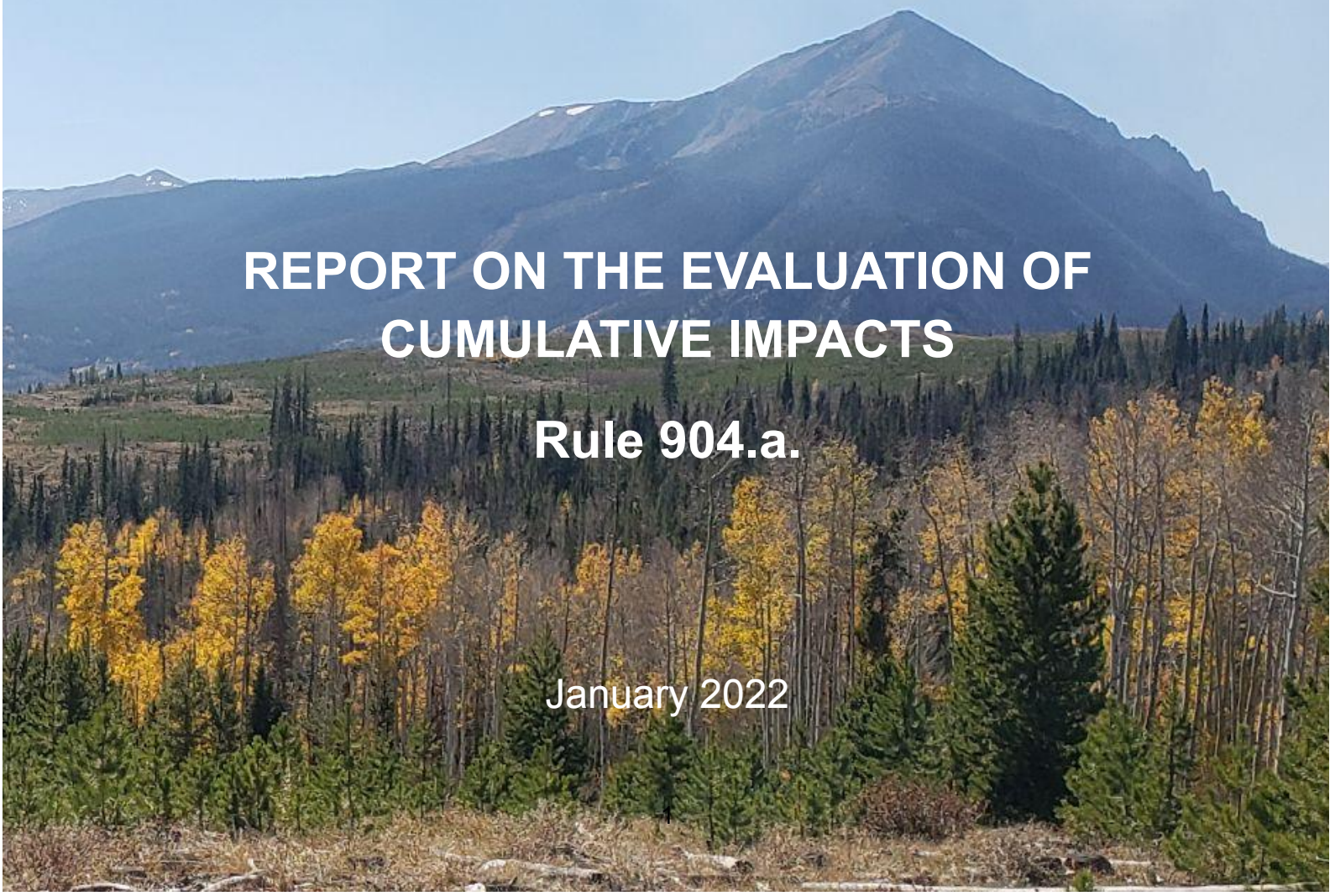
COLORADO

Oil & Gas Conservation Commission

Department of Natural Resources



REPORT ON THE EVALUATION OF CUMULATIVE IMPACTS

Rule 904.a.

January 2022

COLORADO
Oil & Gas Conservation Commission
Department of Natural Resources

1120 Lincoln Street, Suite 801
Denver, CO 80203

Commissioners,

It is with great satisfaction that I provide you with the first annual Cumulative Impacts Report. This report is intended to inform the Commission of data, trends, and considerations in your evaluation of cumulative impacts so that you may address them.

In response to the Mission Change Rulemakings, Staff worked to promptly provide operators with the means to report this data with their applications. Throughout the past twelve months, significant time was dedicated to various electronic form and database changes, culminating in the November 2021 roll out of the current version of the Webform Form 2B (Cumulative Impacts Data Identification). Guidance writing, internal workflow improvements, and various Webforms bug fixes are ongoing.

As the first year of Oil and Gas Development Plan (OGDP) approvals after the Mission Change rules went into effect on January 15, 2021, the data set included in this report is small – it is limited to the seven approved OGDPs. This report focuses on presenting summaries of the data collected so far and identification of data fields that will inform future evaluation of cumulative impacts. Some data has not yet been collected as it was not applicable for these approved OGDPs, such as additional information about High Priority Habitats. This information will be included in subsequent reports as applicable.

This first report is intended to set the foundation for subsequent reports, and also acknowledges that with additional data in future years, the specific fields or ways to present data may need to evolve as our understanding of the data and/or the impacts evolves. For example, three Comprehensive Area Plans (CAPs) were filed in 2021, which will contribute collective information that may provide additional insight to cumulative impacts. As another example, year over year reviews of data may provide insight to trends that inform impacts and/or effectiveness of mitigation measures. In short, while this report presents informative data in ways in which we hope to build upon, we acknowledge that the quantity and quality of data and our understanding of cumulative impacts will evolve, and this report will evolve with them.

Looking forward, Staff and I are committed to continuing to collect and evaluate data. Future reports will be presented by the last day of February covering the previous calendar year. I look forward to continuing to build our knowledge of cumulative impacts as we expand our dataset and continue to learn.

Sincerely,

Julie Murphy, Director

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Background

On April 16, 2019, Governor Polis signed Senate Bill 19-181 (SB19-181) into law. SB19-181 changed the Oil and Gas Conservation Act's (the "Act") legislative declaration to direct the Commission to "[r]egulate the development and production of the natural resources of oil and gas in the state of Colorado in a manner that protects public health, safety, and welfare, including protection of the environment and wildlife resources," C.R.S. § 34-60-102(1)(a)(I) (2020). Subsequently the Commission began a series of rulemakings to accomplish this and other specifics identified in SB19-181, including directing the Commission to adopt rules, in consultation with the Colorado Department of Public Health and Environment ("CDPHE"), to "evaluate and address the potential cumulative impacts of oil and gas development." C.R.S. § 34-60-106(11)(c)(II). These rulemakings are referred to as the Mission Change Rulemakings. Part of the evaluation of cumulative impacts is met through the adoption of Rule 904: Evaluating Cumulative Impacts.

Primary to this rule is an annual report to the Commission. This is the first annual report. This report was compiled with data from Oil and Gas Development Plans (OGDPs) submitted after Jan. 15, 2021, and approved by the Commission during the 2021 calendar year. In this first year, there were seven approved OGDPs. This report was also compiled with contributions from the CDPHE's Air Pollution Control Division (APCD) and Colorado Parks and Wildlife (CPW), and supplements their reports and/or recent presentations to the Commission.

