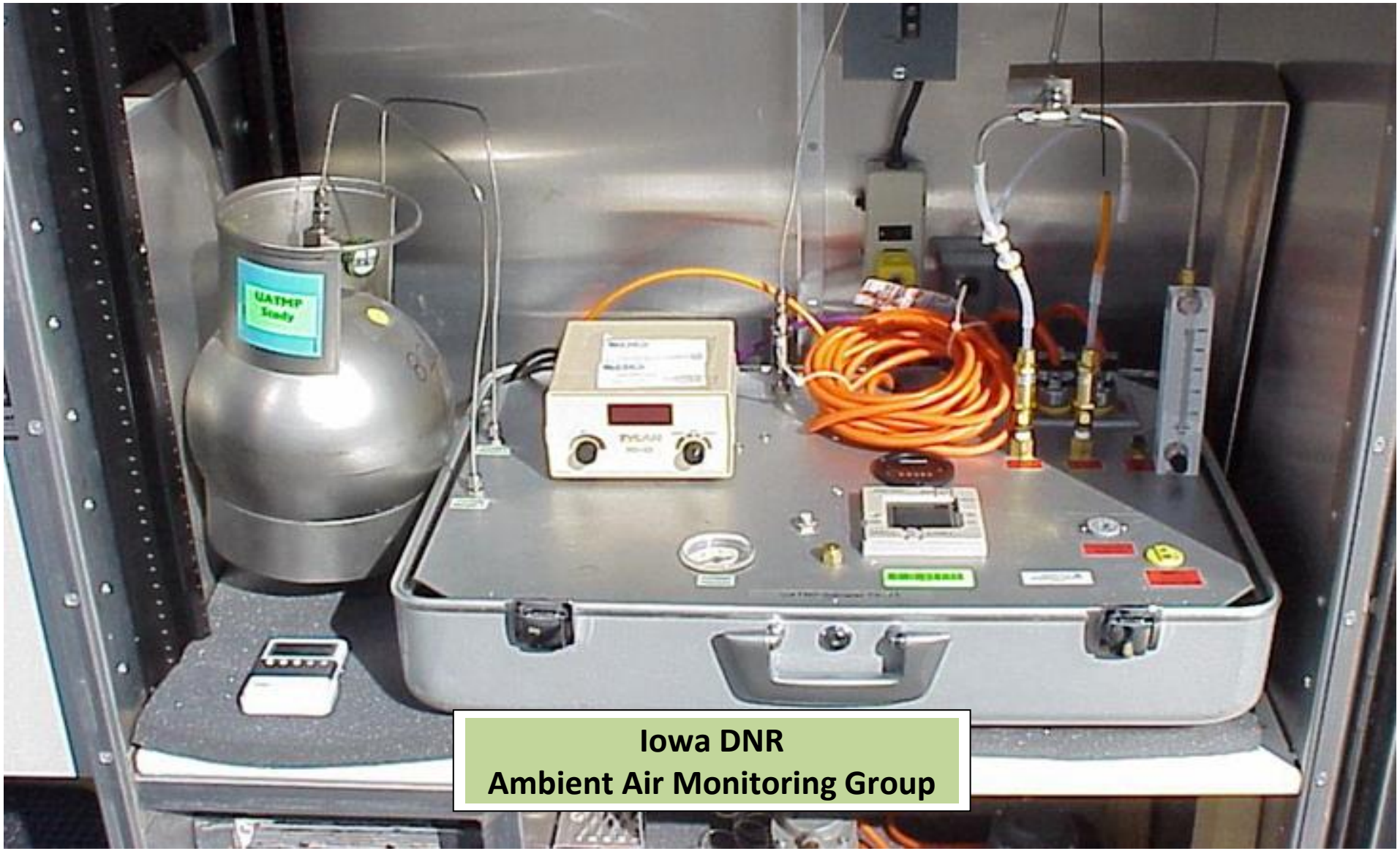
Iowa Toxics Sampling 2014

Results for Benzene, Acetaldehyde, and Formaldehyde



Iowa DNR
Ambient Air Monitoring Group

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Summary

Scope

Section 112 of the Clean Air Act [1] contains the federal strategy for protecting the public from air toxics emissions. The Act specifies a particular list of air toxics called "hazardous air pollutants" (HAPs) for regulatory action [2]. Emitters of large amounts of these HAPs are subject to regulations that require adoption of work practices or installation of control technologies in order to reduce HAP emissions [3]. The Act requires a periodic assessment of the residual health risk posed by the HAPs [4] and adoption of additional control standards where necessary [5].

In order to establish long term trends in HAP concentrations across the nation as a component of its residual risk assessment, the Environmental Protection Agency (EPA) has funded national air toxics trends stations (NATTS) [6]. These sites contain a standard suite of samplers and analytical protocols [7]. Unlike NATTS sites, Iowa's air toxics sites do not have instrumentation to measure toxic metals, polycyclic aromatic hydrocarbons, or black carbon.

A review of the historical air toxics monitoring dataset [8] argues that benzene, formaldehyde, 1,3-butadiene, acrolein, arsenic, hexavalent chromium, and diesel particulate pose the greatest risk to the public health on a national level. Only two of the seven national risk drivers are discussed in this report, and only four are quantified by the limited air toxics sampling currently conducted in Iowa.

Sampling Schedules

Samples were gathered on a nominal schedule of one sample every twelfth day. In calculations of average pollutant levels and cancer risks, samples collected on a more frequent schedule were averaged over the twelve day period between scheduled samples to estimate a one in twelve sampling schedule and avoid introduction of bias to the data. The monitoring schedule for formaldehyde and acetaldehyde was accelerated to one in six days during ozone season (April through October).

Data Capture

For the purpose of this report, we define a valid twelve-day average as an average constructed from one or more samples collected during the scheduled twelve-day sampling period. The data capture rate is defined as the ratio of the number of valid twelve-day averages divided by the number of scheduled twelve-day periods in the year (30). EPA data analysis guidelines usually require 75% data completeness across each sampling quarter.

Several sites failed to meet quarterly completeness guidelines for benzene. Cedar Rapids, Public Health and Des Moines, Health Dept. failed to meeting requirements in quarter 2 (50%

each). In quarter 3 Cedar Rapids, Public Health and Davenport, Jefferson School failed to meet the completeness requirement (71% each).

Data Handling

This report characterizes only the cancer risk associated with exposure to the toxic contaminants measured, and does not quantify other "non-cancer" risks such as neurological or reproductive damage associated with the measured exposure levels. The cancer risk associated with a given exposure level was quantified only when an Air Unit Cancer Risk was available in EPA's Integrated Risk Information System (IRIS) database. Pollutants were selected for inclusion in this report based on the screening criterion that the excess cancer risk resulting from a lifetime exposure to the average contaminant concentration was greater than the EPA benchmark of one in a million. When calculating the cancer risks and annual summary statistics for the selected pollutants, reported data values less than the method detection limit (MDL) are replaced with data values equal to half the MDL. No sites reported concentrations under the MDL in 2014.

Precision Data

Precision data are reported for the total number of collocated pairs of canisters or cartridges collected. Precision statistics shown in this report have been calculated according to 40 CFR Part 58, Appendix A (2006) using the methodology applicable to collocated fine particulate data pairs. The formulas are reproduced in Appendix A.

Results of the Analysis

Formaldehyde, acetaldehyde, and benzene concentrations were measured at levels above the EPA benchmark at all Iowa sites. Formaldehyde levels measured during the study period are associated with a much higher cancer risk than any other pollutant measured in this study.

IRIS specifies different levels of certainty associated with its cancer risk factors. Benzene is classified as a known human carcinogen (Class A). Formaldehyde is a Class B1 carcinogen, and acetaldehyde is classified as a Class B2 carcinogen. Class B contains probable human carcinogens; Class B1 pollutants are associated with limited evidence of carcinogenicity in humans but sufficient evidence of carcinogenicity in animals, whereas a B2 classification indicates only sufficient evidence of carcinogenicity in animals. [9].

A primary contaminant is directly emitted into the ambient air from its source. A secondary contaminant is formed from a chemical reaction of other contaminants already present in the atmosphere from natural or anthropogenic sources.

