Supplementary Material for

Uncontrolled combustion of shredded tires in a landfill – Part 2: Population exposure, public health response, and an air quality index for urban fires

Ashish Singh, Scott N. Spak, Elizabeth A. Stone, Jared Downard, Robert Bullard, Mark Pooley, Pamela A. Kostle, Matthew W. Mainprize, Michael D. Wichman, Thomas Peters, Douglas Beardsley, Charles O. Stanier

Contents of Supplemental Material:

List of Tables

Section 1: Chronology of the tire fire and response

The fire was first reported during the evening of May 26, 2012 under conditions of clear skies, low $PM_{2.5}$ levels, and warm temperatures. Initial winds were southeasterly, carrying the plume to the northwest and away from populated areas. Populated areas to the north of the landfill were first impacted on May 27, and then areas to the southeast of the landfill on May 28. The plume dispersed most efficiently from May 26 – 28, as indicated by retrospective dispersion modeling. Over the next few days, more stable atmospheric conditions led to higher concentrations of $PM_{2.5}$, measured up to 377 $\mu g\ m^{-3}$ at 8.4 km from the fire on May 30.

High concentrations impacted populated areas in the north, and northeast on June 2 and 3 during periods of low wind speeds, low boundary layer heights, and increased atmospheric stability. The fire-related pollutants $PM_{2.5}$, SO_2, particle number, EC, and PAH peaked in Iowa City from June 1-3 (Downard et al., co-submitted). Dispersion improved on June 3, as boundary layer heights increased to over 2 km.

A "stir, burn and cover" operation began on June 4 to manage the fire. In general, the plume was dispersed very effectively from June 4 until June 7, and then had moderate impacts north of the landfill during June 7-10. Retrospective dispersion model classifies June 7-8 as the period 2^{nd} least conducive to dispersion, but the June 7 and 8 plumes were not captured by monitors. The fire was declared under control and the emergency operation stopped on June 12. Additional detail on weather, PM concentrations, sampler activities, and associated AERMOD predictions are found in the following table.

Table S1. Chronology of Meteorology, Air Quality, and Air Quality Management Activities

Time period	Meteorology	Air Quality	Sampling, Forecasting, and Risk Management Activities
May 26 (Sat)	The fire was first reported during the evening (6:38 PM) of May 26, 2012. Conditions at the start of the fire were hot (high of 32°C), with clear skies and winds from the southeast. This carried the plume initially to sparsely populated areas to the northwest of the landfill.	Conditions at the start of the fire were clean ($PM_{2.5}$ of ~7 μg m^{-3}). Retrospective modeling shows the significant impact area (AQI>100, 1 h averaging time) extending a maximum distance of 1.3 km from the landfill.	Iowa City contacts Johnson County Public Health (JCPH) for public health concerns about smoke. JCPH contacts Linn County Public Health (LCPH) and the State Hygienic Laboratory (SHL).
May 27-28 (Sun-Mon)	Hot and clear or partly cloudy conditions continued on the 27^{th} and 28^{th}, but with shifting winds, first southerly winds which carried the plume into the populated Coralville area on May 27, and then westerly and northwesterly winds bringing the plume to a residential neighborhood and close to a school (Weber Elementary) on May 28.	The peak value of benzene sampled during the fire is taken: 8.3 ppb at 300 m away from the fire on the 28th. Retrospective dispersion modeling indicates excellent plume dispersion during this period. Maximum (modeled) peak 8 h smoke concentration in a densely populated area is in Coralville IA at ~0.6 μg/m^3 $PM_{2.5}$ smoke. Significant impact area (AQI>100, 8 h averaging time) is modeled to extend a maximum distance of 0.7 km from the landfill.	Public health advisory appears in the local newspaper.[1] JCPH in contact with the IDNR for technical assistance. TO-15 canister samples begin at 5:30 PM on May 27. May 27 is a 1-in-3 sampling day for the IA-AMS $PM_{2.5}$ speciation sampler. This sampler is changed to every day operation.
May 29-31 (Tue-Thu)	Conditions shifted to cooler (high of 27°C) on May 29 with strong northwesterly winds. Cool and windy conditions, with some rain, prevailed on the May 30 and 31, with wind directions from the north and east (and therefore carrying the plume away from the populated areas).	No impact of the fire on Iowa City, Coralville, or North Liberty is expected due to the wind direction; out of the plume, the 24 h PM_{10} filter (AMS site) reads 16 μg/m^3, while the Hoover $PM_{2.5}$ BAM averages 3.7 μg/m^3. Retrospective dispersion modeling has the plume to the south of the landfill for the entirety of this period, and the significant impact area (AQI>100, 8 h averaging time) modeled to extend up to 3.8 km to the southeast of the landfill. The Stanier group trailer achieves an interception of a well-diluted smoke plume at BDR on May 30 ($\Delta PM_{2.5}$ of 0.7 μg/m^3 on a 6.3 μg/m^3 background, 30 min average). A hand held Dust Trak reads an instantaneous reading of 377 μg/m^3 at a distance of 8.2 km from the fire.	Handheld surveys of $PM_{2.5}$ and CO begin. JCPH sends an official request (on 5/31) for State and Federal assistance in air monitoring and assessment. The Stanier group trailer is first deployed on May 29 but is just to the east of the plume and records clean conditions. The first SHL PM_{10} sample at IA-AMS is taken on May 30 and the first WRF-AERMOD and HPAC dispersion model forecasts are produced.

Time period	Meteorology	Air Quality	Sampling, Forecasting, and Risk Management Activities
June 1-3 (Fri-Sun)	On June 1-3, under cool conditions (highs of 20-27 C) light westerly winds threaten downtown Iowa City with landfill smoke and bring the plume to the IA-AMS and Hoover sites. This Friday – Sunday period is of special concern because an outdoor music festival is scheduled with large crowds in downtown Iowa City. Low boundary layer heights and neutral / stable conditions during some portions of this period.	Instantaneous $PM_{2.5}$ by Dust Trak is 510 $\mu g/m^3$ on June 1 at 2.4 km from the fire. June 2 is the day of the highest EC filter loading (AMS). PAH (24 h) is ~140 times background levels (AMS). During early morning of June 3, calm conditions and fog form, and high concentrations are recorded at the sites to the east of the landfill (1 h values of 48 and 71 $\mu g/m^3$ at AMS and Hoover, respectively). Reports of strong odor and respiratory irritation on the east side of Iowa City are noted. The retrospectively modeled area of significant impact (AQI > 100, 8 h averaging) extends farthest on the 2^{nd}, out to 5.8 km from the landfill into Coralville, and 4.4 km towards Iowa City, crossing Mormon Trek Blvd. into the west side neighborhood of University Heights (but not reaching downtown Iowa City under 8 h averaging). Maximum 8 h modeled concentrations of smoke in downtown Coralville and downtown Iowa City are 16 and 6 $\mu g/m^3$, respectively.	Iowa City mayor signs a Local Disaster Declaration document (June 1) facilitating access to state and federal resources. Also on June 1, EPA region 7 personnel on site in Iowa City and participate in coordination meetings (SHL, JCPH, DNR, EPA) reviewing sampling activities and assessment. WRF-AERMOD forecasts shared with the JCPH predict limited dispersion, with hourly smoke concentrations in excess of 50 $\mu g/m^3$ in populated areas up to 9 km from the landfill. A plume transect experiment samples plume size distribution and number concentration at 3 distances.
June 4-7 (Mon-Thu)	From June 4-7, light easterly winds and favorable conditions for vertical plume dispersion prevail, carrying the plume up and away from populated areas. Heavy equipment operation at the landfill site begins on June 3 as part of the "stir burn and cover" operation and this creates a darker and larger smoke plume.	The highest instantaneous concentration of the fire period is recorded on a DustTrak instrument, 2000 $\mu g/m^3$ at a distance of 1.0 km under very smoky conditions during the morning of June 4. Upwind of the plume, the average $PM_{2.5}$ in Iowa City (Hoover) during this time is 9.4 $\mu g/m^3$ and the highest 1 h concentration is 21 $\mu g/m^3$. The modeled area of significant impact (AQI > 100, 8 h averaging) extends to 1.5 km to the northwest of the landfill.	WRF-AERMOD forecasts predicting excellent vertical dispersion of the plume are shared with JCPH. Handheld and TO-15 canister sampling is suspended.

