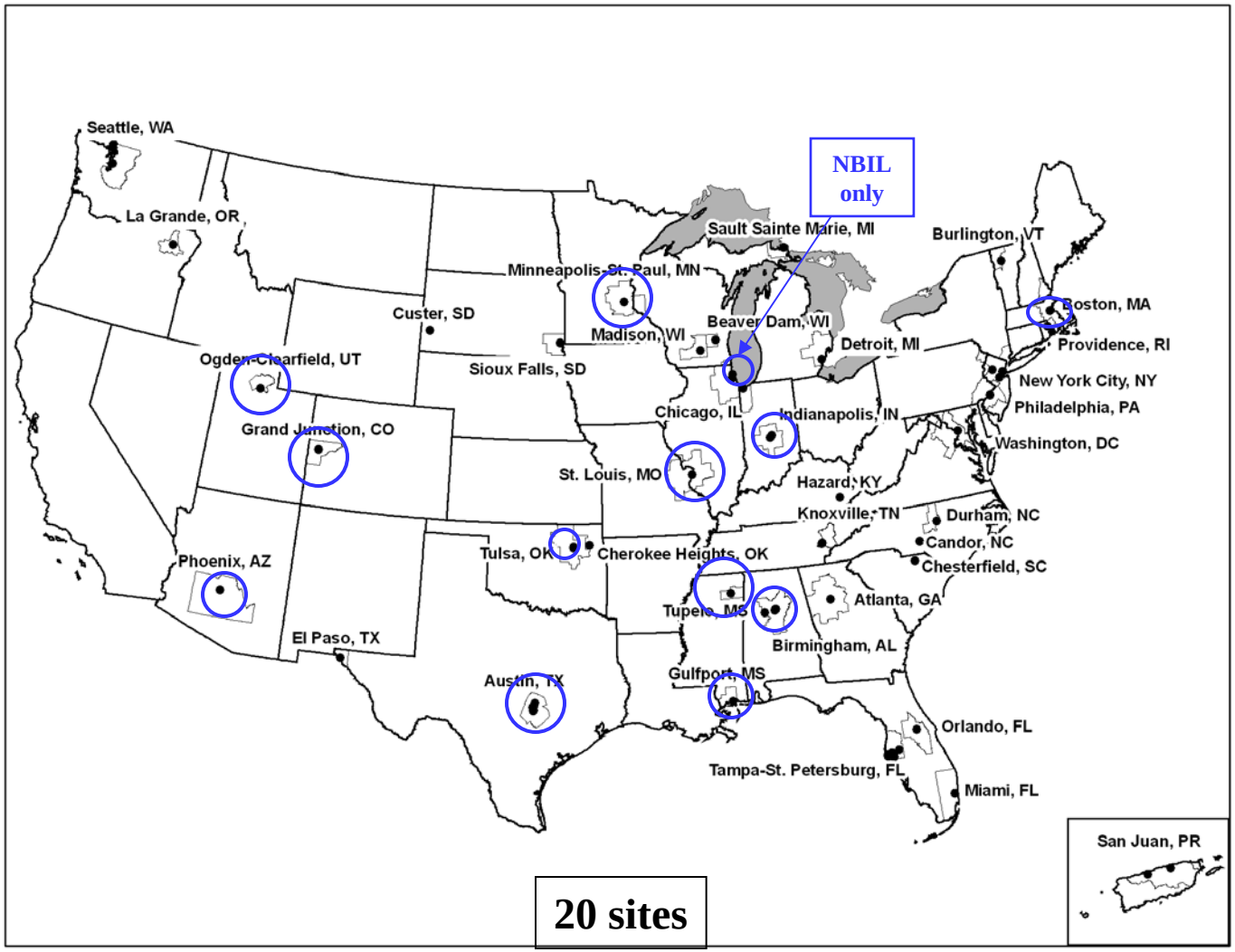


34 sites

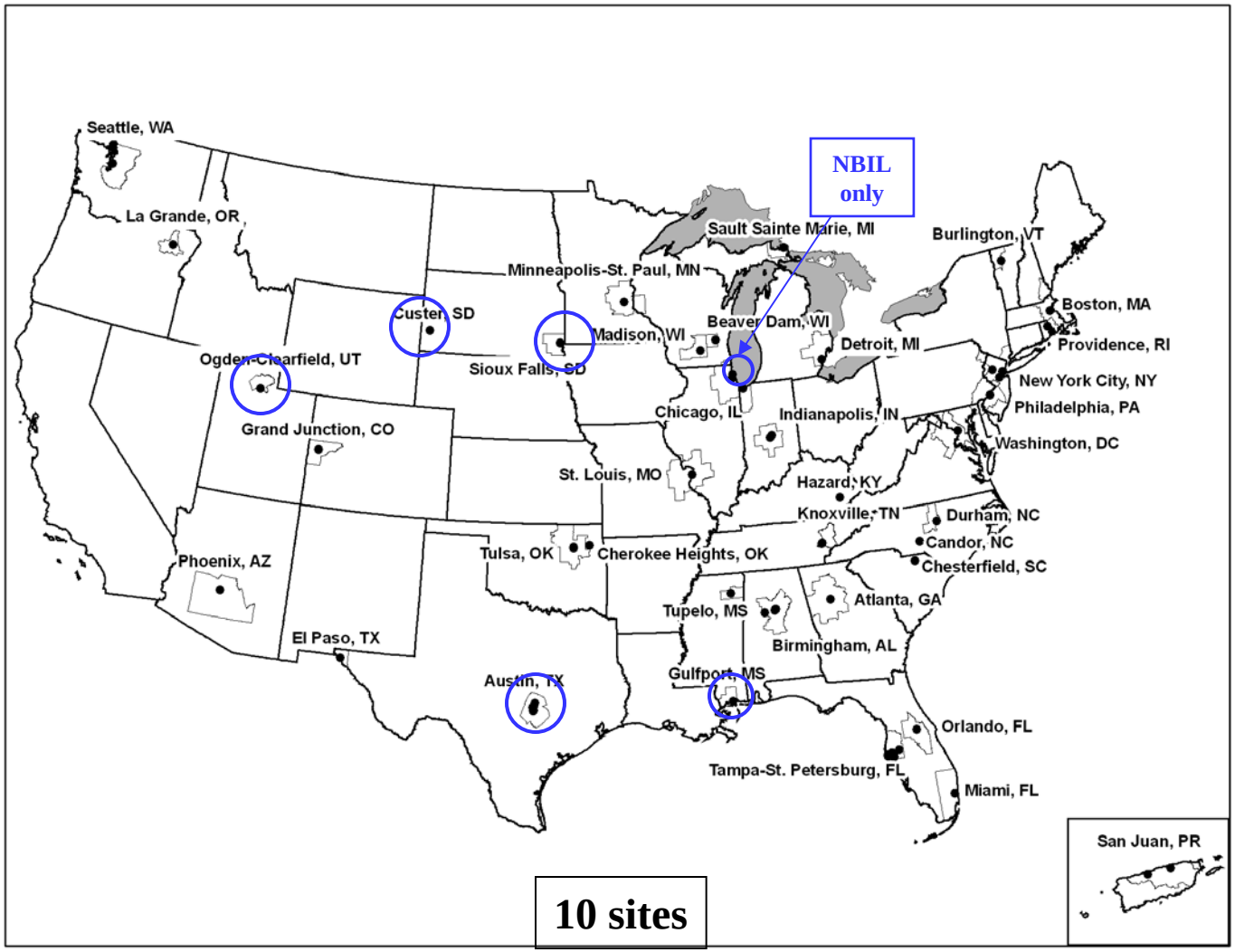
Carbonyl Monitoring Sites (TO-11A)