Benzene is a primary contaminant, with emissions largely attributed to vehicular traffic. Formaldehyde and acetaldehyde are both primary and secondary contaminants. Motor vehicle

emissions contribute to primary emissions by incomplete combustion of fuel; secondary formation results from photochemical oxidation of exhaust pipe pollutants. Secondary formation of these pollutants is enhanced in the summertime due to suitable weather conditions such as higher temperature and greater hours of sunlight. Formaldehyde is also produced in large quantities by natural events such as forest or brush fires [10]. In interpreting the results of the risk assessment contained in this type of report, EPA has encouraged States to compare the risks caused by toxic outdoor air pollution to other risks experienced in everyday life. The highest excess lifetime cancer risk identified in this report is approximately three excess cancers per 100,000 people (3×10^{-5}), associated with average formaldehyde levels at the urban Des Moines monitoring site and source-oriented site in Clinton. For comparison, according to the 2014 edition of *Injury Facts* published by the National Safety Council, the lifetime risk of dying in a motor vehicle accident as 8.9×10^{-3}, or approximately 280 times higher. The lifetime risk of being killed by lightning is 7.4×10^{-6}, or approximately 4.3 times lower than developing cancer at this level of formaldehyde exposure [11].

References

1. Federal rules regulating air toxics: http://www.epa.gov/ttn/atw/eparules.html

2. Current list of HAPs and their health effects: http://www.epa.gov/ttn/atw/hlthef/hapindex.html

3. EPA regulations limiting HAPs emissions: http://www.epa.gov/ttn/atw/mactfnlalph.html

4. EAP's latest national assessment of health risks due to HAPs: http://www.epa.gov/ttn/atw/natamain/

5. Residual risk assessments: http://www.epa.gov/ttn/atw/rrisk/rtrpg.html

6. Current list of NATTS sites: http://www.epa.gov/ttnamti1/files/ambient/airtox/nattsite.pdf

7. Sampling protocol used to operate NATTS sites: http://www.epa.gov/ttn/amtic/files/ambient/airtox/NATTS_Model_QAPP.pdf

8. Historical review of air toxics monitoring data: http://www.ladco.org/reports/toxics/sti/

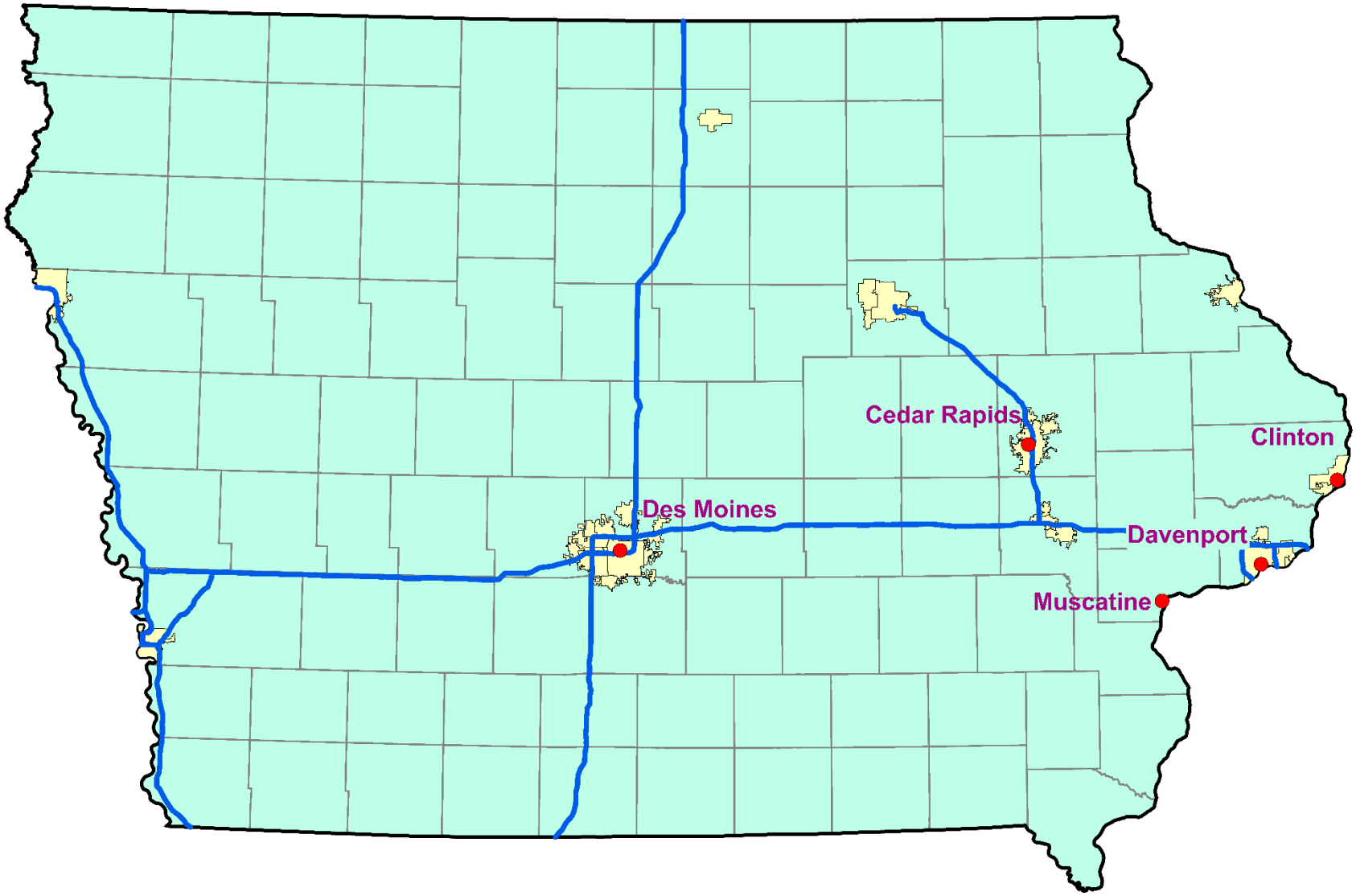
9. Integrated Risk Information System: http://www.epa.gov/iris

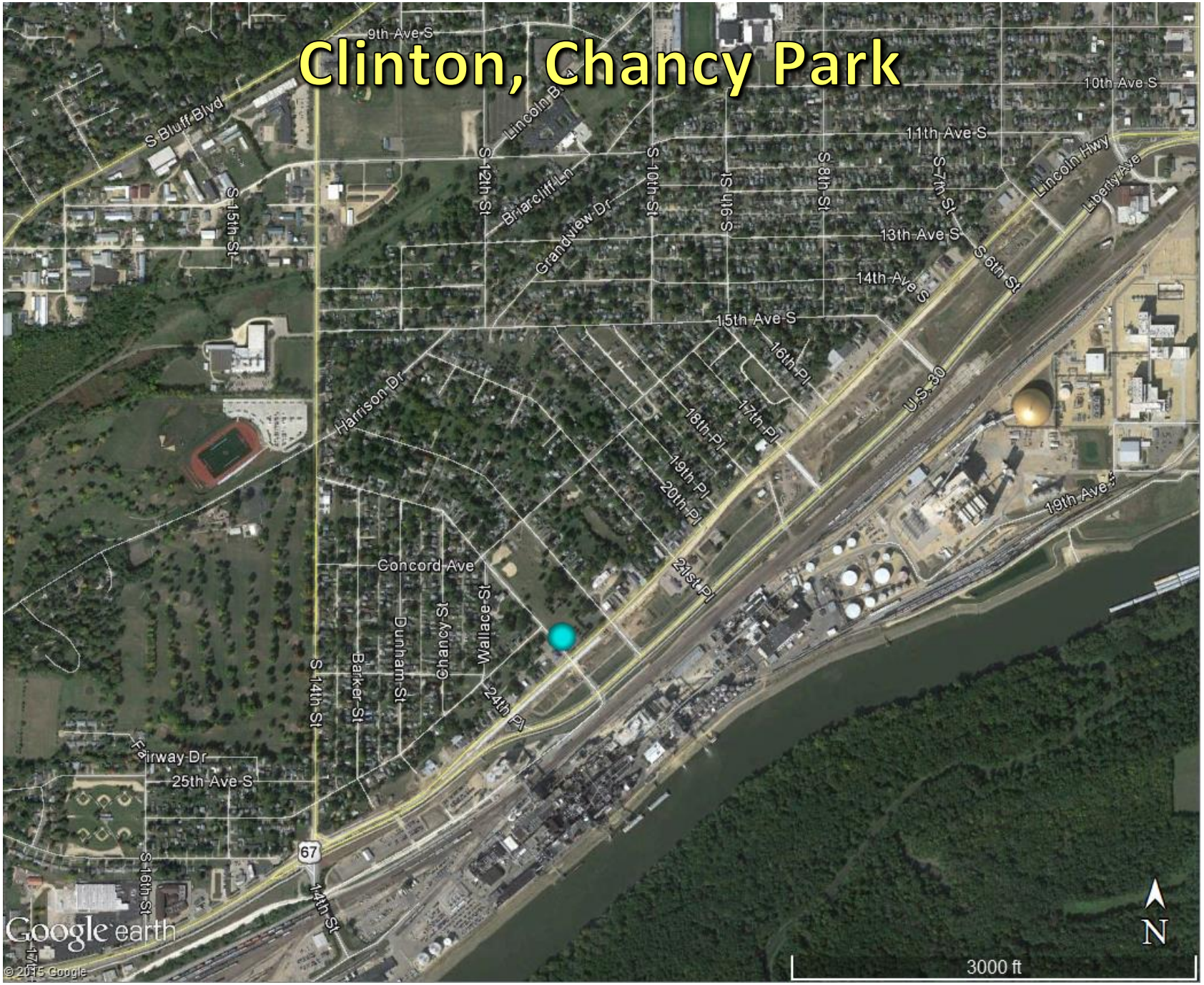
10. Reinhardt TE, Ottmar RD. "Baseline Measurements of Smoke Exposure Among Wildland Firefighters." Journal of Occupational and Environmental Hygiene 2004 Sep; 1 (9):593-606. http://www.ncbi.nlm.nih.gov/pubmed?term=Baseline%20Measurements%20of%20Smoke%20Exposure%20Among%20Wildland