904.a.(1) Data Gathered

Subparagraph 1 of 904.a. includes a report of data gathered in the Cumulative Impacts Data Evaluation Repository (CIDER). CIDER is composed of data submitted on the complete Form 2B: Cumulative Impact Data Identification[1]. Some information provided on these forms are estimates as operators plan their oil and gas location and activity, with some of these actual values being reported after the activity is complete. Certain additional data submitted with the Application to Drill (Form 2) or Oil and Gas Location Assessment (Form 2A) may be referenced to present data within this report.

In 2021, seven OGDPs associated with eight locations were approved by the Commission and are included in this report. Of these OGDPs, three were in the DJ Basin, three were located in the eastern plains (two of which were helium OGDPs associated with three wells), and one was on the West Slope.

[1] This Cumulative Impact report does not include approved partial Form 2Bs submitted pursuant to Rule 803.b.(2).A. This partial form includes some but not all of the information discussed in this report, and has been omitted here.

Figure 1: Number of OGDPs Approved

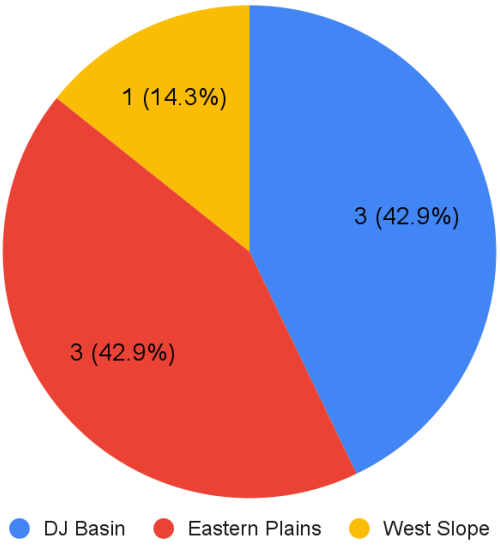
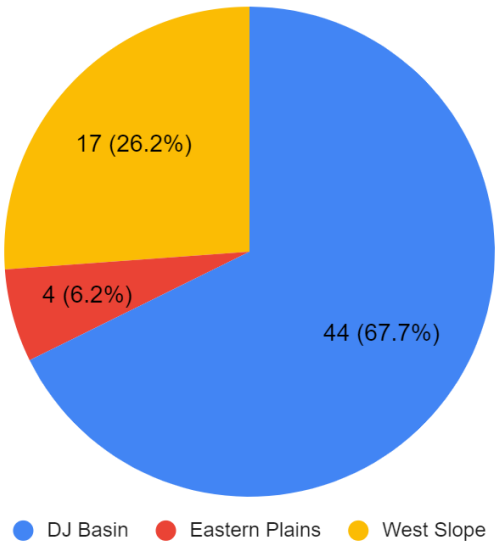


Figure 2: Number of Wells Approved



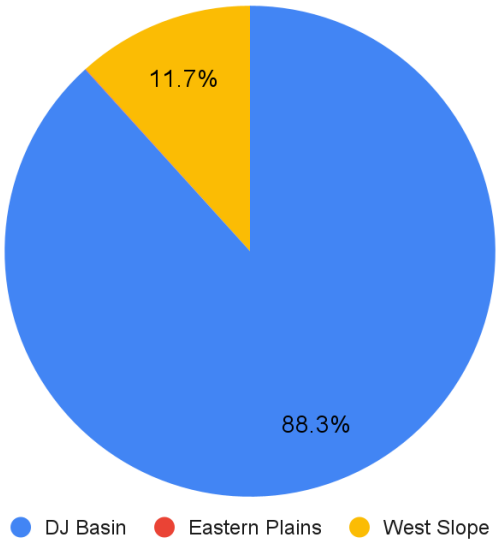
CIDER Data

Water and Liquid Storage

Water Usage

Estimated planned water usage during drilling and completion activities is characterized by water source: surface water, groundwater, recycled water, and unspecified. Future reports will include the actual water used pursuant to Rule 431.b.; no volumes were available for 2021. These volumes will be reported on the associated Form 5s (Drilling and Completions Report) and Form 5As (Completed Interval Report) for wells within these approved OGDPs.

Figure 3: Total Water Usage



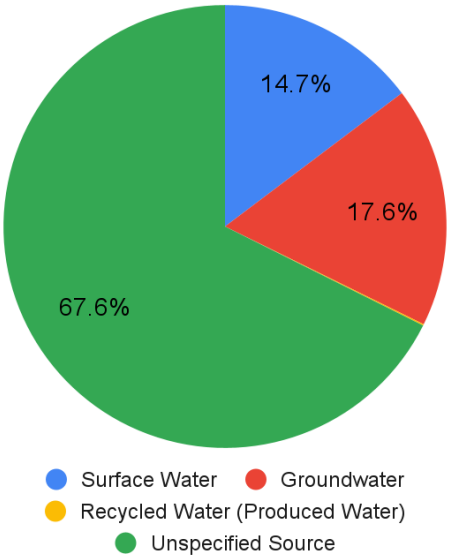
The DJ Basin contributed the majority of the estimated planned water usage, primarily driven by the number of wells approved in this basin. The average per well value is included in the table below. Three of the four Eastern Plains wells (two of the three OGDPs) are shallow helium wells drilled with air rotary drilling systems, and have no hydraulic fracturing or other completions planned, therefore, water use will be much lower for these wells than a traditional oil and gas well. Indeed, these three helium wells combined are estimated to use less than half of the water that the single natural gas well will require. Additional differences are expected to be

driven by differing well design between operating areas (horizontal v. vertical, lateral length, depth, etc.).

Table 1: Total Water Use Per Well

Operating Area	Water Use Per Well (bbl)
DJ Basin	348,606
Eastern Plains	1,529
West Slope	119,500

Figure 4: DJ Basin Water Use



The West Slope planned a significant portion of water use from recycled produced water. Only one other OGDP reported using recycled water, a DJ Basin OGDP with 0.5% estimated planned recycled water use. Other OGDPs had none or less than 1% recycled water use. The remaining water is split between surface and groundwater. One OGDP had a significant water volume unspecified, and shared that it is expected to be a combination of groundwater and surface water. For the Eastern Plains, the two helium OGDPs will use groundwater, while the remaining natural gas OGDP will use surface water.

