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A FORCE FOR NATURE

U.S. DEPT OF INTERIOR
BUREAU OF LAND MGMT
COLO STATE OFFICE DENVER

2015 DEC 14 PM 3:50

December 14, 2015

Via Hand Delivery

Ruth Welch
State Director
U.S. Bureau of Land Management
Colorado State Office
2850 Youngfield St.
Lakewood, CO 80215

Re: Protest of February 2016 Competitive Oil and Gas Lease Sale

Dear Ms. Welch:

Pursuant to 43 C.F.R. § 3120.1-3, WildEarth Guardians hereby protests the Bureau of Land Management's ("BLM's") proposal to offer five publicly owned oil and gas lease parcels covering 4,912.33 acres of land in the Tres Rios Field Office of Colorado for competitive sale on February 11, 2016. These parcels include public lands managed by BLM in Dolores County, Colorado. The specific parcels being protested include the following, as identified by the BLM's in its Final February 2016 Oil and Gas Sale List:[1]

Lease Serial Number	Acres	County
COC77454	196.44	Dolores
COC77455	1519.90	Dolores
COC77456	503.64	Dolores
COC77457	1612.35	Dolores
COC77458	1080.00	Dolores

In support of its proposed leasing, the agency prepared a Determination of Adequacy Under the National Environmental Policy Act ("DNA"), DOI-BLM-CO-S010-2015-0020-DNA. A DNA does not satisfy NEPA's requirement that the impacts of major federal actions be analyzed and assessed. Rather, a DNA adopts prior NEPA analyses. In this case, the BLM's DNA relies upon a 2013 Final Environmental Impact Statement prepared for the BLM's Tres

[1] This list, which was made available on November 13, 2015, is on the BLM's website at http://www.blm.gov/style/medialib/blm/co/programs/oil_and_gas/Lease_Sale/2016/february.Par.42602.File.dat/sale_notice%20February%2011,%202016.pdf.

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Rios Field Office, San Juan National Forest Land and Resource Management Plan (hereafter "2013 LRMP FEIS").

As will be explained, the BLM's proposal to lease falls short of ensuring compliance with NEPA, 42 U.S.C. § 4331, *et seq.* The BLM's reliance on the 2013 LRMP FEIS to satisfy the agency's obligations to analyze and assess the reasonably foreseeable impacts of oil and gas leasing is wholly inappropriate as it fails to present any site-specific analysis and disclosure of impacts. The DNA does not demonstrate that a stand-alone NEPA analysis is not required in this case or that the potentially significant impacts of leasing have been adequately analyzed and assessed.[2]

STATEMENT OF INTEREST

WildEarth Guardians is a nonprofit environmental advocacy organization dedicated to protecting the wildlife, wild places, wild rivers, and health of the American West. WildEarth Guardians is headquartered in Santa Fe, New Mexico, but has offices and staff throughout the western United States, including in Denver. On behalf of our members, Guardians has an interest in ensuring the BLM fully protects public lands and resources as it conveys the right for the oil and gas industry to develop publicly owned minerals. More specifically, Guardians has an interest in ensuring the BLM meaningfully and genuinely takes into account the climate implications of its oil and gas leasing decisions and objectively and robustly weighs the costs and benefits of authorizing the release of more greenhouse gas emissions that are known to contribute to global warming. WildEarth Guardians submitted comments on the BLM's proposed leasing on September 11, 2015.

The mailing address for WildEarth Guardians to which correspondence regarding this protest should be directed is as follows:

WildEarth Guardians
1536 Wynkoop, Suite 310
Denver, CO 80202

STATEMENT OF REASONS

WildEarth Guardians protests the BLM's February 11, 2016 oil and gas lease sale over the agency's failure to adequately analyze and assess the climate impacts of the reasonably foreseeable oil and gas development that will result in accordance NEPA, 42 U.S.C. § 4331, *et seq.*, and regulations promulgated thereunder by the White House Council on Environmental Quality ("CEQ"), 40 C.F.R. § 1500, *et seq.*

[2] For purposes of this protest, we hereby incorporate by reference comments on the BLM' and attachments thereto submitted by WildEarth Guardians on September 11, 2015. These documents should be a part of the BLM's record its DNA.

NEPA is our "basic national charter for protection of the environment." 40 C.F.R. § 1500.1(a). The law requires federal agencies to fully consider the environmental implications of their actions, taking into account "high quality" information, "accurate scientific analysis," "expert agency comments," and "public scrutiny," prior to making decisions. *Id.* at 1500.1(b). This consideration is meant to "foster excellent action," meaning decisions that are well informed and that "protect, restore, and enhance the environment." *Id.* at 1500.1(c).

To fulfill the goals of NEPA, federal agencies are required to analyze the "effects," or impacts, of their actions to the human environment prior to undertaking their actions. 40 C.F.R. § 1502.16(d). To this end, the agency must analyze the "direct," "indirect," and "cumulative" effects of its actions, and assess their significance. 40 C.F.R. §§ 1502.16(a), (b), and (d). Direct effects include all impacts that are "caused by the action and occur at the same time and place." 40 C.F.R. § 1508.8(a). Indirect effects are "caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable." *Id.* at § 1508.8(b). Cumulative effects include the impacts of all past, present, and reasonably foreseeable actions, regardless of what entity or entities undertake the actions. 40 C.F.R. § 1508.7.

An agency may prepare an environmental assessment ("EA") to analyze the effects of its actions and assess the significance of impacts. *See* 40 C.F.R. § 1508.9; *see also* 43 C.F.R. § 46.300. Where effects are significant, an Environmental Impact Statement ("EIS") must be prepared. *See* 40 C.F.R. § 1502.3. Where significant impacts are not significant, an agency may issue a Finding of No Significant Impact ("FONSI") and implement its action. *See* 40 C.F.R. § 1508.13; *see also* 43 C.F.R. § 46.325(2).

Here, the BLM fell short of complying with NEPA with regards to analyzing and assessing the potentially significant climate impacts of oil and gas leasing. In support of its proposed leasing, the agency did not actually prepare any NEPA analysis, but rather relied on a programmatic FEIS prepared in 2013 for the Tres Rios Field Office, San Juan National Forest Land and Resources Management Plan.[3] This FEIS, however, fails to analyze the reasonably foreseeable greenhouse gas emissions that would result from selling and producing oil and gas from the oil and gas lease parcels, as well as failed to assess the significance of any emissions, particularly in terms of carbon costs.

In response to comments, the BLM acknowledged that climate change is a very serious issue and that proper analysis and assessment under NEPA is necessary. *See* DNA, Attachment E at Response to Comments #15. In spite of this, the BLM made no effort to analyze the reasonably foreseeable greenhouse gas emissions that would result from development of the proposed leases. Instead of using readily available information and methods, including analyses that other BLM offices have been perfectly capable of preparing, the agency instead asserts that it is simply impossible to estimate such emissions. *See id.* The issue, however, is not that it is impossible to estimate emissions, but that BLM believes it cannot estimate emissions as precisely as it prefers to. This is not allowed under NEPA. Although the agency may believe

[3] The DNA is available on the BLM's website at http://www.blm.gov/style/medialib/blm/co/programs/oil_and_gas/Lease_Sale/2016/february.Par.44429.File.dat/DNA_Worksheet_2016_Lease_Sale_Final_to_SO_10-Nov-2015.pdf.

that without definitive development proposals, it cannot project impacts, the whole point of leasing oil and gas is to facilitate development. The BLM cannot claim that the act of leasing carries with it no intention to foster future development. Regardless, because leasing conveys a right to develop, absent any stipulations that provide the agency with authority to constrain or even prevent future development to limit greenhouse gas or climate impacts, the BLM has no basis to assert that it is appropriate to wait to conduct its legally required analysis under NEPA, or worse, assert that there would be no reasonably foreseeable emissions associated with its proposed action. Here, no such stipulations have been proposed, rendering invalid BLM's assertion that the proposed leasing would pose no significant impacts to the human environment.

In any case, the BLM has completely failed to provide information and analysis, even brief information and analysis, supporting its determination that no NEPA analysis is necessary for the proposed leases. Either the BLM must prepare an EIS or it cannot proceed with the lease sale as proposed. Below, we detail how BLM's proposal fails to comply with NEPA.

1. The BLM Failed to Analyze and Assess the Direct, Indirect, and Cumulative Impacts of Greenhouse Gas Emissions that Would Result from Issuing the Proposed Lease Parcels

The BLM completely rejected analyzing and assessing the potential direct and indirect greenhouse gas emissions, including carbon dioxide and methane, that would result from the reasonably foreseeable development of the proposed leases and emissions that would result from consumption of oil and gas produced from the leases. Although acknowledging that development of the lease parcels would occur and that greenhouse gas emissions would be produced, no analysis of these emissions was actually prepared. In fact, the BLM claims such an analysis would not be "prudent." DNA, Attachment E at Response to Comments #16.

The BLM relies on the 2013 LRMP FEIS to argue that an appropriate analysis has been completed. The FEIS, however, contains no analysis of the reasonably foreseeable greenhouse gas emissions that would result from development and ultimate consumption of oil and gas from the leases. Furthermore, to the extent the FEIS does present a cumulative analysis of reasonably foreseeable greenhouse gas emissions associated with construction and production of oil and gas wells, this analysis fails to address the reasonably foreseeable impacts of oil and gas processing, refining, and ultimate consumption. Put another way, it fails to disclose the full life-cycle impacts of oil and gas that will be produced in the Field Office.

To cover for its lack of analysis, the BLM asserts that future development is uncertain and that any analysis of impacts would be "speculative" and therefore "have little value to the decisionmaker." DNA, Attachment E at Response to Comments #15. The BLM asserts that such an analysis would not be "prudent." DNA, Attachment E at Response to Comments #16. NEPA, however, has no "prudency" exemption and does not allow agencies to summarily refuse to comply. Further, the BLM does not get to avoid complying with NEPA because it cannot precisely analyze and assess impacts. In fact, CEQ regulations are clear that where the impacts of a proposed action are "highly uncertain," this is a sign that an action poses significant impacts and therefore should be analyzed in an EIS. 40 C.F.R. § 1508.27(b)(4).

The BLM's position is all the more egregious given that other BLM Field Offices, including, but not limited to, the Four Rivers Field Office in Idaho, the Billings Field Office in Montana, the Miles City Field Office in Montana, the Royal Gorge Field Office in Colorado, and others have not only estimated reasonably foreseeable greenhouse gas emissions associated with the development of oil and gas leases, but clearly do not believe that such information is speculative or not useful to analyze under NEPA.

In the Four Rivers Field Office of Idaho, the BLM utilized an emission calculator developed by air quality specialists at the BLM National Operations Center in Denver to estimate likely greenhouse gases that would result from leasing five parcels. *See* Exhibit 1, BLM, "Little Willow Creek Protective Oil and Gas Leasing," EA No. DOI-BLM-ID-B010-2014-0036-EA (February 10, 2015) at 41, available online at https://www.blm.gov/epl-front-office/projects/nepa/39064/55133/59825/DOI-BLM-ID-B010-2014-0036-EA_UPDATED_02272015.pdf (last accessed Dec. 14, 2015). Relying on a report prepared in 2013 for the BLM by Kleinfelder, the agency estimated that 2,893.7 tons of carbon dioxide equivalent ("CO_2e") would be released per well. *Id.* at 35. Based on the analyzed alternatives, which projected between 5 and 25 new wells, the BLM estimated that total greenhouse gas emissions would be between 14,468.5 tons and 72,342.5 tons annually. *Id.*

In both the Billings and Miles City Field Offices of Montana, the BLM estimated likely greenhouse gas emissions from development of oil and gas leases. To do so, the agency first calculated annual greenhouse gas emissions from oil and gas activity within the Field Offices. *See* Exhibit 2, BLM, "Environmental Assessment for October 21, 2014 Oil and Gas Lease Sale," DOI-BLM-MT-C020-2014-0091-EA (May 19, 2014) at 51, available online at http://www.blm.gov/style/medialib/blm/mt/blm_programs/energy/oil_and_gas/leasing/lease_sales/2014/oct__21_2014/july23posting.Par.88257.File.dat/BiFO%20Oct%202014%20EA.pdf (last accessed Dec. 11, 2015) and Exhibit 18 to Guardians' Sept. 11, 2015 Comments. The BLM then calculated total greenhouse gases by assuming that the percentage of acres to be leased within the federal mineral estate of the Field Offices would equal the percentage of emissions. *Id.* Although we have concerns over the validity of this approach to estimate emissions (an "acre-based" estimate of emissions is akin to estimating automobile emissions by including junked cars, which has the misleading effect of reducing the overall "per car" emissions), nevertheless it demonstrates that the BLM has the ability to estimate reasonably foreseeable greenhouse gas emissions associated with oil and gas leasing and that such estimates are valuable for ensuring a well-informed decision.

In the Royal Gorge Field Office of Colorado, the BLM contracted with URS Group Inc. to prepare an analysis of air emissions from the development of seven oil and gas lease parcels. *See* Exhibit 3, URS Group Inc., "Draft Oil and Gas Air Emissions Inventory Report for Seven Lease Parcels in the BLM Royal Gorge Field Office," Prepared for BLM, Colorado State Office and Royal Gorge Field Office (July 2013). This report estimated emissions of carbon dioxide and methane on a per-well basis and estimated the total number of wells that could be developed in these seven parcels. *See* Exhibit 3 at 3 and 5. This report was later supplanted by the Colorado Air Resource Management Modeling Study, or CARMMS, which estimated reasonably foreseeable emissions of greenhouse gases, criteria pollutants, and hazardous air pollutants associated with oil and gas development throughout Colorado, as well as part of New

Mexico, and modeled air quality impacts. *See* Exhibit 4, ENVIRON, "Colorado Air Resource Management Modeling Study (CARMMS) 2021 Modeling Results for the High, Low and Medium Oil and Gas Development Scenarios," Prepared for BLM Colorado State Office (January 2015), available online at http://www.blm.gov/style/medialib/blm/co/information/nepa/air_quality.Par.97516.File.dat/CARMMS_Final_Report_w-appendices_012015.pdf (last accessed Dec. 14, 2015). As part of the CARMMS report, the BLM estimated per well emissions, including greenhouse gas emissions, in tons per year, as follows:

Phase	PM_{10}	$PM_{2.5}$	VOC	CO	NO_X	SO_2	CO_2	CH_4	N_2O	HAP
Conventional Construction	5.21	0.64	0.05	0.23	0.72	0.02	108.1	0.00	0.00	0.01
CBM Construction	3.37	0.44	0.03	0.12	0.36	0.01	56.58	4.06	0.00	0.00
Conventional Production	1.15	0.15	6.67	1.30	0.73	0.00	251.9	17.14	0.00	0.43
CBM Production	2.25	0.25	13.10	1.13	0.62	0.00	181.6	19.05	0.00	1.31

Although the BLM may assert that analyzing the impacts of the proposed leases is impossible, this claim is undercut by the fact that the 2013 LRMP FEIS did provide some estimates of cumulative greenhouse gas emissions from oil and gas development, clearly indicating the possibility of a site-specific analysis of direct and indirect impacts.

The BLM finally attempts to argue that an analysis of greenhouse gas emissions is more appropriate at the drilling stage. We have yet to see the BLM actually prepare such a site-specific analysis in conjunction with an oil and gas lease development proposal. Recent analyses prepared for drilling in the Tres Rios Field Office confirms that no such analysis is conducted by the BLM. *See* Exhibit 5, BLM, "Environmental Assessment, D.J. Simmons, Inc. Two Pinto Wells Project, Pinto 1-7 and Pinto 3-17 Oil Wells, Dolores County, Colorado," DOI-BLM-CO-S010-2012-0036-EA (July 2013). What's more, this argument has no merit as the agency has proposed no stipulations that would grant the BLM discretion to limit, or outright prevent, development of the proposed leases on the basis of greenhouse gas emissions and/or climate concerns. The BLM is effectively proposing to make an irreversible commitment of resources, which is the hallmark of significance under NEPA. *See* 42 U.S.C. § 4332(c)(v) and 40 C.F.R. § 1502.16. The failure to prepare an EIS—or any analysis for that matter—for the proposed leases is therefore contrary to NEPA.

2. The BLM Failed to Analyze the Costs of Reasonably Foreseeable Carbon Emissions Using Well-Accepted, Valid, Credible, GAO-Endorsed, Interagency Methods for Assessing Carbon Costs that are Supported by the White House

Compounding the failure of the BLM to make any effort to estimate the greenhouse gas emissions that would result from reasonably foreseeable oil and gas development is that the agency also rejected analyzing and assessing these emissions in the context of their costs to society. It is particularly disconcerting that the agency refused to analyze and assess costs using the social cost of carbon protocol, a valid, well-accepted, credible, and interagency endorsed method of calculating the costs of greenhouse gas emissions and understanding the potential significance of such emissions.

The social cost of carbon protocol for assessing climate impacts is a method for "estimat[ing] the economic damages associated with a small increase in carbon dioxide (CO2) emissions, conventionally one metric ton, in a given year [and] represents the value of damages avoided for a small emission reduction (i.e. the benefit of a CO2 reduction)." Exhibit 13 to Guardians' Sept. 11, 2015 Comments. The protocol was developed by a working group consisting of several federal agencies, including the U.S. Department of Agriculture, EPA, CEQ, and others, with the primary aim of implementing Executive Order 12866, which requires that the costs of proposed regulations be taken into account.

In 2009, an Interagency Working Group was formed to develop the protocol and issued final estimates of carbon costs in 2010. These estimates were then revised in 2013 by the Interagency Working Group, which at the time consisted of 13 agencies, including the Department of Agriculture. This report and the social cost of carbon estimates were again revised in 2015. *See* Exhibit 6, Interagency Working Group on Social Cost of Carbon, "Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866" (July 2015), available online at https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf (last accessed Dec. 15, 2015).

Depending on the discount rate and the year during which the carbon emissions are produced, the Interagency Working Group estimates the cost of carbon emissions, and therefore the benefits of reducing carbon emissions, to range from $10 to $212 per metric ton of carbon dioxide. *See* Chart Below. In July 2014, the U.S. Government Accountability Office ("GAO") confirmed that the Interagency Working Group's estimates were based on sound procedures and methodology. *See* Exhibit 19 to Guardians' Sept. 11, 2015 Comments.

Revised Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

Most recent social cost of carbon estimates presented by Interagency Working Group on Social Cost of Carbon. The 95th percentile value is meant to represent "higher-than-expected" impacts from climate change. *See* Exhibit 6 at 3.

Although often utilized in the context of agency rulemakings, the protocol has been recommended for use and has been used in project-level decisions. For instance, the EPA recommended that an EIS prepared by the U.S. Department of State for the proposed Keystone XL oil pipeline include "an estimate of the 'social cost of carbon' associated with potential increases of GHG emissions." Exhibit 17 to Guardians' Sept. 11, 2015 Comments

More importantly, the BLM has also utilized the social cost of carbon protocol in the context of oil and gas leasing. In recent Environmental Assessments for oil and gas leasing in Montana, the agency estimated "the annual SCC [social cost of carbon] associated with potential development on lease sale parcels." Exhibit 2 at 71. In conducting its analysis, the BLM used a "3 percent average discount rate and year 2020 values," presuming social costs of carbon to be $46 per metric ton. *Id.* In Idaho, the BLM also utilized the social cost of carbon protocol to analyze and assess the costs of oil and gas leasing. Using a 3% average discount rate and year 2020 values, the agency estimated the cost of carbon to be $51 per ton of annual CO_2e increase. *See* Exhibit 1 at 81. Based on this estimate, the agency estimated that the total carbon cost of developing 25 wells on five lease parcels to be $3,689,442 annually. *Id.* at 83.

To be certain, the social cost of carbon protocol presents a conservative estimate of economic damages associated with the environmental impacts climate change. As the EPA has noted, the protocol "does not currently include all important [climate change] damages." Exhibit 13 to Guardians' Sept. 11, 2015 Comments. As explained:

> The models used to develop [social cost of carbon] estimates do not currently include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature because of a lack of precise information on the nature of damages and because the science incorporated into these models naturally lags behind the most recent research.

Id. In fact, more recent studies have reported significantly higher carbon costs. For instance, a report published this month found that current estimates for the social cost of carbon should be increased six times for a mid-range value of $220 per ton. *See* Exhibit 15 to Guardians' Sept. 11, 2015 Comments at 2. In spite of uncertainty and likely underestimation of carbon costs, nevertheless, "the SCC is a useful measure to assess the benefits of CO2 reductions," and thus a useful measure to assess the costs of CO2 increases. Exhibit 13 to Guardians' May 25, 2015 EA Comments.

That the economic impacts of climate change, as reflected by an assessment of social cost of carbon, should be a significant consideration in agency decisionmaking, is emphasized by a recent White House report, which warned that delaying carbon reductions would yield significant economic costs. *See* Exhibit 7, Executive Office of the President of the United States, "The Cost of Delaying Action to Stem Climate Change" (July 2014), available online at https://www.whitehouse.gov/sites/default/files/docs/the_cost_of_delaying_action_to_stem_climate_change.pdf (last accessed Dec. 15, 2015). As the report states:

> [D]elaying action to limit the effects of climate change is costly. Because CO_2 accumulates in the atmosphere, delaying action increases CO_2 concentrations. Thus, if a policy delay leads to higher ultimate CO_2 concentrations, that delay produces persistent economic damages that arise from higher temperatures and higher CO_2 concentrations.

> Alternatively, if a delayed policy still aims to hit a given climate target, such as limiting CO_2 concentration to given level, then that delay means that the policy, when implemented, must be more stringent and thus more costly in subsequent years. In either case, delay is costly.

Exhibit 7 at 1.

The requirement to analyze the social cost of carbon is supported by the general requirements of NEPA, specifically supported in federal case law, and by Executive Order 13,514. As explained, NEPA requires agencies to analyze the consequences of proposed agency actions and consider include direct, indirect, and cumulative consequences. In terms of oil and gas leasing, an analysis of site-specific impacts must take place at the lease stage and cannot be deferred until after receiving applications to drill. *See New Mexico ex rel. Richardson v. Bureau of Land Management*, 565 F.3d 683, 717-18 (10th Cir. 2009); *Conner v. Burford,* 848 F.2d 1441 (9th Cir.1988); *Bob Marshall Alliance v. Hodel,* 852 F.2d 1223, 1227 (9th Cir.1988).

To this end, courts have ordered agencies to assess the social cost of carbon pollution, even before a federal protocol for such analysis was adopted. In 2008, the U.S. Court of Appeals for the Ninth Circuit ordered the National Highway Traffic Safety Administration to include a monetized benefit for carbon emissions reductions in an Environmental Assessment prepared under NEPA. *Center for Biological Diversity v. National Highway Traffic Safety Administration*, 538 F.3d 1172, 1203 (9th Cir. 2008). The Highway Traffic Safety Administration had proposed a rule setting corporate average fuel economy standards for light trucks. A number of states and public interest groups challenged the rule for, among other things, failing to monetize the benefits that would accrue from a decision that led to lower carbon dioxide emissions. The Administration had monetized the employment and sales impacts of the proposed action. *Id.* at 1199. The agency argued, however, that valuing the costs of carbon emissions was too uncertain. *Id.* at 1200. The court found this argument to be arbitrary and capricious. *Id.* The court noted that while estimates of the value of carbon emissions reductions occupied a wide range of values, the correct value was certainly not zero. *Id.* It further noted that other benefits, while also uncertain, were monetized by the agency. *Id.* at 1202.

More recently, a federal court has done likewise for a federally approved coal lease. That court began its analysis by recognizing that a monetary cost-benefit analysis is not universally required by NEPA. *See* High *Country Conservation Advocates v. U.S. Forest Service*, ---F. Supp.2d---, 2014 WL 2922751 (D. Colo. 2014), citing 40 C.F.R. § 1502.23. However, when an agency prepares a cost-benefit analysis, "it cannot be misleading." *Id.* at 3 (citations omitted). In that case, the NEPA analysis included a quantification of benefits of the project. However, the quantification of the social cost of carbon, although included in earlier analyses, was omitted in the final NEPA analysis. *Id.* at p. 19. The agencies then relied on the stated benefits of the project to justify project approval. This, the court explained, was arbitrary and capricious. *Id.* Such approval was based on a NEPA analysis with misleading economic assumptions, an approach long disallowed by courts throughout the country. *Id.* at pp. 19-20.

A recent op-ed in the New York Times from Michael Greenstone, the former chief economist for the President's Council of Economic Advisers, confirms that it is appropriate and acceptable to calculate the social cost of carbon when reviewing whether to approve fossil fuel extraction. *See* Exhibit 8, Greenstone, M., "There's a Formula for Deciding When to Extract Fossil Fuels," *New York Times* (Dec. 1, 2015), available online at http://www.nytimes.com/2015/12/02/upshot/theres-a-formula-for-deciding-when-to-extract-fossil-fuels.html?_r=0 (last accessed Dec. 15, 2015).

In light of all this, it appears more than reasonable to have expected the BLM to take into account carbon costs as part of its NEPA analyses. The agency did not. Instead, the BLM rejected the notion that a social cost of carbon analysis was appropriate, implicitly concluding that there would be no cost associated with the proposed oil and gas leasing.

In response to Guardians' comments, the BLM provides various excuses for rejecting addressing the social cost of carbon emissions associated with reasonably foreseeable oil and gas development. Each of these excuses fall flat.

It is first important to point out that the BLM does not deny that social cost of carbon is a valid and useful method to assess climate impacts. Instead, the agency asserts that such an analysis would be "challenging" and "uncertain." DNA, Attachment E at Response to Comments #16. However, the BLM does not get to avoid complying with NEPA because an analysis would be challenging or uncertain.

As to the "challenging" nature of the analysis, calculating the social cost of carbon amounts to a simple multiplication equation. Other BLM Field Offices have been able to complete such simple multiplication equations. We understand that multiplication can at times be challenging, but presume that the Tres Rios Field Office staff have acquired the ability to conduct such mathematical exercises

The BLM also confusingly asserts that analyzing social cost of carbon would lead to an "unbalanced" analysis. DNA, Attachment E at Response to Comments #16. It is unclear what exactly the agency means in making this statement, but it appears the BLM may be asserting that assessing carbon costs would not lead to what it perceives to be an "apples to apples" assessment of costs and benefits. Putting aside the merits of this argument, it is unclear how rejecting conducting any assessment of carbon costs leads to any more of a "balanced" assessment of costs and benefits. Here, in spite of the BLM's concern over balance, the agency only assesses purported economic "benefits" with no mention at all of any costs. By any measure, the current analysis is not balanced because it only represents one side of a cost-benefit analysis. For BLM to assert that assessing carbon costs would somehow skew the outcome of this already one-sided analysis is difficult, if not impossible, to comprehend.

Even if, as the BLM believes, it would not produce an "apples to apples" type of economic assessment, the costs of carbon are still a relevant consideration in the NEPA process. Particularly given that the social cost of carbon protocol is meant to illustrate economic damages, the relevancy of carbon costs appears unquestionable. Rejecting any and all consideration of carbon costs does not resolve any perceived "imbalance" in the NEPA process, but rather it signals that the BLM did not make a well-informed decision.

The fact that the BLM has, in the context of other oil and gas lease sale environmental analyses, clearly acknowledged that social cost of carbon analyses are appropriate, useful, and possible, the refusal of the agency to similarly undertake such analyses in the current context is unsupported under NEPA and cannot stand to support the decision to offer the aforementioned lease parcels for sale and issuance in February 2016.

Sincerely,

Jeremy Nichols
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Ex. 1

BLM

U.S. Department of the Interior
Bureau of Land Management

Environmental Assessment
DOI-BLM-ID-B010-2014-0036-EA

Little Willow Creek
Protective Oil and Gas Leasing

February 10, 2015

U.S. Department of the Interior
Bureau of Land Management
Four Rivers Field Office
3948 Development Avenue
Boise, ID 83705

NATIONAL SYSTEM OF PUBLIC LANDS

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1.0 Introduction

Leasing

The Mining and Minerals Policy Act of 1970 declares that it is the continuing policy of the Federal Government to foster and encourage private enterprise in the development of a stable domestic minerals industry and the orderly and economic development of domestic mineral resources. The Mineral Leasing Act of 1920, as amended, authorizes the Secretary of the Interior to lease federal oil and gas. The Bureau of Land Management (BLM) is the Interior agency delegated the authority to manage the United States' mineral resources. The BLM's oil and gas leasing programs are codified under 43 CFR 3100, in accordance with the authority of the Mineral Leasing Act of 1920, as amended, the Federal Land Policy and Management Act (FLPMA) of 1976, and the Energy Policy Act of 2005.

The decision as to which public lands and minerals are open for leasing and what leasing stipulations may be necessary is made during the land use planning process. Surface management/use for mineral extraction on non-BLM administered land overlaying federal minerals will be determined by the BLM in consultation with the appropriate surface management agency or the private surface owner at the time such surface use is proposed by the leaseholder or designated agent. Under the Mineral Lease Act, issuing oil and gas leases is a discretionary authority conveyed to the Secretary of Interior. In carrying out the mineral leasing authority conveyed through the Mineral Leasing Act, the BLM must comply with other applicable federal laws and regulations, including, but not limited to the Endangered Species Act, the National Historic Preservation Act, the Clean Water Act, the Clean Air Act, and the Energy Policy Act.

Offering federal mineral estate parcels for lease and subsequently issuing oil and gas leases are strictly administrative actions, which, in and of themselves, do not cause or directly result in any surface disturbance. Issuance of an oil and gas lease does convey to the lessee the exclusive right to use as much of the leased land as is reasonably necessary to explore for and extract oil and gas resources from the lease area, subject to the terms of the lease, including stipulations (43 CFR 3101.1-2 and 3101.1-3), regulations pertaining to oil and gas leasing, Onshore Orders, and with prior approval of the Authorized Officer. However, depending on lease stipulations, post-leasing activities may or may not result in impacts to surface resources. Only where stipulations or conditions do not preclude disturbance to surface resources is the action considered an irretrievable commitment of resources. The BLM may issue leases to protect the public interest when uncompensated drainage is occurring or may occur, provided the lease does not convey an irreversible or irretrievable commitment of resources.

As part of the lease issuance process, nominated parcels are reviewed against the appropriate land use plan, and stipulations are attached to mitigate any known environmental or resource conflicts that may occur on a given lease parcel. As stated above, on-the-ground impacts would potentially occur when a lessee applies for and receives approval to explore, occupy and/or drill on the lease. The BLM cannot determine at the leasing stage whether or not a lease would actually be explored or developed.

Oil and gas leases are issued for a 10-year period and continue for so long thereafter as oil or gas is produced in paying quantities. If a lessee fails to produce oil and/or gas, does not make annual rental payments, does not comply with the terms and conditions of the lease, or relinquishes the lease, then ownership of the minerals leased revert back to the federal government and may be offered for lease again. Drilling wells on a lease is not permitted until the lessee or operator secures BLM's approval of a drilling permit and a surface use plan as specified in 43 CFR 3162.3-1 (Drilling applications and plans) and submits a reclamation bond. Subsequent well operations, such as re-drilling, deepening, repairing casing, plugging-back, performing non-routine fracturing jobs, etc. also require the prior approval of the authorized officer (43 CFR 3162.3-2).

Leasing in the Four Rivers Field Office

While parcels totaling over 180,000 acres of federal land in southwest Idaho have been nominated for competitive oil and gas leasing, BLM has to-date deferred leasing any lands until completion of the Four Rivers Resource Management Plan/EIS (FRMP). Currently, there are no federal oil and gas leases in the field office. The FRMP will replace the 1987 Cascade RMP which currently addresses leasing in the western portion of the Four Rivers Field Office. BLM is considering leasing in this isolated circumstance because of the federal mineral reserve drainage that may occur existing wells are put into production in sections with federal minerals in the Willow Field or on private lands in the proposed leasing area.

There are currently 15 wells that have been drilled on private or State leases in and/or near the Willow and Hamilton Fields and are capable of production, and three wells that have been approved but haven't been drilled. Four existing wells and two proposed wells are within 0.5 miles of federal mineral resources. Several of the wells are located in sections with federal mineral estate (Map 1). The existing wells are classified as "shut in pending a pipeline" indicating that they are capable of production.

The BLM determined the boundary of the proposed leasing area by including all lands with federal minerals in the industry-designated Willow Field, as well as those lands with federal minerals located in sections that are within one mile of a well that has been drilled or permitted. Only the lands with federal minerals would be leased within the proposed leasing area boundary. There are no lands with federal minerals in the Hamilton Field.

In November 2013, Alta Mesa Services, Inc., a company that is currently developing a newly discovered natural gas field, made application to the Idaho Oil and Gas Conservation Commission (IOGCC) to omit federal lands in T. 8 N., R. 4 W., Section 3, from a drilling unit it proposed in Section 3. If the federal minerals are omitted from the drilling unit and a producing well is drilled on the private lands (with private minerals) in Section 3, drainage of the federal mineral estate could occur. The opportunity to recover the underlying resource would be lost, and the federal government, acting on behalf of the American taxpayer, would be unable to collect royalties on the extracted mineral resources.

Leasing would protect the American taxpayers' correlative rights, and production royalties could be collected. The BLM considers Alta Mesa's application to the IOGCC to be evidence of potential drainage in Section 3. Lands that are otherwise unavailable for leasing may be leased if there is an imminent threat of drainage [see 43 CFR 3120.1-1(d)]. Because of this threat and the likelihood of IOGCC receiving more applications to omit the federal mineral estate in sections where wells have been drilled or proposed, BLM is considering leasing the federal mineral estate within this limited area at this time.

1.1 Need for and Purpose of Action

The purpose of this proposal is to protect the federal mineral resource from uncompensated drainage, and surface resources from potential damage, in and near the Willow Field, Payette County, Idaho. Drainage is defined as the migration of oil and gas in an underground reservoir, due to a pressure reduction caused by production from wells bottomed in the reservoir. Because oil and gas are fluids, they can flow underground across property boundaries. Subsurface (i.e. mineral) ownership boundaries are the same as those upon the surface, projected downward to the center of the earth. Sub-surface mineral rights in the U.S. generally belong to the owner of the surface land, unless they have been severed from the surface. According to an old common law concept termed the rule of capture, the first person to gain control over the resource (by extracting the resource from the ground) gains exclusive ownership over that resource. In this way, an operator may permissibly extract, or drain, oil and gas from beneath the land of another, if the extraction is lawfully conducted on his own property. The rule of capture gives land owners an incentive to pump out oil as quickly as possible by speeding up their operations or drilling multiple, closely spaced wells to capture, or drain, the oil or gas resource of their neighbors. Very dense drilling can result in dissipation of the pressure within a reservoir, and therefore incomplete extraction of the resource.

To mitigate this danger, many state governments have sought to supersede the rule of capture with conservation acts that enforce prorationing, pooling, and limits on density of drilling, to avoid physical waste, ensure maximum ultimate recovery, and to protect the correlative rights of neighboring owners. The correlative rights doctrine is a legal doctrine limiting the rights of landowners to an oil or gas reservoir to a reasonable share, based on the amount of land owned by each on the surface above. Correlative rights concepts such as pooling and unitization replace the rule of capture in those states that have them, thereby protecting the rights of mineral estate owners from drainage.

Uncompensated drainage means that federal mineral resources are being produced by wells on adjacent lands without compensation to the United States in the form of royalties that would otherwise be required if the federal mineral estate were leased under the Mineral Leasing Act, as amended. A prime responsibility of the BLM is to protect the United States from the loss of royalty that results from drainage (uncompensated drainage). For unleased lands, the objectives of BLM's drainage protection program may be accomplished by leasing and requiring the lessee to take protective measures to prevent uncompensated drainage of oil or gas from the lease.

This action is needed because natural gas wells have been or are proposed to be drilled on private land adjacent to BLM-administered lands and/or adjacent to lands where BLM owns only the subsurface mineral estate (referred to as split estate). The current and proposed wells in and north of the Willow Field constitute a threat, or potential threat, of uncompensated drainage to the federal mineral estate. Drilling has resulted in the discovery of commercial quantities of natural gas and natural gas condensate in the Willow and Hamilton fields, and those areas are being developed for commercial production. According to the current Idaho well spacing order, only one well can be drilled per 640-acre governmental section (IDAPA 20.07.02.330.02; IOGCC 2013a). The Idaho Department of Lands has approved drilling permit applications for several wells on private lands which would drain minerals reserved to the United States within the well spacing unit designated by the State of Idaho (IOGCC 2014).

In a September 4, 2014 IOGCC hearing, the commission voted 4-1 to reconsider a request by Alta Mesa to omit federal mineral resources. If federal minerals are omitted from a drilling unit, BLM would be unable to collect the royalties it is due for its proportionate share of production from the drilling unit; therefore, the BLM considers these resources threatened by uncompensated drainage. While 43 CFR 3162.2-2 offers several protective measures BLM may take to avoid uncompensated drainage on unleased lands besides leasing, they require the cooperation of the owner-of-interest in the producing well. BLM has offered several times to enter into a communitization or compensatory royalty agreement; however. Alta Mesa has refused to do so, leaving leasing as the only alternative to address drainage.

1.2 Decision to Be Made

The responsible official will decide whether to recommend that the BLM Idaho State Office offer lands in the proposed lease area and which, if any, stipulations and/or notices should be attached to the leases.

1.3 Summary of Proposed Action

The BLM proposes to offer five parcels (totaling 6,349 acres; Map 2) at a spring 2015 competitive oil and gas lease sale. Stipulations and lease notices would apply on BLM-administered surface and subsurface in the lease area. The offering and subsequent issuance of oil and gas leases is strictly an administrative action, which, in and of itself, would not cause or directly result in any surface disturbance.

1.4 Location and Setting

The proposed 15,644-acre Little Willow Creek oil and gas lease area is located 4-12 miles east of Payette, Idaho (Map 1). The topography is characterized by gently rolling hills. Vegetation is dominated by annual and perennial grass with occasional shrub stands. Rural homes and agricultural fields are primarily associated with Little Willow Creek.

In the proposed lease area, only 6% of surface lands are BLM-administered and the remaining are privately owned; however, the BLM administers 41% of the subsurface mineral estate. Two oil and gas fields to the south have been designated by oil and gas developers. The Willow Field overlies a portion of the Little Willow Creek proposed lease area and currently has eight oil and gas wells. Further south, the Hamilton Field has six wells. Most wells in the area are classified as shut in pending a pipeline (IOGCC 2014).

1.5 Conformance with Applicable Land Use Plan

Leasing is in conformance with the 1988 Cascade Resource Management Plan (CRMP) which makes 456,289 acres (94% of area) available for leasable mineral exploration and development (CRMP Record of Decision page 3). The proposed lease parcels are within the area determined available for leasable mineral exploration and development. The CRMP directs the BLM to manage geological, energy, and minerals resources on the public lands so that significant scientific, recreational, ecological and educational values will be maintained or enhanced. Generally, the public lands are available for mineral exploration and development, subject to applicable regulations and Federal and State laws. The CRMP states that: "Approval of an application for lease is subject to an environmental analysis and may include stipulations to protect other resources." Additional NEPA documentation is needed prior to leasing to address new circumstances or information bearing on the environmental consequences of leasing that was not considered within the broad scope analyzed in the CRMP Environmental Impact Statement.

1.6 Relationship to Statutes, Regulations, and Other Requirements

This EA was prepared in accordance with the National Environmental Policy Act of 1969 (NEPA) and in compliance with all applicable laws and regulations, including Council on Environmental Quality (CEQ) regulations (40 CFR Parts 1500-1508), U.S. Department of the Interior (DOI) requirements (Department Manual 516, Environmental Quality), and/or other federal statutes and executive orders.

Other applicable Federal laws to which the lessee must comply include but are not limited to, the following:

<u>Leasable Minerals</u>

It is BLM policy, as derived from various laws, including the Mineral Leasing Act of 1920 (MLA) and the Federal Land Policy and Management Act of 1976 (FLPMA), to make mineral resources available for disposal and to encourage development of mineral resources to meet national, regional, and local needs. Ensuring that the federal mineral estate is protected from uncompensated drainage of fluid mineral resources is a basic BLM function. 43 CFR 3100.2-1 states "Upon a determination by the authorized officer that lands owned by the U.S. are being drained of oil or gas by wells drilled on adjacent lands . . . Such lands may also be offered for lease in accordance with part 3120 of this title." 43 CFR 3120.1-1 states that "All lands available for leasing shall be offered for competitive bidding under this subpart, including but not limited to . . . (d) Lands which are otherwise unavailable for leasing but which are subject to drainage (protective leasing)."

Any purchaser of a federal oil and gas lease is required to comply with all applicable federal, state, and local laws and regulations, including obtaining all necessary permits required prior to the commencement of project activities.

Environmental Quality

Clean Water Act of 1972 (33 U.S.C. §1251 et seq.): Regulates surface water discharges and storm-water runoff. Section 313 requires federal agencies be in compliance with all federal, state, interstate, and local requirements. In Idaho, the Idaho Department of Environmental Quality (IDEQ) implements the Clean Water Act. Additionally, the IDEQ develops total maximum daily loads (TMDLs) for water bodies.

Safe Drinking Water Act of 1974 as amended: Authorizes the U.S. Environmental Protection Agency (EPA) to set national health-based standards for drinking water to protect against both naturally-occurring and man-made contaminants that may be found in drinking water. The EPA, IDEQ, and others work together to make sure that the standards are met.

Clean Air Act of 1970 as amended (42 U.S.C. §7401 et seq.): Sets rules for air emissions from engines, gas processing equipment and other sources associated with drilling and production activities.

Special Status Species

Endangered Species Act (ESA) of 1973 as amended (16 USC 1531): Section 7 of the ESA outlines the procedure for federal interagency cooperation to conserve federally listed species and their designated habitats. Section 7(a) (2) of the ESA states that each federal agency shall, in consultation with Secretary, ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of a listed species' habitat within the project area.

Special Status Species Management Manual for the Bureau of Land Management (BLM Manual 6840): National policy directs BLM State Directors to designate sensitive species in cooperation with the state fish and wildlife agency. This manual establishes policy for management of species listed or proposed for listing pursuant to the ESA and Bureau sensitive species that are found on BLM-administered lands; this policy is to conserve and to mitigate adverse impacts to sensitive species and their habitats. Where relevant to the activities associated with this action, effects to special status species are analyzed in this EA.

Migratory Bird Treaty Act, *Executive Order 13186*, and *BLM Memorandum of Understanding WO-230-2010-04* (between BLM and US Fish and Wildlife Service [USFWS]): Federal agencies are required to evaluate the effects of proposed actions on migratory birds (including eagles) pursuant to the *National Environmental Policy Act of 1969* (NEPA) "or other established environmental review process;" and restore and enhance the habitat of migratory birds, as practicable. Federal agencies are also required to identify where unintentional take reasonably attributable to agency actions is having, or is likely to have, a measurable negative effect on migratory bird populations. With respect to those actions so identified, the agency shall develop and use principles, standards, and practices that will lessen the amount of unintentional take, developing any such conservation efforts in cooperation with the Service. Effects to migratory birds are analyzed in this EA.

Bald and Golden Eagle Protection Act of 1940 as amended (16 USC 668-668d): This act provides for the protection of bald and golden eagles by prohibiting, except under certain specified conditions, the taking, possession and commerce of such birds. Agencies are required to evaluate: 1) whether take is likely to occur from activities associated with the proposed activity and 2) the direct, indirect, and cumulative impacts the proposal may have on the ability to meet the preservation standard of the Act that the USFWS has interpreted to mean "compatible with the goal of stable or increasing breeding populations." Effects to bald and golden eagles are analyzed in this EA.

Cultural Resources

Idaho BLM has the responsibility to manage cultural resources on public lands pursuant to the National Historic Preservation Act of 1966 (as amended), the 2012 Programmatic Agreement Among the Bureau of Land Management, the Advisory Council on Historic Preservation, and the National Conference of State Historic Preservation Officers and the State Protocol Agreement Between the Idaho State Director of the BLM and the Idaho State Historic Preservation Officer (1998) and other internal policies.

Social and Economic

Executive Order 12898 (February 1994): Federal agencies are directed to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations," including tribal populations. The accompanying Presidential Memorandum emphasizes the importance of using the NEPA review process to promote environmental justice.

1.7 Scoping and Development of Issues

Scoping

BLM began scoping for the Little Willow Creek lease sale on July 8, 2014 when the Four Rivers Field Manager sent a scoping packet and/or letter to all land owners with property in or adjacent to the Little Willow Creek proposed lease area and to the Four Rivers Field Office's interested public mailing list seeking scoping comments on the lease proposal. BLM also activated a web page on the BLM NEPA Register to make scoping and informational materials available to the public. The webpage can be reviewed at: https://www.blm.gov/epl-front-office/eplanning/planAndProjectSite.do?methodName=renderDefaultPlanOrProjectSite&projectId=39064&dctmId=0b0003e8806d22d8.

On Thursday July 17, 2014 the BLM hosted a public meeting at the Payette County Courthouse. BLM answered questions and accepted comments at the meeting and provided an address and website to send in additional scoping comments about the proposed leasing. Approximately 45 people attended the meeting and 12 individuals and organizations provided scoping comments. Many of the issues were outside the scope of the leasing decision. The public was primarily concerned with drilling which would be analyzed in a subsequent NEPA document if an Application for Permit to Drill (APD) is received by BLM (Appendix 1). The intent of BLMs scoping effort was to identify issues related to the proposed leasing.

Issues Development
Issues may be defined as a point or matter of discussion, debate, or dispute about a proposed action based on the potential environmental effects (BLM Handbook H-1790-1). Issues are concerns directly or indirectly caused by implementing the proposed action; these are used to develop alternatives to the proposed action. Relevant public comments and issues were used in the development of this EA, including those received in response to the Scoping Document mailed July 8, 2014. Comments not considered issues to analyze in this EA are ones that are: 1) outside the scope of the proposed action and thus irrelevant to the decision being made; 2) already decided by law, regulation, RMP, or other higher level decision; 3) conjectural and not supported by scientific or factual evidence; or 4) not necessary for making an informed decision. The following issues were identified from comments and scoping letters received during the scoping effort:

1. Leasing could indirectly impact air quality in the proposed lease area if exploration and development occur.
2. Leasing could indirectly impact water quality in the proposed lease area if exploration and development occur.
3. Leasing could indirectly pollute ground water in the proposed lease area if exploration and development wells require hydraulic fracturing (fracking).
4. Leasing could indirectly impact sensitive plant species in the proposed lease area if exploration and development occur.
5. Leasing could indirectly impact sensitive wildlife species in the proposed lease area if exploration and development occur.

These issues are addressed in Section 3.0. Although development in the Willow and Hamilton fields has not indicated the need for substantial fracking (Johnson et. al. 2013), the issue is addressed primarily in Water Resources (Section 3.5). The IDT also analyzed the indirect effects of leasing on the following resources: soils, vegetation, cultural resources, recreation, visual resources, lands and realty, livestock management, minerals, and social and economics.

2.0 Description of the Alternatives

2.1 Alternative A - No Federal Mineral Estate Leasing/Continue Present Management

The federal mineral estate in a 15,644 acre area in Payette County, including 996.85 (997) acres of BLM-administered lands and 5,352.35 (5,352) acres of split estate, would not be offered for lease. Development of State and private leases could occur in the area; however, the federal mineral estate would not be available at least until the FRMP is completed. State (Appendix 2) or other stipulations developed by the lessor and lessee would apply to other leases.

2.2 Alternative B – Leasing Federal Mineral Estate with No Surface or Subsurface Occupancy Stipulations

The federal mineral estate in a 15,644 acre area in Payette County, including 997 acres of BLM-administered lands and 5,352 acres of split estate, would be offered for lease in up to five parcels[A] (Table 1, Map 2, Appendix 3).

Table 1. Mineral estate acreages by parcel, surface, and subsurface ownership, proposed Little Willow Creek oil and gas leasing area, Payette County, Idaho.

Parcel	Federal Mineral Estate[1]			Other Mineral Estate[2]		Total
	Federal/Federal	Private/Federal	Total	Private/Private	Private/State	
A	212	1,536	1,748	3,811	0	5,549
B	237	312	549	1,353	0	1,903
C	235	1,140	1,374	1,142	0	2,516
D	274	1,311	1,585	1,186	394	3,165
E	39	1,052	1,091	1,313	98	2,502
Total	997	5,352	6,349	8,799	492	15,644

[1]Acreages presented in this table and throughout the document are rounded to the nearest acre. More accurate figures would be developed if a lease is offered.
[2] The BLM has no control over these resources. The values are provided strictly for informational purposes.

The following stipulations would apply to the federal mineral estate:

No Surface Occupancy (NSO) – 1: Surface occupancy and use on BLM-administered and split estate lands would be prohibited until the Four Rivers Resource Management Plan (FRMP) is finalized.

No Sub-surface Occupancy (NSSO) – 1: Subsurface occupancy and use on federal mineral estate lands would be prohibited until the FRMP is finalized.

Upon finalization of the FRMP, the leases would be modified by replacing NSO-1 and NSSO-1 with stipulations consistent with the FRMP. Development of State and private leases would be as described in Section 2.1; however, drainage of the federal mineral estate would be allowed and typical royalties would be applied.