11. Mortality Odds: http://www.nsc.org/learn/safety-knowledge/Pages/injury-facts-chart.aspx

Air Toxics Monitoring Network 2014				
Site ID	**Site Label**	**City**	**Address**	**County**
190450019	Clinton, Chancy Park	Clinton	23rd & Camanche	Clinton
191130040	Cedar Rapids, Public Health	Cedar Rapids	500 11th St. NW	Linn
191390020	Muscatine, Musser Park	Muscatine	Oregon St. & Earl Ave.	Muscatine
191530030	Des Moines, Health Dept.	Des Moines	1907 Carpenter Ave.	Polk
191630015	Davenport, Jefferson School	Davenport	10th St. & Vine St.	Scott

Iowa 2014 Air Toxics Monitoring Network

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10th Ave S
11th Ave S
13th Ave S
14th Ave S
15th Ave S
19th Ave S
25th Ave S
S Bluff Blvd
S 15th St
S 12th St
S 10th St
S 9th St
S 8th St
S 7th St
S 6th St
S 14th St
S 16th St
Lincoln Hwy
Liberty Ave
Lincoln Dr
Briarcliff Ln
Grandview Dr
Harrison Dr
16th Pl
17th Pl
18th Pl
19th Pl
20th Pl
21st Pl
24th Pl
U.S. 30
Concord Ave
Wallace St
Chancy St
Dunham St
Barker St
Fairway Dr
67
Google earth
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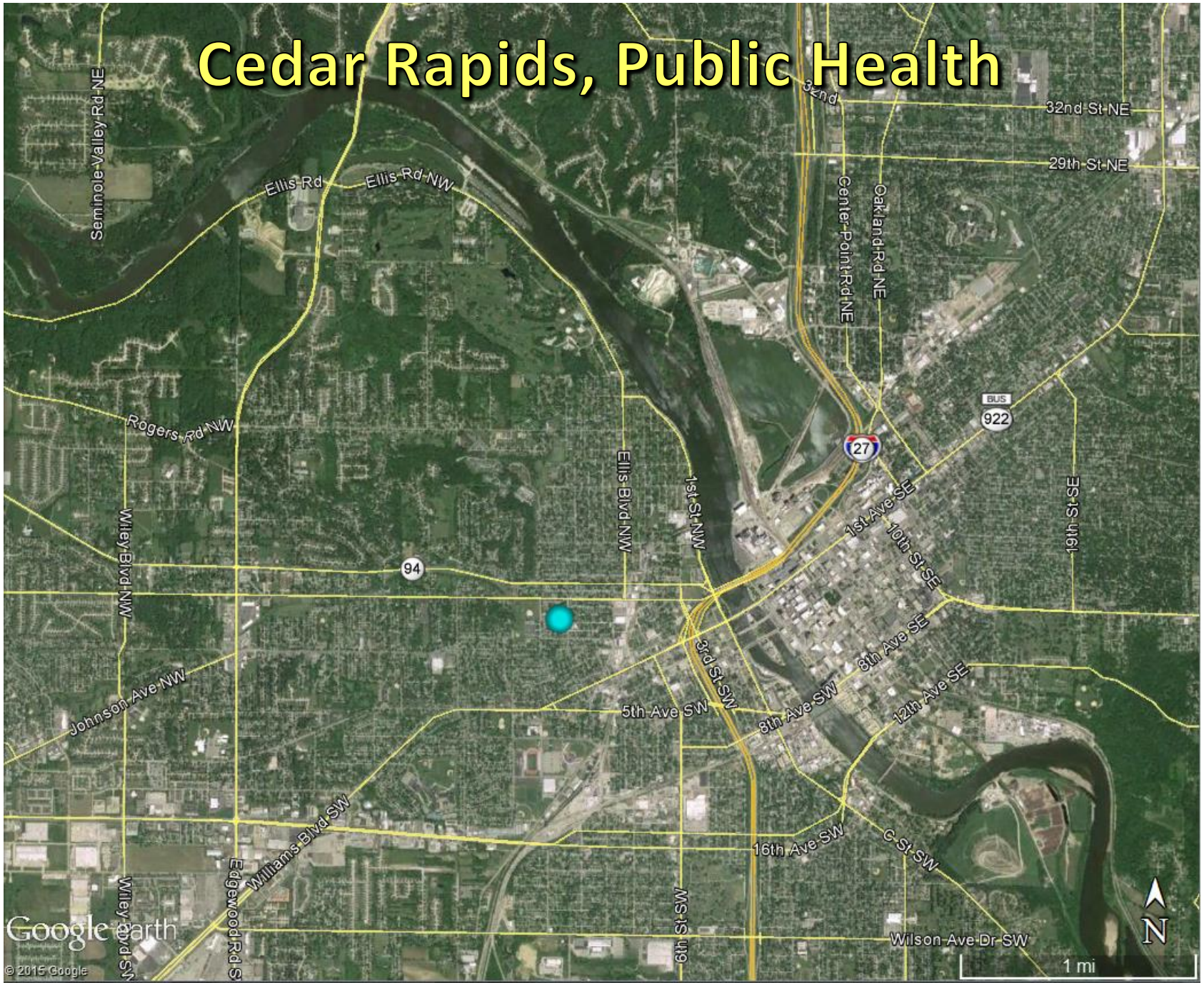
3000 ft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Ellis Rd
Ellis Rd NW
32nd St NE
29th St NE
Center Point Rd NE
Oakland Rd NE
BUS
922
27
Rogers Rd NW
Ellis Blvd NW
1st St NW
1st Ave SE
10th St SE
19th St SE
Wiley Blvd NW
94
8th Ave SE
12th Ave SE
3rd St SW
8th Ave SW
Johnson Ave NW
5th Ave SW
Williams Blvd SW
16th Ave SW
C St SW
Edgewood Rd SW
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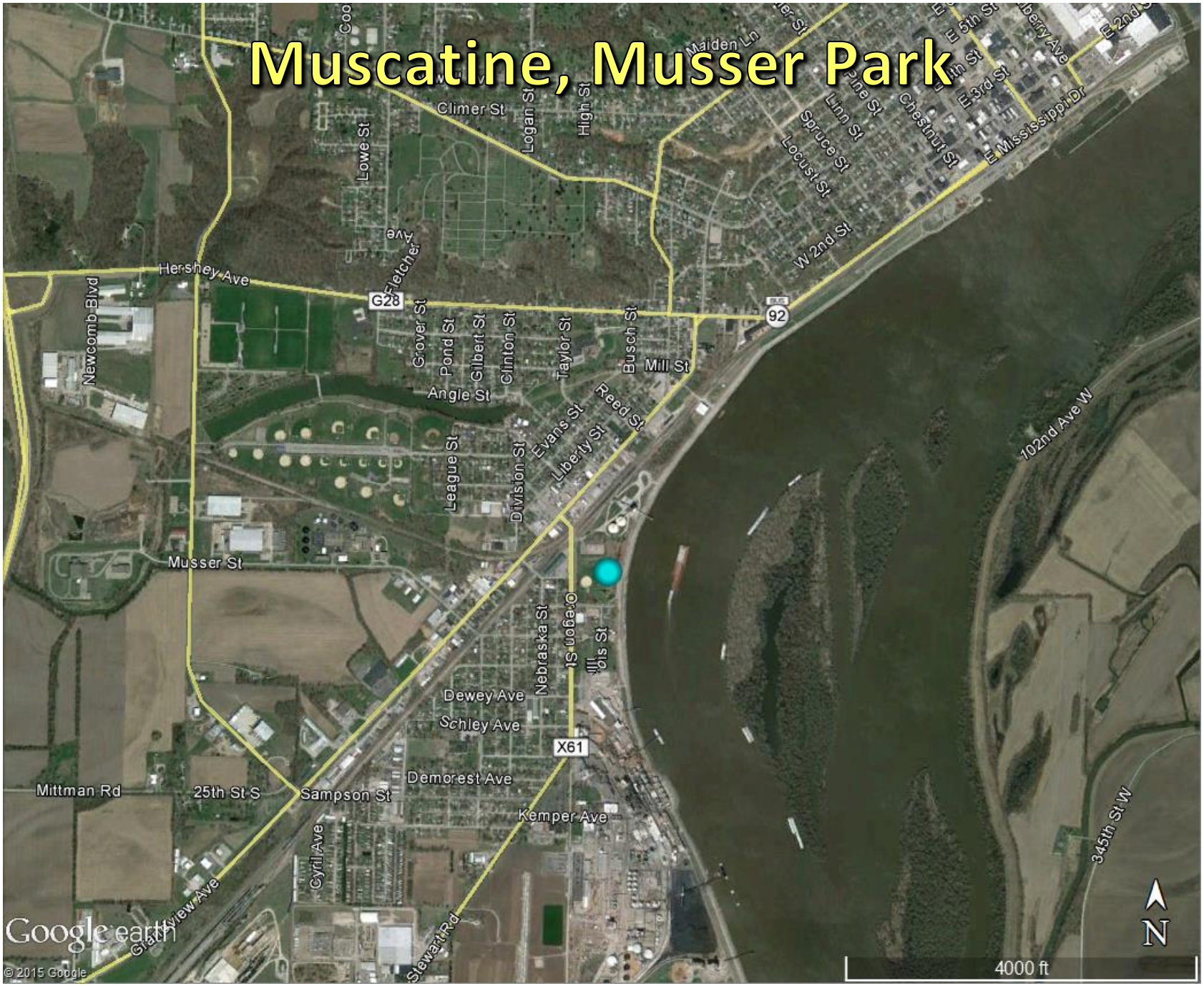
