Bureau of Land Management
Summary of Cumulative Oil and Gas Hazardous Air Pollutant Analysis

1. Introduction

The National Environmental Policy Act (NEPA), 42 United States Code (U.S.C.) Chapter 55, requires federal agencies to consider the environmental impacts of its actions as a way to help "attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences." 42 U.S.C. § 4331. *See also* 42 U.S.C. § 4321 (statement of Congressional purpose); 42 U.S.C. § 4336e (defining "major federal actions" to which the law applies). The U.S. Court of Appeals for the Tenth Circuit has recognized that NEPA "requires agencies to consider the environmental impact of their actions as part of the decision-making process and to inform the public about these impacts." *Diné Citizens Against Ruining Our Env't v. Haaland*, 59 F.4th 1016, 1025 (10th Cir. 2023) ("*Diné* CARE II"), citing *Citizens' Comm. to Save Our Canyons v. U.S. Forest Serv.*, 297 F.3d 1012, 1021 (10th Cir. 2002). Pursuant to NEPA, the BLM conducts environmental reviews at all stages of its processes leading to the extraction of oil and gas from BLM lands. In *Diné CARE II*, the U.S. Court of Appeals for the Tenth Circuit held that BLM's NEPA analysis was insufficient in relevant part because the analysis "did not account for the cumulative impact to [Hazardous Air Pollutant (HAP)] emissions from the wells … While BLM considered the cumulative impacts of the criteria pollutants from the approximately 3,000 wells, it did not include any analysis of the anticipated HAP emissions from the construction of those wells over a period of years." *Diné CARE II*, 59 F.4th at 1047.[1]

This paper summarizes the actions the BLM has undertaken to address the court's holding in regard to analysis of cumulative HAP emissions and the associated effects on public health from oil and gas leasing and development. Section 2 describes the broad-scale implications of the ruling for BLM oil and gas leasing and development decisions, and the cumulative oil and gas HAPs analysis approach implemented to address the ruling and BLM's obligations under NEPA. Section 3 focuses on the results of the analysis as it pertains to Applications for Permit Drill (APDs) in the BLM New Mexico's Farmington Field Office, 370 of which were the subject of the *Diné CARE II* lawsuit.[2]

2. Cumulative HAPs Analysis

The Tenth Circuit Court holding highlighted the need for BLM to take immediate action to develop a cumulative oil and gas HAPs analysis. In formulating a methodology to address the Tenth Circuit concerns, the BLM had an existing blueprint for assessing air quality-related

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[1] The federal Clean Air Act defines a Hazardous Air Pollutant as "any air pollutant" of which "emissions, ambient concentrations, bioaccumulation or deposition of the substance are known to cause or may reasonably be anticipated to cause adverse effects to human health or adverse environmental effect." 42 U.S.C. § 7412.

[2] The Tenth Circuit remanded a subset of 199 of the challenged APDs that were approved and therefore ripe for review to the District Court for the District of New Mexico for a decision on remand as to remedy.

impacts at a regional scale, the recently completed 2032 BLM Regional Air Modeling Study (Ramboll 2023a). This study, which modeled criteria air pollutant concentrations across western states with significant oil and gas development (Figure 1), is being used to provide the hard look at impacts on air quality and air quality related values from BLM-authorized oil and gas decisions in the Western US. Employing a similar approach, the BLM contracted for a regional modeling study over the same area to assess HAP emissions from BLM-authorized oil and gas development activities (Ramboll 2023b). The model output allows the BLM to compare concentrations of HAPs to calculated risk-based thresholds in order to provide the hard look at the effects on public health required by NEPA.

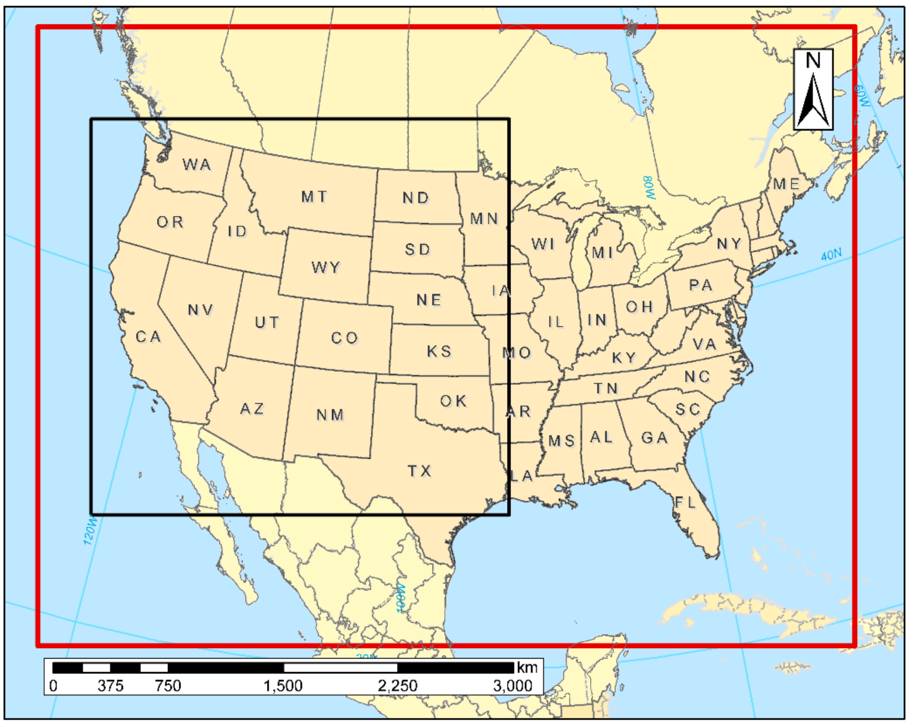


Figure 1. 36 km resolution continental US and 12 km resolution western US modeling

2.1. Cumulative Oil and Gas HAPs Analysis

2.1.1. Cumulative Oil and Gas HAPs Modeling Study

In designing the cumulative oil and gas HAPs modeling study (Ramboll 2023b), the BLM was able to rely on its experience related to air quality modeling of oil and gas development activities. As part of the design, the BLM took into consideration the thresholds to compare heath impacts against, as directed by the *Diné* Care II ruling.