Time period	Meteorology	Air Quality	Sampling, Forecasting, and Risk Management Activities
June 7-12 (Thu-Tue)	The evening of June 7 to June 10 brings southerly winds carrying the plume north towards Coralville and North Liberty. Conditions transition to westerly and northwesterly winds and cooler temperatures on June 11 and 12. The fire is declared fully under control and the stir, burn and cover operation is stopped on June 12.	Elevated EC concentration (AMS) on June 7, and the highest IA-AMS PM_{10} sample (29 μg/m^3) is taken on June 8. No visible smoke from the landfill as of June 12. The modeled area of significant impact (AQI > 100, 8 h averaging) extends to 3.9 km to the north of the landfill, towards North Liberty. A peak 8 h average concentration of landfill smoke of 2.7 μg/m^3 is modeled for the North Liberty library, 11.4 km from the landfill.	

[1] (Source: Press Citizen) The Johnson County Health Department warns residents in the path of the smoke to avoid exposure to the smoke as much as possible. Persons who have respiratory, heart or other conditions which may be aggravated by smoke and the young and elderly should shelter in place with outside sources of air shut off. Most home air conditioning units recirculate air from the interior and should be sufficient. Businesses and other structures which draw in outside air should close outside air sources if the smoke plume is present. Avoid outdoor activities such as exercising if the smoke plume is present. Nursing homes, day cares and other businesses which care for the elderly, very young and persons with respiratory diseases should take special care to monitor the health of clients and to minimize exposure to the smoke plume.

By June 4, the public health advisory was unchanged in a press release by the City of Iowa City. However, the following two additional sentences were added: Concentration (increase and decrease) of particulate matter and other irritants in the smoke are greatly affected by weather conditions. Individuals are the best judges of their own health and should take appropriate protective measures based on their health status.

Section 2. Supporting Information on Measurement Location and Measurement Methods

Table S2. Measurement site information

Site	Latitude, Longitude	Distance to landfill site (km)	Observations	Dates
University of Iowa Air Monitoring Site (IA-AMS)	41.6647, -91.5845	4.2	Particle Size Distribution, PN, CO_2, SO_2, CO (6/1-6/4); $PM_{2.5}$ filters for speciation (05/27-06/10); PM_{10} mass (05/31-06/10)	see dates at left
Hoover Elementary Site[a]	41.6572, -91.5035	10.5	Continuous 1 h $PM_{2.5}$, 24 h $PM_{2.5}$ (gravimetric)	ongoing routine monitoring site
Black Diamond Road (BDR)	41.6188, -91.6422	3.2	Particle Size Distribution, PN, CO_2, SO_2, CO	05/30/2012-06/01/2012
Plume Transect				
1. Site A	41.6366,-91.6173	1.3		06/01/2012
2. Site B	41.6248, -91.6150	3.2	Particle size distribution, PN, BC	06/01/2012
3. Site C	41.6143, -91.5907	4.8		06/01/2012
Landfill	41.6469, -91.6194	0.3	VOC (TO-15, TO-12 Air Toxic)	06/01/2012
Community Samples				
Weber School	41.6472, -91.5969	2.4	VOC (TO-15 & 12)	5/28/2012
University of Iowa, Pentacrest	41.6614, -91.5361	7.6	"	06/02/2012
Camp Cardinal Rd.	41.6678, -91.5969	3.4	"	05/27/2012
Dane Road, SW	41.6117, -91.5605	6.7	"	06/01/2012
Slothower St.	41.6548, -91.6100	1.6	"	06/01/2012
First Ave. and 22nd Ave. Coralville	41.6803, -91.5967	4.5	"	05/27/2012
Forever Green Rd. and Route 965, N. Liberty	41.7257, -91.6151	8.3	"	05/27/2012

[a] EPA SLAMS Network in Iowa City for residential population exposure at Hoover Elementary School

Table S3: Characterization method overview, organized by sampling method (offline or real-time) and compound class

Analyte	Method and Instrumentation	Research Group[4]	Site(s)	Smoke Characteriztaion[2]	Numerical Emission Factor	Exposure Assessment[3]	Handheld	Hazard Ratio
TO-15, TO-12 VOCs	Collection in 6L canisters and GC/MS	SHL	Various	C		E, R		●
$PM_{2.5}$, PM_{10}	Beta Attenuation and Gravimetric filter (low volume)	SHL	Hoover ($PM_{2.5}$ & PM_{10}); IA-AMS (PM_{10})[5]			E, R		
$PM_{2.5}$ speciation (OC, EC, inorganic ions, metals and organic molecular markers)	Various, see text	Stone	IA-AMS	C	●	R		●
SO_2	UV fluorescence (Teledyne 100E)	Stanier	BDR, IA-AMS	C	●	R		●
CO_2	Infrared absorption (Vaisala 343 GMP)	Stanier	BDR, IA-AMS		●			
CO	NDIR absorption (Thermo 48i-TLE)	Stanier	BDR, IA-AMS	C	●			
CO	TSI 7575 Q-Track with electro-chemical CO sensor (IAQ-Probe Model 982)	JCPH	Various			E	●	
$PM_{2.5}$	Beta attenuation (BAM-1020)	SHL	Hoover			E, R		
$PM_{2.5}$	Light scattering photometer (TSI Dust Track-8532)[1]	JCPH	various			E	●	
Particle size distribution	Scanning Mobility Particle Sizer and Aerosol Particle Sizer	Stanier	BDR, IA-AMS, plume transect	P	●	R		●
Particle number (PN)	Condensation particle counter (TSI CPC 3786)	Stanier	BDR, IA-AMS, plume transect	P	●	R		

[1]Sensitive in to particles from 0.1-10 µm; [2]C indicates chemical characterization; P indicates physical characterization; [3]E indicates used mainly for exposure assessment during the incident; R indicates mainly used for retrospective assessment; [4] State Hygienic Lab (SHL), Johnson County Public Health (JCPH); [5]PM10 at IA-AMS is gravimetric mid volume sampler installed just for the tire fire period.

