Health Risk Evaluation of Site Specific Ambient Air Measurements in Garfield County, Colorado (July – September 2017)

January 3, 2018

Prepared for:

Garfield County Public Health
195 West 14th Street
Rifle, Colorado 81650

Prepared by:

COLORADO
Oil & Gas Health Information & Response
Department of Public Health & Environment

Phone: (303) 389-1687
Email: cdphe_oghealth@state.co.us
www.colorado.gov/oghealth

Executive Summary

Garfield County Public Health (GCPH) collected air samples between July to September 2017 to measure multiple volatile organic compounds (VOCs) near a newly developed oil and gas well in Battlement Mesa. GCPH requested the Oil and Gas Health Information and Response (OGHIR) program at the Colorado Department of Public Health and Environment (CDPHE) to conduct a health risk evaluation of these VOC air samples.

Although these data are limited, the main findings from this evaluation suggest:

- All air concentrations of individual and combined VOCs were below long-term non-cancer health guideline values established by state and federal agencies. Seven of the 79 VOCs did not have health guideline values and therefore, were not evaluated.
- Cancer risks estimates for benzene and ethylbenzene individually and combined were within the US EPA generally acceptable risk range of $1x10^{-6}$ to $1x10^{-4}$ (Table 3).
- The non-cancer and cancer risk estimates were similar for both downwind and upwind samples.

Overall, the evaluation of the air samples during this time indicates a low risk of cancer and long-term non-cancer health effects due to VOC exposure in the vicinity of this oil and gas operation.

Background

Garfield County Public Health (GCPH) is conducting an ongoing evaluation of the air quality near a newly developed oil and gas well in Battlement Mesa, operated by URSA Operating Company, LLC. GCPH requested the Oil and Gas Health Information and Response (OGHIR) Program at the Colorado Department of Public Health and Environment (CDPHE) to conduct a health risk evaluation of the measured VOCs in the third quarter air samples.

Purpose

The purpose of this assessment was to evaluate the health risks from the measured volatile organic compounds.

Methods

VOC air sampling

GCPH contracted Air Resource Specialists (ARS) to design and build a conditional sampler to collect air samples south of the URSA well pad in Battlement Mesa. One sample per month from July to September 2017 (a total of three samples) was collected by GCPH staff over a week long period with the conditional sampler designed to collect ambient air samples when prevailing winds were coming from the direction of the well-pad (termed downwind). An upwind sample was simultaneously collected to provide background measurements (termed upwind). Samples were analyzed for VOC's following EPA's Method TO-12. Details of the VOC sampling study area available via GCPH/ARS.

Health risk evaluation

A screening level health risk evaluation was performed in accordance with the US Environmental Protection Agency guidance[1].

1. Exposure Evaluation
   Because these samples were collected over approximately 1-2 weeks, they more likely represent long-term average exposures rather than short-term (i.e. one hour or less) exposures. Although the emissions from the monitored oil and gas site during the current phase of operation will be much less than a lifetime of exposure, long-term exposure assumes a person lives or stays near a given monitoring location for 24 hours per day, 365 days per year, for a lifetime (i.e., 70 years). It also assumes the measured concentrations of the VOCs in the air remain constant over the entire 70-year exposure period.

2. Health Effect Evaluation
   Non-cancer health effects: A non-cancer health guideline value (HGV) is defined as the exposure level that is likely to be without appreciable risk of adverse non-cancer health effects in an exposed population, including sensitive individuals. The HGV for each VOC is expressed as a concentration in units of parts per billion. Long-term (chronic) HGVs were used to compare to the air measurements. There were no long-term HGV's for 1-dodecene, 1-nonene, 1-octene, 1-undecene, cis-2-hexene, cyclopentene and n-tridecane and therefore, these VOCs were not evaluated in this health risk assessment.

[1] US EPA (2004). Air Toxics Technical Resource Manual, EPA-453-K-04-001A.

Cancer health effects: For VOCs that could cause cancer, VOC concentrations associated with 1x 10^{-6} (one in one million) to 1x10^{-4} (one in ten thousand) cancer risk levels were used as comparison values. For example, a risk level of one in a million (1x10^{-6}) implies that up to 1 out of one million equally exposed people could contract cancer if exposed continuously (i.e. 24 hours per day) to the specific concentration over a lifetime (i.e. 70 years). This would be in addition to those cancer cases that would normally occur in an unexposed population of one million people. The level of cancer risk that is of concern is a matter of individual, community, and regulatory judgment. However, the EPA typically considers risks below 1 x 10^{-6} to be so small as to be negligible. Therefore, the EPA uses a cancer risk of one in a million (1 x 10^{-6}) as a regulatory goal, which means that regulatory programs are generally designed to try to reduce risk to this level. However, the EPA considers all cancer risks lower than 1 in 10,000 (1x10^{-4}) to be "acceptable".