Figure 5: Eastern Plains Water Use

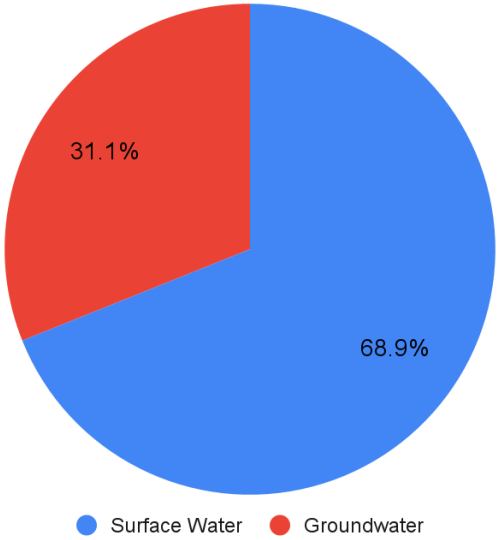
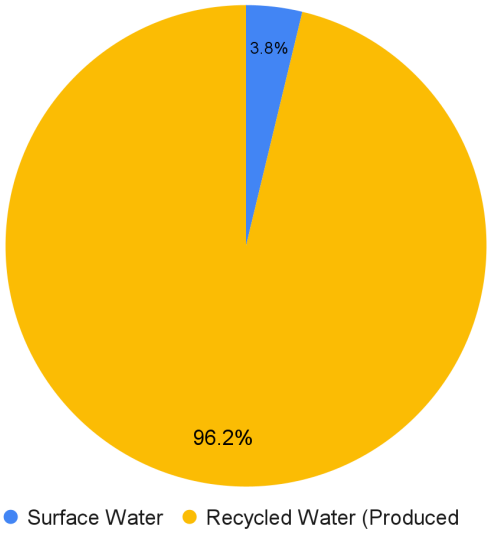


Figure 6: West Slope Water Use



Water Resources

All OGDP Locations were within half of a mile of a Water of the State and greater than one mile from a Public Water System Intake. One OGDP Location was less than half a mile from a riparian corridor, with the remaining greater than half a mile from a riparian corridor. The DJ Basin had OGDP Locations nearest to wetlands on average. Three OGDPs were greater than half a mile from a wetland and were not included in the averages below.

Table 2: Distance to Wetlands w/in Half Mile

Operating Area	Nearest Wetland Distance (ft)	Average Wetland Distance (ft)
DJ Basin	15[2]	457
Eastern Plains	800	800
West Slope	823	823

Liquid Product Storage

Condensate/Oil and Produced Water capacity per OGDP are greatest in the DJ Basin. The two helium OGDPs (and three associated wells) only accounted for 40 of 1,240 total bbls of produced water capacity on the Eastern Plains and none of the condensate/oil capacity. Even with these outliers, Condensate/Oil and Produced Water capacity per well are greatest in the Eastern Plains.

Table 3: Average Tank Capacity

Operating Area	Average Oil/Condensate Capacity (bbl)		Average Produced Water Capacity (bbl)	
	Per OGDP	Per Well	Per OGDP	Per Well
DJ Basin	2,479	169	853	58
Eastern Plains	400	300	413	310
West Slope	1,000	59	0	0

Wildlife

High Priority Habitat

The High Priority Habitats (HPHs) within one mile of the Oil and Gas Location and the total disturbed acreage are collected.

[2]The COGCC placed a Condition of Approval on the Form 2A for this OGDP stating that prior to spudding the first well, the operator will conduct a wetland survey to verify the condition of the wetland. This survey has since been completed; the location was determined to be greater than 500 feet from any jurisdictional wetland.

Three OGDP Locations had an HPH within one mile: one in the DJ Basin, one on the Eastern Plains, and one on the West Slope. Of the six HPHs within one mile, five of them were over 4,000 ft away from the OGDP Location. No Locations were within an HPH.

Table 4: Distance to High Priority Habitat

Operating Area	Nearest HPH Distance (ft)	Average HPH Distance (ft)
DJ Basin	4,845	5,030
Eastern Plains	4,966	4,966
West Slope	711	2,989

Colorado Parks and Wildlife

No OGDP approved in 2021 triggered a rule-based requirement for consultation with CPW. CPW conducted several pre-application consultations involving discussions on compensatory mitigation in 2021 in preparation for OGDP application submissions. For the OGDPs approved in 2021, no compensatory mitigation fees were identified or collected by CPW. In addition, no operator compensatory mitigation projects were completed. For future reports, the collection of compensatory mitigation fees and details around associated projects may occur in reports for the year following the approval of the OGDP as the fees are not collected until 30 days prior to the submission of the Form 42 Construction Notification. CPW will provide a standalone compensatory mitigation report to accompany future cumulative impact reports. No report was prepared this year due to the lack of compensatory mitigation requirements in 2021.

CPW has further provided consultation on Sundry (Form 4) and Well Abandonment (Form 6) activities this year as a result of additional Mission Change Rulemaking changes to Rule 312.a. This has resulted in over 40 additional consultations from CPW. In addition, CPW has provided more than 20 consultations regarding potential waivers associated with Rule 1202.a.(3). These activities have resulted in increased opportunities to protect wildlife resources and reclaim habitat related to these oil and gas development activities.

Lastly, CPW has completed two large landscape-scale Wildlife Mitigation Plan (WMP) agreements with operators in CPW's Northwest Region to proactively plan development and more effectively avoid, minimize, and mitigate impacts to wildlife resources.

Land Use

The land use data provides information about the existing land use within a one-mile radius of an approved OGDP Location. The land surrounding the DJ Basin OGDP Locations is primarily crop land. The land surrounding the other OGDP Locations is primarily non-crop land. Non-crop land is defined as land that is not being used to cultivate or harvest crops, and is not formally subdivided as industrial, commercial, or residential. The four non-crop land designations are rangeland, forestry, recreational, and other.