In regards to which HAPs to consider in the analysis, the *Diné CARE II* Court specifically mentioned five HAPs—benzene, toluene, ethylbenzene, mixed xylenes, and n-hexane—as applying to oil and gas development activities based on the National Emission Standards for HAPs (NESHAPs; *see* 43 Code of Federal Regulations [C.F.R.] Part 63). For this study, the BLM chose to include six key HAPs—benzene, toluene, ethylbenzene, xylene, n-hexane, and formaldehyde—because these compounds are common in the oil and gas sector and consistent with regulatory requirements described in the Environmental Protection Agency's (EPA's) New Source Performance Standards, *see* 43 C.F.R. Part 60, and NESHAPs.

Oil and gas emissions for the HAPs described above were compiled using the emission inventories developed for the 2032 BLM Regional Air Modeling Study (Ramboll 2023a); these emission inventories were derived using Annual Energy Outlook oil and gas production forecasts for 2032[3]. Using these emission inventories reflected the best available information for projected oil and gas development on BLM-administered lands in the western United States. It also allowed for consistency of modeled sources with the BLM Regional Air Modeling Study (Ramboll 2023a) and enabled the BLM to rapidly deploy a solution for providing the cumulative oil and gas HAPs analysis required by the Tenth Circuit and to incorporate this analysis into current BLM resource management planning efforts, namely the North Dakota Resource Management Plan (RMP), which is nearing finalization and for which incorporation of this analysis was deemed critical.

The Council for Environmental Quality (CEQ) regulations define cumulative impacts as the incremental effects of the action when added to the effects of other past, present, and reasonably foreseeable actions regardless of what agency (federal or non-federal) or person undertakes such other actions. 40 C.F.R. § 1508.1(g)(3). Thus, the cumulative effects analysis includes both a geographic (spatial) and a temporal component.

Use of a photochemical grid model provided the spatial component of the analysis. Spatially, the study modeled projected HAP concentrations from existing and reasonably foreseeable new federal and non-federal oil and gas-related emission sources throughout the Western United States using a 12-kilometer modeling domain, the same domain as used in the BLM Regional Air Modeling Study. Use of a regional photochemical model also allows for simulation of potential transport of HAP emissions both within and between airsheds of basins where development of oil and gas is ongoing or forecasted. Within the modeling platform, emissions from point sources were mapped to their geographic coordinates, while emissions from nonpoint sources were allocated by federal and non-federal mineral designation based on spatial surrogates developed for the 2032 BLM Regional Air Modeling Study (Ramboll 2023a). This modeling domain allows the BLM to analyze the effects of projected HAP concentrations on public health across the western states, supporting future oil and gas-related decisions within the Farmington Field Office and in field offices throughout the Western United States.

Temporally, the study estimated HAP emissions and modeled HAP concentrations from all existing and reasonably foreseeable federal and non-federal oil and gas-related development

[3] This approach was used for all BLM field offices except Newcastle and North Dakota, for which new reasonably foreseeable development scenarios had been developed in support of ongoing RMP revision efforts.

anticipated to occur through 2032[4]. Within the modeling platform, existing and reasonably foreseeable HAP emissions were distributed into months, days, and hours using temporal profiles and source/profile cross-references for the oil and gas sector from the EPA's emission modeling platform, an approach that aligns with the methodology EPA uses in its Air Toxics Screening Assessment (EPA 2022). As described by that document, this approach is also consistent with EPA's Guidelines for Carcinogen Risk Assessment (EPA 2005a) and EPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (EPA 2005b).

2.1.2. Public Health Analysis

The cumulative HAPs modeling study provided modeled oil and gas concentrations of HAPs to compare against health-based risk thresholds. While the *Diné CARE II* ruling referenced only cancer risk, modeled annual concentrations of HAPs were compared to health risk thresholds[5] to assess both cancer risk and noncancer effects from inhalation of the modeled HAPs. Cancer risk was assessed by multiplying the annual modeled concentration of each carcinogenic pollutant by its cancer unit risk estimate found in EPA 2021 and summing the values to determine the long-term cumulative oil and gas individual cancer risk from inhalation of multiple substances.

Noncancer health effects were assessed by calculating the hazard quotient for each HAP (annual modeled concentration divided by the reference concentration for chronic inhalation; EPA 2021) and summing the hazard quotient of all six HAPs to determine the overall hazard index. HAP emissions and concentrations as well as associated cancer risk, hazard index, and hazard quotient values by modeling grid cell were used by the BLM to develop an interactive web-based tool[6] that the BLM can utilize in formulating analyses that provide a hard look at the effects on public health from oil and gas leasing and permitting decisions.

3. Farmington Field Office Cumulative Oil and Gas HAPs Analysis

This report provides a summary of modeling results and risk calculations for the grid cells comprising the geographic area corresponding to the Farmington Field Office (the entirety of San Juan, Sandoval, Rio Arriba, and McKinley Counties, which make up the New Mexico portion of the San Juan Basin). This spatial scope of analysis was identified based on the regional nature of air pollution and to facilitate analysis using the best available air quality data, which are generally provided at the county level.

[4] EPA's 2016v2 modeling platform (EPA 2022d), the most advanced dataset at the time of model development, includes emissions for the years 2016, 2023, 2026, and 2032. Future year 2032 was used in this modeling assessment. The Western Regional Modeling for the FFO and RPFO included all the wells that were producing and expected to be producing up to 2032. The HAPs modeling followed the RFDs for both the FFO and the RPFO up until 2032, but total RFD production was not analyzed because of the limits of the current EPA data.
[5] Since the cumulative HAPs modeling for oil and gas development was performed, the Non-Carcinogenic Chronic Health-Based Threshold concentration for ethylbeneze was updated (see Table 3).
[6] BLM Integrated Air Resource Tool, HAP Viewer, https://www.blm.gov/content/iart/.