3. Risk Characterization

Non-cancer health effects

Individual VOCs: A hazard quotient (HQ) was determined for each individual VOC that had an established HGV. This ratio is a risk estimate that compares the maximum or average air concentration for each VOC to long-term HGV. HQs are an indication of whether there is potential cause for concern for adverse health effects.

Combined VOCs: When simultaneous exposures to multiple chemicals in the air can occur, it is important to evaluate the potential for risks to human health from combined exposures. To evaluate the combined risk, a Hazard Index or HI is used. An HI is calculated by adding together all of the individual HQs. This total HI is a conservative approximation of the total non-cancer risk for exposure to all of the VOCs.

HQs and His are calculated as follows:

$$HQ = \frac{\text{air measurement}}{HGV}$$

HQ = Hazard Quotient
HGV = Health Guideline Value

HI= HQ1+HQ2+HQ3+….

HQs and HIs are evaluated as follows:

- If HQ or HI is less than 1, no further evaluation is necessary and it can generally be concluded that potential for adverse health effects from the exposures measured in this study is low.
- If HQ or HI is greater than or equal to 1, further evaluation is recommended.

Cancer health effects:

To estimate the potential for increased cancer risks, the VOC concentration at each risk level within the generally "acceptable" risk range (1x10^{-4} to 1x10^{-6}) was compared to the exposure measurements. Combined cancer risks were also evaluated for all known cancer causing VOCs. This approach assumes the combined effect of each of the VOCs is additive.

Results

- All air concentrations of VOCs were below long-term non-cancer health guideline values (Table 2).
  - Benzene concentrations in August had the highest hazard estimates of approximately 0.18 (canister 1 / downwind) and 0.16 (canister 2 / upwind).
  - All other VOCs were at least 100 times below their respective non-cancer long term health guideline value.
- Cancer risks estimates for benzene and ethylbenzene individually or together were within the acceptable risk range of $1x10^{-6}$ to $1x10^{-4}$ (Table 3).
  - Cancer risk estimates for the two substances were the same for both the upwind and downwind samples.
- In general, the non-cancer and cancer risk estimates were similar for both downwind and upwind samples.

Limitations

The following limitations must be considered when interpreting the results from this air sampling:

- This air sampling represents a "snapshot" of VOC concentrations from all emission sources in the area during separate week long periods. This sampling technique may not accurately capture peak exposures and samples collected under different conditions and times could have different results.
- Other substances may be emitted from oil and gas that were not sampled in this study and exposure to these substances may result in additional health risk.

Conclusions

Although these data are limited, the evaluation of the air samples during this time indicates a low risk of long-term harmful health effects due to VOC exposure in the vicinity of this oil and gas operation.

Table 1. Air measurements compared to non-cancer long-term (chronic) health guideline values (HGV). All values are in ppbV.

