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Summary of Colorado Public Health Studies 2005-2012 (compiled by Kent Kuster, Oil and Gas Liaison, CDPHE)

This document contains selected information obtained from published reports to provide a quick summary of available information on public health studies conducted in Colorado from 2005-2012. This document is not meant to reflect an opinion on the studies, but simply to provide summary information. Individuals are encouraged to read the studies to obtain all of the available information on potential health impacts from oil and gas development in Colorado.

Garfield County Air Toxics Inhalation Screening level Human Health Risk Assessment, June 2005-May 2007 - CDPHE Disease Control and Environmental Epidemiology Division

Study Purpose

Determine if residents are being exposed to airborne concentrations of VOCs via inhalation that may pose unacceptable risks to human health using monitoring data from fourteen (14) fixed sites in Garfield County from June 2005 through May 2007.

Conclusion

Overall, the non-cancer hazards on either a chronic or short-term (average) basis do not exceed an acceptable value of one and the cancer risk estimates are at, or slightly above, the upper-end of EPA's acceptable risk range (1 to 100 excess cancers per 1 million individuals). Although the estimated exposures are not likely to result in significant cancer and non-cancer health effects, this screening-level analysis stresses the need for continued air monitoring and source apportionment.

Potential Uncertainties

The monitoring study only looked at a total of 43 air toxics and some important air toxics are absent which may underestimate potential risks. Most importantly, the study is based on the limited monitoring data collected on a once per month or once per quarter basis which is significantly lower than the EPA National Air Toxic Program recommended data collection frequency on a once per 6-day basis. Additionally, science is currently unable to assess exposures to multiple air toxics simultaneously. Overall, uncertainties and limitations exist in the methods used to assess exposure and toxicity. Due to these limitations, this investigation is best viewed as a "snapshot" of air quality.

Quantitative evaluation of the risks to humans from environmental contamination is frequently limited by uncertainty (lack of knowledge) regarding a number of important exposure and toxicity factors. This lack of knowledge is usually circumvented by making estimates based on whatever limited data that are available, or by making assumptions based on professional judgment when no reliable data are available. Because of these assumptions and estimates, the results of risk calculations are themselves uncertain, and it is important for risk managers and the public to keep this in mind when interpreting the results of a risk assessment.

Garfield County Air Toxics Inhalation: Screening Level Human Health Risk Assessment, 2008- CDPHE Disease Control and Environmental Epidemiology Division

Study Purpose

Based on the work completed in 2007 and 2008, the Garfield County Public Health Department in 2009 requested that the CDPHE determine if residents in Garfield County are being exposed to airborne concentrations of measured air toxics such as speciated non-methane organic compounds and carbonyls that may pose unacceptable health risks via inhalation.

Conclusion

The available information suggests a potential for public health impacts across the oil and gas development areas in Garfield County. The estimated cumulative lifetime cancer risks for the 6 air toxics with known toxicity values are at or slightly above the high-end of EPA's acceptable cancer risk range of 1 to 100 excess cancers in a million (1E-06 to 1E-04) across all monitoring sites. Each of the 20 individual air toxics assessed at any monitoring site have a chronic noncancer hazard estimate well below an acceptable value of one. However, when accounting for the cumulative chronic noncancer hazards for all of these 20 air toxics the chronic noncancer hazard estimate is just below the acceptable level of one across the two monitoring sites.

The findings of this risk assessment support the need for the following:

- Continue long-term air monitoring; increase the frequency of sampling; and include in the sampling of a complete list of contaminants associated with oil and gas development.
- Implement short-term (acute) air monitoring by collecting 1-hour air samples in order to evaluate health risks posed by intermittent peak exposures.
- Determine source apportionment including sources other than the oil and gas operations, such as stationary industrial sources and mobile traffic sources.
- Continue management of the risk posed by potential exposures to air toxics as a result of increase in oil and gas development activities (e.g., additional monitoring, sample analysis, and action as appropriate).