3.1. Emissions Inventory Development

The 3,000 wells referenced in the *Diné CARE II* analysis corresponded to the anticipated level of development that was projected to occur in the Farmington Field Office based on the reasonably foreseeable development scenario (Crocker and Glover 2018) prepared in support of an oil and gas amendment to the Farmington Field Office RMP (BLM 2020). This estimate reflected the total number of wells (federal, tribal, and non-federal) that were projected to be developed in the field office planning area over a 20-year planning horizon (2018 to 2037).

To develop an estimate of HAP emissions in the Farmington Field Office needed for the cumulative oil and gas HAPs analysis, oil and gas emissions for the six relevant HAPs were compiled using the emission inventories developed for the circa 2032 BLM Regional Air Modeling Study (Ramboll 2023a). The emissions inventory for the Farmington Field Office was based on Annual Energy Outlook oil and gas projections for the San Juan Basin. These projections describe the reasonably foreseeable oil and gas development anticipated to occur within the San Juan Basin projected out to 2032, providing the temporal component of the cumulative oil and gas analysis as described by the CEQ regulations. These projections reflect the best currently available information for projected oil and gas development in the San Juan Basin (and thus the Farmington Field Office).

Emissions of HAPs were distinguished as coming from federal or non-federal sources to allow the BLM to analyze the contribution of impacts from BLM-authorized activities as well as the impacts from cumulative (federal and non-federal) oil and gas activity. In addition, federal emissions were estimated separately for existing oil and gas activity (pre-2020) and new oil and gas activity (2020 to 2032). A description of the oil and gas-related sources included in the emissions inventory and the methodology for the emissions inventory can be found in Section 2.1 of the BLM Cumulative Hazardous Air Pollutants Modeling Final Report (Ramboll 2023b). As described in Section 2.1.1, above, point and non-point sources were spatially allocated within the modeling domain to model the concentration of HAPs that could be experienced by individuals within each 12-kilometer modeling grid.

3.2. Carcinogenic and Non-carcinogenic Risk Calculations

As described in Section 2.1.2, above, the cumulative oil and gas HAPs modeling study generated modeled concentrations of HAPs based on projected HAP emissions from federal and non-federal oil and gas activity. These concentrations were used to assess cancer risk and noncancer health effects by comparing the HAP concentrations against health-based thresholds (EPA 2021). As described in Section 3.2 of the BLM Cumulative Hazardous Air Pollutants Modeling Final Report (Ramboll 2023b), inhalation exposure concentration (EC) was assumed to be the same as the modeled ambient air concentrations of HAPs, providing a conservative estimate of risk because no adjustment was made for factors such as time spent indoors (which would result in lower exposure levels).

Risk characterization is a description of the nature and, often, magnitude of human risk, including resulting uncertainties. Risk characterization is accomplished by integrating information from the components of the risk assessment and synthesizing an overall conclusion about risk that is complete, informative, and useful for decision makers (EPA 2000). A "bright line" in risk characterization refers to a threshold value that separates acceptable and unacceptable levels of risk. It is regarded as a clear and unambiguous limit used to determine whether a particular level of exposure to a hazardous substance is safe or not.

Bright lines were not used in the analysis of the cumulative oil and gas HAPs results to determine if a particular risk level is acceptable or not, as no such construct for risk exists within the Clean Air Act framework akin to the national ambient air quality standards (that is, there are no national ambient air quality standards against which to compare modeled HAP concentrations). Rather, values or ranges of values published by EPA (e.g., AirToxScreen [National Air Toxics Assessment] or 40 C.F.R. 300.430 [Remedial Investigation/Feasibility Study]) were used to provide useful context to risk estimates associated with the cumulative oil and gas HAPs study.

3.2.1. Carcinogenic Risk Calculations

Cancer inhalation risk was calculated for three of the six HAPs—benzene, ethylbenzene, and formaldehyde—by multiplying the annual modeled concentration by the cancer unit risk estimate shown in Table 1. The other modeled HAPs—toluene, xylenes, and n-hexane—had a cancer risk estimate of zero, indicating that they do not have an associated cancer risk. Total cancer risk was estimated by summing the individual cancer risks for benzene, ethylbenzene, and formaldehyde. As described in the BLM Cumulative Hazardous Air Pollutants Modeling Final Report (Ramboll 2023b), while no explicit risk thresholds are available, EPA uses 1 in 1 million and 100 in 1 million risk for context (EPA 2022).

Table 1. Cancer Unit Risk Estimates (EPA 2021)

HAP	Cancer Unit Risk Estimate (1/[ug/m^3])
Benzene	0.0000078
Toluene	0
Ethylbenzene	0.0000025
Xylenes	0
n-Hexane	0
Formaldehyde	0.000013

The most conservative procedure for estimating carcinogenic risk is to assume constant exposure based on a 70-year lifetime exposure. However, it is a common and accepted risk assessment procedure to refine the assumed duration of exposure based upon geographic unit-specific sociological information. EPA exposure assessment guidance states that risk assessments may require adjusted air concentrations be used to represent continuous exposure (EPA 2024).