Metals Monitoring Sites (IO-3.5)

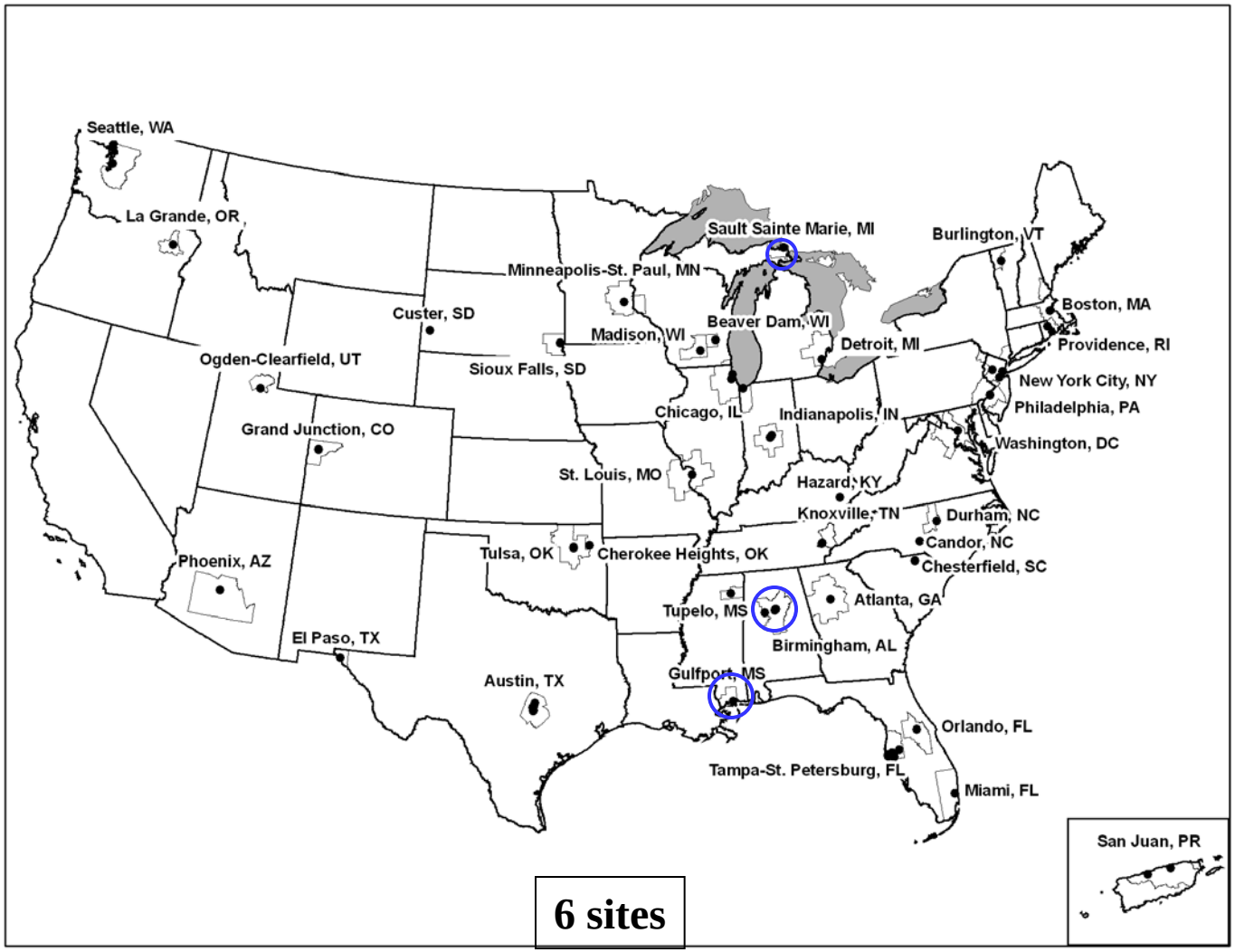


SNMOC/TNMOC Monitoring Sites (SNMOC)