Figure 7: Total Land Use

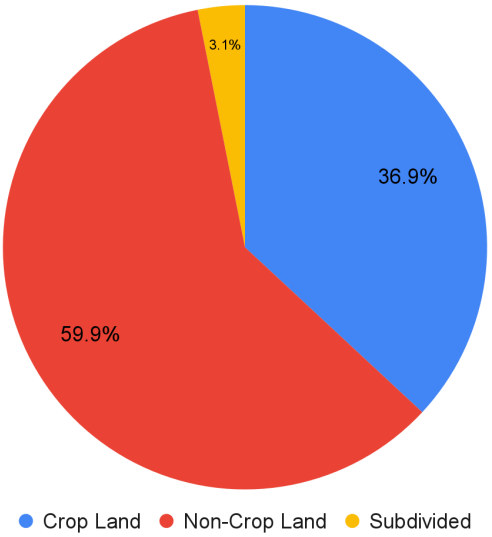


Figure 8: DJ Basin Land Use

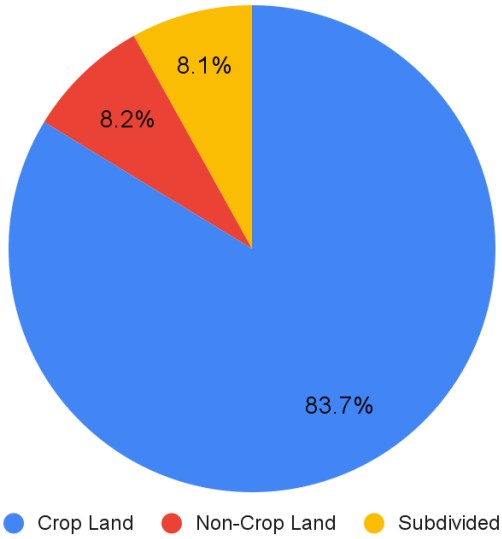


Figure 9: Eastern Plains Land Use

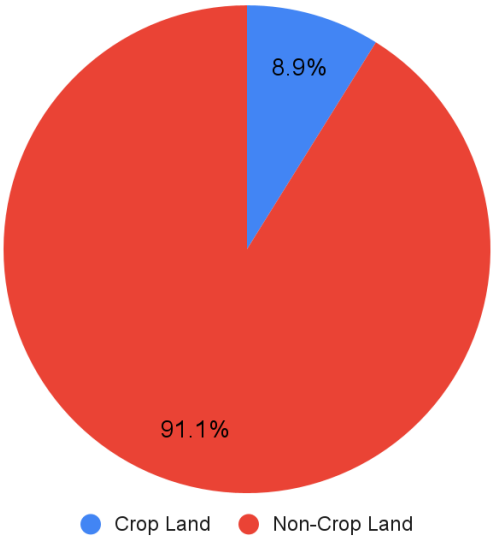
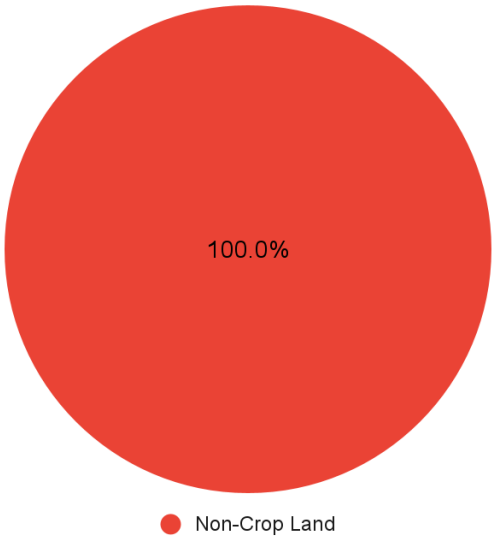


Figure 10: West Slope Land Use



Surface disturbance is expected to be the greatest during the construction phase. After interim reclamation has occurred, the remaining disturbed area (the production surface) will be the disturbance that exists for the longest period of time. Both construction and post-interim reclamation disturbances per OGDP Location were greatest in the DJ Basin. This is likely due to the additional surface equipment required to handle the oil,gas, and water produced from this area. The Eastern Plains had the highest construction and interim reclamation disturbances per well, however, the three Eastern Plains OGDP Locations accounted for only four wells, with two OGDPs being single well locations. The DJ Basin and West Slope OGDPs, by comparison, had many more wells associated with a single OGDP.

Table 5: Construction Disturbance

Operating Area	Total Construction Disturbance (acre)	Avg Construction Disturbance per OGDP (acre)	Avg Construction Disturbance per Well (acre)
DJ Basin	40.44	13.48	0.92
Eastern Plains	12.20	4.07	3.05
West Slope	4.89	4.89	0.29
Total	57.53	8.22	0.89

Table 6: Interim Reclamation Disturbance

Operating Area	Total Post-Interim Reclamation Disturbance (acre)	Avg Post-Interim Reclamation Disturbance per OGDP (acre)	Avg Post-Interiem Reclamation Disturbance per Well (acre)
DJ Basin	17.99	6.00	0.41
Eastern Plains	5.40	1.80	1.35
West Slope	1.08	1.08	0.06
Total	24.47	3.50	0.38

The approved DJ Basin OGDP Locations had the highest number of proximate Residential Building Units (RBUs) and existing oil and gas locations. One OGDP Location was approved within a Disproportionately Impacted Community (DIC) in the DJ Basin. No OGDPs had Locations within one mile of any School Facilities, Child Care Centers, or High Occupancy Building Units.

Table 7: Proximity Information

Operating Area	OGDPs Locations Approved	Residential Building Units (0'-2000')	Residential Building Units (2001-5280')	OGDP within DIC	Existing Oil & Gas Locations (1 mile)
DJ Basin	3	16	141	1	87
Eastern Plains	4	0	2	0	1
West Slope	1	0	0	0	4

Air Quality

Emissions estimates are provided based on anticipated production and operating conditions. The actual emissions will be reported in the APCD Oil and Gas Emissions Inventory Reporting program for the oil and gas industry (Regulation Number 7, Part D, Section V) for both Pre-Production and Production operations. Future years' reports may include a comparison of these estimated values to actual values. Note that in the tables below, Pre-Production

operations include the construction, drilling, and completion phases, while Production emissions are estimated for the first full year that all wells are producing on a given Location.

Table 8: Emissions Per OGDP

Operating Area	Pre-Production Emissions Per OGDP			Production Emissions Per OGDP		
	Methane (ton)	VOC (ton)	HAP (lb)	Methane (ton/yr)	VOC (ton/yr)	HAP (lb/yr)
DJ Basin	3.90	21.39	120.22	5.53	20.11	2534.29
Eastern Plains	0.71	1.54	2.68	1.28	11.05	54.14
West Slope	603.54	8.35	1758.12	223.30	34.03	3325.00

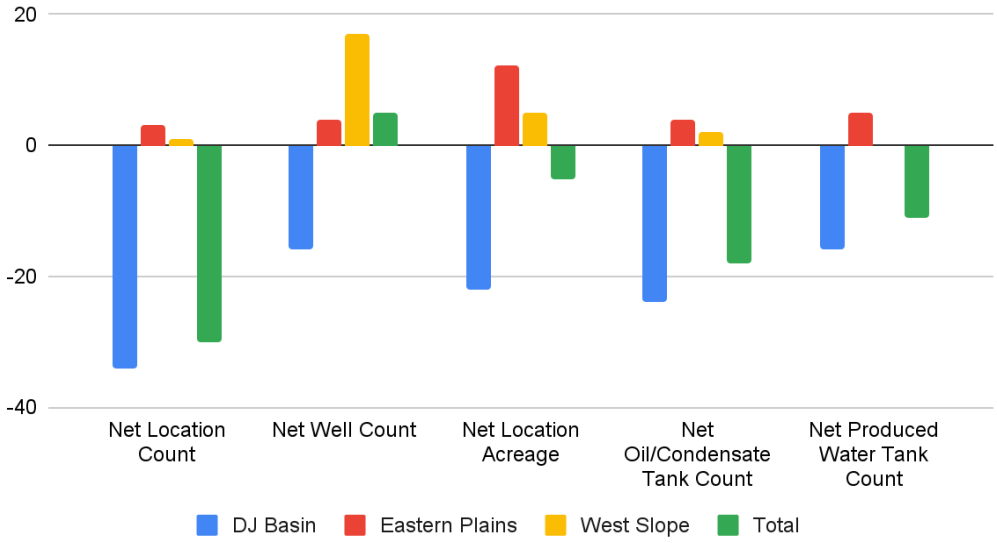
Table 9: Emissions Per Well

Operating Area	Pre-Production Emissions Per Well			Production Emissions Per Well		
	Methane (ton)	VOC (ton)	HAP (lb)	Methane (ton/yr)	VOC (ton/yr)	HAP (lb/yr)
DJ Basin	0.27	1.46	8.20	0.38	1.37	172.79
Eastern Plains	0.53	1.15	2.01	0.96	8.29	40.61
West Slope	35.50	0.49	103.42	13.14	2.00	195.59

Net Impacts

Some adverse impacts will have a beneficial offset, as presented below. The net value takes into account the wells plugged and abandoned, existing well pad count and associated acreage reclaimed, and tanks removed as estimated in the Form 2B. The actual location and well information to be reclaimed or plugged, respectively, has been required as a condition of approval, ordered by the Commission during the hearings for the associated OGDPs. While there is a net increase in the number of wells permitted and potentially drilled, there will be a net decrease in the number and acres of Oil and Gas Locations and the number of storage tanks, both produced water and condensate, in the future as these wells are plugged, tanks are decommissioned, and locations are reclaimed.