The adjusted air concentration may be estimated by the following equation:

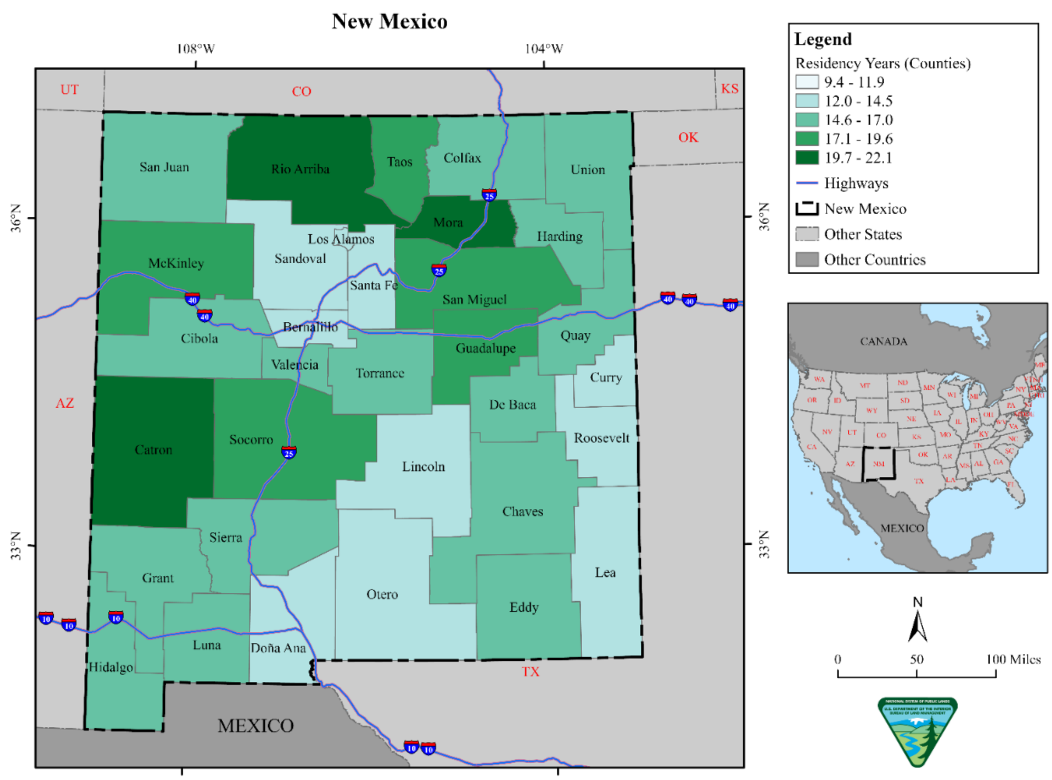
$$Conc_{ADJ} = Conc_{AIR} \times ET \times \frac{1\ day}{24\ hours} \times EF \times ED/AT$$

Where:
- $Conc_{ADJ}$ = adjusted concentration of contaminant in air (mg/m^3 or µg/m^3)
- $Conc_{AIR}$ = Concentration of contaminant in air (mg/m^3 or µg/m^3)
- ET = Exposure time (hours/day)
- EF = Exposure frequency (days/year)

ED = Exposure duration (years)
AT = Averaging time (days)

Because cancer risk is based on a 70-year lifetime exposure, the BLM refined the cancer risk assessments in its interactive web-based tool to present both the upper range of risk based on a 70-year exposure and an adjusted risk based on the average household residency rates for each county in the modeling domain (Lin 2023). Time factors for exposure calculations (from the equation above) used in this study include: 1) Exposure time (ET) is assumed to be 24 hours/day, and 2) exposure frequency (EF) (in days/year) is assumed to be 365 days/year. Mathematically, when using the time factors cited above, exposure duration reduces to county residency in years divided by 70 years to yield a simple ratio representing exposure duration (sometimes called the exposure adjustment factor).[7] Adjusted risk can be computed by multiplying the upper range of risk (represented by the assumption of constant exposure of an air concentration of a carcinogenic compound over the 70-year lifetime exposure) by the exposure adjustment factor.

Figure 2 shows the average householder residency periods for New Mexico by county (see Lin 2023 for data sources). The residency factors for counties within the Farmington Field Office are 18.5 years for McKinley County, 19.8 for Rio Arriba, 14.1 for Sandoval, and 15.5 for San Juan.



This map was compiled in December 2023. No warranty is made by the Bureau of Land Management (BLM) as to the accuracy reliability, or completeness of these data for individual use or aggregate use with other data, or for purposes not intended by BLM. Spatial information may not meet National Map Accuracy Standards. This information may be updated without notification.

[7] p. 3-90, Converse County FEIS AQTSD, https://eplanning.blm.gov/public_projects/66551/200129860/20023773/250029977/Converse_County_FEIS_Appendix_A_AQTSD.pdf.

Figure 2. Residency Periods in Years for Counties in New Mexico

3.2.2. Non-carcinogenic Risk Calculations

A reference concentration for chronic inhalation (RfC) is defined by EPA as the threshold to assess noncancer health effects. RfC values for the HAPs included in this study are shown in Table 2. Hazard quotients (HQ) were calculated for each HAP by dividing the modeled HAP concentration by its RfC. An HQ value of 1 or less signifies a low likelihood of noncancerous health issues resulting from exposure, while an HQ value exceeding 1 indicates that there is a potential for adverse effects but does not predict the statistical likelihood of them occurring.

Table 2. Non-Carcinogenic Chronic Health-Based Threshold Concentrations (EPA 2021)

HAP	Non-Carcinogenic Health-Based Chronic Threshold Concentration (mg/m^3)
Benzene	0.03
Toluene	5.0
Ethylbenzene	0.3*
Xylenes	0.1
n-Hexane	0.7
Formaldehyde	0.0098

* The updated threshold for ethylbenzene is shown in EPA 2021 to be 0.26.

Chronic noncancer hazards from multiple HAPs were assessed by summing individual HAP HQs to derive a hazard index (HI). An HI equal to or less than 1 suggests no expected non-cancer-related health issues from exposure. To demonstrate that a pollutant has a significant chronic hazard, it is necessary to establish that the chronic HI exceeds 1 and that at least 10,000 people are exposed to this pollutant.