Potential Uncertainties

Overall, it is important to note that the cancer risks are likely to be underestimated in this assessment because cancer toxicity values are only available for a small number of air toxics. Also, health risk assessments provide predictions of hypothetical health risks, which are intended as screening tools for risk managers and cannot be used to make realistic predictions of

biological effects. Finally, this investigation is best viewed as a "snapshot" of air quality due to the uncertainties and limitations in the methods used to assess exposure and toxicity.

Community Health Risk Analysis of Oil and Gas Industry Impacts in Garfield County, 2008 - Teresa Coons and Russell Walker

Study Purpose

In 2008, St. Mary's Saccomanno Research Institute and Mesa State College, with the help of communities in Garfield County, released a study of health risks related to oil and gas industry activities. The study purpose was to conduct a comprehensive study of health and environmental risks to residents of Garfield County. The study conducted over a period of three years, had two major components: a risk analysis based on environmental exposure data and modeling and a comprehensive health study to provide a baseline assessment of the health of Garfield County residents.

Conclusions

Risk Assessment - Risk modeling indicates that there are industry factors that could present a public health risk. Benzene emissions during uncontrolled flow back present the greatest cancer threat. The results of the risk assessment for air also indicate that reference concentrations for non-cancer effects may be exceeded for some situations. The use of best management practices can reduce that risk.

Health Study - At the present time based on our data sources there is not a health crisis in Garfield County, but there are some health trends that should be monitored. We cannot say conclusively that any of these health trends are directly related to the presence of natural gas industry activities or to other factors. Based on the data available to us from state, hospital association, and healthcare provider sources, the health of people in Garfield County is not different from the health of residents in other Western slope counties.

Potential Uncertainties

Lack of baseline health data with which to determine trends or changes, relatively new presence of the industry in the region and both risk and causation involve probability statements; may not be able to say with certainty that a particular health condition is caused by an exposure to potentially toxic materials. There are numerous gaps and uncertainties in our understanding of pollution from natural gas operations in Garfield County. The motivation for the recommendations is to reduce these uncertainties and fill data gaps. Better information is needed in order to make complete and accurate evaluation to threats to human health.

Garfield County Health Consultation prepared by CDPHE in Cooperation with ATSDR 2008 (Principal Investigator Raj Goyal)

Study Purpose

The purpose of this document is to identify any potential public health implications resulting from inhalation of volatile organic compounds in Garfield County and recommend actions to reduce exposure if necessary.

Conclusions

Data reviewed in this health consultation indicate that the ambient air quality in Garfield County constitutes an indeterminate public health hazard, for all current exposures, based on the estimated theoretical cancer risks as well as noncancer hazards and the uncertainties associated with the available data.

Potential Uncertainties

Three major sources of uncertainty were factored into this conclusion: (1) the ability to realistically and continuously monitor ambient air at all places of interest and in the breathing zone of the exposed population; (2) the reality that some of the monitoring locations may detect emissions from sources other than the oil and gas development activities; and (3) the inability to adequately capture intermittent peak exposures, as indicated by grab sampling events. Overall, given the uncertainty in the limited data and uncertainty in the exposure patterns of the community, more air monitoring is urged.

Garfield County Health Consultation prepared by CDPHE in Cooperation with ATSDR 2010 (Principal Investigator Raj Goyal)

Study Purpose

Garfield County Public Health Department requested evaluation of the 2008 air quality monitoring data; identify any potential health implications resulting from inhalation of ambient air in Garfield County and recommend actions to reduce the exposure, if necessary.

Conclusions

It cannot currently be determined if breathing ambient air in the monitored areas of Garfield County could harm people's health.

Potential Uncertainties

The cancer risks and noncancer hazards for 65 out of 86 contaminants cannot be quantitatively estimated due to limited toxicological information evaluation based on the available toxicity information. It should be noted that the current state of the science is unable to assess exposures to complex mixtures of air toxics, especially, synergistic and antagonistic interactions at low levels. Not all compounds that may have been associated with natural gas development were measured.