Figure 11: Net Impacts



Data Limitations

In late 2020 and early 2021, in response to the various changes in the SB19-181 associated rule changes, Staff worked to revise the existing electronic Form 2A (Oil and Gas Location Assessment) and develop the new electronic Forms 2B (Cumulative Impact Data Identification) and 2C (OGDP Certification). The updated Forms 2A and 2C were released for operator use in the Commission's existing electronic form application, known as eForms, within a few days of the January 15th, 2021 rule implementation date. The Form 2B was initially deployed as a spreadsheet for operators to use along with the released 2A and 2C with the final eForms version of the 2B being made available shortly thereafter. The first OGDP was submitted in March 2021 via eForms. Coincident with Staff updating and developing electronic forms associated with SB-18, technical developers were contending with the COGCC eForms application framework (Microsoft Silverlight) reaching its end-of-life in October 2021. This necessitated a replacement application, called Webforms, to be developed and implemented concurrent with deployment of the four new and 25 revised forms. To prevent potential issues with form submission and data management, electronic forms were developed simultaneously in both the existing eForms and the new Webforms applications. Upon final completion of the Webforms application, Forms 2A, 2B, 2C (and other eForms) were transferred, robustly tested, and formally deployed using Webforms in November 2021. Throughout the entire electronic forms development process, Staff was also creating guidance documents and establishing new internal processes and workflows to meet the needs of the new rules. Guidance writing, internal workflow improvements, and various Webforms bug fixes are ongoing.

CIDER is the compilation of data fields on the Form 2B: Cumulative Impacts Data Identification, which are used to help inform Staff and the Commission about information and data needed to evaluate potential cumulative impacts. CIDER is solely a data collection tool for Staff and

Commissioners, and does not conduct the evaluation of cumulative impacts itself. This report includes an assessment of the data in CIDER in order to present it here. CIDER collects dozens of data fields that were not previously collected. This database format allows for enhanced data evaluation and review. However, Staff acknowledge that sometimes quantitative data is not sufficiently informative to begin to evaluate cumulative impacts; instead, data may be more useful in a spatial review. For example, the DJ Basin OGDPs included 16 RBUs within 2,000 ft of an oil and gas location; this statistic does not indicate how close within this 2,000 ft radius the RBUs are, or whether the houses are dispersed within this radius or more densely concentrated in one neighborhood, etc. Data is presented above in an effort to inform the Commission, and the evaluation of such data on a future OGDP review may be more informative or appropriate on associated diagrams or maps. Future reports may include a combination of quantitative and spatial information, however spatial information may be most complete within OGDP or CAP applications. Additionally, qualitative data collected on the Form 2B can be difficult to evaluate, as descriptive language can sometimes be interpreted in more than one way and cannot easily be measured for accuracy or bias.

904.a.(2) Greenhouse Gas Roadmap

GHG Report to Colorado Legislature

In December 2021, in support of Colorado's Greenhouse Gas Pollution Reduction Roadmap ("GHG Roadmap"), the APCD published the GHG Emissions Reduction Progress Report to the Colorado Legislature. This report is required every odd numbered year and includes progress towards greenhouse gas (GHG) emission reduction goals, any updated cost-benefit analysis developed for rules adopted to attain the goals, and any recommendations for future legislative action. Parts of this report are summarized below. This legislative report also includes, via its Appendix A, a summary by the Colorado Energy Office of the 2021 legislative session and the 31 bills related to the implementation of the GHG Roadmap.

APCD's Colorado 2021 Greenhouse Gas Inventory Update was published in September of 2021. This document summarizes Colorado's greenhouse gas emissions from 2005 to 2019 and updates projections for emissions between 2020 and 2050. Of note, Colorado's GHG emissions decreased by 9% between 2005 and 2019. The Electric Power sector remains the largest source of Colorado's GHG emissions, followed by transportation, then fuel combustion to heat buildings and provide heat for industrial processes (listed in the inventory as residential, commercial, and industrial fuel use). Natural gas and oil systems is the fourth largest contributor of total GHG and the largest contributor of methane.

The APCD and Air Quality Control Commission (AQCC) undertook over a dozen actions to support the GHG reduction goals, discussed further in this report, including initiating internal administrative actions, creating or advancing policies and programs, and adopting regulatory actions. Actions that impact the oil and natural gas sector include, but are not limited to,

- Creation of a Climate Change Unit within the APCD
- Creation of an Office of Innovation and Planning within the APCD
- Creation of an AQCC GHG Strategy Subcommittee
- Adoption of a resolution to ensure GHG reduction goals are met
- Completion of three rulemakings that address emissions from the oil and natural gas sector

Further, the AQCC anticipates eight additional rulemakings to further GHG reductions. One was completed after the APCD report to the legislature was finalized that directly regulates the oil and natural gas sector. Additional rulemakings planned for GHG reporting, permitting requirements, and ozone planning are expected to also impact the oil and natural gas sector.

The APCD report to the legislature concluded that “there is a technically feasible, cost-effective path to achieving the GHG reduction goals set forth in HB19-1261... As a result of [agency regulation and legislative initiatives] Colorado is achieving significant and cost effective reductions of GHG emissions that will go a long way toward meeting the goals set forth in HB 19-1261. But additional work will be necessary during the next few years and throughout the decade to achieve the 2025 and 2030 goals. While an ongoing commitment of resources will be necessary, this work can be successfully completed within existing statutory authorities granted to the [AQCC] and [APCD].”

As the fourth largest source of GHG emissions, the oil and gas sector is a significant piece to the overall GHG roadmap. In recognition of the critical role oil and gas emissions play, the General Assembly adopted House Bill 21-1266 (the Environmental Justice Act), mandating specified percentages of reductions in oil and gas sector emissions by 2025 and 2030. The 2021 oil and gas emission reduction rulemaking, discussed further below, will be a step towards emission reductions from this sector. The APCD continues to study emissions from this sector - having completed aerial and ground-based survey work in 2021 that seeks to inform top-down analysis of oil and gas emissions. APCD anticipates having the results of those surveys in the spring of 2022. APCD also anticipates that the Air Quality Enterprise, created by the General Assembly in 2020, will conduct additional studies and research into the sector's emissions - the results of which will inform future APCD and COGCC work.

AQCC Rulemaking

In December 2021, the AQCC adopted revisions to Regulations Number 7 and 22 to achieve the necessary statewide GHG emission reductions to implement the GHG Roadmap and HB21-1266, the Environmental Justice Act. The AQCC was required to adopt regulations to meet specified percentages of GHG reduction over a baseline. The percentages and baselines differ based upon the GHG Roadmap sector in which the equipment and resulting GHG emissions are bucketed.