3.3. Sources of Uncertainty in Health Risk Estimation

3.3.1. Emissions Quantification and Spatial Allocation

The estimates of HAP emissions from projected oil and gas development were based on the best available information at the time of study development. Sources of uncertainty, which may either overestimate or underestimate HAP emissions that contribute to potential health risk, include: 1) uncertainty in the estimation of emissions, 2) uncertainty in the spatial allocation of emissions from sources that have not yet been developed, and 3) uncertainty in the timing of emission sources.

The emissions presented herein represent a snapshot of estimated emissions for circa 2032 based on the methodology described in Section 3.1. Actual rates of development over time may differ based on market conditions, changes in technology, or a variety of other factors that could result in a greater or lesser amount of oil and gas development than is represented here. Conversely, the emissions in this study may be inherently conservative for the estimated rate of development because emissions from wells are assumed to occur at a steady rate, while actual emissions would likely decline as production decreases over time.

It is important to note that in estimating and simulating the transport and fate of oil and gas emissions from sources not yet realized (i.e., future upstream and midstream sources of emissions associated with the projected increase in development represented by basin-specific reasonably foreseeable development numbers), exact locations of sources cannot be known. As noted in Ramboll 2023b, for future nonpoint oil and gas emissions that are allocated at the county level, spatial surrogates by mineral designation were utilized to spatially allocate emissions to 12-kilometer grid cells. The spatial surrogates were developed using the information provided by BLM as part of the 2032 BLM Regional Air Modeling Study (Ramboll 2023a). These surrogates were assigned to emissions sources based on source classification code[8]. Thus, future year emissions are allocated spatially within a basin according to assumed relationships between upstream and midstream emission sources, which may or may not correspond to a specific location of any wellsite development at the APD stage. Lastly, the timing of well development within an area may differ from what has been modeled, resulting in differing emissions and resultant HAP concentrations.

3.3.2. Health Risk Estimation

The estimates of health risks are based on the current state of knowledge, and the cumulative oil and gas HAPs study followed well established practices for estimating emissions, simulating the transport and fate of these emissions, and estimating public health impacts. However, there is uncertainty associated with the processes of risk assessment.

Sources of uncertainty, which may either overestimate or underestimate risk, include: 1) extrapolation of toxicity data in animals to humans (e.g., in the estimation of the cancer unit risk factors), 2) uncertainty in the estimation of emissions (discussed above), 3) uncertainty in the air dispersion models, and 4) uncertainty in the exposure estimates.

This uncertainty stems from the lack of data in many areas, which necessitates the use of assumptions. Such assumptions are consistent with current scientific knowledge and state-of-the-practice for both air modeling and risk assessment procedures, but are often designed to be conservative on the side of health protection in order to avoid underestimation of public health risks. Examples include: 1) use of a simplifying assumption that a person will be exposed to the exact same air concentration of specific hazardous compounds each year for the assumed period of exposure (70 years or less), 2) estimated duration of exposure is either based upon the simplifying assumption of a person residing at the same location for 70 years or use of sociological information to derive average length of residency for geographic units (i.e., county, state, country), 3) simplified exposure duration calculations associated with this study do not take into account more refined exposure adjustments such as number of hours per day a person would be in their home as opposed to being away (e.g., being at a person's place of employment for specified period of hours per day) or the average number of days per year a person would be at their residence, and 4) the simulated air concentrations from this study represent outdoor concentrations air concentrations and do not account for outdoor/indoor air exchange rates, which would attenuate the concentration of a person indoors by a certain amount depending upon air exchange rates, thus this study assumes exposure to the full annual air concentration (dose).

[8] The EPA uses source classification codes (SCCs) to classify different types of activities that generate emissions. Each SCC represents a unique source category-specific process or function that emits air pollutants.

In reality, annual concentrations of compounds will vary from year to year. When using more simple air quality models such as the AMS/EPA Regulatory Model (AERMOD) model, it is customary to use 5 years of airport meteorological data. Annual average air concentrations are calculated for each year of the 5-year meteorological record. Since risk assessment procedures are often designed to be conservative for protection of public health, choice of the maximum annual average over that 5-year period is deemed acceptable, and risk values are estimated from the maximum annual concentration. However, with this study or when considering EPA's AirToxScreen to help characterize inhalation risk, regional photochemical transport models are used. The complexity and resource-intensive nature of regional photochemical modeling, as compared to AERMOD, effectively prohibits exercise of such models for more than one or several calendar years. Thus, annual concentration from CAMx/RTRAC used in this study may not be conservative due to the interannual variability of meteorological factors over a wide geographic region, which could result in differences in annual air concentrations from year to year.

3.3.3. Limits on Use of this Information

Due to the uncertainties described above, the risk estimates in this study should not be interpreted as actual rates of disease in the exposed population, but rather as estimates of potential risk, based on current knowledge and a number of assumptions. However, a consistent approach to risk assessment is useful to compare different sources and different substances to characterize potential public health issues that may result from emissions and transport of hazardous air pollutants resulting from oil and gas operations. Additionally, since locations and geographic distributions of emissions from emission sources yet to be developed within specific basins are not known in actuality, risk estimates should largely be used to characterize the range of conditions that could be realized (if full estimated oil and gas development were to occur) across an entire basin airshed as opposed to any specific location within that airshed.

3.4. Farmington Field Office Model Results

The cumulative oil and gas HAPs modeling study provides an assessment of the health effects of HAPs originating from cumulative oil and gas production. A photochemical model is used to estimate the cumulative ambient air concentrations of six HAPs (benzene, toluene, ethylbenzene, xylenes, n-hexane, and formaldehyde) resulting from emissions from federal and non-federal oil and gas sources. These six HAPs were selected by BLM for study because these compounds are common in the oil and gas sector and consistent with regulatory requirements described in the EPA's New Source Performance Standards and NESHAPs.