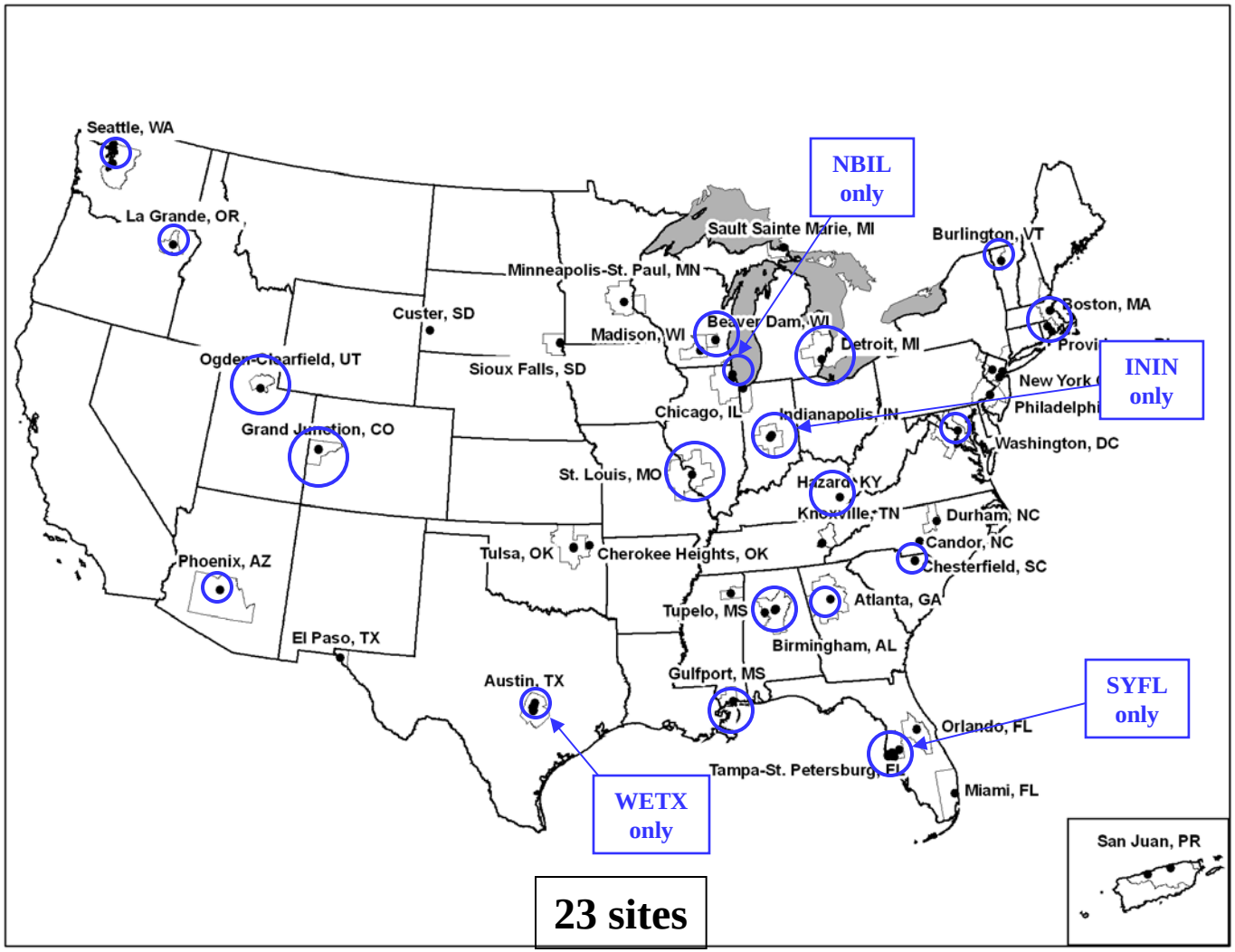
10 sites

SVOC Monitoring Sites (TO-13A)



6 sites

Hexavalent Chromium Monitoring Sites (EPA/ERG Cr^{6+})



Completeness

Type	Average MDL Ranges	MDL Range Units	Valid Samples	Total # of Samples	% Completeness
VOC	0.0031- 0.1066	ppbv	1,328	1,449	92
Carbonyls	0.0011-0.0082	ppbv	1,838	1,927	95
Metals-PM_{10}	0.0245 – 0.6072	ng/m^3	472	478	99
Metals-TSP	0.0308 – 0.7033	ng/m^3			
SNMOC/TNMOC	0.0794 - 0.7133	ppbC	375	395	95
SVOC	0.06 - 0.52	pg/m^3	183	194	94
HexChrome	0.0129	ng/m^3	987	1,020	97

Note: UATMP Data Quality Objective (DQO) for completeness = 85%

Data Analysis Products: Statistical Summaries

Central Tendency and Data Distribution

Pollutant	# Detects	Minimum (ppbv)	Maximum (ppbv)	Arithmetic Mean (ppbv)	Mode (ppbv)	Median (ppbv)	Geometric Mean (ppbv)	First Quartile (ppbv)	Third Quartile (ppbv)	Standard Deviation (ppbv)	Coefficient of Variation
Acetonitrile	896	0.06	502.25	6.14	0.43	0.95	1.20	0.37	3.19	25.53	4.16
Acetylene	1,326	0.01	39.70	0.94	0.45	0.61	0.65	0.39	1.04	1.50	1.60
Acrolein	1,048	0.05	5.37	0.41	0.16	0.27	0.30	0.18	0.47	0.45	1.11
Acrylonitrile	70	0.02	2.06	0.21	0.05	0.13	0.14	0.09	0.27	0.26	1.25
tert-Amyl Methyl Ether	12	0.01	0.22	0.04	0.01	0.03	0.02	0.01	0.03	0.06	1.37
Benzene	1,329	0.05	9.87	0.37	0.20	0.27	0.28	0.18	0.42	0.45	1.21
Bromochloromethane	0	NA									
Bromodichloromethane	42	0.01	0.09	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.59
Bromoform	3	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	<0.01	<0.01
Bromomethane	1,208	0.01	31.10	0.04	0.01	0.01	0.01	0.01	0.02	0.89	20.66
1,3-Butadiene	1,132	0.01	1.36	0.05	0.02	0.04	0.04	0.02	0.07	0.06	1.16
Carbon Tetrachloride	1,326	0.01	0.22	0.10	0.10	0.10	0.10	0.08	0.12	0.03	0.31
Carbon Disulfide	1,018	0.01	78.80	2.09	0.02	0.73	0.48	0.07	2.34	4.33	2.07
Chlorobenzene	65	0.01	0.10	0.03	0.02	0.03	0.03	0.02	0.04	0.02	0.61
Chloroethane	842	0.01	0.48	0.02	0.01	0.02	0.02	0.01	0.02	0.03	1.38
Chloroform	934	0.01	2.40	0.05	0.02	0.02	0.03	0.02	0.04	0.11	2.18
Chloromethane	1,329	0.15	4.72	0.62	0.58	0.59	0.59	0.51	0.67	0.22	0.35
Chloromethylbenzene	8	0.01	0.07	0.03	0.01	0.02	0.02	0.01	0.03	0.02	0.70
Chloroprene	17	0.01	0.12	0.03	0.03	0.03	0.03	0.02	0.04	0.03	0.77
Dibromochloromethane	39	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.01	<0.01	0.34
1,2-Dibromoethane	1	NA									
m-Dichlorobenzene	29	0.01	0.09	0.02	0.01	0.01	0.02	0.01	0.02	0.02	0.95
o-Dichlorobenzene	15	0.01	0.06	0.02	0.01	0.01	0.01	0.01	0.03	0.01	0.78
p-Dichlorobenzene	987	0.01	3.75	0.05	0.01	0.02	0.02	0.01	0.04	0.20	4.24
Dichlorodifluoromethane	1,329	0.11	1.17	0.54	0.54	0.54	0.53	0.49	0.58	0.09	0.17
1,1-Dichloroethane	0	NA									
1,2-Dichloroethane	30	0.01	0.85	0.05	0.01	0.02	0.02	0.01	0.02	0.15	3.25
1,1-Dichloroethene	8	0.03	0.17	0.09	0.11	0.10	0.08	0.05	0.12	0.05	0.51
cis-1,2-Dichloroethylene	34	0.04	0.34	0.13	0.08	0.11	0.12	0.08	0.17	0.07	0.50
trans-1,2-Dichloroethylene	8	0.01	0.08	0.02	0.01	0.01	0.02	0.01	0.02	0.02	1.08