Analysis of Data Obtained from the Garfield County Air Toxics Study – Summer 2008 - CDPHE Air Pollution Control Division

Study Purpose

The study was intended to be used as a screening tool with the purpose of determining whether or not further, more in depth, air pollution research should be performed in the area. The ultimate goal of the study was to further develop the basis for decisions on how Garfield County can best manage the impacts of air pollution caused by energy development.

Conclusions

This study was performed at eight different well pad sites throughout Garfield County. Four of the sites were undergoing drilling activities and the other four were undergoing completion activities. The data collected at each of these sites indicates that the completion activities have

the potential for higher emissions of organic compounds into the surrounding area compared to drilling operations. This study provides support for the push to convert all well completions over to green completion technology in Colorado and elsewhere. The addition of this technology could help reduce future emissions. The addition of sampling around well pads that are undergoing activities other than drilling and completion could also be useful.

Potential Uncertainties

The scope of this air monitoring effort was not intended to serve as an all encompassing large scale assessment of all possible processes within the energy development industry or address every potential variable (seasonality, temporal, operational, etc.). Rather, it was designed to compare and estimate the potential emissions from these two processes taking place on a well pad.

Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources - Colorado School of Public Health 2012

Study Purpose

To estimate health risks for exposures to air emissions from an unconventional natural gas development project in Garfield County, Colorado with the goal of supporting risk prevention recommendations in a health impact assessment.

Conclusions

These preliminary results indicate that health effects resulting from air emissions during development of unconventional natural gas resources are mostly likely to occur in residents living nearest the well pads and warrant further study. Risk prevention efforts should be directed towards reducing air emission exposures for persons living and working near wells during well completions.

Potential Uncertainties

As with all risk assessments, scientific limitations may lead to over-or underestimation of the actual risks. The risk assessment also was limited by the spatial and temporal scope of the available monitoring data. The ½ mile cut point for defining the two different exposed populations in the exposure scenarios was based on complaint reports from residents living within ½ mile of existing unconventional natural gas development, which were the only available data. The actual distance which residents may experience greater exposures from air emissions may be less than or greater than a ½ mile, depending upon dispersion and local topography and meteorology. These limitations and uncertainties in our risk assessment highlight the preliminary nature of the results.

Hydrocarbon Emissions Characterization in the Colorado Front Range - A Pilot Study by NOAA Gabrielle Petron 2012

Study Purpose

A pilot study focused on describing and interpreting the measured variability in methane CH₄ and C 3-5 alkanes observed in the Colorado Front Range. The researcher used data from air samples collected at the NOAA tall tower located in Weld County as well as continuous CH₄

observations and discrete targeted samples from an intensive mobile sampling campaign in the Colorado Front Range. These atmospheric measurements are then used together with other emissions data sets to provide an independent view of methane and non-methane hydrocarbon emissions inventory results.

Conclusions

The analysis of the tower (300-m tall tower in SW corner of Weld County) reveals a strong alkane and benzene signature in the air masses coming from northeastern Colorado (natural gas is composed primarily of "alkanes" such as methane, ethane and propane, with methane comprising up to 90% of the gas). Using a Mobile Lab platform sampling was conducted downwind from different methane sources and both the tower and mobile lab revealed a common source for the alkanes. The alkanes did not correlate with combustion tracers, so the authors hypothesize that the observed alkanes were emitted by the same source located over the Denver-Julesburg Basin. The measured alkanes indicate that Weld County methane emissions from oil and gas production and processing in Colorado has most likely underestimated the methane attributed to natural gas by a factor of two.

Potential Uncertainties

More measurements are needed to further evaluate the various potential sources associated with oil and gas operations (For example, glycol dehydrators and condensate tank flash emissions). More targeted multi-species well-calibrated atmospheric measurements are needed to evaluate current future bottom-up inventory emissions calculations for fossil fuel sector and to reduce uncertainties on absolute flux estimates for climate and air quality relevant trace gases.