The BLM's interactive web-based tool was used to extract anticipated emissions for the four counties that represent the Farmington Field Office. The web-based tool, or integrated air resources tool (iART), is a platform that hosts a collection of tools designed to facilitate screening-level assessments of land management projects with the potential to impact air resources. The results of the Western Regional HAPs modeling were incorporated into iART to help streamline the geospatial analysis of cumulative oil and gas HAPs that the BLM may be required to complete for future NEPA projects. As indicated by the data in Table 3, total federal HAP emissions from oil and gas sources comprise approximately 70 percent of oil and gas HAP emissions in the four-county planning area.

Table 3. Circa 2032 Oil and Gas HAP Emissions in the Farmington Field Office by County and Mineral Designation

	Hazardous Air Pollutants (tons/year)*						
County	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylenes**	**n-Hexane**	**Formaldehyde**	**Total**
Existing Federal							
McKinley	1.13	0.71	0.10	0.21	7.36	3.65	13.15
Rio Arriba	70.90	29.70	6.59	27.40	198.00	481.00	813.59
Sandavol	6.01	3.34	0.40	2.08	37.80	24.00	73.63
San Juan	107.00	43.20	10.60	40.70	136.00	757.00	1,094.50
Total	*185.04*	*76.95*	*17.69*	*70.39*	*379.16*	*1,265.65*	*1,994.87*
New Federal							
McKinley	0.55	0.57	0.11	0.23	5.20	1.22	7.88
Rio Arriba	34.90	23.60	3.86	11.70	159.00	64.00	297.06
Sandavol	20.10	14.00	4.84	9.17	81.60	22.20	151.91
San Juan	64.90	43.80	8.73	23.00	248.00	128.00	516.43
Total	*120.45*	*81.97*	*17.54*	*44.10*	*493.80*	*215.42*	*973.28*
Total Federal (Existing plus New)							
McKinley	1.69	1.27	0.21	0.43	12.60	4.87	21.07
Rio Arriba	106.00	53.30	10.50	39.00	357.00	545.00	1,110.80
Sandavol	26.10	17.30	5.24	11.30	119.00	46.20	225.14
San Juan	172.00	87.10	19.30	63.70	384.00	885.00	1,611.10
Total	*305.79*	*158.97*	*35.25*	*114.43*	*872.60*	*1,481.07*	*2,968.11*
Non-Federal							
McKinley	1.28	0.95	0.15	0.31	12.40	3.38	18.46
Rio Arriba	37.20	18.50	4.10	14.00	116.00	205.00	394.80
Sandavol	11.90	7.75	2.09	4.63	74.80	26.00	127.17
San Juan	72.80	38.90	7.85	25.80	200.00	345.00	690.35
Total	*123.18*	*66.10*	*14.19*	*44.74*	*403.20*	*579.38*	*1,230.78*
Oil and Gas Total							
McKinley	2.97	2.22	0.35	0.75	25.00	8.25	39.54
Rio Arriba	143.20	71.80	14.60	53.00	473.00	750.00	1,505.60
Sandavol	38.00	25.10	7.30	15.90	193.80	72.20	352.30
San Juan	244.80	126.00	27.20	89.50	584.00	1,230.00	2,301.50
Total	*428.97*	*225.12*	*49.45*	*159.15*	*1,275.80*	*2,060.45*	*4,198.94*

The BLM's interactive web-based tool was used to extract modeled HAP concentrations for the four counties that represent the Farmington Field Office (Table 4). Concentrations are presented as a range to account for the range of concentrations modeled to occur across each county.

Table 4. Circa 2032 Oil and Gas HAP Concentrations in the Farmington Field Office by County and Mineral Designation

	Hazardous Air Pollutant Concentrations (µg/m^3)						
Source	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylene**	**n-Hexane**	**Formaldehyde**	**Total HAPs**
McKinley County							
Existing Federal	0.0001 to 0.0026	<0.0001 to 0.0009	<0.0001 to 0.0002	<0.0001 to 0.0006	0.0001 to 0.0137	0.0021 to 0.0481	0.0024 to 0.0661
New Federal	0.0001 to 0.0047	<0.0001 to 0.0028	<0.0001 to 0.0007	<0.0001 to 0.0014	0.0003 to 0.0263	0.0011 to 0.0265	0.0016 to 0.0624
Total Federal	0.0002 to 0.0073	0.0001 to 0.0037	<0.0001 to 0.0008	<0.0001 to 0.0020	0.0004 to 0.0338	0.0032 to 0.0742	0.0039 to 0.1285
Non-Federal	0.0002 to 0.0045	<0.0001 to 0.0025	<0.0001 to 0.0005	<0.0001 to 0.0012	0.0003 to 0.0355	0.0027 to 0.0479	0.0033 to 0.0922
Total Oil and Gas	0.0004 to 0.0115	0.0001 to 0.0062	<0.0001 to 0.0014	<0.0001 to 0.0032	0.0007 to 0.0693	0.0060 to 0.1196	0.0073 to 0.2112
Rio Arriba County							
Existing Federal	0.0005 to 0.0432	0.0001 to 0.0155	<0.0001 to 0.0031	0.0001 to 0.0122	0.0010 to 0.4230	0.0173 to 0.9010	0.0190 to 1.3980
New Federal	0.0004 to 0.0326	0.0002 to 0.0190	<0.0001 to 0.0040	0.0001 to 0.0080	0.0011 to 0.1460	0.0072 to 0.1340	0.0090 to 0.3436
Total Federal	0.0009 to 0.0670	0.0003 to 0.0302	0.0001 to 0.0055	0.0001 to 0.0171	0.0021 to 0.4297	0.0245 to 1.0140	0.0280 to 1.7416
Non-Federal	0.0005 to 0.0308	0.0002 to 0.0143	<0.0001 to 0.0027	0.0001 to 0.0083	0.0011 to 0.1080	0.0149 to 0.2480	0.0168 to 0.4121
Total Oil and Gas	0.0015 to 0.0779	0.0004 to 0.0349	0.0001 to 0.0072	0.0002 to 0.0197	0.0033 to 0.4371	0.0394 to 1.2480	0.0488 to 1.8249
Sandoval County							
Existing Federal	0.0002 to 0.0155	0.0001 to 0.0074	<0.0001 to 0.0007	<0.0001 to 0.0038	0.0004 to 0.0865	0.0071 to 0.1480	0.0078 to 0.2619
New Federal	0.0003 to 0.0427	0.0001 to 0.0251	<0.0001 to 0.0073	<0.0001 to 0.0129	0.008 to 0.1460	0.0036 to 0.1240	0.0049 to 0.0624
Total Federal	0.0005 to 0.0511	0.0002 to 0.0284	<0.0001 to 0.0081	0.0001 to 0.0159	0.0012 to 0.2115	0.0107 to 0.2720	0.0127 to 0.6199
Non-Federal	0.0004 to 0.0241	0.0001 to 0.0131	<0.0001 to 0.0037	<0.0001 to 0.0072	0.0009 to 0.0998	0.0077 to 0.2050	0.0092 to 0.3530
Total Oil and Gas	0.0009 to 0.0745	0.0003 to 0.0406	0.0001 to 0.0118	0.0001 to 0.0231	0.3113 to 0.3113	0.0184 to 0.4770	0.0219 to 0.9383
San Juan County							
Existing Federal	0.0001 to 0.0517	<0.0001 to 0.0168	<0.0001 to 0.0037	<0.0001 to 0.0145	0.0002 to 0.2070	0.0044 to 0.9690	0.0048 to 1.2627
New Federal	0.0002 to 0.0473	0.0001 to 0.0272	<0.0001 to 0.0057	<0.0001 to 0.0130	0.0005 to 0.1630	0.0021 to 0.1760	0.0029 to 0.4322
Total Federal	0.0003 to 0.0772	0.0001 to 0.0322	<0.0001 to 0.0064	<0.0001 to 0.0209	0.0007 to 0.2247	0.0064 to 1.1450	0.0076 to 1.6949
Non-Federal	0.0002 to 0.0347	0.0001 to 0.0189	<0.0001 to 0.0035	<0.0001 to 0.0090	0.0005 to 0.1180	0.0049 to 0.4120	0.0059 to 0.5960
Total Oil and Gas	0.0006 to 0.1007	0.0002 to 0.0489	<0.0001 to 0.0096	0.0001 to 0.0270	0.0013 to 0.2950	0.0114 to 1.5570	0.0135 to 2.0382