Section 3. VOC Sampling Methodology and Results Detail

Ambient VOC concentrations were determined by EPA methods TO-12 and TO-15 (EPA, 1999). Ten grab samples, representing background and plume-impacted air, were collected in pre-cleaned 6-L Summa canisters (Entech Silonite™). Analysis was by gas chromatography (GC) mass spectrometry (Agilent Technologies 7890A, 5975C; 60 m DB-1 column) with canister autosampler (Entech 7016), dynamic dilution (Entech 4600A), and pre-concentration (Entech 7100A). Each analysis used 500 cm^3 of sample and 100 cm^3 of internal standard, and thermal desorption into the GC by splitless injection. Initial calibration range for all 54 analytes was nominally 0.5 to 10 ppbv.

Table S4: All TO-15 and selected TO-12 VOC measured during the tire fire

	Species	Method detection limit	Method of detection	Coralville –End st/22nd Avenue	Iowa City- Camp Cardinal/Melrose	Iowa City near landfill	North Liberty, forevergreen road/965	Weber School, Iowa City	Iowa City Penta crest (not in plume)	Dane RD SW, Iowa city (in plume)	Iowa City, near fire	Slothower road, Iowa City (in plume)	Iowa City Penta crest (in plume)
		(ppbv)		05/27/2012/17:58	5/27/2012 18:11	5/27/2012 17:34	5/27/2012 17:40	5/28/2012 16:53	6/1/2012 15:20	6/1/2012 18:52	6/1/2012 15:32	6/1/2012 17:50	6/2/2012 7:00
	Aromatic												
1	Benzene	0.17		0.08	0.07	8.27	0.63	0.05	0.05	0.45	>10	0.08	0.18
2	Toluene	0.16		0.11	0.06	8.64	0.5	0.16	0.05	0.32	>10	0.11	0.15
3	Ethylbenzene	0.18		<0.18	<0.18	0.66	<0.18	<0.18	<0.18	<0.18	>10	<0.18	<0.18
4	m,p Xylene	0.26		<0.26	<0.26	2.03	<0.26	<0.26	<0.26	<0.26	>10	<0.26	<0.26
5	o-Xylene	0.11		<0.11	<0.11	0.62	<0.11	<0.11	<0.11	<0.11	10	<0.11	<0.11
6	Styrene	0.1		<0.1	<0.1	0.59	<0.1	<0.1	<0.1	<0.1	>10	<0.1	<0.1
7	1, 2 4-Trimethylbenzene	0.14		<0.14	<0.14	0.27	<0.14	<0.14	<0.14	<0.14	7.53	<0.14	<0.14
8	1, 3 5-Trimethylbenzene	0.16	GCMS volatiles, EPA TO-15	<0.16	<0.16	0.14	<0.16	<0.16	<0.16	<0.16	3.52	<0.16	<0.16
9	Benzyl Chloride	0.31		<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31
10	Chlorobenzene	0.13		<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	0.21	<0.13	<0.13
11	1,3 Dichlorobenzene	0.09		<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09
12	1,4 Dichlorobenzene	0.1		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
13	1,2 Dichlorobenzene	0.2		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
14	1,2,4 Trichlorobenzene	0.23		<0.23	<0.23	<0.23	<0.23	<0.23			<0.23	<0.23	<0.23
	Halocarbon compounds												
15	Chloroform	0.11		<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11

	Species	Method detection limit	Method of detection	Coralville –End st/22nd Avenue	Iowa City- Camp Cardinal/Melrose	Iowa City near landfill	North Liberty, forevergreen road/965	Weber School, Iowa City	Iowa City Penta crest (not in plume)	Dane RD SW, Iowa city (in plume)	Iowa City, near fire	Slothower road, Iowa City (in plume)	Iowa City Penta crest (in plume)
		(ppbv)		05/27/2012/17:58	5/27/2012 18:11	5/27/2012 17:34	5/27/2012 17:40	5/28/2012 16:53	6/1/2012 15:20	6/1/2012 18:52	6/1/2012 15:32	6/1/2012 17:50	6/2/2012 7:00
	Tetrachloroethene	0.16		<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
16	Carbon tetrachloride	0.33		0.08	0.1	0.09	0.07	0.1	0.1	0.12	0.11	0.1	0.14
17	Dichlorodifluoromethane	0.23		0.51	0.51	0.53	0.5	0.56	0.51	0.61	0.56	0.48	0.65
18	Dichlorotetrafluoromethane	0.17		<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17
19	Chloromethane	0.3		0.62	0.64	0.59	0.54	0.67	0.71	0.66	0.67	0.59	0.74
20	Chloroethane	0.26		<0.26	<0.26	<0.26	<0.26	<0.26	<0.26	<0.26	<0.26	<0.26	<0.26
21	Trichloroflurormethane	0.17		0.23	0.24	0.25	0.22	0.24	0.22	0.26	0.24	0.19	0.3
22	1,1,2 Trichloro,1,2,2-trifluroethane	0.18		0.06	0.08	0.08	0.08	0.09	0.08	0.08	0.08	0.06	0.09
23	1,1 Dichoroethene	0.19		<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
24	Trans 1,2 Dichloroethane	0.14		<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14
25	cis 1,2 Dichloroethane	0.22		<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22
26	Chloroprene	0.13		<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13
27	1,1,1 Trichloroethane	0.27		<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27	<0.27
28	1,1 Dichoroethane	0.07		<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07
29	1,2 Dichoroethane	0.09		<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09
30	Trichloroethene	0.16		<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
31	1,2 Dichloropropane	0.21		<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
32	1,1,2 Trichloroethane	0.26		<0.26	<0.26	<0.26	<0.26	<0.26	<0.26	<0.26	<0.26	<0.26	<0.26

	Species	Method detection limit	Method of detection	Coralville –End st/22nd Avenue	Iowa City- Camp Cardinal/Melrose	Iowa City near landfill	North Liberty, forevergreen road/965	Weber School, Iowa City	Iowa City Penta crest (not in plume)	Dane RD SW, Iowa city (in plume)	Iowa City, near fire	Slothower road, Iowa City (in plume)	Iowa City Penta crest (in plume)
		(ppbv)		05/27/2012/17:58	5/27/2012 18:11	5/27/2012 17:34	5/27/2012 17:40	5/28/2012 16:53	6/1/2012 15:20	6/1/2012 18:52	6/1/2012 15:32	6/1/2012 17:50	6/2/2012 7:00
33	Bromodichloromethane	0.15		<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
34	Dibromochloromethane	0.32		<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32	<0.32
35	1,2 Dibromoethane	0.13		<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13
36	Bromoform	0.25		<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
37	Bromomethane	0.19		<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
38	1,1,2,2 Tetrachloroethane	0.2		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
39	Hexachlorobutadiene	0.24		<0.24	<0.24	<0.24	<0.24	<0.24			<0.24	<0.24	<0.24
	Aliphatic compounds												
40	Acetylene	0.73		0.13	0.17	0.72	0.39	0.18	0.12	0.15	7.73	0.35	0.28
41	Propylene	0.16		<0.16	<0.16	5.54	0.91	<0.16	<0.16	0.26	>10	<0.16	<0.16
42	1,3 butadiene	0.24		<0.24	<0.24	0.91	<0.24	<0.24	<0.24	<0.24	8.13	<0.24	<0.24
43	Vinyle Chloride	0.18		<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18
44	Methly-t-butyl ether (MBTE)	0.12		<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12
45	Ethly tert butly ether	0.19		<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
46	tert amyl methyl ether	0.21		<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
47	Ethly acrylate	0.1		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
48	Methyl methacrylate	0.14		<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14
49	Cis-1,3 Dichloropropene	0.16		<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16
50	Trans 1,3 Dicholoropropene	0.17		<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17

