Iowa Toxics Sampling 2021

Results for Acetaldehyde and Formaldehyde

Iowa DNR Ambient Air Monitoring Group

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Summary

Scope

Section 112 of the Clean Air Act contains the federal strategy for protecting the public from air toxics emissions, also known as "hazardous air pollutants" (HAPs) [Reference 1]. HAPs are pollutants that are known or suspected to cause cancer, other serious health effects, or adverse environmental effects. The Clean Air Act provides a list of 188 HAPs for regulatory action [Reference 2]. Emitters of large amounts of these HAPs are subject to regulations, by the Environmental Protection Agency (EPA) and its regulatory partners at the State and local level. Such regulations can require adoption of work practices or installation of control technologies in order to reduce HAP emissions [Reference 3].

To assist with the regulation of HAPs, the Clean Air Act requires a periodic, national air toxics assessment (NATA) of the estimated public health risk posed by outdoor HAPs [Reference 4]. NATA provides broad estimates of the risk of developing cancer and serious noncancer health effects over census tracts across the country. From the 2014 NATA, formaldehyde contributed to about half of the nationwide average cancer risk from breathing air toxics and is considered a national cancer risk driver which is a pollutant that contributes most to risks and hazards [Reference 5]. Acetaldehyde is considered a national cancer risk contributor, which is a pollutant that may also have an impact but is generally less important at the national and regional scales than drivers. In 2021, EPA presented an updated Air Toxics Strategy [Reference 6]. Air Toxics Screening Assessment (AirToxScreen) is the successor to the previous National Air Toxics Assessment, or NATA, and is part of EPA's new approach to air toxics that provides updated data and risk analyses on an annual basis [Reference 7]. The 2017 AirToxScreen provided similar results to the 2014 NATA; formaldehyde contributed to about 55% of the nationwide total cancer risk from breathing air toxics, and acetaldehyde about 7%.

EPA developed the National Air Toxics Trends Station (NATTS) network to obtain long term monitoring data for outdoor HAP concentrations across the nation of consistent quality [Reference 8]. The current NATTS network consists of 27 sites across the United States, and a listing of these sites are provided as a pdf document on EPA's website, [Reference 9]. These sites contain a standard suite of samplers and analytical protocols [Reference 10] and can monitor over 100 pollutants.

There are no NATTS sites in Iowa, but Iowa does have five of its own air toxic monitoring sites. Unlike NATTS sites, Iowa's air toxics sites do not have instrumentation to measure toxic metals, polycyclic aromatic hydrocarbons, or black carbon (particulate matter emitted from sources that burn fossil fuels). Iowa air toxic sites monitor for acetaldehyde and formaldehyde.

Sampling Schedules

For the Iowa Air Toxic Monitoring Network, the sampling schedule for formaldehyde and acetaldehyde is based on Iowa's ozone season. Iowa's ozone season, as defined by EPA, is March through October. Air toxic samples were collected at a frequency of one sample every sixth day inside ozone season and one sample every twelfth day outside ozone season following the EPA sampling schedule calendar. For calculations of average pollutant levels and cancer risks, 12-day block averages were created. The days in a given block are the days between two days on EPA's one in twelve day sampling schedule, including the later of the two days that bracket this interval. Averaging over these 12-day blocks, instead of averaging over the raw data, is performed in order to avoid biasing the average due to accelerated sampling during ozone season.

Data Capture

For the purpose of this report, a valid twelve-day average is determined from the average of one or more samples collected during the scheduled twelve-day sampling period (12-day block). The annual 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, which is 30 twelve-day periods for 2021. All Iowa toxic sampling sites were 90% or greater for the annual data capture. EPA data analysis guidelines typically require 75% data completeness across each sampling quarter. Quarterly completeness is the ratio of the number of valid twelve-day averages within a quarter divided by the number of scheduled twelve-day periods in that quarter. All Iowa sites met this quarterly data capture goal for formaldehyde and acetaldehyde.

Data Handling

This report characterizes only the cancer risk associated with exposure to the toxic contaminants measured, and does not quantify other "non-cancer" public health 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 inhalation unit cancer risk was available in EPA's Integrated Risk Information System (IRIS) database. For the purpose of this report, a unit cancer risk of 1-in-1 million implies that, if 1 million people are exposed to the same concentration of a pollutant continuously (every day, 24 hours per day) over 70 years (an assumed lifetime), no more than one person is expected to or would likely contract cancer from this exposure [Reference 11]. Note, this risk would be in addition to any cancer risk borne by a person not exposed to these air toxics.

The EPA's IRIS program uses weight of evidence and hazard descriptors to categorize chemicals for carcinogenicity [Reference 12]. Chemicals are organized into groups based on their descriptor, from Group A "Carcinogenic to Humans" to Group E "Evidence of Non-carcinogenicity for Humans" [Reference 13]. Group B contains probable human carcinogens, "Probably Carcinogenic to Humans". Formaldehyde is a Group B1 carcinogen. B1 pollutants are associated with limited evidence of carcinogenicity in humans but sufficient evidence of carcinogenicity in animals. Acetaldehyde is classified as a Group B2 carcinogen. B2 classification for pollutants indicates only sufficient evidence of carcinogenicity in animals.

Precision Data

Precision statistics are calculated from the results of the analysis of duplicate cartridges. Precision statistics shown in this report have been calculated using the methodology applicable to collocated fine particulate data pairs as specified in the Code of Federal Regulations (CFR), Title 40, Chapter 1, Subchapter C, Part 58, Appendix A (typically referenced as 40 CFR Part 58, Appendix A). The formulas are reproduced in this document as Appendix A.

Results of the Analysis

EPA's current process of estimating cancer risk is based on the unit risk estimate for inhalation as discussed in the Data Handling section above. To restate, the unit cancer risk represents the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent over a lifetime at a concentration of 1 microgram per cubic meter (µg/m3) in air [Reference 13]. Formaldehyde and acetaldehyde concentrations were measured at levels above the EPA benchmark of one in a million excess lifetime cancer risk at all Iowa sites. Comparing the 2021 averages among the five Iowa sites, formaldehyde is associated with a much higher excess lifetime cancer risk than acetaldehyde. When the calculated 2021 formaldehyde excess cancer risk is compared to acetaldehyde excess cancer risk for each of the Iowa sites, formaldehyde ranges from approximately 2.8 times greater than acetaldehyde at Chancy Park in Clinton to approximately 12.5 times greater than acetaldehyde at the Department of Health building in Des Moines.

Reviewing the results of the network sites, formaldehyde levels at Davenport were the highest in the Iowa network, with approximately 50 excess cancer risks per million, calculated using the site's annual average. Acetaldehyde levels at Chancy Park in Clinton were the highest in the network, with approximately 11.2 excess cancer risks per million, calculated using the site's annual average.