[A] Because an oil and gas lease cannot be larger than 2,560 acres (43 CFR 3120.2-3), the 6,352-acre federal mineral estate was divided into smaller parcels. BLM has the discretion to parcel the lands in any configuration. During public scoping, at least one split estate land owner expressed a desire to bid on parcels to which he/she owns the surface estate. BLM has addressed the land owner's concern by making the leases smaller, and by dividing the federal mineral estate in a manner that minimizes the number of split estate landowners on a single lease (the only exception to this is Parcel A, which has multiple split estate landowners, but lies entirely within the industry-designated Willow Field).

2.3 Alternative C - Leasing Federal Mineral Estate with Cascade RMP Stipulations and Additional Lease Notices

The federal mineral estate in a 15,644 acre area in Payette County, including 997 of BLM-administered lands and 5,352 acres of split estate, would be offered for lease in up to five parcels (Table 1, Map 2, Appendix 3). The leases would be subject to standard lease terms and the following stipulations associated with listed species (S-1) and cultural resources (S-2), applicable CRMP stipulations, and lease notices. Lease notices were developed for sensitive resources that were not addressed in the CRMP. Development of State and other leases would be as described in Section 2.1. The following stipulations and lease notices would apply where appropriate (Appendix 3):

Freshwater Aquatic Habitat

Controlled Surface Use (CSU) -1: Surface occupancy and use would be prohibited within 500 feet from the edge of reservoirs, ponds, streams, wetlands, and riparian habitat. Introduction of chemical toxicants or sediments to riparian areas as a result of exploration or production would not be allowed.

CSU-2: A minimum 100 foot riparian buffer zone would be provided from the edge of any riparian habitat to protect riparian vegetation, fisheries, and water quality. The following activities would be generally excluded: new road construction that parallels streams. Best management practices would be used when construction cannot be avoided.

Special Status Plant Species

CSU-3: Occupancy and use, including surface and subsurface rights-of-way, would be prohibited in Type 1-4 special status plant element occurrences.

Big Game Range[B]

CSU-4: No surface use would be allowed in crucial winter range from November 15 to May 15 or crucial antelope fawning range between May 1 and June 30.

Sensitive Wildlife Species

CSU-5: No surface use would be allowed within a 0.75 mile radius of ferruginous hawk or Swainson's hawk nests from March 15 to June 30.

CSU-6: No surface use would be allowed within a 0.75 mile radius of an osprey nest from April 15 to August 31.

CSU-7: No surface use would be allowed within a 0.25 mile radius of a burrowing owl nest from March 15 to June 30.

[B] From the CRMP: "Those areas where big game animals have demonstrated a definite pattern of use each year or an area where animals tend to concentrate in significant numbers (from Interagency Guidelines for Big Game Range Investigation-Idaho Department of Fish & Game, Bureau of Land Management, U.S. Forest Service)." For the purposes of this action, the BLM worked in cooperation with IDFG to delineate winter ranges using current animal distribution data.

Wildlife Species of Concern

CSU-8: No surface use would be allowed within a 0.75 mile radius of a golden eagle nest from February 1 to June 30.

CSU-9: No surface use would be allowed within a 0.75 mile radius of a prairie falcon nest from March 15 to June 30.

CSU-10: No surface occupancy would be allowed within a 0.5 mile radius of a heron rookery.

Fragile Soils

Lease Notice (LN) -1: The lessee is hereby notified that special location, design and construction mitigation measures may be required to minimize, to the extent possible, the potential long-term and short-term adverse impacts of oil and gas operations within fragile soils, and to avoid them wherever there is a practicable alternative.

Fragile soil areas, in which the performance objective would be enforced, are defined as follows:

1) Areas rated as highly or severely erodible by wind or water, as described by the National Cooperative Soil Survey for Payette County or as described by on-site inspection.
2) Areas with slopes ≥30%, if they also have one of the following soil characteristics:
    a. a surface texture that is sand, loamy sand, very fine sandy loam, fine sandy loam, silty clay or clay;
    b. a depth to bedrock <20 inches;
    c. an erosion condition that is rated as poor; or
    d. a K-factor >0.32.

Floodplain Management

LN-2: The lessee is hereby notified that special location, design and construction mitigation measures may be required to minimize, to the extent possible, the potential long-term and short-term adverse impacts of oil and gas operations within the 100-year floodplain associated with occupancy and modification of the floodplain, and to avoid direct and indirect floodplain development wherever there is a practicable alternative. Under Executive Order 11988: Floodplain Management; the BLM is required to restore and preserve the natural and beneficial values served by floodplains for actions related to federal activities and programs affecting land use.

Endangered Species (Mandatory)

Stipulation (S) –1: The lease area may now or hereafter contain plants, animals, or their habitats determined to be threatened, endangered, or other special status species. BLM may recommend modifications to exploration and development proposals to further its conservation and management objective to avoid BLM-approved activity that will contribute to a need to list such a species or their habitat. BLM may require modifications to or disapprove proposed activity that is likely to result in jeopardy to the continued existence of a proposed or listed threatened or endangered species or result in the destruction or adverse modification of a designated or proposed critical habitat. BLM will not approve any ground-disturbing activity that may affect any such species or critical habitat until it completes its obligations under applicable requirements of the Endangered Species Act as amended, 16 U.S.C. § 1531 et seq., including completion of any required procedure for conference or consultation.

Special Status Mammals

LN-3: The lease may, in part or in total, contain important southern Idaho ground squirrel (SIDGS), a candidate species, and pygmy rabbit habitats as identified by the BLM, either currently or prospectively. The operator may be required to implement specific measures to reduce impacts of oil and gas operations on SIDGS populations and habitat quality. Such measures shall be developed during the application for permit to drill on-site and environmental review process and will be consistent with the lease rights granted. Measures may include (in order of priority):

1. Avoid areas occupied by SIDGS and pygmy rabbits.
2. When oil and gas facilities are deemed necessary within unoccupied SIDGS or pygmy rabbit habitat, minimize pad size, road width, and the size of other disturbed areas.
3. New construction of roads, pipelines, and rights-of-way would be planned to minimize the effects of fragmenting wildlife habitat.
4. Restore unneeded areas to native or other appropriate vegetation (shrubs, perennial grasses, and forbs as identified by the SIDGS Working Group) immediately upon vacancy of temporary use sites or permanent closure of well sites to provide forage for nearby SIDGS.
5. Construct power transmission lines outside of SIDGS occupied habitat (including a 0.25-mile buffer) whenever possible. If transmission lines are deemed necessary through or within 0.25 miles of SIDGS colonies, locate poles outside of active burrow systems and consider 1) burying transmission lines, or 2) installing raptor anti-perching devices on transmission lines.

Migratory Birds and Raptors

LN-4: The Operator is responsible for compliance with provisions of the Migratory Bird Treaty Act by implementing one of the following measures: a) avoidance by timing - ground disturbing activities would not occur from April 15 to July 15; b) habitat manipulation - render proposed project footprints unsuitable for nesting prior to the arrival of migratory birds (blading or pre-clearing vegetation must occur prior to April 15 within the year and area scheduled for activities between April 15 and July 15 of that year to deter nesting; or c) survey-buffer-monitor surveys would be conducted by a BLM approved biologist within the area of the proposed action and a 300 foot buffer from the proposed project footprint between April 15 to July 15 if activities are proposed within this timeframe. If nesting birds are found, activities would not be allowed within 0.1 miles of nests until after the birds have fledged. If active nests are not found, construction activities must occur within 7 days of the survey. If this does not occur, new surveys must be conducted. Survey reports would be submitted to the appropriate BLM Office.

CSU-11: No surface occupancy would be allowed within 1 mile of an active bald eagle or peregrine falcon nest. No surface use would be allowed from December 1 and March 31 where wintering bald eagles or peregrine falcons occur.

Water Quality

LN-5: The operator may be required to implement specific measures to reduce impacts of oil and gas operations on water quality and quantity. Such measures shall be developed during the application for permit to drill on-site and environmental review process and will be consistent with the lease rights granted.

Cultural Resources (Mandatory)

S-2: This lease may be found to contain historic properties and/or resources protected under the National Historic Preservation Act (NHPA), American Indian Religious Freedom Act, Native American Graves Protection and Repatriation Act, E.O. 13007, or other statutes and executive orders. The BLM would not approve any ground disturbing activities that may affect any such properties or resources until it completes its obligations under applicable requirements of the NHP A and other authorities. These obligations may include a requirement that you provide a cultural resources survey conducted by a professional archaeologist approved by the State Historic Preservation Office (SHPO). If currently unknown burial sites are discovered during development activities associated with this lease, these activities must cease immediately, applicable law on unknown burials will be followed and, if necessary, consultation with the appropriate tribe/group of federally recognized Native Americans will take place. The BLM may require modification to exploration or development proposals to protect such properties, or disapprove any activity that is likely to result in adverse effects that cannot be successfully avoided, minimized or mitigated.

LN-6: The Surface Management Agency is responsible for assuring that the leased lands are examined to determine if cultural resources are present and to specify mitigation measures.

Lands and Realty

LN-7: Land Use Authorizations incorporate specific surface land uses allowed on BLM-administered lands by authorized officers and those surface uses acquired by BLM on lands administered by other entities. These BLM authorizations include rights-of-way, leases, permits, conservation easements, and recreation and public purpose leases and patents.

Paleontological Resources

CSU-12: No surface occupancy would be allowed on sites with known paleontological values. Surface rights-of-way would be routed to avoid paleontological resources.

LN-7: This lease has is located in geologic units rated as being moderate to very high potential for containing significant paleontological resources. The locations meet the criteria for Class 3, 4 and/or 5 as set forth in the Potential Fossil Yield Classification System, WO IM 2008-009, Attachment 2-2. The BLM is responsible for assuring that the leased lands are examined to determine if paleontological resources are present and to specify mitigation measures. Guidance for application of this requirement can be found in WO IM 2008-009 dated October 15, 2007, and WO IM 2009-011 dated October 10, 2008. Prior to undertaking any surface-disturbing activities on the lands covered by this lease, the lessee or project proponent shall contact the BLM to determine if a paleontological resource inventory is required. If an inventory is required, the lessee or project proponent will complete the inventory subject to the following:

- The project proponent must engage the services of a qualified paleontologist, acceptable to the BLM, to conduct the inventory.
- The project proponent will, at a minimum, inventory a 10-acre area or larger to incorporate possible project relocation which may result from environmental or other resource considerations.

A paleontological inventory may identify resources that may require mitigation to the satisfaction of the BLM as directed by WO IM 2009-011 including possible project relocation which may result from environmental or other resource considerations.

2.4 Additional Considerations for Alternatives B-C

For split estate portions of the lease area, the BLM provided courtesy notification to private landowners that their lands are considered in this NEPA analysis and would be considered for inclusion in an upcoming lease sale. If any activity were to occur on such split estate parcels, the lessee and/or operator would be responsible for adhering to BLM requirements as well as formulating and reaching an agreement with the private surface landowners regarding access, surface disturbance, and reclamation (Onshore Oil and Gas Order No. 1). Standard lease terms, stipulations, conditions, and operating procedures would apply to these parcels (43 CFR 3101 and 3160 and 3162).

Standard operating procedures, best management practices, conditions of approval (COA), and lease stipulations could change over time to meet overall RMP and BLM policy objectives. The COA's would be attached to permits for oil and gas lease operations to address site-specific concerns or new information not previously identified in this environmental assessment process. In some cases new lease stipulations may need to be developed, and these types of changes may require an RMP amendment. For example, if climate change results in hotter and drier conditions, RMP objectives would be unreachable under current management. In this situation, management practices might need to be modified to continue meeting overall RMP management objectives. An example of a climate related modification is the imposition of additional conditions of approval to reduce surface disturbance and implement more aggressive dust treatment measures. Both actions reduce fugitive dust, which would otherwise be exacerbated by the increasingly arid conditions that could be associated with climate change.

Oil and gas leases would be issued for a 10-year period and would continue for as long thereafter as oil or gas is produced in paying quantities. If a lessee fails to produce oil and gas, does not make annual rental payments, does not comply with the terms and conditions of the lease, or relinquishes the lease, ownership of the minerals leased would revert back to the federal government, and the lease could be resold.

Well drilling on a lease would not be permitted until the lease owner or operator secures approval of a drilling permit and a surface use plan specified at 43 CFR 3162.

Drainage

LN-A: Parts of this lease may potentially be subject to drainage by wells located on adjacent private lands. The lessee shall, within 6 months of the drilling and completion of any productive well on the adjacent private lands, submit for approval by the authorized officer:

1. Plans for protecting the lease from drainage (43 CFR § 3162.2-3). The plan must include either (a) a completed Application for Permit to Drill for each of the necessary protective wells, or (b) a proposal for inclusion in a unitization or communitization agreement for the affected portion of the lease. Any agreement should provide for an appropriate share of the production from the offending well to be allocated to the lease; or
2. Engineering, geologic and economic data to demonstrate to the authorized officer's satisfaction that no drainage has occurred or is occurring and/or that a new protective well(s) would have little or no chance of production sufficient to yield a reasonable rate of return in excess of the costs of drilling, completing and operating the well.

If no plan, agreement, or data is submitted and drainage is determined to be occurring, compensatory royalty will be assessed. Compensatory royalty will be assessed on the first day following expiration of the 6-month period, and shall continue until a protective well has been drilled and placed into production status, or until the offending well ceases production, whichever occurs first. The lessee shall be obligated to pay compensatory royalty to the Office of Natural Resources Revenue (ONRR) at a rate to be determined by the BLM authorized officer.

Split Estate

LN-B: Portions of the surface estate of this lease are privately owned (i.e. split estate lands). While the Federal mineral lessee has the right to enter the property for necessary purposes related to lease development, the lessee is responsible for making arrangements, formalized in a Surface Use Agreement, with the surface owner prior to entry upon the lands. Lessee is hereby informed that the United States will not participate as a third party in negotiations between the lessee and the surface owner. Any agreement reached between the lessee and the surface owner(s) will not be binding on the United States.

Prior to submitting an Application for Permit to Drill (APD) for BLM's approval, lessee is required to submit the name, address, and phone number of the surface owner, if known, in its APD. The lessee must also make a good faith effort to provide a copy of their Surface Use Plan of Operations to the surface owner. After the APD is approved, the operator must make a good faith effort to provide a copy of the Conditions of Approval to the surface owner.

The lessee will be required to certify to the BLM in writing that: (1) It made a good faith effort to notify the surface owner before entry; and (2) That a Surface Use Agreement with the surface owner has been reached, or that a good faith effort to reach an agreement failed. If no agreement can be reached with the surface owner, the lessee must submit an adequate bond (minimum of $1,000) to the BLM, for the benefit of the surface owner, sufficient to pay for loss or damages. The surface owner has the right to appeal the sufficiency of the bond.

Once a parcel is leased, the lessee has the right to explore for and develop oil and gas resources, subject to standard lease terms and special stipulations pertaining to the conduct of operations. The conduct of operations by the lessee on all parcels would be subject to the following terms from the back of the standard lease form, which state:

"Conduct of Operations (SF-3100-11, Section 6)

Lessee shall conduct operations in a manner that minimizes adverse impacts to the land, air, and water, to cultural, biological and other resources, and to uses or users. Lessee shall take reasonable measures deemed necessary by the lessor to accomplish the intent of this section. To the extent consistent with lease rights granted, such measures may include, but not limited to, modification to siting or design of facilities, timing of operations, and specification of interim and final reclamation measures. Lessor reserves the right to continue existing uses and to authorize future uses upon or in leased lands, including the approval of easements or right-of-way. Such uses shall be conditioned so as to prevent unnecessary or unreasonable interference with rights of lessee.

Prior to disturbing the surface of the leased lands, lessee shall contact lessor to be apprised of procedures to be followed and modifications or reclamation measures that may be necessary. Areas to be disturbed may require inventories or special studies to determine the extent of impacts to other resources. Lessee may be required to complete minor inventories or short-term special studies under guidelines provided by lessor. If in the conduct of operations, threatened or endangered species, objects of historic or scientific interest, or substantial unanticipated environmental effects are observed, lessee shall immediately contact lessor. Lessee shall cease any operations that would result in destruction of such species or objects."

3.0 Affected Environment and Environmental Consequences

3.1 Introduction

Direct and indirect impacts of the proposed actions will be discussed for BLM-administered and split estate lands. Cumulative impacts for other activities will be discussed for all ownerships in the cumulative impacts analysis area. Analyses will be based on the RFDS created for this document (Table 2, Section 3.1.2, and Appendix 1)

Impact Descriptors

Effects can be temporary (short-term) or long lasting/permanent (long-term). These terms may vary somewhat depending on the resource; therefore, each will be quantified by resource where applicable. Generally speaking:

- **Short-term**: 0-3 years (effects are changes to the environment during and following ground-disturbing activities that revert to pre-disturbance conditions, or nearly so, immediately to within a few years following the disturbance).
- **Long-term**: >3 years (effects are those that would remain beyond short-term ground disturbing activities).

The magnitude of potential effects is described as being major, moderate, minor, negligible, or no effect and is interpreted as follows:

- **Major** effects have the potential to cause substantial change or stress to an environmental resource or resource use. Effects generally would be long-term and/or extend over a wide area.
- **Moderate** effects are apparent and/or would be detectable by casual observers, ranging from insubstantial to substantial. Potential changes to or effects on the resource or resource use would generally be localized and short-term.
- **Minor** effects could be slight but detectable and/or would result in small but measurable changes to an environmental resource or resource use.
- **Negligible** effects have the potential to cause an indiscernible and insignificant change or stress to an environmental resource or use.
- **No effect** = no discernible effect.

3.1.1 General Discussion of Impacts

The act of leasing parcels, itself, does not affect resources. If the proposed parcels are leased, it remains unknown whether development would actually occur, and if so, where specific wells would be drilled and where facilities would be placed. This would not be determined until the BLM receives an application for permit to drill (APD) in which detailed information about proposed wells and facilities would be provided for particular leases. Therefore, this EA discusses potential effects that could occur in the event of development. The amount of development is based on potential well densities and associated activities described in a Reasonably Foreseeable Development Scenario (RFDS) developed for the proposed lease area (Section 3.1.2). As per NEPA regulations at 40 CFR 1502.14(f), 40 CFR 1502.16(h), and 40 CFR 1508.20, mitigation measures to reduce, avoid, or minimize potential impacts are identified by resource below.

Upon receipt of an APD, the BLM would initiate a site-specific NEPA analysis to more fully analyze and disclose site-specific effects of specifically identified activities. In all potential exploration and development scenarios, the BLM would require the use of best management practices (BMP) documented in "Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development" (USDI and USDA 2007), also known as the "Gold Book." The BLM could also identify APD Conditions of Approval (COA), based on site-specific analysis that could include moving the well location, restrict timing of the project, or require other reasonable measures to minimize adverse impacts (43 CFR 3101.1-2 Surface use rights; Lease Form 3100-11, Section 6) to protect sensitive resources, and to ensure compliance with laws, regulations, and land use plans.

3.1.2 Reasonably Foreseeable Development Scenario Summary and Assumptions

If the proposed area is leased, the RFDS describes four phases of exploration and development that could occur: exploration, drilling, field development and production, and abandonment (Appendix 1). The RFDS and EA use the following assumptions.

1. One well would be drilled per government section of approximately 640 acres (based on State well spacing order).
2. Federal lease wells would require an APD and subsequent site-specific NEPA analysis. Additional site-specific requirements, termed Conditions of Approval (COA), may be attached to the approved APD.
3. The total surface disturbance, including well pad, pipeline, and road construction, is assumed to be approximately 5 acres per well. After the well is drilled, the pad size and road widths would be minimized and unneeded acreage would be reclaimed.
4. The lessee would seek approval for a drilling permit from IDL for fee land wells.
5. Wells would be drilled using conventional drilling techniques (i.e., vertical holes that would not require hydraulic fracturing - based on recent drilling in the adjacent Willow and Hamilton fields and on the geologic characteristics of the reservoir).
6. Producing wells would be incorporated into the Willow Field unit development. Dry wells would be plugged and abandoned in accordance with State and federal requirements, and the site would be reclaimed.
7. Oil and gas leases would be issued for an initial term of 10 years, subject to extension if there is drilling occurring or if there is a producing well on the lease.
8. Where gas is present at more than one layer, dual completion would be identified, targeted, and permitted resulting in 1 well/640 acres.

The level of drilling and associated activities would depend on available lease parcels and the effect of stipulations. Between 2 and 25 wells could be drilled in the proposed lease area resulting in 7 to 87.5 acres of surface disturbance (Table 2). The Lessee on adjacent State and private leases is currently bonded for 11-30 wells and they have drilled eight. A total of 17 wells have been permitted and drilled, three within the proposed lease area (Map 1). Within the boundaries of the Hamilton and Willow (exclusive of the proposed lease area) fields, up to 53 new wells could be developed at 1 well/640 acres (Table 2).

Table 2. Acres of surface disturbance for new wells and associated infrastructure, Little Willow Creek lease area (Alternatives A-C) and potential wells in the Hamilton and Willow fields, Payette County, Idaho.

Activity	Alternative			Field[1]	
	A	B	C	Hamilton	Willow
New Wells (#)	2	22	25	47	6
Well Pad Disturbance (2.5 acres/pad)	5	55	62.5	117.5	15
New Roads (0.25 miles/well)	0.5	5.5	6.25	11.75	1.5
Road Disturbance (4 acres/mile)	2	22	25	47	6
Total Surface Disturbance (acres)	7	77	87.5	164.5	21

[1] Based on 1 well/640 acres for sections that do not currently have a well.

3.2 Soils

3.2.1 Affected Environment – Soils

Detailed soil surveys for Idaho have been published by the Natural Resources Conservation Service (NRCS). The proposed lease area is characterized by sloping lava plateaus with gently to moderately sloping alluvial fans (cone-shaped deposits of sediment crossed and built up by streams), terraces, and bottom lands. Soils in the lease area are mainly coarse sandy loams, sandy loams, and silt loams (USDA NRCS 2014). Soil erosion susceptibility indices (K-factors) are categorized into the following ranges: low (K ≤ 0.15), moderate (K = 0.16 - 0.40), and high (K ≥ 0.41). Erosion potential of these soils ranges from moderate (coarse sandy loams) to high (silt loams). K-factors range from 0.20 to 0.64.

The majority of soils are moderately susceptible to erosion (Table 3, Map 3). Approximately 79% of soils (784 acres) are moderately susceptible and 21% (213 acres) are highly susceptible to erosion in the BLM/BLM category; 65% of soils (3,495 acres) are moderately susceptible and 35% (1,899 acres) are highly susceptible in the Private/BLM category. In the Private/Private category 49% of soils are moderately susceptible to erosion and 51% are highly susceptible to erosion (Table 3).

Table 3. Acres of Ownership Categories (Surface/Subsurface Management) in Each K-factor Range.

K-factor Range	Management or Ownership Surface/Subsurface)[1]			Total
	BLM/BLM	Private/BLM	Private/Private	
Moderate (K = 0.16-0.40)	784 (79%)	3,495 (65%)	4,495 (49%)	8,774 (56%)
High (K ≥ 0.41)	213 (21%)	1,899 (35%)	4,758 (51%)	6,870 (44%)
Total Acres	997	5,394	9,253	15,644
K-factor ≤ 0.32	682 (68%)	3,031 (56%)	3,891 (42%)	7,604 (49%)
K-factor > 0.32	314 (32%)	2,364 (44%)	9,253 (58%)	8,040 (51%)
Total Acres	997	5,394	9,253	15,644

[1]BLM/BLM = BLM manages land surface and subsurface minerals; Private/BLM = BLM manages subsurface minerals (federal mineral estate); Private/Private = land surface and subsurface minerals privately owned.

Alternative C stipulations (Section 2.3) specific to Fragile Soils provide a lease notice (LN-1) indicating mitigation would be required in certain situations. In particular, soils with K-factors greater than 0.32 on slopes greater than 30% would require mitigation to limit erosion. Approximately 51% of the proposed lease area contains soils with K-factors above this threshold (Table 3, Figure 1).

3.2.2 Environmental Consequences – Soils

Impacts to soils are based on the RFDS created for this document (Table 2, Appendix 1).

3.2.2.1 General Discussion of Impacts

Soils are investigated to determine erosion hazard and reclamation suitability by evaluating slope and soil properties such as texture, organic matter content, structure, permeability, depth, available water capacity, and salt concentration. Site specific mitigation would limit but not eliminate impacts to soils in the proposed lease area. The extent of impacts to soils would depend on the amount and type of disturbance associated with particular activity, as well as the erosion risk of a given area. As slopes become steeper, the risk of soil instability increases. Actions that alter soil characteristics such as plant cover and composition (amount and species), soil structure, permeability, and compaction may increase erosion potential.

Figure 1. Typical topography, slope, and soil conditions of BLM land in the proposed lease area.

Direct impacts from exploration and development include mixing and breaking down soil components, compaction, and removal of soils in the short term (0-3 years) and long term (>3 years). Compaction alters soil structure (e.g., reduced porosity, increased bulk density) and, therefore, its functionality (e.g., its ability to support healthy vegetation communities and to properly cycle water and nutrients) over the long term (USDA and USFS 2006). Indirect impacts to soils would include removal of ground cover (e.g., vegetation, microbiotic crusts, and litter) in the short term, thus exposing soil surface to wind and water erosion and colonization by weedy, invasive, disturbance related vegetation (e.g., cheatgrass) and or noxious weeds (e.g., rush skeletonweed) over the long term. Reclamation would be required once wells and infrastructure are no longer in use; therefore, soil structure and function would improve from disturbance related levels over the long term.

Oil and gas exploration and development could increase the potential for fire ignitions due to sparks from heavy equipment and/or vehicles, particularly when soils and vegetation are dry. If a fire burns hot enough, it may impact soil directly by altering its physical properties. Physical properties of soils that are dependent on organic matter (e.g., soil structure, pore space, aggregation) could be affected by heating during a fire (USFS RMRS 2014). Fire could also impact soil hydrology (i.e., infiltration) by increasing water repellency (USFS RMRS 2014). However, fires generally move quickly through shrub and grass communities like those in the proposed lease area. Therefore, it is more likely that soils would be indirectly impacted by the loss of vegetative cover leaving them exposed to erosion, as well as alterations in vegetation which, in turn, could alter soil chemistry and overall productivity over the long term.

3.2.2.2 Alternative A

No BLM managed surface or subsurface/federal mineral estate parcels would be leased, so soils would not be directly impacted in these parcels. Oil and gas activities (wells, well pads, and road construction) on private surface/subsurface could disturb up to 7 acres of soils and remove up to 7 acres of vegetation per the RFDS. Moderate to major, direct and indirect, adverse impacts to soils (compaction, soil loss, loss of structure and function, and colonization by weedy plants) would occur over the short and long term on the 7 acres (<0.1% of the proposed lease area). Soils in the high range for erosion susceptibility would incur greater impacts than soils in the moderate range if disturbed (Table 3). Risk of fire starts would be low because there would be little oil and gas development (two wells plus infrastructure); therefore, fire related soil impacts would be minor. Overall impacts to soils would be negligible due to the very small disturbance footprint possible under this scenario.

3.2.2.3 Alternative B

The BLM would issue leases on 997 BLM surface acres and 5,352 acres of federal mineral estate; however, the NSO and NSSO stipulations would preclude any direct disturbance to soils in these parcels until the FRMP is completed. Impacts to soils, including potential fire related impacts, would be identical to Alternative A (i.e., up to 7 acres of moderate to major disturbance) until implementation of the FRMP.

The RFDS for this alternative indicates up to 22 wells and associated infrastructure would cause direct soil impacts on up to 77 acres (0.5% of the proposed lease area) including BLM surface and federal mineral estate, and private surface/subsurface lands. These soils could sustain moderate to major, adverse, direct impacts, such as compaction and removal, and indirect impacts, such as reduction in productivity, over the short and long term associated with well and well pad development and road building. Minor (e.g., limited vegetation disturbance and wildfires) to major (e.g., roads and activities increase disturbances and wildfires) indirect impacts could occur where vegetation shifts to exotic annual dominated communities (e.g., associated with roads or wildfires) occur and soil protection is reduced or eliminated. These areas would be more susceptible wind and water erosion over the long term. However, the extent (magnitude and scale) of impacts would depend on land use designations and stipulations set forth in the FRMP.

3.2.2.4 Alternative C

Impacts would be similar to those described in Alternative B (Section 3.2.2.3); however, per the RFDS, direct impacts on up to 88 acres (0.6% of the proposed lease area) could occur on BLM surface, federal mineral estate, and private lands. Indirect impacts would be more likely to affect federal mineral estate lands in this scenario because of the increased amount of disturbance and closer proximity of disturbances. Direct and indirect impacts associated with well and road construction could be reduced where fragile soils are avoided (LN-1, Section 2.3).

3.2.3 Mitigation

Prior to authorization, proposed actions (APDs) would be evaluated on a case-by-case basis and would be subject to mitigation measures in order to maintain the soil system. Where residual impacts are expected based on future site specific APD analyses, measures would be taken to reduce, avoid, or minimize potential impacts to soil resources from exploration and development activities. Examples of mitigation include avoiding excessively steep slopes and areas poorly suited to reclamation, limiting the total area of disturbance, rapid reclamation, erosion/sediment control, soil salvage, re-vegetation, weed control, slope stabilization, surface roughening, and protective fencing.

3.2.4 Cumulative Impacts – Soils

Cumulative impacts to soils are based on the RFDS created for this document (Appendix 1), the Willow Field RFDS, and the actions identified below.

3.2.4.1 Scope of Analysis

The cumulative impact analysis area (CIAA) includes the proposed lease area and the Willow Field southwest of the lease area plus a 0.5-mile buffer totaling approximately 32,460 acres (50 square miles) (Map 3). The CIAA contains private, State, and BLM surface and federal mineral estate lands. This area was selected because the lands it encompasses have similar topographic, geologic, and soil attributes; soil condition (due to land use and wildfire) and susceptibility to erosion (K-factors) are also similar.

3.2.4.2 Current Conditions, Effects of Past and Present Actions, and Reasonably Foreseeable Future Actions

Soil conditions in the CIAA are nearly identical to those in the proposed leased area; the proposed lease area makes up the majority of the CIAA and the Willow Field has undergone similar disturbances. The levels and intensities of anthropogenic activities across all land jurisdictions in the CIAA has perpetuated increases of early successional, highly disturbed landscapes (Leu and Hanser 2011) that are at higher risk for cumulative soil impacts. Past, ongoing, and future land uses contributing to soil conditions include livestock grazing, agricultural development, rights-of-way, and oil and gas development. Wildfire, though not a land use, has also influenced soil conditions.

Livestock Grazing - Both BLM and private lands within CIAA, the proposed lease area in particular, encompass portions of the Sand Hollow, Rock Quarry Gulch, Dahnke, Hashegan, and Kaufman grazing allotments. Livestock grazing can damage soils via compaction, disruption of the soil profile, and remove vegetative cover exposing soils to erosion, particularly where livestock tend to congregate. Historic and recent grazing management in these allotments have contributed to overall soil condition. Livestock grazing would continue at current levels into the foreseeable future.

Agricultural Development - Conversion from shrub and grass communities to cultivated croplands on private land has altered soils on approximately 28% (8,962 acres) of the CIAA. Future agricultural development is unlikely (or would be negligible) because water necessary for crop production is limited.

Rights-of-way (power lines, roads) - Three short power line segments totaling approximately one mile are present in the CIAA. Power lines typically have two-track roads associated with them which disturb and impact soils. Approximately 9 miles of developed roads including the Little Willow Road (7.8 miles) and Big Willow Road (1.2 miles) run through the CIAA. These features combined have a disturbance footprint of approximately 40 acres; which, to a small degree, have contributed to present soil conditions across the CIAA. Future roads would be constructed in association with development of wells, well pads, and other infrastructure or facilities necessary to maintain oil and gas production. Road construction and maintenance would continue to affect soil erosion and displacement within maintained buffers. These effects are spatially restricted and occur over a continuous temporal scale.

Oil and Gas Development - Currently there are 11 wells and 1 well surface site in the CIAA. An estimated 30-41 acres (depending on infrastructure) of soils have been disturbed in the CIAA to date due to oil and gas exploration and development. An additional 6 wells could be drilled in the Willow Field portion of the CIAA in the future disturbing 21 acres of soils.

Wildfire - Approximately 16,655 acres (51 %) of the CIAA has burned at least one time. Multiple fires have burned within the CIAA, mainly in the 1980s, with some overlap. These fires have perpetuated increases of disturbance related plants, which are indicative of decreased soil productivity.

3.2.4.3 Alternative A – Cumulative Impacts

Disturbance from two wells and related infrastructure (7-acre footprint) would produce negligible short and long term impacts to soils when combined with ongoing and future land uses and disturbance. An additional 6 wells in the Willow Field portion of the CIAA would disturb soils on approximately 21 acres (<0.1% of the CIAA). Livestock grazing, rights-of-way construction and maintenance, and Willow Field oil and gas development combined would produce overall minor to moderate soil impacts over the short and long term. No or negligible additional impacts would occur from development of agriculture due limited water availability necessary for these actions. Wildfires could produce minor to major direct and indirect impacts to soils depending on their size and frequency.

3.2.4.4 Alternatives B and C– Cumulative Impacts

Development of 22 to 25 wells (77-87.5-acre footprint) and related infrastructure would produce minor short and long term impacts to soils in the CIAA when combined with ongoing and future land uses and disturbance. Cumulative impacts to soils from ongoing and future actions including livestock grazing, agricultural development, roads and ROWs, oil and gas development, and wildfire would be identical to those described for Alternative A.

3.3 Vegetation

3.3.1 Affected Environment – Vegetation

<u>General Vegetation</u>

Two ecological sites comprise the majority of the proposed lease area. South Slope Granitic 8-12 is associated with coarse sandy loams and is the primary ecological site occurring on steeper slopes and upper portions of gentle slopes. Loamy 8-12 is associated with sandy loams and silt loams which are present in the bottoms, on toe slopes, and lower portions of steeper slopes.

Basin big sagebrush and bluebunch wheatgrass vegetation communities are characteristic of South Slope Granitic 8-12 sites, and Wyoming big sagebrush and bluebunch wheatgrass with Thurber's needlegrass are characteristic of Loamy 8-12 sites. However, based on 2014 site visits, current plant communities on BLM-administered lands are largely dominated by cheatgrass, an invasive annual grass, and introduced annual forbs (e.g., tall tumblemustard, tansymustard, and clasping pepperweed); which is a result of frequent wildfires in the 1980s and recurring spring livestock grazing (Map 4). Between 1980 and 1986, approximately 49% of the area burned once, 15% burned twice, and 3% burned three times. Perennial plant species occasionally present include Sandberg bluegrass, crested wheatgrass, rabbitbrush, and small pockets of remnant bitterbrush, stiff sagebrush, and Wyoming big sagebrush. In general, north-facing slopes are wetter and contain slightly more perennial vegetation than south-facing, drier slopes; therefore, northerly slopes tend to be more resistant to disturbance and support more resilient plant communities.

General vegetation cover types mapped for the proposed lease area are consistent with observations made during site visits (
Table 4). Exotic Annuals (i.e., cheatgrass and introduced annual mustards) is the dominant cover type for all ownership configurations (Figure 2). Big Sagebrush (mainly Wyoming big sagebrush and/or basin big sagebrush with cheatgrass and Sandberg bluegrass) is the second most common cover type followed by Bunchgrass (mainly Sandberg bluegrass with cheatgrass and occasionally shrubs) and Stiff Sagebrush (mainly stiff sagebrush with cheatgrass, Sandberg bluegrass, and introduced forbs) on BLM/BLM and Private/BLM. On Private/Private, agriculture is the second most common cover type followed by Big Sagebrush. All remaining cover types comprise 4% each or less for all ownership configurations.

Table 4. Acres of general vegetation cover types[1] and percent composition by mineral ownership, Little Willow Creek proposed lease area, Payette County, Idaho.

General Cover Type	Ownership (Surface/Subsurface)[2]			Total Acres
	BLM/BLM	Private/BLM	Private/Private	
Agriculture	3.3 (<1%)	145.6 (3%)	3,004.6 (33%)	3,153.5 (20%)
Big Sagebrush[3]	258.4 (26%)	1,216.3 (23%)	1,478.6 (16%)	2,953.3 (19%)
Bitterbrush	6.6 (<1%)	15.6 (<1%)	15.8 (<1%)	38.0 (<1%)
Bunchgrass	112.5 (11%)	434.2 (8%)	336.2 (4%)	883.0 (6%)
Exotic Annuals	460.4 (46%)	3,125.0 (59%)	3,756.8 (41%)	7,342.2 (47%)
Greasewood	29.8 (3%)	63.1 (1%)	95.6 (1%)	188.5 (1%)
Salt Desert Shrub	28.2 (3%)	155.3 (3%)	112.9 (1%)	296.4 (2%)
Stiff Sagebrush	91.4 (9%)	162.0 (3%)	346.5 (4%)	599.9 (4%)
Wet Meadow	1.1 (<1%)	3.5 (<1%)	29.0 (<1%)	34.0 (<1%)
Other[4]	3.1 (<1%)	13.9 (<1%)	30.1 (<1%)	47.1 (<1%)
Total Acres[5]	995	5,335	9,206	15,536

[1] Pacific Northwest National Laboratory vegetation mapping data (2002).

[2] BLM/BLM = BLM manages land surface and subsurface minerals; Private/BLM = BLM manages subsurface minerals (federal mineral estate); Private/Private = land surface and subsurface minerals privately owned.
[3] Big Sagebrush Mix and Big Sagebrush were combined because the two have nearly identical components.
[4] Other includes Mountain Big Sagebrush, Mountain Shrubs, Rabbitbrush, Sparse Vegetation, Urban, and Water; which were combined because they represent a small portion (<15 acres in each ownership category) of the proposed lease area.
[5] Total acres are slightly less than 15,644 due to GIS processing of PNNL data set (raster data vs. vector data).

Figure 2. Typical vegetation on BLM surface and mineral estate land in the proposed lease area. Note tall tumble mustard, cheatgrass, and Sandberg bluegrass in the foreground and a patch of green rabbitbrush in the background.

Riparian Vegetation

There are 39 acres (<1% of the total lease acres) in the Wet Meadow cover type, which is indicative of riparian vegetation (e.g., cottonwoods, willows, rushes, and sedges) (Table 4). The vast majority of the Wet Meadow cover type (35 acres) is on private lands with private subsurface; only 1.1 acres are on BLM surface managed lands (BLM/BLM) and 3.5 acres are on federal mineral estate (Private/BLM). These areas are mainly associated with Little Willow Creek and the McIntyre Canal and are primarily on private land with private subsurface (Map 5). Additionally, National Wetland Inventory mapping shows approximately 56 acres (which overlap the Wet Meadow cover type to a small degree) of water features (e.g., emergent wetlands, ponds, seeps, and reservoirs) (Map 6). These features are typically used as livestock water sources and are generally sparsely vegetated as a result.

Special Status Plants (SSP)
Two sensitive plant species are mapped in the proposed lease area, an element occurrence (EO) of Snake River goldenweed (BLM Type 3 SSP) and an historical EO of calcareous buckwheat (BLM Type 3 SSP). Three additional EOs of Snake River goldenweed and one EO of Aase's onion (BLM Type 2 SSP) are present within 1 mile of the proposed lease area (Map 5). The calcareous buckwheat was last observed in 1933 and may no longer exist; further, the mapping precision for this EO is very low (G precision)[C], so it is possible that the EO is actually outside the proposed lease area.

Three of the Snake River goldenweed EOs (which includes the EO in the proposed lease area) were not given condition ranks. However, EO records from 2000 indicated that these EOs occurred in dry grasslands-annual grasslands with some perennial species-within weedy rangeland with occasional fire disturbance. Based on the degradation of the vegetation communities across the proposed lease area, and that these EOs are largely mapped in the annual grass cover type, population viability is likely poor. The fourth EO was given a condition rank of D signifying poor estimated viability; the 2006 EO report indicated that the area had burned multiple times and was dominated by annual weeds with few remaining shrubs, and population numbers were drastically lower than previous years. The Aase's onion EO was ranked B for condition in 1995 indicating good estimated viability; however, the EO report states the area had burned, shrubs had not re-established, and cheatgrass was common.

Noxious Weeds
'Noxious' is a legal designation given by the Director of the Idaho State Department of Agriculture to any plant having the potential to cause injury to public health, crops, livestock, land or other property (Idaho Statute 22-2402). The Boise District BLM has an active weed control program that annually updates the locations of noxious weeds and treats known weed infestations utilizing chemical, mechanical, and biological control techniques. Infestations of noxious weeds are treated contingent upon the BLM annual weed budget, employee availability, and noxious weed priority.

There are no noxious weeds mapped in the proposed lease area according to BLM Boise District noxious weeds database. However, numerous infestations of rush skeletonweed and Scotch thistle have been recorded in the vicinity (within three to five miles). Many of these infestations have been chemically treated at least once since 2001. Although no noxious species have been recorded within the proposed lease area boundary, it is likely that they do occur to some degree based on the degraded state of vegetation communities.

3.3.2 Environmental Consequences – Vegetation
Impacts to vegetation are based on the RFDS created for this document (Table 2, Appendix 1).

[C] G is the lowest precision and is typically applied by the Idaho Fish and Game's Idaho Natural Heritage program to historic observations and or observations lacking GPS data. A large buffer is created around a centroid, indicating that the location of the EO likely occurs/occurred somewhere within the polygon, but confidence is low as to its precise location. This EO is not depicted on the map provided because the location polygon is so large (77miles^2).

3.3.2.1 General Discussion of Impacts

Site specific mitigation and stipulations would limit impacts to sensitive vegetation (SSPs) and sensitive areas (riparian areas). The level of impacts to vegetation would depend on the amount and type of disturbance associated with a given activity.

General Vegetation

Lease development would directly impact vegetation by removing, damaging (i.e., breakage, trampling), or burying plants. When vegetation is removed and soil is exposed, noxious and invasive species may spread degrading overall condition of plant communities. The influx of machinery and vehicle travel associated with development, production, and improved access would increase the risk of fire starts, especially once vegetation has cured (late summer). Fire would damage or remove vegetation and potentially further degrade vegetation community structure and function. Burned areas would be more susceptible to noxious and invasive species colonization/spread and overall habitat degradation. Roads and degraded habitats would increase fragmentation by reducing the size of and increasing the distance between native vegetation stands.

Surface disturbing activities could also indirectly affect vegetation by disrupting seed banks and mixing, eroding, or compacting soils. Soil erosion would reduce the substrate available for plants and soil compaction could limit seed germination. Fugitive dust generated by construction activities and travel along dirt roads could affect nearby plants by depressing photosynthesis, disrupting pollination, and reducing reproductive success. Impacts to plants occurring after germination but prior to seed set could be particularly harmful as both current and future generations would be affected.

Riparian Vegetation

Direct and indirect impacts to riparian vegetation by surface disturbing activities would be the same as those described for general vegetation. However, mitigation and stipulations would likely prevent direct impacts to riparian vegetation, except on private lands with private mineral estate.

Special Status Plants

Direct impacts by surface disturbing activities would be the same as those described for general vegetation; however, mitigation and stipulations could prevent direct impacts. Networks of oil and gas infrastructure, roads in particular, could create pollinator and seed dispersal barriers. Vegetation removal and displacement by invasive and/or noxious species would also cause indirect impacts to sensitive plants via habitat degradation. Habitat fragmentation could also lead to a decrease in pollinators over time. All of these factors could decrease long-term EO viability.

Noxious Weeds

Both rush skeletonweed and Scotch thistle are capable of invading and dominating disturbed areas (roadsides, areas burned by wildfire, etc.) over a wide range of precipitation regimes and habitats (Sheley and Petroff 1999). Road building and use would create corridors and seed sources for noxious weed establishment and spread. Noxious weed inventories and treatments could offset some impacts.

3.3.2.2 Alternative A

General Vegetation

Development and production on private surface with private subsurface could disturb up to 7 acres (<0.1% of the proposed lease area) of vegetation. Moderate to major, direct (i.e., removal, breakage, and burying of vegetation) and indirect (e.g., influx of noxious and invasive species, disruption of seed bank, and plant community degradation) impacts would occur over the short (0-3 years) and long (>3 years) term in the isolated areas associated with wells and roads. The federal mineral estate (6,349 acres) would not be leased, so vegetation would not be directly affected in these parcels.

Vegetation in the unleased area could receive similar negligible to minor indirect impacts where invasive annuals, noxious weeds, or fires spread from developed areas. The degree of indirect impacts would depend on the condition and components of plant communities prior to disturbance. Those plant communities maintaining shrubs and native perennial grasses could better resist invasive and noxious weed invasions; however, they would be less resistant if affected by fire. New and upgraded roads would cause minor increased fragmentation.

The threat of fire ignitions could increase a minor amount by equipment use and vehicles travelling on existing and new (0.5 miles) access roads. The extent of impacts to vegetation across all jurisdictions would be influenced by fire size and behavior, as well as the pre-fire vegetation community conditions.

Riparian Vegetation

There would be no impacts to riparian vegetation or habitat on BLM-administered land or federal mineral estate. The extent of short- and long- term direct impacts (i.e., removal or damage) and long-term indirect impacts (i.e., habitat degradation) to riparian vegetation on private mineral estate would depend on the proximity of the disturbance. Any impacts would likely come from access roads associated with wells/well pads.

Special Status Plants

The Snake River goldenweed EO, or other currently mapped special status plant EOs, would not be directly impacted (i.e., removed or damaged). Long-term indirect impacts, such as habitat degradation or fragmentation, would be negligible because overall habitat condition is already relatively poor and the 0.5 mile of new access roads would be ≥2.5 miles away.

Noxious Weeds

The 0.5 miles of new roads could serve as minor noxious and invasive species corridors over the long term.

3.3.2.3 Alternative B

General Vegetation
The NSO and NSSO stipulations would apply until the FRMP is finalized and implemented; therefore, until that time, direct impacts to vegetation would be similar to those described for Alternative A (Section 3.3.2.2).

The RFDS for this alternative specifies up to 77 acres (0.5% of the proposed lease area) of vegetation on private surface and subsurface would sustain moderate to major, adverse, direct impacts (i.e., removal, breakage, and burying of vegetation). Minor to major indirect impacts (e.g., influx of noxious and invasive species, disruption of seed bank, and plant community degradation) could occur over the long term. Because wells and roads would occur throughout the proposed lease area, both private and federal mineral estate lands could be adversely affected. Moderate increases in habitat fragmentation could occur, especially where invasive species increase adjacent to roads. Minor (access restricted by private landowners and fire starts remain similar to current levels) to major (access not restricted and fire starts increase substantially) wildfire impacts could degrade vegetation conditions increasing fragmentation over the long term. However, the extent (magnitude and scale) of impacts to vegetation would depend on land use designations and stipulations set forth in the FRMP.

Riparian Vegetation
Direct impacts (i.e., removal or damage) to riparian areas would not occur on federal mineral estate lands. Long-term indirect impacts on BLM surface and federal mineral estate riparian vegetation would be similar to Alternative A (Section 3.3.2.2) and depend on the proximity of the disturbance. The extent of indirect impacts could be greater than Alternative A because more development would require more access roads (0.5 versus 5.5 miles of new access roads).

Special Status Plants
No direct impacts to the Snake River goldenweed EO or other currently mapped special status plant EOs would occur. Long-term indirect impacts to SSPs on BLM surface and federal mineral estate could be minor to moderate, but would depend on the proximity of the disturbance. However, the degree of these impacts could be greater than Alternative A because development could occur within 0.2 miles of the EO. Increased fragmentation and wildfire potential would adversely affect the EO over the long term.

Noxious Weeds
The 5.5 miles of new roads (and upgrades of existing roads) accessing 22 wells would serve as minor to moderate noxious and invasive species corridors over the long term.

3.3.2.4 Alternative C

General Vegetation
The same area would be leased as Alternative B, but Cascade RMP stipulations and other lease notices for development would apply specific to riparian areas and SSPs. According to the RFDS, up to 87.5 acres (0.6% of the proposed lease area) would sustain moderate to major, adverse, direct impacts (i.e., removal, breakage, and burying of vegetation). Vegetation community degradation, increased invasive species, seed bank disruption, and wildfire impacts would be similar to those described in Alternative B (Section 3.3.2.3); however, federal mineral

reserve lands (with minor exceptions associated with avoidance buffers) would be more likely to be affected because direct disturbances would occur on rather than adjacent to these lands.

Riparian Vegetation
Negligible indirect impacts could occur over the short and long term. Stipulations CSU-1 and CSU-2 (Section 2.3) would preclude direct impacts and limit indirect impacts.

Special Status Plants
Impacts (habitat degradation and fragmentation) would be similar to those described for Alternative B (Section 3.3.2.3); however, development could occur closer to EOs producing greater indirect impacts.

Noxious Weeds
The 6.25 miles of new access roads associated with 25 wells would increase the threat of noxious and invasive species spread slightly more than Alternative B (Section 3.3.2.3), but would remain in the minor to moderate range, overall. There are no stipulations or mitigation specific to noxious weeds under this scenario, but the Boise District BLM's annual weed control program could help mitigate noxious weed expansion.