Substance*	Canister 1 (Downwind)			Canister 2 (Upwind)			Chronic HGV
	July	August	Sep.	July	August	Sep.	
1,2,3-Trimethylbenzene	ND	ND	0.03	ND	ND	0.11	12 [I]
1,2,4-Trimethylbenzene	0.15	0.27	0.10	0.24	0.15	ND	12 [I]
1,3,5-Trimethylbenzene	ND	ND	0.03	ND	ND	ND	12 [I]
1-Hexene	0.04	0.08	ND	0.05	ND	0.06	50 [T]
1-Pentene	0.10	0.12	0.04	0.12	0.09	0.10	560 [T]
2,2-Dimethylbutane	0.06	0.05	0.05	ND	0.03	0.02	100 [T]
2,3-Dimethylbutane	ND	0.07	0.09	ND	ND	0.03	99 [R]
2,3-Dimethylpentane	ND	0.04	0.05	ND	ND	ND	2200 [T]
2,4-Dimethylpentane	0.06	0.06	0.04	0.04	0.03	0.02	2200 [T]
2-Methyl-2-butene	ND	0.06	0.05	ND	0.07	0.05	560 [T]
2-Methylheptane	ND	ND	0.12	ND	ND	ND	380 [T]
2-Methylhexane	ND	ND	0.18	ND	ND	ND	2200 [T]
2-Methylpentane	ND	ND	0.48	ND	ND	ND	90 [T]
3-Methylheptane	0.11	0.11	0.10	0.04	0.06	0.04	380 [T]
3-Methylhexane	0.32	0.34	0.18	0.18	0.24	0.16	2200 [T]
3-Methylpentane	0.26	0.22	0.21	0.12	0.14	0.10	100 [T]
Acetylene	0.27	0.22	0.55	ND	0.12	0.30	2500 [T]
a-Pinene	0.04	ND	ND	0.03	ND	ND	63 [T]
Benzene	ND	1.64	0.49	ND	1.54	0.31	9.39 [I]
b-Pinene	0.47	ND	ND	0.75	ND	ND	63 [T]
cis-2-Butene	0.02	0.03	ND	ND	ND	0.03	700 [T]
Cyclohexane	0.58	0.55	0.44	0.36	0.35	0.24	1743 [I]
Cyclopentane	0.05	0.05	0.05	0.03	0.03	0.02	120 [T]
Ethane	19.55	20.45	23.05	8.45	9.80	8.00	NA
Ethylbenzene	0.19	0.18	0.13	0.16	0.10	0.16	230 [I]
Ethylene	1.39	2.49	1.33	1.93	1.82	1.92	5300 [T]
Isobutane	1.43	1.45	1.64	0.52	0.66	0.48	10000 [T]
Isoprene	0.16	0.13	0.07	0.23	0.12	0.19	2 [T]
Isopropylbenzene	ND	ND	ND	0.02	0.01	0.02	81 [T]
Methylcyclohexane	0.43	0.90	0.91	ND	0.58	0.29	400 [T]
Methylcyclopentane	0.45	0.32	0.30	0.25	0.20	0.13	75 [T]
m-Ethyltoluene	0.79	0.16	ND	0.26	ND	ND	25 [T]
m-Xylene/p-Xylene	0.32	0.32	0.24	0.12	0.22	0.16	23 [T]
n-Butane	1.54	1.52	1.75	0.65	0.74	0.66	10000 [T]
n-Decane	0.11	0.10	0.14	0.10	0.07	0.06	175 [T]
n-Dodecane	0.22	0.13	0.13	0.52	0.11	0.06	210 [R]
n-Heptane	0.45	0.38	0.35	0.18	0.26	0.15	2200 [T]
n-Hexane	0.83	0.58	0.52	0.40	0.36	0.27	198 [I]
n-Nonane	0.17	0.18	0.16	ND	0.12	0.10	38 [P]
n-Octane	0.44	0.43	0.35	0.27	0.30	0.21	75 [T]
n-Pentane	0.76	0.66	0.73	0.38	0.40	0.32	8000 [T]
n-Propylbenzene	0.04	0.06	ND	0.10	0.04	ND	203 [P]
n-Undecane	0.11	0.14	0.16	0.34	0.10	0.08	55 [T]
o-Xylene	0.18	0.19	0.17	0.28	0.17	0.15	23 [T]
Propane	5.97	6.20	7.13	2.55	2.93	2.57	8000 [T]
Propylene	0.99	1.19	0.49	1.37	1.14	1.07	1743 [C]
Toluene	9.87	10.57	5.14	24.71	11.24	6.09	1327 [I]
trans-2-Butene	0.23	0.19	ND	0.11	0.23	ND	700 [T]
trans-2-Pentene	0.14	0.06	0.03	0.10	0.09	0.04	560 [T]

*Only substances that were above the detection limit in at least one sample and had a health guideline value are reported in the table. I = US EPA; A = ATSDR (US Agency for Toxic Substances and Disease Registry); P= PPRTV (US EPA Provisional Peer Reviewed Toxicity Values); C= CalEPA (California Office of Environmental Health Hazard Assessment); T= TCEQ (Texas Commission on Environmental Quality); R = Read Across; NA = no health value available- substance is considered an asphyxiant at extremely high exposures with no other toxicological effects.

Table 2. Non-cancer long-term risk estimates for individual VOCs for both downwind and upwind samples. The risk estimate is the ratio that compares the air concentration for each VOC to long- term HGV (see Table 1). A value below 1 indicates that the air concentration was below the HGV.