Regarding the other Iowa sites for formaldehyde, the 2021 calculated excess lifetime cancer risks are similar for the Musser Park in Muscatine, Des Moines and Chancy Park in Clinton sites, were 38, 37, and 32 excess cancer risks per million. The Cedar Rapids site was calculated at 28 excess cancer risks per million for formaldehyde. Regarding acetaldehyde, the calculated excess lifetime cancer risks were similar for Musser Park in Muscatine and Davenport at values of 4.7 and 4.5 per million, respectively. The Des Moines and Cedar Rapids sites were similar, calculated at 3.0 and 2.8 excess cancer risks per million, respectively, for acetaldehyde.

Formaldehyde and acetaldehyde are both primary and secondary contaminants, though about 83 percent of ambient formaldehyde and 90 percent of ambient acetaldehyde are formed by secondary reactions [Reference 14]. A primary contaminant is directly emitted into the ambient air from its source. A secondary contaminant is formed from a chemical reaction with other contaminants already present in the atmosphere from natural or anthropogenic sources. Motor vehicle emissions contribute to primary emissions by incomplete combustion of fuel; secondary formation of these contaminants results from photochemical oxidation of exhaust pipe pollutants. Secondary formation of these contaminants 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 events such as forest or brush fires [Reference 15].

In interpreting the results of the risk assessment contained in this type of report, EPA has encouraged States to compare the risks associated with toxic outdoor air pollutants to other risks experienced in everyday life. The highest excess lifetime cancer risk calculated in this report is approximately 50 excess cancers per million, associated with the 2021 annual average formaldehyde level in Davenport. For comparison, according to the lifetime odds of death for selected causes in United States published by the National Safety Council in 2020, the lifetime risk of dying in a motor vehicle accident is 1 in 101, or approximately 200 times higher. Using the Davenport site 2021 average level of formaldehyde exposure for comparison, the lifetime risk of dying due to a dog attack is 1 in 69,016, or approximately 3 times lower than the risk of developing cancer [Reference 16].

References

1. Hyperlink is for EPA web site which provides information on hazardous air pollutants (HAPs).

2. Hyperlink is for EPA website that lists current hazardous air pollutants.

3. Hyperlink is for EPA website discussing regulations limiting HAP emissions.

4. Hyperlink is for the EPA National Air Toxics Assessment website (2014 is the latest national assessment of health risks due to HAPs).

5. Hyperlink is for the EPA pdf document "2014 NATA Summary of Results".

6. Hyperlink is for EPA 2021 Air Toxics Strategy pdf document

7. Hyperlink is for EPA Air Toxics Screening Assessment web page

8. Hyperlink is for EPA website regarding National Air Toxics Trends Stations.

9. Hyperlink is for EPA website listing current NATTS sites.

10. Hyperlink is for the EPA PDF Document titled Technical Assistance Document for the NATTS Program, dated October 2016.

11. Hyperlink is for EPA website titled "Frequently Asked Questions for NATA".

12. Hyperlink is for EPA Integrated Risk Information System website.

13. Hyperlink is for EPA Risk Assessment for Carcinogenic Effects website.

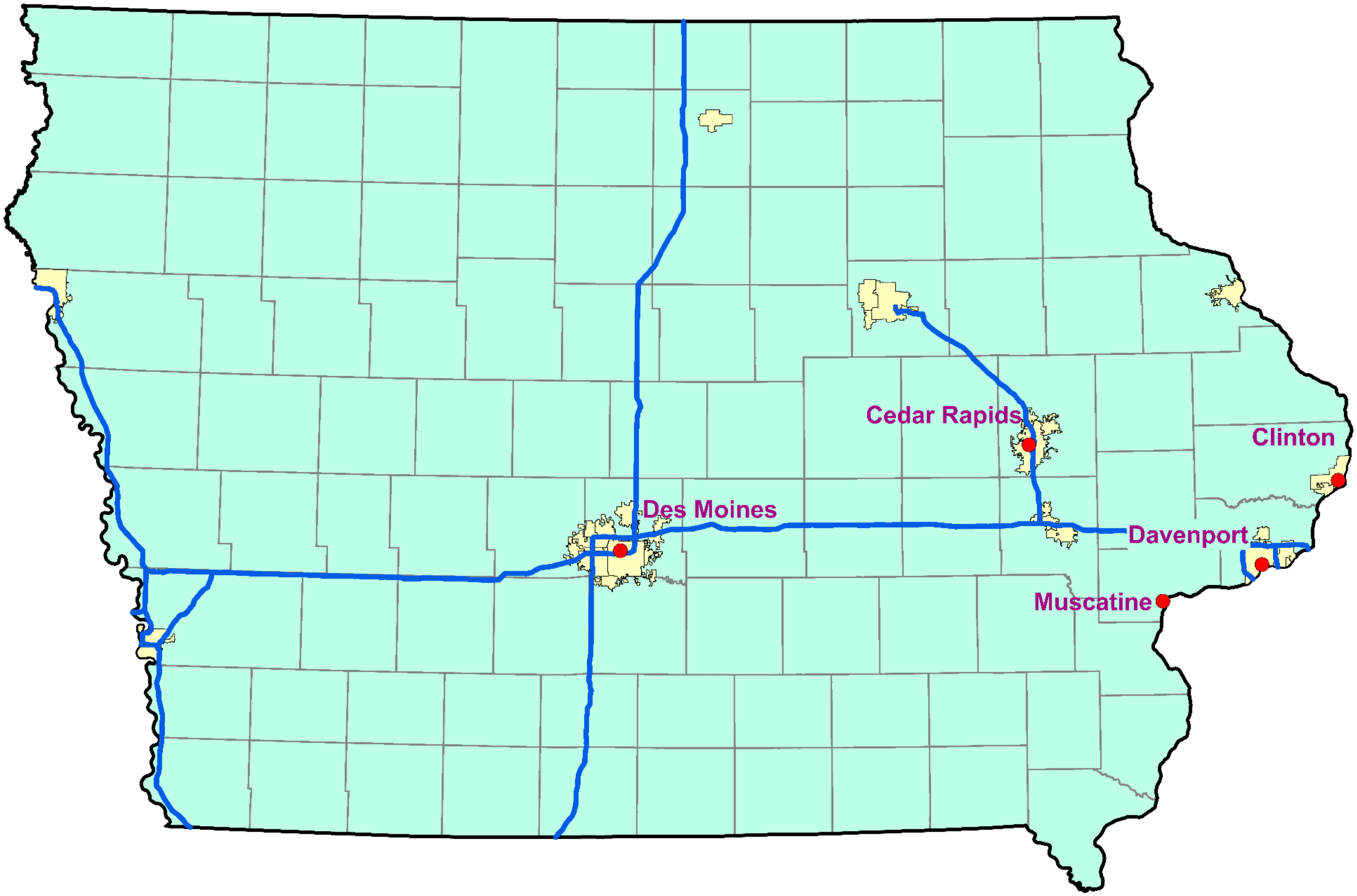
14. Hyperlink is for documented cited as: Weinhold, Bob. "Pollution Portrait: The Fourth National-Scale Air Toxics Assessment." Environmental Health Perspective, June 2011; 119(6): A254-A257.