Data Analysis Products: Evaluating Risk

- Risk Screening: Guidance from EPA Region 4 document:
  "A Preliminary Risk-Based Screening Approach for Air Toxics"

- Acute Risk: compare ATSDR and CALEPA acute risk factors against daily measurements

- Intermediate Risk: compare ATSDR and CALEPA intermediate-term risk factors against seasonal averages

- Chronic Risk:
  - Compared annual average concentrations with 1999 NATA modeled concentrations
  - Computed EPA cancer and noncancer risk using URE and RfC factors

Data Analysis Products: Risk Screening

- Methodology used in the 2005 UATMP Report. Modification of EPA Region 4 Risk Screening Guidance document
- Methodology is limited to HAPs; not all HAPs have a risk screening factor.
- Daily concentrations were compared to a risk screening factor
- If a concentration was greater than its risk screening factor, then the concentration “failed the screen”
- A total of 10,787 of 23,602 applicable concentrations (45.77%) failed their screens.

Data Analysis Products: Risk Screening

- The pollutants contributing to the Top 95% of the total failed screens were identified as Program-wide Pollutants Of Interest:

  - Acetaldehyde (1,814 failed screens)
  - Acrolein (1,048)*
  - Arsenic (431)
  - Benzene (1,329)*
  - 1,3-Butadiene (1,011)
  - Carbon tetrachloride (1,323)
  - *p*-Dichlorobenzene (642)
  - Formaldehyde (1,599)
  - Hexachloro-1,3-butadiene (86)*
  - Hexavalent chromium (86)
  - Manganese (307)
  - Naphthalene (90)
  - Tetrachloroethylene (535)

* Pollutant failed 100% of its screen

- This approach was also used to identify the pollutants of interest on a per site basis.

Data Analysis Products: Short-term (Acute) Risk

Pollutant	ATSDR Short-term MRL ($\mu g/m^3$)	CAL EPA REL ($\mu g/m^3$)	# of ATSDR Exceedances	# CAL EPA REL Exceedances
Formaldehyde	49	94	26	12
Acrolein	0.11	0.19	1,048	1,019
Benzene	28.75	NA	1	NA

DRAFT – DO NOT CITE OR QUOTE

Data Analysis Products: Intermediate-term Risk

Pollutant	ATSDR Intermediate-term MRL ($\mu g/m^3$)	# of Winter Exceedances	# of Spring Exceedances	# of Summer Exceedances	# of Autmun Exceedances
Formaldehyde	40	0	1	1	1
Acrolein	0.09	20	13	21	22

DRAFT – DO NOT CITE OR QUOTE

Data Analysis Products: Chronic Risk

Table 6-7. Chronic Risk Summary for the Monitoring Site in Colorado

Pollutant	Cancer URE ($\mu g/m^3$)	Noncancer RfC ($\mu g/m^3$)	1999 NATA			2006 UATMP		
			Modeled Concentration ($\mu g/m^3$)	Cancer Risk (in-a-million)	Noncancer Risk (HQ)	Annual Average ($\mu g/m^3$)	Cancer Risk (in-a-million)	Noncancer Risk (HQ)
Grand Junction, Colorado (GPCO) - Census Tract 08077000800								
Acetaldehyde	0.0000022	0.009	0.58	1.28	0.06	2.35 ± 0.20	5.17	0.26
Acrolein	NR	0.00002	0.02	NR	1.04	0.63 ± 0.16	NR	31.26
Acrylonitrile	0.000068	0.002	<0.01	0.15	<0.01	0.09 ± 0.03	5.96	0.04
Benzene	0.0000078	0.03	0.56	4.39	0.02	1.85 ± 0.23	14.41	0.06
1,3-Butadiene	0.00003	0.002	0.04	1.25	0.02	0.20 ± 0.04	5.91	0.1
Carbon Tetrachloride	0.000015	0.04	0.21	3.19	0.01	0.58 ± 0.06	8.77	0.01
***p*-Dichlorobenzene**	0.000011	0.8	0.01	0.14	<0.01	0.09 ± 0.03	0.99	<0.01
Dichloromethane	0.00000047	1	0.21	0.10	<0.01	0.41 ± 0.09	0.19	<0.01
Formaldehyde	5.5E-09	0.0098	0.73	<0.01	0.07	4.00 ± 0.32	0.02	0.41
Hexachloro-1,3-butadiene	0.000022	0.09	<0.01	0.03	<0.01	0.07 ± <0.01	1.59	<0.01
Hexavalent Chromium	0.012	0.0001	<0.01	0.03	<0.01	<0.01	0.36	<0.01
Tetrachloroethylene	0.0000059	0.27	0.07	0.42	<0.01	0.34 ± 0.09	2.03	<0.01
Xylenes	NR	0.1	0.53	NR	0.01	5.40 ± 0.81	NR	0.05