Substance	Canister 1 (Downwind)			Canister 2 (Upwind)		
	July	August	September	July	August	September
1,2,3-Trimethylbenzene	ND	ND	0.0026	ND	ND	0.0091
1,2,4-Trimethylbenzene	0.0124	0.0224	0.0082	0.0204	0.0129	ND
1,3,5-Trimethylbenzene	ND	ND	0.0025	ND	ND	ND
1-Decene	ND	ND	ND	ND	ND	ND
1-Hexene	0.0007	0.0016	ND	0.0010	ND	0.0013
1-Pentene	0.0002	0.0002	0.0001	0.0002	0.0002	0.0002
1-Undecene	ND	ND	ND	ND	ND	
2,2-Dimethylbutane	0.0006	0.0005	0.0005	ND	0.0003	0.0002
2,3-Dimethylbutane	ND	0.0007	0.0009	ND	ND	0.0003
2,3-Dimethylpentane	ND	0.0000	0.0000	ND	ND	
2,4-Dimethylpentane	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2-Methyl-2-butene	ND	0.0001	0.0001	ND	0.0001	0.0001
2-Methylheptane	ND	ND	0.0003	ND	ND	ND
2-Methylhexane	ND	ND	0.0001	ND	ND	ND
2-Methylpentane	ND	ND	0.0053	ND	ND	ND
3-Methylheptane	0.0003	0.0003	0.0003	0.0001	0.0002	0.0001
3-Methylhexane	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001
3-Methylpentane	0.0026	0.0022	0.0021	0.0012	0.0014	0.0010
Acetylene	0.0001	0.0001	0.0002	ND	0.0000	0.0001
a-Pinene	0.0007	ND	ND	0.0005	ND	ND
Benzene	ND	0.1750	0.0522	ND	0.1638	0.0330
b-Pinene	0.0074	ND	ND	0.0119	ND	ND
cis-2-Butene	0.0000	0.0000	ND	ND	ND	0.0000
cis-2-Hexene	ND	ND	ND	ND	ND	ND
Cyclohexane	0.0003	0.0003	0.0002	0.0002	0.0002	0.0001
Cyclopentane	0.0004	0.0004	0.0004	0.0002	0.0002	0.0002
Ethane	NA	NA	NA	NA	NA	NA
Ethylbenzene	0.0008	0.0008	0.0006	0.0007	0.0004	0.0007
Ethylene	0.0003	0.0005	0.0003	0.0004	0.0003	0.0004
Isobutane	0.0001	0.0001	0.0002	0.0001	0.0001	0.0000
Isoprene	0.0801	0.0640	0.0357	0.1160	0.0583	0.0933
Isopropylbenzene	ND	ND	ND	0.0002	0.0002	0.0002
Methylcyclohexane	0.0011	0.0022	0.0023	ND	0.0015	0.0007
Methylcyclopentane	0.0060	0.0043	0.0040	0.0033	0.0026	0.0018
m-Ethyltoluene	0.0316	0.0062	ND	0.0102	ND	ND
m-Xylene/p-Xylene	0.0139	0.0141	0.0102	0.0052	0.0097	0.0070
n-Butane	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001
n-Decane	0.0006	0.0006	0.0008	0.0006	0.0004	0.0004
n-Dodecane	0.0011	0.0006	0.0006	0.0025	0.0005	0.0003
n-Heptane	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001
n-Hexane	0.0042	0.0029	0.0026	0.0020	0.0018	0.0013
n-Nonane	0.0045	0.0047	0.0042	ND	0.0032	0.0026
n-Octane	0.0059	0.0058	0.0047	0.0036	0.0040	0.0027
n-Pentane	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
n-Propylbenzene	0.0002	0.0003	ND	0.0005	0.0002	ND
n-Undecane	0.0020	0.0025	0.0029	0.0062	0.0019	0.0015
o-Xylene	0.0077	0.0080	0.0073	0.0121	0.0072	0.0063
Propane	0.0007	0.0008	0.0009	0.0003	0.0004	0.0003
Propylene	0.0006	0.0007	0.0003	0.0008	0.0007	0.0006
Toluene	0.0074	0.0080	0.0039	0.0186	0.0085	0.0046
trans-2-Butene	0.0003	0.0003	ND	0.0002	0.0003	ND
trans-2-Pentene	0.0003	0.0001	0.0001	0.0002	0.0002	0.0001

Table 3. Summary of air measurements compared to lowest VOC concentration at each risk level within the generally "acceptable"[1] risk range ($1x10^{-4}$ to $1x10^{-6}$).

Substance	Range of Air Measurement[2] (ppb)	Cancer Risk Estimate		
		Air Concentration at $1x10^{-6}$ (ppb)	Air Concentration at $1x10^{-5}$ (ppb)	Air Concentration at $1x10^{-4}$ (ppb)
Benzene[3]	0.31 - 1.64	0.041[2]	0.41[2]	4.1[2]
Ethylbenzene[4]	0.09 - 0.19	0.092[3]	0.92[3]	9.2[3]

[1]A one in a million cancer risk ($1x10^{-6}$) is considered a minimal cancer risk. A one in ten thousand cancer risk ($1x10^{4}$) is considered the upper limit of the US EPA "acceptable" range.
[2]Range of air measurements of all samples (Canister 1 and 2).
[3]Determined using the US EPA inhalation unit risk of 7.8 $x10^{-6}$ per $\mu g/m^3$.
[4]Determined using the CalEPA inhalation unit risk of $2.5x10^{-6}$ per $\mu g/m^3$.