15. Hyperlink is for document cited as: Liao, Jin et al. “Formaldehyde evolution in US wildfire plumes during the Fire Influence on Regional to Global Environments and Air Quality experiment (FIREX-AQ)”, Atmospheric Chemistry and Physics, 2021, Volume 21, issue 24, 18319-18331.

16. Hyperlink is for the National Safety Council website listing the Lifetime Mortality Odds.

Iowa 2021 Air Toxics Monitoring Network

Site Location Map

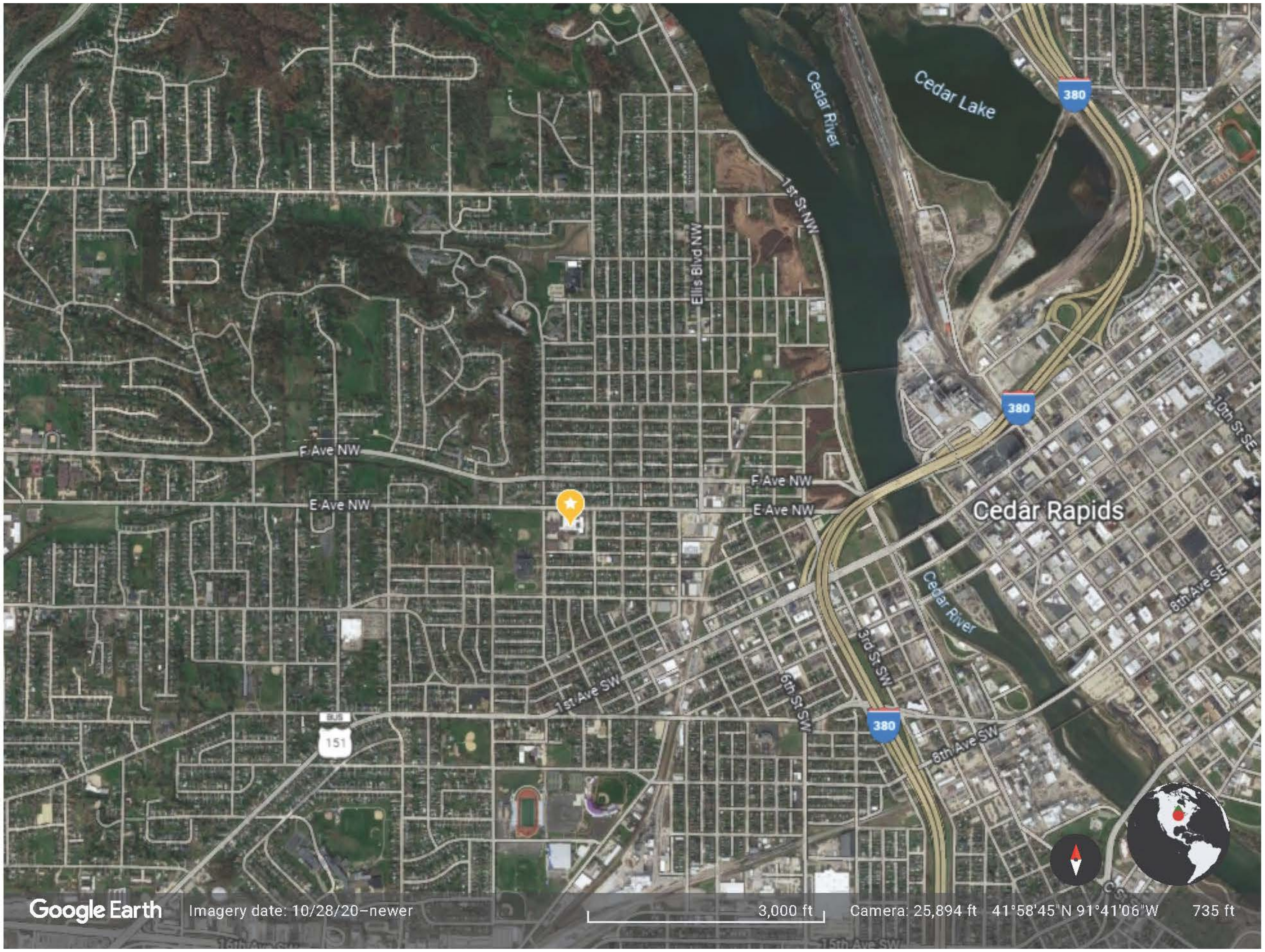


Air Toxics Monitoring Network 2021 Site Details

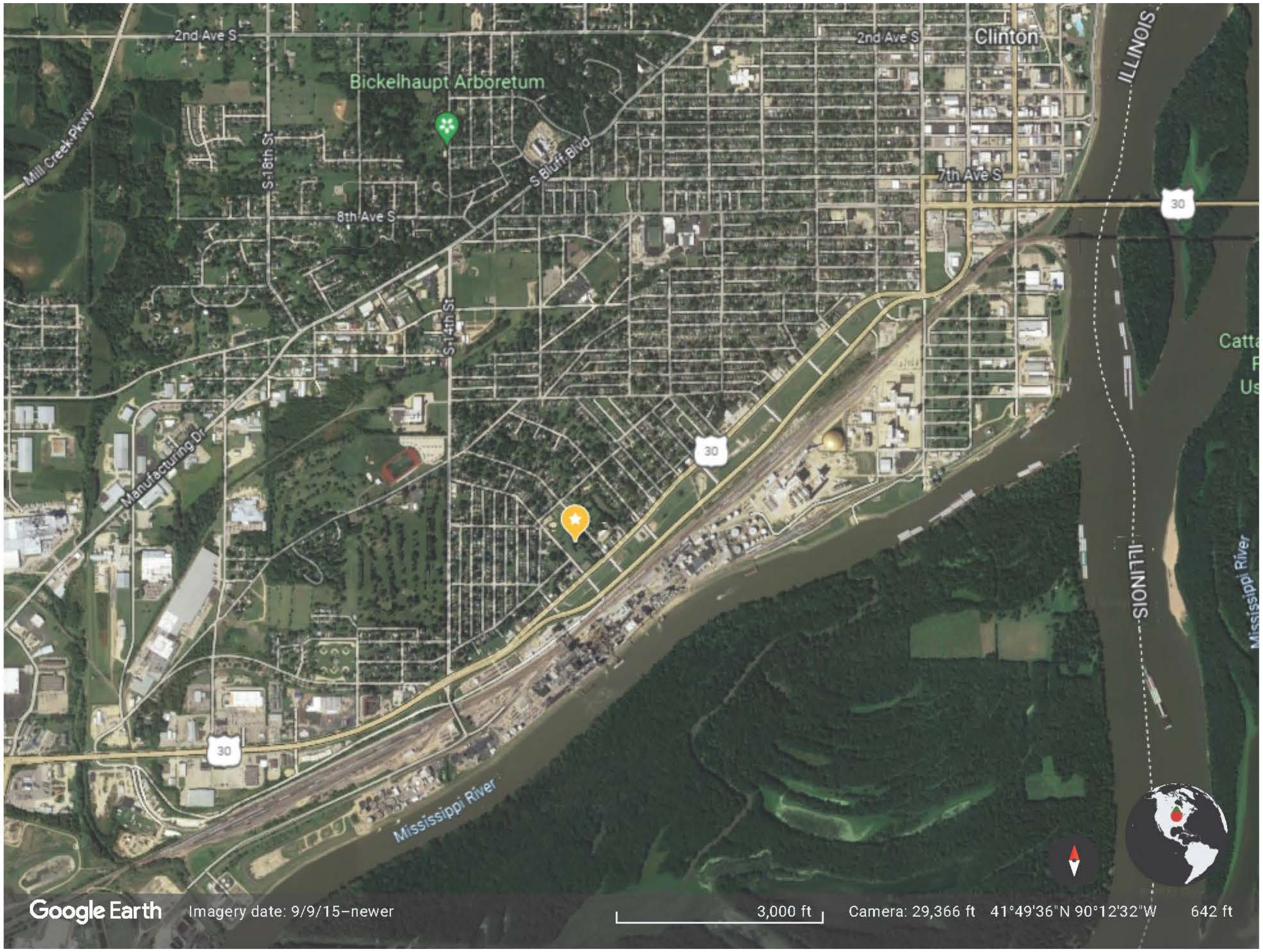
Site ID	Site Label	City	Address	County
191130040	Cedar Rapids, Public Health	Cedar Rapids	500 11th St. NW	Linn
190450019	Clinton, Chancy Park	Clinton	23rd & Camanche	Clinton
191630015	Davenport, Jefferson School	Davenport	10th St. & Vine St.	Scott
191530030	Des Moines, Health Dept.	Des Moines	1907 Carpenter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