Muscatine, Musser Park
Climer St
Logan St
High St
Lowe St
Maiden Ln
Pine St
Linn St
Spruce St
Locust St
Chestnut St
E 5th St
E 3rd St
E Mississippi Dr
Liberty Ave
E 2nd St
W 2nd St
Fletcher Ave
Hershey Ave
G28
92
Newcomb Blvd
Grover St
Pond St
Gilbert St
Clinton St
Taylor St
Busch St
Mill St
Angle St
Reed St
Evans St
Liberty St
Division St
League St
Musser St
Nebraska St
Oregon St
Illinois St
Dewey Ave
Schley Ave
X61
Demorest Ave
Kemper Ave
Mittman Rd
25th St S
Sampson St
Cyril Ave
Glenview Ave
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345th St W
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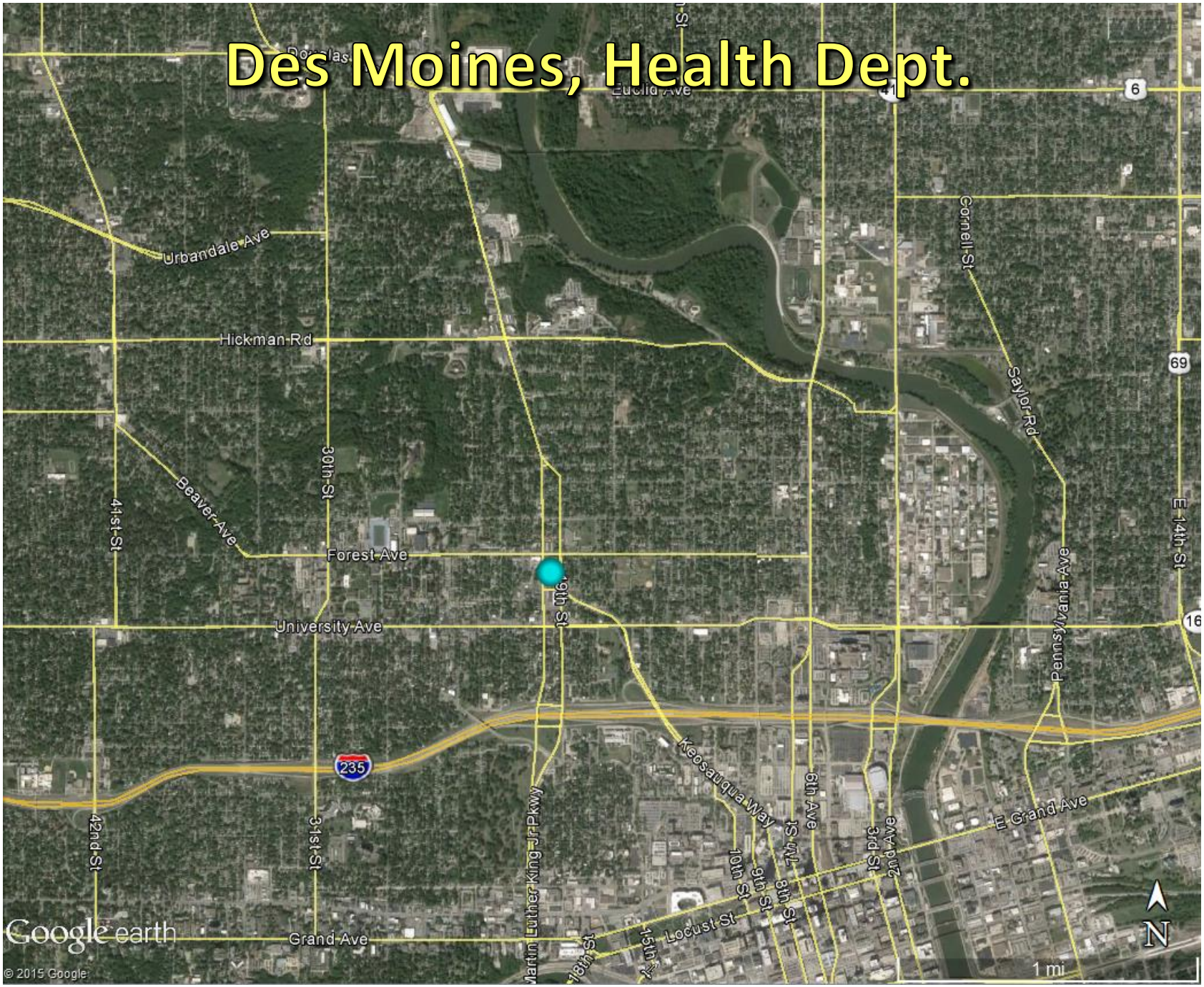
Des Moines, Health Dept.
Urbandale Ave
Hickman Rd
Beaver Ave
41st St
30th St
Forest Ave
University Ave
9th St
Keosauqua Way
6th Ave
Cornell St
Saylor Rd
Pennsylvania Ave
E 14th St
E Grand Ave
2nd Ave
3rd St
7th St
8th St
10th St
9th St
Locust St
Martin Luther King Jr Pkwy
42nd St
31st St
Grand Ave
235
6
69
16
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Davenport, Jefferson School
E 29th St
W Central Park Ave
Hickory Grove Rd
Eastern Ave
N Lincoln Ave
W Locust St
E Locust St
Kirkwood Blvd
Bridge Ave
E 12th St
Waverly Rd
N Division St
N Marquette St
N Gaines St
N Harrison St
E 4th St
E 3rd St
E River Dr
61
67
W River Dr
Arsenal Bridge
Rockingham Rd
Centennial Bridge
Rodman Ave
Bect Ave
1st Ave
92
24th St
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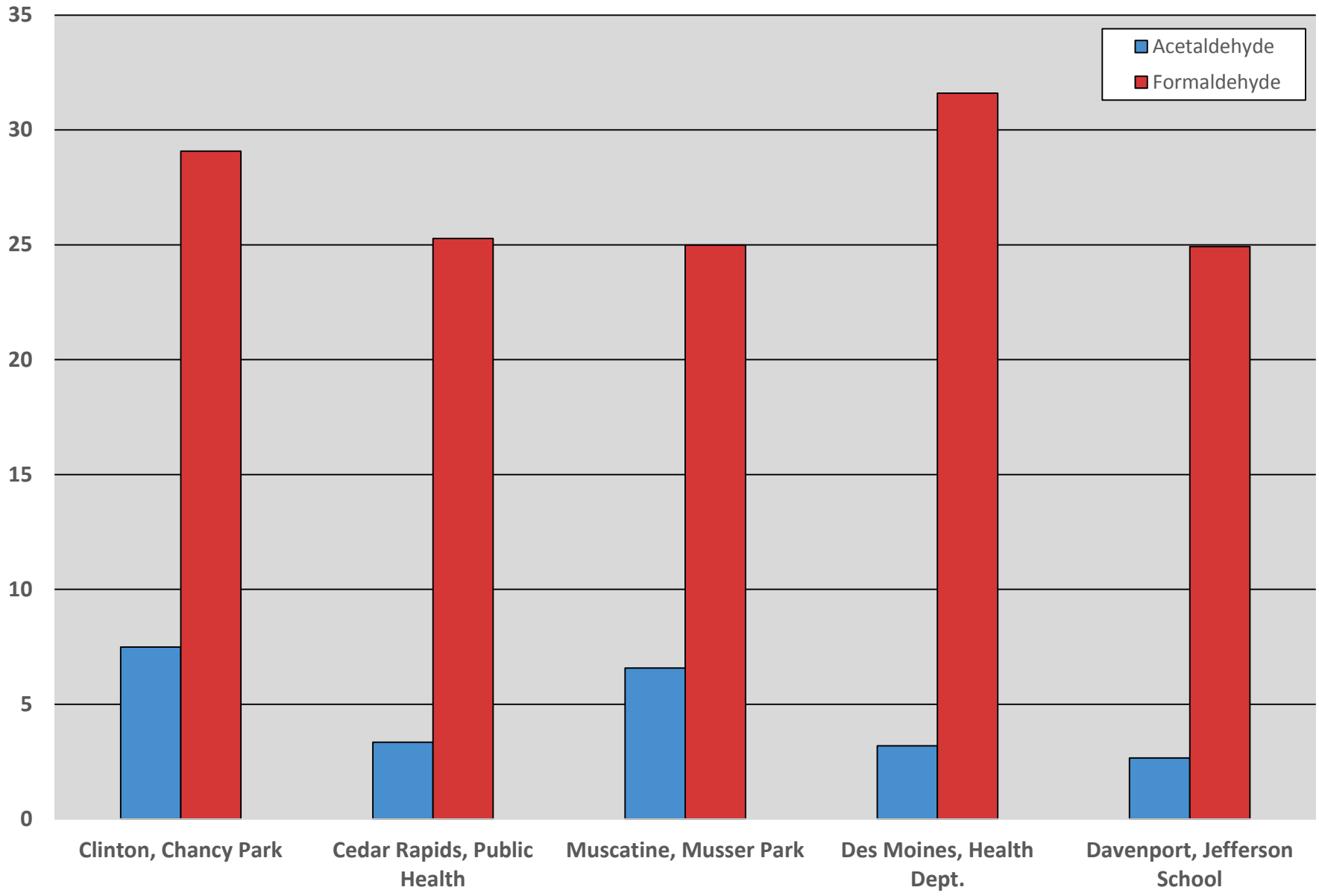
Excess Cancer Risk per Million People, Aldehydes – 2014