BOLD indicates a pollutant of interest
ND = no NATA data available
NR = a risk factor is not available and therefore, no risk calculation can be made

DRAFT – DO NOT CITE OR QUOTE

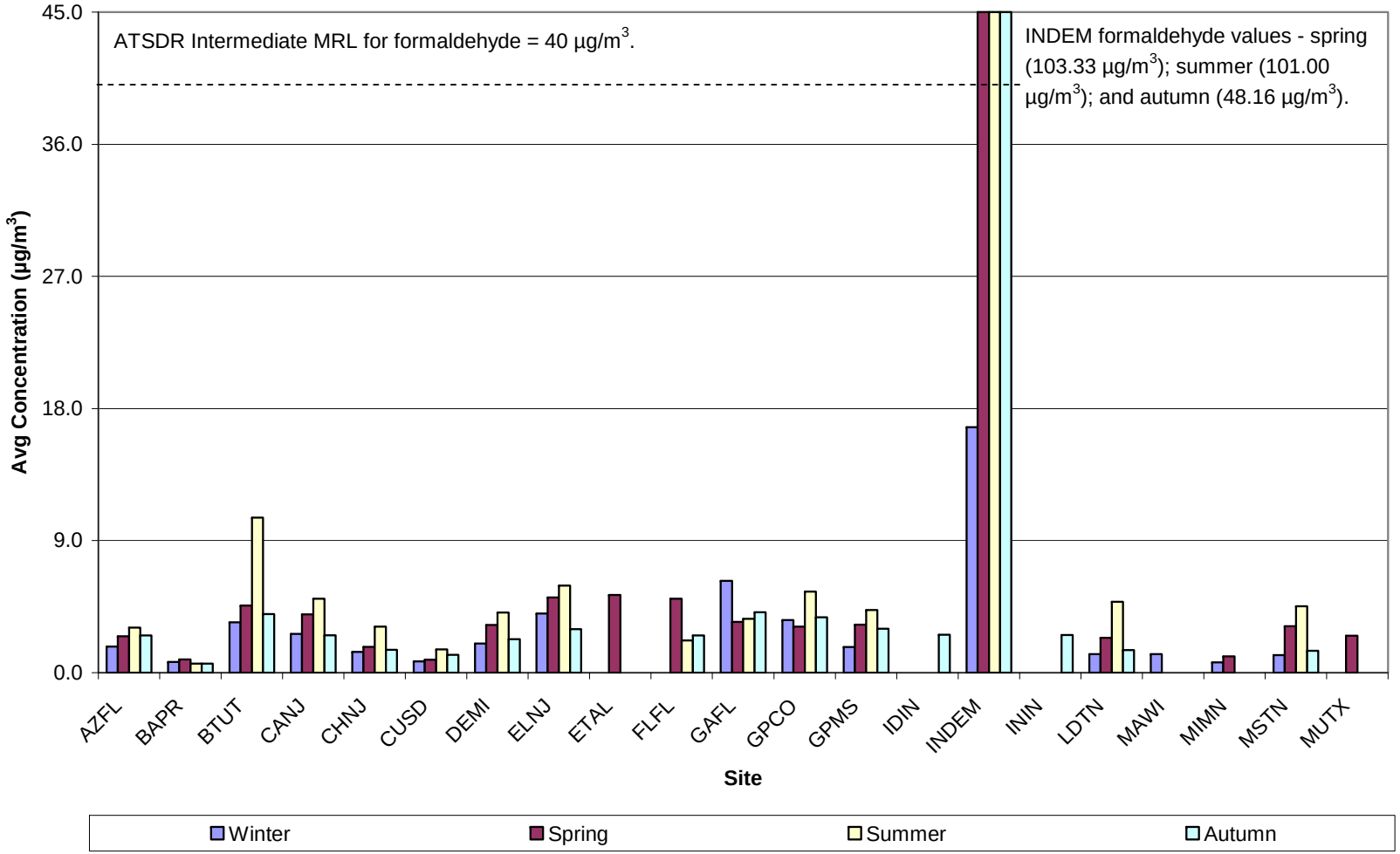
Data Analysis Products: Correlation

Table 18-5. Pollutants of Interest Concentration Correlations with Selected Meteorological Parameters at the New Jersey Monitoring Sites