Site Photos

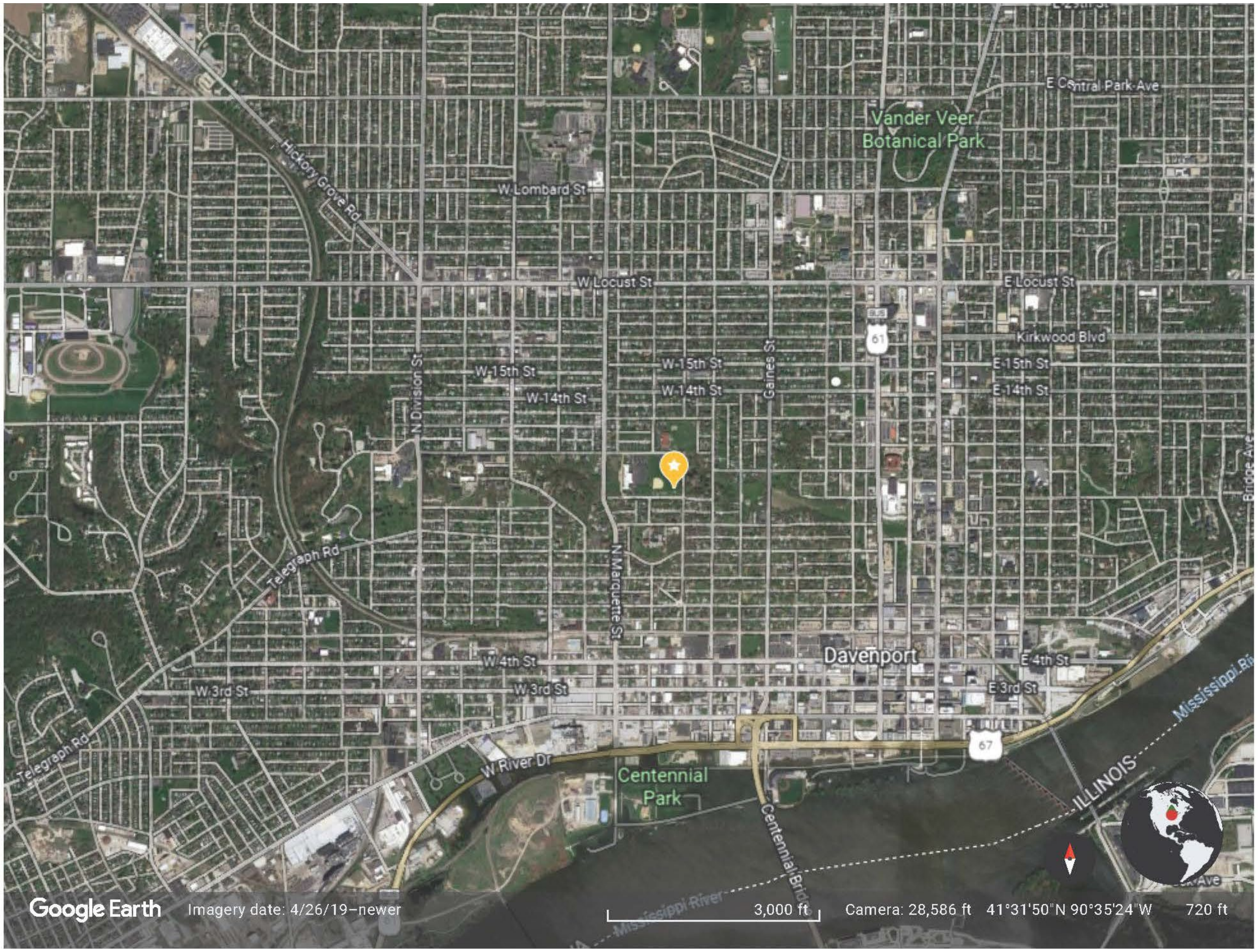
[Cedar Rapids, Public Health]