3.3.3 Mitigation

Site specific mitigation would be addressed at the APD stage of exploration and development. If necessary, COAs could be applied including re-vegetation strategies using native and/or desirable non-native plant species, soil enhancement practices, modification of livestock grazing, and fencing of reclaimed areas. Noxious weed inventories and treatments may also be required.

Special Status Plants
Section 7 of the Endangered Species Act (ESA) requires BLM land managers to ensure that any action authorized, funded, or carried out by the BLM is not likely to jeopardize the continued existence of any threatened or endangered species and that it avoids any appreciable reduction in the likelihood of recovery of affected species. Consultation with the U. S. Fish and Wildlife Service (FWS) is required on any action proposed by the BLM or another federal agency that affects a listed species or that jeopardizes or modifies critical habitat.

The BLM's Special Status Species Policy outlined in BLM Manual 6840, Special Status Species Management, is to conserve listed species and the ecosystems on which they depend and to ensure that actions authorized or carried out by BLM are consistent with the conservation needs of special status species and do not contribute to the need to list any of these species. The BLM's policy is intended to ensure the survival of those plants that are rare or uncommon, either because they are restricted to specific uncommon habitat or because they may be in jeopardy due to human or other actions. The policy for federal candidate species and BLM sensitive species is to ensure that no action that requires federal approval should contribute to the need to list a species as threatened or endangered.

Prior to any exploration or development, the BLM would conduct site specific rare and sensitive plant surveys. If rare (threatened, endangered, proposed, or candidate species) or sensitive plants

(SSPs) are found, avoidance stipulations (e.g., disturbance buffers) would be applied. If listed species are found, BLM would consult with the USFWS during the analysis phase of processing an ADP.

3.3.4 Cumulative Impacts – Vegetation

Cumulative impacts to vegetation are based on the RFDS created for this document (Appendix 1), the Willow Field RFDS, and the actions described below.

3.3.4.1 Scope of Analysis

The CIAA for vegetation, consistent with the soils CIAA, encompasses the proposed lease area and the Willow field totaling plus a 0.5-mile buffer totaling approximately 32,460 acres (50 miles^2) (Map 4). This area was selected because it contains similar ecological sites and plant community components, conditions are similar, and oils and gas leasing and development is occurring (land uses are comparable).

3.3.4.2 Current Conditions, Effects of Past and Present Actions, and Reasonably Foreseeable Future Actions

Conditions across the CIAA are similar to conditions in the proposed lease sale perimeter: vegetation communities have been degraded and are largely dominated by non-native, weedy, annual species with small patches of remnant native shrubs and perennial grasses. There are no additional special status plants or noxious weeds mapped within the CIAA. Past, ongoing, and future land uses contributing to condition of vegetation include livestock grazing, agricultural development, rights-of-way, and oil and gas development. Wildfire has also been instrumental in shaping the vegetation community components and overall condition.

Livestock Grazing - Both BLM and private lands within CIAA, the proposed lease area in particular, encompass portions of the Sand Hollow, Rock Quarry Gulch, Dahnke, Hashegan, and Kaufman grazing allotments. Livestock grazing can damage and remove vegetation, especially where livestock tend to congregate. Historic and recent grazing management in these allotments have contributed to overall plant community condition. Livestock grazing would continue at current levels into the foreseeable future.

Agricultural Development - Conversion from shrub and grass communities to cultivated croplands on private land has occurred on approximately 28% (8,962 acres) of the CIAA. Future agricultural development is unlikely (or would be negligible) because water necessary for crop production is limited.

Roads and Rights-of-way (ROW) - Road or ROW (powerlines and pipelines) construction and subsequent ongoing maintenance (e.g., blading, grading, and/or spraying) along these features will continue to affect vegetation within and adjacent to maintained buffers. Blading and grading disturb soils and vegetation and often create conditions conducive to noxious and invasive species establishment. Spraying of these sites helps to keep weeds and weedy species relatively restricted to the maintained buffers or to a minimum (e.g., around powerline poles, which are kept relatively free of vegetation to prevent fire). As a result, upland vegetation is often sparse in these locations. Road construction and maintenance would continue to impact vegetation within maintained buffers. These effects are generally spatially restricted and occur over a continuous temporal scale.

Three short power line segments totaling approximately one mile are present in the CIAA. Power lines typically have two-track roads associated with them which disturb and impact vegetation. Approximately 9 miles of developed roads including the Little Willow Road (7.8 miles) and Big Willow Road (1.2 miles) run through the CIAA. Combined, these features have a disturbance footprint of approximately 40 acres; which has contributed to present plant community conditions. Additional roads are anticipated to access wells, well pads, and other infrastructure or facilities necessary to maintain oil and gas production.

Oil and Gas Development - Currently there are 11 wells and 1 well surface site in the CIAA. Vegetation on approximately 30-41 acres (depending on infrastructure) has been removed or disturbed to date due to oil and gas exploration and development. An additional 6 wells could be drilled in the Willow Field portion of the CIAA which would disturb approximately 21 acres of vegetation.

Wildfire - Several fires have burned across the CIAA, mainly in the 1980s. Approximately 51 % (16,655 acres) of the CIAA has burned at least one time. These fires have perpetuated increases of disturbance related plants, degrading overall vegetation community conditions. Disturbance related vegetation often equates to fine fuels which burn readily creating a negative feedback loop.

3.3.4.3 Alternative A – Cumulative Impacts

Disturbance from two wells and related infrastructure would produce negligible additive short- and long-term impacts to vegetation. In the Willow Field portion of the CIAA, an additional 6 wells would disturb vegetation on approximately 21 acres (<0.1% of the CIAA) combined with the 30-41 acres of existing disturbance would produce minor impacts over the short and long term. Ongoing livestock use in areas grazed each spring (before seed set) could perpetuate disturbance related plants. Sensitive plants could also be impacted directly via trampling by livestock. Rights-of-way construction and maintenance would produce overall minor impacts to vegetation including habitat degradation and fragmentation over the short and long term. Wildfires could produce minor to major direct and indirect impacts to vegetation depending on fire size and frequency. Further agricultural development is improbable, so no additional impacts to vegetation would take place.

3.3.4.4 Alternatives B and C – Cumulative Impacts

Development of 22 to 25 wells and related infrastructure totaling 77 to 87.5 acres of disturbance would produce minor short and long term additive impacts to vegetation in the CIAA. Cumulative impacts to vegetation from ongoing and future actions identified in section 3.3.3.2 (livestock grazing, agricultural development, roads and ROWs, oil and gas development, and wildfires) would be identical to those described for Alternative A.

3.4 Air Resources

Air resources include air quality, air quality related values (AQRVs), and climate change. As part of the planning and decision making process, the BLM considers and analyzes the potential effects of BLM and BLM-authorized activities on pollutant emissions and on air resources.

The Environmental Protection Agency (EPA) has the primary responsibility for regulating air quality, including seven criteria air pollutants subject to National Ambient Air Quality Standards (NAAQS). Pollutants regulated under NAAQS include carbon monoxide (CO), lead, nitrogen dioxide (NO2), ozone, particulate matter with a diameter less than or equal to 10 microns (PM10), particulate matter with a diameter less than or equal to 2.5 microns (PM2.5), and sulfur dioxide (SO2). Two additional pollutants, nitrogen oxides (NOx) and volatile organic compounds (VOCs) are regulated because they form ozone in the atmosphere. Air quality regulation is also delegated to the IDEQ. Air quality is determined by pollutant emissions and emission characteristics, atmospheric chemistry, dispersion meteorology, and terrain. The AQRVs include effects on soil and water such as sulfur and nitrogen deposition and lake acidification, and aesthetic effects such as visibility.

Climate is the composite of generally prevailing weather conditions of a particular region throughout the year, averaged over a series of years. Climate change includes both historic and predicted climate shifts that are beyond normal weather variations.

3.4.1 Affected Environment – Air Resources

Air Quality

Based on data from monitors located in Baker County Oregon (west and generally upwind of the lease area) and Ada and Canyon counties (southeast and generally downwind of the lease area), air quality in Payette County is believed to be much better than required by the NAAQS. The EPA air quality index (AQI) is an index used for reporting daily air quality (http://www.epa.gov/airdata/) to the public. The index tells how clean or polluted an area's air is and whether associated health effects might be a concern. The EPA calculates the AQI for five criteria air pollutants regulated by the Clean Air Act (CAA): ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these pollutants, EPA has established NAAQS to protect public health. An AQI value of 100 generally corresponds to the primary NAAQS for the pollutant. The following terms help interpret the AQI information:

- **Good** – The AQI value is between 0 and 50. Air quality is considered satisfactory and air pollution poses little or no risk.
- **Moderate** – The AQI is between 51 and 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.
- **Unhealthy for Sensitive Groups** – When AQI values are between 101 and 150, members of "sensitive groups" may experience health effects. These groups are likely to be affected at lower levels than the general public. For example, people with lung disease are at greater risk from exposure to ozone, while people with either lung disease or heart disease

are at greater risk from exposure to particle pollution. The general public is not likely to be affected when the AQI is in this range.

- **Unhealthy** – The AQI is between 151 and 200. Everyone may begin to experience some adverse health effects, and members of the sensitive groups may experience more serious effects.
- **Very Unhealthy** – The AQI is between 201 and 300. This index level would trigger a health alert signifying that everyone may experience more serious health effects.

AQI data show that there is little risk to the general public from air quality in the analysis area (Table 5). Based on available aggregate data for Baker, Ada, and Canyon counties (the nearest counties with monitoring data) for years 2011–2013, more than 84% of the days were rated "good" and the three-year median daily AQI was 19 to 32. Moderate or lower air quality days were typically associated with winter inversions or summer wildfire activity.

Table 5. Air Quality Index Report – Analysis Area Summary (2011-2013), Baker County Oregon and Ada Canyon Counties Idaho.

County[1]	# Days in Period	Median AQI	# Days rated Good	Percent of Days Rated Good	# Days Rated Moderate	# Days Rated Unhealthy for Sensitive Groups	# Days Rated Unhealthy	# Days Rated Very Unhealthy
Baker	1,084	28	915	84	167	2	0	0
Ada	1,088	32	917	84	157	11	2	1
Canyon	1,019	19	925	91	87	4	3	0

Source: EPA 2013a.

Emissions in Payette County are low, due to a small populations and little industrial activity. Based on 2011 emission inventory data available from the EPA National Emission Inventory, oxides of nitrogen, carbon monoxide, ≤10 micron particulate matter (PM_{10}), volatile organic compounds, and carbon dioxide were the most common non-biogenic emissions in Payette County (EPA 2014a). As described above, these emissions occur in an area with good air quality.

Table 6. Annual emissions (tons/year) of typical pollutants, typical annual emissions for a well (Upper Green River, Wyoming), and emissions for the reasonably foreseeable development scenario wells (Payette County) and cumulative impacts analysis area (Baker, Ada, Canyon, and Payette counties), Idaho and Oregon.

Pollutant	**Payette County**	**Cumulative Impacts Analysis Area**	**Per Well[1]**	**Alternative (%increase over Payette County values)**			**Hamilton and Willow Fields[(2)]**
				A	**B**	**C**	
NOx (Oxides of Nitrogen)	1,445.4	24,851.4	14.6	29.2 (2%)	321.2 (22.2%)	365 (25.3%)	774 (3.1%)
CO (Carbon Monoxide)	6,308.3	149,894.3	3.9	7.8 (0.1%)	85.8 (1.4%)	97.5 (1.6%)	207 (0.1%)
SO_2 (Sulfur Dioxide)	39.1	2,800.2	0.0004	0.0008 (<0.01%)	0.0088 (0.02%)	0.01 (0.03%)	0.02 (0.001%)
PM_{10} (Particulates	6,195.6	61,101.9	6.7	13.4	147.4	167.5	355.1

Pollutant	Payette County	Cumulative Impacts Analysis Area	Per Well[1]	Alternative (%increase over Payette County values)			Hamilton and Willow Fields[(2)]
				A	B	C	
with diameters ≤10 microns or ≤10 x 10^{-6} meters)				(0.2%)	(2.4%)	(2.7%)	(0.7%)
$PM_{2.5}$ (Particulates with diameters ≤ 2.5 microns or ≤2.5 x 10^{-6} meters)	828.4	12,815.4	0.8	1.6 (0.2%)	17.6 (2.1%)	20.0 (2.4%)	42.4 (0.3%)
VOCs (Volatile Organic Compounds)	1,123.1	28,539.1	5.2	10.4 (0.9%)	114.4 (10.2%)	130.0 (11.6%)	275.6 (1.0%)
HAPs (Hazardous Air Pollutants)							
Benzene	18.2	583.2	0.12	0.2 (1.3%)	2.6 (14.5%)	3.0 (16.5%)	6.4 (1.2%)
Toulene	67.4	1,509.5	0.22	0.4 (0.7%)	4.8 (7.2%)	5.5 (8.2%)	11.7 (0.8%)
Ethylbenezene	9.7	190.3	0.00003	0.00006 (<0.01%)	0.0007 (0.01%)	0.0008 (0.01%)	0.002 (0.001%)
Xylene	39	801.5	0.17	0.3 (0.9%)	3.7 (9.5%)	4.3 (10.9%)	9.0 (1.1%)
n-Hexane	23	615.1	0.20	0.4 (1.7%)	4.4 (19.1%)	5.0 (21.7%)	10.6 (1.7%)
Total HAPs	157.3	3,654.6	0.72	1.4 (0.9%)	15.8 (10.2%)	18.0 (11.4%)	38.2 (1.0%)
GHGs (Greenhouse Gases)							
CO_2 (Carbon Dioxide)	240,158	4,029,296	2,582.1	5,164.2 (2.2%)	56,806.2 (23.7%)	64,552.5 (26.9%)	136,851.3 (3.4%)
CH_4 (Methane)	28.6	1,478.8	14.1	28.2 (98.6%)	310.2 (1,085%)	352.5 (1,233%)	747.3 (50.5%)
N_xO (Nitrous Oxides)	8.4	169.0	0.05	0.1 (1.2%)	1.1 (13.1%)	1.3 (14.9%)	2.7 (1.6%)
CO_2 eq (Global Warming Potential)[3]	243,362	4,112,744	2,893.7	5,787.4 (2.4%)	63,661.4 (26.2%)	72,342.5 (29.7%)	153,366.1 (3.7%)

[1] Source: Kleinfelder (2014)
[2] %increase over CIAA
[3] GWP (Global Warming Potential/Carbon Dioxide Equivalent [CO_2eq]) for CO_2 =1, CH_4 = 21, and N_2O = 310.

Air resources also include visibility, which can be degraded by regional haze caused in part by sulfur, nitrogen, and particulate emissions. Based on trends identified during 2000-2009, visibility has improved slightly near the analysis area on the haziest and clearest days. Blue-shaded circles in Figure 3 indicate negative deciview (dv) changes, which mean that people can see more clearly at greater distances.

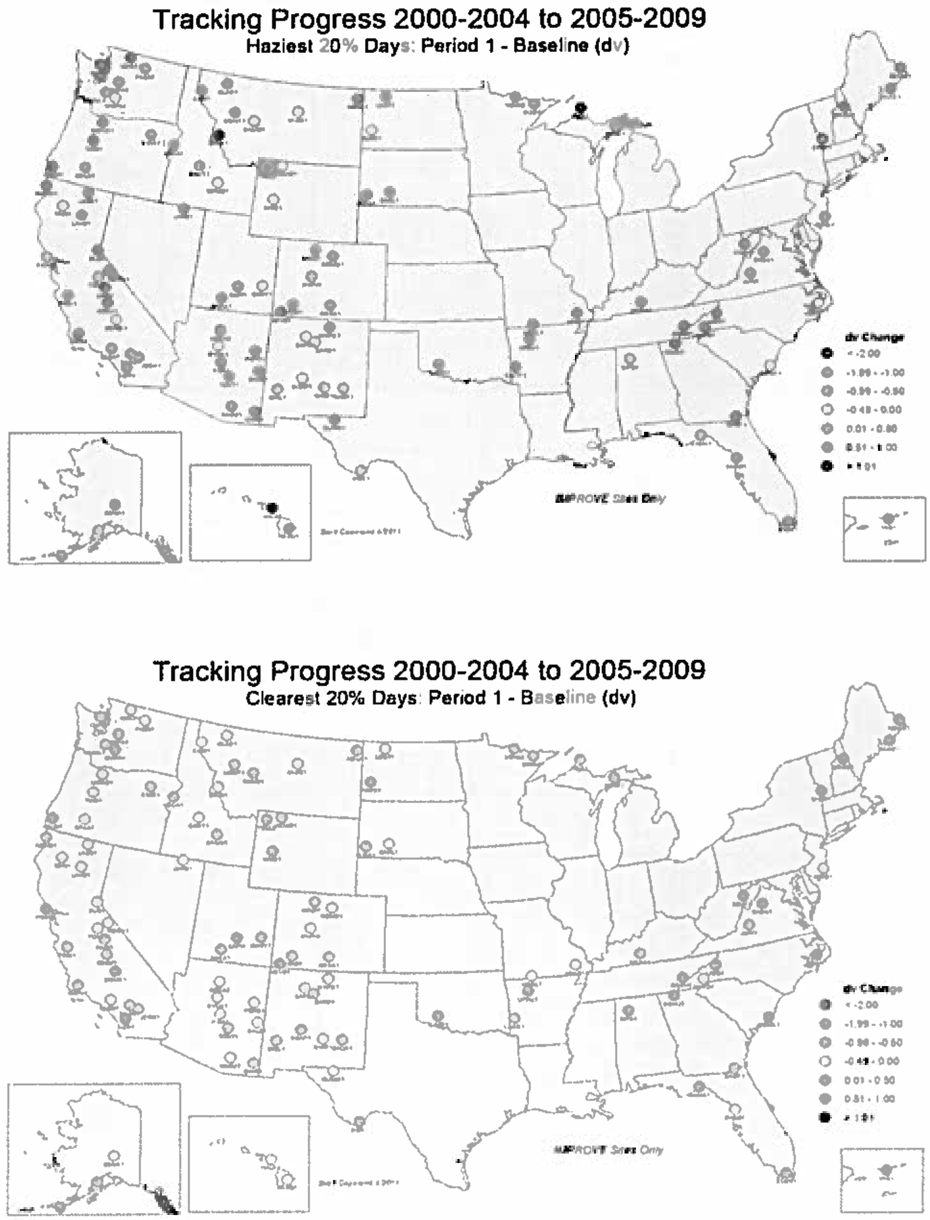

Figure 3. Visibility trends on haziest and clearest days, 2000-2009 (IMPROVE 2011).

Climate Change/Greenhouse Gasses

Climate change is defined by the Intergovernmental Panel on Climate Change (IPCC) as "a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and persist for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity" (IPCC 2007).

The Intergovernmental Panel on Climate Change (Climate Change SIR[D] 2010) states, "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." Global average temperature has increased approximately 1.4°F since the early 20th century (Climate Change SIR 2010). Warming has occurred on land surfaces, oceans and other water bodies, and in the troposphere (lowest layer of earth's atmosphere, up to 4-12 miles above the earth). Other indications of global climate change described by the IPCC (Climate Change SIR 2010) include:

- Rates of surface warming increased in the mid-1970s and the global land surface has been warming at about double the rate of ocean surface warming since then;
- Eleven of the last 12 years rank among the 12 warmest years on record since 1850;
- Lower-tropospheric temperatures have slightly greater warming rates than the earth's surface from 1958-2005.

As discussed and summarized in the Climate Change SIR, earth has a natural greenhouse effect wherein naturally occurring gases such as water vapor, CO_2, methane, and N_2O absorb and retain heat. Without the natural greenhouse effect, earth would be approximately 60°F cooler (Climate Change SIR 2010). Current ongoing global climate change is caused, in part, by the atmospheric buildup of greenhouse gases (GHGs), which may persist for decades or even centuries. Each GHG has a global warming potential that accounts for the intensity of each GHG's heat trapping effect and its longevity in the atmosphere (Climate Change SIR 2010). Increased GHG emissions of CO_2, methane, N_2O, and halocarbons since the start of the industrial revolution have substantially increased atmospheric concentrations of these compounds compared to background levels. At such elevated concentrations, these compounds absorb more energy from the earth's surface and re-emit a larger portion of the earth's heat back to the earth rather than allowing the heat to escape into space than would be the case under more natural conditions of background GHG concentrations.

A number of activities contribute to the phenomenon of climate change, including emissions of GHGs (especially carbon dioxide and methane) from fossil fuel development, large wildfires, activities using combustion engines, changes to the natural carbon cycle, and changes to radiative forces and reflectivity (albedo) due to soot deposition and other surface changes. It is important to note that GHGs will have a sustained climatic impact over different temporal scales due to their differences in global warming potential (described above) and lifespans in the atmosphere. For example, CO_2 may last 50 to 200 years in the atmosphere while methane has an average atmospheric life time of 12 years (Climate Change SIR, 2010).

With regard to statewide GHG emissions, Idaho ranks in the lowest decile when compared to all states. The estimate of Idaho's 2011 GHG emissions of 28.5 million metric tons (MMt) of

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[D] Although the Climate Change SIR was developed for oil and gas leasing activities in Montana, North Dakota, and South Dakota, conclusions from broader scale analyses/findings are applicable in Idaho.

carbon dioxide equivalent (CO_2e) accounted for approximately 0.43% of the U.S. GHG emissions (WRI 2014).

Some information and projections of impacts beyond the project scale are becoming increasingly available. Chapter 3 of the Climate Change SIR describes impacts of climate change in detail at various scales, including the state scale when appropriate. The following summary characterizes potential changes identified by the EPA (EPA 2014a) that are expected to occur at the regional scale, where the Proposed Action and its alternatives could occur. The EPA identifies Idaho as part of the Northwest region (EPA 2014a):

- The region is expected to experience warmer temperatures with less snowfall.
- Temperatures are expected to increase more in winter than in summer, more at night than in the day, and more in the mountains than at lower elevations.
- Earlier snowmelt means that peak stream flow would be earlier, weeks before the peak needs of ranchers, farmers, recreationalists, and others. In late summer, rivers, lakes, and reservoirs would be drier.
- More frequent, more severe, and possibly longer-lasting droughts are expected to occur.

Other impacts could include:
- Increased particulate matter in the air as drier, less vegetated soils experience wind erosion.
- Shifts in vegetative communities which could threaten plant and wildlife species.
- Changes in the timing and quantity of snowmelt which could affect both aquatic species and agricultural needs.

Projected and documented broad-scale changes within ecosystems of the U.S. are summarized in the Climate Change SIR. Some key aspects include:
- Large-scale shifts have already occurred in the ranges of species and the timing of the seasons and animal migrations. These shifts are likely to continue. Climate changes include warming temperatures throughout the year and the arrival of spring an average of 10 days to two weeks earlier through much of the U.S. compared to 20 years ago. Multiple bird species now migrate north earlier in the year.
- Fires, insect epidemics, disease pathogens, and invasive weed species have increased and these trends are likely to continue. Changes in timing of precipitation and earlier runoff increase fire risks.
- Insect epidemics and the amount of damage that they may inflict have also been on the rise. The combination of higher temperatures and dry conditions have increases insect populations such as pine beetles, which have killed trees on millions of acres in western U.S. and Canada. Warmer winters allow beetles to survive the cold season, which would normally limit populations; while concurrently, drought weakens trees, making them more susceptible to mortality due to insect attack.

More specific to Idaho, additional projected changes associated with climate change described in Section 3.0 of the Climate Change SIR (2010) include:
- Temperature increases are predicted to be between 3 to 5°F at the mid-21st century.

- Precipitation may increase in winter by up to 25%, remain stable during the spring and fall, and decrease by up to 25% during the summer.
- Predicted annual runoff for 2041–2060 compared to 1901–1970 is expected to remain stable.
- Wildland fire risk is predicted to continue to increase due to climate change effects on temperature, precipitation, and wind. One study predicted an increase in median annual area burned by wildland fires in southern Idaho based on a 1°C global average temperature increase to be 111%.

While long-range regional changes might occur within this analysis area, it is impossible to predict precisely when they could occur. The following example summarizing climate data for the Idaho Southwestern Valleys illustrates this point at a regional scale. A potential regional effect of climate change is earlier snowmelt and associated runoff. This is directly related to spring-time temperatures. Over a 119-year record, temperatures increased 0.08 degrees per decade (Figure 4). This would suggest that runoff may be occurring earlier than in the past. However, data from 1994-2014 indicates a 0.5 degree per decade cooling trend (Figure 5). This example is not an anomaly, as several other 20-year windows can be selected to show either warming or cooling trends. Some of these year-to-year fluctuations in temperature are due to natural processes, such as the effects of El Niños, La Niñas, and the eruption of large volcanoes. This information illustrates the difficulty of predicting actual short-term regional or site-specific changes or conditions which may be due to climate change during any specific time frame.

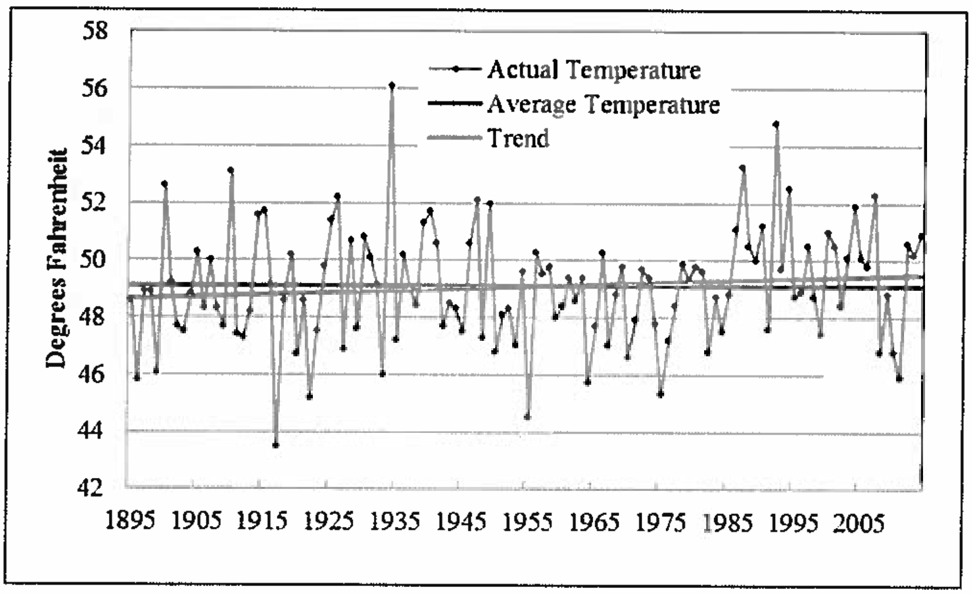

Figure 4. Regional climate summary of spring temperatures (March-May) for Idaho Southwestern Valleys, from 1895-2014. (Source: NOAA website http://www.ncdc.noaa.gov/oa/climate/research/cag3/wn.html)

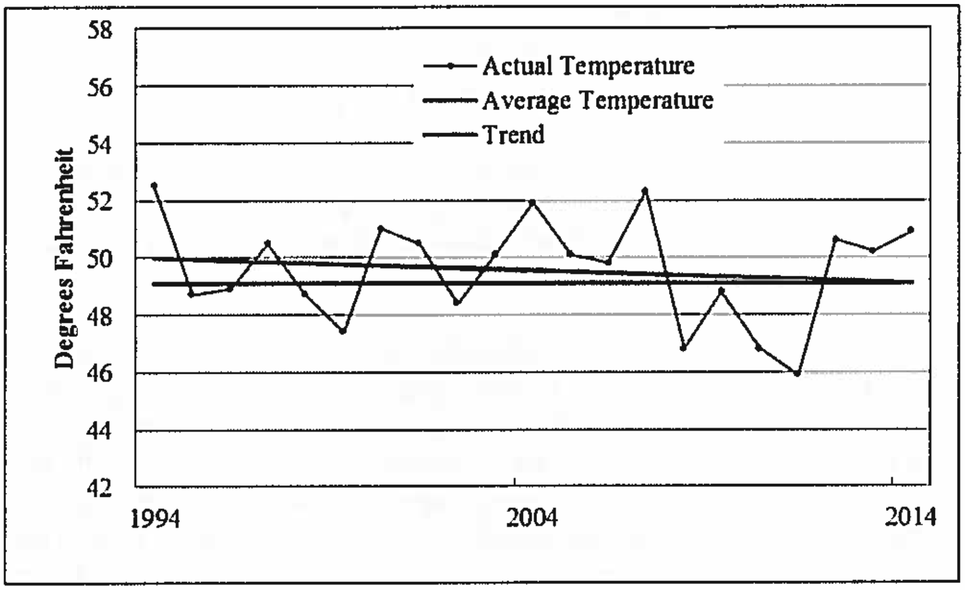

Figure 5. Regional climate summary of spring temperatures (March-May) for Idaho Southwestern Valleys, from 1994-2014. (Source: NOAA website http://www.ncdc.noaa.gov/oa/climate/research/cag3/wn.html)

3.4.2 Environmental Consequences – Air Resources

Impacts to air resources are based on the RFDS created for this document (Table 2, Appendix 1).

3.4.2.1 General Discussion of Impacts

Air Quality

Potential impacts of development could include increased airborne soil particles blown from new well pads or roads; exhaust emissions from drilling equipment, compressors, vehicles, and dehydration and separation facilities; as well as potential releases of GHGs and VOCs during drilling or production activities. The amount of increased emissions cannot be precisely quantified at this time since it is not known for certain how many wells might be drilled, the types of equipment needed if a well were to be completed successfully (e.g., compressor, separator, dehydrator), or what technologies may be employed by a given company for drilling any new wells. The degree of impact would also vary according to the characteristics of the geologic formations from which production occurs, as well as the scope of specific activities proposed in an APD. Oxides of nitrogen, carbon monoxide, volatile organic compounds, carbon dioxide, and methane are the most common emissions from a typical well (Green River, Wyoming; Table 6). The Kleinfelder report provides estimated pollutants for wells in three locations (San Juan, Uinta/Piceance, and Upper Green River basins). This analysis uses the Upper Green River values which represent the upper end of pollution production in the examples. The majority of pollution occurs during the production phase, where fugitive emissions (e.g., leaking pipes and valves) and dump valves (used to control the amount of fluid in the product) are the primary sources.

Climate Change/Greenhouse Gases

Sources of GHGs associated with development of lease parcels include construction activities, operations, and facility maintenance in the course of oil and gas exploration, development, and production. Estimated GHG emissions are discussed for these specific aspects of oil and gas activity because the BLM has direct involvement in these steps. Anticipated GHG emissions are based on emissions calculators developed by air quality specialists at the BLM National Operations Center in Denver, Colorado, based on a typical well in Green River Wyoming (Table 6).

3.4.2.2 Alternative A

Air Quality

Two new State lease wells and associated infrastructure would have minor adverse impacts on air quality over the long term. Small increases in nitrogen oxides (2%), carbon monoxide (0.1%), sulfur dioxide (<0.01%), and particulate matter (0.4%) would occur annually (Table 6). Good AQI values would likely predominate; however, well emissions could slightly increase the number of moderate AQI days especially during inversions. There would be negligible decreases in visibility, primarily within 1-2 miles of the wells.

Climate Change/Greenhouse Gases

Emissions from two new wells on State leases would increase Payette County's annual carbon dioxide equivalent production by 2.4% (Table 6).

3.4.2.3 Alternative B

Air Quality

Twenty-two new BLM lease wells and associated infrastructure would have moderate adverse impacts on air quality over the long term. Increases in nitrogen oxides (22%), carbon monoxide (1.4%), sulfur dioxide (0.02%), and particulate matter (4.5%) would occur annually (Table 6). The percent of days rated good AQI could decrease, especially during inversions. There would be minor decreases in visibility, primarily within 1-2 miles of the wells.

Climate Change/Greenhouse Gases

Twenty-two new wells on BLM leases would increase Payette County's annual carbon dioxide equivalent production by 26.2% (Table 6).

3.4.2.4 Alternative C

Air Quality

Twenty-five new BLM lease wells and associated infrastructure would have moderate adverse impacts on air quality over the long term. Controlled surface use stipulations could reduce some pollutants when or where they are in effect (e.g., the winter use restriction CSU-4 would reduce or eliminate some pollutants [e.g., PM_{10}] between December 1 and March 31; minimizing disturbance of fragile soils could reduce dust over the long term). Increases in nitrogen oxides (25%), carbon monoxide (1.6%), sulfur dioxide (0.03%), and particulate matter (5.1%) would occur annually (Table 6). The percent of days rated good AQI could decrease, especially during inversions. There would be minor decreases in visibility, primarily within 1-2 miles of the wells.

Climate Change/Greenhouse Gases

Twenty-five new wells on BLM leases would increase Payette County's annual carbon dioxide equivalent production by 29.7% (Table 6).

3.4.3 Mitigation

The BLM encourages industry to incorporate and implement BMPs to reduce impacts to air quality and climate change by reducing emissions, surface disturbances, and dust from field production and operations. Measures may also be required as COAs on permits by either the BLM or IDEQ. The BLM also manages venting and flaring of gas from federal wells as described in the provisions of Notice to Lessees (NTL) 4A, Royalty or Compensation for Oil and Gas Lost.

Some of the following measures could be imposed at the development stage:

- flare or incinerate hydrocarbon gases at high temperatures to reduce emissions of incomplete combustion;
- install emission control equipment of a minimum 95% efficiency on all condensate storage batteries;
- install emission control equipment of a minimum 95% efficiency on dehydration units, pneumatic pumps, produced water tanks;
- operate vapor recovery systems where petroleum liquids are stored;
- use Tier II or greater, natural gas or electric drill rig engines;
- operate secondary controls on drill rig engines;
- use no-bleed pneumatic controllers (most effective and cost effective technologies available for reducing volatile organic compounds (VOCs));
- operate gas or electric turbines rather than internal combustions engines for compressors;
- use nitrogen oxides (NO_x) emission controls for all new and replaced internal combustion oil and gas field engines;
- water dirt and gravel roads during periods of high use and control speed limits to reduce fugitive dust emissions;
- perform interim reclamation to re-vegetate areas of the pad not required for production facilities and to reduce the amount of dust from the pads.
- co-locate wells and production facilities to reduce new surface disturbance;
- use directional drilling and horizontal completion technologies whereby one well provides access to petroleum resources that would normally require the drilling of several vertical wellbores;
- operate gas-fired or electrified pump jack engines;
- install velocity tubing strings;
- use cleaner technologies on completion activities (i.e. green completions), and other ancillary sources;
- use centralized tank batteries and multi-phase gathering systems to reduce truck traffic;
- forward looking infrared (FLIR) technology to detect fugitive emissions; and
- perform air monitoring for NO_x and ozone (O_3).

Specifically with regard to reducing GHG emissions, Section 6.0 of the Climate Change SIR identifies and describes in detail commonly used technologies to reduce methane emissions from natural gas production operations. Technologies discussed in the Climate Change SIR and as summarized in Table 7 (reproduced from Table 6-2 in Climate Change SIR), display common methane emission technologies reported under the EPA Natural Gas STAR Program and associated emission reduction, cost, maintenance, and payback data.

Table 7. Selected methane emission reductions reported under the EPA Natural Gas STAR Program.

Source Type / Technology	Annual Methane Emission Reduction [1] (Mcf/yr)	Capital Cost Including Installation ($1,000)	Annual Operating and Maintenance Cost ($1,000)	Payback (Years or Months)	Payback Gas Price Basis ($/Mcf)
Wells					
Reduced emission (green) completion	7,000 [2]	$1 – $10	>$1	1 – 3 yr	$3
Plunger lift systems	630	$2.6 – $10	NR	2 – 14 mo	$7
Gas well smart automation system	1,000	$1.2	$0.1 – $1	1 – 3 yr	$3
Gas well foaming	2,520	>$10	$0.1 – $1	3 – 10 yr	NR
Tanks					
Vapor recovery units on crude oil tanks	4,900 – 96,000	$35 – $104	$7 – $17	3 – 19 mo	$7
Consolidate crude oil production and water storage tanks	4,200	>$10	<$0.1	1 – 3 yr	NR
Glycol Dehydrators					
Flash tank separators	237 – 10,643	$5 – $9.8	Negligible	4 – 51 mo	$7
Reducing glycol circulation rate	394 – 39,420	Negligible	Negligible	Immediate	$7
Zero-emission dehydrators	31,400	>$10	>$1	0 – 1 yr	NR
Pneumatic Devices and Controls					
Replace high-bleed devices with low-bleed devices					
End-of-life replacement	50 – 200	$0.2 – $0.3	Negligible	3 – 8 mo	$7
Early replacement	260	$1.9	Negligible	13 mo	$7
Retrofit	230	$0.7	Negligible	6 mo	$7
Maintenance	45 – 260	Negl. to $0.5	Negligible	0 – 4 mo	$7
Convert to instrument air	20,000 (per facility)	$60	Negligible	6 mo	$7
Convert to mechanical control systems	500	<$1	<$0.1	0 – 1 yr	NR
Valves					
Test and repair pressure safety valves	170	NR	$0.1 – $1	3 – 10 yr	NR
Inspect and repair compressor station blowdown valves	2,000	<$1	$0.1 – $1	0 – 1 yr	NR

Source Type / Technology	Annual Methane Emission Reduction [1] (Mcf/yr)	Capital Cost Including Installation ($1,000)	Annual Operating and Maintenance Cost ($1,000)	Payback (Years or Months)	Payback Gas Price Basis ($/Mcf)
Compressors					
Install electric compressors	40 – 16,000	>$10	>$1	>10 yr	NR
Replace centrifugal compressor wet seals with dry seals	45,120	$324	Negligible	10 mo	$7
Flare Installation	2,000	>$10	>$1	None	NR

Source: Multiple EPA Natural Gas STAR Program documents. Individual documents are referenced in Climate Change SIR (2010).

[1] Unless otherwise noted, emission reductions are given on a per-device basis (e.g., per well, per dehydrator, per valve, etc).

[2] Emission reduction (Mcf = thousand cubic feet of methane) is per completion, rather than per year.

NR = not reported

3.4.4 Cumulative Impacts – Air Resources

Cumulative impacts to air resources are based on the RFDS created for this document (Appendix 1), RFDS for Hamilton and Willow fields, and the actions discussed below.

3.4.4.1 Scope of Analysis

The CIAA includes the airshed associated with Ada, Baker, Canyon, and Payette counties. Because of prevailing wind patterns, changes in Baker County air quality would affect Payette County and impacts from Payette County air quality would dissipate at the eastern side of Ada County. The analysis period covers the 10-year lease period; however, pollutants are reported by their annual production levels.

3.4.4.2 Current Conditions and Effects of Past and Present Actions

Because of a large population base (615,335 people in 2013), Ada and Canyon counties contribute substantial amounts of nitrogen oxides (79%), PM_{10} (83%), volatile organic compounds (75%), hazardous air pollutants (87%), and GHG (80%) to the four-county total pollution (Table 6). Baker County, with a relatively small population (16,018 people in 2013) and large area (3,068 mi^2 compared with 2,047 mi^2 for the other three counties combined), accounts for 71% of methane production, while other pollutant contributions vary from 7-24% of totals. The majority of growth during the 10-year period is expected to occur in Ada and Canyon counties; therefore, pollutant contributions from growth-related activities (e.g., construction, vehicle emissions, dust, and manufacturing) in these counties would be expected remain similar or increase proportionately more than Baker and Payette counties.

3.4.4.3 Reasonably Foreseeable Future Actions

An estimated 53 wells could come into production in the Hamilton (33,400 acres) and Willow (7,000 acres outside the proposed lease area) fields (Map 1). These wells would contribute from<0.01-3.4% of most pollutants; however, they would cause a 51% increase in methane production annually. AM Idaho (Alta Mesa's Idaho subsidiary) is constructing a hydrocarbon liquid treatment (dehydrator) facility (4 miles south of New Plymouth, Idaho), an ancillary processing facility (1 mile east of New Plymouth), and associated pipelines from wells to the facilities. AM Idaho has applied for an IDEQ air quality permit for the facilities. Typical pollutants include NO_x, CO, particulate matter, HAP, and VOCs; however, the levels are unknown.

3.4.4.4 Alternative A – Cumulative Impacts

Two additional wells in the proposed lease area would have negligible additive impacts to air quality and GHG pollutants over the long term. Wells in the Hamilton and Willow fields and gas processing facilities would have minor (e.g., 3.7% CO2 eq increase in CIAA) to major (51% methane increase in CIAA) additive impacts (Table 6), whereas, with the exception of methane gas, growth-related activities would account for the majority of pollutant increases.

3.4.4.5 Alternative B– Cumulative Impacts

Twenty-two wells in the proposed lease area would have negligible additive impacts to air quality and most GHG pollutants over the long term and would account for a 1.5% increase in methane over current levels (Table 6). Pollutants from other sources would be as described in Alternative A (Section 3.4.4.4).

3.4.4.6 Alternatives C and D – Cumulative Impacts

Twenty-five wells in the proposed lease area would have negligible additive impacts to air quality and most GHG pollutants over the long term and would account for a 1.6% increase in methane over current levels (Table 6). Pollutants from other sources would be as described in Alternative A (Section 3.4.4.4).

3.5 Water Resources

3.5.1 Affected Environment – Water Resources

Surface Hydrology and Water Quality

Surface water quality in the planning area is variable due to the highly erratic discharge and moderately to highly erosive nature of the geologic parent material and soils. Perennial streams retain water year-round and have variable flow regimes. Big Willow (0.8 miles) and Little Willow (5 miles) creeks, perennial streams in the proposed lease area, are not a directly associated with proposed lease parcels. Intermittent streams flow during the part of the year when they receive sufficient water from springs, ground water, or surface sources such as snowmelt or storm events. Ephemeral streams flow only in direct response to precipitation and snowmelt. Ephemeral and intermittent streams (approximately 22 miles) occur in the proposed lease area with 8.2 miles directly associated with federal mineral estate. The Bolton and Patton irrigation canals parallel the north side of Little Willow Creek and the McIntyre and Nelson canals parallel on the south side. These canals remove the majority of water from Little Willow Creek during the irrigation season.

The National Wetland Inventory mapping identifies approximately 56 acres of wetland and riparian areas that are associated with perennial streams, canals, and ponds (Map 5). There are two springs and one seep associated with federal mineral estate. There are three ponds associated with federal mineral estate and seven other ponds in the proposed lease area. The ponds are fed by intermittent/ephemeral streams or irrigation runoff and are typically used as livestock water sources.

Big Willow Creek has an EPA approved temperature total maximum daily level (TMDL) that is not being met (IDEQ 2014). Little Willow Creek below Paddock Valley Reservoir was rated as Unassessed Waters (IDEQ 2014). In 2007, Little Willow Creek suspended sediment levels ranged from 10-165 mg/L. High levels (>30 mg/L) were associated with the irrigation season (May 1 – September 30) and IDEQ recommended a target of 22 mg/L during that period to support cold water aquatic beneficial uses.

There are 352 acres of 100-year floodplain associated with Little Willow and Big Willow creeks and an ephemeral drainage; however, only acre is associated with federal mineral estate.

The lease parcels are located within four hydrologic unit code (HUC) 6 watershed subbasins: Little Willow Creek (HUC 1705012208), Big Willow Creek (HUC 1705012207), Payette River-Snake River (HUC 1705012209), and Jacobsen Gulch – Snake River (HUC 1705011502) (Table 8). The acreage federal mineral reserve comprises between 0.06% (Payette River – Snake River) and 6.2% (Little Willow Creek) of each watershed.

Table 8. Acres and percentage of Level 6 HUC watersheds associated with federal mineral estate and Little Willow Creek lease area, Payette County, Idaho.

Watershed		Federal Mineral Reserve		Total Lease Area	
Name	Acres	Acres	% Watershed	Acres	% Watershed
Little Willow Creek	98,464	6,094	6.2	14,182	14.4
Big Willow Creek	98,919	84	0.08	694	0.7
Payette River – Snake River	177,466	106	0.06	629	0.4
Jacobsen Gulch – Snake River	91,054	67	0.07	139	0.2

Ground Water

The quality and availability of ground water varies greatly across Idaho. Residents in Payette County commonly get their ground water from aquifers consisting of unconsolidated, alluvial valley-fill materials, typically sand and gravel deposits. Alluvial aquifers occur in terrace deposits and within the floodplains, and along the channels of larger streams, tributaries, and rivers, and are important sources of ground water. Based on 41 wells in the lease area authorized by IDWR, typical domestic supply wells in the area are between 37-405 feet deep with standing water occurring at 5-330 feet and production occurring between 7-533 feet. Well water is typically used for domestic, livestock, and irrigation purposes.

Nitrate is present in shallow ground water beneath the Payette Valley at concentrations that occasionally exceed the drinking water standard of 10 milligrams per liter (mg/L; IDEQ 2012). Arsenic has been detected in exceedance of the drinking water standard of 0.010 mg/L. Fluoride has been detected occasionally at concentrations that exceed the drinking water standard of 4 mg/L, and dissolved iron and manganese have exceeded the secondary standards of 0.3 mg/L and 0.05 mg/L, respectively.

3.5.2 Environmental Consequences – Water Resources

Impacts to water resources are based on the RFDS created for this document (Table 2, Appendix 1).

3.5.2.1 General Discussion of Impacts

Surface Hydrology and Water Quality

The magnitude of the impacts to water resources would be dependent on the specific activity, season, proximity to waterbodies, location in the watershed, upland and riparian vegetation condition, effectiveness of mitigation, and the time until reclamation success. Surface disturbance effects typically are localized, short-term, and occur from implementation through vegetation reestablishment. As acres of surface-disturbance increase within a watershed, so could the effects on water resources.

Oil and gas exploration and development could cause the removal of vegetation, soil compaction, and soil disturbance in uplands within the watershed, 100-year floodplains of non-major streams, and non-riparian, ephemeral waterbodies. The potential effects from these activities could be accelerated erosion, increased overland flow, decreased infiltration, increased water temperature, channelization, and water quality degradation associated with increased sedimentation, turbidity, nutrients, metals, and other pollutants. Erosion potential can be further increased in the long term by soil compaction and low permeability surfacing (e.g. roads and well pads) which increases the energy and amount of overland flow and decreases infiltration, which in turn changes flow characteristics, reduces ground water recharge, and increases sedimentation and erosion.

Water withdrawals for drilling operations would lead to reduced aquifer water levels, reduced streamflow, and impacts to some water quality parameters associated with stream flow. These impacts to water quality may include increased water temperature, decreased concentrations of dissolved oxygen, and increases in other parameters such as salinity levels, sodium adsorption ratio, and introduction of drilling pollutants (e.g., organic acids, alkalis, diesel oil, crankcase oils, hydrochloric and hydrofluoric acids, chloride, sodium, calcium, magnesium, potassium, polycyclic aromatic hydrocarbons, lead, arsenic, barium, antimony, sulfur, zinc, and naturally occurring radioactive materials) (TEEIC 2014). Ground water removal would result in a depletion of flow in nearby streams and springs if the aquifer is hydraulically connected to such features. Typically produced water from conventional oil and gas wells is from a depth below useable aquifers.

Ground Water

Spills, drilling fluids, fracking fluids, or produced fluids could potentially impact surface and ground water resources over the long term. Drilling in the proposed lease area would most likely pass through useable ground water. Potential impacts to ground water resources could occur if proper cementing and casing programs are not followed. This could include loss of well integrity, failed cement, surface spills, and/or the loss of drilling, completion, and hydraulic fracturing fluids into groundwater. It is possible for chemical additives used in drilling activities to be introduced into ground water producing formations without proper casing and cementing of the well bore. Concentrations of these additives also vary considerably and are not always known because different mixtures can be used for different purposes in gas development and even in the same well bore. Changes in porosity or other properties of the rock being drilled can result in the loss of drilling fluids. When this occurs, drilling fluids can be introduced into ground water in the absence of proper cementing and casing. Site specific conditions and drilling practices determine the probability of this occurrence and determine the ground water resources that could be impacted. Some or all of the produced water from these leases is likely to be injected in wells for disposal. Improper construction and management of reserve and evaporation pits could degrade ground water quality through leakage and leaching.

The potential for adverse ground water impacts caused from hydraulic fracturing are currently being investigated by the EPA. Currently, water use to drill one well ranges between 1 and 6 million gallons. In fracturing a well, companies have estimated that generally they use a ratio of 0.5% hydraulic chemical fluid mix to 1.5 million gallons of water. That translates to a minimum of 5,000 gallons of chemicals into one well for every 1.5 million gallons of water used to fracture a well. In addition to changing the producing formations' physical properties by increasing the flow of water, gas, and/or oil around the well bore; hydraulic fracturing can also introduce chemical additives into the producing formations. Production zones generally do not contain fresh water. Types of chemical additives used in drilling activities may include acids, hydrocarbons, thickening agents, lubricants, and other additives that are operator and location specific. These additives are not always used in these drilling activities and some are likely to be benign such as bentonite clay and sand. Concentrations of these additives also vary considerably because different mixtures can be used for different purposes in oil and gas development and even in the same well bore. If contamination of aquifers from any source occurs, changes in ground water quality could impact springs and residential wells that are sourced from the affected aquifers.