In October 2020, the AQCC established a target for the oil and gas (O&G) sector of the GHG Roadmap of a 36% reduction from the 2005 baseline by 2025 and a 60% reduction from the 2005 baseline by 2030 (an estimated 13 million metric tons (MMT) CO_2e by 2025 and additional 8 MMT CO_2e by 2030). The Environmental Justice Act, signed into law on July 2, 2021, memorializes in statute the AQCC's October 2020 sector-specific percentage reductions, and provides additional requirements for the rulemakings to achieve these goals. Pursuant to the Environmental Justice Act, the AQCC was required to, by January 1, 2022, adopt regulations to ensure that the state meets its GHG reduction targets for the O&G sector, and must also ensure that Industrial Sector emissions (including those from oil and gas fuel combustion equipment) are reduced. These regulations must prioritize near-term reductions and include additional protections for disproportionately impacted communities ("DI Communities").

The AQCC also adopted regulatory revisions and new programs that meaningfully reduce emissions of GHG and co-pollutants in DI Communities. The revisions to Regulation Number 7 adopted by the AQCC in December 2021 ensure, in DI Communities: quicker and more frequent testing of combustion devices; more frequent leak inspections and earlier repair of leaking components; quicker, and more, reductions from certain midstream operations; and control of more well liquids unloading events.

Finally, the AQCC adopted a section of Regulation Number 7 to act as a counterpart to COGCC Rule 904. Regulation Number 7 Part B Section V.D. requires that the APCD provide to the COGCC annual reports already required to be presented to the AQCC, for example, information reported to the APCD in the Regulation No. 7 in the Oil and Gas Emissions Inventory. These reports from the APCD to the COGCC may be referred to or used to compile sections of this cumulative impacts report in future years.

904.a.(3) APCD Oil and Gas Emissions Inventory

In 2019, the AQCC adopted a new annual emissions reporting requirement in Regulation Number 7 Part B Section V (Oil and Natural Gas Operations Emissions Inventory). To minimize confusion with other inventory efforts, such as the GHG inventory discussed above, the APCD refers to this as the Oil and Gas Annual Emissions Reporting Program. The first annual reports were submitted in June 2021. The APCD received 186 reports from 118 companies. The APCD is still working to review all of the data submitted. The APCD is also working to build a database that will enable the processing of these annual emission reports to facilitate more transparency and data sharing. In December 2021, the AQCC determined to require operators to submit both APCD identifying information (e.g. AIRS ID) and COGCC location IDs, to facilitate the agencies' ability to share information about operations and correlate information between agencies.

904.a.(4) Ozone Trends

Ozone Reclassification

The Denver Metro/North Front Range (DM/NFR) area has been designated by the US Environmental Protection Agency (EPA) as a nonattainment area for ozone, under both the 2008 National Ambient Air Quality Standard (NAAQS) of 75 parts per billion (ppb) as well as the 2015 NAAQS of 70 ppb. For the 2008 NAAQS, the ozone nonattainment area is currently classified as Serious. Under the Clean Air Act, APCD expects the area to be reclassified from Serious to Severe in early 2022. For the 2015 NAAQS, the ozone nonattainment area (which, as described below, includes all of Weld County) is currently classified as a Marginal nonattainment area; however, APCD expects the area to be reclassified to Moderate in early 2022. In addition, moderate and greater ozone nonattainment areas must submit a State Implementation Plan (SIP) that, among other things, includes reasonably available control technology requirements for certain types of sources. The due date for these SIPs will be included in the EPA reclassification notices. On top of requirements in a SIP, these reclassifications will continue to have impacts on the permitting and construction of larger air pollution sources, which may affect oil and gas operations.

Ozone Report to Commission

On December 8, 2021, the Commission heard an APCD report on the 2021 summer ozone season. A few highlights from this presentation are included below.

Ozone, for the most part, is a secondarily formed air pollutant at ground level, resulting from the reactions of hydrocarbons with oxides of nitrogen in the presence of sunlight. Due to the meteorology in the DM/NFR area, the highest ozone values typically occur along the foothills due to upslope convection winds and reaction time. The two primary anthropogenic sources of ozone precursors are motor vehicles and oil and gas development, each accounting for up to 40% of the total emissions (depending on the location).

2020 and 2021 were both unusually high ozone years. In 2020, there were a number of wildfires that caused increases in ozone. Wildfire smoke contains both hydrocarbons and oxides of nitrogen and, over time, react to form ozone. 2021 was even more atypical. Not only were there wildfire smoke influences, but the 500 millibar pressure height (which has a good correlation with high ozone) was the highest seen since measurements started in 1940. With the combination, the DM/NFR area had the worst summer ozone season since at least 2003.

Figure 12: North Front Range Days Over the NAAQS

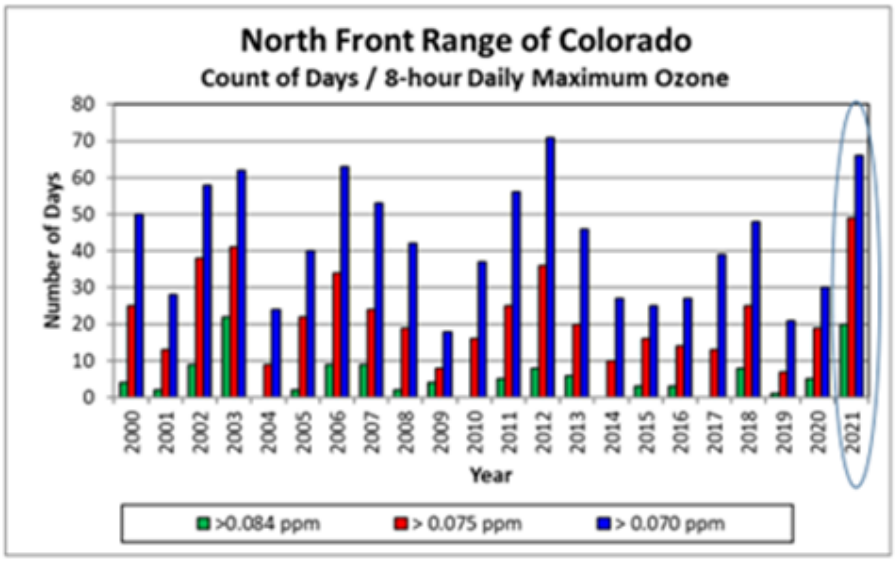
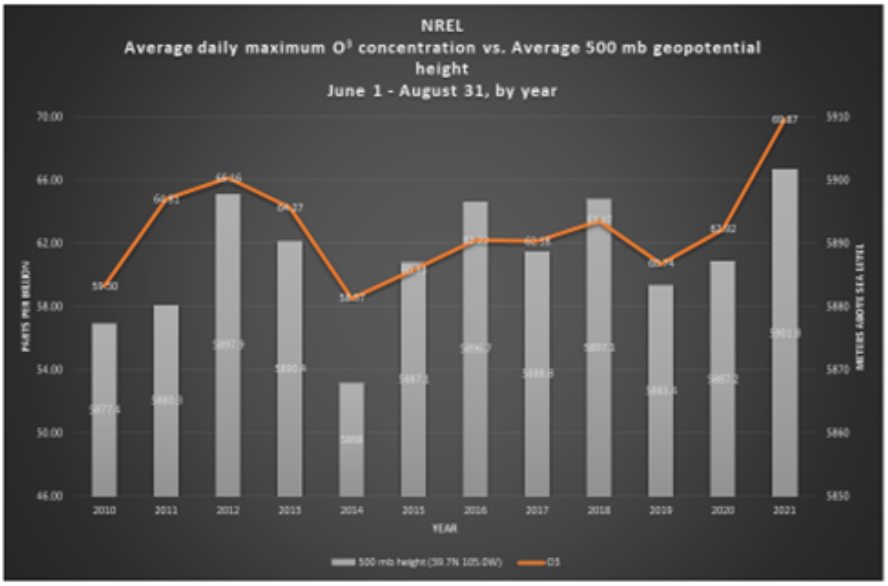


Figure 13: Average Daily Maximum O3 Concentration



Decreasing ozone concentrations in the DM/NFR is a continued priority for the APCD. Sources of ozone precursors will continue to be examined to determine the best options for reducing emissions. Oil and gas development will continue to be a focus for new emission reductions regulations as well as other sources such as non-road vehicles, lawn and garden, and personal care products.