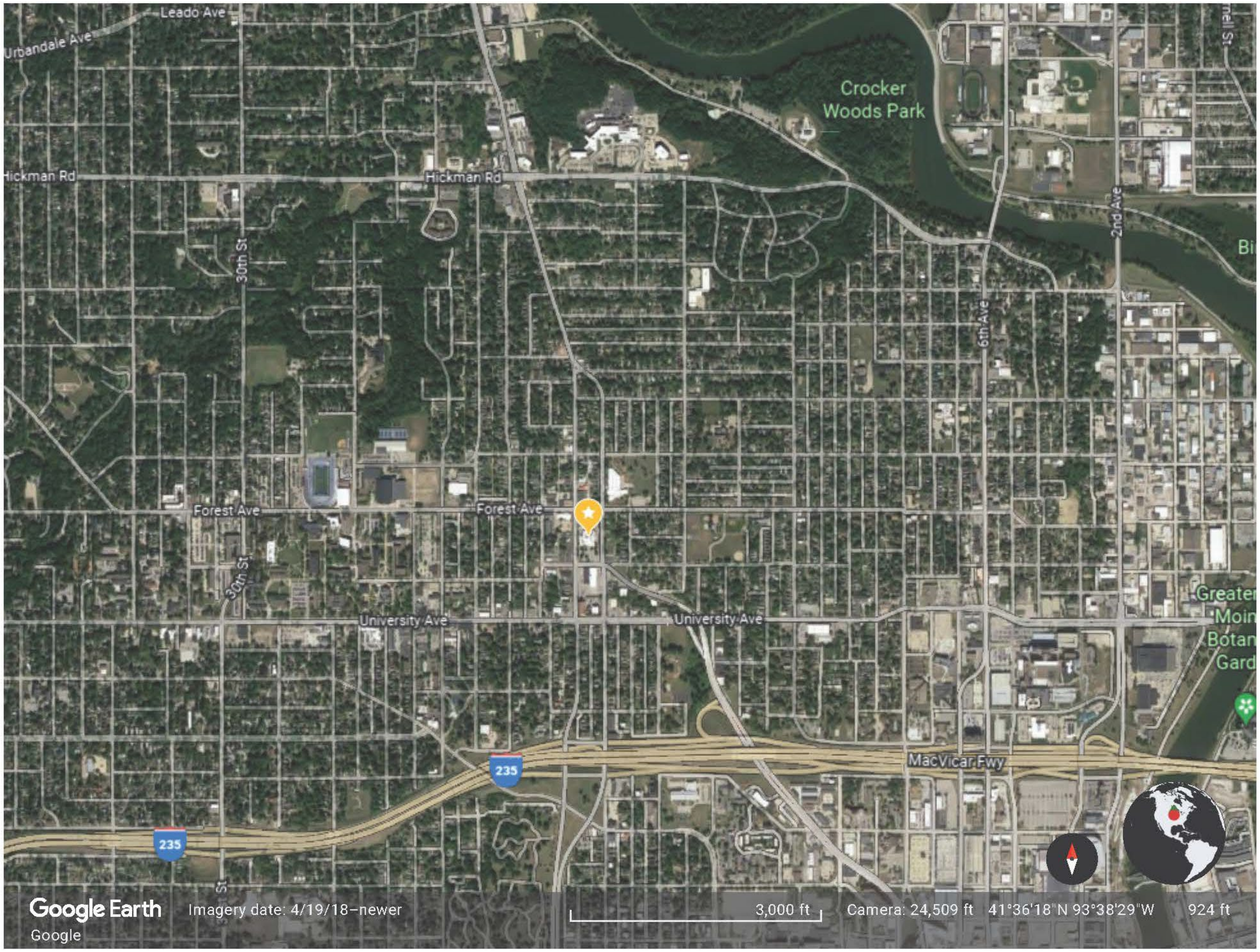
[Clinton, Chancy Park]



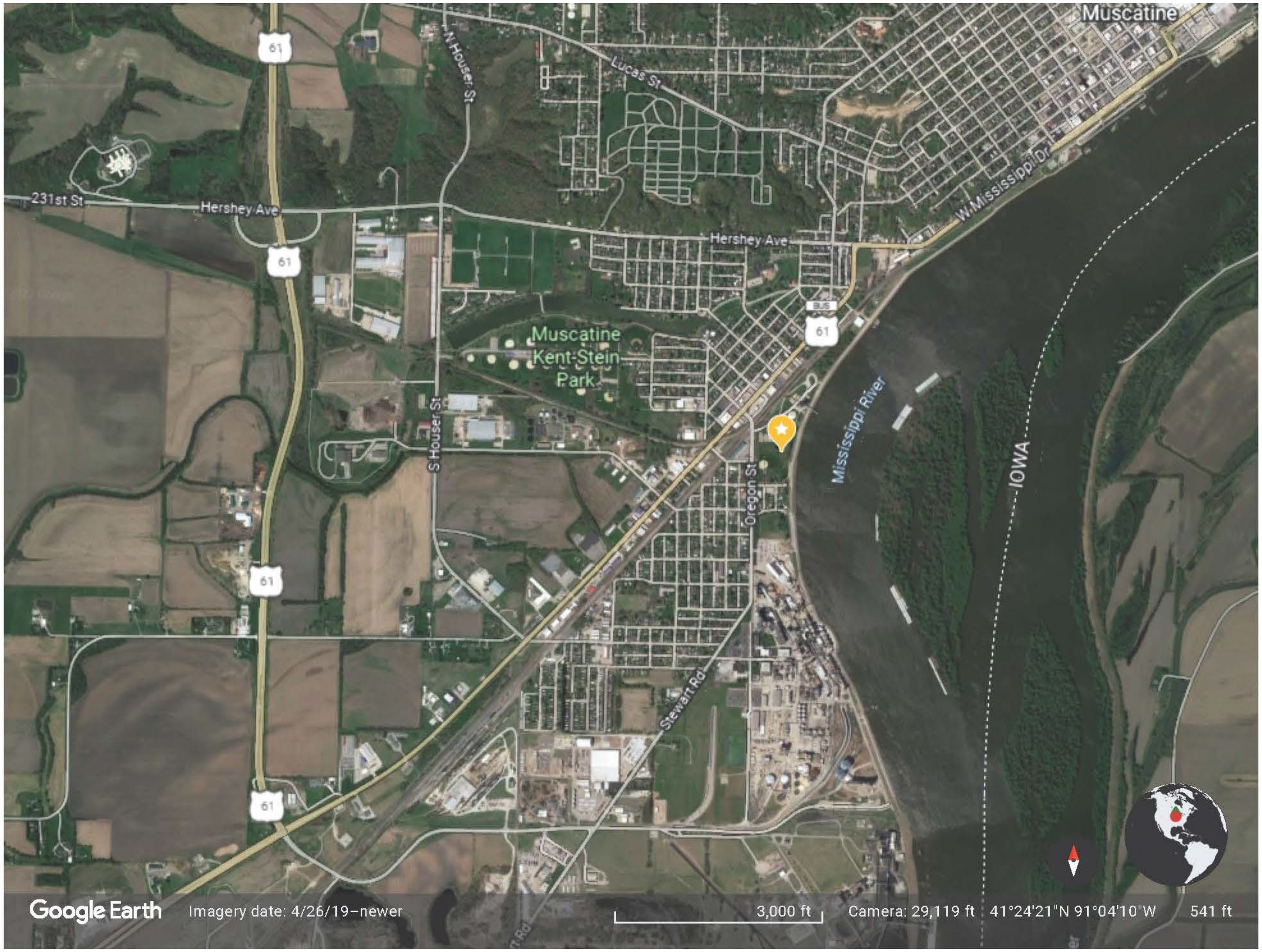
[Davenport, Jefferson School]