If contamination of freshwater aquifers from oil and gas development occurs, changes in ground water quality could impact springs and residential wells if these springs and residential wells are sourced from the same aquifers that have been affected. Direct impacts to surface water would likely be greatest shortly after the start of construction activities and would likely decrease in time due to natural stabilization, and reclamation efforts. Ground water impacts would be less evident and occur on a longer time scale. Construction activities would occur over a relatively short period (commonly less than a month); however, natural stabilization of the soil can sometimes takes years to establish to the degree that would adequately prevent accelerated erosion caused by compaction and removal of vegetation. Spills or produced fluids (e.g., saltwater, oil, fracking chemicals, and/or condensate in the event of a breech, overflow, or spill from storage tanks) could result in contamination of the soil onsite, or offsite, and may potentially impact surface and ground water resources in the long term.

Not all wells resulting from an APD would employ fracturing, and water consumption would be temporary. Oil and gas wells are cased and cemented at a depth below all usable water zones; consequently impacts to water quality at springs and residential wells are not expected.

However, faulty cementing or well casing could result in methane migration to upper zones. Should hydrocarbon or associated chemicals for oil and gas development in excess of EPA/IDEQ standards for minimum concentration levels migrate into culinary water supply wells, springs, or systems, it could result in these water sources becoming non-potable.

For federal mineral estate wells, Onshore Order #2 requires that the proposed casing and cementing programs shall be conducted as approved to protect and/or isolate all usable water zones. For State-regulated wells, IDAPA 20.07.02 provides similar requirements from initial drilling to plugging. Authorization of exploration and production activities would require full compliance with local, state, and federal directives and stipulations that relate to surface and ground water protection.

3.5.2.2 Alternative A

Surface Hydrology and Water Quality

Not leasing 6,349 acres would limit surface disturbance in those areas. Vegetation and soil conditions would be maintained over the long term minimizing sediment input to waterbodies from 6% of the Little Willow Creek watershed and negligible (0.2%) portions of other watersheds (Table 8). Development of two wells and associated infrastructure (7 acres of disturbance) would have negligible (~0.001% of Little Willow Creek watershed) direct impacts to surface hydrology. Negligible (>0.25 miles from stream) to moderate (<200 feet from stream) short-term sediment inputs could occur to Little Willow Creek until vegetation reestablishment occurs. Produced water and pollutants carried by natural events would cause adverse water quality impacts where pollutants reach Little Willow Creek. The longevity and severity of the impacts would depend on the type of pollutant. Ground water depletion could adversely affect Little Willow Creek.

Ground Water

Direct development and production ground water impacts would not occur on 6,349 acres. Development of two wells could have negligible (well casings are effectively implemented) to major (well casings fail and persistent, toxic pollutants are introduced) adverse effects to ground water quality in the Little Willow Creek drainage. Up to 15 domestic and agricultural wells in the immediate vicinity and downstream could be affected.

3.5.2.3 Alternative B

Surface Hydrology and Water Quality

Leasing 6,349 acres with NSO and NSSO stipulations would limit surface disturbance in those areas. Vegetation and soil conditions would be maintained over the long term minimizing sediment input to waterbodies from 6% of the Little Willow Creek watershed and negligible (0.2%) portions of other watersheds (Table 8). Development of 22 wells and associated infrastructure (77 acres of disturbance) would have negligible to minor direct impacts to surface hydrology, primarily where roads collect and convey water rather than allowing infiltration. Impacts from sediment inputs would be similar to Alternative A (Section 3.5.2.2); however, four additional wells could be drilled near Little Willow and Big Willow creeks. Produced water and pollutant impacts could affect Little Willow and Big Willow creeks. Four additional wells would increase the probability of adverse water quality and ground water depletion impacts.

Ground Water
Direct development and production ground water impacts would not occur on 6,349 acres. Development of 22 wells could have negligible (well casings are effectively implemented) to major (persistent, toxic pollutants are introduced) adverse effects to ground water quality in the Little Willow and Big Willow drainages; however, the number of wells could increase the probability of a pollution event. Up to 54 domestic and agricultural wells in the immediate vicinity and downstream could be affected.

3.5.2.4 Alternative C

Surface Hydrology and Water Quality
Leasing 6,349 acres with CSU stipulations would limit surface disturbance in those areas. Vegetation and soil conditions would be maintained over the long term minimizing sediment input to waterbodies from 6% of the Little Willow Creek watershed and negligible (0.2%) portions of other watersheds (Table 8). Development of 25 wells and associated infrastructure (88 acres of disturbance) would have similar hydrology and sediment impacts to Alternative B (Section 3.5.2.3); however, 500 foot CSU buffers from waterbodies would help limit sediment inputs (Map 5). Fewer surface occupancy restrictions would allow wells to be placed further from streams relative to Alternative B. Produced water and pollutant impacts could affect Little Willow and Big Willow creeks; however, CSU buffers would reduce the probability of pollutants reaching waterbodies.

Ground Water
Direct development and production ground water impacts could occur on <6,162 acres. Development of 25 wells could have similar impacts to those described in Alternative B (Section 3.5.2.3); however, the probability of a pollution event could be slightly greater.

3.5.3 Mitigation

Mitigation measures that minimize the total area of disturbance, control wind and water erosion, reduce soil compaction, maintain vegetative cover, control nonnative species, and expedite rapid reclamation (including interim reclamation) would maintain surface hydrology processes and water quality. Methods to reduce erosion and sedimentation could include: reducing surface disturbance acres; installing and maintaining adequate erosion control; proper road design, road surfacing, and culvert design; road/infrastructure maintenance; use of low water crossings; and use of isolated or bore crossing methods for waterbodies and floodplains. In addition, applying mitigation to maintain adequate, undisturbed, vegetated buffer zones around waterbodies and floodplains could reduce sedimentation and maintain water quality. Lining ponds would minimize seepage of potentially toxic chemicals into ground water. Closing and rehabilitating ponds promptly, when no longer functional or needed, would exposure to toxic substances. Appropriate well completion, the use of Spill Prevention Plans, and Underground Injection Control (UIC) regulations would mitigate ground water impacts. Site-specific mitigation and reclamation measures would be described in the COAs.

Known water bearing zones in the lease area are protected by drilling requirements and, with proper practices, contamination of ground water resources would be unlikely (IOGCC 2013b; IDAPA 20.07.02). Casing along with cement would be extended well beyond fresh-water zones to insure that drilling fluids remain within the well bore and do not enter ground water. Potential impacts to ground water at site specific locations are analyzed through the NEPA review process at the development stage when the APD is submitted. This process includes geologic and engineering reviews and onsite oversight to ensure that cementing and casing programs are adequate to protect all downhole resources. All water used would have to comply with State water rights regulations and a source of water would need to be secured by industry that would not harm senior water rights holders.

3.5.4 Cumulative Impacts – Water Resources

Cumulative impacts to water resources are based on the RFDS created for this document (Appendix 1), RFDS for Hamilton and Willow fields, and the actions discussed below.

3.5.4.1 Scope of Analysis

The 65,700-acre CIAA includes portions of the Little Willow Creek, Big Willow Creek, and Payette River-Snake River (north of the Farmers Canal) Level 6 HUC watersheds downstream of the eastern boundary of the proposed lease area and the majority of the Payette Valley Flow System (Map 5). This represents an area that could potentially be affected by surface runoff and ground water pollutants. The analysis period covers the 10-year lease period; however, pollutants would be expected to travel at different rates in different systems. Surface pollutants could reach the downstream portion of the CIAA relatively quickly once they enter flowing waters. Conversely, ground water pollutants would likely take considerably longer to travel beyond the source.

3.5.4.2 Current Conditions and Effects of Past and Present Actions

Sagebrush and other shrubs (11,067 acres; 17% of CIAA), exotic annuals (13,716 acres; 21%), agriculture (35,404 acres; 54%), urban (2,271 acres; 3%), and perennial bunchgrass (2,452 acres; 4%) comprise the majority of cover types. Roads, ploughed fields and exotic annual cover provide the lowest degree of watershed protection. Watershed stability is at greatest risk where these cover types occur in moderate or highly erosive soils. Most agricultural lands are irrigated with surface (from canals) or ground water.

There are approximately 56.5 miles of perennial streams (Payette River, Little Willow and Big Willow creeks) and all are influenced by irrigation outtake and return flows. There are approximately 2,000 acres of wetland, riparian, and pond habitat. Stream and riparian conditions are similar to those described in Section 3.6.1. The 9,760 acres of floodway are primarily associated with the Payette River. There are 1,305 water wells, most occur south of the Payette River or northwest of the confluence of Little Willow Creek and the Payette River.

Potential pollutant sources include pesticides from agricultural and urban areas, chemicals from industrial and retail businesses, runoff from roadways, and 15 existing oil and gas wells. The amount of pollutants from these sources is unknown.

3.5.4.3 Reasonably Foreseeable Future Actions

At least 37 additional oil and gas wells could be drilled (1 well/640 acres in the portions of the Willow and Hamilton fields in the CIAA). Pollutants from development and production would be as described in Section 0. Wildfires, as described in other sections, would be expected to cause short-term increases in sediment inputs and watershed instability until vegetation cover is reestablished.

3.5.4.4 Alternative A – Cumulative Impacts

Surface Hydrology and Water Quality

Not leasing 6,349 acres (10% of the CIAA) would have negligible to minor additive benefits to surface hydrology and water quality. Wildfires, exotic annuals, and ploughed fields would potentially affect much larger areas. Rain events in these areas could result in minor to major sediment inputs to floodways and streams. Burned riparian areas would recover within five years, but upland areas would likely become dominated by exotic annuals and remain susceptible to erosion events. The extent of ground water withdrawal for irrigation is unknown. Irrigation water removal and return water pollutants (both agricultural and urban) would annually have moderate to major adverse water quality impacts to perennial streams. Development and production at up to 37 oil and gas wells would have negligible surface hydrology impacts, but could have negligible (no spills occur, spills are largely contained on site, or spills are non-pollutant materials) to major (spills affect domestic water supplies with toxic pollutants) adverse water quality impacts.

Ground Water

Not leasing 6,349 acres would have negligible additive ground water benefits. Agricultural activities (e.g., ground water pumping, pollution input from leaking wells) would have minor (seasonal reductions in water availability, pollution stays in immediate vicinity of well) to major (increased use of ground water during extended drought periods, pollutants migrate from well to domestic water supplies) adverse impacts to ground water availability and quality over the short and long term. Pollutants from industrial and urban sources could have minor to major short or long term adverse impact to ground water quality. Development and production at up to 37 oil and gas wells would have negligible (well casings are effectively implemented, ground water is not used to produce gas) to major (persistent, toxic pollutants are introduced; ground water is used to produce gas) adverse effects to ground water availability and quality.

3.5.4.5 Alternatives B and C – Cumulative Impacts

Surface Hydrology and Water Quality

Leasing 6,349 acres with some surface stipulations and development of 22-25 wells and associated infrastructure would have negligible to minor additive impacts to surface hydrology and increased sediment input. Minor to moderate additive water quality impacts from produced water and pollutants could occur. Impacts from other activities would be as described in Alternative A (Section 3.5.4.4).

Ground Water
Development and production at 22-25 wells would have negligible (well casings are effectively implemented) to major (persistent, toxic pollutants are introduced) adverse additive effects to ground water availability and quality. Impacts from other activities would be as described in Alternative A (Section 3.5.4.4).

3.6 Wildlife/Special Status Animals

3.6.1 Affected Environment – Wildlife/Special Status Animals
Habitats support a variety of special status wildlife including southern Idaho ground squirrel (SIDGS), a candidate species under the ESA, 14 other mammal species, 17 bird species, three amphibian species, and three reptile species (Appendix 4). Habitat conditions are described for representative groups of animals (migratory birds, southern Idaho ground squirrels, big game, and amphibians/fish).

Vegetation composition has been shaped by physical site characteristics such as aspect, soils, precipitation, and disturbances (primarily wildland fire, livestock grazing, and agricultural development). Fires and long-term spring grazing have reduced the diversity and abundance of native perennial forbs and grasses, favoring exotic annuals. The resulting conditions (Section 3.2.1) generally provide poor quality habitat for most species. Shrub-dominated communities comprise 32% of cover, annual and perennial grasslands and agriculture characterize the remainder. Although these disturbances have occurred on all aspects, native vegetation is less resilient on the hotter, drier southerly aspects than the cooler, moister northerly aspects; therefore, southerly aspects are dominated by exotic grasses and northerly aspects are dominated by native vegetation. This has resulted in major habitat fragmentation. The proposed lease area has approximately 36.6 miles of roads and trails (1.5 miles/mi^2). Access to many roads is restricted by private landowners; therefore, the majority of roads have minor fragmentation and disturbance impacts.

Migratory Birds and Raptors
The analysis area encompasses over 15,000 acres; therefore, bird habitat will be analyzed at a landscape scale, where birds are typically affected on a population level (Paige and Ritter 1999). Because the area lacks contiguous sagebrush habitat and suitable cover of native perennial bunchgrasses and forbs, it does not support stable populations of sagebrush-obligate species such as greater sage-grouse[E]. These sagebrush obligates require a large mosaic of big sagebrush cover

[E] Based on 2014 sage-grouse habitat maps developed by BLM and IDFG and lek monitoring data, the proposed lease area is approximately 1 mile from R2 (sagebrush with annual grass understory) habitat, 5 miles (isolated habitat) from key (sagebrush with perennial grass understory) and preliminary general habitat [areas outside of breeding habitat that support important seasonal (winter, summer, fall habitat, migration corridors) or year-round habitat for sage-grouse], and 6.5 miles (contiguous habitat) from key and preliminary priority [areas that have the highest conservation value (breeding, nesting, brood-rearing) to maintaining sage-grouse populations] sage-grouse habitats. The closest leks are 9.5 (active) or 10.5 (inactive) miles away.

types, inter-mixed with native bunchgrasses and forbs. Other sagebrush obligates including Brewer's sparrow, sage sparrow, and sage thrasher could be present during the spring and summer; however, these species are also sensitive to fragmented sagebrush habitats and they occur in low numbers.

Grassland associated species such as long-billed curlew, western meadowlark, vesper sparrow, and horned lark utilize short grassland habitat for nesting, breeding, and brood-rearing. Long-billed curlew populations have declined in nearby areas (i.e., Long-billed Curlew Habitat Area of Critical Environmental Concern 8-20 miles southeast of the lease area) primarily due to recreational activities and development. Between 1966 and 2012, vesper sparrow, western meadowlark, and horned lark populations in Idaho have also declined. Northern harrier, red-tailed hawk, ferruginous hawk, golden eagle, American kestrel, and turkey vulture are common birds of prey that hunt for insects, small mammals, birds, and carrion throughout the area, year-round or during annual migrations.

Riparian associated species including warblers, flycatchers, and sparrows utilize shrub and tree dominated habitat along Little Willow and Big Willow creeks for nesting, brood rearing, and foraging. Little Willow Creek provides marginal quality habitat that is substantially influenced by agricultural activities and is primarily characterized by herbaceous-dominated vegetation with scattered stands of cottonwood, willow, and Russian olive. Big Willow Creek provides good quality habitat that is characterized by a fairly contiguous cottonwood overstory with interspersed willow and herbaceous communities or understories.
Resident (e.g., golden eagle, red-tailed hawk, Cooper's hawk) and migratory (e.g., burrowing owl, short-eared owl, prairie falcon) birds use the area for nesting, brood rearing, foraging, and migration. Surveys for raptor nests have not occurred in or adjacent to the lease parcels. Although fires have degraded much of the habitat, it does provide suitable habitat for a variety of prey species including small mammals, song birds, reptiles, and insects.

<u>Burrowing Mammals</u>
Southern Idaho Ground Squirrel - Southern Idaho ground squirrels inhabit drainage bottoms and adjacent gradual slopes in small scattered populations, below approximately 3,200 feet elevation. Historically, SIDGS primarily occupied sandier soils that supported big sagebrush/bunchgrass/forb communities with antelope bitterbrush (Yensen 1991). In the absence of a reliable and nutritious diet provided by native grasses and forbs, SIDGS are subject to the highly variable productivity and nutritional value of exotic annuals. When annual precipitation is relatively low, poor productivity of exotic annuals may not provide enough nutritional sustenance to enable squirrels to store enough fat to survive their long over-wintering period (torpor). The availability of forbs plays a crucial role in the torpor persistence of juvenile male ground squirrels (Barrett 2005). Torpor begins in late June or early July when vegetation begins to dehydrate and desiccate, and lasts until late January or early February when squirrels emerge from their burrows.

Currently, SIDGS habitat is dominated by exotic annuals and provides limited sagebrush cover with perennial herbaceous understories needed to support a stable squirrel population; medusahead is common throughout the area, especially on south aspects, and is indigestible for

SIDGS due to its high silica content. The majority of known SIDGS colonies occur on adjacent private lands (IDFG 2013). There is a paucity of SIDGS monitoring data for the area, but it is likely that SIDGS utilize habitat on the northerly aspects of public land to some degree, as these areas tend to support more native vegetation.

Pygmy Rabbit - The pygmy rabbit is the smallest North American rabbit species (USFWS 2010). On September 30, 2010, the USFWS concluded that the pygmy rabbit does not currently warrant listing under the ESA (USFWS 2010). This species is typically found in areas of tall, dense sagebrush cover and are considered a sagebrush-obligate species because they are highly dependent on sagebrush to provide both food and shelter throughout the year (Green and Flinders 1980; Katzner and Parker 1997). Pygmy rabbits have been found from 2,900 feet to over 6,000 feet in elevation in southwestern Idaho. Although low sagebrush density and prevalence of cheatgrass provides marginal habitat, pygmy rabbits have been observed in the proposed lease area.

Big Game

The area provides limited winter habitat for antelope and mule deer as south slopes are typically dominated by annual grasses and do not support adequate shrub cover. Mule deer inhabiting the area are part of the Weiser-McCall Population Management Unit (IDFG 2010b). Deer winter range has been adversely impacted by wildfire, as fire has reduced the abundance of important shrub species such as bitterbrush and sagebrush that deer depend on for food and thermal cover during the winter. The spread of noxious weeds also poses a threat to mule deer winter range. The area may provide marginally better elk winter range because of their grass species dietary preferences even during winter. Elk inhabiting the area are part of the Weiser River Zone delineated by the Idaho Department of Fish and Game (IDFG). Threats to elk winter range habitat include noxious weed invasion such as yellow starthistle and whitetop (IDFG 2010a). Big game may avoid the area during late summer, fall, and winter due to lack of shrub cover on southerly slopes, reduced abundance of perennial grasses and forbs, and off-highway vehicle (OHV) activity. The proposed lease area occurs on the western edge of identified winter range and is characterized by regular human disturbance associated with low density rural residences and associated agricultural activities. Approximately 77% of the proposed lease area and 94% of lands associated with federal mineral reserves are considered big game winter range (Map 6).

Aquatic Species

Perennial and intermittent water sources provide breeding and brood-rearing habitat for a variety of amphibian, reptile, and fish species. Degraded water quality (e.g., increased temperature levels, sediment loads, and agricultural pollutants) and irrigation dewatering, especially in Little Willow Creek, may limit the suitability or productivity for some species. Adjacent uplands provide important foraging areas for amphibians and reptiles. Some species (e.g., western toad) may move up to 3.9 miles (1.2 miles on average) from breeding areas and occupy areas away from water sources (Bull 2006).

Bats

Up to 11 special status bat species could occur in the area. The species rely on natural (e.g., tress, cliffs, and caves) or manmade (e.g., buildings) structures for roosting and hibernating.

They are typically nocturnal insect foragers in a variety of habitats including forest, shrub, grass, or agriculture dominated areas. Little brown bats typically forage up to 0.6 miles from a roost area; however, ranges diminish to predominantly 0.1 miles in July when females are lactating and insect densities are high (Henry et. al. 2002).

3.6.2 Environmental Consequences – Wildlife/Special Status Animals

Impacts to wildlife are based on the RFDS created for this document (Table 2, Appendix 1).

3.6.2.1 General Discussion of Impacts

The use of standard lease terms and stipulations could minimize, but not preclude impacts to wildlife. Oil and gas development which results in surface disturbance could directly and indirectly impact aquatic and terrestrial wildlife species. The scale, location, and pace of development, combined with implementation of mitigation measures and the specific tolerance of the species to human disturbance all influence the severity of impacts to wildlife species and habitats.

Direct impacts would include disturbance or interruption of activities, vehicle collisions, powerline collisions and electrocutions, nest abandonment, habitat avoidance, displacement of wildlife species resulting from human presence and increased predation. Disturbances (e.g., natural gas development activities, OHV use) can adversely affect songbird habitat use (Ingelfinger 2001; Barton and Holmes 2007). The impacts were greatest within 330 feet of high traffic volume roads where $\leq$60% population reductions occurred even when traffic volumes were less than 12 vehicles/day. Noise and human activities can disrupt key activities such as breeding displays, brooding, and foraging. Road mortality can be influenced by travel speed, species abundance, species susceptibility, coincidence of vehicle and animal activity, and proximity to key habitats. Hawks and owls are more susceptible to electrocution especially where wingspans are wider than the line spacing, whereas quail, pheasants, ducks, and songbirds are more susceptible to collision hazards (Bevanger 1998).

Indirect impacts would include loss or reduction in suitability of habitat, improved habitat for undesirable (non-native) competitors, species or community shift to species or communities more tolerant of disturbances, barriers to species migration and dispersal, and habitat fragmentation. Increases in invasive and noxious weed species that displace native plant species would adversely affect habitat structure and quality, reducing habitat suitability for most species while favoring species that tolerate poor habitat quality.

<u>Migratory Birds and Raptors</u>

Construction and development activities can effect migratory bird's nesting season from as early as February 15; however, activity from March 15th through August 15th poses the greatest impact to migratory birds by disrupting breeding behavior and breeding success. Nest occupancy for some species (e.g., golden eagle and ferruginous hawk) may not be affected during the production phase (Wallace 2014). Response to disturbances during winter, when birds are stressed by environmental conditions could adversely affect survivability. During the winter, 97% of raptors flushed when humans on foot were within 385 feet and 38% flushed when vehicles were within 245 feet (Holmes et. al. 1993). Take of bald and golden eagles or any other migratory species would not be anticipated; however, take may occur indirectly as a result of vehicle collisions and other related actions associated with development.

Burrowing Mammals

Construction of well pads and roads could directly eliminate habitat. Vehicle traffic and increased raptor perch sites associated with powerlines and other infrastructure would increase mortality. Reduced habitat quality (e.g., increases in invasive annuals and noxious weeds) and increased fragmentation would adversely affect SIDGS annual body condition, survival rates, and population viability (Barrett 2005) and pygmy rabbit diet quality and cover (Larrucea and Brussard 2008).

Big Game

Well pad and road construction would reduce available habitat. Roads and associated disturbances would reduce suitability of adjacent habitat. Short and long-term responses to development and production activities vary by species and habitat type (Hebblewhite 2008). Mule deer avoided areas when development was initiated and did not become acclimated to activities as time passed; instead, avoidance distances increased as development progressed (Sawyer et. al. 2006). The distance animals were displaced increased from 1.7 to 2.3 miles away from well pads during the first three years of development. Mule deer densities decreased 46% in the developed area over a four year period. Animals forced to winter at higher elevations with increased snow levels would have reduced survival rates. Habitat loss and fragmentation were better predictors of antelope winter habitat use than distance to well pads and roads (Beckman et. al. 2008). In areas with relatively limited pre-development disturbance, major ungulate responses (e.g., avoidance or abandonment) could occur when oil and gas development of 0.3–1.3 wells/mi^2 and 0.3-1.6 linear road miles/mi^2 occurred (Hebblewhite 2008).

Aquatic Species

Noise and lights from development activities could disrupt breeding behavior annually. Road mortality would affect species that spend part of their life cycle in terrestrial habitats (Carr 2002). Pollutants discharged into aquatic systems could cause behavioral changes, mutations, or mortality at all life stages (Lefcort et. al. 1998).

Bats

Lights and noise associated with human activities could cause short-term disruptions in foraging behavior and success. Persistent disturbances near roost sites could cause avoidance or abandonment. Bat responses to disturbances vary by species, and some species (e.g., big brown bat) may be more tolerant than others (Duchamp et. al. 2004). Infrastructure (e.g., powerlines) could cause increased collision mortality. Actions that reduce insect productivity (e.g., reduced habitat quality, pollutants) would reduce available prey.

3.6.2.2 Alternative A

Migratory Birds and Raptors

Development of two wells and associated infrastructure would have minor adverse short- and long-term disturbance, mortality, and habitat quality reduction impacts. An additional 0.5 miles of roads would cause a negligible increase in fragmentation and disturbance. Low levels of localized disturbance would occur throughout the year over the long term. Up to 7 acres of habitat would be directly eliminated and use would be reduced on 70 acres because of disturbance.

Burrowing Mammals

Development of two wells and associated infrastructure would have minor adverse short- and long-term mortality and habitat quality reduction impacts. An additional 0.5 miles of roads and powerlines would cause a minor increase in SIDGS mortality. Up to 7 acres of habitat would be directly eliminated. Depending on the location of roads and well pads, impacts to pygmy rabbits could be negligible (development >0.35 miles from sagebrush) to major (development in an occupied sagebrush stand).

Big Game

Depending on their location and animal responses, development of two wells and associated infrastructure would have minor (wells adjacent to existing disturbances that animals have become habituated to) to major (at least one well on the east side of the lease area that effectively keeps animals from using the remainder of the lease area) disturbance impacts. Changes in habitat fragmentation (beyond the disturbance component) and habitat quality would have minor adverse long-term impacts. Animals habituated to low levels of disturbance could be displaced to adjacent agricultural areas over the short term when moderate or greater development disturbances occur during winter use periods.

Aquatic Species

Depending on their location, development of two wells and associated infrastructure would have negligible (>0.5 miles from wetland/riparian habitat with no possibility of pollution input) to moderate (<0.1 miles from wetland/riparian habitat with potential pollution input) disturbance and pollutant impacts.

Bats

Development of two wells and associated infrastructure would have negligible (located >0.75 miles from roost sites) to minor (located <0.5 miles from roost sites) adverse short- and long-term disturbance, mortality, and prey reduction impacts.

3.6.2.3 Alternative B

No direct habitat loss (77 acres of well pads and roads) would occur on the 6,349 acre federal mineral estate until the FRMP was implemented; however, loss could occur in adjacent areas that are developed prior to FRMP implementation. Stipulations derived from the FRMP could help mitigate impacts described below.

Migratory Birds and Raptors

Development of 22 wells and associated infrastructure would have moderate to major adverse short- and long-term disturbance, mortality, and habitat quality reduction impacts. An additional 5.5 miles of roads would cause a major increase in fragmentation and disturbance because regular activity would occur in most of the proposed lease area. Moderate levels of disturbance would occur throughout the year and lease area over the long term. Up to 77 acres of habitat would be directly eliminated and use would be reduced on 770 acres because of disturbance.

Burrowing Mammals
Development of 22 wells and associated infrastructure would have moderate to major adverse short- and long-term mortality and habitat quality reduction impacts. An additional 5.5 miles of roads and powerlines would cause minor to moderate increases in SIDGS mortality. Up to 77 acres of habitat could be directly eliminated. Habitat quality changes would adversely affect both species; however, impacts to pygmy rabbits would be greater because of their year-round activity patterns. Depending on the location of roads and well pads, impacts to pygmy rabbits could be negligible (development >0.35 miles from sagebrush) to major (development in an occupied sagebrush stand).

Big Game
Development of 22 wells (1 well/mi^2) and associated infrastructure would have moderate to major adverse short- and long-term disturbance, habitat fragmentation, and habitat quality reduction impacts. Road densities would increase to 1.7 miles/mi^2, but vehicle traffic throughout the area would increase substantially, especially during the development phase. Existing unmaintained roads would be upgraded and become potentially more accessible throughout the year and to a greater number of users, increasing disturbance and fragmentation. Access restrictions by private landowner could limit disturbances to development and production activities. The activities would make the area unsuitable winter range for animals that do not become habituated to higher disturbance levels. Animals habituated to low levels of disturbance could be displaced to adjacent agricultural areas over the short and long (until development is completed) term when moderate or greater development disturbances occur during winter use periods. Increases in invasive and noxious weed species would further degrade habitat; however, improved access that helps fire suppression efforts could reduce fire size and associated habitat loss.

Aquatic Species
Development of 22 wells and associated roads would have minor to moderate adverse short- and long-term disturbance, mortality, and pollutant impacts. Ponds and streams downslope from well pads would be most susceptible to surface-flow pollutant impacts. Contaminated ground water that connects to streams could have negligible (short-term, non-toxic pollutants) to major (persistent toxicant introduced) adverse impacts on up to 5.8 miles of perennial streams in the proposed lease area and potentially downstream areas.

Bats
Development of 22 wells and associated infrastructure would have minor (disturbance located >0.75 miles from roost sites) to moderate (located <0.5 miles from roost sites) adverse short- and long-term disturbance, mortality, and prey reduction impacts. Disturbance tolerant species would be less affected than intolerant species. Reduced insect production associated with decreased habitat quality would adversely affect all species over the long term.

3.6.2.4 Alternative C

Migratory Birds and Raptors

Development of 25 wells and associated infrastructure would have similar disturbance, mortality, and habitat quality reduction impacts as described in Alternative B (Section 3.6.2.3). An additional 6.8 miles of roads would cause a major increase in fragmentation because roads would occur throughout the lease area. Up to 88 acres of habitat would be directly eliminated and use would be reduced on 875 acres because of disturbance. Winter and spring surface use restrictions would reduce or eliminate lessee-related disturbance and mortality impacts during critical periods; however, increased access by non-lessee users could offset those benefits. No surface occupancy within 0.5 miles of heron rookeries would minimize lessee-related disturbances and habitat impacts.

Burrowing Mammals

Development of 25 wells (1 well/mi^2) and associated infrastructure would have moderate adverse short- and long-term mortality and habitat quality reduction impacts. An additional 6.8 miles of roads and powerlines would cause minor to moderate increases in SIDGS mortality. Avoidance of burrow sites would eliminate direct impacts to those important areas, but up to 88 acres of foraging habitat could be eliminated and infrastructure that increases disturbance and raptor perch sites could adversely affect adjacent burrow sites. Habitat quality change impacts would be as described in Alternative B (Section 3.6.2.3). Controlled surface use restrictions would benefit burrowing mammals that occur in restricted areas by reducing (winter and spring restrictions that coincide with critical periods of pygmy rabbits) or eliminating (spring restrictions that coincide with SIDGS active periods) lessee-related disturbances.

Big Game

Development of 25 wells and associated infrastructure would have moderate to major adverse short- and long-term disturbance, habitat fragmentation, and habitat quality reduction impacts. Road densities would increase to 1.8 miles/mi^2, but controlled surface use restrictions would reduce or eliminate lessee-related disturbances during the winter. If exceptions are granted to surface use restrictions, then disturbances from development and production activities could have minor (1-2 one-day exceptions during the course of a winter) to major (exceptions throughout the winter) short and long terms impacts similar to those described in Alternative B (Section 3.6.2.3). If exceptions are minimalized, animals would be less likely to move to adjacent agricultural lands (as described in Alternative B, Section 3.6.2.3). Other road-related and habitat quality impacts would be as described in Alternative B (Section 3.6.2.3). Overall winter range suitability could be similar to Alternative B or slightly improved depending on how animals respond to infrastructure and wells despite surface use restrictions.

Aquatic Species

Surface occupancy and pollutant restrictions would minimize or eliminate development and production related disturbance, mortality, and pollutant impacts to key aquatic habitat. Development of 25 wells and associated roads would have minor to moderate adverse short- and long-term disturbance and mortality impacts to species that utilize areas >500 feet from riparian habitats.

Bats

Development of 25 wells and associated infrastructure would have similar disturbance, mortality, and prey reduction impacts described in Alternative B (Section 3.6.2.3). Spring controlled surface use restrictions and riparian habitat buffers would benefit bats by reducing or eliminating activities in important foraging and roosting areas.

3.6.3 Mitigation

Measures would be taken to prevent, minimize, or mitigate impacts to terrestrial and aquatic species from exploration and development activities. Lease stipulations to mitigate impacts on wildlife would be placed on leases for crucial winter range (timing limitation), migratory birds and raptors (controlled surface use), burrowing mammals (lease notice), Endangered Species Act (Section 7 Consultation), and fragile soils (lease notice) stipulations which would protect additional habitat. Prior to authorization, activities would be evaluated on a case-by-case basis, and the project could be subject to additional mitigative COAs. Mitigation could include rapid revegetation, project relocation (<660 feet), or pre-disturbance wildlife species surveying. If oil and gas development is proposed in suitable habitat for threatened or endangered species, consultation with the USFWS would occur to determine if additional terms and conditions would need to be applied. Adherence to Avian Powerline Interaction Committee (APLIC) guidelines could help reduce or eliminate electrocution mortality.

The following operational measures would help reduce wildlife impacts. If drilling operations require evaporation ponds, cover ponds with nets to exclude migratory birds. Ponds should be checked frequently (daily) for trapped wildlife. Report trapped wildlife (live and dead) to BLM, FWS, and IDFG no later than 24 hours of initial discovery. Lighting at sites should be directed specifically to where needed to minimize potential impacts to wildlife and turned off when not in use. To minimize predators or nuisance wildlife at work sites, place an appropriately sized dumpster with lid at each site during construction activities and check/dump as needed. Prohibit workers from bringing dogs to well sites during drilling and site maintenance actions to avoid predation/harassment of wildlife. Enforce speed limits of 25 MPH on spur roads and well pads to reduce wildlife collision risk.

3.6.4 Cumulative Impacts - Wildlife/Special Status Animals

Cumulative impacts to wildlife are based on the RFDS created for this document (Appendix 1) and the actions discussed below.

3.6.4.1 Scope of Analysis

The 81,518-acre CIAA (13% BLM, 4% State, and 83% private) includes a 3-mile buffer around the proposed lease area and north of the Payette River (Map 6). This area was selected because it corresponds to typical foraging or dispersal movements or disturbance response distances for a variety of species. The lease period of 10 years will be used for the temporal analysis limit because most disturbance impacts are associated with lease activities and site reclamation would address some longer term impacts such as habitat quality and fragmentation.

3.6.4.2 Current Conditions and Effects of Past and Present Actions

The CIAA supports the same species described above. Migratory birds and raptors are common throughout the area. Pygmy rabbits are uncommon and SIDGS are present throughout most of the area. About 60% of the area, primarily in the north and east, is considered big game winter range. Approximately 36 miles of perennial streams and river provide marginal to suitable habitat for aquatic species.

Vegetative Cover and Habitat Conditions – Sagebrush and other shrubs (26,809 acres; 33% of CIAA), exotic annuals (29,807 acres; 37%), agriculture/urban (16,531 acres; 20%), and perennial bunchgrass (7,936 acres; 10%) comprise the majority of cover types. Sagebrush understory conditions vary by slope and aspect, with steeper and north facing slopes generally having a more intact native understory than gentler and south facing slopes. Approximately 79% of the area has burned one or more times, with most of the fires occurring during the 1980s. Where shrubs have become re-established in areas burned prior to 1990, exotic annuals are dominant or co-dominant in the understory. Conditions on the Little Willow (14 miles) and Big Willow (11.8 miles) creeks are similar to those described above. The Payette River (9.8 miles) is characterized by cottonwood and willow overstories with shrub and herbaceous understories.

Disturbance – The CIAA is characterized by low density rural development. Disturbance factors include agricultural activities, OHV use, hunting, and other recreational uses. Nonresident access is restricted in much of the CIAA by private landowners. Recreational use is greatest during the spring and fall.

Roads – There are approximately 197 miles of roads (1.5 miles/mi^2) including 9.3 miles of highway, 45 miles of maintained roads, and 142.7 miles of unmaintained roads. The majority of maintained roads are associated with developed areas on Little Willow and Big Willow creeks or the Payette River. There are 9 miles of designated trails east of the Big Willow and Stone Quarry roads junction. Within big game winter range, approximately 1,172 acres are designated as closed to motorized vehicles, 127 acres are designated as open, and the remainder are designated limited to existing roads.

Powerlines - The CIAA includes two transmission lines (26.5 miles) and numerous distribution lines (74.7 miles). Transmission lines are built to APLIC standards; however, most distribution lines are not. Therefore, both types represent collision hazards, but only the distribution lines represent electrocution hazards. The majority of distribution lines are within 0.3 miles of Little Willow and Big Willow creeks or the Payette River.

Livestock Grazing – The CIAA includes all or portions of 10 BLM-administered livestock grazing allotments (32,550 acres; 40% of CIAA). The allotments are used primarily during the spring, with some season long (e.g., Kauffman) or winter (e.g., Sand Hollow) use occurring. Undeveloped private lands outside BLM allotments and agricultural fields (fall-winter) are also used for grazing.

3.6.4.3 Reasonably Foreseeable Future Actions

Oil and Gas Lease Development and Production – There are 11 existing or planned wells (Map 1, IOGCC 2014). There are approximately 4,960 acres of State-managed mineral resources, some of which have been leased, but drilling has not been initiated. Exploration is currently being conducted in the eastern two-thirds of the CIAA. Approximately 15 wells could be drilled in the Willow Field between the Payette River and the proposed lease area.

Agricultural/Residential Development – Development causes a direct loss of wildlife habitat and activities associated with the developed areas can cause disturbance over the long term. Limited residential development would occur on the western boundary of the CIAA. Negligible increases in agricultural development would be expected because of limited water resources. If water resources decline, some fields could go fallow, creating marginal wildlife habitat. New development would require additional powerlines and other infrastructure.

Recreation Uses – Off-highway vehicle use would be expected to remain static (e.g., increased access restrictions imposed by private landowners) or increase (e.g., in response to increasing populations) over time. Approximately 384 acres along the Payette River are managed by the IDFG in the Payette River Wildlife Management Area to benefit wildlife and sportsmen.

Wildfire – Although not planned events, wildfires would be expected to periodically occur and may increase in size and frequency in response to climate change. Loss of shrubs and increased dominance of exotic annuals in burned areas would reduce habitat structure and quality over the short term. Adverse effects would persist over the long term where native perennials don't re-establish.

3.6.4.4 Alternative A – Cumulative Impacts

Two additional wells and associated infrastructure would have negligible additive disturbance, mortality, habitat quality reduction, and fragmentation impacts over the short and long term. Ongoing activities and existing roads and powerlines would cause minor (away from developed areas) to moderate (adjacent to developed areas along Little Willow and Big Willow creeks) disturbance and mortality impacts throughout the CIAA. Livestock grazing, especially in consistent spring use areas, would favor exotic annuals and early seral native and non-native species throughout undeveloped portions of the CIAA. Development and production activities of at least 26 wells would have moderate disturbance, mortality, and fragmentation impacts over the short and long term on approximately 20% of the CIAA. The majority of wells would be within 0.5 miles of perennial streams, but only nine wells would be within 1.5 miles of big game winter range. Additional agricultural and residential development would have minor disturbance, habitat loss, and fragmentation impacts over the long term. Depending on size, wildfires would have minor to major long-term adverse impacts on habitat quality and fragmentation.

3.6.4.5 Alternatives B and C – Cumulative Impacts

Development and production activities at 22 to 25 wells in the proposed lease area would have moderate additive disturbance, mortality, habitat quality reduction, and fragmentation impacts over the short and long term. Timing and other restrictions in Alternative C wells would help reduce spatial and temporal overlap with other disturbances (e.g., other oil and gas development, recreation use) and habitat quality and fragmentation impacts. Impacts from ongoing and foreseeable future actions would be as described in Alternative A (Section 3.6.4.4).

3.7 Cultural Resources

3.7.1 Affected Environment – Cultural Resources

The BLM is responsible for identifying, protecting, managing, and enhancing cultural resources which are located on public lands, or that may be affected by BLM undertakings on non-Federal lands, in accordance with the National Historic Preservation Act (NHPA) of 1966, as amended. The procedures for compliance with the NHPA are outlined in regulation under 36 CFR 800. Cultural resources include archaeological, historic, and architectural properties, as well as traditional life-way values and/or traditional cultural properties important to Native American groups.

Common prehistoric archaeological site types in Payette County include rock art, artifact scatters, burials, and tool manufacture. Common historic archaeological sites are the remains of farmsteads, homesteads, depressions, artifact scatters, foundations, cabins, sheepherder camps, and historic inscriptions.

A literature search (Level I or Class I) of Idaho State Historic Preservation Office records and a 2001 Class III survey (498 acres associated with Idaho Power right-of-way) identified 11 sites within a one-mile search radius. Records were reviewed to determine what types and numbers of known cultural resources are present within or adjacent to the lease area. Seven sites are prehistoric, three sites are historic, and one site includes prehistoric and historic artifacts. None of the sites were considered eligible for listing on the National Register of Historic Places (NRHP).

3.7.2 Environmental Consequences – Cultural Resources

Impacts to cultural resources are based on the RFDS created for this document (Table 2, Appendix 1).

3.7.2.1 General Discussion of Impacts

Ground disturbing activities could alter the characteristics of an eligible property by diminishing the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Other effects to cultural resources from surface disturbance activities include the destruction, damage, or alteration to all or part of the cultural resource and diminishing the property's significant historic features as a result of the introduction of visual, atmospheric, or audible elements. Activities that adversely affect adjacent vegetation conditions and soil stability could increase erosion that would degrade or destroy site context.

3.7.2.2 Alternative A
Development of two wells and associated infrastructure could adversely affect cultural resources on private lands.

3.7.2.3 Alternative B
Leasing with a NSO stipulation would preclude ground disturbing impacts to cultural resources on 6,349 acres. Changes in vegetation condition and erosion could have negligible long-term impacts for eligible properties adjacent to ground disturbing activities.

3.7.2.4 Alternative C
Compliance with Cultural Resources S-2 would ensure that no sites would be disturbed or destroyed before they are inventoried and evaluated for eligibility for listing in the NRHP. Historic and archeological sites that are eligible for listing in the National Register of Historic Places or potentially eligible to be listed would either be avoided or have the information in the sites extracted through archeological data recovery prior to surface disturbance.

3.7.3 Mitigation
Specific mitigation measures including site avoidance, excavation, or data recovery would have to be determined when site-specific development proposals are received. Most surface-disturbing situations for cultural resources would be avoided by project redesign or relocation. Unavoidable, significant properties would be site-specifically mitigated with concurrence with the State Historic Preservation Office prior to implementation of a project.

3.7.4 Cumulative Impacts – Cultural Resources
Because the alternatives would cause none to negligible impacts to cultural resources, cumulative impacts will not be discussed.

3.8 Paleontological Resources

3.8.1 Affected Environment – Paleontological Resources
According to Section 6301 of the Paleontological Resource Protection Act of 2009 Omnibus Public Lands Bill, Subtitle D, SEC. 6301, paleontological resources are defined as "any fossilized remains, traces, or imprints of organisms, preserved in or on the earth's crust, that are of paleontological interest and that provide information about the history of life on earth" (Paleontological Resource Protection Act of 2009 Omnibus Lands Bill, Subtitle D, SEC. 6301-3612 (P.L. 59-209; 34 Stat. 225; 16 U.S.C. 431-433). Significant fossils are defined by BLM policy as including all vertebrate fossil remains and those plant and invertebrate fossils determined to be scientifically unique, on a case-by-case basis. Paleontological resources do not include archaeological and cultural resources.

The proposed lease area includes Miocene (sedimentary rocks associated with flood basalts; 5-23 million years BP) and Pleistocene and Pliocene (older sediments and sedimentary rocks, gravel, sand, and silt deposited in fans; 11,700 to 5.3 million years BP) epochs, and Quaternary (alluvial gravel, sand, and silt deposits associated with Little and Big Willow creeks; 0-2.6 million years

BP) period deposits. Paleontological surveys have not been conducted in the proposed lease area; however, a diversity of fossiliferous resources could be expected to occur and fossilized remains of horse, beaver, camel, and elephant-like animals have been found in the Glenns Ferry Formation (Erasthem-Vanir 2009).

The BLM utilizes the Potential Fossil Yield Classification (PFYC) as a planning tool for identifying areas with high potential to yield significant fossils. The system consists of numbers ranging from 1-5 (low to high) assigned to geological units, with 1 being low potential and 5 being high potential to have significant fossil resources. The potential to yield significant fossil resources is never 0. It is anticipated that most significant fossil resources are located in those geologic units with a PFYC of 3 or greater. However, significant fossil resources could be discovered anywhere. Rock units not typically fossiliferous can in fact contain fossils in unique circumstances.

The BLM classified geologic formations that have a high Potential Fossil Yield Classification (PFYC) of 3 or higher should be specifically reviewed for paleontological resources. Much of the proposed lease area falls within the Glenns Ferry Formation which has a Class 5 PFYC and should be evaluated for fossil resources before and potentially during ground-disturbing activities.

3.8.2 Environmental Consequences – Paleontological Resources

Impacts to paleontological resources are based on the RFDS created for this document (Table 2, Appendix 1). The analysis assumes that surveys conducted prior to ground disturbing activities would identify paleontological resources on the surface (see CSU 12 and LN 7).

3.8.2.1 General Discussion of Impacts

Surface-disturbing activities could potentially alter the characteristics of paleontological resources through damage, fossil destruction, or disturbance of the stratigraphic context in which paleontological resources are located, resulting in the loss of important scientific data. Identified paleontological resources could be avoided by project redesign or relocation before project approval which would negate the need for the implementation of mitigation measures. Increased public access could result in vandalism or collection of paleontological resources. Conversely, surface-disturbing activities could potentially lead to the discovery of paleontological localities that would otherwise remain undiscovered due to burial or omission during review inventories. The scientific retrieval and study of these newly discovered resources would expand our understanding of past life and environments of Idaho.

3.8.2.2 Alternative A

Infrastructure development associated with two wells could directly impact paleontological resources on up to 7 acres on private lands. Increased public access could expose areas surrounding new roads to negligible to minor vandalism or collection impacts.

3.8.2.3 Alternative B

Infrastructure associated with 22 wells would not occur on 6,349 acres of BLM-administered and split estate lands; therefore, there would be no direct impacts to paleontological resources in these areas. Direct impacts could occur on up to 77 acres of private lands where development does occur. Increased access could have negligible (private landowners restrict public access) to moderate (access is not restricted) vandalism and collection impacts.

3.8.2.4 Alternative C

Infrastructure development associated with 25 wells could directly affect up to 88 acres; however, identification and avoidance or documentation/collection would minimize these impacts. Impacts from increased access would be as described in Alternative B (Section 3.8.2.3).

3.8.3 Mitigation

The application of lease terms, the paleontological conditional surface use stipulation (CSU 11), and the paleontological lease notice (LN 7) at leasing, provides protection to paleontological resources during development. The paleontological lease notice is applied to all lease parcels, requiring a field survey prior to surface disturbance. These survey requirements could result in the identification of paleontological resources. Avoidance of significant paleontological resources or implementation of mitigation prior to surface disturbance would protect paleontological resources.

However, the application of lease terms only allows the relocation of activities up to 200 meters, unless otherwise documented in the NEPA document, and cannot result in moving the activity off lease. Specific mitigation measures could include, but are not limited to, site avoidance or excavation. Avoidance of paleontological properties would be a best management practice. However, should a paleontological locality be unavoidable, significant fossil resources must be mitigated prior to implementation of a project. These mitigation measures and contingencies would be determined when site specific development proposals are received.

3.8.4 Cumulative Impacts – Paleontological Resources

Because paleontological resource impacts would be avoided or mitigated on BLM-administered and split estate lands, cumulative impacts will not be discussed.

3.9 Recreation

3.9.1 Affected Environment – Recreation

BLM only manages recreational opportunities and experiences on BLM-administered surface lands. Recreational activities enjoyed by the public on BLM lands in the proposed lease area include hunting, hiking, and OHV activities. Benefits and experiences enjoyed by recreational users include opportunities for solitude, spending time with families, enhancing leisure time, improving sports skills, enjoying nature, and enjoying physical exercise. The 997 acres of BLM-administered lands proposed for lease have limited legal public access (i.e., no public easements or rights-of-way across private property). The lack of public access limits use of the BLM parcels for recreational use by the general public. None of the BLM-administered lands occur in special recreation management areas (SRMAs) or recreation areas. Motorized use on BLM-administered lands is limited to existing roads and trails.

3.9.2 Environmental Consequences – Recreation

Impacts to recreation are based on the RFDS created for this document (Table 2, Appendix 1).

3.9.2.1 General Discussion of Impacts

Road construction that leads to or across BLM-administered lands would create or improve public access to those lands. However, access across private lands between public rights-of-way and public lands would still be at the discretion of the landowner. Noise and traffic associated with development and production could detract from the rural physical and social setting or disrupt some activities (e.g., hunting).

3.9.2.2 Alternative A

Infrastructure development associated with two wells would create none to negligible increases in BLM-administered land access. Public lands would be beyond the potential well sites; therefore, no new roads would be constructed to BLM-administered lands. Development and production activities would cause negligible adverse changes in user experiences.