Site / Pollutant	Clinton, Chancy Park	Cedar Rapids, Public Health	Muscatine, Musser Park	Des Moines, Public Health	Davenport, Jefferson School
Formaldehyde	29 (±2)	25 (±3)	25 (±3)	32 (±5)	25 (±5)
Acetaldehyde	7.5 (±1.7)	3.3 (±0.5)	6.6 (±1.6)	3.2 (±0.3)	2.7 (±0.4)

Values listed in parentheses represent the 95% Confidence Interval.

Excess Cancer Risk per Million People, Aldehydes – 2014



Concentration Summary – Aldehydes (ppb)

Site / Pollutant	Clinton, Chancy Park	Cedar Rapids, Public Health	Muscatine, Musser Park	Des Moines, Public Health	Davenport, Jefferson School
Formaldehyde	1.8 (±0.1)	1.6 (±0.2)	1.6 (±0.2)	2.0 (±0.3)	1.6 (±0.3)
Acetaldehyde	1.9 (±0.4)	0.8 (±0.1)	1.7 (±0.4)	0.8 (±0.1)	0.7 (±0.1)

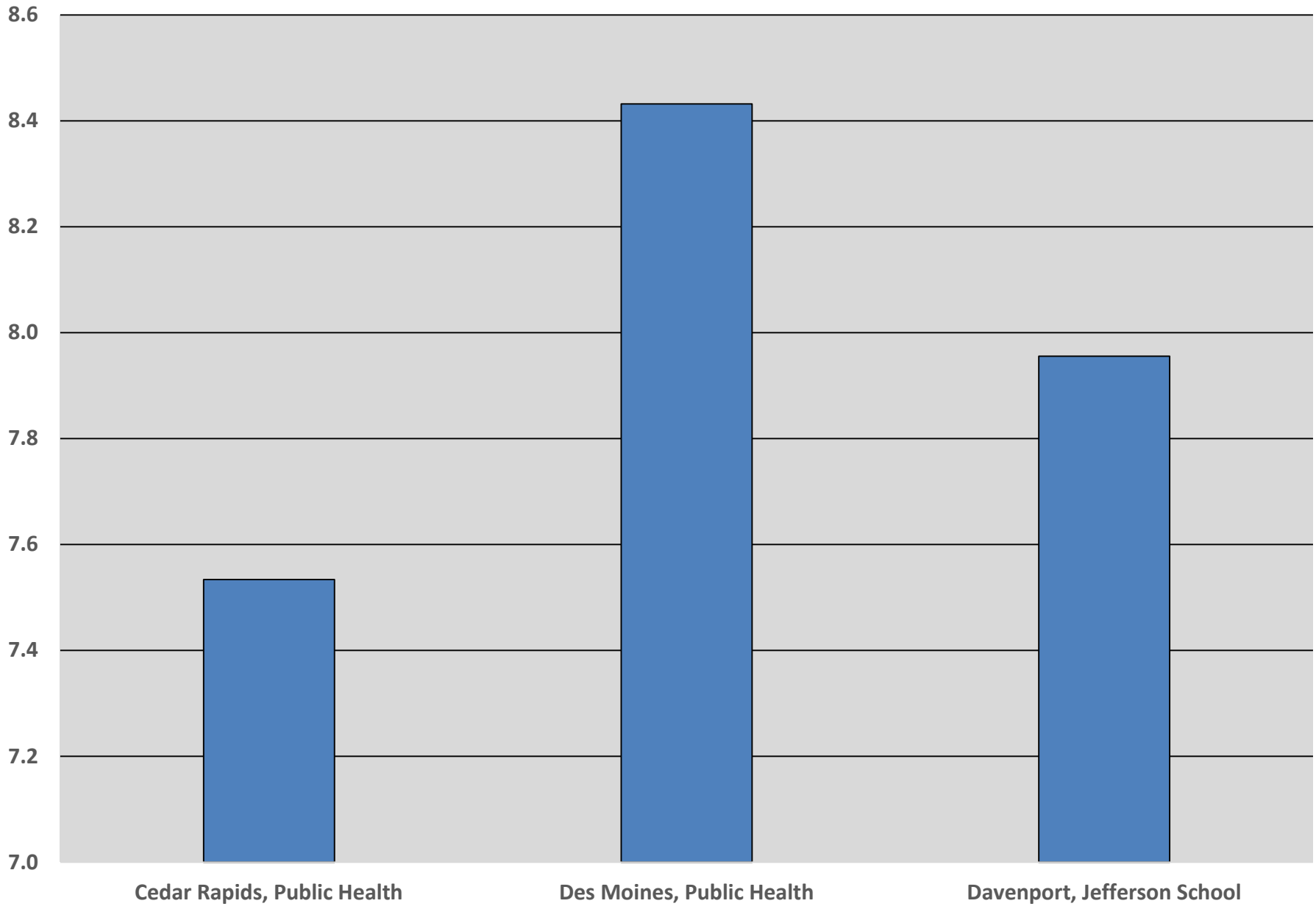
Notes: Values indicated are the average concentrations in parts per billion measured at each site in 2013.
Data from enhanced summer monitoring at the site were averaged to prevent seasonal bias.
Values listed in parentheses represent the 95% Confidence Interval for the mean.

