5 Uncertainty Evaluation

The risk estimates presented in this air toxic risk assessment are not fully probabilistic estimates but conditional estimates given a considerable number of assumptions about exposure and toxicity. Therefore, 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 addressed 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. A qualitative discussion of the major uncertainties in this risk assessment is provided below.

5.1 Uncertainties in Exposure Assessment

5.1.1 Air Monitoring

The collection and monitoring of ambient air is one of the largest sources of uncertainty. The uncertainty stems from the inability to realistically monitor continuously at all places of interest. Thus, a decision is made to monitor a portion of the time and in specific locations and apply the results to a broader area. The monitoring data at each station reflect 2-5 years of chemical concentrations in air, based on 24-hour sampling conducted every 6th day. It is uncertain how well this dataset reflects the lifetime exposure assumed in this risk assessment as changes in meteorology and chemical emissions could lead to lower or higher concentrations in air from year-to-year. To reduce this uncertainty would require monitoring over several years, or modeling based on changes in meteorology and chemical emissions.

Monitoring locations may or may not be representative of air concentrations to which an individual is exposed in the breathing zone 24 hours a day for a lifetime. Some of these monitoring locations are placed in areas with mixed industrial use or heavier traffic patterns. Potential health impacts associated with contaminant concentrations at these locations could over-estimate the true risk since they may not reflect the actual long-term residential exposure concentration. Additionally, they could underestimate true risk to people living near sources of high concentrations of contaminant emissions.

Finally, a large uncertainty stems from inability to monitor intermittent peak exposure, especially, for evaluating acute health effects. The nature of oil and gas operations is such that emissions vary strongly with time. To reduce this uncertainty, short-term or continuous air monitoring is needed. A lack of this information limits the ability to fully characterize acute risks. Therefore, the potential for acute risks is likely underestimated in this evaluation.

Air Quality Data

Overall, the available data for all SNMOCs and carbonyls is of high analytical quality. For the GCPH air studies (2008 to 2012), sampling was conducted on a once every 6th day for the speciated non-methane organic compounds (approximately 60 samples per year) and once every 12th day for the carbonyls (approximately 30 samples per year). While this follows general EPA protocols, the quantity of data is less than ideal for a robust statistical analysis on a one-year basis and can lead to an increased uncertainty.

5.1.2 Other Exposure Sources

It is important to note that residential and indoor sources such as paints, home furnishings, cleaning products, building materials, and other indoor sources of air toxics are not evaluated in this assessment. Many chemicals have been shown to accumulate in indoor environments, which could increase exposure. In addition, there are other multiple local outdoor emission sources that can impact air quality in the Garfield County. Among these are mobile and other stationary sources (e.g., traffic along the I-70 corridor, seasonal forest fires, gas stations and dry cleaners). The contribution from different outdoor sources is not evaluated in this assessment. However, the findings of the subsequent ambient air quality monitoring studies from 2008 to 2012 indicated that some of the primary chemicals (e.g., light alkanes, benzene, toluene, ethylbenzene, and xylene) associated with petroleum and natural gas emission sources are higher in rural Garfield County than in other urban areas (e.g., Grand Junction) outside the County (GCPH, 2009, 2010a, 2010b, and 2012). The measured concentrations of these compounds from 2008 to 2011 are also found to be higher in Garfield County than the urban U.S. averages measured by EPA urban network.

5.1.3 Exposure Parameters

Another source of uncertainty in estimating exposures is the assumption that all individuals will receive the same amount of chemical. This assumption does not take into account variability in parameters such as breathing rates, absorption rates, body weight, lung surface area, and frequency of exposure. This range of variability is, however, difficult to assess. Therefore, standard EPA default factors representing the upper limit of exposure parameters are used in this assessment.

5.1.4 Air Toxics of Potential Concern

Approximately 90 chemicals were both monitored and analyzed. However, there are additional chemicals (e.g., metals, halogenated hydrocarbons, and polycyclic aromatic hydrocarbons) that may need to be monitored and analyzed to fully understand the potential risks associated with oil and gas activities in the region. In view of this situation, it is possible that this evaluation may underestimate the potential risks posed by oil and gas activities.

5.2 Uncertainties in Toxicity Assessment

5.3 Uncertainty in Risk Estimation due to Multiple Contaminants

Interactions among components within petroleum, as well as other air and chemical exposures are not well understood. However, the interactions among the components of petroleum should be considered since petroleum may contain several hundred hydrocarbons. The hydrocarbons present in the petroleum mixture principally include alkanes, alkenes, and aromatic BTEX compounds. Therefore, the number of possible interactions in a complex mixture of petroleum is very large. However, it is not possible to reliably predict the effects of these complex interactions.

Both carcinogenic and noncarcinogenic risks for multiple contaminants are assumed to be additive, in accordance with the EPA guidance for health risk assessment of chemical mixtures. This assumption, however, is associated with several limitations and, therefore, there is potential for under- or over-estimation of risk. For example, the assumption of additivity of risk does not account for synergistic or antagonistic chemical interactions.

Overall, 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.

5.4 Uncertainty in Risk Characterization

A large amount of uncertainty is associated with the health risk estimates derived in this evaluation. All the risk estimates in this evaluation are based on annual average (95% upper confidence limit on the arithmetic mean) air concentrations and reasonably conservative exposure assumptions and toxicity values. Therefore, the estimated risk is expected to be reasonably high-end risk but not the maximum risk estimate because for some chemicals and some individuals there may be underestimation of risk. As a result, several areas of uncertainty/limitation have been discussed above in this report with regard to the under-estimation, under- or over-estimation; and over-estimation.

Overall, the available information suggests a potential underestimation of risk because of the following major uncertainties/limitations: (1) lack of air monitoring data for all air toxics emanating from oil and gas operations; (2) lack of toxicity values for all air measured air toxics; (3) lack of continuous air monitoring data and toxicity values for acute risk evaluation; (4) lack of updated toxicity values for formaldehyde, which is the second major risk contributor; (5) availability of more conservative toxicity values for benzene from other state and federal agencies other than EPA; (6) potential increase in exposure due to accumulation of some air toxics in indoor environments; and (7) potential increase in exposure for individuals living near “hot spots” or point sources.