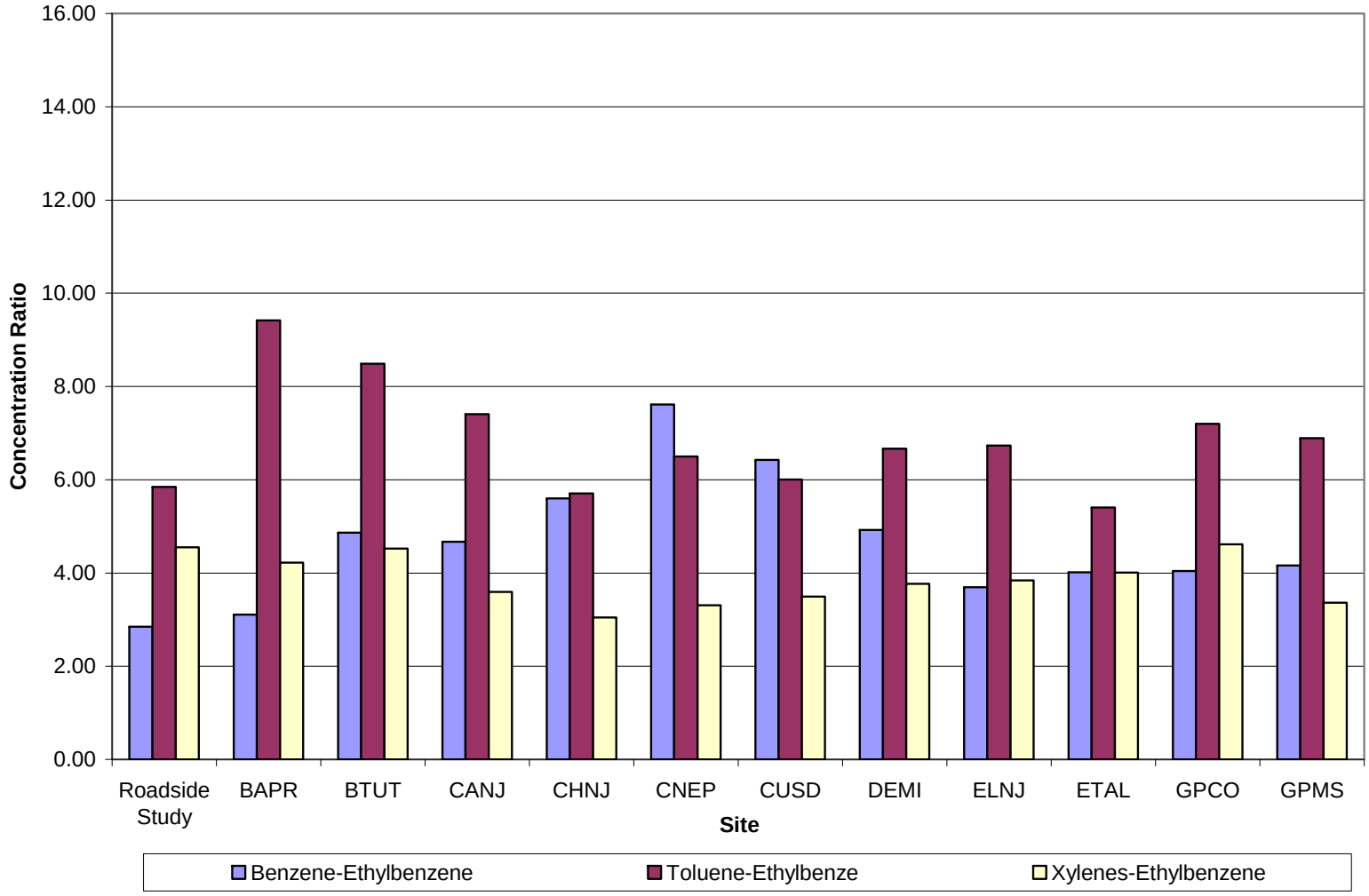
Pollutant	# Detects	Maximum Temperature	Average Temperature	Dew Point Temperature	Wet Bulb Temperature	Relative Humidity	Sea Level Pressure	Scalar Wind Speed
Camden, New Jersey – CANJ								
1,3-Butadiene	52	-0.29	-0.35	-0.29	-0.34	0.06	0.18	-0.35
Acetaldehyde	57	0.58	0.51	0.40	0.45	-0.09	0.16	-0.43
Acrolein	42	0.15	0.15	0.12	0.14	-0.03	-0.18	0.27
Benzene	53	-0.05	-0.11	-0.03	-0.08	0.15	0.10	-0.37
Bromomethane	53	0.13	0.08	-0.03	0.01	-0.18	0.10	-0.24
Carbon Tetrachloride	53	0.53	0.54	0.56	0.56	0.19	-0.14	0.12
Formaldehyde	57	0.68	0.63	0.45	0.54	-0.19	0.03	-0.26
p-Dichlorobenzene	51	0.36	0.33	0.31	0.32	0.06	0.10	-0.32
Tetrachloroethylene	52	-0.29	-0.30	-0.13	-0.24	0.33	0.12	-0.36
Chester, New Jersey – CHNJ								
1,3-Butadiene	37	-0.40	-0.42	-0.50	-0.45	-0.43	-0.01	0.40
Acetaldehyde	58	0.13	0.03	0.01	0.01	-0.02	0.24	-0.37
Acrolein	41	0.08	0.07	0.02	0.05	-0.11	0.15	-0.06
Benzene	58	-0.51	-0.55	-0.42	-0.50	0.13	0.03	-0.08
Carbon Tetrachloride	58	0.48	0.52	0.54	0.54	0.28	-0.17	0.06
Formaldehyde	58	0.68	0.60	0.54	0.57	0.05	-0.01	-0.39
Tetrachloroethylene	45	-0.31	-0.37	-0.34	-0.36	-0.04	0.05	-0.04