3.9.2.3 Alternative B

Infrastructure associated with 22 wells would not occur on 6,349 acres of BLM-administered and split estate lands; therefore, there would be none to negligible increases in BLM-administered land access. Development and production activities would cause minor to moderate (e.g., activities adversely affect game species) adverse changes in user experiences.

3.9.2.4 Alternative C

Infrastructure development associated with 25 wells would create minor improvements in BLM-administered land access. Most BLM parcels have existing road access; therefore, upgrading those roads could allow better year-round access by a wider range of users. Development and production activities could cause minor to moderate (e.g., activities adversely affect game species) adverse changes in user experiences.

3.9.3 Mitigation

Because of the isolated nature of public lands in the area, no mitigation would be required.

3.9.4 Cumulative Impacts - Recreation

Because the alternatives would cause primarily none to minor impacts to recreation activities and experiences and public land access is at the discretion of private landowners, cumulative impacts will not be discussed.

3.10 Visual Resources Management

3.10.1 Affected Environment – Visual Resources Management

Visual Resource Management (VRM) is the system used to designate and manage the visual resources on public land. In the lease area, the CRMP designated 112 acres as Class III and 885 acres as Class IV (Map 7). A Class III VRM area classification means the level of change to the character of the landscape should be moderate. Changes caused by management activities should not dominate the view of the casual observer and should not detract from the existing landscape features. Any changes made should repeat the basic elements found in the natural landscape such as form, line, color and texture. A Class IV VRM area classification means that the characteristic landscape can provide for major modification of the landscape. The level of change in the basic landscape elements can be high. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements. An existing 230 kV line traverses Class III and IV lands in the northern portion of the proposed lease area. Human influences are relatively unnoticeable on the remainder of BLM-administered lands that are characterized by mixed vegetation communities, fencing, and unimproved two-track roads.

3.10.2 Environmental Consequences – Visual Resources Management

Impacts to visual resources are based on the RFDS created for this document (Table 2, Appendix 1).

3.10.2.1 General Discussion of Impacts

Disturbance of existing vegetation and creation of permanent linear (e.g., roads, powerlines) and point (e.g., well pads and structures) features would alter the form, line, color, and texture of the natural landscape.

3.10.2.2 Alternative A

Development of two wells on private lands would have no impact on VRM characteristics.

3.10.2.3 Alternative B

Development of 22 wells on private lands would have no impact on VRM characteristics.

3.10.2.4 Alternative C

Development of wells and associated infrastructure on BLM-administered lands could have negligible (Class IV) to minor (Class III) adverse impacts on visual resources. It would introduce more noticeable man-made structures to the natural environment.

3.10.3 Mitigation

All oil and gas development would implement, as appropriate for the site, BLM BMPs for VRM, regardless of the VRM class. This includes, but would not be limited to, proper site selection, reduction of visibility, minimizing disturbance, selecting color(s)/color schemes that blend with the background and reclaiming areas that are not in active use. Repetition of form, line, color and texture when designing projects would reduce contrasts between landscape and development. Wherever practical, no new development would be allowed on ridges. Overall, the goal would be to not reduce the scenic values that currently exist.

3.10.4 Cumulative Impacts – Visual Resources Management

Because the changes associated with the potential development would be in conformance with VRM guidance for Class III and IV lands, cumulative impacts will not be discussed.

3.11 Lands and Realty

3.11.1 Affected Environment – Lands and Realty

Lands and realty actions will only occur on BLM-administered surface lands. The affected environment consists of 997 acres of BLM-administered public lands (or 16% of the total acreage proposed for lease). Rights-of-way currently exist for an Idaho Power 230-kV powerline (IDI-13054; 0.53 miles long by 100 feet wide; 6.4 acres) and associated access roads (1.71 miles of roads 14 feet wide; 2.9 acres) and for the Little Willow Irrigation District's Nelson Canal (IDB-0019666; 0.12 miles) (Map 7).

3.11.2 Environmental Consequences – Lands and Realty

3.11.2.1 General Discussion of Impacts

Standard oil and gas lease terms recognize prior existing rights. Development activities could require rights-of-way that overlay and adversely affect existing rights-of-way. Rights-of-way applications would be analyzed through a NEPA process that would identify potential resource impacts which would likely be similar to impacts described in this document.

3.11.2.2 Alternative A

Development of two wells and associated infrastructure would not affect existing public lands or rights-of-way. The IDI-13054 right-of-way is >2 miles north of the proposed well sites.

3.11.2.3 Alternative B

Development of 22 wells and infrastructure outside BLM-administered mineral rights would not directly affect IDI-13054. Activity could occur within a 0.6-mile segment of the powerline corridor that occurs on private lands.

3.11.2.4 Alternative C

Development of 25 wells and associated infrastructure would have a negligible impact on IDI-13054. Roads associated with the right-of-way could be improved and used for oil and gas infrastructure which would improve access to the powerline. The powerline right-of-way occupies <1% of BLM-administered lands and occurs to the north of where infrastructure would likely occur; therefore, it could be readily avoided.

3.11.3 Mitigation

The split estate lease notice would require the lessee to attempt to work with the surface owner through execution of a Surface Use Agreement. A bond would be required, for the benefit of the surface owner, if no agreement was reached. Measures would be taken to avoid disturbance or impacts to existing rights-of-way, in the event of any oil and gas development activities. Any new "off-lease" or third party rights-of-way required across federal surface for exploration and/or development would be subject to lands and realty stipulations to protect other resources as determined by environmental analyses. In order to protect the existing rights-of-way it is recommended that LN-7 be applied to lease parcels associated with IDI-13054 and IDB-0019666.

3.11.4 Cumulative Impacts - Lands and Realty

Because the alternatives would cause no or negligible impacts to the existing rights-of-way, cumulative impacts will not be discussed.

3.12 Livestock Management

3.12.1 Affected Environment – Livestock Management

The proposed lease area includes portions of five BLM-administered grazing allotments (Map 8). The allotments are permitted for cattle and use periods are in the spring, spring through fall, or winter (Table 9). Total allotment sizes range from 1,488 acres (Danke Allotment) to 15,643 acres (Sand Hollow Allotment), with federal mineral estate affecting 306 acres (Sand Hollow Allotment) to 1,095 acres (Danke Allotment) (Table 10). The allotments have several range improvements including fences, stock ponds, wells, and roads (Map 8). Livestock grazing is not currently permitted on 184 acres of BLM-administered lands in the proposed lease area.

Table 9. Permit information for five allotments affected by proposed Little Willow Creek lease, Payette County, Idaho.

Allotment		Permittee	Livestock		Season of Use	Permitted AUMs
Name	Number		Kind	#		
Dannke	00084	Larry Dahnke	C	150	4/1 – 5/15	58
Hashagen	00248	Wolfe Ranches	C	112	3/16 – 4/15*	114
Kauffman	00163	Randall	C	200	4/1 – 10/10**	25
Rock Quarry Gulch	20131	Kauffman	C	130	4/11-8/10	115
Sand Hollow	00254	Rocky Comfort Cattle Co.	C	1,302	10/26-3/15***	1,509

*Season and numbers are not restricted to those shown above provided overuse and deterioration do not occur to the federal range.

**Livestock numbers will be coordinated between BLM and the Lessee and may vary within the permitted use period, however, AUMs may not be exceeded. Any change to the scheduled use requires prior approval.

***Season and numbers of livestock are not restricted to those shown above provided overuse and deterioration does not occur to the public lands and the use is covered by the OX CRMP.

Table 10. Federal mineral reserve acres by allotment, amount of allotment in lease area, and total allotment size (acres) for five allotments affected by proposed Little Willow Creek lease, Payette County, Idaho.

Allotment	Federal Mineral Reserve		Lease Area		Allotment Total			
	BLM	Private	BLM	Private	BLM	State	Private	Total
Dannke	269	826	269	992	496	0	992	1,488
Hashagen	198	743	198	1,619	511	0	1,901	2,412
Kauffman	57	613	57	1,335	67	0	1,770	1,837
Rock Quarry Gulch	217	824	217	1,620	563	0	1,940	2,503
Sand Hollow	59	247	59	669	4,935	603	10,105	15,643

There are 23.1 miles of allotment boundary and 3.5 miles of pasture fencing in the five allotments. Natural or reservoir water sources occur in the Hashagen and Kaufman allotments.

3.12.2 Environmental Consequences – Livestock Management

Impacts to livestock management are based on the RFDS created for this document (Table 2, Appendix 1).

3.12.2.1 General Discussion of Impacts

Standard oil and gas lease terms recognize prior existing rights. Oil and gas development would result in a loss of vegetation for livestock grazing (e.g., direct removal, introduction of unpalatable plant species), decreased vegetation palatability due to fugitive dust, disrupted livestock management practices, increased vehicle collision injuries and mortalities, altered water quality and availability, and decreased grazing capacity (Fowler and Witte 1985). These impacts would vary from short-term impacts to long-term impacts depending on the development level, reclamation success, and the type of vegetation removed.

Oil and gas development activity would reduce BLM's ability to manage livestock grazing while meeting or progressing towards meeting the Idaho Standards of Rangeland Health (USDI 1997). Development and associated disturbances could reduce available forage or alter livestock distribution which could lead to overgrazing or other localized grazing impacts. Construction of roads, especially in areas of rough topography could improve livestock distribution.

3.12.2.2 Alternative A

Development of two wells and associated infrastructure would occur outside and, therefore, would not directly affect BLM-administered allotments. Negligible impacts from fugitive dust could occur.

3.12.2.3 Alternative B

Development of 22 wells and associated infrastructure on private lands would have negligible (Sand Hollow Allotment) to minor (Hashagen and Rock Quarry Gulch allotments) vegetation loss, palatability, collision, and capacity impacts over the short and long term. Approximately 32% of the development could occur in the allotments (2,982 acres of private lands with no split estate minerals in the allotments/9,292 acres in the proposed lease area); therefore, direct habitat loss would occur on approximately 25 acres (7 wells and 1.75 miles of roads). Changes in palatability and desirable species composition adjacent to roads would depend on the amount of dust generated and the distance it travelled. Roads that cross allotment or pasture boundaries could have moderate to major disruption impacts where animals are able to freely move between use areas. Changes in water availability and quality could occur in the Hashagen and Kaufman allotments. Minor adverse rangeland health impacts could occur on BLM-administered lands, primarily in the Danke, Hashagen, and Rock Quarry Gulch allotments where BLM-administered lands make up 21-25% of the allotment within the proposed lease area.

3.12.2.4 Alternative C

Development of 25 wells and associated infrastructure on private lands would have negligible (Sand Hollow Allotment; e.g., no direct impacts, possible dust and disturbance impacts) to moderate (Danke Allotment; e.g., reduced forage capacity caused by increased weeds) vegetation loss, palatability, collision, and capacity impacts over the short and long term. Based on allotment acreages and well spacing, none (Sand Hollow Allotment) to two wells (Danke, Hashagen, and Rock Quarry Gulch allotments) could be developed. Direct loss of vegetation would be ≤7 acres in a given allotment and 25 acres total in the five allotments. Impacts to livestock operations, water, and rangeland health would be as described in Alternative B (Section 3.12.2.3).

3.12.3 Mitigation

Measures would be taken to prevent, minimize, or mitigate impacts to livestock grazing from exploration and development activities. Prior to authorization, activities would be evaluated on a case-by-case basis, and the project would be subject to mitigation measures. Mitigation could potentially include controlling livestock movement by maintaining fence line integrity, fencing facilities, installing cattleguards, re-vegetation of disturbed sites, and fugitive dust control.

3.12.4 Cumulative Impacts - Livestock Management

Cumulative impacts to livestock management are based on the RFDS created for this document (Appendix 1) and the actions identified below.

3.12.4.1 Scope of Analysis

The 23,891-acre CIAA includes all lands associated with the five allotments associated with proposed lease (Table 10). Allotments represent an administrative boundary that addresses most components of an individual's livestock operation. Changes in vegetation conditions outside the allotments that could indirectly affect the allotments are discussed in Soils and Vegetation Cumulative Impacts (Section 3.2.4). The lease period of 10 years will be used for the temporal analysis limit because most impacts are associated with lease activities and site reclamation.

3.12.4.2 Current Conditions and Effects of Past and Present Actions

Vegetation Conditions – Major cover types include shrubs (10,793 acres; 45% of CIAA), exotic annuals (9,511 acres; 40%), and perennial grasses (3,512 acres; 15%). Exotic annuals are the dominant cover type in the Danke, Hashagen, and Rock Quarry Gulch (southern portion allotments. All of the Danke, Hashagen, and Rock Quarry Gulch and significant portions of the Sand Hollow and Kaufman allotments burned in the 1980s. Where shrubs have recovered, exotic annuals are dominant or co-dominant with perennial species in the understory. Species composition is the most important palatability influence, with areas dominated by medusahead providing the least palatable forage except during early spring green-up. Rangeland health assessments have not been conducted on the allotments. Consistent moderate or greater livestock use during the growing period would result in downward perennial grass trends and increased exotic annuals. Perennial grasses would be less affected by dormant season use and could be maintained in the absence of other disturbances (e.g., wildfire).

Disturbance – Disturbance impacts include leaving gates open, harassing livestock, and shooting livestock. There are approximately 46 miles of roads in the allotments, but almost all are unimproved 2-tracks that require access through private lands. Non-livestock related use occurs primarily during the spring and fall by OHV users and hunters. There are existing gas wells on the Hashagen (one well) and Kauffman (two wells) allotments. There are approximately 84 miles of allotment and pasture fences.

3.12.4.3 Reasonably Foreseeable Future Actions

Oil and Gas Lease Development and Production – There are approximately 765 acres of State-managed mineral resources (679 acres in Sand Hollow Allotment, 75 acres in Hashagen Allotment, and 5 acres in Dannke Allotment), some of which may have been leased, but drilling has not been initiated. An unknown amount of private land has also been leased. One additional well could be drilled in the Kaufman Allotment and up to seven wells could be drilled in the Sand Hollow Allotment that would not affect federal mineral estate.

Wildfire – Although not planned events, wildfires would be expected to periodically occur and may increase in size and frequency in response to climate change. Conversion of perennial grass understories to exotic annuals in burned areas would reduce forage quality and availability over the long term. Loss of shrub cover would reduce soil moisture and shorten growing periods. Burned public lands are typically rested one or more growing seasons until recovery objectives are met.

3.12.4.4 Alternative A – Cumulative Impacts

Not leasing federal mineral estate would have no additive impacts. Changes in vegetation conditions caused by livestock grazing and wildfires would have moderate to major adverse impacts to livestock forage where exotic annuals replace perennials and rangeland health standards would not be met over the long term. Larger wildfires would have moderate to major short-term adverse impacts to livestock operations where post-fire rest is implemented. Recreation, OHV, and development/production would cause negligible to moderate short-term disturbance impacts. An additional eight wells and associated infrastructure would cause negligible direct forage loss and decreased forage palatability, but could cause minor to moderate decreases in vegetation conditions where increased access and use increased exotic annuals and noxious weeds.

3.12.4.5 Alternatives B and C– Cumulative Impacts

Development and production activities at 7 to 10 wells in the proposed lease area would have minor to moderate additive vegetation condition and disturbance impacts over the short and long term. Impacts from ongoing and foreseeable future actions would be as described in Alternative A (Section 3.12.4.4).

3.13 Minerals (Fluid)

3.13.1 Affected Environment – Minerals (Fluid)

The proposed lease area occurs in the Payette River Valley, at an elevation of between 2,000 and 3,000 feet. It is on the northern edge of the western Snake River Plain, an approximately 40-mile wide, northwest-trending graben structure, filled with sediments of Plio-Pleistocene Lakes Idaho and Bruneau and intercalated basalts. These sediments are referred to as the Idaho Group (Pliocene) and Payette Formation (Miocene). While there is no type section for the Payette Formation, it is described as a thick body of fresh-water and continental sediments, generally made up of ash, clay, shale, and sandstone, with an occasional lignite bed (Buwalda 1923). The sediments are known to contain organic material, including petrified tree stumps, fresh-water shells and mammalian fossils, such as ancestral horses and camels. Strata seen at Payette extend westward across the Snake River for long distances into Oregon. The Payette Formation has been measured at over 4,000 feet in a deep well at Ontario, Oregon.

The Willow and Hamilton fields have been designated by the oil industry to delineate areas believed to have a natural gas reservoir large enough to sustain commercial development (Map 1). Developers describe the reservoir as being a sequence of fluvial sands, ranging from 500 to 800 feet thick, except where replaced/interrupted by volcanics (IOGCC 2013a). In the ML Investments #1-10 well, located in T. 8 N., R. 4 W., Section 10, the fluvial sand was found at 4,100 feet. Another sand layer is described at the 3,750 foot depth. The fluvial sands are porous and have consistent characteristics across the reservoir. They are overlain by 1,700 – 3,500 feet of lacustrine shale, which provides a regional topseal. Both sands are believed to be adequately drained by a well spacing of one well per 640 acres (IOGCC 2013a). The Western Idaho Basin is characterized primarily by conventional non-associated gas; however, conventional associated (with oil) and tight sand gasses may also be present, but shale-associated gas resources are not thought to be present (Johnson et. al. 2013). Conventional non-associated and associated gases typically can be extracted with smaller scale fracking (well-bore stimulation; Johnson et. al. 2013 pg. 8); however, tight sand and shale-associated gases likely would require fracking to extract.

Although BLM had numerous leases in the 1980's in the area, there are no current federal oil and gas leases in Payette County. In 2014, the Idaho Department of Lands (IDL) leased approximately 4,100 acres of State-owned minerals in Payette County. The remainder of the 20,288 acres of State-owned minerals in Payette County were leased between 2006 and 2013. The State currently has approximately 85,000 acres leased for oil and gas development statewide. There are no wells on federal mineral estates in Payette County; however, there is one producing well and 10 shut-in wells pending pipelines located on private lands (Table 11).

Table 11. Existing development activity on federal and State leases, Payette County, Idaho.

Well Type	Federal Estate	Private and State Leases
Drilling Well(s)	0	4
Producing Gas Well(s)	0	1
Shut-in Well(s) (pending pipeline)	0	10
Permitted, not Drilled Well(s)	0	2
Temporarily Abandoned Well(s)	0	1

3.13.2 Environmental Consequences – Minerals (Fluid)

Impacts to minerals are based on the RFDS created for this document (Table 2, Appendix 1).

3.13.2.1 General Discussion of Impacts

Issuing a lease provides the lessee with the exclusive right to explore for and develop oil and gas. Natural gas produced from federal mineral estate would enter the public markets. The production of oil and gas would result in the irreversible and irretrievable loss of these resources. Royalties and taxes would accrue to the federal and state treasuries from the lease parcel lands. There would be a reduction in the known amount of oil and gas resources. If the federal mineral estate is not leased, but is omitted by the Idaho Oil and Gas Conservation Commission (IOGCC), then they could be drained without compensation.

Stipulations applied to various areas with respect to occupancy, timing limitation, and control of surface use could affect oil and gas exploration and development, both on and off the federal parcel. Leases issued with major constraints (NSO stipulations) may decrease some lease values, increase operating costs, and require relocation of well sites, and modification of field development. Leases issued with moderate constraints (timing limitation and controlled surface use stipulations) may result in similar but reduced impacts, and delays in operations and uncertainty on the part of operators regarding restrictions.

3.13.2.2 Alternative A

The federal mineral estate could remain in place over the short and long terms if they were not leased. The two additional wells would occur in privately-owned mineral estate ≥0.5 miles from federal mineral estate. However, if the federal mineral estate were omitted by the IOGCC, then at least 493 acres of the federal mineral estate within 0.5 miles of existing wells (based on 1 well/640 acre spacing) could be drained.

Because of mineral ownership patterns, not leasing 6,349 acres of federal mineral estate could have moderate to major adverse effects on the ability to develop and produce State- and privately-owned fluid minerals. Lease values and operating costs could be adversely affected. Development of non-federal reserve minerals would not be adversely affected if the IOGCC omits the federal mineral estate.

3.13.2.3 Alternative B

The NSO and NSSO stipulations affecting 6,349 acres would cause minor to moderate decreased lease values and increased operating costs. Developing 22 wells on private lands would allow oil and gas production from the majority of federal mineral estate and State- and privately-owned minerals. Because of well spacing limitations, minerals from up to 1,920 acres of federal mineral estate would not be available because of NSO and NSSO stipulations. However, because of the interspersion of private lands in the proposed lease area, the amount of unavailable federal mineral estate would be expected to be much less.

3.13.2.4 Alternative C

Developing 25 wells would allow oil and gas production from almost all the federal mineral estate and State- and privately-owned minerals. Because of their proximity to federal mineral estate outside the lease area and current well spacing, some minerals at the periphery of the lease area might not be available for production. Applying lease stipulations would cause minor decreased lease values and minor to moderate increased operating costs, primarily during the development phase. The special status plant species and freshwater aquatic habitat stipulations would affect approximately 190 acres of federal mineral estate (Maps 4 and 5). The big game winter range stipulation would affect 4,800 acres (Map 6). Fragile soils are associated with approximately 2,600 acres of federal mineral estate and floodplains would affect <1 acre (Maps 3 and 5). Impacts from other resource stipulations and lease notices cannot be determined at this time because surveys have not been conducted for the resources; however, migratory birds, raptors, burrowing mammals, and bats likely are associated with most of the federal mineral estate.

3.13.3 Mitigation

Applying the drainage stipulation in Alternative C would ensure that the lessee of a parcel adequately addresses the issue of uncompensated drainage.

3.13.4 Cumulative Impacts – Minerals (Fluid)

Cumulative impacts to fluid minerals are based on the RFDS created for this document (Table 2, Appendix 1) and the actions described below.

3.13.4.1 Scope of Analysis

The CIAA is the 15,644-acre Little Willow Creek proposed oil and gas lease area because only federal minerals in the lease area would be available. Well spacing guidance should prevent uncompensated drainage from the federal mineral estate outside the proposed lease area. The lease period of 10 years will be used for the temporal analysis limit because the federal mineral estate would be available for production during that time period, but not necessarily beyond.

3.13.4.2 Current Conditions and Effects of Past and Present Actions

In addition to the 6,349 acres of federal mineral estate, the CIAA includes 493 acres of State-owned minerals and 8,799 acres of private-owned minerals. The lease status of the State and private minerals is unknown. Six wells (three drilled and pending pipelines and three in the process of being drilled) occur in (three wells) or within 0.5 miles (three wells) of the CIAA. The wells are associated with privately-owned minerals; however, one well is within 0.15 miles of State-owned minerals.

3.13.4.3 Reasonably Foreseeable Future Actions

Two wells on privately-owned minerals could be drilled. Wells associated with State-owned minerals could be subject to stipulations for unstable soils, wildlife, threatened and endangered species, and floodplains (Appendix 2). Private lessors could also incorporate stipulations in their lease agreements; however, their scope is unknown.

3.13.4.4 Alternative A – Cumulative Impacts

Not leasing 6,349 acres of federal mineral estate could have minor (if the federal mineral estate is omitted) to moderate (if not omitted) adverse additive impacts to the value of unleased State- and privately-owned minerals. Stipulations associated with State-owned minerals could have minor adverse impacts on lease values and operating costs.

3.13.4.5 Alternative B – Cumulative Impacts

Leasing 6,349 acres of federal mineral estate with NSO and NSSO stipulations could have minor (if stipulations have a limited effect on accessibility) to moderate (if stipulations affect accessibility) adverse additive impacts to the value of unleased State- and privately-owned minerals. Stipulations associated with State-owned minerals would be as described in Alternative A (Section 3.13.4.4).

3.13.4.6 Alternative C – Cumulative Impacts

Leasing 6,349 acres of federal mineral estate with stipulations and lease notices would have minor adverse additive impacts to the value of unleased State- and privately-owned minerals. Stipulations associated with State-owned minerals would be as described in Alternative A (Section 3.13.4.4).

3.14 Social and Economic

3.14.1 Affected Environment – Social and Economic

Social and Environmental Justice

The 2010 Payette County population was 22,623, an increase of 10% from 2000. In comparison, the state population increased 21% between 2000 and 2010, Ada and Canyon counties increased 30.4% and 43.7% respectively. The 2010 Payette County population density was 55 persons/mi^2, compared to 18.8 for Idaho as a whole and 370 and 313 for Ada and Canyon counties respectively. The areas in the vicinity of the proposed lease area are home to farms, ranches, and dispersed residences.

As defined in Executive Order 12898, minority, low income populations, and disadvantaged groups are present in Payette County. Between 2008 and 2012, 19.2% of Payette County's population lived below the poverty line compared to 15.1% of Idaho's total population (Payette County QuickFacts, USCB 2014). The County is not very ethnically or racially diverse. In 2010, 85% of residents identified themselves as being non-Hispanic or Latino ethnicity and 15% of residents reported having Hispanic ancestry (US Census Bureau 2010). Non-white races including African American, Asian, American Indian, Pacific Islander, and others accounted for 11% of the population. In 2010, American Indians accounted for 1.1% of Payette County's population compared to 1.4% for the state as a whole. Tribes in Idaho and elsewhere have an interest in lands in Payette County; however, BLM is unaware of potential interest involving the proposed lease area.

Economics

In 2011, Payette County supported 9,606 jobs and had a 9.1% unemployment rate (Table 12). Non-services related industries (e.g., farm, construction, and manufacturing) accounted for 2,868 jobs, while service related industries (e.g., wholesale, retail, transportation, finance, real estate, and health care) accounted for 5,330 jobs and government accounted for 1,146 jobs (U.S. Department of Commerce 2011). In 2012, labor earnings of $325 million included $100 million in non-services related, $153 million in services related, and $47 million in government related earnings. The 2011 per capita income was $29,475. Total personal income (TPI) in 2011 was estimated to be $667 million including a net residential inflow of $105 million (earnings gained from outside the county – earnings leaving the county). Total personal income includes labor and non-labor income, including money earned on investments (interest, dividends, and rents) and transfer payments relating to age (Medicare and Social Security payments) or poverty (Medicaid or welfare assistance). Idaho had 147 people employed in oil and gas extraction activities statewide in 2011 (IPAA 2012).

Table 12. Employment (2011) and personal income (2012) by industry, Payette County, Idaho.

Industry	Employment (jobs)	Personal Income (Thousands of 2012 dollars)	Average Income/Job (Thousands of 2012 dollars)
Farm	974	$28,255	$29
Forestry & Related Activities	na	na	na
Mining (incl. fossil fuels)[1]	na	na	na
Construction[1]	780	$25,285	$32.4
Manufacturing	1,114	$46,321	$41.6
Utilities	95	$10,480	$110.3
Wholesale Trade[1]	278	$9,247	$33.3
Retail Trade[1]	734	$13,380	$18.2
Transportation & Warehousing[1]	341	$13,446	$39.4
Information	111	$6,604	$59.5
Finance & Insurance[1]	381	$9,798	$25.7
Real Estate & Rental & Leasing[1]	426	$3,543	$8.3
Professional & Tech. Services[1]	313	$10,763	$34.4
Management of Companies[1]	90	$8,503	$94.5
Admin. & Waste Services[1]	526	$9,587	$18.2
Educational Services	90	$868	$9.6
Health Care & Social Assistance[1]	844	$35,832	$42.5
Arts, Entertainment, and Rec	94	$545	$5.8
Accommodation & Food Services[1]	294	$3,843	$13.1
Other Services[1]	713	$16,977	$23.8
Government[1]	1,146	$47,312	$41.3
Total	9,606	$325,048	$33.8

[1] Industries that typically add jobs to support oil and gas leasing, exploration, and production activities.

Oil and Gas Leasing and Production

Local economic effects of leasing federal minerals for oil and gas exploration, development, and production are influenced by the number of acres leased, the number of wells drilled, and the estimated levels of production. These activities influence local employment, income, and public revenues (indicators of economic impacts). There are no federal-administered leases in the area; however, in 2014, the IDL leased 4,006 acres of State owned lands and minerals in Payette County.

Leasing - Federal oil and gas leases generate a one-time lease bid as well as annual rents. Parcels containing federal minerals, which have been approved for leasing, are auctioned off periodically to interested parties starting at a minimum bid of $2.00 per acre. Many parcels leased at auction generate bonus bids in excess of the minimum bid. In 2014, bonus bids ranged from $50.24/acre (October) to $79.68/acre (January) for State leases; however, because no leases have been offered, figures for federal minerals are not available. Once federal minerals are leased, leases are subject to annual rent or royalty payments. Rent on leased minerals is $1.50 per acre per year for the first five years and $2.00 per acre per year thereafter. Typically, oil and gas leases expire after 10 years unless drilling activity on these parcels results in one or more producing wells.

Production – Idaho currently has one producing well on private land and none associated with federal mineral estate (IPAA 2012, IDL 2014). Of 18 Payette County gas wells currently permitted by IDL, one is in production, 10 have been drilled and are shut pending a pipeline (Table 11). Once production begins, federally leased minerals are considered to be held by production and lease holders are required to pay royalties on production instead of annual rent. The BLM also considers mineral leases to be held by production if they have been incorporated into fields or units working cooperatively to increase extraction capabilities.

Federal oil and gas production is subject to production taxes or royalties. On public domain lands, these federal oil and gas royalties generally equal 12.5% of the value of production (43 CFR 3103.3.1), of which 50% would be allocated to the State and 50% would be allocated to the U.S. Treasury. In Idaho, 90% of federal mineral royalty revenues that the state receives are distributed to the Public School Income Fund and 10% distributed to the general fund of the counties where the revenue was generated. For State leases, a 12.5% production royalty is distributed to the permanent fund of the appropriate beneficiary, other State agencies, and the General Fund. The 2.5% production tax goes to the producing county (11.2% of tax revenue), cities within the producing county (11.2%), public schools (11.2%), local economic development (6.4%), and an oil and gas conservation fund (60%).

Local Economic Contribution - Oil and gas development has the potential to stimulate economic activity in a number of sectors throughout the region. Exploration, development, and production activities create a multiplier effect in the local economy as money spent in the oil and gas related industries is spent and re-spent in other industries (Table 12).

3.14.2 Environmental Consequences – Social and Economic

Impacts to the social and economic environment are based on the RFDS created for this document (Table 2, Appendix 1).

3.14.2.1 General Discussion of Impacts

<u>Social and Environmental Justice</u>

Development of a lease may generate impacts to people living near or using the area in the vicinity of the lease. Oil and gas exploration, drilling, or production could create an inconvenience to these people due to increased traffic and traffic delays, noise, and visual impacts. This could be especially noticeable in areas where oil and gas development has been minimal. The amount of inconvenience would depend on the activity affected, traffic patterns within the area, noise levels, length of time, and season these activities occurred, etc. Creation of new access roads into an area could allow increased public access and exposure of private property to vandalism. For split estate leases, surface owner agreements, standard lease stipulations, and BMPs could address many of the concerns of private surface owners. Production and development activities could disproportionately affect disadvantaged groups where the activities are specifically targeted to their communities or properties to the benefit or avoidance of non-disadvantaged groups. They could also provide job opportunities for those groups.

<u>Economics</u>
Local and/or out-of-state workers could be hired or contracted to meet the direct and indirect needs of development and production. Individual income for workers typically associated with development and production activities would vary from $8,300 to $94,500 annually (Table 12). Mining-related jobs would likely pay above the median income ($32,400/year). Total new jobs created could be relatively low because some work would be short-term in nature. For each million dollars in gas production, 2.4 jobs could be created in the county of production (Weber 2012). Employees may shift to higher paying energy-related jobs creating a labor shortage for local employers. Sudden influxes of workers could reduce affordable housing availability. An influx of workers and equipment without commensurate financial support could adversely affect public and private sector infrastructure (schools, hospitals, law enforcement, fire protection, and other community needs), especially in rural communities. Tax, royalty, spending, and income revenues associated with leasing, development, and production would benefit local, county, State, and national economies. Stipulations that affect access to mineral resources could reduce economic return for lessors and lessees. Activities that increase access to mineral resources could benefit other mineral rights holders. Activities that adversely affect health, safety, or the environment could cause short- or long-term decreases in personal income and property values. Wildlife depredation on agricultural fields could adversely affect productivity of some crops (e.g., winter wheat, alfalfa).

Disclosure of the direct, indirect, and cumulative effects of GHG emissions provides information on the potential economic effects of climate change including effects that could be termed the "social cost of carbon" (SCC). The EPA and other federal agencies developed a method for estimating the SCC and a range of estimated values (EPA 2014). The SCC estimates damages associated with climate change impacts to net agricultural productivity, human health, property damage, and ecosystems. Using a 3% average discount rate and year 2020 values, the incremental SCC is estimated to be $51 per ton of annual CO_2eq increase.

3.14.2.2 Alternative A

<u>Social and Environmental Justice</u>
Not leasing the federal mineral estate in the project area would limit the development potential of the project area to only two wells, both located on private lands. Developing two wells and associated infrastructure would have minor short-term impacts from increased traffic and noise and long-term visual, public access, and vandalism impacts. Limited increases in access and

worker influx would occur. There are disadvantaged groups in Payette County, but they do not appear to be disproportionately associated with the two wells or the proposed lease area.

Economics

By not leasing, federal, state, or local revenues would not be generated from leasing, rents, or royalties from federal mineral estate. If BLM does not lease the federal minerals, it is likely that the IOGCC would allow the federal mineral estate to be omitted from the drilling unit. Moderate (if 493 acres associated with existing wells are omitted) to major (if up to 6,349 acres throughout the lease area are omitted) resource and revenue losses would occur if the IOGCC omitted the federal mineral estate and productive wells are drilled on private lands in the same unit. Development and production of two wells would cause minor employment and income increases. Negligible to minor impacts to labor and housing availability and infrastructure would occur over the short term. Adjacent mineral rights holders would experience minor beneficial (omission allowed) or moderate adverse (omission not granted) financial impacts. Adverse water quality and availability (Section 3.5.2.2), safety, and environmental impacts would primarily affect individual landowners in the immediate vicinity of the wells. Negligible wildlife depredation losses could occur.

Based on the GHG emission estimate (Table 6), the annual SCC associated with two wells would be $295,137 (in 2011 dollars). Estimated SCC is not directly comparable to economic contributions reported above, which recognize certain economic contributions to the local area and governmental agencies, but do not include all contributions to private entities at the regional and national scale. Direct comparison of SCC to the economic contributions reported above is also not appropriate because costs associated with climate change are borne by many different entities.

3.14.2.3 Alternative B

Social and Environmental Justice

Developing 22 wells and associated infrastructure would have moderate to major short-term increased traffic and noise impacts and long-term visual impacts. Minor (access controlled by private landowners) to major (access not controlled by private landowners) access and vandalism impacts could occur over the long term. A moderate worker influx could adversely affect traditional lifestyles. Disadvantaged groups in Payette County would not be directly affected by the wells, but access to affordable housing and social services in nearby communities could be reduced during the short term.

Economics

Federal, state, or local revenues would be generated from leasing and rents ($9,528 to $12,704 annually) during the 10-year lease period. The NSO and NSSO stipulations could reduce the lease value and bonus bid amounts. Developing and maintaining 22 wells would have minor to moderate short-term and negligible long-term job increases. Royalty income would depend on how productive the wells are and cannot be estimated at this time. Minor to moderate impacts to labor and housing availability and infrastructure would occur over the short term. Adjacent mineral rights holders would experience moderate financial benefits where access to their minerals improved. Adverse water quality and availability (Section 3.5.2.3), safety, and environmental impacts could have negligible (wells remain intact and don't affect ground water) to major (surface and ground water adversely affected by multiple wells) to the adjacent landowners and downstream communities. Minor to moderate wildlife depredation losses could occur. Based on the GHG emission estimate (Table 6), the annual SCC associated with 22 wells would be $3,246,711 (in 2011 dollars).

3.14.2.4 Alternative C

<u>Social and Environmental Justice</u>

The impacts of developing 25 wells and associated infrastructure would be as described in Alternative B (Section 3.14.2.3).

<u>Economics</u>

Leasing 6,349 acres and associated development and production would have similar revenue, job, labor and housing availability, infrastructure, and adjacent mineral rights holder impacts as described in Alternative B (Section 3.14.2.3). The impact of CSU stipulations on lease value would be less than Alternative B and royalty income could be greater. Adverse water quality and availability (Section 3.5.2.4), safety, and environmental impacts would be similar to Alternative B; however, the freshwater aquatic habitat CSU stipulation could provide minor to moderate surface water protection. Minor wildlife depredation losses could occur. Based on the GHG emission estimate (Table 6), the annual SCC associated with 25 wells would be $3,689,442 (in 2011 dollars).

3.14.3 Mitigation

Measures that limit or control dust, noise, odors and protect visual impacts and water quality resources would help reduce social and economic impacts (Dahl et. al. 2010).

3.14.4 Cumulative Impacts – Social and Economic

Cumulative impacts to the social and economic environment are based on the RFDS created for this document (Table 2, Appendix 1), RFDS for the Willow and Hamilton fields, and the activities identified below.

3.14.4.1 Scope of Analysis

Payette County will serve as the CIAA. Although social and economic costs and benefits could occur at regional, state, national, and international levels, the majority would occur at the county level. The lease period of 10 years will be used for the temporal analysis limit because the federal mineral estate would be available for production during that time period, but not necessarily beyond.

3.14.4.2 Current Conditions and Effects of Past and Present Actions

Current Payette County social and economic conditions are described in Section 3.14.1. All State-owned minerals (Section 3.13.1) and an unknown acreage of privately-owned minerals have been leased in recent years. The State leases will expire between 2016 (14,181 acres) and 2024. The existing 17 oil and gas wells have been developed over several years, although the majority of work occurred since 2011. Exploration work is ongoing in the County. The effect of these activities on social and economic conditions, beyond State lease rental returns, is unknown.

3.14.4.3 Reasonably Foreseeable Future Actions

Oil and Gas Lease Development and Production – Development of wells and associated infrastructure would occur on private and State leases in the Willow and Hamilton (one new well proposed October 2014) fields. Current development is approximately two to four wells annually.

3.14.4.4 Alternative A – Cumulative Impacts

Social and Environmental Justice

Development of two wells and associated infrastructure would have negligible additive traffic, noise, visual, access, vandalism, and worker influx impacts. Development of up to 53 wells in the Hamilton and Willow fields would have minor impacts. The county's population base is large enough that changes associated with oil and gas development would be relatively unnoticeable.

Economics

Not leasing federal mineral estate would have negligible additive adverse revenue impacts. Development of two wells and associated infrastructure would have negligible additive employment, income, labor and housing availability, infrastructure, water quality and availability, and SCC impacts. Development of up to 53 wells in the Hamilton and Willow fields would have minor revenue, employment, income, labor and housing availability, infrastructure, safety, and environmental impacts. Development in the Hamilton and Willow fields could cause minor (water availability affected by increased use) to moderate (water quality adversely affected by persistent pollutants) water quality and availability and SCC ($7,660,302) impacts. The county's economic and employment base is large enough that changes associated with oil and gas development would be relatively unnoticeable.

3.14.4.5 Alternatives B and C – Cumulative Impacts

Social and Environmental Justice

Leasing federal mineral estate and the subsequent development of 22-25 wells and associated infrastructure would have minor additive traffic, noise, visual, access, vandalism, and worker influx impacts. Impacts from other oil and gas development would be as described in Alternative A (Section 3.14.4.4).

Economics

Leasing federal mineral estate and the subsequent development of 22-25 wells and associated infrastructure would have minor additive employment, income, labor and housing availability, and infrastructure impacts and minor to moderate additive water quality and availability and SCC impacts. Impacts from other oil and gas development would be as described in Alternative A (Section 3.14.4.4).

4.0 Consultation and Coordination

4.1 List of Preparers

Name	Position
Jonathan Beck	Planning and Environmental Coordinator, ID State Office and Boise District
Aimee Betts	Associate District Manager, Boise District
M.J. Byrne	Public Affairs, Boise District
Tate Fischer	Field Office Manager, Four Rivers
Sarah Garcia	Rangeland Management Specialist, Four Rivers
Lara Hannon	Natural Resource Specialist/Acting NEPA Specialist, Boise District
Valerie Lenhartzen	Geologist, Four Rivers
Matthew McCoy	Assistant Field Office Manager, Four Rivers
David Murphy	Branch Chief, Realty, ID State Office
Karen Porter	Geologist, ID State Office
Larry Ridenhour	Outdoor Recreation Planner, Four Rivers
Dean Shaw	Archaeologist, Four Rivers
Mark Steiger	Botanist, Four Rivers
Allen Tarter	Natural Resource Specialist (Riparian), Four Rivers

4.2 List of Agencies, Organizations, and Individuals Consulted

Affected Landowners and Permittees (84 individual or companies within 1 mile of proposed lease area)
Allen and Kirmse, Ltd
Alta Mesa Service, Inc., c/o F. David Murrell
Burns Paiute Tribe, Tribal Chairman
Canyon County Commissioners
Confederate Tribes of the Umatilla, Tribal Chairman
Congressman Raul Labrador
Energy West Corp.
Gem County Commissioners
Grazing Board Resource Area Representatives, Phil Soulen
Grazing Board Resource Area Representatives, Stan Boyd
Grazing Board Resource Area Representatives, Weldon Branch
Idaho Citizens Against Resource Extraction
Idaho Conservation League, John Robinson
Idaho Department of Agriculture
Idaho Department of Fish & Game c/o Rick Ward
Idaho Department of Lands c/o Grazing Program Manager
Idaho Governor, CL "Butch" Otter
Idaho Lieutenant Governor Brad Little
Idaho Office of Energy Resources, c/o John Chatburn

Larry Craig
Moffitt Thomas and Associates
Nez Perce Tribes, Tribal Chairman
SBS Associates, LLC
Senator Jim Risch
Senator Mike Crapo
Shoshone-Bannock Tribe, c/o Nathan Small
Shoshone-Paiute Tribe, c/o Ted Howard
Trendwell Energy Corp.
US Fish and Wildlife Service
Washington County Commissioners
Weiser-Brown Oil Co, c/o Richard Brown
Western Watersheds Project
WildLands Defense, Katie Fite

Native American Consultation

BLM is required to consult with Native American tribes to "help assure (1) that federally recognized tribal governments and Native American individuals, whose traditional uses of public land might be affected by a proposed action, will have sufficient opportunity to contribute to the decision, and (2) that the decision maker will give tribal concerns proper consideration" (U.S. Department of the Interior, *BLM Manual Handbook H-8120-1*). Tribal coordination and consultation responsibilities are implemented under laws and executive orders that are specific to cultural resources which are referred to as "cultural resource authorities," and under regulations that are not specific which are termed "general authorities." Cultural resource authorities include: the *National Historic Preservation Act of 1966*, as amended (NHPA); the *Archaeological Resources Protection Act of 1979*; and the *Native American Graves Protection and Repatriation Act of 1990, as amended.* General authorities include: the *American Indian Religious Freedom Act of 1979*; the NEPA; the FLPMA; and *Executive Order 13007-Indian Sacred Sites*. The proposed action is in compliance with the aforementioned authorities.

Southwest Idaho is the homeland of two culturally and linguistically related tribes: the Northern Shoshone and the Northern Paiute. In the latter half of the 19th century, a reservation was established at Duck Valley on the Nevada/Idaho border west of the Bruneau River. Today, the Shoshone-Paiute Tribes residing on the Duck Valley Reservation actively practice their culture and retain aboriginal rights and/or interests in this area. The Shoshone-Paiute Tribes assert aboriginal rights to their traditional homelands as their treaties with the United States, the Boise Valley Treaty of 1864 and the Bruneau Valley Treaty of 1866, which would have extinguished aboriginal title to the lands now federally administered, were never ratified.

Other tribes that have ties to southwest Idaho include the Bannock Tribe and the Nez Perce Tribe. Southeast Idaho is the homeland of the Northern Shoshone Tribe and the Bannock Tribe. In 1867 a reservation was established at Fort Hall in southeastern Idaho. The Fort Bridger Treaty of 1868 applies to BLM's relationship with the Shoshone-Bannock Tribes. The northern part of the BLM's Boise District was also inhabited by the Nez Perce Tribe. The Nez Perce signed treaties in 1855, 1863 and 1868. BLM considers off-reservation treaty-reserved fishing, hunting, gathering, and similar rights of access and resource use on the public lands for all tribes that may be affected by a proposed action.

The BLM initiated consultation with the Shoshone-Paiute Tribes during the June 19, 2014 Wings and Roots Program, Native American Campfire meeting. At that time, the Tribes were provided an information "early alert" with updated information from the June 12, 2014, field trip. The Shoshone-Paiute Tribes did not respond to a July 3, 2014 scoping letter, but will be consulted once again at the December 2014 Wings and Roots Program, Native American Campfire meeting.

4.3 Public Participation

The BLM received public scoping comments from the following individuals and entities (see Section 8.0 Comment Response for comments specific to the draft EA):

Alta Mesa Services, Inc.
Idaho Concerned Residents for the Environment (ICARE)
Idaho Office of Energy Resources
Idaho Petroleum Council
Idaho Residents Against Gas Extraction (IRAGE)
Jason Williams
JoAnn Higby
Lyndsey Winters Juel
Marilyn Richardson
Terry Paulus
William Fowkes and Alice Whitford
Western Watersheds Project (WWP)

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6.0 Appendices

6.1 Appendix 1. Reasonably foreseeable development scenario for the proposed Little Willow Creek oil and gas lease area, Payette County, Idaho.

REASONABLY FORESEEABLE DEVELOPMENT SCENARIO

FOR

PROTECTIVE OIL AND GAS LEASING

IN PARTS OF
TOWNSHIP 8 NORTH, RANGE 4 WEST
TOWNSHIP 9 NORTH, RANGE 4 WEST, AND
TOWNSHIP 9 NORTH, RANGE 3 WEST
BOISE MERIDIAN

FOUR RIVERS FIELD OFFICE
IDAHO

Prepared by: ________________________________ Date: ____________
Karen Porter
BLM Idaho State Office Geologist

SUMMARY

The BLM's Four Rivers Field Office is currently analyzing the environmental effects of offering 6474.62 acres of federal mineral estate for competitive oil and gas leasing. This RFDS is being written in support of that analysis, to inform the public and the preparers of the environmental assessment of the disturbance that could occur as a result of leasing the lands, so that the environmental impacts can be determined and mitigation measures, in the form of lease stipulations, can be developed to minimize those impacts. The BLM plans to offer these lands in a lease sale in early 2015, in order to protect the federal mineral estate from potential drainage caused by the development of a natural gas field that is presently occurring on private lands, referred to by the developer as the Willow Field.

According to an April 16, 2013 order by the Idaho Oil and Gas Conservation Commission, well spacing in the area is one well per government section, or 640 acres. In the northern part of the field, lands with reserved federal mineral estate (also called split estate) are intermingled with some of the private lands, causing conflicts for the developer. Idaho BLM has been deferring leasing in the Four Rivers FO while the current land use plan, the CRMP, is being revised. The CRMP/EIS was completed in 1987, and, while it identified lands closed to leasing and identified some areas as No Surface Occupancy, the analysis does not meet current BLM standards for oil and gas leasing. One major component that is missing is an analysis based on a Reasonably Foreseeable Development Scenario, or RFDS. Therefore, this RFDS describes the likely disturbance that could occur if BLM were to select any of the alternatives being proposed.

This Reasonably Foreseeable Development Scenario (RFDS) indicates that the following impacts could occur, by alternative:

Alternative A (No Action) - If BLM does not lease in the project area, development drilling could occur in only 2 sections- T. 8 N., R. 4 W., section 2, and T. 9 N., R. 4 W., section 36. The lands in these sections are private and do not contain any federal mineral estate. Technically only two wells could be drilled in the project area. This would result in approximately 10 acres of disturbance.

Alternative B (Lease with NSO/NSSO) - Offering leases with NSO/NSSO would allow those sections that have lands with federal mineral estate to be drilled, however the drilling could not occur on the federal mineral estate. The only federal action would be to administer the leases and collect royalties. As there is only one section that has 100% federal minerals (T 9 N., R. 4 W., section 26) and there are 25 sections within the project boundary, technically Alt B could result in up to 24 wells. However, in looking at the topography of each section, it is noted that there are several sections where the private land is either inaccessible or is too steep to be suitable as a drill site. Two sections- T. 9 N., R. 4 W., section 13, and T. 9 N., R. 3 W., section 17- do not have favorable private land conditions for drilling. Therefore, if Alt B were selected, it is estimated that 22 wells would be drilled in the project area, resulting in 77 acres of disturbance.

Alts C (Lease with Cascade RMP stipulations and additional lease notices) - Generally all

federal minerals would be available for development, resulting in the drilling of 25 wells (one per section), and 88 acres of disturbance.

It is anticipated that one geophysical exploration program would occur and that it would likely be conducted along existing roads or trails or by overland travel, thereby causing minor impacts to surface resources.

INTRODUCTION

This report describes the anticipated level of oil and gas exploration and development activity associated with issuing oil and gas leases in the project area. This projection is necessary so that the impacts to other natural resources can be analyzed in an environmental assessment, and to determine what if any stipulations, in addition to those on the standard lease form and those required by BLM policy, may be necessary to attach to the leases in order to mitigate those impacts.