	Species	Method detection limit	Method of detection	Coralville –End st/22nd Avenue	Iowa City- Camp Cardinal/Melrose	Iowa City near landfill	North Liberty, forevergreen road/965	Weber School, Iowa City	Iowa City Penta crest (not in plume)	Dane RD SW, Iowa city (in plume)	Iowa City, near fire	Slothower road, Iowa City (in plume)	Iowa City Penta crest (in plume)
		(ppbv)		05/27/2012/17:58	5/27/2012 18:11	5/27/2012 17:34	5/27/2012 17:40	5/28/2012 16:53	6/1/2012 15:20	6/1/2012 18:52	6/1/2012 15:32	6/1/2012 17:50	6/2/2012 7:00
51	Octane	0.14		<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14
	Terpenoid compounds		To-12 Speciated non-Methane Organics										
52	α-Pinene	0.06		0.31	0.13	0.08	<0.06	<0.06	0.1	0.76	0.38	<0.06	<0.06
53	Isoprene	0.08		4.13	1.77	2.49	0.47	0.54	0.14	0.39	16.14	0.31	0.24
	Carbonyl compounds												
54	Acrolein	0.08	GCMS volatiles, EPA TO-15	0.17	0.17	1.5	0.24	0.14	<0.08	<0.08	1.7	<0.08	<0.08
55	Methly ethyl ketone	0.18		<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18
56	Methyl Isobutyl Ketone	0.16		<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	3.47	<0.16	<0.16
57	Ethane	0.03	To-12 Speciated non-Methane Organics	3.85	3.81	41.7	3.73	4.7	2.5	4.07	>20	2.5	3.07
58	propane	0.1		1.99	2.09	20.4	1.85	3.04	0.59	1.5	>20	0.59	1.68
59	Butane	0.1		1	1.06	6.07	0.74	1.4	0.29	1.08	>20	0.31	0.54
60	Isopentane	0.08		0.78	0.64	3.67	0.5	0.56	0.3	1.05	>20	0.37	0.75
61	Hexane	0.18		0.18	0.16	1.1	0.17	0.19	0.08	0.17	15.58	0.13	0.18
62	Nonane	0.05		0.11	0.07	0.37	<.05	0.17	0.21	0.16	5.39	<.05	0.06
63	Isopropyl benzene	0.07		<0.07	<0.07	0.6	<0.07	<0.07	<0.07	0.09	12.21	<.07	<.07
64	m-ethyltoluene	0.08		<0.08	<0.08	1.53	0.11	<0.08	0.12	0.22	>20	0.15	0.11
65	p-ethyltoluene	0.1		<0.1	<0.1	0.76	0.8	<0.1	0.05	0.15	>20	0.08	0.06
66	1-decene	0.08		0.11	0.09	2.58	0.09	0.09	0.15	0.17	>20	0.19	0.21
67	Decane	0.08		0.04	0.07	1.13	<0.08	<0.08	<0.08	0.11	18.3	0.09	<0.08

	Species	Method detection limit	Method of detection	Coralville –End st/22nd Avenue	Iowa City- Camp Cardinal/Melrose	Iowa City near landfill	North Liberty, forevergreen road/965	Weber School, Iowa City	Iowa City Penta crest (not in plume)	Dane RD SW, Iowa city (in plume)	Iowa City, near fire	Slothower road, Iowa City (in plume)	Iowa City Penta crest (in plume)
		(ppbv)		05/27/2012/17:58	5/27/2012 18:11	5/27/2012 17:34	5/27/2012 17:40	5/28/2012 16:53	6/1/2012 15:20	6/1/2012 18:52	6/1/2012 15:32	6/1/2012 17:50	6/2/2012 7:00
68	Dodecane	0.08		<0.08	<0.08	0.13	0.08	0.06	<.08	<0.08	3.4	0.03	<.08
69	m-dimethyle benzene	0.05		<0.05	<0.05	0.08	<0.05	<0.05	<0.05	0.19	1.75	<0.05	<0.05
70	p-dimethyl benzene	0.04		0.09	0.08	0.49	0.07	0.2	<0.04	<0.04	11.7	0.24	0.14

Section 4. Support on the acute hazard ratio calculation

Table S5. Acute hazard ratios derived from concentrations or emission factors from this work and from other ambient and laboratory combustion studies.

CAS	Species	TLV-TWA[a]	STEL or Ceiling[b]	AEGL-1 (1 hr, mg/m3)	EPA Lab burn[d]			Westley,CA tire fire[e]			This study, VOC canister			This study emission factor			Pooled oil burn[f]		
		(mg/m3)	(mg/m3)		EF (mg/kg)	HR	Rank	Conc. (µg/m3)	HR x1000	Rank	Conc. (µg/m3)	HR x1000	Rank	EF (mg/kg)	HR	Rank	EF (mg/kg)	HR	Rank
none	PM_{25}	3	-	-	-	-		-	-		-	-		5350	357 **	2	-	-	
7446-09-5	SO_2	0.65	0.66[i]	0.52	-	-		-	-		-	-		7090	13528	1	-	-	
630-08-0	CO	29	458	-	1.2E+05	262 *	2	229	0.50 *	2	-	-		-	-		30000	65 *	3
none	PM_{10}	10	-	-	1.5E+05	2980 **	1	557	11.1 **	1	-	-		-	-		-	-	
none	BC	3.5	-	-	-	-		8	0.46 **	2	-	-		2410	138 **	3	-	-	
71-41-2	Benzene	1.6	16[ii]	166	2205	13.3	7	9.2	0.055	3	26.4	0.16	2	-	-		251	1.5	5
92-52-4	Biphenyl	1.26	-	-	330	52 **	3	-	-		-	-		-	-		-	-	
100-40-3	Vinylcyclohexene	0.44	-	-	108	49 **	4	-	-		-	-		-	-		-	-	
100-52-7	Benzaldehyde	8.8	17.4[i]	-	664	38 *	5	-	-		-	-		-	-		44	2.5 *	4
91-20-3	Naphthalene	52	79[i]	-	1195	15.2 *	6	-	-		-	-		-	-		44	0.6	6
108-95-2	Phenol	19.2	60[iii]	58	714	12.4	8	-	-		-	-		-	-		-	-	
106-99-0	1,3-Butadiene	4.4	11.1[ii]	1482	160	0.108	14	1.1	7E-4	4	1.5	0.001	6	-	-		-	-	
108-88-3	Toluene	75	565[iii]	754	2519	3.3	12	-	-		32	0.04	3	-	-		42	0.06	7
100-41-4	Ethyl benzene	87	543[iii]	143	632	4.4	11	-	-		2.9	0.02	4	-	-		10	0.07	7
95-13-6	Indene	23.7	71[iv]	-	339	4.8 *	10	-	-		-	-		-	-		-	-	
100-42-5	Styrene	85	170[i]	85	646	7.6	9	-	-		2.51	0.03	4	-	-		-	-	
95-63-6	1,2,4-Trimethylbenzene	123	-	688	826	1.2	13	-	-		1.3	0.002	5	-	-		32	0.05	7