DRAFT – DO NOT CITE OR QUOTE

Data Analysis Products: Seasonal Variability



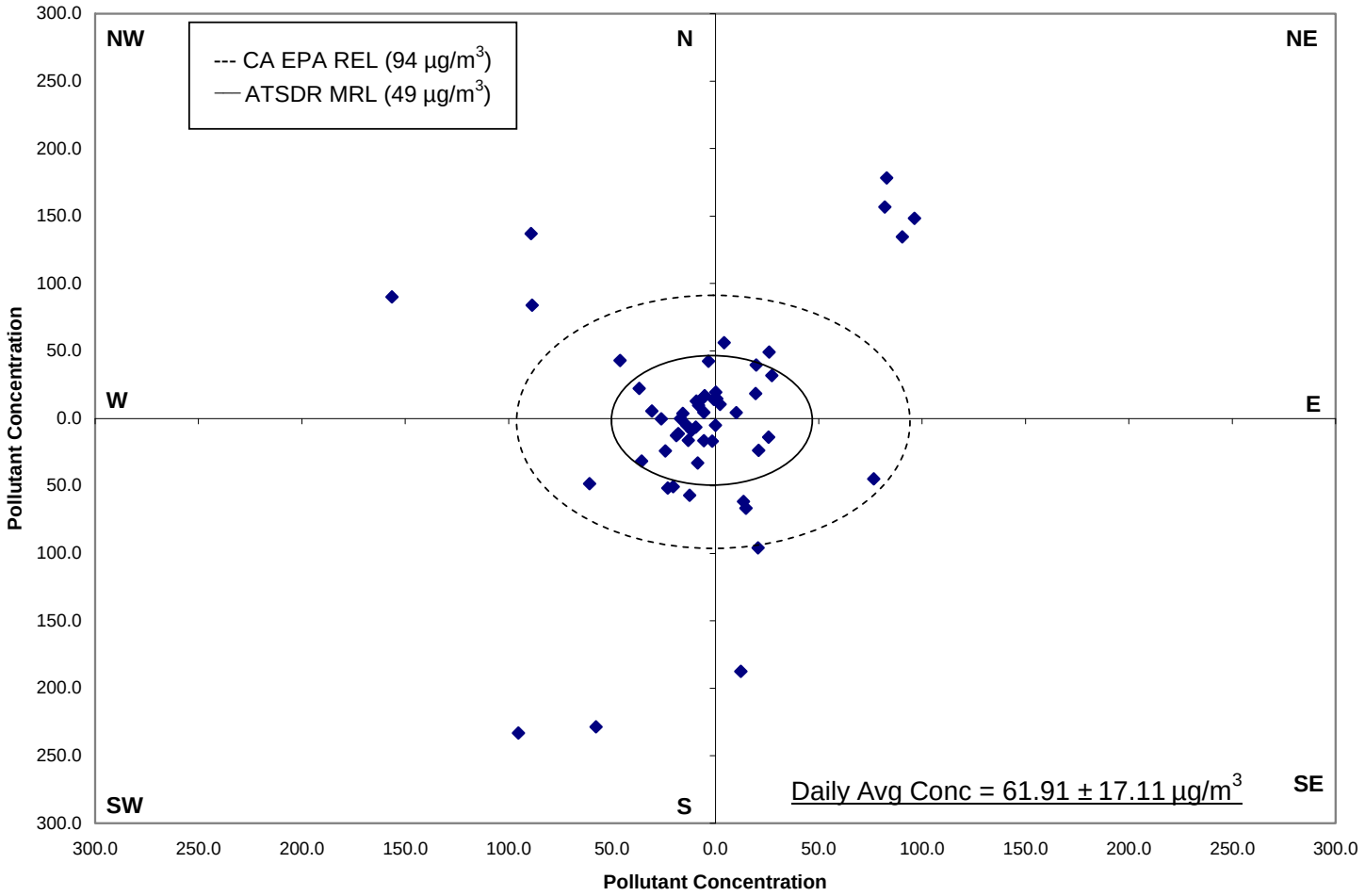
Data Analysis Products: BTEX Ratios



DRAFT – DO NOT CITE OR QUOTE

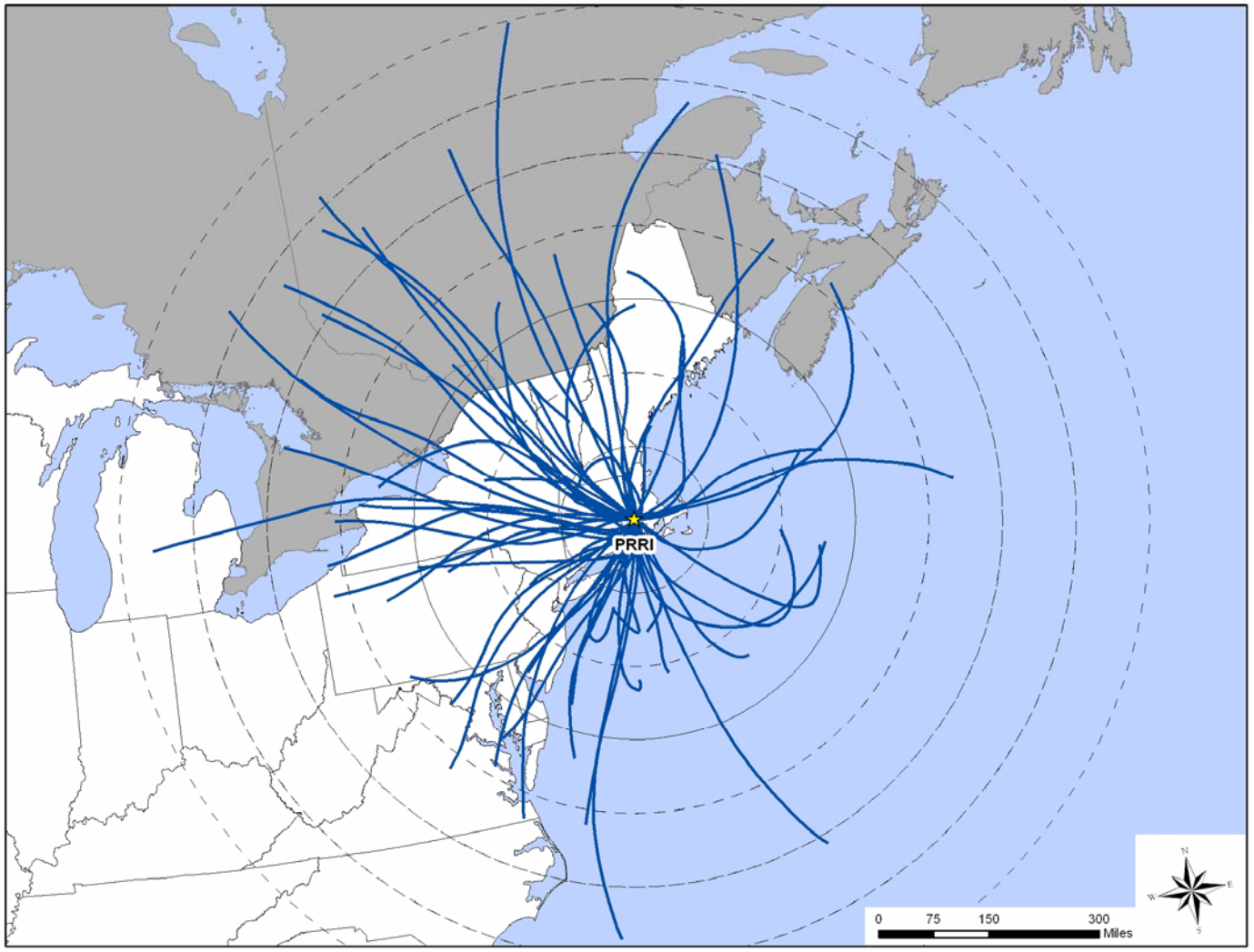
Data Analysis Products: Pollution Rose Analysis