Excess Cancer Risk* per Million People, Benzene – 2014

Site / Pollutant	Cedar Rapids, Public Health	Des Moines, Public Health	Davenport, Jefferson School
Benzene	**7.5 (±1.4)**	**8.4 (±1.9)**	**8.0 (±1.6)**

*IRIS lists two cancer risk estimates for Benzene, and the higher risk estimate is used for the statistics in this report.
Values listed in parentheses represent the 95% Confidence Interval.

Excess Cancer Risk per Million People, Benzene – 2014



Concentration Summary – Benzene (ppb)

Site / Pollutant	Cedar Rapids, Public Health	Des Moines, Public Health	Davenport, Jefferson School
Benzene	**0.30 (±0.06)**	**0.34 (±0.08)**	**0.32 (±0.06)**

Notes: Values indicated are the average concentrations in parts per billion measured at each site in 2013. Values listed in parentheses represent the 95% Confidence Interval for the mean.

Percent Data Capture

Site / Pollutant	Clinton, Chancy Park	Cedar Rapids, Public Health	Muscatine, Musser Park	Des Moines, Public Health	Davenport, Jefferson School
Formaldehyde	**97%**	**100%**	**93%**	**97%**	**97%**
Acetaldehyde	**97%**	**100%**	**93%**	**97%**	**97%**
Benzene	**-**	**80%***	**-**	**80%***	**77%***

Note: Values indicated represent the number of valid samples taken relative to the scheduled number of samples at each site in 2014.

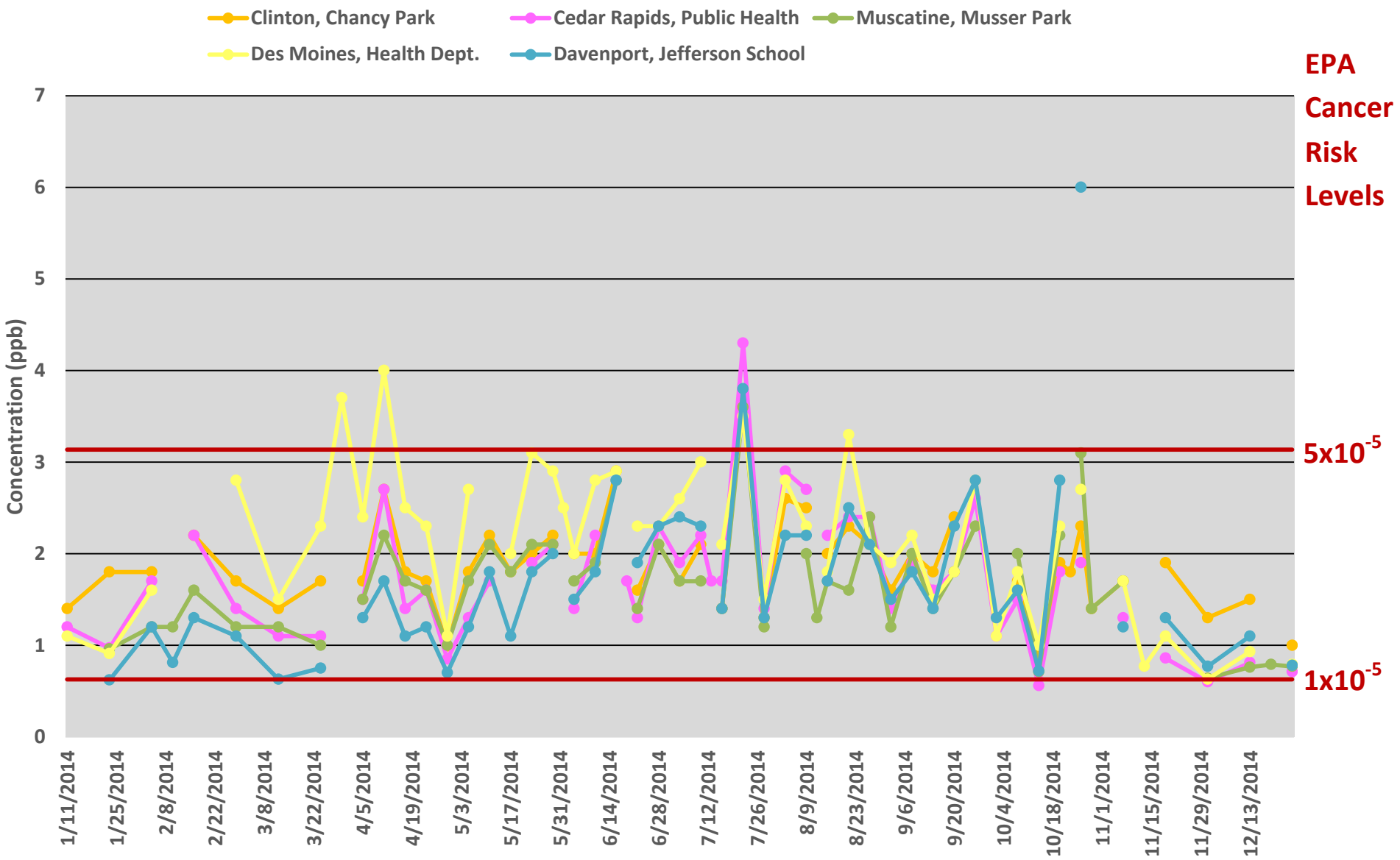
*Benzene failed to meet quarterly completeness (75%) during quarter 2 at Cedar Rapids and Des Moines. Benzene failed to meet quarterly completeness at Cedar Rapids and Davenport during quarter 3.