Ozone Boundary Change

On November 30, 2021, the EPA published a revision to Colorado's initial air quality designation under the 2015 NAAQS to include all of Weld County, effective December 30, 2021. The DC Circuit had remanded the designation to EPA in a July 10, 2020 decision. The northern area of

Weld County is defined as the portion of Weld County that lies north of a line beginning at a point on Weld County's eastern boundary and Logan County's western boundary intersected by 40 degrees, 42 minutes, 47.1 seconds north latitude, proceed west on 40 degrees, 42 minutes, 47.1 seconds north latitude until this line intersects Weld County's western boundary and Larimer County's eastern boundary (approximately Weld County Road 100).

The result of this action is that northern Weld County is now a marginal ozone nonattainment area under the 2015 NAAQS of 70 ppb, with a major source threshold of 100 tpy (versus 250 tpy) for VOC or NOx. Because Colorado did not attain the 2015 NAAQS by August 2021, APCD expects EPA to reclassify the 2015 NAAQS ozone nonattainment area from marginal to moderate. EPA will specify the due date for Colorado to submit its moderate area state implementation plan (SIP) in the reclassification notice.

904.a.(5) Evolving & New Innovative Technologies & Measures

The oil and natural gas industry has and continues to evolve. One demonstration of this evolution is seen in the Best Management Practices (BMPs) included in Form 2As (Oil and Gas Location Assessments). The following are examples of BMPs more recently being included in the OGDP applications that relate to protecting public health, safety, welfare, the environment and wildlife resources, and minimizing cumulative impacts resulting from oil and gas activity. Not all of these activities are new practices as of this year; instead, they are or may be becoming more widely used.

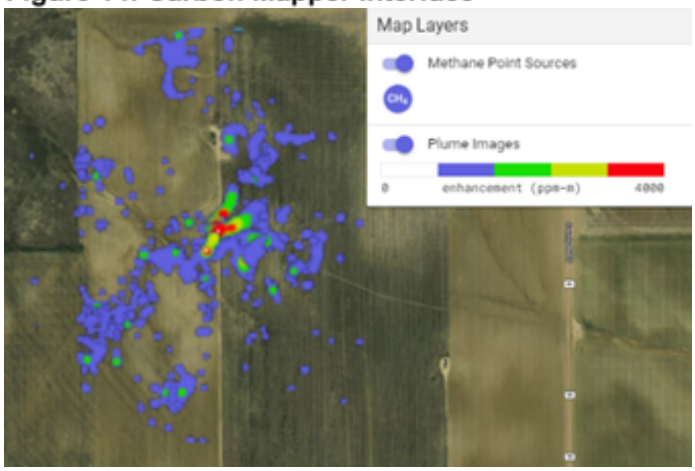
- Use of a quiet completions fleet during completion operations
- Use of automatic light sensors
- Operation of a "tankless" facility without condensate and/or produced water tanks
    - Where "tankless" is not included, LACT units, and surge vessels are some alternate BMPs included
- Remote monitoring and camera technology

A new item with the addition of beneficial impacts on the Form 2B this year has been the inclusion of plans to plug and abandon wells and reclaim locations in the same or adjacent Drilling and Spacing Unit (DSU) or Wellbore Spacing Units (WSU). This has resulted in the decommissioning of wells and locations with less protective design and operation, resulting in a net improvement in facility design and operation that offers more or upgraded protections. Also new in 2021 is the availability or distribution of operators' information and/or communication in Spanish.

Aerial surveys are another innovative tool that is being used for monitoring of oil and gas emissions. Flights focused on methane emissions were performed in collaboration with the APCD and funded by the Mark Martinez and Joey Irwin Memorial Public Projects Fund. These

flights took place in July and September 2021, covering much of the Denver-Julesburg basin. An aircraft owned by the University of Arizona conducted the primary surveys utilizing an airborne infrared imaging spectrometer that was able to quantify plumes with an emissions rate as low as 15 kg/hour. Data from these aerial surveys are available at https://carbonmapperdata.org/map.

Figure 14: Carbon Mapper Interface



In addition, an aircraft owned by the University of Maryland, in cooperation with the University of Colorado, conducted aerial survey flights during the September 2021 period. This aircraft included a proton transfer reaction-time of flight mass spectrometer for benzene and other volatile organic compounds, as well as a compact airborne multispecies spectrometer for ethane. Along with ground survey efforts, these results will be available in the spring of 2022.

Many new technologies or measures have been more widely adopted as a result of recent air quality rulemaking. For example, new facilities are now required to be constructed with non-emitting pneumatic controllers. Significantly, AQCC Regulation Number 7 requires that "Owners or operators of drilling operations that begin on or after May 1, 2021, must monitor air quality at and/or around the pre-production and early production operations." (VI.C.1.) The purpose of this monitoring is to detect, evaluate, and reduce as necessary hazardous air pollutant emissions, ozone precursor emissions, or methane emissions. Prior to this new section of the regulation, some operators voluntarily performed some air monitoring near pre-production activities, but the data were not routinely shared. This has been a significant new requirement that all operators are required to "submit an air quality monitoring plan" for approval, perform air monitoring, and "submit monthly reports of monitoring."

To-date, 92 monitoring plans from 21 different operators have been submitted to the APCD for review. Monitoring by operators is generally being performed for total volatile organic compounds (TVOC) using sensors that are solar powered and have cellular connectivity to transmit data in real-time. Models from at least seven different manufacturers are being used. These TVOC units are either based on photoionization detectors or metal oxide sensors. Often, these sensors have been paired with a trigger device that collects a whole-air canister sample automatically when the TVOC level exceeds a set threshold. These canisters are then analyzed in a laboratory for a suite of organic compounds. As reports are being

received, which include not only the TVOC data, but also meteorological and canister analysis data, they are reviewed by the APCD for concerns or issues.

Finally, Staff continues to be made aware of and learn about additional new and innovative technologies, and are evaluating ways to increase awareness of such technologies. For example, oil and natural gas that would otherwise be flared is being converted into electricity for use in mobile data centers.[3] To assist in Staff awareness of new technologies, a link has been added to the newly created Cumulative Impacts page of the COGCC website to collect additional information on an ongoing basis. Any information submitted on this webpage will be reviewed by staff for applicability and relevance, and may be included in subsequent reports.