Figure 11-6. Formaldehyde Pollution Rose at INDEM



DRAFT – DO NOT CITE OR QUOTE

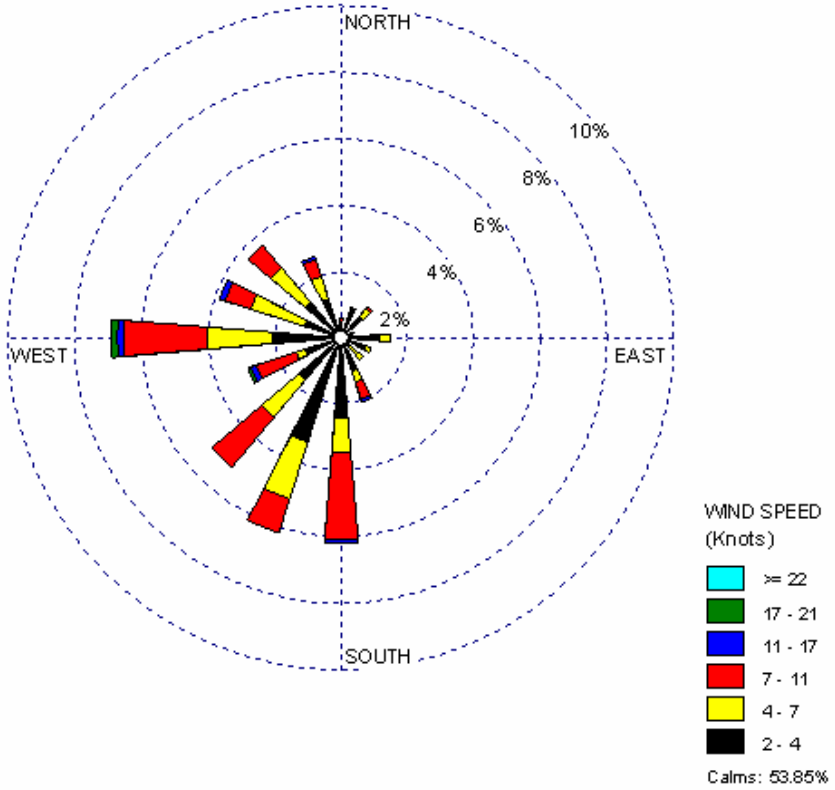
Data Analysis Products: Composite Back Trajectories



DRAFT – DO NOT CITE OR QUOTE

Data Analysis Products: Sampling Day Wind Rose

Figure 12-4. Wind Rose of Sample Days for the HAKY Monitoring Site



Data Analysis Products: 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?

Data Analysis Products: Toxicity-Weighted Emissions

- 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

Data Analysis Products: Toxicity-Weighted Emissions

- 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.

Data Analysis Products: Toxicity-Weighted Emissions

- Approach:
  - Step 1 – Obtain the HAP data from the 2002 NEI
  - 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

Data Analysis Products: Toxicity-Weighted Emissions

- 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

Data Analysis Products: Toxicity-Weighted Emissions

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-Weighted Emissions	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)**

Data Analysis Products: Toxicity-Weighted Emissions

S4MO Cancer Risk

Rank	Pollutant	Cancer Risk (in-a-million)	Tox Weight Emissions 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

Data Analysis Products: Toxicity-Weighted Emissions

Lake County, IN (FIPS=18-089) Noncancer Toxicity-Weighted Emissions

Rank	Noncancer Pollutant	Emissions (tpy)
1	HCl	1,133.2
2	Toluene	1,000.2
3	Xylenes	703.6
4	Benzene	410.0
5	Methanol	243.6
6	Hexane	232.5
7	Formaldehyde	195.9
8	MEK	184.9
9	Acetaldehyde	147.9
10	Ethylbenzene	125.2

Rank	Pollutant	Noncancer-Weighted Emissions	Relative Weight (to acetaldehyde)
1	Manganese*	813,675	49.5
2	Acrolein*	492,628	30.0
3	HCl	56,662	3.4
4	Arsenic	30,703	1.9
5	Nickel	25,638	1.6
6	1,3-Butdiene	20,724	1.3
7	Formaldehyde	19,991	1.2
8	Chlorine	19,571	1.2
9	Naphthalene	17,042	1.0
10	Acetaldehyde	16,431	1.0

*** Manganese emissions = 40.7 tpy (Rank=20); acrolein emissions = 9.9 tpy (Rank=28)**

DRAFT – DO NOT CITE OR QUOTE

Data Analysis Products: Toxicity-Weighted Emissions

INDEM Noncancer Risk

Rank	Pollutant	Noncancer Risk (hazard quotient)	Tox Weight Emissions Rank
1	Formaldehyde	6.32	7
2	Acetaldehyde	0.51	10

Data Analysis Products: Toxicity-Weighted Emissions

- Cancer Toxicity - Among the UATMP counties (44):

Pollutant	# Counties*
Benzene	35
Cr^{6+}	1
Arsenic	1
Methylene Chloride	1
Coke Oven Emissions	4
Naphthalene	1
POM as non 15-PAH	1

Cr^{6+}:
Lee County, MS

Arsenic:
Mayes County, OK

Methylene Chloride:
Barceloneta Municipio, PR

Coke Oven Emissions:
Jefferson County, AL
Lake County, IN
Marion County, IN
Wayne County, MI

Naphthalene:
Broward County, FL

POM as non-15-PAH:
Union County, OR

Data Analysis Products: Toxicity-Weighted Emissions

- Noncancer Toxicity - Among the UATMP counties (44):

Pollutant	# Counties
Acrolein	42
Manganese*	2

*** Lake County, IN and Dane County,WI**

Wrap-Up

- The 2006 UATMP consisted of 59 sites in 38 locations.
- Over 180,000 concentrations were collected
- Completeness among all the sample types were greater than 92%
- Population exposure appeared to be the main focus, as most sites were located in residential locations and urban/suburban land use types.
- Thirteen pollutants were identified as pollutants of interest across the 2006 network using a risk screening approach. Site-specific pollutants of interest were also identified.

Wrap-Up

- Formaldehyde, acrolein, and benzene each recorded daily measurements that were greater than ATSDR's short-term MRL.
- Formaldehyde and acrolein recorded seasonal averages that were greater than ATSDR's intermediate-term MRL.
- Cancer and noncancer risk were calculated and compared to the 1999 NATA risk values.
- Toxicity-weighted pollutant emissions were calculated at the county-level and ranked; these values were compared to the ambient monitoring ranking of concentrations.

Questions?

Regi Oommen
Eastern Research Group
regi.oommen@erg.com
919-468-7829

EPA WAM: Mr. Michael N. Jones, 919-541-0528
jones.mike@epa.gov