CAS	Species	TLV-TWA[a] (mg/m3)	STEL or Ceiling [b] (mg/m3)	AEGL-1 (1 hr, mg/m3)	EPA Lab burn[d]			Westley,CA tire fire[e]			This study, VOC canister			This study emission factor			Pooled oil burn[f]		
					EF (mg/kg)	HR	Rank	Conc. (µg/m3)	HR x1000	Rank	Conc. (µg/m3)	HR x1000	Rank	EF (mg/kg)	HR	Rank	EF (mg/kg)	HR	Rank
138-86-3	Limonene	557	-	-	3239	1.16 **	13	-	-		-	-		-	-		-	-	
none	Xylene, mixed	434	651[i]	564	2013	3.6	12	-	-		9.9	0.017	5	-	-		25	0.04	7
98-82-8	Cumene	246	-	246	398	1.62	13	-	-		-	-		-	-		-	-	
107-02-8	Acrolein	0.23	0.23[i,C]	0.07	-	-		-	-		3.4	49	1	-	-		11	160	1
50-00-0	Formaldehyde	0.37	2.46[ii]	1.11	-	-		-	-		-	-		-	-		139	126	2
590-86-3	Isovaleraldehyde	4.7	-	-	-	-		-	-		-	-		-	-		5	0.3 **	6
75-07-0	Acetaldehyde	45	45[i,c]	81	-	-		-	-		-	-		-	-		32	0.4	6
67-64-1	Acetone	1188	1782[i]	475	-	-		-	-		-	-		-	-		20	0.04	7
111-84-2	Nonane	1050	-	-	-	-		-	-		-	-		-	-		13	0.003 **	9
338-23-4	Methyl ethyl ketone	590	885[i]	590	-	-		-	-		-	-		-	-		7	0.01	8
50-32-8	B[a]P	-	-	-	114	-		0.15	-		-	-		3.6	-		7	-	

Abbreviations: Emission factor (EF); Concentration (Conc.), and Hazard ratio (HR)

*STEL used in place of AEGL; **5 x TLV used in place of AEGL; **(a)** ACGIH: Documentation of the Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs). 2014. A summary of recent values can be found at https://www.osha.gov/dsg/annotated-pels/tablez-1.html; **(b)** STEL or Ceiling values (c) are based on (i) ACGIH, (ii) OSHA (iii) NIOSH (iv) Australian STEL; **(d)** Shredded tire combustion in EPA (1997). Values also reported in Lemieux et al. (2004); **(e)** Westley tire fire - 1 hr max concentration from Westley Livingston site at 4-5 miles downwind of the tire fire. **(f)** Crude oil emission factor are taken from Lemieux et al 2004 , table 8, page 20 [values are based from the original research work of Booher and Janke 1999]

Section 5. Support of the Multi-Pollutant AQI

An example calculation of the 1-h AQI resulting from 300 $\mu g/m^3$ of tire fire smoke.

The result can be seen from Table 5, and is 330. But additional details regarding the calculation are shown here.

- 300 $\mu g/m^3$ of $PM_{2.5}$ at 1-h averaging time alone, with no copollutants, carries an AQI of 188
- SO_2 is co-emitted, and will be at a concentration of 398 $\mu g/m^3$, or 152 ppb. This has a 1-h AQI of 135 as calculated at http://www.airnow.gov/index.cfm/index.cfm?action=resources.conc_aqi_calc
- The the SO_2 AQI contribution as 134.9.
- With p=1, these combine to 323
- These two compounds represent 97.9% of the total AQI.

The remaining 2.1% contribution are from a number of VOC compounds (listed in Table 6).

One of them is benzene, and its contribution is detailed here.

Benzene is coemitted with a mass ratio (relative to $PM_{2.5}$) of 0.41, so it is present in a concentration of 124 $\mu g/m^3$, or 38.7 ppb. This is associated with a benzene AQI contribution of 0.21. This is calculated as follows.

1. The first AQI breakpoint of SO_2 at the 1-h averaging time is AQI 50, concentration of 91.7 $\mu g/m^3$, or 35 ppb.
2. The AEGL-1 (1-h) for SO_2 is 200 ppb.
3. The AEGL-1 (1-h) for benzene is 52 ppm, or 52,000 ppb.
4. We convert from 38.7 ppb of benzene to a fraction of AEGL-1. The result is 7.44×10^{-4}
5. We construct an "equivalent" SO_2 concentration using 7.44×10^{-4} x $AEGL\text{-}1_{SO2}$, or 0.15 ppb SO_2
6. We determine the AQI for 0.15 ppb SO_2 (which is 0.15/35 x 50 = 0.21 AQI points).

We note that the OSHA STEL is a factor 10.4 lower than the AEGL-1, and using it as the basis for the calculation would increase the impact of benzene somewhat.

Some pollutants don't have an AEGL-1. For example, biphenyl. It has an AEGL-2 of 9.6 ppm. The estimate of the airborne concentration of biphenyl is 18.5 $\mu g/m^3$ (2.9 ppb), so the equivalent SO_2 concentration would be the AEGL-2 of SO_2 (750 ppb) x 2.9 / 9600 or 0.23 ppb of SO_2. This would have an AQI of 0.23 / 35 x 50 = 0.33 AQI units which matches the calculated value.

Table S6. AQI Categories (from Wildfire Smoke A Guide for Public Health Officials; Revised July 2008, With 2012 AQI Values)

Category	Notes
Good 0-50	If smoke exposure is forecast, implement communication plan.
Moderate 51-100	Issue public service announcements (PSAs) advising public about health effects and symptoms and ways to reduce exposure. Distribute information about exposure avoidance.
Unhealthy for Sensitive Subgroups 101-150	If smoke event projected to be prolonged, evaluate and notify possible sites for cleaner air shelters. If smoke event projected to be prolonged, prepare evacuation plans.
Unhealthy 151-200	Consider closing schools, possibly based on school environment and travel considerations. Consider canceling public events, based on public health and travel considerations.
Very unhealthy 201-300	Consider closing some or all schools (newer schools with a central air cleaning filter may be more protective than older leakier homes). Cancel outdoor events (e.g., concerts, sporting events).
Hazardous	Close schools. Cancel outdoor events (e.g., concerts, sporting events). Consider closing workplaces not essential to public health. If PM level is projected to remain high for a prolonged time, consider evacuation of sensitive subpopulations

Table S7. Expanded version of Table 5 that includes additional tracers of the tire fire smoke (benzene, CO, and SO_2, 1,3 butadiene, acrolein, CO_2, and $PM_{2.5}$ B[a]P), using emission factor ratios. Additional columns can be added based on what measurements are available, using emission factor ratios, or Δconcentration ratios. These are prepared assuming p=1.