3.5. Farmington Field Office Cumulative Oil and Gas Chronic Carcinogenic and Non-Carcinogenic Results

The modeled oil and gas HAPs long-term (annual) concentrations were assessed for cancer risk and noncancer effects from inhalation for the Farmington Field Office for the three modeled oil and gas production source groups (existing federal, new federal, and total non-federal). Lifetime cancer risks for each pollutant have been calculated based on the modeled HAP concentrations. Total lifetime cancer risk from the exposure to three HAPs (benzene, ethylbenzene, and formaldehyde) were calculated by summing the individual cancer risks for each pollutant. Total cancer risk is below 100 in 1 million for context (Table 5).

Table 5. Estimated Cancer Risk from Circa 2032 Oil and Gas Production in the Farmington Field Office by Mineral Designation

County	Cancer Risk* from Existing Federal Wells (per million)	Cancer Risk* from New Federal Wells (per million)	Cancer Risk* from Nonfederal Wells (per million)	Cancer Risk* from Cumulative Oil and Gas Production	Adjusted Cancer Risk** From Cumulative Oil and Gas Production
McKinley	0.04 to 0.84	0.02 to 0.55	0.05 to 0.88	0.11 to 2.21	0.03 to 0.58
Rio Arriba	0.29 to 15.51	0.13 to 2.75	0.25 to 4.27	0.67 to 21.74	0.19 to 6.15
Sandavol	0.12 to 2.76	0.07 to 3.11	0.13 to 3.91	0.32 to 9.60	0.06 to 1.93
San Juan	0.07 to 16.70	0.04 to 4.02	0.09 to 7.18	0.20 to 27.48	0.04 to 6.09

*Cancer risk from emissions of benzene, ethylbenzene, and formaldehyde
**Adjusted residency risk based on residency factors by county (17.3 years for McKinley County, 19.8 years for Rio Arriba County, 14.1 for Sandoval County, and 15.5 for San Juan County)

Chronic noncancer hazards from multiple air toxics are assessed by calculating the individual HQ of each pollutant and the overall HI. Table 6 provides the chronic noncancer HQs and HI for each county in the Farmington Field Office. The HI for oil and gas production in each county is below one, indicating no substantial chronic non-cancer health effects from oil and gas production.

Table 6. Estimated Hazard Quotients and Hazard Index from Circa 2032 Oil and Gas Production in the Farmington Field Office by Mineral Designation