904.a.(6) Academic or Government Reports

Literature related to cumulative impacts to public health, safety, welfare, the environment and wildlife resources from oil and gas development are numerous. Below are academic or government reports published in 2021 related to the impacts of oil and gas activities that are not referenced elsewhere in this report.

Agerton, Mark and Gilbert, Ben and Upton, Gregory. 2021. *The Economics of Natural Gas Venting, Flaring and Leaking in U.S. Shale: An Agenda for Research and Policy* Last Revised 2021. USAEE Working Paper No. 20-460. https://ssrn.com/abstract=3655624 (Accessed January 2022)

Bo Gao, Melissa K. Mitton, Clay Bell, Daniel Zimmerle, T. K. K. Chamindu Deepagoda, Arsineh Hecobian, Kathleen M. Smits. 2021. *Study of methane migration in the shallow subsurface from a gas pipe leak.* Elementa: Science of the Anthropocene. https://doi.org/10.1525/elementa.2021.00008 (Accessed January 2022)

Colorado Department of Natural Resources. 2021. *Opportunities to Improve Sensitive Habitat and Movement Route Connectivity for Colorado's Big Game Species.* https://drive.google.com/file/d/1nKR7fdQpcLHsU_z7XoJz5s7jXdvLwUqs/view (Accessed January 2022)

Colorado Oil and Gas Conservation Commission. 2021. *Idle & Plugged Well Methane Emissions Literature Review.* https://drive.google.com/file/d/17S9WBKhYjwG-Behqb80gYu4MoH7LSE4q/view (Accessed January 2022)

[3] In May 2021, Denver based Crusoe Energy announced an expansion of their Denver headquarters.

Dinkins, J.B., K.J. Lawson, J.L. Beck. 2021. *Influence of environmental change, harvest exposure, and human disturbance on population trends of greater sage-grouse.* PLoS ONE 16(9):e0257198. https://doi.org/10.1371/journal.pone.0257198 (Accessed January 2022)

Duchardt C.J., A.P. Monroe, J.A. Heinrichs, M.S. O'Donnell, D.R. Edmunds, C.L. Aldridge. 2021. *Prioritizing restoration areas to conserve multiple sagebrush-associated wildlife species.* Biological Conservation. https://doi.org/10.1016/j.biocon.2021.109212 (Accessed January 2022)

Lawrence, A.J., S.A. Carleton, W.R. Gould, and C.T. Nichols. 2021. Lesser Prairie-Chicken Survival in Varying Densities of Energy Development. The Journal of Wildlife Management 1-11. https://doi.org/10.1002/jwmg.22084 (Accessed January 2022)

Northrup, J.M., C.R. Anderson, Jr., B.D. Gerber, G. Wittemyer. 2021. Behavioral and Demographic Responses of Mule Deer to Energy Development on Winter Range. Wildlife Monographs 208:1–37; https://doi.org/10.1002/wmon.1060 (Accessed January 2022)

Olsen, A.C., J.P. Severson, J.D. Maestas, D.E. Naugle, J.T. Smith, J.D. Tack, K.H. Yates, and C.A. Hagen. 2021. *Reversing tree expansion in sagebrush steppe yields population-level benefit for imperiled grouse.* Ecosphere 12(6):e03551. https://doi.org/10.1002/ecs2.3551 (Accessed January 2022)

Olsen, A.C., J.P. Severson, B.W. Allred, M.O. Jones, J.D. Maestas, D.E. Naugle, K.H. Yates, and C.A. Hagen. 2021. Reversing Tree Encroachment Increases Usable Space for Sage‐Grouse during the Breeding Season. Wildlife Society Bulletin 45(3):488–497. https://doi.org/10.1002/wsb.1214 (Accessed January 2022)

Staff is also aware of ongoing studies, which will be reviewed for relevancy and may be included in the report covering the period of time in which they are published. For example, Staff is aware of an oil and gas health survey being conducted by the City and County of Broomfield. Of note, the reports accompanying the aerial surveys discussed above are expected to be published in 2022. Finally, reports may be submitted to Staff for review via the link on the newly created Cumulative Impacts page of the COGCC website. Any academic or government reports or studies submitted on this webpage will be reviewed by staff for applicability and relevancy, and may be included in subsequent reports.

904.a.(7) Information Requested by Commission

Subparagraph (7) is a placeholder for additional information to be included as requested by the Commission. This first report does not contain information in this section. As described below, this section will be built upon as the Commission requests additional information be included in future years.

904.a.(8) Recommendations

Subparagraph (8) of 904.a. solicits recommendations from the Director for future rulemakings, guidance, workgroups, or studies to address cumulative impacts. This first report's focus is on presenting the data collected, therefore the recommendation below assists in efforts to improve future reports.

As mentioned above, Subparagraph (7) allows the Commission to request additional information be included in this report. The following is a summary of our recommendation to provide this feedback in a constructive and ongoing manner.

This report is intended to evolve as our data, understanding, and methods to evaluate and address cumulative impacts evolve. Therefore, as Commissioners' understanding and evaluation of cumulative impacts evolves, the Director intends to accept requests for additional content for this report. Requests will be included in future reports upon agreement by the full Commission and the Director, and are subject to data availability. These requests can happen at any point during the year. Requests made in a calendar year may require additional data or review, which may result in a delay in inclusion. For example, should the Commission request data in 2022 which is not yet collected, it may require changes to COGCC forms, which may not go into effect until 2023 to be included in the report to the Commission in 2024.

An example of such data request is an evaluation of spud versus plugged and abandoned well counts. Where the net impacts above provide information on the approved OGDP plans to plug and abandon wells, the activity occurs in later years. It may be beneficial to understand actual plugging and abandonment activities as they may be initiated outside of the OGDP process. Well spud activity is reported via Form 42 (Notice of Spud). Plugged and abandoned (PA) wells are reported complete via Form 6 (Subsequent Report of Abandonment). Data from this form included in future reports may be presented as follows.

In 2021, 645 wells were noticed for spud on a Form 42 (Notice of Spud). By contrast, 924 wells were reported as PA'd via a processed Form 6 (Subsequent Report of Abandonment), resulting in a net reduction of 297 wells. Both spud and plug and abandonment activities in the DJ Basin are primary contributors to these data. This difference between the number of wells spud versus

the number of wells PA'd could be driven by time-dependent changes in reservoir characteristics of the basin, social considerations for areas with higher population density, economic burden for operators related to market fluctuations, compliance burden in the nonattainment area, OGDP permitting considerations, and/or other factors. Finally, in 2021, approximately 270 Form 6s (Notice of Intent to Abandon) were approved within HPH. Approval of this notice is precursory to actual plugging activities, and indicates the operator's intent to plug wells and reclaim locations within the HPH within the next six months.

Table 10: Spud and Plug and Abandon Activity

Operating Area	Count of Wells Spud	% of 2021 Spud	Count of Wells Plugged	% of 2021 Plugged
DJ Basin	561	87.0%	888	94.3%
Eastern Plains	5	0.7%	12	1.2%
West Slope	79	10.9%	42	4.3%
Total	**645**	100.0%	**942**	100.0%