1-h Average Pollutant in Tire Smoke							1-h Average Background $PM_{2.5}$ (µg/m^3)					
Benzene (ppb)	Benzene (µg/m^3)	CO (ppb)	CO (µg/m^3)	SO_2 (ppb)	SO_2 (µg/m^3)	$PM_{2.5}$ (µg/m^3)	0	10	20	30	40	50
0	0	0	0	0	0	0	0	13	26	39	52	62
0.015	0.047	20	23	0.5	1.3	1	2	15	28	42	54	64
0.029	0.094	40	46	1.0	2.7	2	4	17	30	44	55	65
0.044	0.14	60	68	1.5	4	3	6	19	33	46	57	67
0.06	0.19	80	91	2.0	5	4	8	21	35	48	59	69
0.07	0.24	100	114	2.5	7	5	10	23	37	50	61	71
0.15[a]	0.47	199	228	5	13	10	21	34	47	59	69	79
0.29	0.94	398	456	10	27	20	41	54[b]	67	77	87	97
0.44[b]	1.4	597	684	15	40	30[c]	62	74[a]	84	94	104	114
0.7	2.4	996	1140	25	67	50[d]	99	109	119	129	139	149
1.5	4.7	1990	2280	51	133	100	184	194	204	214	222	225
2.9	9.4	3981	4560	102	266	200	281	284	286	288	291	293
4.4[e]	14	5971[f]	6840	152	400	300	330	333	335	337	340	342

[a]This row corresponds to the instantaneous benzene concentration measured at the Pentacrest (downtown Iowa City) on June 2 in a "not in plume / background" sample. Background $PM_{2.5}$ was ~10 µg/m^3 placing that hour in the "good" category. A background concentration of 0.05 ppb has been subtracted from the measured value.

[b]This row corresponds to the instantaneous benzene concentration measured in North Liberty on May 27, and at Dane Rd. on June 1. Background $PM_{2.5}$ was ~10 µg/m^3 placing those conditions in the "moderate" category. A background concentration of 0.05 ppb has been subtracted from the measured value.

[c]This row corresponds to the worst 1h datapoint from IA-AMS (based on measurements of $PM_{2.5}$). Background $PM_{2.5}$ was ~10 µg/m^3 placing those conditions in the "moderate" category.

[d]This row corresponds to the worst 1h datapoint from Hoover Elementary (based on measurements of $PM_{2.5}$). Background $PM_{2.5}$ was ~10 µg/m^3 placing those conditions in the "unhealthy for sensitive subpopulations" category.

[e]Both of the plume intercepts (May 28 and June 1) near the landfill (300 m from the landfill fire) had benzene in excess of 4.4 ppb, placing them in the "hazardous" category. The June 1 AQI is corroborated by acrolein and 1,3 butadiene (see h and i) while the May 28 has a much higher ratio of benzene to these other compounds (see g and h).

[f]This row corresponds to instantaneous CO measurements Kansas Ave. (1.0 km) from the plume under "very smoky" conditions on June 4. The CO concentration as a marker of the multipollutant mixture identifies the period as "hazardous" even though the health effect of CO itself is not considered in the AQI and the level of CO is below the TLV-TWA of 29,000 $\mu g/m^3$

1-h Average Pollutant in Tire Smoke							1-h Average Background $PM_{2.5}$ (µg/m^3)					
1,3 Butadiene (ppb)	1,3 Butadiene (µg/m^3)	Acrolein (ppt)	Acrolein (ng/m^3)	CO_2 (ppm)	CO_2 (mg/m^3 C)	$PM_{2.5}$ BaP (ng/m^3)	0	10	20	30	40	50
0	0	0	0	0	0	0	0	13	26	39	52	62
0.020	0.044	0.87	2	0.31	0.15	0.70	2	15	28	42	54	64
0.040	0.088	1.7	4	0.61	0.30	1.4	4	17	30	44	55	65
0.060	0.13	2.6	6	0.92	0.45	2.1	6	19	33	46	57	67
0.080	0.18	3.5	8	1.23	0.60	2.8	8	21	35	48	59	69
0.10	0.22	4.4	10	1.53	0.75	3.5	10	23	37	50	61	71
0.20	0.44	8.7	20	3.1	1.5	7.0	21	34	47	59	69	79
0.40	0.90	17	40	6.1	3.0	14	41	54[b]	67	77	87	97
0.60	1.3	26	60	9.2	4.5	21	62	74[a]	84	94	104	114
1.0[g]	2.2	44	100	15	7.5	35	99	109	119	129	139	149
2.0	4.4	87[h]	200	31	15	70	184	194	204	214	222	225
3.0	8.8	174	400	61	30	140	281	284	286	288	291	293
4.0[i]	13	262[j]	600	92	45	210	330	333	335	337	340	342

[g]This row corresponds to the instantaneous 1,3 butadiene measurement at the landfill edge on May 28, placing the sampling the "unhealthy for sensitive subpopulations" category. This conflicts with the benzene measurements (see note e).

[h]This row marks the acrolein MDL for the TO-15 sampling done during the Iowa City fire

[i]This row corresponds to the instantaneous 1,3 butadiene measurement at the landfill edge on June 1. This places the sample in the "hazardous category" and matches the determination based on benzene (note e) and acrolein (note j).

[j]The instantaneous acrolein at the landfill fire edge on June 1 exceeded this row's threshold by a factor of 6. This places the sample in the "hazardous category" and matches the determination based on benzene (note e) and 1,3 butadiene (note i).

8-h Average Pollutant in Tire Smoke							8-h Average Background $PM_{2.5}$ (µg/m^3)					
Benzene (ppb)	Benzene (µg/m^3)	CO (ppb)	CO (µg/m^3)	SO_2 (ppb)	SO_2 (µg/m^3)	$PM_{2.5}$ (µg/m^3)	0	10	20	30	40	50
0	0	0	0	0	0	0	0	23	45	64	82	100
0.015	0.047	20	23	0.5	1.3	1	3	26	48	67	85	102
0.029	0.094	40	46	1.0	2.7	2	6	29	52	69	87	105
0.044	0.14	60	68	1.5	4	3	9	32	54	72	90	107
0.06	0.19	80	91	2.0	5	4	12	35	57	74	92	110
0.07	0.24	100	114	2.5	7	5	15	38	59	77	95	112
0.15	0.47	199	228	5	13	10	30	53	72	90	108	125
0.29	0.94	398	456	10	27	20	61	79	97	115	132	150
0.44	1.4	597	684	15	40	30[k]	87	105[c]	123	140	157	173
0.7	2.4	996	1140	25	67	50	138	155	172	188	192	196
1.5	4.7	1990	2280	51	133	100	231	235	239	244	248	252
2.9	9.4	3981	4560	102	266	200	318	328	338	348	358	368
4.4	14	5971	6840	152	400	300	444	449	454	459	465	470

[k]This row corresponds to the worst 8-h period from Hoover Elementary (based on measurements of $PM_{2.5}$). Background $PM_{2.5}$ was ~10 µg/m^3 placing those conditions in the "unhealthy for sensitive subpopulations" category.