Annual Toxics Precision Statistics

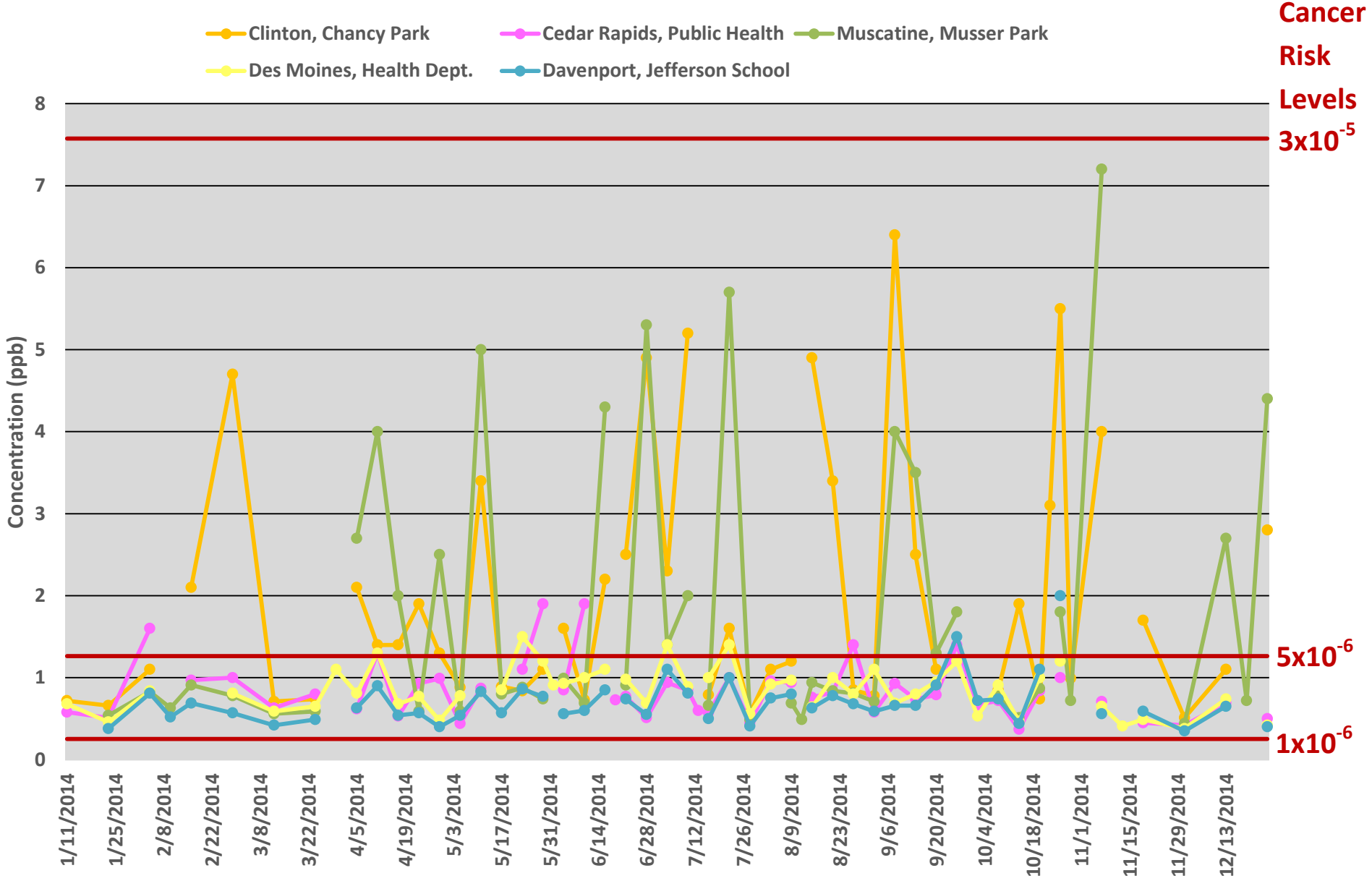
Statistic / Pollutant	Number of Pairs	Coefficient of Variation	Lower 90% Confidence Limit	Upper 90% Confidence Limit
Formaldehyde	64	3.25%	2.84%	3.80%
Acetaldehyde	64	3.30%	2.89%	3.87%
Benzene	23	5.43%	4.39%	7.20%

Notes: Statistic generated from collocated sample pairs. Coefficient of variation and confidence limits were calculated according to 2006 methods in Appendix A.

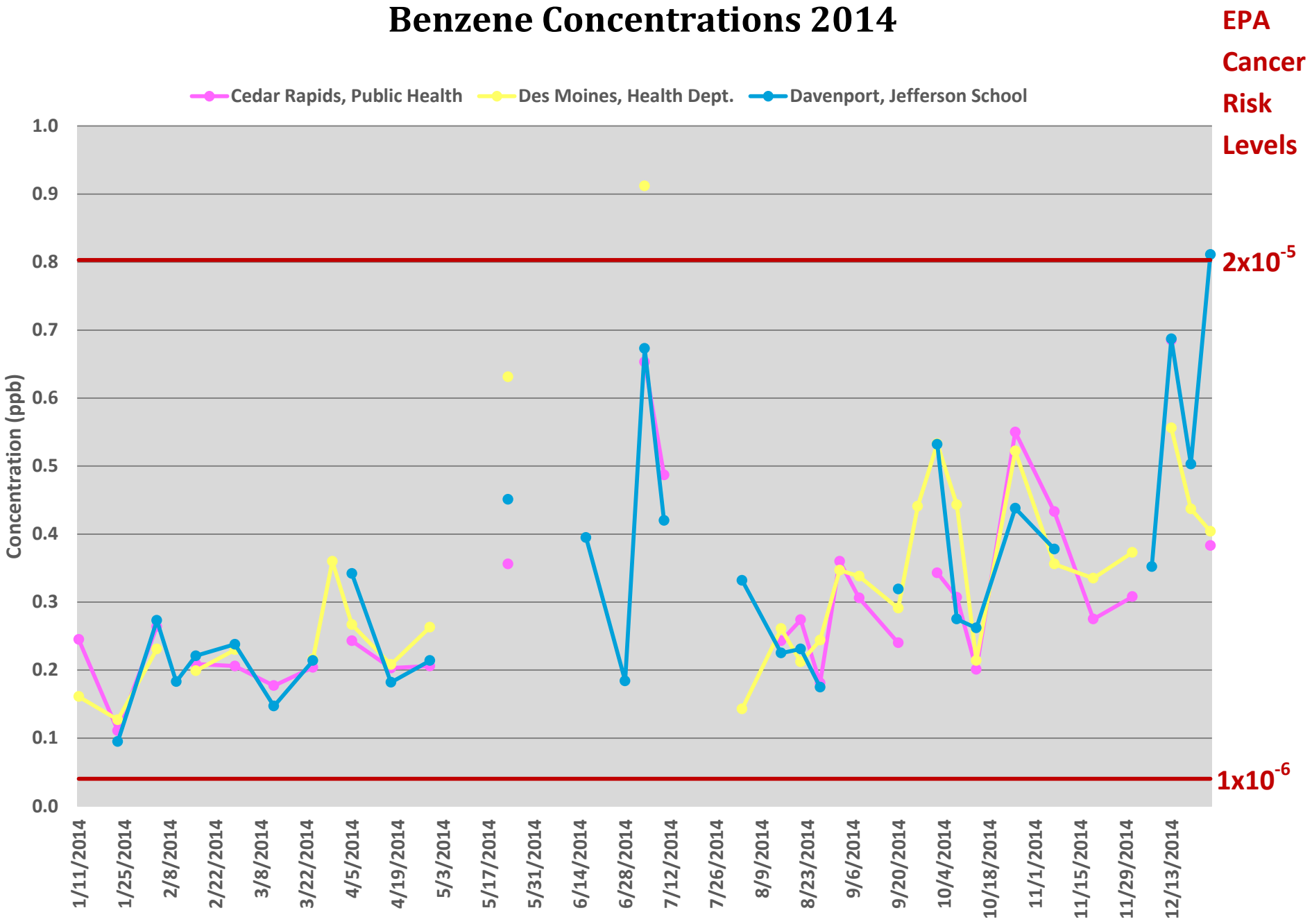
Formaldehyde Concentrations 2014



Acetaldehyde Concentrations 2014



Benzene Concentrations 2014



Raw Data – Formaldehyde Concentration (ppb)