ASSUMPTIONS AND DISCUSSION

- It is assumed that one well would be drilled per government section of approximately 640 acres. This is based on the state of Idaho's well spacing order.

- If a well is to be located on a federal lease, the lessee will be required to submit a drilling permit (APD) to BLM for approval prior to commencing operations. Site-specific NEPA would then be conducted, and additional site-specific requirements, termed Conditions of Approval, may be attached to the APD. If the well is to be located on fee lands, the lessee would seek approval for a drilling permit from the Idaho Department of Lands.

- If drilling is proposed on split estate lands, the lessee will be required to contact the surface owner and attempt to reach an agreement concerning surface access prior to submitting the APD. In accordance with BLM's Onshore Order Number One, upon submitting an APD, the lessee or its operator must certify to the BLM that: (1) It made a good faith effort to notify the private surface owner before entry; and (2) A Surface Access Agreement with the surface owner has been reached, or that a good faith effort to reach an agreement failed. The Surface Access Agreement may include terms or conditions of use, be a waiver, or an agreement for compensation. BLM is not a party to the surface agreement, however if no agreement is reached with the surface owner, the operator is required to submit an adequate bond (minimum of $1000) to the BLM for the benefit of the surface owner, in an amount sufficient to compensate for any loss of crops or damage to tangible improvements. This is a separate and distinct bond from the reclamation bond required under 43 CFR 3104.

- Based on the recent drilling that has occurred in the Willow Field, it is assumed that any well drilled would be a vertical hole, and that it would not require hydraulic fracturing. It is also assumed that the well would be a natural gas well.

- If the well is productive, it is assumed that it would be incorporated into the Willow Field unit development. If dry, the well would be plugged and abandoned, and the site would be reclaimed.

- Oil and gas leases are issued for an initial term of 10 years, subject to extension if there is drilling occurring or if there is a producing well on the lease.

ANTICIPATED SURFACE DISTURBANCE DUE TO OIL AND GAS ACTIVITIES

The following phases of oil and gas exploration/development are typical in searching for and developing an oil and gas resource:

1. Geophysical Exploration
2. Drilling Phase
3. Field Development and Production
4. Plugging and Abandonment

These phases are discussed in detail below.

Phase One: Geophysical Exploration

While a geophysical exploration program may have already been conducted, for the sake of this report it is anticipated that one geophysical exploration program may be conducted during the 10-year initial term of the leases. Geophysical techniques are often implemented to identify subsurface geologic structures and determine drilling targets. The BLM reviews and approves geophysical operations on a case by case basis, and a lease is not necessary for such work. Gravity, magnetics, and seismic reflection are the most common techniques used. Both gravity and magnetic surveys cause very little disturbance as the instruments used are small and easily transportable in light vehicles or OHVs. These surveys can cover large areas and take only weeks to conduct. It is preferable to use existing roads, yet some overland travel is sometimes necessary. In addition, both gravity and magnetic surveys can be completed from aircraft, virtually eliminating surface disturbance.

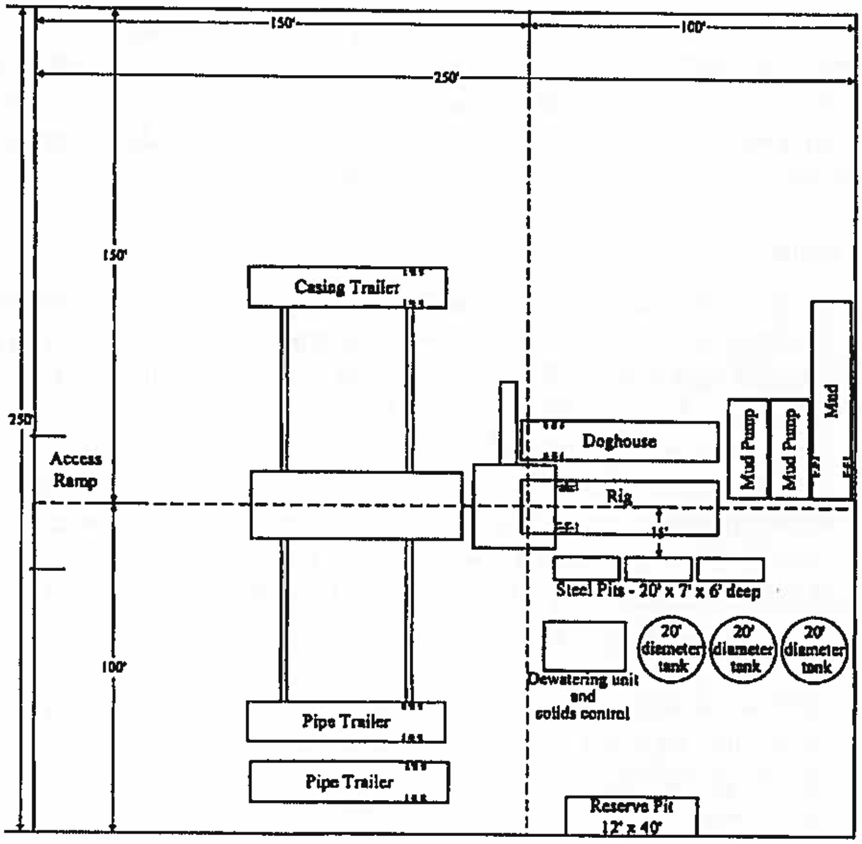
Seismic reflection surveys- either 2D or 3D- are the most commonly used geophysical tool. They require a seismic energy source and an array of receptors that are laid down in rows on the ground surface. Shock waves are created by vibrating or thumping the ground. Reflected seismic waves are recorded by a series of surface equipment along a 3- to 5-mile line. The general principle of seismic reflection is to send elastic waves (using an energy source such as dynamite explosion or Vibroseis) into the Earth, where each layer within the Earth reflects a portion of the wave's energy back and allows the rest to refract through. These reflected energy waves are recorded over a predetermined time period by receivers that detect the motion of the ground in which they are placed. On land, the typical receiver used is a small, portable instrument known as a geophone, which converts ground motion into an analogue electrical signal. In preparation for gathering the seismic data, the survey crew establishes a grid, with source lines running one direction and receiver lines running a different direction. The source lines mark the points where either explosives or vibroseis vehicles will be placed. The receiver lines mark points where geophones (small devices inserted into the ground that pick up reflected vibrations) are placed to take readings when either a small explosion is set off or, more commonly, the vibroseis vehicles are used. Either method is used to send vibrations underground that are reflected back to the surface where readings are taken by geophones on the receiver lines and transferred to a data recorder vehicle. A crew of 10 to 15 people with five to seven vehicles is used, and several square miles can be surveyed in a single day. The geophones are then retrieved from the ground, and moved to the next survey area.

Phase Two: Drilling Phase

Given Idaho's well spacing requirements, it is assumed that a single well would be drilled in each section. If the proposed well is located on lands with federal minerals (i.e. on a federal lease), the lessee is required to submit an APD to BLM. If the proposed well is located on lands with private or state minerals, the lessee would submit a drilling permit application to the Idaho Department of Lands. Drilling on federal mineral estate would be analyzed by BLM in a site-specific NEPA document, and would involve coordination with the surface owner. Conditions of Approval, specific to the proposed activity and site, would be developed and attached to the drilling permit. These conditions, as well as the lease contract itself and any additional stipulations, would need to be complied with. A reclamation bond is required, and if necessary, a surface owner bond would be held by BLM on the surface owner's behalf.

Vehicle access to each drill pad would be required, to transport the drill rig, personnel, and other heavy equipment to the drill site. Existing roads may be used, however may require upgrading. Most of the individual parcels can be accessed off of the Little Willow Creek road, which is paved. Two-track and gravel roads that branch off of Little Willow Creek may require upgrading. Typically, roads are constructed with a 20-foot wide graveled running surface with adjacent ditches and berms, for a total disturbance width of about 40 feet. It may be necessary to haul in gravel to obtain a good road base, as well as a base for the well pad. In the area of the subject parcels, there are several good gravel roads that provide access to some part of the section that would be an appropriate drilling site. It is unlikely that the lessee would need access to the top of the bluffs on which many of the parcels lie. Given the existing road density in the area, it is assumed that an average of 1/4 of a mile of new road construction would be required to access the drill sites. Surface disturbance from the construction of 1/4 mile of road equals approximately one acre.

A drill pad is required to accommodate the rig and equipment. Previous drill pads in the Willow Field have been approximately 1.5 acres in size, however this report assumes a larger pad of 2.5 acres (300' x 350'). Topsoil and existing vegetation is scraped from the well pad site and stored on site for reclamation. The drill pad must be level, possibly requiring some cut-and-fill of the site. In addition to the drill rig, the well pad may house a reserve pit for storage or disposal of water, drill mud, and cuttings; several mud pits and pumps, drill pipe racks, a fuel tank, a water tank, a generator and several compressors, equipment storage, and several trailers for temporary lab and office quarters. To date, reserve pits associated with developing the Willow Field have all been lined with a 12-mil synthetic liner. Below is a schematic diagram of an actual well pad (from Bridge Energy Resources' drilling permit application to IDL):



Getting the rig and ancillary equipment to the site may require 15 to 20 trips by full-sized tractor-trailers, with a similar amount for de-mobilizing the rig. There would be 10 to 40 daily trips for commuting and hauling in equipment. Drilling operations would likely occur 24 hours a day and seven days a week. It takes approximately one month to drill one well. A drilling operation generally has from 10 to 15 people on-site at all times, with more people coming and going periodically with equipment and supplies.

Well drilling also requires water. As much water as possible is recycled on site, yet about 5,000 to 15,000 gallons of water may be needed each day depending on well conditions. Initially, water would need to be provided, either by wells or trucked in, to meet demands. Many oil or gas wells encounter water at depth when drilling for oil and/or gas, as it may be part of the oil and gas reservoir, and can be utilized when production is ongoing.

Production wells drilled in the Willow Field to-date have been 24 inches in diameter at the surface, gradually narrowing (telescoping) to 8¾ inches at the bottom of the well. In order to drill these deep, large-diameter holes, a large drilling rig is utilized. The top of the drill rig derrick could be as much as 155 feet above the ground surface, and the rig floor could be at least 25 feet above the ground surface. These rigs are typically equipped with diesel engines, fuel and drilling mud storage tanks, mud pumps, and other ancillary equipment. Once drilling commences, drilling fluid or mud is continuously circulated down the drill pipe and back to the surface equipment. The purpose of the drilling mud is to balance underground hydrostatic pressure, cool the drill bit, and flush out rock cuttings.

The risk of an uncontrolled flow from the reservoir to the surface (occasionally caused by encountering a pressurized thermal pocket) is greatly reduced by using a blowout preventer—a series of hydraulically-actuated steel rams that can close quickly around the drill string or casing to seal off a well. The BOP is pressure-tested after installation to ensure proper operation. Steel casing is run into completed sections of the borehole and cemented into place. The casing provides structural support to maintain the integrity of the borehole and isolates underground formations.

Exploration holes drilled to-date in the Willow Field have ranged in depth from 2500 to 6900 feet. At the conclusion of well testing, if paying quantities of oil and gas are not discovered, the operator is required to plug and abandon the well according to State standards. Cement plugs are placed above and below water-bearing units with drilling mud placed in the space between plugs. When abandonment is complete, the site is reclaimed, which includes pad and road recontouring, topsoil replacement, and seeding with approved mixtures. Erosion control measures would be incorporated into the reclamation design as needed.

The drilling site could be active for approximately one year, from the start of drill pad and access road construction; through drilling and well testing; to completion of plugging the hole and reclamation.

Phase Three: Field Development and Production

Where oil and gas flow to the surface naturally, control valves and collection pipes are attached to the well head. Otherwise a pump may be installed. Oil is typically produced along with water and gas. Once the raw hydrocarbon reaches the surface, it would be routed through a pipeline to a central production facility, which gathers and separates the produced fluids (oil, gas and water). A production facility is currently being constructed on private lands on the east side of the town of New Plymouth, and dehydration plant has been constructed on Highway 30, immediately north of Interstate 84. The production facility processes the hydrocarbon fluids and separates oil, gas and water. The oil must usually be free of dissolved gas before export. Similarly, the gas must be stabilized and free of liquids and unwanted components such as hydrogen sulphide and carbon dioxide. Any water produced would be treated at these facilities before disposal. Produced water at the well site is disposed of either through surface discharge, evaporation ponds or re-injection into the producing formation.

The producing life span of an oil or gas field varies depending on field characteristics. A field may produce for a few years to many decades. Commodity price, recovery technique, and the political environment also affect the life of a field. Abandonment of wells may begin as soon as they are depleted or wells may be rested for a period of time or drilled to a different horizon, and put back into production.

Phase Four: Abandonment

If paying quantities of oil and gas are not discovered, or at the end of the producing life span of a producing well or field, the operator is required to plug and abandon the well according to Federal and State standards and reclaim the disturbed areas. To plug a well, cement plugs are placed above and below water-bearing units with drilling mud placed in the space between plugs. When well abandonment is complete, equipment and surface facilities are removed, and the site is reclaimed. In a producing field, underground pipelines are often plugged and left in place in order to avoid re-disturbing these areas. Site reclamation includes pad and road obliteration and recontouring, topsoil replacement, and seeding with approved mixtures. Erosion control measures would be incorporated into the reclamation design as needed.

CONCLUSION

Surface disturbance associated with the anticipated leasing of the federal mineral estate in the project area would be approximately 5 acres per well. One well can be drilled per section according to the State of Idaho's well spacing order. Therefore, depending on which alternative is selected, between 10 acres and 125 acres could be disturbed. Pad and access road construction, drilling and well testing, and reclamation would take an estimated 4-6 months, depending on well depth and drilling conditions encountered. It is reasonably likely that well testing would be favorable for production, in which case a pipeline would likely be installed to transport the hydrocarbons to a central production facility located off-lease, located on private land several miles to the south. It is anticipated that one geophysical survey program would be completed during the life of the lease. This disturbance would be temporary, on the order of weeks, and would result in minor to negligible surface impacts.

This RFDS meets the requirements of BLM's Manual Section 1624-2 in describing potential surface impacts that could occur as a result of leasing the federal mineral estate in the project area.

6.2 Appendix 2. State lease stipulations in the vicinity of the proposed Little Willow Creek lease area, Payette County, Idaho.

1. Construction Notification. Lessee shall notify and obtain approval from Idaho Department of Lands (IDL) prior to constructing well pads, roads, power lines, and related facilities that may require surface disturbance on the tract. Lessee shall submit a surface use plan of operations to IDL and obtain approval before beginning surface disturbance activities. Lessee shall comply with any mitigation measures stipulated in IDL's approval.
2. Surface Owner Notification. If the State does not own the surface, the Lessee must contact the owner of the surface in writing at least 30 days prior to any surface activity. A copy of the correspondence shall be sent to IDL.
3. Unstable Soils. Due to unstable soil conditions on this tract and/or topography that is rough and/or steep, surface use may be restricted or denied. Seismic activity may be restricted to surface shots.
4. Metalliferous/Gem Lease. This lease is issued subject to a prior existing State of Idaho metalliferous/gem lease. Lessee's rights to search, develop, and produce oil and gas may be restricted by such prior existing lease rights.
5. Wildlife Concerns. Potential wildlife conflicts have been identified for this tract. The applicant must contact the Idaho Department of Fish and Game (IDFG) in the area for advice on alleviating any possible conflicts caused by the Lessee's proposed activities. Documentation that IDFG requirements have been satisfied unless otherwise authorized by IDL is required. Additional mitigation measures may also be required.
6. Threatened and Endangered Plant Species. Plant species of concern have been identified on or near this tract. A vegetation survey in areas of proposed activity will be required prior to disturbance. Identified rare plant species will be avoided, unless otherwise authorized by the IDL.
7. Threatened and Endangered Animal Species. Animal species of concern have been identified on or near this tract. A survey in areas of proposed activity will be required prior to disturbance. Identified habitat of threatened and endangered species will be avoided, unless otherwise authorized by the IDL.
8. Navigable Waters and Infrastructure. Unless otherwise approved by IDL in writing, wells and related surface infrastructure, including new road construction, are prohibited within 1/4 mile of the mean high water mark of a navigable river, lake or reservoir, including direct tributary streams of navigable waterways, on or adjacent to this tract. No surface occupancy is allowed within the bed of a river, stream, lake or reservoir, islands and accretions or abandoned channels.
9. Floodplain. Due to the floodplain/wetlands area(s), surface use may be restricted or denied.
10. Surveys. If the lessee completes a successful oil and/or gas well, and if land title is disputed, the lessee shall fund professional land surveys as needed to determine the location and acreage encompassed by the spacing and/or pooling unit and the state lease acreage within that unit. Surveys shall be conducted by a licensed land surveyor acceptable to IDL, and shall be prepared pursuant to survey requirements provide by the IDL.
11. Public Trust Lands. This tract contains navigable riverbeds. No surface occupancy is allowed within the bed of the navigable river, abandoned channels, or on islands and

accretions. In addition, upon completion of a successful well, where river title is disputed, the Lessee will file an interpleader action under Rule 22 of Idaho Rules of Civil Procedure in the local District Court, or other court having jurisdiction, in which the leased lands are located for all acreage within the lease in which the title is disputed. The Lessee shall name all potential royalty claimants as defendants.

12. Existing Surface Uses. Due to existing surface uses (such as center pivots, wheel lines, etc.) development on this tract may be restricted.
13. Activity restrictions. No activity shall be allowed within 100 feet of any perennial or seasonal stream, pond, lake, wetland, spring, reservoir, well, aqueduct, irrigation ditch, canal, or related facilities without prior approval of the IDL.
14. Sage Grouse. Active sage-grouse lek(s) have been identified on or adjacent to this tract. No activities shall occur on the tract until the proposed action has been approved in writing by the Director of the Department. If surface activity is proposed on the tract, the Department will consult with the Director of Idaho Department of Fish and Game (IDFG) for their comments, concerns and recommendations. Additional mitigation measures may be required, including no-surface-occupancy buffers and/or timing restrictions, which may encompass part or the entire tract.
15. No Surface Occupancy. No Surface Occupancy shall be allowed on this tract.

6.3 Appendix 3. Legal description of lease parcels and applicability of Alternative C stipulations and lease notices.

Legal description of lease parcels.

Parcel	Legal Description			Acres
	Township/Range	Section	Quartersection/Lot	
A	T. 08 N R. 04 W	01	Lots 1-4; S½NE¼; S½NW¼; N½SE¼	364.78
		03	Lots 3 and 4; SW1/4NW1/4; W½SW1/4	185.11
		04	Lots 1 and 2; S½NE¼; SE¼NW¼; SE¼; E½SW¼	426.53
		05	Lots 1-3; SE¼NW¼; E½SW¼	223.22
		08	E½NW¼	79.39
		12	NW¼; SW¼	312.44
		13	N½SE¼; SE¼SW¼	117.49
		24	NE¼NW¼	39.32
	Total			**1,748.29**
B	T. 09 N R. 04 W	28	N½NE¼; SW¼NE¼; NW¼; W½SE¼; N½SW¼	430.33
		32	SW¼NW¼	38.88
		33	NE¼NW¼; NW¼SE¼	80.03
	Total			**549.25**
C	T. 09 N R. 04 W	26	All	628.28
		27	E½NE¼; SW¼NE¼; W½NW¼; N½SE¼; SE¼SE¼	312.27
		34	NE¼; NE¼SE¼; S½SE¼	276.04
		35	N½NW¼; SW¼NW¼; SW¼SW¼	157.90
	Total			**1,374.49**
D	T. 09 N R. 03 W	18	Lots 2-4	125.56
		19	Lots 1 and 4; NE¼NW¼	123.06
	T. 09 N R. 04 W	13	S½NE¼; E½NW¼; S½	469.41
		24	N½NE¼; SW¼NE¼; S½SE¼; NW¼SE¼; W½	551.35
		25	W½	316.36
	Total			**1,585.74**
E	T. 09 N R. 03 W	17	S½NE¼; SE¼; W½	544.94
		18	NE¼; N½SE¼; SE¼SE¼	273.15
		20	NW¼NE¼; N½NW¼; SW¼NW¼	155.79
		29	N½NE¼; NE¼NW¼	117.55
	Total			**1,091.43**
Total				**6,349.20**

Applicability of stipulations and lease notices by parcel.

Stipulation/Lease Notice	Parcel[1]				
	A	B	C	D	E
Freshwater Aquatic Habitat CSU-1: 500' buffer from surface waters	Y	N	N	Y	Y
Freshwater Aquatic Habitat CSU-2: 100' buffer from surface waters	Y	N	N	Y	Y
Special Status Plants CSU -3: Types 1-4	P	Y	P	P	P
Big Game Range CSU-4: No surface use December 1 – March 31 any species; May 1 – June 30 antelope	Y	Y	Y	Y	Y
Sensitive Wildlife Species CSU-5: No surface use ≤0.75 miles of ferruginous and Swainson's hawk nests March 15 – June 30	P	P	P	P	P
Sensitive Wildlife Species CSU-6: No surface use ≤0.75 miles of osprey nests April 15 – August 31	P	P	P	P	P

Stipulation/Lease Notice	Parcel[1]				
	A	B	C	D	E
Sensitive Wildlife Species CSU-7: No surface use ≤0.25 miles of burrowing owl nests March 15 – June 30	P	P	P	P	P
Wildlife Species of Concern CSU-8: No surface use ≤0.75 miles of golden eagle nests February 1 – June 30	P	P	P	P	P
Wildlife Species of Concern CSU-9: No surface use ≤0.75 miles of prairie falcon nests March 15 – June 30	P	P	P	P	P
Wildlife Species of Concern CSU -10: No surface use ≤0. 5 miles of heron rookery	P	P	P	P	P
Fragile Soils LN-1: Minimize adverse impacts to fragile soils	Y	Y	Y	Y	Y
Floodplain Management LN-2: Minimize adverse impacts to 100-year floodplain	Y	Y	N	N	N
Endangered Species S-1: Consultation and mitigation to protect listed species and critical habitat.	Y	Y	Y	Y	Y
Special Status Mammals LN-3: Minimize adverse impacts to SIDGS and pygmy rabbits.	P	P	P	P	P
Migratory Birds and Raptors LN-4: Compliance with MBTA by minimizing adverse impacts to migratory birds.	P	P	P	P	P
Migratory Birds and Raptors CSU-11: No surface use ≤1 mile of active bald eagle or peregrine falcon nest. No surface use December 1 – March 31 where wintering bald eagles or peregrine falcons are present.	P	P	P	P	P
Water Quality LN-5: Reduce impacts on water quality and quantity.	Y	Y	Y	Y	Y
Cultural Resources S-2: Comply with applicable statutes and executive orders.	Y	Y	Y	Y	Y
Cultural Resources LN-6: Cultural resource survey.	Y	Y	Y	Y	Y
Lands and Realty LN-7: Existing authorizations.	Y	Y	Y	Y	Y
Drainage LN-A: Wells on adjacent private lands.	Y	Y	Y	Y	Y
Split Estate LN-B: Surface use agreement required on split-estate.	Y	Y	Y	Y	Y
Paleontological Resources CSU-12: No surface use on identified resources.	Y	Y	Y	Y	Y
Paleontological Resources LN-7: Paleontological resource survey.	Y	Y	Y	Y	Y

[1] Y – applies to at least a portion of the parcel. P – potentially applies based on subsequent survey work. N – would not apply to that parcel.

6.4 Appendix 4. Idaho BLM special status animal species known to, or potentially occurring, in the Little Willow Creek lease area, Payette County, Idaho.

Type 1. Federally Listed Species and Critical Habitat: Includes species that are listed under the Endangered Species Act as Threatened (T) or Endangered (E) and designated critical habitats.

Type 2. BLM Special Status Species: Includes FWS Candidate (C), Delisted within 5-years (D), Proposed (P), Experimental Population (XN), and Proposed Critical Habitat (PCH); and BLM Sensitive Species.

The proposed lease area does not currently provide habitat for any Type 1 species. The proposed lease area is outside the range or typical habitat of the following special status animal species that occur in the Four Rivers Field Office, so they will not be considered further: Idaho giant salamander, Cassin's finch, Columbian sharp-tailed grouse, flammulated owl, harlequin duck, Lewis' woodpecker, mountain quail, bull trout, redband trout, white sturgeon, ashy pebblesnail, California floater, bighorn sheep, coast mole, fisher, grizzly bear, northern Idaho ground squirrel, Piute ground squirrel, and wolverine.

Note* NI=No impacts due to leasing and associated activities
DI=direct impacts due to leasing and associated activities
ID=indirect impacts due to leasing and associated activities

Common Name	Scientific Name	Habitat	Management Considerations
Amphibians			
Northern Leopard Frog	*Rana pipiens*	Wetlands, riparian areas, and adjacent uplands	DI – Adverse water quality impacts could cause mortality or affect breeding, etc. Discussed in Section 3.6.2 (Aquatic Species).
Western Toad	*Bufo boreas*	Ponds, streams, and adjacent uplands.	DI – Adverse water quality impacts could cause mortality or affect breeding, etc. Discussed in Section 3.6.2 (Aquatic Species).
Woodhouse's Toad	*Bufo woodhousii*	Grasslands, shrublands, agricultural areas, and ponds.	DI – Adverse water quality impacts could cause mortality or affect breeding, etc. Discussed in Section 3.6.2 (Aquatic Species).
Birds			
Bald Eagle	*Haliaeetus leucocephalus*	Winter migrant to lease area. Habitat includes lakes, reservoirs, streams, and uplands.	NI - No known nesting pairs are present. ID – Could occur for wintering birds where activities affect big game presence and winterkill. Discussed in Section 3.6.2 (Migratory Birds and Raptors).

Common Name	Scientific Name	Habitat	Management Considerations
Black Tern	*Chlidonias niger*	Open water lakes (>10 acres), ditches, and emergent wetlands.	ID – Activities could disturb migrating birds, but lease area doesn't provide nesting habitat.
Black-throated Sparrow	*Amphispiza bilineata*	Breeds in barren and grassy hillsides with scattered sagebrush and rabbitbrush.	DI/ID – Activities could reduce nesting foraging habitat, but lease area is on northern edge of species range.
Brewer's Sparrow	*Spizella breweri*	Sagebrush-steppe, nests in shrubs.	ID – Extensive sagebrush stands are not present; however, activities could affect species during migration.
Burrowing Owl	*Athene cunicularia*	Gently-sloping areas of shrubsteppe.	DI – Ground disturbing activities could destroy nests. ID - Activities could disturb or reduce prey species. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Ferruginous Hawk	*Buteo regalis*	Open country, nests on ground or rock outcrops, forages in shrubsteppe and grassland habitats.	ID – Activities could disturb or reduce prey species. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Golden Eagle	*Aquila chrysaetos*	Open country, nests on cliffs and artificial structures, forages in shrubsteppe and grassland habitats.	ID – Activities could disturb or reduce prey species. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Grasshopper Sparrow	*Ammodramus savannarum*	Shrubsteppe grasslands	DI/ID – Activities could reduce nesting and foraging habitat. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Greater Sage-grouse (C)	*Centrocercus urophasianus*	Sagebrush obligate.	NI - Outside currently delineated ranges, area lacks key habitat component.
Green-tailed Towhee	*Pipilo chlorurus*	Shrubsteppe in areas with high diversity of shrub species.	ID – Shrub stands are limited; however, activities could affect species during migration.
Loggerhead Shrike	*Lanius ludovicianus*	Shrubsteppe, open woodlands. Nests in tall shrubs and small trees.	ID – Activities could disturb or reduce nesting habitat and prey species. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Long-billed Curlew	*Numenius americanus*	Short-grass or mixed-prairie with flat rolling topography.	DI/ID – Activities could disrupt breeding, reduce nesting and foraging habitat. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Northern Goshawk	*Accipiter gentilis*	Aspen stands and conifer forests	NI – Habitat not present, occasional migrants could be affected by activities.
Olive-sided Flycatcher	*Contopus cooperi*	Montane or coniferous forests and riparian areas.	ID – Disturbance of birds using riparian areas during migration.
Sage Sparrow	*Amphispiza belli*	Sagebrush-steppe, nests in shrubs.	ID – Extensive sagebrush stands are not present; however, activities could affect species during migration.

Common Name	Scientific Name	Habitat	Management Considerations
Sage Thrasher	*Oreoscoptes montanus*	Sagebrush obligate	ID – Extensive sagebrush stands are not present; however, activities could affect species during migration.
Short-eared Owl	*Asio flammeus*	Large expanses of shrubsteppe and grasslands.	DI/ID – Activities could disrupt breeding, reduce nesting and foraging habitat. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Willow Flycatcher	*Empidonax trailii*	Dense willow riparian areas.	ID – Pollution could reduce prey species. Discussed in Section 3.6.2 (Migratory Birds and Raptors).
Yellow-billed Cuckoo (T)	*Coccyzus americanus*	Thick, wide riparian corridors, primarily dominated by cottonwoods. Known only as rare erratic breeder in the Snake River corridor mainly in southeast Idaho. Limited potential habitat occurs in area.	NI - Outside currently delineated ranges, area lacks key habitat component.
Mammals			
Big Brown Bat	*Eptesicus fuscus*	Rural areas and fields.	ID – Activities could reduce foraging success and prey habitat. Discussed in Section 3.6.2 (Bats).
Canyon Bat (formerly Western pipistrelle)	*Parastrellus hesperus*	Canyons and deserts in rock crevices, under rocks, and burrows	DI/ID – Activities could eliminate burrows, reduce foraging success and decrease prey habitat. Discussed in Section 3.6.2 (Bats).
Fringed Myotis	*Myotis thysanoides*	Caves, rock crevices, and open areas.	ID – Activities could reduce foraging success and prey habitat. Northeastern edge of range. Discussed in Section 3.6.2 (Bats).
Grey wolf	*Canus lupus*	Generalist habitat species. Follows big game herds.	ID - Could occur where activities affect big game presence.
Hoary Bat	*Lasiurus cinereus*	Trees, cavities, and open areas.	ID – Activities could reduce foraging success and prey habitat. Discussed in Section 3.6.2 (Bats).
Little Brown Bat	*Myotis lucifugus*	Forested lands near water, caves, and drier open areas.	ID – Activities could reduce foraging success and prey habitat. Discussed in Section 3.6.2 (Bats).
Long-eared Myotis	*Myotis evotis*	Coniferous forest and associated with forest-woodland riparian areas	ID – Insect prey base could be adversely affected by habitat alterations. Discussed in Section 3.6.2 (Bats).
Long-legged Myotis	*Myotis volans*	Coniferous forest and deserts; may change habitat seasonally	ID – Insect prey base could be adversely affected by habitat alterations. . Discussed in Section 3.6.2 (Bats).
Pallid Bat	*Antrozous pallidus*	Arid, semi-arid uplands, sparsely vegetated grasslands, buildings, and caves.	ID – Activities could reduce foraging success and prey habitat. Discussed in Section 3.6.2 (Bats).

Common Name	Scientific Name	Habitat	Management Considerations
Pygmy Rabbit	*Brachylagus idahoensis*	Thick big sagebrush with deep soils.	DI/ID – Burrow destruction, vehicle mortality, foraging habitat. Discussed in Section 3.6.2 (Burrowing Mammals).
Silver-haired Bat	*Lasionycteris noctivagans*	Riparian areas, ponds, and streams.	ID – Activities could reduce foraging success. Pollution could reduce prey species. Discussed in Section 3.6.2 (Bats).
Southern Idaho Ground Squirrel (C)	*Spermophilus brunneus endemicus*	Sagebrush and grasslands	DI/ID – Burrow destruction, vehicle mortality, foraging habitat. Discussed in Section 3.6.2 (Burrowing Mammals).
Spotted Bat	*Euderma maculatum*	Rocky canyons and cliffs, forages over sagebrush.	ID – Insect prey base could be adversely affected by habitat alterations. Discussed in Section 3.6.2 (Bats).
Townsend's Big-eared Bat	*Plecotus townsendii*	Winter in stable-climate caves, forage over sagebrush.	ID – Insect prey base could be adversely affected by habitat alterations. Discussed in Section 3.6.2 (Bats).
Western Small-footed Myotis	*Myotis ciliolabrum*	Winters in lava tube caves and rock crevices, under boulders, and beneath loose bark in summer	ID – Insect prey base could be adversely affected by habitat alterations. Discussed in Section 3.6.2 (Bats).
Yuma Myotis	*Myotis yumanensis*	Wide elevation range including riparian, desert scrub and mesic woodland and forested areas.	ID – Insect prey base could be adversely affected by habitat alterations. Discussed in Section 3.6.2 (Bats).
Reptiles			
Great basin Black-collared Lizard	*Crotaphytus bicinctores*	Deserts, presence of rocks and boulders.	DI/ID – Vehicle mortality, loss of habitat and prey. Discussed in Section 3.6.2
Longnose Snake	*Rhinocheilus lecontei*	Deserts, grasslands, and rocky canyons.	DI/ID – Vehicle mortality, loss of habitat and prey. Discussed in Section 3.6.2
Western Ground Snake	*Sonora semiannulata*	Deserts with loose or sandy soils.	DI/ID – Vehicle mortality, loss of habitat and prey. Discussed in Section 3.6.2

8.0 Comment Responses

A Draft EA was made available to the public with a 30-day comment period (December 22, 2014 to January 21, 2015). Comments were received from the Idaho Conservation League (ICL); Randy and Thana Kauffman (K); the State of Idaho (SoI) including Office of Energy Resources, Department of Fish and Game, Office of Species Conservation, and Department of Environmental Quality; WildLands Defense (WLD); and WildEarth Guardians (WEG). Responses to summarized comments are provided below (organized by major topic) and the EA was modified as necessary to address some comments.

Land Use Plan

ICL-1: *The CRMP is outdated.*

WLD-7: *The CRMP is outdated and inadequate.*

WEG-7: *Leasing should be deferred until a new RMP is completed.*

Under normal circumstances, BLM offers lands nominated by the public for leasing, that have been identified in a land use plan as eligible and available for leasing. However, BLM regulations state that lands which are subject to drainage should be leased, even if they are otherwise unavailable for leasing (43 CFR 3120.1-1(d)). BLM has determined that the lands currently being considered for lease are or soon will be threatened by drainage of federally-owned oil and gas.

BLM IM 2010-117, Oil and Gas Leasing Reform Land Use Planning and Lease Parcel Reviews states: "There are other considerations that should be taken into account when determining the availability of parcels for lease." Field offices should consider whether… "There is a risk of drainage to Federal mineral resources due to development of nearby non-Federal parcels if the parcel is not leased (based upon a determination made by a Petroleum Engineer or Petroleum Geologist)."

The1988 CRMP provided a variety of stipulations related to issues and resources identified during that process (Section 2.3); however, BLM guidance allows for additional requirements to address changing resource concerns. According to IM 2010-117, "If a proposed modification to the terms of a stipulation changes the extent, but does not result in a new planning decision (e.g., the timing limitation protective radius increases from 2 miles to 3 miles, but the stipulation remains a moderate constraint), no plan amendment is required. The site-specific NEPA compliance documentation for the lease, however, may need to analyze the proposed stipulation modification if this analysis has not already been conducted in the NEPA documentation associated with the land use plan." Lease notices are included in Alternative C to address additional resource concerns.

WLD-13 and WEG-6: *The CRMP does not support oil and gas leasing.*

The CRMP Final EIS analyzed the effects of designating areas open to gas leasing. This EA analyzes several alternatives, including Alternative C, which includes stipulations based on management direction from the CRMP. If post-lease actions are proposed (exploration and/or development), additional NEPA will be conducted to analyze site-specific effects of the proposed actions.

7.0 Maps

If you are viewing this via the following link on the NEPA Register:
https://www.blm.gov/epl-front-office/eplanning/planAndProjectSite.do?methodName=renderDefaultPlanOrProjectSite&projectId=39064&dctmId=0b0003e8806d22d8
Please find the maps in the home page's sidebar under Maps. Select "Map Package to accompany Little Willow Creek Protective Leasing EA".

NEPA Adequacy

WLD-1: *An EIS is needed to address the impacts.*
The act of leasing (Alternatives B and C) would not constitute a major federal action that would significantly affect the quality of the human environment; therefore, an Environmental Impact Statement is not required. The BLM will determine the level of NEPA analysis needed when/if an APD is received. See also WLD-13 and WEG-6.

WLD-2: *The cumulative effects areas are not adequate.*
See cumulative effects sections in the EA. The CIAAs were selected based on BLM's knowledge of current oil and gas leasing in the area and the RFDS developed for this EA. It is difficult to speculate what will be nominated for oil and gas leasing in the future, as well as how much exploration and development will result. The RFDS created for this EA is BLM's best estimate and was analyzed in relative detail in the Environmental Consequences and Cumulative Impacts sections (Section 3.0).

WLD-5: *Adequate baseline information for a variety of resources was not provided or considered; therefore, none of the alternatives can be adequately analyzed.*
The interdisciplinary team used the best available resource data to create the baselines for analyzing alternatives (e.g., data from BLM, USDA/NRCS, IDFG/IFWIS, IDEQ, IDWR, EPA, US Census Bureau, etc.). The affected environment sections provide summaries of baseline data.

WLD-9: *The BLM must consider a broad range of alternatives and mitigation actions to protect air, water, and natural resources and human health. The proposed protection measures are inadequate.*
The alternatives analyzed provide a range of protection measures to federal mineral reserves and associated lands and resources. Direct impacts to resources associated with federal mineral reserve lands would not occur in Alternative A and indirect impacts would be limited. Direct impacts to resources associated with federal mineral reserve lands would also not occur in Alternative B; however, indirect impacts would occur. Direct and indirect impacts to resources associated with federal mineral reserve lands would occur in Alternative C; however, a variety of protective measures would help limit their degree. This EA begins to identify potential mitigation measures; however, APDs and associated NEPA analyses would help guide development of the most appropriate measures.

WLD-11: *The proposed lease and associated EA represents a piecemeal approach and does not adequately address all alternatives.*
The BLM is following its national guidance on the NEPA approach for leasing and subsequent, if any, drilling. Leasing and post-lease activities are not analyzed in the same NEPA document, since nationally, only about 10% of oil and gas leases ever get drilled. It is impossible to speculate precisely where, how, and what post-lease activities will occur, since a lease can be for up to 2,560 acres in size. BLM has taken a hard look at the impacts of leasing in this area with three alternatives and over 100 pages of analysis in this EA.

If an APD is proposed once a lease is issued, BLM will conduct a thorough and in-depth analysis that is site- and activity-specific. Mitigation measures in the form of enforceable Conditions of Approval would be attached to each APD. The BLM lease terms and stipulations, onshore orders, and regulations must be followed, and a performance bond must be accepted by BLM before any surface disturbing activities can occur. The BLM will monitor and inspect operations to ensure that the lessee is in compliance with BLM's requirements for both surface as well as down-hole resources.

WEG-1: *Leasing the BLM parcels may enable expanded drilling on State and/or private lands.* The range of alternatives clearly indicates that leasing would likely increase drilling opportunities on State and/or private lands. Existing (2) and proposed wells (2) occur on non-federal leases in the proposed lease area (Map 1). The RFDS and associated analyses recognize how many wells could be drilled within the lease area without (Alternative A – 2 new wells) or with (Alternatives B and C – 22 or 25 new wells, respectively) a federal lease. The current State well spacing of 1 well/640 acres was one of the factors used to determine the number of wells that could be drilled by alternative. The EA also recognizes that if federal minerals are omitted, then up to 25 new wells could potentially be drilled. With few exceptions (e.g., visual resource management and realty rights-of-way designations that do not apply to non-federal lands), potential impacts were described irrespective of land ownership.

WLD-12: *The drainage explanation and current status of leases in the area are unclear.*
WEG-5: *Drainage is not a compelling reason for leasing.*
Based on a current State of Idaho well spacing of 1 well/640 acres the BLM assumes that a well could drain mineral reserves in a 640 acre area regardless of ownership. Four existing wells and two proposed wells are within 0.5 miles of federal mineral resources. The existing wells are classified as "shut in pending a pipeline" indicating that they are producing wells. In a September 4, 2014 IOGCC hearing, the commission voted 4-1 to reconsider a request by Alta Mesa to omit federal mineral resources. If federal minerals are omitted from a drilling unit, BLM would be unable to collect the royalties it is due for its proportionate share of the drilling unit; therefore, the BLM considers these resources threatened by uncompensated drainage.

While 43 CFR 3162.2-2 offers several protective measures that BLM may take to avoid uncompensated drainage on unleased lands, they all require the cooperation of the owner-of-interest in the producing well, except for leasing. The BLM has offered several times to enter into a communitization or compensatory royalty agreement with Alta Mesa; however, Alta Mesa has rejected those offers. Existing and proposed wells provide some indication of non-BLM lease activity; however, the BLM does not have specific knowledge of existing leases in the proposed lease area.

WLD-14: *The proposed action violates the laws and policies described in Section 1.6.*
The BLM disagrees and finds that impacts to sensitive resources can be mitigated by application of stipulations, lease terms and conditions, onshore orders, and regulations for leasing.

Alternatives
K-1: *Parcel A should be split into two parcels along the Little Willow Road.*

The BLM will consider this comment prior to releasing the Notice of Lease Sale. The environmental impacts would be the same.

Vegetation
WLD-21: *Site specific surveys are lacking and impact magnitudes are discounted because of current conditions.*
The IDFG report information specific to the EOs in the proposed leasing area and CIAAs was added (Section 3.3.1). This information supports the current conditions and conclusions presented in the EA.

Air Resources
Table 6 in the Draft EA incorrectly used oxides of nitrogen values rather than nitrous oxides values for calculating greenhouse gas production. The nitrous oxides and consequently CO_2 eq values have been adjusted accordingly.

WLD-22: *The referenced air quality report is biased and inadequate.*
WLD-19: *Potential impacts to climate change are not adequately addressed.*
ICL-2: *Substantial increases in carbon dioxide equivalent emissions need to be mitigated.*
The BLM contracted the Kleinfelder Report to evaluate air quality impacts associated with oil and gas development activities for the Four Rivers RMP. The report provides detailed emission estimates of criteria pollutants, greenhouse gases (GHG), and key hazardous air pollutants (HAPs) anticipated to be released during each phase of oil and gas development for a representative oil and gas well in the western United States. The report acknowledges that defining a "representative" oil and gas well for the entire western U.S. is extremely challenging as there are numerous variables that can materially affect the emissions. Such variables include oil and gas composition, difficulty drilling the geologic formation, oil and gas production rate, equipment at the well site, emission controls, and the amount of produced water that may be associated with oil and gas production, among many others. Five well types (three natural gas wells and two oil wells), representative of different oil and gas basins in the western U.S., were evaluated.

The three types of natural gas wells were summarized as:

1. Uinta/Piceance Basin represents deep (15,000 feet) wells which may be drilled into shale with dry gas. These wells produce a moderate amount of condensate (420 gal/day) and 168,000 gal/yr of produced water. Methane emissions are estimated at 12.2 tons/yr (Table 13) and the Global Warming Potential (GWP) is estimated at 2,825 tons of CO_2 eq/yr.

2. San Juan Basin represents shallow (2,500-7,000 feet) wells with dry gas. These wells produce little to no condensate (210 gal/day) and 33,600 gal/yr of produced water. Other equipment included in the emissions inventory includes a pumpjack engine (to remove water) and a condensate tank. Average gas production per well, over the life of the well is estimated to be 27.8 MMscf/day (million cubic feet/day). Methane emissions

estimated at 6.1 tons per year. GWP is estimated at 791 tons of CO_2 equivalent.

3. Upper Green River Basin represents deep wells drilled into non-shale formations with wet gas, and higher condensate production (1,260 gal/day) and 126,000 gal/yr of produced water. More water vapor is present in the gas at this well, so each well site contains a dehydrator, separator, and line heater. The wells are drilled at relatively high density. Average gas production per well, over the life of the well is estimated to be 4.0 MMscf/day. Methane emissions estimated at 14.1 tons per year (Table 13). GWP is estimated at 3,194 tons of CO_2 equivalent.

Table 13. Total GHG emissions (tons/year) for two wells, Kleinfelder Report.

	Upper Green River Basin			San Juan Basin		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Construction Phase	33.84	0.001	0.0003	33.84	0.001	0.0003
Development Phase	1900.27	1.11	0.0498	561.61	1.05	0.0389
Operation Phase	947.96	12.99	0.0018	56.44	4.99	0.0004
Total	2882.07	14.10	0.0519	651.89	6.05	0.0396

For the Upper Green River Basin well, the following methane emissions (tons/year) are estimated, broken out by the development stage of the well:

Construction Phase 0.001 tons/yr
Sources: tailpipe of construction equipment, trucks

Development Phase (i.e. drilling and well treatment)

Sources:	Drill rig engine	0.03	(18 days, 24 hrs)
	Well frac engine	0.04	(7 days, 24 hrs)
	Frac flowback venting	0.94	(100 hrs)
	Workover venting	0.094	(once, 5000 Scf)
	TOTAL	1.104 tons methane/yr	

Operational Phase (i.e. Production activities)

Sources:	Fugitive emissions	3.16	
	(97 valves, 348 connectors, 12 OE lines, 6 PR valves)		
	Process heaters	0.0178	
	Wellsite tank flashing	0.552	
	Pneumatic devices:		
	Dump valves	8.896	four (4) valves, intermittent bleed
	Pneumatic controller	0.229	(low bleed)
	Pneumatic pumps	0.131	(chemical sandpiper, glycol)
	TOTAL	12.99 tons methane/yr	

The construction and development (drilling) phases of oil and gas development are not major sources of methane emissions; however, methane releases during the development phase can occur, resulting mainly from actuation of gas-operated valves during well operations and from fugitive gas leaks along the infrastructure required for the production and transmission of gas.

Several pneumatic devices are used at the wellhead to control the amount of fluid in the product. Raw natural gas must be free of oil and water before it is piped to a processing plant. This liquid removal takes place in a vessel called a separator, located at or near the wellhead. A pneumatic controller regulates the fluid level in the separator. When the fluid reaches a certain level, the controller's pilot directs gas to a diaphragm valve, which opens and dumps the liquid into a storage tank. Liquid separators at most older well sites have pneumatic controllers with dump valves that vent natural gas continuously. Newer valves (intermittent) vent only when fluid levels are actively being controlled, and emit only so much gas as is needed to open the dump valve so it can close again at the end of the dump cycle (from Devon Energy Corp. website "Tiny Valve- Big Difference").

The number of pneumatic devices used on a well is presumably determined by the amount of condensate (oil) and water produced. Since this information is not known, it is difficult to determine which gas well in the Kleinfelder Report is representative of conditions in the Little Willow Field. Because many of the input parameters for drilling and operations on the Little Willow Creek wells are unknown, BLM used the pollutant values for the Upper Green River Basin well in Table 6 of the EA. This represents a worst-case scenario for emissions at a natural gas well. A review of emissions inventories that have been conducted by other BLM offices in areas with more densely spaced wells than in Idaho (where spacing is limited to one well per 640 acres) reveals that the Kleinfelder Report used by BLM for this EA is conservative. It is likely that actual emissions at a Willow Field well head would be lower than the Upper Green River well (i.e., other inventories reported lower emissions values for GHG than what was used in this EA).

Implementation of mitigation measures (Section 3.4.3) at the APD processing stage could markedly reduce these emission values. The potential increases are substantial for Payette County, which currently produces limited amounts of Greenhouse Gases; however, when considered at larger scales [e.g., the four-county CIAA where they could account for a 1.7% increase over current levels or 0.001% of the 2012 US CO_2 eq production of 7,195 million tons (EPA: http://www.epa.gov/climatechange/ghgemissions/gases.html)], they represent negligible to minor increases. At the time an APD is submitted, additional NEPA analysis would be conducted, and a Condition of Approval can be attached to the APD that requires methane emissions not exceed a certain threshold, based on the best available information and analysis at that time.

The BLM is currently working at the national level to adopt new standards regarding venting and flaring to reduce natural gas waste and methane pollution. According to a DOI news release dated January 23, 2015, the new draft standards are scheduled to be put out for public comment this spring. According to the standard lease terms, the Willow Creek leases would be subject to those new standards, even if the leases are issued prior to adoption of the new standards.

SoI-3: *The BLM needs to consider air and water quality impacts and appropriate stipulations to maintain them if leasing occurs.*
Air and water quality impacts are discussed in Sections 3.4.2 and 3.5.2, respectively. While there would be no impacts associated with issuing leases, post-lease activities could be proposed that would result in impacts as discussed in those sections. Potential mitigation measures are identified in Sections 3.4.3 and 3.5.3. For air quality, these measures would be further refined based on site- and project-specific circumstances and would be imposed as APD Conditions of Approval, described in Section 3.4.3, as appropriate.

Section 2.3 of the EA provides lease stipulations and notices designed to protect water resources under Alternative C. For example, Freshwater Aquatic Habitat stipulations (CSU 1 and CSU 2) protect surface water quality in sensitive areas. Lease notices to inform the lessee that protective measures may be required if post-lease activities are proposed to minimize impacts within the 100-year floodplain (LN-2) and to minimize impacts to water quality and quantity (LN-5). Additionally, BLM is currently working at the national level to adopt new regulations regarding hydraulic fracturing. A final rule is anticipated in spring 2015. According to the standard lease terms, the Willow Creek leases would be subject to those new standards, even if the leases are issued prior to adoption of the new standards.