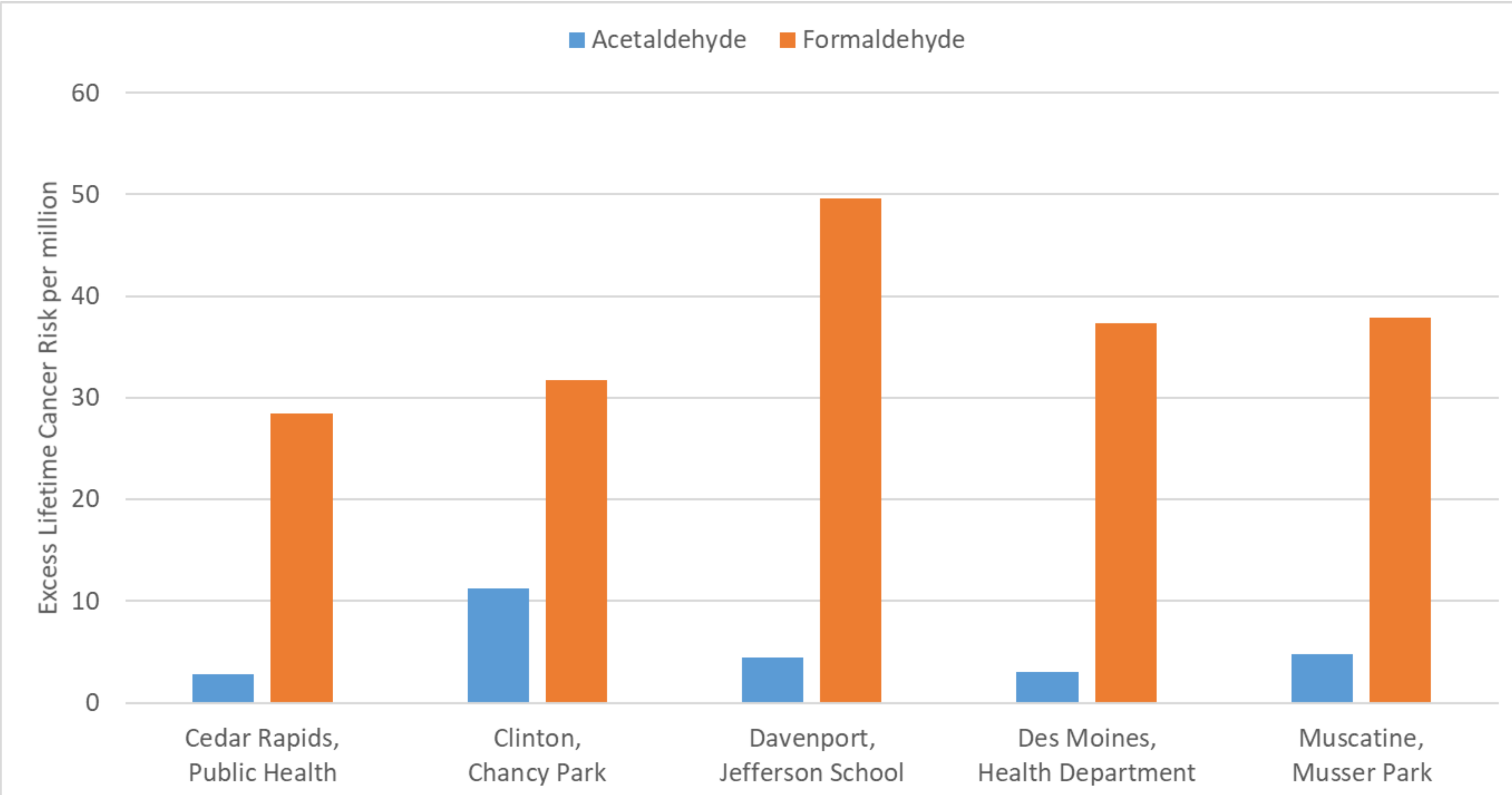
[Des Moines, Health Department]



Muscatine, Musser Park



2021 Graph of Excess Cancer Risk per Million for Iowa Sites



2021 Annual Average Concentration[1] (ppb)

Site / Pollutant	Cedar Rapids, Public Health	Clinton, Chancy Park	Davenport, Jefferson School	Des Moines, Health Dept.	Muscatine, Musser Park
Formaldehyde	1.8 (±0.3)	2.0 (±1.2)	3.1 (±1.5)	2.3 (±0.3)	2.4 (±0.4)
Acetaldehyde	0.7 (±0.1)	2.8 (±1.0)	1.1 (±0.6)	0.8 (±0.1)	1.2 (±0.5)

2021 Annual Excess Cancer Risk per Million

Site / Pollutant	Cedar Rapids, Public Health	Clinton, Chancy Park	Davenport, Jefferson School	Des Moines, Health Dept.	Muscatine, Musser Park
Formaldehyde	28 (±5)	32 (±19)	50 (±25)	37 (±5)	38 (±7)
Acetaldehyde	2.8 (±0.4)	11.2 (±4.1)	4.5 (±2.2)	3.0 (±0.4)	4.7 (±1.8)

2021 Annual Percent Data Capture[2]

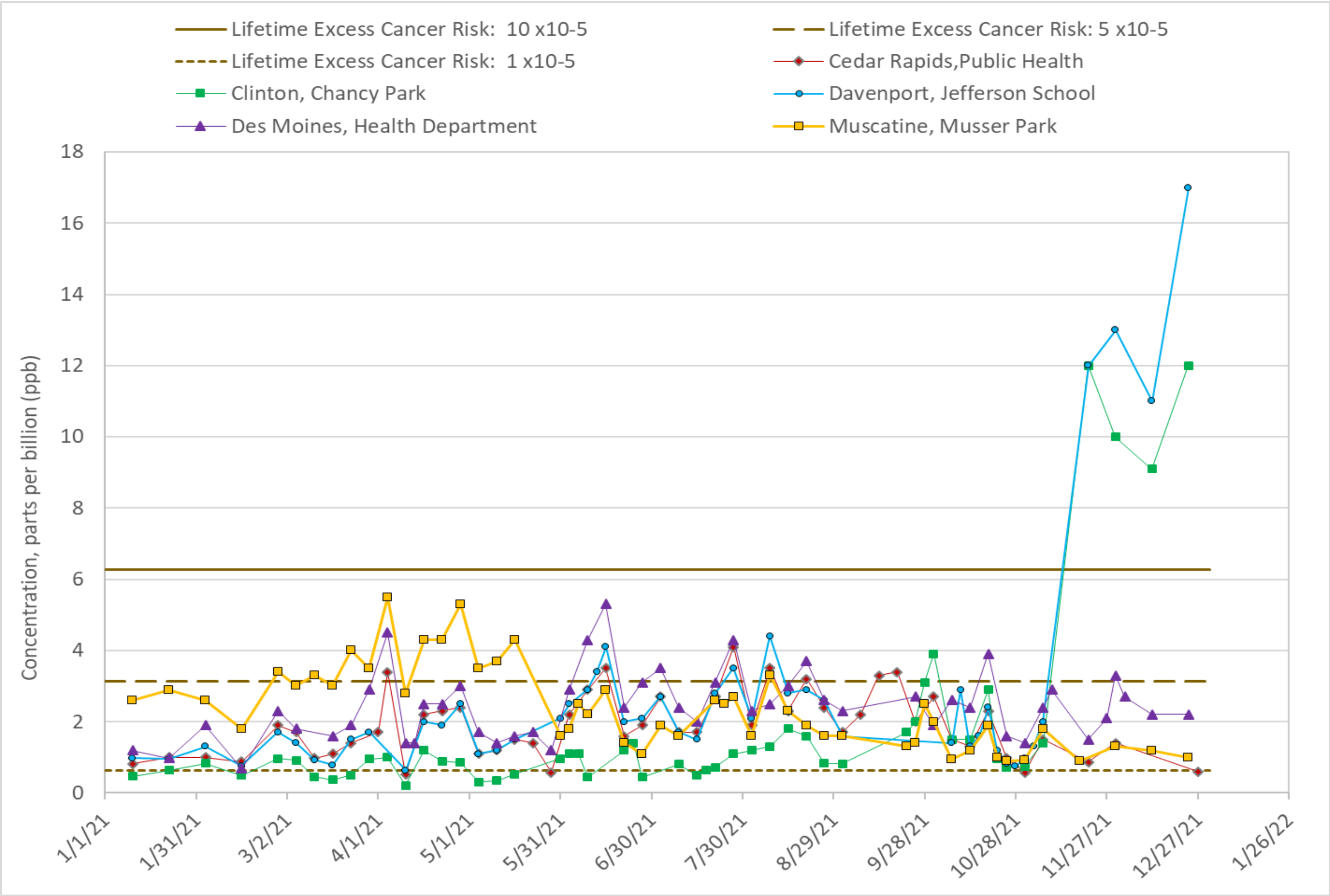
Site / Pollutant	Cedar Rapids, Public Health	Clinton, Chancy Park	Davenport, Jefferson School	Des Moines, Health Dept.	Muscatine, Musser Park
Formaldehyde	93%	93%	90%	97%	97%
Acetaldehyde	93%	93%	90%	97%	97%