8-h Average Pollutant in Tire Smoke							8-h Average Background $PM_{2.5}$ ($\mu g/m^3$)					
1,3 Butadiene (ppb)	1,3 Butadiene ($\mu g/m^3$)	Acrolein (ppt)	Acrolein (ng/m^3)	CO_2 (ppm)	CO_2 (mg/m^3 C)	$PM_{2.5}$ BaP (ng/m^3)	0	10	20	30	40	50
0	0	0	0	0	0	0	0	23	45	64	82	100
0.020	0.044	0.87	2	0.31	0.15	0.70	3	26	48	67	85	102
0.040	0.088	1.7	4	0.61	0.30	1.4	6	29	52	69	87	105
0.060	0.13	2.6	6	0.92	0.45	2.1	9	32	54	72	90	107
0.080	0.18	3.5	8	1.23	0.60	2.8	12	35	57	74	92	110
0.10	0.22	4.4	10	1.53	0.75	3.5	15	38	59	77	95	112
0.20	0.44	8.7	20	3.1	1.5	7.0	30	53	72	90	108	125
0.40	0.90	17	40	6.1	3.0	14	61	79	97	115	132	150
0.60	1.3	26	60	9.2	4.5	21	87	105[c]	123	140	157	173
1.0	2.2	44	100	15	7.5	35	138	155	172	188	192	196
2.0	4.4	87	200	31	15	70	231	235	239	244	248	252
3.0	8.8	174	400	61	30	140	318	328	338	348	358	368
4.0	13	262	600	92	45	210	444	449	454	459	465	470

24-h Average Pollutant in Tire Smoke							24-h Average Background $PM_{2.5}$ ($\mu g/m^3$)					
Benzene (ppb)	Benzene ($\mu g/m^3$)	CO (ppb)	CO ($\mu g/m^3$)	SO_2 (ppb)	SO_2 ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	0	10	20	30	40	50
0	0	0	0	0	0	0	0	42	67	88	112	137
0.015	0.047	20	23	0.5	1.3	1	5	47	70	91	115	140
0.029	0.094	40	46	1.0	2.7	2[l]	10	52[e]	73	94	118	143
0.044	0.14	60	68	1.5	4	3	15	54	76	97	121	146
0.06	0.19	80	91	2.0	5	4	20	57	79	100	125	150
0.07	0.24	100	114	2.5	7	5	25	60	82	103	128	153
0.15	0.47	199	228	5	13	10[m]	49	75[d]	96	119	144	160
0.29	0.94	398	456	10	27	20	82	104	127	152	167	173
0.44	1.4	597	684	15	40	30	111	134	159	175	180	186
0.7	2.4	996	1140	25	67	50	174	190	195	201	206	211
1.5	4.7	1990	2280	51	133	100	246	251	257	262	267	272
2.9	9.4	3981	4560	102	266	200	368	378	388	398	408	418
4.4	14	5971	6840	152	400	300	494	504	514	524	534	544

[l]This row corresponds to the worst 24-h period from IA-AMS (based on dispersion model of $PM_{2.5}$). Background $PM_{2.5}$ was ~10 $\mu g/m^3$ placing the category as "good." This is corroborated by B[a]P measurements (see note n).

[m]This row corresponds to the worst 24-h period from Hoover Elementary (based on measurements of $PM_{2.5}$). Background $PM_{2.5}$ was ~10 $\mu g/m^3$ placing those conditions in the "moderate" category.

24-h Average Pollutant in Tire Smoke							24-h Average Background $PM_{2.5}$ ($\mu g/m^3$)					
1,3 Butadiene (ppb)	1,3 Butadiene ($\mu g/m^3$)	Acrolein (ppt)	Acrolein (ng/m^3)	CO_2 (ppm)	CO_2 (mg/m^3 C)	$PM_{2.5}$ BaP (ng/m^3)	0	10	20	30	40	50
0	0	0	0	0	0	0	0	42	67	88	112	137
0.020	0.044	0.87	2	0.31	0.15	0.70	5	47	70	91	115	140
0.040	0.088	1.7	4	0.61	0.30	1.4[n]	10	52[e]	73	94	118	143
0.060	0.13	2.6	6	0.92	0.45	2.1	15	54	76	97	121	146
0.080	0.18	3.5	8	1.23	0.60	2.8	20	57	79	100	125	150
0.10	0.22	4.4	10	1.53	0.75	3.5	25	60	82	103	128	153
0.20	0.44	8.7	20	3.1	1.5	7.0	49	75[d]	96	119	144	160
0.40	0.90	17	40	6.1	3.0	14	82	104	127	152	167	173
0.60	1.3	26	60	9.2	4.5	21	111	134	159	175	180	186
1.0	2.2	44	100	15	7.5	35	174	190	195	201	206	211
2.0	4.4	87	200	31	15	70	246	251	257	262	267	272
3.0	8.8	174	400	61	30	140	368	378	388	398	408	418
4.0	13	262	600	92	45	210	494	504	514	524	534	544

[n]This row corresponds to the worst 24-h period from IA-AMS (based on 24-h B[a]P measurements). Background $PM_{2.5}$ was ~10 $\mu g/m^3$ placing the category as "good." This is corroborated by dispersion modeling (see note k).

Section 6. After Action Review by Johnson County Department of Public Health

AFTER ACTION REVIEW

EVENT SUMMARY –

Incident Name: Landfill Fire of 2012
Dates of Assignment: May 26 – June 9, 2012
After Action Review – Air Quality Monitoring Activities

At 6:38 pm on Saturday, May 26, the Fire Department responded to a call of a fire at the Iowa City Landfill, 3900 Hebl Ave., one mile west of Hwy 218 in Iowa City. The fire appears to have started at the working face of the landfill where garbage was dumped earlier in the day.

The fire then spread to the landfill liner system which includes a drainage layer of approximately 1.3 million shredded tires. Once the fire was in the drainage system, strong south winds spread it quickly along the west edge of the landfill cell.Landfill staff used bulldozers to cut a gap in the shredded tire layer to contain the fire, but the fire spread across the gap before it could be completed. Staff regrouped and cut two additional fire breaks to halt the rapidly moving fire.

Protecting the health and safety of the public and workers onsite remained the number one priority for the City and all cooperating agencies as the tire shreds continued to burn. Also of primary concern was keeping the fire from spreading to adjacent landfill cells and to a portion of the new cell that was successfully isolated in the days following the fire's ignition. On June 1, Iowa City Mayor Matt Hayek signed a Local Disaster Declaration document. The declaration facilitated access to state and federal resources, including advanced air quality monitoring and thermal imaging technology to assist with mitigating the incident.