Air Emissions Case Study Related to Oil and Gas Development in Erie, Colorado prepared by CDPHE 2012

Study Purpose

To measure air emissions that may be associated with the well completion activities in Erie Colorado. In July of 2012, a natural gas production company began work on the drilling and completion of a number of wells on one well pad on the west side of Erie. This location is near a residential area and two elementary schools: Red Hawk Elementary to the south-southwest and Erie Elementary to the east. In response to the community's concerns, the CDPHE's Air Pollution Control Division (APCD) conducted monitoring in two locations after work on the wells began, primarily during completion activities.

Conclusions

This study provides a snapshot in time for this natural gas completion activity at this well pad only. The completion activities at this well pad were done using reduced emission or "green" completion techniques, which are a "best management" requirement designed to minimize air emissions from well completions. The air sampling results are consistent with what would be expected. No significant concentrations were recorded that could be directly attributed to well completion operations at this well pad. Concentrations of likely oil and gas related compounds such as ethane and propane were found to be slightly higher at the Erie sites than in downtown Denver, but much lower than in Platteville where greater oil and gas activity is taking place. Similarly, methane levels at the Erie sites were consistent with other locations, and were higher than in Denver, and lower than in Platteville. Toluene and benzene levels were higher at one Erie monitor than the other, likely due to emissions from truck traffic.

The monitored concentrations of benzene, one of the major risk driving chemicals, are well within acceptable limits to protect public health, as determined by the U.S. Environmental Protection Agency. The concentrations of various compounds are comparatively low and are not likely to raise significant health issues of concern.

Potential Uncertainties

This study includes a limited data set and may or may not be representative of conditions and potential emissions at other locations. It should be noted the current state of the science is unable to estimate the potential risks due to exposure from multiple chemicals at the same time, which may be higher.

An Exploratory Study of Air Quality near Natural Gas Operations - 2012 Theo Colborn, Kim Schultz, Lucille Herrick, and Carol Kwiatkowski

Study Purpose

The exploratory study was designed to assess air quality in a rural western Colorado area where residences and gas wells co-exist. Sampling was conducted before, during, and after drilling and hydraulic fracturing of a new natural gas well pad.

Conclusions

The data in this study show that air sampling near natural gas operations reveals numerous chemicals in the air, many associated with natural gas operations. Weekly air sampling for 1 year revealed that the number of non-methane hydrocarbons (NMHCs) and their concentrations were highest during the initial drilling phase and did not increase during hydraulic fracturing in this closed-loop system. Although concentrations of polycyclic aromatic hydrocarbons (PAHs) found in this study appear low, they may have clinical significance.

In order to determine how to reduce human exposure for both those who work on the well pads and those living nearby, systematic air quality monitoring of natural gas operations must become a regular part of permitting requirements. NMHCs need far more attention not only because of their potential immediate and long term chronic health effects, but also for their secondary indirect health and environmental impacts as precursors to ozone.

Potential Uncertainties

The concentrations at which these chemicals were detected in the air are far less than U.S. government safety standards such as NIOSH Recommended Exposure Limits and OSHA Permissible Exposure Limits (NIOSH 1992; OSHA 1993). However, government standards are typically based on the exposure of a grown man encountering relatively high concentrations of a chemical over a brief time period, for example, during occupational exposure. Consequently, such standards may not apply to exposure scenarios faced by individuals (including pregnant women, children, and the elderly) experiencing chronic, sporadic, low-level exposure, 24 hours a day 7 days a week in natural gas neighborhoods. Safety standards also do not account for the kinds of effects found from low-level exposure to endocrine disrupting chemicals (Vandenberg *et al.* 2012), which can be particularly harmful during prenatal development and childhood. In addition, our study would have benefited from more baseline samples. Unfortunately, there was no way to know exactly when drilling would start and we were only alerted when the drill rig was being installed. If we were to sample again, we would rotate sampling every six days and

at varied times around the clock. Most importantly, we would record meteorological data on-site throughout each sampling period. In rural mountainous areas, where local topography varies greatly, public sources of weather data may not be applicable for air quality research.