Date	Clinton, Chancy Park	Cedar Rapids, Public Health	Muscatine, Musser Park	Des Moines, Health Dept.	Davenport, Jefferson School
1/11/14	1.4	1.2		1.1	
1/23/14	1.8	0.97	0.96	0.91	0.62
2/4/14	1.8	1.7	1.2	1.6	1.2
2/10/14			1.2		0.81
2/16/14	2.2	2.2	1.6		1.3
2/28/14	1.7	1.4	1.2	2.8	1.1
3/12/14	1.4	1.1	1.2	1.5	0.63
3/24/14	1.7	1.1	1	2.3	0.75
3/30/14				3.7	
4/5/14	1.7	1.5	1.5	2.4	1.3
4/11/14	2.7	2.7	2.2	4	1.7
4/17/14	1.8	1.4	1.7	2.5	1.1
4/23/14	1.7	1.6	1.6	2.3	1.2
4/29/14	0.99	0.85	1	1.1	0.7
5/5/14	1.8	1.3	1.7	2.7	1.2
5/11/14	2.2	1.7	2.1		1.8
5/17/14	1.8		1.8	2	1.1
5/23/14	2	1.9	2.1	3.1	1.8
5/29/14	2.2	2.1	2.1	2.9	2
6/1/14				2.5	
6/4/14	2	1.4	1.7	2	1.5
6/10/14	2	2.2	1.9	2.8	1.8
6/16/14	2.9		2.8	2.9	2.8
6/19/14		1.7			
6/22/14	1.6	1.3	1.4	2.3	1.9
6/28/14	2.1	2.3	2.1	2.3	2.3
7/4/14	1.7	1.9	1.7	2.6	2.4
7/10/14	2.1	2.2	1.7	3	2.3
7/13/14		1.7			
7/16/14	1.4	1.7	1.4	2.1	1.4
7/22/14	3.7	4.3	3.6	3.5	3.8
7/28/14	1.3	1.4	1.2	1.5	1.3
8/3/14	2.6	2.9		2.8	2.2
8/9/14	2.5	2.7	2	2.3	2.2
8/12/14			1.3		
8/15/14	2	2.2	1.7	1.8	1.7
8/21/14	2.3	2.4	1.6	3.3	2.5
8/27/14	2.1	2.4	2.4	2.1	2.1
9/2/14	1.6	1.4	1.2	1.9	1.5
9/8/14	2	1.9	2	2.2	1.8
9/14/14	1.8	1.6	1.4	1.5	1.4
9/20/14	2.4	1.8	1.8	1.8	2.3
9/26/14		2.6	2.3	2.8	2.8
10/2/14		1.1		1.1	1.3
10/8/14	1.7	1.5	2	1.8	1.6
10/14/14	0.85	0.56	0.71	1	0.72
10/20/14	1.9	1.8	2.2	2.3	2.8
10/23/14	1.8				
10/26/14	2.3	1.9	3.1	2.7	6
10/29/14	1.4		1.4		
11/7/14	1.7	1.3	1.7	1.7	1.2
11/13/14				0.77	
11/19/14	1.9	0.86		1.1	1.3
12/1/14	1.3	0.6	0.64	0.63	0.77
12/13/14	1.5	0.81	0.76	0.93	1.1
12/19/14			0.79		
12/25/14	1	0.71	0.77	0.79	0.78

Raw Data – Acetaldehyde Concentration (ppb)

Date	Clinton, Chancy Park	Cedar Rapids, Public Health	Muscatine, Musser Park	Des Moines, Health Dept.	Davenport, Jefferson School
1/11/14	0.72	0.58		0.68	
1/23/14	0.66	0.51	0.54	0.46	0.38
2/4/14	1.1	1.6	0.83	0.84	0.81
2/10/14			0.63		0.52
2/16/14	2.1	0.97	0.91		0.69
2/28/14	4.7	1	0.78	0.81	0.57
3/12/14	0.71	0.63	0.56	0.59	0.42
3/24/14	0.74	0.8	0.59	0.65	0.49
3/30/14				1.1	
4/5/14	2.1	0.62	2.7	0.81	0.63
4/11/14	1.4	1.3	4	1.3	0.9
4/17/14	1.4	0.53	2	0.68	0.54
4/23/14	1.9	0.93	0.59	0.77	0.57
4/29/14	1.3	0.99	2.5	0.48	0.4
5/5/14	0.88	0.44	0.59	0.78	0.54
5/11/14	3.4	0.87	5		0.83
5/17/14	0.89		0.8	0.85	0.57
5/23/14	0.84	1.1	0.88	1.5	0.86
5/29/14	1.1	1.9	0.74	1.2	0.77
6/1/14				0.91	
6/4/14	1.6	0.85	0.99	0.93	0.56
6/10/14	0.73	1.9	0.69	1	0.6
6/16/14	2.2		4.3	1.1	0.85
6/19/14		0.73			
6/22/14	2.5	0.77	0.91	0.98	0.74
6/28/14	4.9	0.51	5.3	0.69	0.55
7/4/14	2.3	0.94	1.4	1.4	1.1
7/10/14	5.2	0.85	2	0.89	0.81
7/13/14		0.6			
7/16/14	0.79	0.57	0.66	1	0.5
7/22/14	1.6	1	5.7	1.4	1
7/28/14	0.57	0.45	0.49	0.56	0.41
8/3/14	1.1	0.96		0.92	0.75
8/9/14	1.2	0.94	0.69	0.97	0.8
8/12/14			0.49		
8/15/14	4.9	0.76	0.94	0.64	0.63
8/21/14	3.4	0.82	0.84	1	0.78
8/27/14	0.85	1.4	0.81	0.8	0.68
9/2/14	0.78	0.58	0.71	1.1	0.59
9/8/14	6.4	0.93	4	0.69	0.66
9/14/14	2.5	0.74	3.5	0.8	0.66
9/20/14	1.1	0.79	1.3	0.95	0.91
9/26/14		1.4	1.8	1.2	1.5
10/2/14		0.67		0.53	0.72
10/8/14	0.85	0.72	0.77	0.91	0.74
10/14/14	1.9	0.37	0.51	0.47	0.44
10/20/14	0.74	0.84	0.87	1	1.1
10/23/14	3.1				
10/26/14	5.5	1	1.8	1.2	2
10/29/14	0.99		0.72		
11/7/14	4	0.71	7.2	0.65	0.56
11/13/14				0.41	
11/19/14	1.7	0.45		0.49	0.59
12/1/14	0.51	0.42	0.44	0.38	0.35
12/13/14	1.1	0.69	2.7	0.74	0.65
12/19/14			0.72		
12/25/14	2.8	0.5	4.4	0.42	0.4

Raw Data – Benzene Concentration (ppb)

Date	Cedar Rapids, Public Health	Des Moines, Health Dept.	Davenport, Jefferson School
1/11/14	0.245	0.161	
1/23/14	0.111	0.127	0.095
2/4/14	0.264	0.231	0.273
2/10/14			0.183
2/16/14	0.209	0.199	0.221
2/28/14	0.206	0.23	0.238
3/12/14	0.177		0.147
3/24/14	0.204	0.216	0.214
3/30/14		0.36	
4/5/14	0.243	0.267	0.342
4/17/14	0.203	0.208	0.182
4/29/14	0.206	0.263	0.214
5/11/14			
5/23/14	0.356	0.631	0.451
6/4/14			
6/16/14			0.395
6/28/14			0.184
7/4/14	0.653	0.912	0.673
7/10/14	0.487		0.42
7/22/14			
8/3/14		0.143	0.332
8/15/14	0.243	0.261	0.225
8/21/14	0.274	0.212	0.231
8/27/14	0.181	0.244	0.175
9/2/14	0.36	0.347	
9/8/14	0.306	0.338	
9/20/14	0.24	0.291	0.319
9/26/14		0.441	
10/2/14	0.343	0.533	0.532
10/8/14	0.307	0.443	0.275
10/14/14	0.201	0.214	0.262
10/26/14	0.55	0.522	0.438
11/7/14	0.433	0.356	0.378
11/19/14	0.275	0.335	
12/1/14	0.308	0.373	
12/7/14			0.352
12/13/14	0.685	0.556	0.687
12/19/14		0.437	0.503
12/25/14	0.383	0.404	0.811

* Indicates sample value reported is less than or equal to the minimum detectable limit.

Appendix A. Precision Calculations

Let c_i^1 and c_i^2 and represent two concentrations from a particular monitoring location taken on the same day. If both are greater than the MDL, then they may be used to estimate the precision of the data at the sampling location as follows:

First compute the average:

$$\overline{c_i} = \frac{c_i^1 + c_i^2}{2}$$

And the mean difference:

$$d_i = \frac{c_i^1 - c_i^2}{\overline{c_i}} * 100$$

Define the coefficient of variation for the pair of samples as:

$$CV_i = \frac{d_i}{\sqrt{2}}$$

Compute the root mean square of the individual coefficients of variation to determine the coefficient of variation of the data at the site for the entire year:

$$CV = \sqrt{\frac{\sum_{i=1}^{n} CV_i^2}{n}}$$

Finally, compute confidence limits in the usual way:

$$\text{Lower Confidence Limit} = CV\sqrt{\frac{n}{X^{-1}(0.05,n)}}$$

$$\text{Upper Confidence Limit} = CV\sqrt{\frac{n}{X^{-1}(0.95,n)}}$$

Where X^{1} represents the inverse of the chi-squared distribution.