The Johnson County Health Department partnered with the State Hygienic Laboratory, Iowa Department of Natural Resources and subject matter experts with the University of Iowa to monitor air quality throughout the region. Officials with the United States Environmental Protection Agency were actively partnering with local and state officials on those issues related to air quality. The following precautions were issued to the general public:

Persons in the path of the smoke plume should avoid exposure to the smoke as much as possible. Persons who have respiratory, heart or other conditions which may be aggravated by smoke, pregnant women, and the young and elderly should shelter in places with outside sources of air shut off. Most home air conditioning units recirculate air from the interior and should be sufficient. Businesses and other structures which draw in outside air should close outside air sources if the smoke plume is present. Avoid outdoor activities such as exercising if the smoke plume is present. Nursing homes, day cares and other businesses which care for the elderly, very young, and persons with respiratory diseases should take special care to monitor the health of clients and to minimize exposure to the smoke plume.

On Tuesday, June 12, Environmental Restoration contactors completed a stir, burn, and cover strategy to finally contain the fire and stop the burning. Heavy equipment was in operation for a period of nine (9) days. Occasion flare-ups remain a possibility while overhaul operations are ongoing. After Action Review (AAR) Lessons Learned Incident Name: Landfill Fire of 2012

Dates of Assignment: May 26 – June 9, 2012

After Action Review – Air Quality

Monitoring Activities

The AAR is a tool that allows teams to learn from what they are doing and improve their performance. It is a structured discussion of specific events, inclusive of the entire team, and focused on learning from action to improve performance.

Lessons learned from the AAR discussion must be captured and put back into action and applied to performance quickly. The AAR is designed to help us understand why objectives were or were not accomplished, what really happened, what lessons can be learned, and how we can apply those lessons to improve performance.

AAR for Air Quality Activities:
June 27, 2012 1:00 – 3:00 pm
Johnson County Health and Human Services Building, Room 119D
Participants: Doug Beardsley and James Lacina, Johnson County Public Health; Scott Spak, U of I Environmental Policy Program at the Public Policy Center; Dave Wilson, JC Emergency Management Coordinator; Robert Bullard, U of I Dept. of Chemical & Biochemical Engineering; Betsy Stone and Jared Downard, U of I Dept. of Chemistry; Pam Kostle and Wanda Reiter-Kintz, State Hygienic Laboratory; Josh Sobaski and Kurt Levetzow, IA Dept. of Natural Resources (by phone); Shane Dodge, Linn County Public Health (by phone);

1. What was the most notable success at the incident that others may learn from? Please explain.

At the incident response level, use of the Incident Command System (ICS) was very instrumental in assuring that roles within the incident were understood and that information was shared and staff kept up-to-date on activities. Cooperation and willingness to help on the part of partner organizations was tremendous. Of particular note were the State Hygienic Laboratory and Linn County Public Health.
Staff from both agencies were on the phone with JCPH early on (and late night) with offers to assist with air monitoring. We had DNR involvement which led to participation by EPA as well to offer technical assistance.

The learning curve, while steep, was handled well by all parties involved. Again, the success was due to the large number of resources and the infrastructure (internet, search engines, access to subject matter experts, teleconferencing, etc.) to access them. Staff at JCPH made the response a priority and had to juggle very full schedules from other duties in order to conduct the monitoring activities (as did staff from other agencies and organizations). This prioritization in order to address an emergency was appreciated.

The early development of a health message related to the smoke and the consistency of the message in light of research and air monitoring seemed to lend to the success of Iowa City's efforts and public information. The City was very open with information and very proactive with making information accessible to the public.

2. What were some of the most difficult challenges faced and how were they overcome? Please explain.

Since this was a new area in which JCPH did not have expertise, we tried to locate some sort of standard approach for monitoring a smoke plume. There was ample research on the constituents of tire fire smoke and some enlightening case studies of other large fires, but we could not locate a "how to" approach on monitoring. We proceeded with what made sense and shared that approach with local, state and federal partners for feedback. There was general consensus that our approach was good. We continued by sharing test results and continuously looked for feedback on monitoring strategies. It turns out that the strategy is fairly simple; drive in to the smoke at varying distances from the source and take samples. Most of our samples were "grab" samples. A better approach would be to take longer term samples to average out exposures. This challenge was overcome by doing what could be done and then being open with the public and being consistent and proactive with the message.

There was some initial confusion about who should be contacted and exact protocols to follow in order to access State and Federal resources. Early involvement of the County EMA was helpful, but sometimes there may have been parallel efforts aimed at the same resource. There was some confusion about "ownership" of SHL resources and how the DNR fit in to that. JCPH was not aware or did not understand the relationship of SHL capabilities and DNR funding of those services and whether or not SHL needed DNR acknowledgement to act. This may have been immaterial, however (no "need to know") as SHL secured whatever acknowledgements were needed. JC EMA was making requests but found that the feedback loop from State partners was inconsistent. This may have been complicated by too many people calling various duty officers (i.e. JCPH called the IDPH duty officer for assistance in contacting SHL and Linn CPH rather than directing all traffic via JC EOC.). Despite any confusion, there was no perceptible delay in deploying resources once we decided where we wanted to get samples.

EMA and SHL will follow up to review who has what authorities and how we can streamline or reaffirm the correct notification procedures to secure air monitoring assets in the future. While we would evaluate the air monitoring efforts as being successful, better coordination would have been welcome. JCPH was primarily coordinating the efforts and communicating with its partners who were providing testing services. Feedback during the AAR was that several strategy meetings with all air monitoring partners involved would have been helpful and may have changes how assets were deployed. Solution: in an incident of this magnitude in the future, staff up the air monitoring branch so a branch director is less involved in actual monitoring activities and has time to focus on coordination and strategy.

Additionally, there was some confusion or duplication when requesting Federal assets in the form of EPA assistance. When JCPH sent in a request for EPA assistance and then spoke with the EPA representative, other communication and/or requests had already been sent to EPA and they had already received deployment orders before speaking with JCPH. We appreciated their prompt response but there were some moments of concern about deployment and "what are they planning to do" on the part of JCPH. It turned out well in this case, which is the bottom line, but it caused a bit of unnecessary worry.

Another challenge or lesson learned was not being aware of and using the full capabilities for air monitoring which exists on the Hazmat vehicles. The Hazmat testing equipment was eventually deployed as the incident got in to the "stir, burn, and cover" activities. EMA will review these capabilities and ensure that they are listed as a resource for similar future events.

3. What changes, additions or deletions are recommended to augment agency training curriculums and/or operating policies?

As mentioned above, we will review our procedures for requesting assistance outside of our jurisdiction. We will review if we should pursue individual agreements with Linn County Public Health and the SHL or if current procedures working through the EOC are adequate to meet liability, reimbursement and other issues associated with receiving assistance. We will continue to train staff in the ICS and role of the EOC.

4. What issues were not resolved to your satisfaction and need further review? Based on what was learned, what is your recommendation for resolution?

There were no major issues which had not been resolved during the course of the incident or have not already been addressed above.

5. What remedies will the organization pursue and who will champion each initiative? If possible, attach timelines for completion.