WLD-4: *The pollution emission zone and local and regional airsheds have not been mapped or adequately analyzed.*
WLD-23: *The air quality cumulative effects analysis is inadequate.*
The analysis areas include Payette County for localized impacts and a four county area (Ada, Baker, Canyon, and Payette) for CIAA. The analyses were conducted at county levels because the EPA provides information at that scale. These counties largely address the area you expressed concerns about (Treasure Valley) and the likely area pollutants would spread from the proposed lease. They include parts of two airsheds identified in Idaho; however, the EPA does not provide data by airsheds. The proposed lease area is 65 (Eagle Cap Wilderness), 67 (Hells Canyon Wilderness), or 72 (Sawtooth Wilderness) miles from the nearest Class 1 airshed areas. With the exception of GHG, which would affect resources at a much larger scale, pollutants from the development and production phase would typically not travel that far. North Ada County is a nonattainment zone for CO and PM_{10}. Maintenance plans are in place to address these issues (EPA 2015, Idaho nonattainment area plans, http://yosemite.epa.gov/r10/airpage.nsf/283d45bd5bb068e68825650f0064cdc2/e2ab2cc6df433b8688256b2f00800ff8?OpenDocument). Ada and Canyon counties are also considered areas of concern for $PM_{2.5}$ and O_3. There are no nonattainment areas in eastern Oregon, but La Grande has a PM_{10} maintenance plan in place. Without mitigation measures, the maximum RFDS of 25 wells add 0.1% and 0.7% respectively to CO and PM_{10} pollutants in the CIAA.

Water Resources
WLD-3: *Water depletion, quality, and protection issues were not adequately addressed.*
WLD-24: *Current water quality conditions need to be clarified.*
The EA provides what is publicly known about water quality in the area (Section 3.5.1). The BLM is not aware of any further pesticide or other chemical testing of ground or surface waters

in the area. Water quality in Little Willow Creek especially is variable because of agricultural influences (dewatering for irrigation and potential pollutants in return flows). Until more specific information at the APD phase is available, the current analysis can only provide a broad range of impacts (Sections 3.5.2 and 3.5.4).

WLD-15: *Aquifer and geological strata should be used to inform analyses on aquatic habitat impacts.*
Information, primarily from IDWR and IDEQ, and analyses concerning aquifers are presented in Water Resources (Section 3.5) under the heading "Ground Water." Aquatic habitat impacts are discussed Section 3.6.2. Stipulations concerning freshwater aquatic habitat are included as part of Alternative C.

WLD-4: *The pollution emission zone has not been mapped.*
The BLM is not clear what you mean by pollution emission zone. The identified CIAA (Section 3.5.4.1) is large enough to consider horizontal pollutant spread through the 10-year analysis period.

WLD-8: *The EA does not adequately address fracking.*
WEG-9: *Impacts of hydraulic fracturing were not adequately addressed.*
While BLM does not anticipate that hydraulic fracturing will be utilized in the Willow Field area, impacts are discussed in Water Resources (Section 3.5.2). If hydraulic fracturing is proposed on a well that has been drilled under an approved APD, it would be analyzed in much greater depth in a subsequent NEPA document. The Idaho Department of Lands has proposed a new rule currently pending the approval of the legislature, which has new requirements including water quality monitoring, should hydraulic fracturing be proposed. Additionally, BLM is currently working at the national level to adopt new regulations regarding hydraulic fracturing. A final rule is anticipated to be released in spring 2015. According to the standard lease terms, the Willow Creek leases would be subject to those new standards, even if leases are issued prior to adoption of the new standards.

Wildlife/Special Status Species

<u>General</u>

WLD-10: *The variety of impacts was not adequately addressed.*
Section 3.6.2.1 describes most of the impacts you identify including disturbance, mortality, changes in habitat quality, fragmentation, and pollution (including erosion and runoff) for the groups of animals they would likely affect. During the APD phase, when the types of development are more clearly identified, impacts would be more readily identified.

<u>Special Status Species</u>

WLD-20: *Inventory requirements for special status species are inadequate.*
SoI-1: *The BLM needs to consider the presence of SIDGS and other special status species and take appropriate measures to inventory and protect them.*
The BLM used the field visits, 2014 Idaho Fish and Wildlife Information System (which includes the referenced SIDGS data), and other data sources to determine presence of special status species in the proposed lease area. Impacts from the proposed actions are discussed in

Section 3.6.2. Sections 2.2, 2.3, 2.4, and 3.6.3 describe measures that would be taken to reduce or avoid impacts. Section 6 of the Lease Terms on the Offer to Lease and Lease for Oil and Gas (Form 3100-11) provide for requiring inventories of resources prior to ground disturbing activities. Lease specific stipulations (S1) and notices (LN-3 and LN-4) also provide for inventory and subsequent mitigation measures. The inventories would occur before and during the APD process and potential impacts would be analyzed in a subsequent EA.

WLD-6: *Leasing would preclude conservation, enhancement, and restoration of sage-grouse and other special status species habitats.*
The proposed lease area is outside any sage-grouse habitat designation; therefore, it would not be a restoration priority for that species. SIDGS are the most prevalent special status species in the proposed lease area. Although development and production activities could degrade habitat, they would not preclude habitat restoration activities once disturbance factors have been stabilized and restoration could be a requirement during the abandonment phase. Efforts to maintain or enhance SIDGS habitat would likely benefit most other special status species.

WLD-16: *The migratory bird and raptor provisions are outdated and scientifically indefensible.*
The winter range avoidance period (November 15 to May 15), which affects 94% of the federal mineral reserve lands, would provide more widespread protections during early breeding and nesting periods for periods not addressed by migratory bird and raptor nesting protections.

WEG-2: *Greater sage-grouse were not adequately addressed.*
The CRMP did not provide leasing stipulations for sage-grouse. Because of historic wildfires and human activities (e.g., livestock grazing), the proposed lease area does not provide suitable sage-grouse habitat. The distances to identified sage-grouse habitat (5-6.5 miles to sagebrush/perennial grass dominated communities [Key, Preliminary General, and Preliminary Priority habitats]) and active leks (9.5 miles)[E] are substantially greater than the 3 mile buffer recommended by Dr. Braun. The proposed lease would not affect sage-grouse in the area; therefore, it would not affect listing decisions.

WEG-4: *Impacts to other sensitive species, especially sagebrush obligates were not adequately addressed.*
Impacts to representative special status species, including SIDGS and sagebrush obligates, are discussed in Sections 3.3.2 and 3.6.2 and Appendix 4. The proposed lease area would affect approximately 4% of the current distribution of SIDGS (based on minimum convex polygon of current and historic locations, assuming 66% of the polygon is suitable habitat). Shrub-dominated communities occur on up to 25% of the lease area, but typically occur in isolated stands (see Figure 1 and Figure 2).

Big Game

SoI-2: *The BLM needs to clarify where big game winter range stipulations would apply, consider impacts to private lands that development would have, and provide adequate measures to avoid disturbance.*
The CRMP used the term crucial; therefore, it was carried forward into this document. The BLM used IDFG data (Map 6) to delineate current big game winter range, combining mule deer,

elk, and pronghorn ranges into one polygon. For Alternative C, the winter timing restriction would apply to all federal mineral estate in winter range (approximately 6,053 acres or 94% of leased lands). Wildlife depredation is discussed in Sections 3.6.2 and 3.14.2. The winter timing restriction was expanded to November 15 to May 15. This expansion is within the 60-day flexibility allowed by BLM policy.

WEG-3: *Impacts to pronghorn winter range were not adequately addressed.*
The EA (Section 3.6.1, Map 6) describe winter ranges for pronghorn, mule deer, and elk. A combination of all three was used for analysis purposes. The CRMP recognized that winter range delineations could change through time[B]; therefore, the winter ranges used in this analysis were developed in cooperation with IDFG using current monitoring information and represent a larger area than was identified in the CRMP. The analyses indicate moderate to major adverse impacts could occur from the proposed levels of development in Alternatives B and C (Sections 3.6.2.3 and 3.6.2.4). The cumulative impacts of changes in habitat conditions from oil and gas production and development and other activities are addressed in Section 3.6.4.

The no surface use limitation (CSU-4) would apply to the exploration, drilling, development and production, and abandonment phases and would cover all activities (e.g., surface disturbing and disruptive). Your concern about exceptions is addressed in Section 3.6.2.4. The proposed lease area is on the periphery of winter range; therefore, it would not affect migration corridors.

Recreation
WLD-17: *Impacts to and by recreationists were not adequately addressed.*
Access to the isolated parcels of BLM-administered lands occurs through private lands. They are near agricultural lands and provide little opportunity for those seeking solitude. Impacts from increased access were addressed in Sections 3.6, 3.7, 3.8, 3.9, and 3.14.

Visual Resources Management
WLD-4: *The visual analysis is inadequate.*
The BLM only manages visual resources on BLM-administered lands. Impacts to visual resources on BLM-administered lands have been analyzed in Section 3.10.

Social and Economic
ICL-3: *Social and economic impacts to landowners were not adequately addressed.*
Social and economic impacts, including land values and use, are addressed in Sections 3.5, 3.13, and 3.14. Private landowners in and adjacent to the proposed lease area have been involved in this process. The concerns raised during the July 20144 scoping period were addressed in the EA. One landowner commented on the EA regarding how parcels were delineated. Analyses during the APD phase will provide more in-depth assessment of these issues.

WLD-4: *The noise zone has not been mapped.*
Noise impacts to wildlife and humans are discussed in Sections 3.6.2 and 3.14, respectively. Noise is an impact that is more appropriately analyzed in the NEPA for an APD, and can be mitigated by applying a Condition of Approval requiring noise reduction measures, if needed.

WEG-8: *The social cost of carbon needs to be addressed.*
The social cost of carbon is addressed in Air Resources and Social and Economic sections 3.4.2 and 3.14.2, respectively.

Other Resources
WLD-18: *Paleontological resources are ignored.*
A paleontological resource stipulation (CSU-12) was added to Alternative C (Section 2.3) and the affected environment and environmental consequences were described (Section 3.8).

Ex. 2

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Billings Field Office
5001 Southgate Drive
Billings, Montana 59101-4669
www.blm.gov/mt

In Reply Refer To:
1600/3100 (MT0010)

Dear Reader:

The Bureau of Land Management (BLM) Billings Field Office has prepared an Environmental Assessment (EA) to analyze the potential effects from offering ten nominated lease parcels with 1282.44 acres of federal surveyed minerals for competitive oil and gas leasing in a sale tentatively scheduled to occur on October 21, 2014.

The EA with an unsigned Finding of No Significant Impact (FONSI) is available for a 30-day public comment period. Written comments must be postmarked by June 20, 2014 to be considered. Comments may be submitted using one of the following methods:

Email:	MT_BillingsFO_Lease_EA@blm.gov
Mail:	Billings Field Office
Attn:	Craig Drake
	5001 Southgate Drive
	Billings, MT 59101

Before including your address, phone number, e-mail address, or other personal identifying information in your comment, you should be aware that your entire comment – including your personal identifying information – will be available for public review. If you wish to withhold personal identifying information from public review or disclosure under the Freedom of Information Act (FOIA), you must clearly state, in the first line of your written comment, "CONFIDENTIALITY REQUESTED." While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so. All submissions from organizations, from businesses, and from individuals identifying themselves as representatives of organizations or businesses, will be available for public review.

Upon review and consideration of public comments, the EA will be updated as needed. Based on our analysis, parcels recommended for leasing in our assessment would be included as part of a competitive oil and gas lease sale tentatively scheduled to occur on October 21, 2014.

Prior to issuance of any leases, the Decision Record and FONSI will be finalized and posted for public review on our BLM website. Please refer to the Montana/Dakotas BLM website at http://blm.gov/qtld for availability of the updated EA and the Lease Sale Notice. From this home page, go to the heading titled "Frequently Requested," where you will find a number of links to information about our oil and gas program. Current and updated information about our EAs, Lease Sale Notices and corresponding information can be found on the link titled "Oil and Gas

Lease Sale Information." Once there, click on 2014, and search for the October 21, 2014 lease sale to review information and analysis.

If you have any questions, or would like more information about the updated EA or upcoming oil and gas lease sale, please contact us at (406) 896-5013.

Sincerely,

James M. Sparks

James M. Sparks
Field Manager

BLM

United States Department of the Interior
Bureau of Land Management

Environmental Assessment DOI-BLM-MT-0010-2014-0011-EA
May 19, 2014

Project Title: Oil and Gas Lease Parcel Sale,
October 21, 2014

Location: Billings Field Office (see Figures 5-9 (Maps) and attached Appendix A for lis lease parcels with number and legal description)

U.S. Department of the Interior
Bureau of Land Management
Billings Field Office
5001 Southgate Drive
Billings, MT 59101
Phone: 406-896-5013
FAX: 406-896-5281

Billings Field Office Oil and Gas Lease Sale EA
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Billings Field Office Oil and Gas Lease Sale EA
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1.0 PURPOSE AND NEED

1.1 Introduction

It is the policy of the Bureau of Land Management (BLM) to make mineral resources available for use and to encourage development of mineral resources to meet national, regional, and local needs. This policy is based on various laws, including the Mineral Leasing Act of 1920 and the Federal Land Policy and Management Act of 1976. The Federal Onshore Oil and Gas Leasing Reform Act of 1987 Sec. 5102(a)(b)(1)(A) directs the BLM to conduct quarterly oil and gas lease sales in each state whenever eligible lands are available for leasing. The Montana State Office conducts mineral estate lease auctions for lands managed by the federal government, whether the surface is managed by the Department of the Interior (BLM or Bureau of Reclamation), United States Forest Service, or other departments and agencies. In some cases the BLM holds subsurface mineral rights on split-estate lands where the surface estate is owned by another party, other than the federal government. Federal mineral leases can be sold on such lands as well. The Montana State Office has historically conducted five lease sales per year.

Members of the public file Expressions of Interest (EOI) to nominate parcels for leasing by the BLM. From these EOIs, the Montana State Office provides draft parcel lists to the appropriate field offices for review. BLM field offices then review legal descriptions of nominated parcels to determine: 1) if they are in areas open to leasing; 2) if new information has come to light which might change previous analyses conducted during the land use planning process; 3) if there are special resource conditions of which potential bidders should be made aware; and 4) which stipulations should be identified and included as part of a lease. Ultimately, all of the lands in proposed lease sales are nominated by private individuals, companies, or the BLM, and therefore represent areas of high interest.

This environmental assessment (EA) has been prepared to disclose and analyze the potential environmental consequences from leasing parcels located in the Billings Field Office (BiFO), to be included as part of a competitive oil and gas lease sale tentatively scheduled to occur October 22, 2014.

The analysis area includes the area surrounding the 10 nominated parcels in Yellowstone County (Figure 5).

1.2 Purpose and Need for the Proposed Action

The purpose of offering parcels for competitive oil and gas leasing is to provide opportunities for private individuals or companies to explore for and develop federal oil and gas resources after receipt of necessary approvals and to sell the oil and gas in public markets.

This action is needed to help meet the energy needs of the people of the United States. By conducting lease sales, the BLM provides for the potential increase of energy reserves for the U.S., a steady source of income, and at the same time meets the requirement identified in the

Energy Policy Act, Sec. 362(2), Federal Oil and Gas Leasing Reform Act of 1987, and the Mineral Leasing Act of 1920, Sec. 17.

The decision to be made is whether to sell and issue oil and gas leases on the lease parcels identified, and, if so, identify stipulations that would be included with specific lease parcels at the time of lease sale.

1.3 Conformance with Land Use Plan(s)

This EA is tiered to the decisions and conforms with information and analysis contained in the Billings Resource Management Plan (RMP) (September 1984) and its associated environmental impact statement. The Billings RMP is the governing land use plan for the Billings Field Office. The Oil and Gas portion of the 1984 Billings RMP was amended by the 1992 Oil and Gas Amendment of the Billings, Powder River, and South Dakota Resource Management Plans and Final Environmental Impact Statement and the 1994 Record of Decision. The 2008 Final Supplement to the Montana Statewide Oil and Gas Environmental Impact Statement and Proposed Amendment of the Powder River and Billings Resource Management Plans (FSEIS) amended the 1984 Billings RMP/EIS with a development alternative for coal bed natural gas production. A more complete description of activities and impacts related to oil and gas leasing, development, production, etc. can be found in Chapter Four – Environmental Consequences (pages 55-77) of the 1992 Oil and Gas RMP/EIS Amendment.

Analysis of leasing the parcels is documented in this EA, and was conducted by Billings Field Office resource specialists who relied on professional knowledge of the areas involved, review of current databases and file information, and site visits (where necessary) to ensure that appropriate lease stipulations were recommended for a specific parcel. Analysis may have also identified the need to defer entire or partial parcels from leasing pending further environmental review.

At the time of this review it is unknown whether a particular lease parcel will be sold and a lease issued. It is unknown when, where, or if future well sites, roads, and facilities might be proposed. Assessment of potential activities and impacts was based on potential well densities discerned from the Reasonably Foreseeable Development (RFD) Scenario developed for the Billings Field Office. Detailed site-specific analysis and mitigation of activities associated with any particular lease would occur when a lease holder submits an application for permit to drill (APD). In this scenario, the BLM would require the use of best management practices (BMPs) documented in Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development-The Gold Book (USDI and USDA 2007) and online at http://www.blm.gov/wo/st/en/prog/energy/oil_and_gas/best_management_practices.html.

Offering the parcels for sale and issuing leases would not be in conflict with any local, county, or state laws or plans.

1.4 Public Scoping and Identification of Issues

Public scoping for this project was conducted through a 15-day scoping period advertised on the BLM Montana State Office website, posted on the Billings Field Office website National

Environmental Policy Act (NEPA) notification log, and individual agency consultation as noted below. Scoping was initiated March 25, 2014; comments were received through April 09, 2014.

The BLM coordinates with Montana Fish, Wildlife and Parks (MT FWP) and the United States Fish and Wildlife Service (USFWS) to manage wildlife habitat because BLM management decisions can affect wildlife populations which depend on the habitat. The BLM manages habitat on BLM managed public lands, while MT FWP is responsible for managing wildlife species populations. The USFWS also manages some wildlife populations, but only those federal trust species managed under mandates such as the Endangered Species Act, Migratory Bird Treaty Act, and the Bald and Golden Eagle Protection Act. Managing wildlife is factored into project planning at multiple scales and is to be implemented early in the planning process.

Coordination with MT FWP and USFWS was conducted for the 10 lease parcels being reviewed. BLM has coordinated with MT FWP and USFWS in the completion of this EA in order to prepare analysis, identify protective measures, and apply stipulations associated with these parcels being analyzed. The BLM consults with the State Historic Preservation Office (SHPO) and Native Americans under Section 106 of the National Historic Preservation Act (NHPA). BLM sent letters to the SHPO, Tribal Presidents, and Tribal Historical Preservation Officers (THPOs) or other cultural contacts for the Crow Tribe and Northern Cheyenne Tribe in Montana at the beginning of the 15 day scoping period informing them of the potential for the 13 parcels to be leased and inviting them to submit issues and concerns BLM should consider in the environmental analysis. The BLM also sent letters to USDA Forest Service, Nez Perce Trail Foundation, Nez Perce Tribal representatives, Confederated Tribes of the Colville Reservation, and Confederated Tribes of the Umatilla Indian Reservation, in order to identify issues that may arise from the proposed action with regard to the Nez Perce National Historic Trail.

The BLM focuses its analysis on issues that are truly significant to the action in question, rather than amassing needless detail (40 CFR 1500.1(b)). Issues have a relationship with the proposed action; are within the scope of analysis; and are amenable to scientific analysis.

Identified Issues from Internal and External Scoping:

Internal Scoping Issues:

- Conservation of Greater Sage-Grouse Habitat
- Conservation of wildlife habitat, other than GSG
- Conservation of riparian, aquatic wildlife and water resources
- Potential conflicts with preserving Cultural Resources and Special Designations, such as National Historic Trails
- Potential conflicts with current Right of Way holders

External Scoping Issues:

- Split estate surface owners expressed concerns about oil and gas development causing adverse impacts to natural resources and anthropogenic values (domestic livestock, disruption and disturbance to residence).

- Interested public sent in approximately forty letters expressing opposition to leasing several parcels (MTM 105431-HW and FC mostly) for a number of reasons, including but not limited to: adverse impacts expected to occur from oil and gas development to wildlife resources, water resources, property values, quality of life, road conditions, human health and safety and overall environmental degradation.
- Special interest /non-profit groups expressed interest in ensuring a thorough environmental analysis is conducted that identifies adverse impacts to the environment.

Issues considered but not analyzed in detail:

The BLM considered the following issues, but decided not to analyze them in further detail. The aspects of the existing environment that the BLM determined to not be present or not potentially impacted by this project include: Areas of Critical Environmental Concern (ACECs); hazardous or solid wastes; Wild and Scenic Rivers; Wilderness Areas; Wild Horse and Burros; Lands with Wilderness Characteristics; and forest products. Thus, the EA contains no further discussion of these issues or resources.

2.0 DESCRIPTION OF ALTERNATIVES, INCLUDING PROPOSED ACTION

2.1 Alternative A - No Action

For EAs on externally initiated Proposed Actions, the No Action Alternative generally means that the Proposed Action would not take place. In the case of a lease sale, this would mean that all expressions of interest to lease (parcel nominations) would be denied or rejected.

The No Action Alternative would exclude all parcels (10 @ 1282.44 acres) within the Billings Field Office from the lease sale. Surface management would remain the same and ongoing oil and gas development would continue on surrounding federal, private, and state leases.

2.2 Alternative B – Proposed Action

The Proposed Action Alternative would be to offer ten parcels of federal minerals for oil and gas lease, covering 1,282.44 acres administered by the Billings Field Office, in conformance with the existing land use planning decisions. The ten parcels would be offered with RMP lease stipulations and/or lease notices as necessary (Appendix A) for competitive oil and gas lease sale and lease issuance. The parcels are located in Yellowstone County in south-central Montana. Parcel number, size, and detailed locations, and proposed stipulations are listed in Appendix A. Map 1 indicates the general location of each parcel.

Of the 1,282.44 acres of federal mineral estate considered in this EA, approximately 240 surface acres in 2 parcels are managed by the BLM. Eight parcels (1,042.44 acres) are split-estate (private surface underlain by federal mineral estate).

In the instance of the parcels which are split-estate, the BLM provided courtesy notification to private landowners that their lands are being considered in this NEPA analysis and would be considered for inclusion in an upcoming lease sale. If any activity were to occur on such split-estate parcels, the lessee and/or operator would be responsible for adhering to BLM requirements as well as reaching an agreement with the private surface landowners regarding access, surface disturbance, and reclamation. Standard lease terms, stipulations, conditions, and operating procedures would apply to these parcels.

Standard operating procedures, best management practices, required conditions of approval (COAs), and the application of lease stipulations change over time to meet overall RMP objectives. The COAs would be attached to permits for oil and gas lease operations to address site-specific concerns or new information not previously identified in the land use planning process. In some cases, new lease stipulations may need to be developed and these types of changes may require an RMP amendment. There is no relief from meeting RMP objectives if local conditions were to become drier and hotter during the life of the RMP. In this situation, management practices might need to be modified to continue meeting overall RMP management objectives. An example of a climate related modification is the imposition of additional conditions of approval to reduce surface disturbance and implement more aggressive dust treatment measures. Both actions reduce fugitive dust, which would otherwise be exacerbated by the increasingly arid conditions that could be associated with climate change.

Oil and gas leases would be issued for a 10-year term and would continue for as long thereafter as oil or gas is produced in paying quantities. If a lessee fails to produce oil and gas, does not make annual rental payments, does not comply with the terms and conditions of the lease, or relinquishes the lease, ownership of the minerals leased would revert back to the federal government, and the lease could be resold.

Drilling of wells on a lease would not be permitted until the lease owner or operator secures approval of a drilling permit and a surface use plan specified at 43 CFR 3162.

2.3 Alternatives Considered, but Eliminated from Further Analysis

Initially, the BLM received 13 Expressions of Interest, an alternative that included leasing all 13 nominated parcels (1682.44 acres) was considered. Three of the parcels, however, are considered unsuitable for leasing at this time. Parcels MTM 105431-HW, MTM 105431-F4, and MTM 105431-E9 all contain resources that are subject to proposed stipulations under the Draft Billings Resource Management Plan.

Parcel MTM 105431-HW contains the unincorporated town of Dean, Montana, a reach of stream designated by MT FWP as Suitable Yellowstone Cutthroat trout recovery habitat and also falls within a state designated Source Water Protection Area. Parcels MTM 105431-E9 and F4 are in close proximity to Greater sage-grouse and Sharptail grouse leks. All of these conditions are addressed with major stipulations to oil and gas development in the Draft Billings Resource Management Plan.

The Billings Field Office is in the process of completing a Resource Management Plan Revision. The process began in 2008 and the draft RMP/EIS was released for public review in March 2013. Oil and gas development and sage-grouse, Yellowstone cutthroat trout and water resource management are key issues identified by public comment in the Scoping Summary Report,

available for review at:
http://www.blm.gov/style/medialib/blm/mt/field_offices/billings/rmp.Par.24693.File.dat/ScopingReport.pdf

The current Billings Field Office RMP is dated 1984, as amended (most notably in 1992, where oil and gas leasing stipulations were updated). Since that time there have been substantial improvements in oil and gas development technology, as well as our understanding of Greater Sage-grouse and Cutthroat trout habitat requirements and development related disturbance impacts. The Draft Billings and Pompey's Pillar National Monument RMP/EIS revision (in progress) would provide stipulations relative to oil and gas development and sage-grouse and Yellowstone Cutthroat trout based upon our current understanding, including those areas where no development may be the appropriate management response. The RMP/EIS also considers alternatives that place major stipulations on Source Water Protection Areas and areas containing unincorporated towns.

Conclusion
The three parcels proposed for deferral encompass 400 acres of federal mineral estate (including 320 acres of BLM administered surface estate). The decision of whether or not to lease the above referenced parcels will be deferred until such time that a final decision on the Billings Field Office RMP has been rendered and will not be considered further in this analysis.

3.0 AFFECTED ENVIRONMENT

3.1 Introduction
This chapter describes the affected environment (i.e., the physical, biological, social, and economic values and resources) within the analysis area, which includes the ten nominated parcels in Yellowstone County (Map 1) and immediately surrounding area that could be affected by implementation of the alternatives described in Chapter 2.

The existing environment is described by the different resources found throughout the analysis area. Within each resource description, lease parcels containing the resource will be listed and analyzed further in Chapter 4.

Unless otherwise stated, resource analysis in this chapter, and Chapter 4, will be described in approximate acres due to scaling and precision parameters associated with the Geographic Information System (GIS), in addition to being referenced to a different land survey.

The Billings Field Office has surface management responsibility for approximately 434,154 acres of BLM-administered public land (herein referred to as public land) and about 690,000 acres of federal mineral estate (oil and gas) within eight counties in south-central Montana (Big Horn, Carbon, Golden Valley, Musselshell, Stillwater, Sweet Grass, Wheatland, and Yellowstone). The Billings Field Office also administers 6,340 acres of public land in Big Horn County, Wyoming (Pryor Mountain Wild Horse Range).

Except for several contiguous blocks of land in Carbon County, most of the public lands described above consist of scattered tracts, intermingled with private and state-owned tracts.

The general climate in south-central Montana is Middle Latitude Steppe. This is a semi-arid region characterized by low rainfall, low humidity, clear skies, and wide ranges in annual and diurnal temperatures. Average annual precipitation is about 14 inches with about one third of that falling in May and June. The driest period is from November to February. Heavy snows are not unusual during the winter. Strong downslope winds known as Chinooks have a thawing and drying effect, and snow seldom accumulates to great depths.

The Billings Field Office management area is situated within the area called the Northwestern Plains, though portions of the management area also include the eastern slope of the Rocky Mountains (Beartooth Range) and several island mountain ranges, including the Pryor Mountains and Bull Mountains. Other mountain ranges within the Billings Field Office management area include the Little Snowy, Snowy, Belts, Crazy, and Absaroka mountains. Several rivers bisect the Billings Field Office management area: the Bighorn, Yellowstone, Musselshell, Clark's Fork of the Yellowstone, Stillwater, and Boulder.

The topography in south-central Montana ranges from moderately steep to steep mountains and canyons to rolling plains and tablelands of moderate relief. Elevations generally range from about 3,000 to 7,000 feet above mean sea level, with mountain peaks rising to over 10,000 feet.

3.2 Air Resources

Air resources include air quality, air quality related values (AQRVs), and climate change. As part of the planning and decision making process, the BLM considers and analyzes the potential effects of BLM and BLM-authorized activities on air resources.

The Environmental Protection Agency (EPA) has the primary responsibility for regulating air quality, including seven criteria air pollutants subject to National Ambient Air Quality Standards (NAAQS). Pollutants regulated under NAAQS include carbon monoxide (CO), lead, nitrogen dioxide (NO_2), ozone, particulate matter with a diameter less than or equal to 10 microns (PM_{10}), particulate matter with a diameter less than or equal to 2.5 microns ($PM_{2.5}$), and sulfur dioxide (SO_2). Two additional pollutants, nitrogen oxides (NO_x) and volatile organic compounds (VOCs) are regulated because they form ozone in the atmosphere. Regulation of air quality is also delegated to some states. Air quality is determined by pollutant emissions and emission characteristics, atmospheric chemistry, dispersion meteorology, and terrain. AQRVs include effects on soil and water, such as sulfur and nitrogen deposition and lake acidification, and aesthetic effects, such as visibility.

Climate is the composite of generally prevailing weather conditions of a particular region throughout the year, averaged over a series of years. Climate change includes both historic and predicted climate shifts that are beyond normal weather variations.

3.2.1 Air Quality

The EPA air quality index (AQI) is an index used for reporting daily air quality to the public. The index tells how clean or polluted an area's air is and whether associated health effects might be a concern. The EPA calculates the AQI for six criteria air pollutants regulated by the Clean Air Act (CAA): ground-level ozone, CO, PM_{10}, $PM_{2.5}$, SO_2, and NO_2. For each of these pollutants, EPA has established national air quality standards to protect public health. An AQI value of 100 generally corresponds to the national air quality standard for the pollutant, which is the level the EPA has set to protect public health. The following terms help interpret the AQI information:

- **Good** - The AQI value is between 0 and 50. Air quality is considered satisfactory and air pollution poses little or no risk.
- **Moderate** - The AQI is between 51 and 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.
- **Unhealthy for Sensitive Groups** - When AQI values are between 101 and 150, members of "sensitive groups" may experience health effects. These groups are likely to be affected at lower levels than the general public. For example, people with lung disease are at greater risk from exposure to ozone, while people with either lung disease or heart disease are at greater risk from exposure to particle pollution. The general public is not likely to be affected when the AQI is in this range.
- **Unhealthy** – The AQI is between 151 and 200. Everyone may begin to experience some adverse health effects, and members of the sensitive groups may experience more serious effects.
- **Very Unhealthy** – The AQI is between 201 and 300. This index level would trigger a health alert signifying that everyone may experience more serious health effects.

AQI data (

Table 1) show that there is little risk to the general public from air quality in the Billings Field Office. During 2010-2012, 84 percent of the days were rated "good." While there have been some days that posed a health risk for sensitive groups, the occurrence is rare (approximately 1 percent). The pollutants that cause the highest AQI values in Yellowstone County are SO_2 and $PM_{2.5}$.

Table 1: USEPA Air Quality Index Report – Billings Field Office Summary (2010-2012).

County	State	# Days with Data	# Days Rated Good	Percent of Days Rated Good	# Days Rated Mod	# Days Rated Unhealthy for Sensitive Groups	# Days Rated Unhealthy or Very Unhealthy
Yellowstone	MT	1,096	924	84	157	15	0

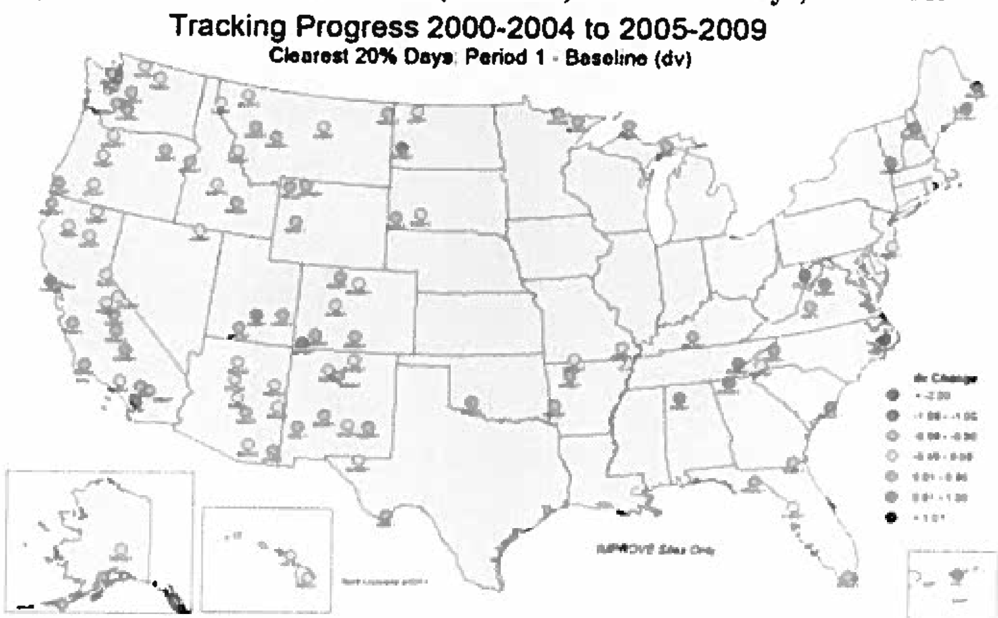
[1] Source: EPA Air Data website (http://www.epa.gov/airdata/ad_rep_aqi.html, accessed December 4, 2013)

An SO_2 nonattainment area has been designated by the USEPA near Laurel, Montana. The circular nonattainment area extends 2 kilometers from the center of a tank at an oil refinery located in the southern portion of Laurel. The lease parcels are not located within the nonattainment area.

Ozone, PM_{10}, and NO_2 are not currently monitored in Yellowstone County or the BiFO. Based on data at the Birney monitor in Rosebud County located east of the BiFO, 2010-2012 monitored ozone, NO_2, and PM_{10} concentrations were 75 percent, 8 percent, and 13 percent of the NAAQS, respectively (MDEQ 2013). Although ozone concentrations above the NAAQS have been monitored in some rural areas in other states with oil and gas activity, moderate ozone concentrations have been monitored in Montana oil and gas areas. Based on 2010-2012 data from monitors located near Sidney and Broadus, Montana, ozone concentrations are approximately 75 percent of the ozone NAAQS (MDEQ 2013).

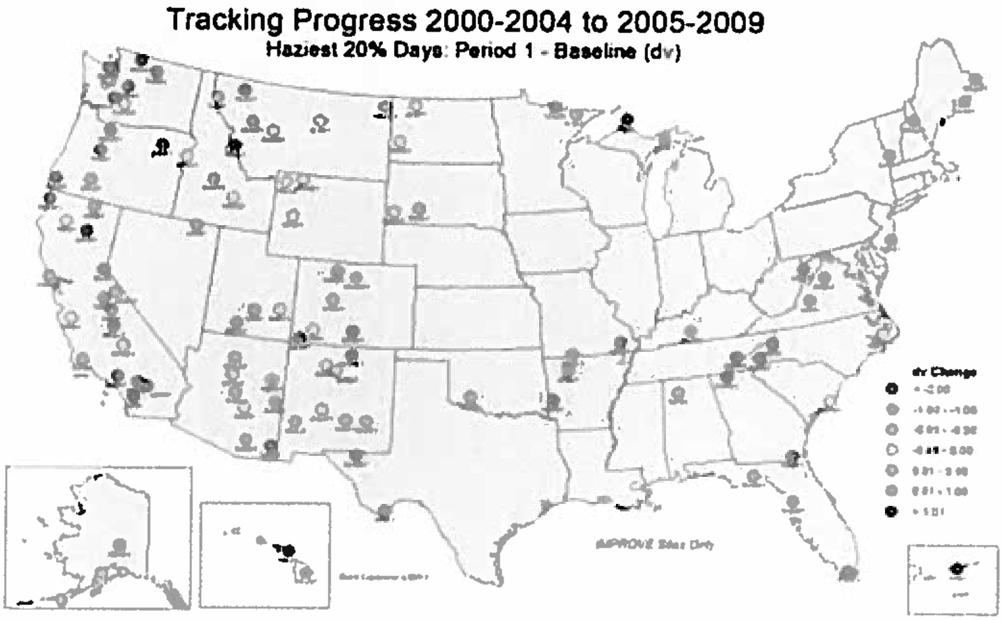
Air resources also include visibility, which can be degraded by regional haze due in part to sulfur, nitrogen, and particulate emissions. Based on trends identified during 2005-2009, visibility has improved at the nearest IMPROVE monitors located in and near Yellowstone National Park on the clearest and haziest days, as shown in Figure 1 and **Figure 2**.

Figure 1: Trends in haze index (deciview) on clearest days, 2005-2009



Source: IMPROVE 2011

Figure 2: Trends in haze index (deciview) on haziest days, 2005-2009



Source: IMPROVE 2011

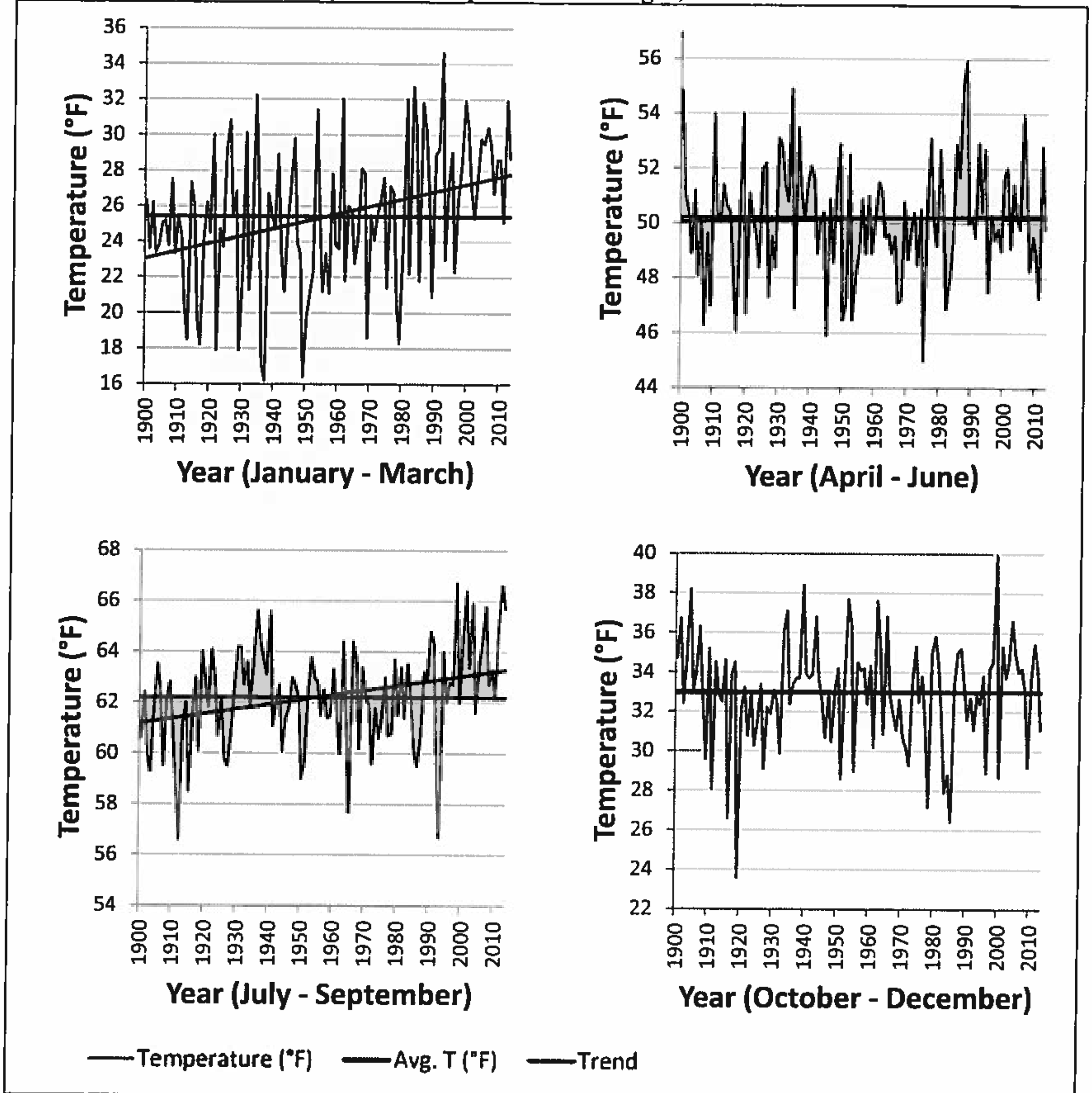
3.2.2 Climate Change

Climate change is defined by the Intergovernmental Panel on Climate Change (IPCC) as "a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and persist for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use." (IPCC 2013). Climate change and climate science are discussed in detail in the Climate Change Supplementary Information Report for Montana, North Dakota, and South Dakota, Bureau of Land Management (Climate Change SIR 2010). This document is incorporated by reference into this EA.

The IPCC states, "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased." (IPCC 2013). The global average surface temperature has increased approximately 1.54°F from 1880 to 2012 (IPCC 2013). Warming has occurred on land surfaces, oceans and other water bodies, and in the troposphere (lowest layer of earth's atmosphere, up to 4-12 miles above the earth).

In south-central Montana, surface air temperatures over the past 114 years have increased by an average of 0.16°F annually (NOAA 2014). Quarterly temperature increases over this period are shown in **Figure 3**. Average temperature increases were 0.42°F for January-March, 0.02°F for April-June, 0.19°F for July-September, and 0.03°F for October-December.

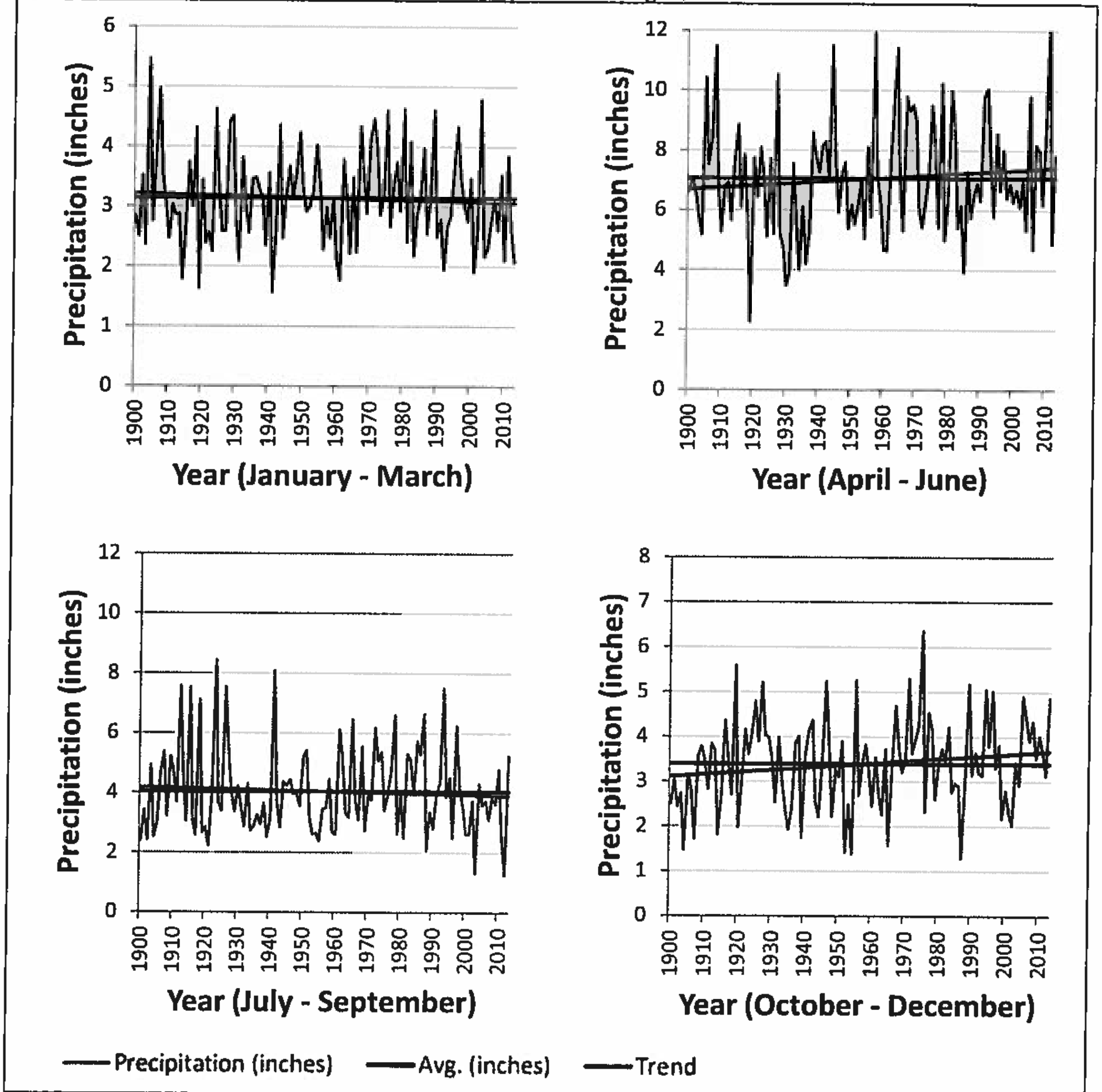
Figure 3: South-Central Montana Temperature Changes, 1900-2013



Source: Adapted from NOAA 2014

Long-term precipitation changes have also been observed globally and in south-central Montana. Total precipitation and shifts in precipitation timing and intensity have been observed. Within south-central Montana, annual precipitation has changed at an annual rate of 0.08 inches per decade from 1900-2013. **Figure 4** illustrates quarterly precipitation changes. Precipitation has increased during the second and fourth calendar quarters, while decreasing in the first and third quarters.

Figure 4: South-Central Montana Precipitation Changes, 1900-2013



Source: Adapted from NOAA 2014

As discussed in the Climate Change SIR (2010), earth has a natural greenhouse effect wherein naturally occurring gases such as water vapor, CO_2, methane, and N_2O absorb and retain heat. Without the natural greenhouse effect, earth would be approximately 60°F cooler (Climate Change SIR 2010). Current ongoing global climate change is linked to the atmospheric buildup of GHGs, which may persist for decades or even centuries. Each GHG has a global warming potential that accounts for the intensity of each GHG's heat trapping effect and its longevity in the atmosphere (Climate Change SIR 2010). The buildup of GHGs such as CO_2, methane, N_2O, and halocarbons since the start of the industrial revolution has substantially increased atmospheric concentrations of these compounds compared to background levels. At such elevated concentrations, these compounds absorb more energy from the earth's surface and re-emit a larger portion of the earth's heat back to the earth rather than allowing the heat to escape into space than would be the case under more natural conditions of background GHG concentrations.

A number of activities contribute to the phenomenon of climate change, including emissions of GHGs (especially carbon dioxide and methane) from fossil fuel development, large wildfires, combustion of fossil fuels, changes to the natural carbon cycle, and changes to radiative forces and reflectivity (albedo). GHGs have a sustained climatic impact over different temporal scales due to their differences in global warming potential (described above) and lifespans in the atmosphere. For example, CO_2 may last 50 to 200 years in the atmosphere while methane has an average atmospheric life time of approximately 12 years (Climate Change SIR 2010).

With regard to statewide GHG emissions, Montana ranks in the lowest decile when compared to all the states (Ramseur 2007). The estimate of Montana's 2005 GHG emissions of 37 million metric tons (MMt) of gross consumption-based carbon dioxide equivalent (CO_2e) account for approximately 0.6 percent of the U.S. GHG emissions (CCS 2007).

Some information and projections of regional impacts is becoming increasingly available. Chapter 3 of the Climate Change SIR describes impacts of climate change in detail at various scales, including the state scale when appropriate. The following bullets summarize potential changes that are expected to occur at the regional scale. The EPA identifies this area as part of the Mountain West and Great Plains region.

The region is expected to experience warmer temperatures with less snowfall. Temperatures are expected to increase more in winter than in summer, more at night than in the day, and more in the mountains than at lower elevations. Earlier snowmelt means that peak stream flow would be earlier, weeks before the peak needs of ranchers, farmers, recreationalist, and others. In late summer, rivers, lakes, and reservoirs would be drier. More frequent, more severe, and possibly longer-lasting droughts are expected to occur. Crop and livestock production patterns could shift northward; less soil moisture due to increased evaporation may increase irrigation needs. Drier conditions would reduce the range and health of ponderosa and lodgepole pine forests, and increase the susceptibility to fire. Grasslands and rangelands could expand into previously forested areas. Ecosystems would be stressed and wildlife such as the mountain lion, black bear, long-nose sucker, marten, and bald eagle could be further stressed.