	Hazard Quotient (HQ)						Hazard Index (HI)
Source	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylene**	**n-Hexane**	**Formaldehyde**	
McKinley County							
Existing Federal	<0.0001 to 0.0003	Range is <0.0001	Range is <0.0001	Range is <0.0001	<0.0001 to 0.0001	0.0003 to 0.0060	0.0003 to 0.0064
New Federal	<0.0001 to 0.0005	Range is <0.0001	Range is <0.0001	<0.0001 to 0.0001	<0.0001 to 0.0001	0.0001 to 0.00033	0.0002 to 0.0040
Total Federal	0.0001 to 0.0008	Range is <0.0001	Range is <0.0001	<0.0001 to 0.0001	<0.0001 to 0.0002	0.0004 to 0.0093	0.0004 to 0.0103
Non-Federal	<0.0001 to 0.0005	Range is <0.0001	Range is <0.0001	<0.0001 to 0.0001	<0.0001 to 0.0002	0.0003 to 0.0060	0.0004 to 0.0067
Total Oil and Gas	0.0001 to 0.0012	Range is <0.0001	Range is <0.0001	<0.0001 to 0.0001	<0.0001 to 0.0003	0.0007 to 0.0150	0.0008 to 0.0167
Rio Arriba County							
Existing Federal	0.0001 to 0.0046	Range is <0.0001	Range is <0.0001	<0.0001 to 0.0005	<0.0001 to 0.0021	0.0022 to 0.1130	0.0022 to 0.1203
New Federal	<0.0001 to 0.0035	Range is <0.0001	<0.0001 to 0.0001	<0.0001 to 0.0003	<0.0001 to 0.0007	0.0009 to 0.0168	0.0010 to 0.0214
Total Federal	0.0001 to 0.0071	Range is <0.0001	<0.0001 to 0.0001	<0.0001 to 0.0007	<0.0001 to 0.0022	0.0031 to 0.1271	0.0032 to 0.1372
Non-Federal	0.0001 to 0.0033	Range is <0.0001	Range is <0.0001	<0.0001 to 0.0004	<0.0001 to 0.0005	0.0019 to 0.0311	0.0019 to 0.0353
Total Oil and Gas	0.0002 to 0.0083	Range is <0.0001	<0.0001 to 0.0001	<0.0001 to 0.0009	<0.0001 to 0.0022	0.0049 to 0.1564	0.0051 to 0.1679
Sandoval County							
Existing Federal	<0.0001 to 0.0017	Range is <0.0001	Range is <0.0001	<0.0001 to 0.0002	<0.0001 to 0.0004	0.0090 to 0.0186	0.0009 to 0.0209
New Federal	<0.0001 to 0.0046	Range is <0.0001	<0.0001 to 0.0001	<0.0001 to 0.0006	<0.0001 to 0.0007	0.0005 to 0.0155	0.0005 to 0.0215
Total Federal	0.0001 to 0.0054	Range is <0.0001	<0.0001 to 0.0001	<0.0001 to 0.0007	<0.0001 to 0.0011	0.0014 to 0.0341	0.0014 to 0.0414
Non-Federal	<0.0001 to 0.0026	Range is <0.0001	<0.0001 to 0.0001	<0.0001 to 0.0003	<0.0001 to 0.0005	0.0010 to 0.0257	0.0010 to 0.0291
Total Oil and Gas	0.0001 to 0.0079	Range is <0.0001	<0.0001 to 0.0002	<0.0001 to 0.0010	<0.0001 to 0.0016	0.0024 to 0.0598	0.0024 to 0.0705
San Juan County							
Existing Federal	<0.0001 to 0.0055	Range is <0.0001	<0.0001 to 0.0001	<0.0001 to 0.0006	<0.0001 to 0.0010	0.0005 to 0.1210	0.0006 to 0.1282
New Federal	<0.0001 to 0.0050	Range is <0.0001	<0.0001 to 0.0001	<0.0001 to 0.0006	<0.0001 to 0.0008	0.0003 to 0.0220	0.0003 to 0.0285
Total Federal	<0.0001 to 0.0082	Range is <0.0001	<0.0001 to 0.0001	<0.0001 to 0.0009	<0.0001 to 0.0011	0.0008 to 0.1430	0.0008 to 0.1534
Non-Federal	<0.0001 to 0.0037	Range is <0.0001	Range is <0.0001	<0.0001 to 0.0004	<0.0001 to 0.0006	0.0006 to 0.0516	0.0006 to 0.0563
Total Oil and Gas	0.0001 to 0.0107	Range is <0.0001	<0.0001 to 0.0001	<0.0001 to 0.0012	<0.0001 to 0.0015	0.0014 to 0.1946	0.0015 to 0.2082

4. References

BLM. 2020. Farmington Mancos-Gallup Resource Management Plan Amendment/Draft Environmental Impact Statement. Farmington Field Office, New Mexico.

Crocker, Kelsey and James F. Glover. 2018. Reasonable Foreseeable Development Scenario for Oil and Gas Activities Mancos-Gallup RMPA Planning Area, Farmington Field Office, northwestern New Mexico.

EPA. 2000. Science Policy Council Handbook "Risk Characterization", EPA 100-B-00-002, December 2000, https://www.epa.gov/sites/default/files/2015-10/documents/osp_risk_characterization_handbook_2000.pdf.

EPA. 2005a. Guidelines for Carcinogen Risk Assessment. EPA/630/P-03/001F. EPA, Washington, DC, https://www.epa.gov/risk/guidelines-carcinogen-risk-assessment.

EPA. 2005b. Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. EPA/630/R-03/003F. EPA, Washington, DC, https://www.epa.gov/sites/default/files/2013-09/documents/childrens_supplement_final.pdf.

EPA. 2021. Dose-Response Assessment for Assessing Health Risks Associated With Exposure to Hazardous Air Pollutants, Table 1, Chronic, https://www.epa.gov/system/files/documents/2021-09/chronicfinaloutput_9_29_2021-12-46-18-pm_0.pdf.

EPA. 2022. Technical Support Document "EPA's Air Toxics Screening Assessment 2018 AirToxScreen TSD," EPA-452/B-22-002, https://www.epa.gov/system/files/documents/2023-02/AirToxScreen_2018%20TSD.pdf.

EPA. 2024. Exposure Assessment Tools by Routes – Inhalation, https://www.epa.gov/expobox/exposure-assessment-tools-routes-inhalation.

Lin, Hebin, PhD. 2023. An Estimate of Average Householder Residency Periods for Seven States.

Ramboll. 2023a. BLM Western US Photochemical Air Quality Modeling for 2032. The main purpose of this study was to understand the regional air quality and air quality related value impacts of oil and gas development and coal mining in the federal mineral estate and assess federal contributions in relation to non-federal and other cumulative emission sources in the western US.

Ramboll. 2023b. BLM Cumulative Hazardous Air Pollutants Modeling Final Report, https://eplanning.blm.gov/eplanning-ui/project/1505069/570.