[1] Data in the Concentration and Cancer Risk tables were averaged over 12 day blocks to prevent seasonal bias. Values listed in parentheses represent the 95% Confidence Interval for the mean.

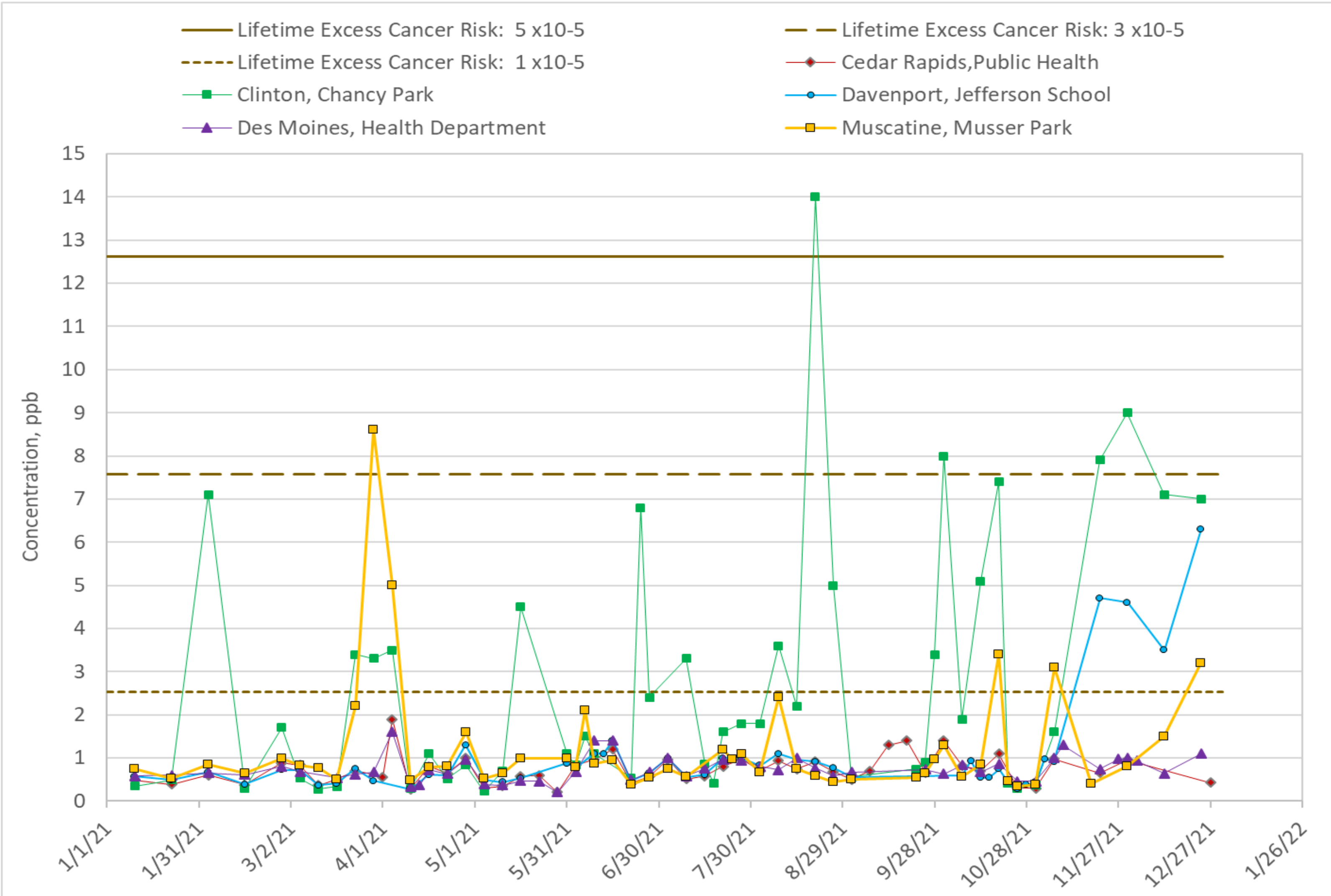
[2] Data capture indicated is the number of 12-day blocks with at least one valid sample, divided by the total number of twelve-day blocks in the calendar year, which was 30 in 2021.

Raw Data

Graph of 2021 Formaldehyde Concentrations



Graph of 2021 Acetaldehyde Concentrations



Raw Data– 2021 Formaldehyde Concentrations (ppb)

Date	Cedar Rapids, Public Health	Clinton, Chancy Park	Davenport, Jefferson Sch.,	Des Moines, Health Dept.	Muscatine, Musser Park
1/10/2021	0.82	0.46	0.97	1.2	2.6
1/22/2021	1	0.63	0.95	0.98	2.9
2/3/2021	1	0.83	1.3	1.9	2.6
2/15/2021	0.88	0.49	0.76	0.68	1.8
2/27/2021	1.9	0.96	1.7	2.3	3.4
3/5/2021	1.7	0.92	1.4	1.8	3
3/11/2021	0.97	0.45	0.93		3.3
3/17/2021	1.1	0.37	0.78	1.6	3
3/23/2021	1.4	0.5	1.5	1.9	4
3/29/2021		0.95	1.7	2.9	3.5
4/1/2021	1.7				
4/4/2021	3.4	1		4.5	5.5
4/10/2021	0.51	0.21	0.64	1.4	2.8
4/13/2021				1.4	
4/16/2021	2.2	1.2	2	2.5	4.3
4/22/2021	2.3	0.89	1.9	2.5	4.3
4/28/2021	2.4	0.86	2.5	3	5.3
5/4/2021	1.1	0.31	1.1	1.7	3.5
5/10/2021	1.2	0.34	1.2	1.4	3.7
5/16/2021	1.5	0.53	1.5	1.6	4.3
5/22/2021	1.4			1.7	
5/28/2021	0.57			1.2	
5/31/2021		0.96	2.1		1.6
6/3/2021	2.2	1.1	2.5	2.9	1.8
6/6/2021		1.1			2.5
6/9/2021	2.9	0.44	2.9	4.3	2.2
6/12/2021			3.4		
6/15/2021	3.5		4.1	5.3	2.9
6/21/2021	1.6	1.2	2	2.4	1.4
6/24/2021		1.4			
6/27/2021	1.9	0.44	2.1	3.1	1.1
7/3/2021	2.7		2.7	3.5	1.9
7/9/2021	1.7	0.81	1.7	2.4	1.6
7/15/2021	1.7	0.49	1.5	2	
7/18/2021		0.63			
7/21/2021	2.7	0.72	2.8	3.1	2.6
7/24/2021					2.5
7/27/2021	4.1	1.1	3.5	4.3	2.7
8/2/2021	1.9	1.2	2.1	2.3	1.6
8/8/2021	3.5	1.3	4.4	2.5	3.3

8/14/2021	2.3	1.8	2.8	3	2.3
8/20/2021	3.2	1.6	2.9	3.7	1.9
8/26/2021	2.4	0.83	2.6	2.6	1.6
9/1/2021	1.7	0.82	1.6	2.3	1.6
9/7/2021	2.2				
9/13/2021	3.3				
9/19/2021	3.4				
9/22/2021		1.7			1.3
9/25/2021	2	2		2.7	1.4
9/28/2021		3.1			2.5
10/1/2021	2.7	3.9		1.9	2
10/7/2021	1.5	1.5	1.4	2.6	0.95
10/10/2021			2.9		
10/13/2021	1.3	1.5	1.3	2.4	1.2
10/16/2021			1.6		
10/19/2021	2.3	2.9	2.4	3.9	1.9
10/22/2021		0.96	1.2		1
10/25/2021	0.98	0.71	0.83	1.6	0.89
10/28/2021			0.75		
10/31/2021	0.58	0.75	0.97	1.4	0.92
11/3/2021			1.3		
11/6/2021	1.5	1.4	2	2.4	1.8
11/9/2021				2.9	
11/18/2021					0.89
11/21/2021	0.87	12	12	1.5	
11/27/2021				2.1	
11/30/2021	1.4	10	13	3.3	1.3
12/3/2021				2.7	
12/12/2021		9.1	11	2.2	1.2
12/24/2021		12	17	2.2	1
12/27/2021	0.6				

Raw Data– 2021 Acetaldehyde Concentrations (ppb)

Date	Cedar Rapids, Public Health	Clinton, Chancy Park	Davenport, Jefferson Sch.	Des Moines, Health Dept.	Muscatine, Musser Park
1/10/2021	0.49	0.35	0.57	0.58	0.74
1/22/2021	0.39	0.49	0.49	0.6	0.53
2/3/2021	0.6	7.1	0.67	0.65	0.85
2/15/2021	0.38	0.3	0.39	0.61	0.64
2/27/2021	0.88	1.7	0.72	0.8	1
3/5/2021	0.83	0.53	0.71	0.68	0.82
3/11/2021	0.37	0.28	0.37		0.76
3/17/2021	0.5	0.34	0.41	0.54	0.51
3/23/2021	0.7	3.4	0.75	0.62	2.2
3/29/2021		3.3	0.47	0.67	8.6
4/1/2021	0.56				
4/4/2021	1.9	3.5		1.6	5
4/10/2021	0.28	0.29	0.28	0.34	0.48
4/13/2021				0.37	
4/16/2021	0.8	1.1	0.61	0.72	0.78
4/22/2021	0.64	0.52	0.59	0.63	0.8
4/28/2021	1	0.83	1.3	0.96	1.6
5/4/2021	0.31	0.23	0.49	0.39	0.52
5/10/2021	0.35	0.7	0.44	0.37	0.64
5/16/2021	0.57	4.5	0.53	0.47	1
5/22/2021	0.6			0.46	
5/28/2021	0.21			0.21	
5/31/2021		1.1	0.87		0.99
6/3/2021	0.83	0.83	0.78	0.68	0.79
6/6/2021		1.5			2.1
6/9/2021	0.97	1.1	1.1	1.4	0.86
6/12/2021			1.1		
6/15/2021	1.2		1.4	1.4	0.94
6/21/2021	0.42	0.54	0.47	0.49	0.38
6/24/2021		6.8			
6/27/2021	0.57	2.4	0.65	0.67	0.54
7/3/2021	0.96		1	1	0.75
7/9/2021	0.51	3.3	0.55	0.58	0.57
7/15/2021	0.58	0.85	0.61	0.75	
7/18/2021		0.42			
7/21/2021	0.8	1.6	1	0.97	1.2
7/24/2021					0.98
7/27/2021	0.96	1.8	1	0.94	1.1
8/2/2021	0.7	1.8	0.82	0.8	0.67
8/8/2021	0.93	3.6	1.1	0.72	2.4

8/14/2021	0.74	2.2	0.96	1	0.74
8/20/2021	0.91	14	0.91	0.76	0.59
8/26/2021	0.68	5	0.77	0.58	0.45
9/1/2021	0.5	0.56	0.55	0.67	0.5
9/7/2021	0.7				
9/13/2021	1.3				
9/19/2021	1.4				
9/22/2021		0.74			0.55
9/25/2021	0.66	0.89		0.73	0.64
9/28/2021		3.4			0.96
10/1/2021	1.4	8		0.63	1.3
10/7/2021	0.82	1.9	0.59	0.83	0.56
10/10/2021			0.93		
10/13/2021	0.7	5.1	0.54	0.67	0.84
10/16/2021			0.55		
10/19/2021	1.1	7.4	0.74	0.86	3.4
10/22/2021		0.42	0.45		0.46
10/25/2021	0.31	0.3	0.29	0.46	0.34
10/28/2021			0.38		
10/31/2021	0.3	0.37	0.44	0.46	0.39
11/3/2021			0.98		
11/6/2021	0.98	1.6	0.91	1	3.1
11/9/2021				1.3	
11/18/2021					0.41
11/21/2021	0.65	7.9	4.7	0.74	
11/27/2021				0.98	
11/30/2021	0.95	9	4.6	1	0.8
12/3/2021				0.93	
12/12/2021		7.1	3.5	0.64	1.5
12/24/2021		7	6.3	1.1	3.2
12/27/2021	0.43				

2021 Precision Statistics

Statistic / Pollutant	Number of Pairs	Coefficient of Variation	Lower 90% Confidence Limit	Upper 90% Confidence Limit
Formaldehyde	**76**	**2.9%**	**2.5%**	**3.3%**
Acetaldehyde	**76**	**2.0%**	**1.8%**	**2.4%**

Note: These Precision Statistics are generated from duplicate sample pairs collected at the five toxic sites. Coefficient of variation and confidence limits are calculated as indicated in Appendix A.

Appendix A. Precision Calculations

Let c_i^1 and c_i^2 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:

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

And the mean difference:

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

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.