Other impacts could include:

- Increased particulate matter in the air as drier, less vegetated soils experience wind erosion.
- Shifts in vegetative communities which could threaten plant and wildlife species.
- Changes in the timing and quantity of snowmelt which could affect both aquatic species and agricultural needs.

Projected and documented broad-scale changes within ecosystems of the U.S. are summarized in the Climate Change SIR. Some key aspects include:

- Large-scale shifts have already occurred in the ranges of species and the timing of the seasons and animal migrations. These shifts are likely to continue (Climate Change SIR 2010). Climate changes include warming temperatures throughout the year and the arrival of spring an average of 10 days to two weeks earlier through much of the U.S. compared to 20 years ago. Multiple bird species now migrate north earlier in the year.
- Fires, insect epidemics, disease pathogens, and invasive weed species have increased and these trends are likely to continue. Changes in timing of precipitation and earlier runoff increase fire risks.
- Insect epidemics and the amount of damage that they may inflict have also been on the rise. The combination of higher temperatures and dry conditions have increases insect populations such as pine beetles, which have killed trees on millions of acres in western U.S. and Canada. Warmer winters allow beetles to survive the cold season, which would normally limit populations; while concurrently, drought weakens trees, making them more susceptible to mortality due to insect attack.

More specific to Montana, additional projected changes associated with climate change described in Section 3.0 of the Climate Change SIR (2010) include:

- Temperature increases in Montana are predicted to be between 3 to 5°F at mid-21st century. As the mean temperature rises, more heat waves are predicted to occur.
- Precipitation increases in winter and spring in Montana may be up to 25 percent in some areas. Precipitation decreases of up to 20 percent may occur during summer, with potential increases or decreases in the fall.
- For most of Montana, annual median runoff is expected to decrease between 2 and 5 percent, but northwestern Montana may see little change in annual runoff. Mountain snowpack is expected to decline, reducing water availability in localities supplied by meltwater.
- Wind power production potential is predicted to decline in Montana based on modeling focused on the Great Falls area.
- Water temperatures are expected to increase in lakes, reservoirs, rivers, and streams. Fish populations are expected to decline due to warmer temperatures, which could also lead to more fishing closures.
- Wildland fire risk is predicted to continue to increase due to climate change effects on temperature, precipitation, and wind. One study predicted an increase in median annual area burned by wildland fires in Montana based on a 1°C global average temperature increase to be 241 to 515 percent.

3.3 Soil Resources

The soil-forming factors (climate, parent material, topography, biota, and age) are variable across the planning area, which results in soils with diverse physical, chemical, and biotic properties. Important properties of naturally functioning soil systems include biotic activity, diversity, and productivity; water capture, storage, and release; nutrient storage and cycling; contaminant filtration, buffering, degradation, immobilization, and detoxification; and biotic system habitat.

Soil restoration potential rates each soil for its inherent ability to recover from degradation, which is often referred to as soil resilience. The ability to recover from degradation means the ability to restore functional and structural integrity after a disturbance. Soil functions that are important include sustaining biological activity, diversity and productivity; capture, storage and release of water; storing and cycling nutrients and other elements; filtering, buffering, degrading, immobilizing and detoxifying contaminants; providing support for plant and animal life

"High potential" indicates that the soil has features that are very favorable for recovery. Good performance can be expected. "Moderate potential" indicates that the soil has features that are generally favorable for recovery. Fair performance can be expected. "Low potential" indicates that the soil has one or more features that are unfavorable for recovery. Poor performance can be expected.

Table 2 shows the acres by soil map unit within each lease parcel, the map unit restoration potential rating, and if soil/slope stipulations have been applied to the lease parcel.

Table 2: Lease Parcels, Soil Map Units, Acres of Soil Type per Lease Unit, and Soil Restoration Potential

Lease Parcel Approx. acres	Soil Map Unit [2]	Acres per lease parcel / percent lease parcel [3]	Soil Restoration Potential
MTM-105431-FA 160 acres	MY	109 / 68%	Moderate
	SM	37 / 23%	Moderate
	EC	11 / 7%	Moderate
MTM-105431-FB 40 Acres	258F	36 / 90%	Moderate
	El	4 / 10%	Moderate
MTM-105431-FC 322 Acres	My	305 / 95%	Moderate
	Sm	6 / 2 %	Moderate
	Ms	12 / 4%	High
MTM-105431-FD 40 Acres	383-E	20 / 50%	Moderate
	Bl	12 / 24%	High
	Ms	4 / 8%	High
	Rk	3 / 8%	Not Rated (rock)
MTM-105431-FE 80 Acres	Rk (rock)	39 / 49%	Not Rated (rock)
	Ms	23 / 29%	High
	285-F	9 / 11%	Moderate
	80-D	10 / 13%	Moderate
MTM-105431-FF 40 Acres	My	40 / 100%	Moderate

MTM-105431-F3 320 Acres	Pc	187 / 58%	High
	Hm	35 / 11%	High
	Mw	28 / 9%	Moderate
	Pl	20 / 6%	High
	Ax	24 / 8%	Low
	Av	21 / 7%	Low
MTM-105431-F5 160 Acres	Ec	35 / 22%	Moderate
	El	21 / 7%	Moderate
	Kn	16 / 10%	High
	He	16 / 10%	High
	El	2 / 1%	Moderate
	Lr	8 / 5%	High
	Pl	10 / 6%	High
	Pl	10 /6%	High
MTM-105431-F6 80 Acres	Kn	14 / 18%	High
	Hz	6 / 8%	High
	Hz	6 /8%	High
MTM-105431-F7 40 Acres	383E	34 /85%	Moderate
	Bf	4 /10 %	High

Lease parcels highlighted indicate where CSU 12-1 Stipulations will be applied in the proposed action.
[2]Soil Map Units <1% of the lease parcel are not listed.
[3]Acres rounded to the nearest whole acre, percent rounded to the nearest whole percent.

Two soil map units (Av, Ax) have a low soil restoration potential. These map units occur in three lease parcels (MTM-105431- F3, F5, F6), however on two of the lease parcels (F5 and F-6) soils map units with a low soil restoration potential compose less than 1 % of the acreage. These soils have a high presence of salt, which impacts the vegetative productivity of the site.

3.4 Water Resources

3.4.1 Surface Hydrology

Surface water resources across the Billings Field Office are present as lakes, reservoirs, rivers, ponds, streams, wetlands, and springs. Water resources are essential to the residents to support agriculture, public water supplies, industry, recreation and other beneficial uses. Water resources and riparian areas are crucial to the survival of many BLM-sensitive fish, reptiles, birds, and amphibians as well as other wildlife.

The ten parcels available for lease sale are within the Upper Yellowstone-Lake Basin sub-basin (HUC-10070004). There are two parcels identified as having surface water resources, MTM 105431-FC and F6. Parcel FC contains an ephemeral drainage with a reservoir on the eastern end. The reservoir, on private surface, fluctuates dramatically seasonally and from year to year depending on climatic conditions. Parcel F6, on BLM public surface, contains a short reach of Twelve Mile Creek and a small intermittent tributary. Both of these stream reaches are intermittent and fluctuate from mostly dry to consistent perennial flow, depending on climatological conditions. Other parcels contain ephemeral drainages that have surface discharge during periods of heavy precipitation, including during site visits in mid-April.

3.4.2 Groundwater

The quality and availability of ground water varies greatly across the three state region (Montana, North Dakota, and South Dakota). Aquifers in western Montana are typically in unconsolidated, alluvial valley-fill materials within intermontane valleys. The intermontane valley aquifers often yield relatively large quantities of high-quality water to relatively shallow water wells. Because many wells are being constructed in these aquifers as development encroaches, fractured bedrock aquifers surrounding the intermontane valleys are becoming important. Residents in eastern Montana and the Dakotas commonly get their ground water from aquifers consisting of unconsolidated, alluvial valley-fill materials, glacial outwash, or consolidated sedimentary rock formations (such as the Fort Union, Hell Creek, Fox Hills, Judith River, and Eagle consolidated formations). In some areas east of the Rocky Mountains, near-surface thick shale deposits such as those of the Colorado Group and Bearpaw (Pierre) Shale severely limit the economic availability of water to wells, or provide water of quality too poor for most uses. Eastern Montana aquifers typically yield less water and produce more salty, or mineralized, water compared to those in western Montana. The water in some eastern aquifers is suitable only for livestock consumption.

Local groundwater conditions within the vicinity of the lease parcels are highly variable and include many of the conditions described above.

Any beneficial use of produced groundwater requires water rights to be issued by Montana Department of Natural Resources and Conservation (MDNRC), as established by law. Produced water has been used for watering stock, irrigation, drilling operations, and industrial applications. Most of the CBNG-produced water is pumped into temporary ponds, where the water evaporates or could potentially infiltrate the soil or shallow aquifers.

3.5 Vegetation Resources

3.5.1 Vegetation Communities: Upland

The ten proposed lease parcels occur in west central Yellowstone County. This area typically receives between 11-14 inches of precipitation annually. Cool season bunchgrasses such as bluebunch wheatgrass *(Agropyron spicatum)*, needle-and-thread (*Hesperostipa comata)*, crested wheatgrass (*Agropyron cristatum)*, and prairie junegrass (*Koeleria macrantha)* are common. Often big sagebrush (*Artemisia Tridentata)* is common and important with the vegetative community. Where soils are shallow and on slopes ponderosa pine (*Pinus ponderosa*) and rocky mountain juniper (*Juniperus scopulorum*) trees are often found. Tree densities vary from small dense islands to solitary or nearly solitary trees within grass/shrubland. In dry overflow channels rhizomatous grasses such as western wheatgrass (*Pascopyrum smithii)*, and silver sagebrush *(Artemisia cana)* may be present and could dominate these generally small areas.

Parcels MTM-105431 F5, and F6 are also known to contain salt influenced vegetative species such as greasewood (*Sarcobatus vermiculatus)*, saltgrass (*Distichlis spicata*), alkali sacaton (*Sporobolus airiodes*), and bottlebrush squirrel tail (*Elymus elymoides*) these species are typically found in low lying areas where salts accumulate and soils are heavy (clay texture dominated). These species may also be found within the other lease parcels.

The Montana Natural Heritage Tracker (MTNHT) was queried. No threatened, endangered, candidate, or special status plant species exist in the areas proposed for leasing.

3.5.2 Vegetative Communities: Wetland/Riparian

One parcel has been identified as containing riparian resources. Parcel MTM 105431-F6 has a short reach of Twelve Mile Creek running through it with an intermittent tributary as well. Both of these stream reaches are intermittent with poorly developed riparian areas, however riparian communities do exist and are composed primarily of rush (juncus sp.) and sedge (carex sp.). A riparian assessment has not been completed on these areas.

Within other parcels, riparian resources have not been identified, although their presence is possible. Much of the leasing parcel area is very arid, but very small riparian communities may be present where ephemeral and intermittent drainages have received above normal precipitation for two of the last three years. It is also possible that the BLM is not aware of springs or small riparian areas, particularly on split estate parcels. If riparian areas are discovered during future development activities, conditions of approval would be established to prevent disturbance and adverse impacts to riparian function.

3.5.3 Vegetative Communities: Invasive, Non-Native Species (INNS)

The BLM considers plants invasive if they have been introduced into an environment where they did not evolve (BLM national website: http://www.blm.gov/wo/st/en/prog/more/weeds.html). Their vigor, combined with a lack of natural enemies, often leads to outbreak populations. Competition from invasive, non-native plants constitutes a potential threat to native plant species and wildlife habitat within the project area. These species could also affect upland health standards, wildlife habitat quality, and native species diversity. The only noted invasive plant species within these lease parcels is trace amounts of Japanese brome and cheat grass, however a weed inventory and mitigation plan would be required during the APD stage before development occurred.

3.5.4 Vegetative Communities: Noxious Weeds

Noxious weeds are any plant species designated by federal or state law or county government as generally possessing one or more of the following characteristics: aggressive and difficult to manage; parasitic; a carrier or host of serious insects or disease; or non-native, new, or not common to the United States (DOI-BLM, 2007 17 Western State Vegetation Programmatic EIS). The only noxious weed recorded on the parcels is trace amounts of whitetop (Cardaria draba), in or near the intermittent stream bottoms of parcel MTM 105431-F5 and F6. Noxious weed control is typically the responsibility of the surface owner or lease holder (federal and private), in cooperation with the local weed boards or county weed departments, when surface disturbance occurs. The BLM does not maintain inventory data for private surface. Typically, Integrated Pest Management (IPM) is the common approach when treating noxious weeds. IPM is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks.

3.6 Special Status Species

3.6.1 Special Status Animal Species

3.6.1.1 Terrestrial Wildlife

Table 3: Billings Field Office Occurrence of BLM Terrestrial Sensitive Species and USFWS Threatened, Endangered, Candidate or Proposed Terrestrial Species

Species	USFWS Status	BLM Status	In Current Range	Suitable Habitat Present
Mammals				
Gray Wolf	None	Special Status Species (SSS)	Yes	Yes
Grizzly Bear**	Threatened	Sensitive	Yes	Yes
Black-footed ferret	Endangered	SSS	Unlikely	Yes
Canada Lynx	Threatened	Sensitive	Possible	No
Black-tailed prairie dog	None	Sensitive	Yes	Yes
Swift fox	None	Sensitive	Possible	Yes
Fisher	None	Sensitive	No	NA
Meadow Jumping Mouse	None	Sensitive	Yes	Yes
Great Basin Pocket Mouse	None	Sensitive	No	N/A
North American Wolverine	Candidate	Sensitive	Possible	No
Long-legged Myotis	None	Sensitive	Yes	Yes
Long-eared Myotis	None	Sensitive	Yes	Yes
Fringe-tailed Myotis	None	Sensitive	No	N/A
Pallid bat	None	Sensitive	No	N/A
Townsend's big-eared bat	None	Sensitive	Yes	Yes
White-tailed prairie dog	None	Sensitive	Yes	Yes
Birds				
Whooping crane – Yellowstone Co. only	Endangered	SSS	Yes	Yes
Mountain plover	Proposed	Sensitive	Yes	Yes
Long-billed curlew	Bird of Conservation Concern (BCC)	Sensitive	Yes	Yes
Bobolink	None	Sensitive	Yes	Yes
Greater sage-grouse	Candidate	Sensitive	Yes	Yes

Species	USFWS Status	BLM Status	In Current Range	Suitable Habitat Present
Burrowing owl	BCC	Sensitive	Yes	Yes
Bald eagle***	BCC	Sensitive	Yes	Yes
Golden eagle	None	Sensitive	Yes	Yes
Ferruginous hawk	None	Sensitive	Yes	Yes
Swainson's hawk	None	Sensitive	Yes	Yes
Peregrine falcon	None	Sensitive	Yes	Yes
Northern goshawk	None	Sensitive	Yes	possible
Sage thrasher	BCC	Sensitive	Yes	possible
Sprague's pipit	Candidate	Sensitive	Yes	No
Loggerhead shrike	BCC	Sensitive	Yes	Yes
Chestnut-collared longspur	BCC	Sensitive	Yes	Yes
McCown's longspur	BCC	Sensitive	Yes	Yes
Baird's sparrow	BCC	Sensitive	Yes	Yes
Brewer's sparrow	BCC	Sensitive	Yes	Yes
LeConte's sparrow	None	Sensitive	Yes	Yes
Nelson's Sharp-tailed sparrow	None	Sensitive	Yes	Yes
Prairie falcon	BCC	None	Yes	Yes
Sage sparrow	BCC	Sensitive	Yes	Yes
Grasshopper sparrow	BCC	None	Yes	Yes
Dickcissel	BCC	Sensitive	Yes	Yes
Blue-gray gnatcatcher	None	Sensitive	Yes	Yes
Harlequin duck	None	Sensitive	Yes	Yes
Fish				
Yellowstone Cutthroat trout	None	Sensitive	Yes	Yes
Amphibians				
Northern leopard frog	None	Sensitive	Yes	Yes
Plains Spadefoot Toad	None	Sensitive	Yes	Yes
Reptiles				
Spiny softshell turtle	None	Sensitive	Yes	Yes
Greater short-horned lizard	None	Sensitive	Yes	Yes
Milk snake	None	Sensitive	Yes	Yes
Western hog-nosed	None	Sensitive	Yes	Yes

Species	USFWS Status	BLM Status	In Current Range	Suitable Habitat Present
snake				

Sources: Lenard et al., 2003; Werner, Maxell, Hendricks, and Flath. 2004; Foresman 2001; MTNHP, 2010; BLM, 2009; USDA – NRCS Plants Database, 2010
**Grizzly bear has been delisted for the Greater Yellowstone ecosystem. In this area it is a Bureau sensitive species.
***Bald eagle has been delisted so has been moved to the sensitive list.

3.6.2 Threatened, Endangered, Candidate, and Proposed Species

Mammals

There are no documented populations or habitats for sensitive or special status mammal species in the lease parcels. Black-tailed prairie dogs are known to inhabit areas near and around the parcels. Table 3 identifies the occurrence of BLM terrestrial Sensitive Species and USFWS Threatened, Endangered, Candidate or Proposed Terrestrial Species in the BLM Billings Field Office planning area.

Birds

Greater Sage-Grouse

In a recent status review, the USFWS (March 2010) determined that the greater sage-grouse was warranted but precluded for listing under the ESA. In 2009, Montana Fish, Wildlife, and Parks (MT FWP), developed and designated sage-grouse core habitat areas. MT FWP Core Area maps were later updated in March, 2011. The BLM issued Instruction Memorandum No. 2012-043, "Greater Sage-Grouse Interim Management Policies and Procedures, Dec. 22, 2011" that identified Preliminary Priority Habitat (PPH) and Preliminary General Habitat (PGH). Greater sage-grouse use a variety of shrub-steppe habitats throughout their life cycle and are considered obligate users of several sagebrush species (USFWS 2005). Primary ongoing threats to greater sage-grouse include loss and deterioration of habitat from such factors as the spread of noxious weeds, infrastructure development, oil and gas development, wildfire, and conifer invasion (USFWS 2005).

The planning area includes approximately 3.68 million acres (all ownerships) of greater sage-grouse habitat, which includes approximately 336,000 acres (9.1 percent) on BLM public lands.

The analysis area is located within designated sage-grouse general habitat. There are two active leks within the analysis area, one within four miles of several parcels and another with three miles. These leks have seen a steady decline in male attendance over the past decade, with approximately 45% few males attending than the long term average. Two other active leks located five and eight miles north of the analysis area show a 50% decline from the long term average.

Overall, the analysis area is located on the southern fringe of general sage-grouse habitat, with all but four parcels in rugged breaks country that is not preferred by sage-grouse. Parcels F2, F5, F6 and F7 are in grass/shrubland habitat conducive to sage-grouse and comprise 640 acres. These parcels are located 2-3 miles from the nearest sage-grouse lek site.

Bald Eagle and Golden Eagle
Bald eagles are not uncommon to the analysis area; however no nests or specific sites are documented in the parcels. Golden eagles are common to the analysis area and are reported to nest near the north-west corner of parcel FC (surface owner report).

BLM-Listed Sensitive Raptors
BLM-listed sensitive raptors in the planning area include the peregrine falcon, burrowing owl, ferruginous hawk, and Swainson's hawk. Burrowing owls are widely distributed across eastern Montana where they occur in open grasslands and use abandoned mammal burrows (primarily prairie dog and badger) for nesting (MNHP 2005). Ferruginous hawks breed in central Montana but rarely occur in the area during winter. Habitat for these hawks includes grasslands, sagebrush, and other brush lands. The Swainson's hawk breeds throughout Montana, generally nesting in river bottom forests, brushy coulees, and shelterbelts. They hunt in grasslands and agricultural areas, especially along river bottoms (MNHP 2005). Peregrine falcons have five known nest sites within the planning area, three of these known nest sites are on BLM public lands, but none are in close proximity to the lease parcels. The USFWS delisted peregrines from the endangered species list in August 1999, and they remain in the population monitoring phase of delisting. Although specific surveys have not been conducted, occurrence of BLM sensitive raptors, within this analysis area, would not be uncommon.

Migratory Birds
As per Executive Order (EO) 13186, Responsibilities of Federal Agencies to Protect Migratory Birds, federal agencies are required to address migratory birds in their management activities. A wide variety of migratory birds occurs in the planning area, and species are generally associated with particular habitat types. Migratory birds of the greatest conservation concern are those with declining population trends and/or those associated with uncommon habitats. As identified by the USFWS, there are 23 species of Birds of Conservation Concern in 2008 in Montana (USFWS 2008). The lease parcels and surrounding area do not contain any populations of these species, however, the nature of migratory birds and the fact that these parcels lie adjacent to a major river course makes it possible for any number of species to be present during migration.

Reptiles
BLM and Montana Natural Heritage Tracker databases do not indicate the presence of sensitive reptile species in these parcels. The habitat in most parcels is conducive to supporting populations of greater short-horned lizard, milk snake and western hog-nosed snake.

Fish
There are no sensitive fish populations within or in close proximity to the lease parcels.

3.6.3 Special Status Plant Species
Special status plant species are those species that require particular management attention due to population or habitat concerns. These include species that are federally listed as threatened and endangered (T&E) species or habitats designated as critical, federally proposed species, proposed critical habitats, federal candidate species, state-listed as T&E, and Montana BLM

sensitive species. The BLM accomplishes its special status plant management through coordination with the USFWS and the Montana Natural Heritage Program (MNHP).

Bureau sensitive species are those species designated by the state director, usually in cooperation with the state agency responsible for management of the species, and state natural heritage programs. BLM sensitive species are those species that:

- could become endangered in or extirpated from a state, or within a significant portion of its distribution,
- are under status review by the USFWS and/or the National Marine Fisheries Service (NMFS),
- are undergoing significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution,
- are undergoing significant current or predicted downward trends in population or density such that federally listed, proposed, candidate, or state-listed status could become necessary,
- typically have small and widely dispersed populations,
- inhabit ecological refugia or other specialized or unique habitats, or
- are state listed but which could be better conserved through application of BLM sensitive species status.

There are no special status plant species listed in the analysis area.

3.7 Wildlife

3.7.1 General Wildlife

The distribution and abundance of wildlife in the planning area are primarily functions of habitat conditions. Wildlife habitat is best characterized by the various vegetation types found in the leasing area. The diversity of vegetation/habitat types in the leasing area is low, ranging from moderate/high cover grasslands to Ponderosa Pine forests.

Special emphasis areas or habitats include those vegetation types that are either rare, support threatened or otherwise sensitive or declining wildlife species or support a high diversity of native wildlife. The 1984 Billings RMP identified five special emphasis areas or habitats in the planning area, including: crucial habitats for big game, upland game birds and waterfowl; crucial habitats for non-game species of special interest and concern to state or other federal agencies; wetland and riparian habitats; existing or potential fisheries habitat; and habitat for state or federally listed threatened and/or endangered species. These habitats are generally distributed across the planning area.

Big Game

Big game species in the project area include but are not limted to mule deer and white-tailed deer, elk and antelope with rare occurrences of black bear and mountain lion. These animals are considered priority species due to the public's interest in them for hunting and aesthetic enjoyment. Parcels FB, FC, FD, FE, F3 and F5 contain mule deer and antelope winter range. It is important to minimize human disturbance during the winter and habitat alteration in big game crucial winter range due to the added stresses animals face during winter months in Montana.

Game Birds

Upland game birds common to the planning area include sharp-tailed grouse, greater sage-grouse, blue grouse, ruffed grouse, wild turkey, ring-necked pheasant, Hungarian partridge, and chukar. Similar to big game species, upland game birds are considered priority species due to the public's interest in them for hunting. The primary threats to upland game bird populations in the planning area include habitat loss, habitat fragmentation, possibly West Nile virus, and adverse weather conditions.

Waterfowl species common in the planning area include Canada geese and 18 species of ducks. The presence of open water is the most important factor for waterfowl production. These areas are protected with riparian/wetland stipulations when present.

The most common game birds in and around these lease parcels are wild turkey, pheasant, sharptail grouse, Hungarian partridge and sage-grouse. Sage-grouse are addressed in the Special Status Species section above.

Non-game Animals

Various non-game priority species occur in the planning area. Also occurring are an undetermined number of small mammals such as ground squirrels, mice, chipmunks, rabbits, skunks, and raccoons that provide the main prey for raptors, larger carnivores, and reptiles. Those species that are also federally listed or are considered BLM sensitive species are discussed in the Special Status Animal Species section above.

Other priority animals include amphibians, which are considered a priority group of species due to their association with rare habitats (wetlands and riparian areas), their sensitivity to environmental conditions, global population declines for some species, and the limited knowledge regarding their occurrence and distribution in the planning area. Amphibians known or expected to occur in the planning area include the tiger salamander, plains spadefoot, Great Plains toad, Woodhouse's toad, boreal chorus frog, and northern leopard frog. These species and their habitat are protected with riparian/wetland stipulations.

3.8 Cultural Resources

Cultural resources consist of the material remains of or the locations of past human activities, including traditional cultural properties (TCP). Cultural resources within the Billings Field Office management boundaries represent human occupation throughout two broad periods: the prehistoric and the historic, with substantial overlap seen in the archaeological record across the region.

Cultural resources relating to the prehistoric period could consist of scatters of flaked and ground stone tools and debris, stone quarry locations, hearths, and other camp debris, stone circles, wooden lodges, and other evidence of domestic structures, occupied or utilized rock shelters and caves, game traps and kill sites, petroglyph and pictographs, stone cairns, and alignments and other features associated with past human activities.

The historic period is characterized by the arrival of fur traders and explorers to the area and is the start of the period for which written records exist. Cultural resources within the Billings Field Office management area that are associated with the historic period consist of fur trading posts, homesteads, historic emigrant and stage trails, Indian war period battle sites, ranch development, railroad installations, mining operations, and Native American sites.

The existence of cultural resources within a specific location is determined through examination of existing records and cultural resource inventory at locations proposed for disturbance on federal lands and on state and private lands if the proposed disturbance is a result of a federal undertaking. Cultural resources are evaluated on split-estate if federal or state minerals are involved.

The Montana State Historic Preservation Office (SHPO) maintains a register of all identified cultural sites within each of Montana's counties, regardless of land ownership, which includes all sites that are listed or eligible for listing on the National Register of Historic Places (NRHP). The SHPO also maintains a database of all cultural resource inventory reports that occurred as a result of cultural inventories throughout the state. A literature and database review for cultural resources was performed to construct an overview of the known cultural resources present in the proposed lease parcels and the cultural resource inventories that have occurred in the proposed lease parcels.

The Bureau of Land Management maintains General Land Office (GLO) records of land patents across the United States. These records indicate where historic homesteads not recorded during a cultural resource inventory might exist. The results of these two reviews are as follows:

Cultural Resource Inventory Report Overview

In the SHPO's Cultural Resources Annotated Bibliography System (CRABS) four (4) cultural resource inventories occurred within/partially within, or at least in the same section as the proposed lease parcels (Table 4). Of the ten (10) proposed leases, four (MTM 105431-FA, FC, FD and FE) have no record of previous cultural resource inventories. Because all four parcels were patented by homesteaders, the possibility of undocumented historic structures exists at these locations. Because of the lack of information on file regarding cultural surveys or cultural sites, there may be eligible sites in some of these lease areas that have not yet been identified, and that may be affected by the proposed leasing and subsequent development.

Table 4: Cultural Resource Inventories

MS #	Author	Title	Date
10693	Munson, Gene Et. Al	CULTURAL RESOURCE INVENTORY AND ASSESSMENT: BILLINGS NORTH	1986
14691	Wood, Garvey C.	EMPIRE SAND AND GRAVEL - FIVE MILE/ALKALAI CREEK ADDITIONAL BORROW SOURCE AND WASTE AREA. BILLINGS NORTHWEST	1993

26686	Peterson, Lynelle and John O Pouley	ARCHAEOLOGICAL INVESTIGATIONS FOR THE RATTLESNAKE BUTTE PROJECT: A 3-D GEOPHYSICAL SEISMIC SURVEY IN YELLOWSTONE COUNTY MONTANA	2002
27615	Brumley, John H.	CULTURAL RESOURCE INVENTORY OF THE TRIANGLE TELEPHONE COOPERATIVES 2004 REED POINT AND MOLT EXCHANGES IN STILLWATER COUNTY, MONTANA	2004

Cultural Resource Site Overview
A search of the SHPO's Cultural Resources Information System (CRIS) reveals a total of three (3) previously recorded cultural resources documented within the lease parcels. Another five (5) occur outside of the prescribed parcels but within the same sections. Of the three within the lease parcels, two (2) are prehistoric and one (1) is historic in nature. The prehistoric sites are a lithic scatter and lithic quarry with material scatter. The historic site is a homestead.

Historic records include original survey plats from the 1890s-early 1900s (General Land Office Records). While these records primarily document the homesteading process and patent assignment for the region, they also contain information about early transportation systems. Search of these records indicates that no significant transportation developed that are not now obscured by modern roadways or railroads.

Additional cultural resources outside the parcels scheduled for the lease sale include the Canyon Creek Battlefield site (24YL0702), the Nez Perce National Historic Trail (NPNHT), the Auto Tour Route following the trail, and several historic sites associated with Calamity Jane. Canyon Creek Battlefield is the location of an encounter between the Nez Perce Tribe and the US Cavalry in 1877. The site is on the National Register of Historic Places (NRHP) and is a unit of the National Park Service. Although these cultural resources do not intersect with any of the parcels considered for lease, development on parcels MTM 105431-FB, MTM 105431-FA and MTM 105431-FE may be within the viewshed of these resources.

Sites listed as "Unresolved" or "Undetermined" in the SHPO's Cultural Resources Information System (CRIS) warrant the same treatment as if they have been determined eligible. The distribution of all prehistoric and historic in the parcels is shown in Table 5.

Table 5: Cultural Resources

Lease Number	Site Number	Site Type	Site Description	NRHP Status
MTM 105431-F5	24YL0154	Historic	Homestead foundation, associated features	NE
MTM 105431-F6	24YL0697	Prehistoric	Lithic scatter	NE
MTM 105431-FF	24YL0580	Prehistoric	Lithic quarry and scatter	U

NE – Not Eligible; U – Unevaluated

3.9 Native American Religious Concerns

BLM's management of Native American Religious concerns is guided through its 8120 Manual: Tribal Consultation Under Cultural Resources Authorities and 8120 Handbook: *Guidelines for Conducting Tribal Consultation*. Further guidance for consideration of fluid minerals leasing is contained in BLM Washington Office Instruction Memorandum 2005-003: Cultural Resources, Tribal Consultation, and Fluid Mineral Leasing. The 2005 memo notes leasing is considered an undertaking as defined in the National Historic Preservation Act. Generally areas of concern to Native Americans are referred to as "Traditional Cultural Properties" (TCPs) which are defined as cultural properties eligible for the National Register because of its association with cultural practices or beliefs that (a) are rooted in that community's history and (b) are important in maintaining the continuing cultural identity of the community (see National Register Bulletin 38). No Traditional Cultural Properties (TCPs) have been formally identified on the Billings Field Office administered public lands.

As part of Coordination and Consultation portion of the 2008 Final Supplement to the Montana Statewide Oil and Gas Environmental Impact Statement and Proposed Amendment of the Powder River and Billings Resource Management Plans, extensive government-to-government consultation occurred among the BLM Miles City/Billings Field Offices and the Crow, Northern Cheyenne, and Lower Brule Sioux tribes. This consultation occurred between 2005 and 2008. Readers should refer to that document for more detailed information. This document can be downloaded from the BLM web page at:
http://www.blm.gov/eis/mt/milescity_seis/fseis/contents.htm

In preparation for this action notification letters were sent to the appropriate authorities of the Nez Perce, Umatilla, Colville, Crow and Northern Cheyenne governments on March 24, 2014. On March 28, 2014, the Tribal Historic Preservation Officer (THPO) of the Nez Perce Tribe, expressed concern via e-mail about possible impacts to the Nez Perce National Historic Trail (NPNHT). Mr. Baird asked whether lease parcels intersect with the NPNHT, which they do not. This is the only comment that has been provided as of this time (8 May 2012). Should additional comments be provided, attempts would be made to accommodate Native American concerns as they become available.

As a result of an ethnographic overview (Peterson and Deaver 2002), 12 sensitive site-types known to exist in the project area were defined. These site types are those mentioned by individuals interviewed and from previous investigations known to be the most likely to cause concern in the Indian communities. Most of these site types are also the easiest to document as having traditional cultural values under Criteria A, B, or C. Site types identified include battle and raiding sites, final resting places (burials), cairns, communal kill sites, fasting beds, homesteads, medicine lodges, rock art, settlements, stone rings, spirit homes, and environmental places (landscapes, water, plant gathering areas, fossils, and mineral collection areas/paint sources). Avoidance is the preferred option for all sites of cultural significance.

3.9.1 Nez Perce Tribe, Confederated Tribes of the Colville Reservation and Confederated Tribes of the Umatilla Indian Reservation

The Nez Perce National Historical Trail (NPNHT) follows the same journey undertaken by a band of the Nez Perce Indian tribe in 1877 during their attempt to flee the U.S. Cavalry. The

1,170 mile (1,883 km) trail was created in 1986 as part of the National Trails System Act and is managed by the U.S. Forest Service. The trail traverses through portions of the states of Oregon, Idaho, Wyoming, and Montana and connects 38 separate sites across these four states that commemorate significant events which occurred to the Nez Perce during their attempt to escape capture by the U.S. Cavalry who were under orders to move the Nez Perce onto a reservation. The trail passes through areas managed by the National Park Service, USFS National Forests, and Bureau of Land Management and private property. Little of the trail is actually a foot trail although much of the journey can be closely followed by roads. The formally recognized corridor of the NPNHT is located on a northwest-southeast diagonal between parcel MTM 105431-FB west of the corridor and MTM 105431-FE and MTM 105431-FA, east of the corridor. The parcels are more than a mile away from the corridor.

3.9.2 Northern Cheyenne

Much of the information in this section was summarized from *The Northern Cheyenne Tribe and Its Reservation: A Report to the U.S. Bureau of Land Management and the state of Montana Department of Natural Resources and Conservation* (Northern Cheyenne Tribe 2002).

Through sacred ways and ceremony, the Cheyenne believe that they can harness the spiritual essence as a power to benefit physical existence. If they do not practice traditional culture and beliefs to maintain the balance and cycle, the spiritual essence would not be available to benefit them or maintain the earth system.

With these belief systems, natural resources become culturally and spiritually important, particularly water (with living spirits), plants (considered to be relatives), animals (also relatives), great birds (messengers to the spirits in Blue-Sky Space) and fossil and mineral sources (used in ceremony). Cultural resources such as burials, ceremonial sites (fasting locations, vision quest sites, sweat lodges, and memorials), homes (tipi rings, historic depressions, foundations, and cabins), community and commercial reservation-era sites, military and exploration-related sites and prehistoric sites (lithic scatters, cairns and petroglyphs) are considered sacred to the Northern Cheyenne (BLM 2008: pgs 3-78 and 3-79).

No TCPs were identified in the Billings Field Office although two were identified in the Miles City (Powder River) planning area (BLM 2008: pg 3-79).

3.9.3 Crow

Much of the information in this section has been summarized from *The Crow Indian Reservation's Natural, Socio-Economic and Cultural Resources Assessment and Conditions Report* (Crow Tribe 2002).

The Crow historical perspective sees time as interlinked so that there is an intimate relationship between the individual and the past. The past (tradition or time) provides the template for the appropriate way to live. The Crow live in constant presence with the past that truly transcends the western concept of time. There are five qualities of time: sacred time, ancient Indian time, historic time, the present, and the future, which have some sequential qualities, but for the Crow, the spirituality of these times is most important.

In this world perception many landscapes and places are sacred. They are sacred because they represent why and how things are done. Sacred sites include cultural material scatters, petroglyphs, tipi rings, homesteads, burial areas, cairns, communal kills, fasting beds, medicine lodges, rock art, stone rings and settlements. Sacred locations and places include water (springs and rivers), spirit homes (springs, rivers, hills and mountains), landscapes (mountains and topographic features), plant and animal procurement areas, fossil areas, and mineral locations (BLM 2008: pg 3-70).

3.10 Paleontology

No paleontological resources have been identified or reported within any of the parcels. Paleontological resources consist of fossil-bearing rock formations containing information that can be interpreted to provide a further understanding about Montana's past. Fossil-bearing rock units underlie the entire planning area. While fossils are relatively rare in most rock layers, there are three geologic formations within the planning area that do contain significant fossil material. Rock units that are known to contain substantial deposits of vertebrate and significant invertebrate fossils are the Fort Union Formation, the Judith River Formation, and the coeval Lance and Hell Creek Formations, herein after referred to as Hell Creek (Lance) Formation. The Judith River and Hell Creek (Lance) Formations are particularly rich in fossil material. Other geological units found in the lease parcels include the Clagett Shale, and the Eagle, Telegraph Creek, and Lennep formations as well as some areas of Quaternary alluvium. Of these, the Clagett Shale and Eagle Formation have some know fossil beds. The Telegraph Creek Formation has not been adequately investigated for paleontological resources to evaluate. The Lennep Formation has no significant paleontological elements.

The Judith River Formation preserves the fossil record from ancient environments including shallow oceans, deltas, rivers, freshwater swamps and lakes. The Judith River Formation contains the fossil remains of plants as well as many animal species including mollusks, fish, amphibians, lizards, small mammals, dinosaurs, and other reptiles.

The Cretaceous Period Hell Creek (Lance) Formation, noted for the occurrence of dinosaur fossils in its beds, preserves the fossil record of a subtropical to tropical environment that was characterized by low plains interrupted by broad swampy bottoms and deltaic areas. Fossil remains from the Hell Creek Formation include a wide variety of plants, mollusks, fish, amphibians, reptiles, birds, small mammals and dinosaurs. Fossil dinosaur remains include *triceratops, anatosaurus, and tyrannosaurus.* The fossil record of plant and animal communities found within the Hell Creek Formation varies between low moist areas and the drier, upland plains environments that were present in the past. The Castle Butte ACEC, located in Yellowstone County within the Billings RMP area, contains outcrops of the Hell Creek Formation, which are noted for their paleontological resources.

Overlying the Cretaceous Period Hell Creek Formation is the Paleocene Tullock Member of the Fort Union Formation marks an important event in time. The Hell Creek (Lance)-Tullock contact represents a time of worldwide extinction for many animals, most notably the dinosaurs, and the beginning of the rapid evolution of mammals. The fossil record from the Fort Union Formation contains evidence of ancient environments that include streamside swamps, bottomlands, and well-established river courses. Fill within ancient river channels contains fossils of fresh water clams and snails. The Tullock and Tongue River Members are both fossil-bearing units of the Fort Union Formation and contain fossils of turtles, fish, reptiles and mammals.

Potential Fossil Yield Classification System

The Potential Fossil Yield Classification (PFYC) system (WO-IM-2008-009) is used to classify paleontological resource potential on public lands in order to assess possible resource impacts and mitigation needs for federal actions involving surface disturbance, land tenure adjustments, and land-use planning. This classification system is based on the potential for the occurrence of significant paleontological resources in a geologic unit and the associated risk for impacts to the resource based on federal management actions. It uses geologic units as base data.

Using the PFYC system, geologic units are classified based on the relative abundance of vertebrate fossils or scientifically significant invertebrate or plant fossils and their sensitivity to adverse impacts, with a higher class number indicating a higher potential for fossil resources (Table 6). Areas with a PFYC rating of 3 or higher would be inventoried for paleontological resources prior to surface disturbing activities. Rankings of 4 and 5 may require on-site monitoring during surface disturbing activities.

Table 6: Potential Fossil Yield Classification (PFYC) Description

PFYC Class	Potential
Class 1	Very Low Potential for Paleontological Resources
Class 2	Low Potential for Paleontological Resources
Class 3	Moderate or Unknown Potential for Paleontological Resources
Class 4	High Potential for Paleontological Resources
Class 5	Very High Potential for Paleontological Resources

Although no paleontological locales have been identified within any of the parcels selected for the lease sale, the potential for discovery of unrecorded paleontological locations exists. Table 7 provides the PFYC class acreage totals for each unit and for the combined lease nominations. The total acreage for PFYC classes 1 and 2 is 184 acres, or about 12% of the total lease acreages. The remaining 88% is divided among PFYC classes 3a, 3b, and 5. All of the lease parcels contain geologic units classified as PFYC Class 3a, 3b and/or 5. In fact, MTM 105431-FB, FD, FE, F3, F5 and F6 have no Class 5 land (Table 8). All parcels except MTM 105431-FC and FE are dominated by units of moderate to unknown fossil yield potential (3a).

Table 7: Potential Fossil Yield Classification Acres

Lease Sale Parcel Number	PFYC Class 1 Acres	PFYC Class 2 Acres	PFYC Class 3a Acres	PFYC Class 3b Acres	PFYC Class 4 Acres	PFYC Class 5 Acres
MTM 105431-FA	0	0	21	0	0	137.5
MTM 105431-FB	0	0	40	0	0	0

Lease Sale Parcel Number	PFYC Class 1 Acres	PFYC Class 2 Acres	PFYC Class 3a Acres	PFYC Class 3b Acres	PFYC Class 4 Acres	PFYC Class 5 Acres
MTM 105431-FC	0	0	145	0	0	185
MTM 105431-FD	0	0	40	0	0	0
MTM 105431-FE	0	0	28	49.5	0	0
MTM 105431-FF	0	0	31	0	0	9
MTM 105431-F3	0	42	277	0	0	0
MTM 105431-F5	0	38	129	0	0	0
MTM 105431-F6	0	38	40	0	0	0
MTM 105431-F7	0	0	27	0	0	20
TOTALS	0	118	778	49.5	0	343

Table 8: Potential Fossil Yield Classification Percentages

Lease		All PFYC Percentages				
	2	3a	3b	4	5	Total
MTM 105431-FA		13			87	100%
MTM 105431-FB		100				100%
MTM 105431-FC		44			56	100%
MTM 105431-FD		100				100%
MTM 105431-FE		36	64			100%
MTM 105431-FF		77			23	100%
MTM 105431-F3	13	87				100%
MTM 105431-F5	23	77				100%
MTM 105431-F6	49	51				100%
MTM 105431-F7		57			43	100%

3.11 Visual Resources

Visual Resource Management (VRM) is BLM's systematic approach to inventorying and managing visual resource values, as mandated by Federal legislation (FLPMA, 1976 and NEPA, 1969). It includes the evaluation of public lands for assignment of inventory classes during Resource Management Plan (RMP) development, as well as the determination of management of Visual Resource Management (VRM) classes and the routine operational management of those classes. The VRM enables the BLM to have a system for managing the human concern for scenery and public acceptance for visible changes to the natural landscape setting. Through this system the BLM is able to objectively measure proposed landscape altering projects for compliance to visual performance standards and apply the use of good design principles to satisfy management objectives.

BLM manages landscapes according to the Visual Resource Management Manual (H-8431-1). VRM Classes establish specific objectives on the management of visual resource values. The VRM objectives set the standards for the planning, design, and evaluation of proposed projects. The VRM classes consider the compatibility between land use decisions and visual values. Management Objectives range from preserving the natural landscape (VRM Class I) to providing for activities which require major modification of the existing landscapes (VRM Class IV).

A Class I VRM area means that the objective is to preserve the existing landscape. This class provides for natural ecological changes, however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract any attention of a casual observer.

The management objective for a Class II VRM is that the existing character of the landscape should be retained. Activities or modifications of the environment should not be evident or attract the attention of the casual observer. Changes caused by management activities must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

The management objective for a Class III VRM area means the level of change to the character of the landscape should be moderate. Changes caused by management activities should not dominate the view of the casual observer and should not detract from the existing landscape features. Any changes made should repeat the basic elements found in the natural landscape such as form, line, color and texture.

The management objective for a Class IV VRM area means that the characteristic landscape can provide for major modification of the landscape. The level of change in the basic landscape elements can be high. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements.

Assessing scenic values and determining visual impacts can be a somewhat subjective process. Objectivity and consistency can be greatly increased by using the basic design elements of form, line, color, and texture, which have often been used to describe and evaluate landscapes, to also describe proposed projects. Projects that repeat these design elements are usually in harmony with their surroundings; those that don't create contrast. By adjusting project designs so the elements are repeated, visual impacts can be minimized.

All of the public land parcels in the proposal have been inventoried and have been assigned a Class "B/"C"" rating. They are currently managed as interim VRM Class III until final designation can be established in the new Billings RMP. Management objectives for this class are consistent with this type of proposal. Should a parcel be leased and an application permit to drill be received, visual management prescriptions would be developed. For non-federal surface lands, BLM does not have the authority to manage for VRM and there is no visual resource inventory of VRM class.

3.12 Special Designations

3.12.1 National Historic Trails

National Historic Trails commemorate historic or pre-historic travel routes that are of significance to the entire nation. A designated trail should generally follow the route of the historic trail but may deviate if necessary. To qualify for designation as a national historic trail, a trail must meet the following criteria:

- have been established by a historic use and have historical significance as a result of that use,
- have historic use of the trail that has had a far and reaching effect on broad patterns of American culture, and
- has significant potential for public recreational or historical interest.

The BiFO manages approximately 12 miles of the Nez Perce (Nimíipuu or Nee-Me-Poo) National Historic Trail. The BiFO managed the portion of trail lies on public land along the Clarks Fork of the Yellowstone River and north toward the Bear's Paw Mountains. The trail stretches from Wallowa Lake, Oregon, to the Bear's Paw Battlefield near Chinook, Montana. It was designated as a National Historic Trail in 1986. This route was used in its entirety only once; however, components of the route were used for generations prior to and after the 1877 flight of the Nez Perce.

The formally recognized corridor of the NPNHT is located on a northwest-southeast diagonal between parcel MTM 105431-FB west of the corridor and MTM 105431-FE and MTM 105431-FA, east of the corridor. The parcels are more than a mile away from the corridor.

3.13 Livestock Grazing

Only lease parcels MTM-105431 F5 and F6 are located on federal surface and within a federal grazing allotment. Lease parcel MTM-105431 F3 is located on private surface but is located in a federal grazing allotment. The remaining lease parcels are located on private land not within a federal grazing allotment. It is assumed that some level of grazing does occur on all lease parcels regardless of surface ownership. Table 9 lists the lease parcels that occur within a federal grazing allotment.

Table 9: Federal Grazing Allotments in Lease Parcels

Lease Parcel	Surface ownership [1]	Allotment number	Allotment Name	Permitted Federal AUMs	Federal Range Improvements Within The Allotment [2]
MTM-105431-F3	Private	5309	Charter	78	Charter Fence
MTM-105431-F5	Public	5354	Ballek	21	Right away Fence Balek Fence Shepherd/Acton Cattle guard
MTM-105431-F6	Public	5324	Kembel	15	No Range Improvements

[1]Indicates the surface ownership status of the lease parcel within the allotment
[2]Range improvements located within the allotment may or may not be located within the lease parcel.

3.14 Recreation and Travel Management

3.14.1 Recreation

The BLM has an important niche in recreation in Montana, providing opportunities for Off-highway vehicle use, camping, hiking, driving for pleasure, picnicking, hunting, whitewater rafting, wildlife viewing, and a wide variety of other pursuits. This role in outdoor recreation is under stress from changing populations, new technologies, and access issues. Population increases, particularly in the metropolitan areas such as Billings and are placing additional demands on recreational use of BLM lands. Current and new forms of recreational activities such as extreme Mountain Biking and traditional uses such as photography, hunting and OHV use, are increasing in popularity. There is also a growing concern for preserving the character and resources upon which this recreation depends.

The BLM Recreational Strategy is to improve access to appropriate recreational opportunities and experiences; ensure a quality experience and enjoyment of natural and cultural resources, and; provide for and receive fair value in recreation.

For the BLM, there has been a shift from activity based to a recreation outcome focused management (OFM) approach. The shift to OFM has essentially required developing and setting sustainable conditions to produce the desired outcome desired by both managers and the public while providing for activities. For the Billings Field Office these settings are generally more primitive and rugged, require more individual responsibility, and have an overall lower density and demand than lands managed by other agencies.

Parcels MTM 105431-F5 and F6 are the only two parcels with BLM managed surface lands. These parcels, with a total of 240 acres, have limited recreation use, with the majority taking place during fall hunting seasons for deer, antelope and upland bird species.

3.14.2 Travel Management

Comprehensive travel management is integral to the character of recreational settings. Travel management decisions support planning decisions such as protecting and/or enhancing landscape character. In general BLM policy, travel is permitted on designated or seasonally limited routes, except in established OHV areas open for motorized use. In the Billings Field Office, travel management takes the existing transportation system created by past resource uses and public access patterns and has created a system to meet the current and future needs for motorized and non-motorized travel based on management objectives. Recreational management objectives and recreation setting prescriptions, including the recreational opportunity spectrum (ROS) and visual resource management (VRM) as well as other resource programs, constrain and guide the kinds and locations of travel routes.

The BLM only manages travel routes on lands where BLM manages the surface. Of the ten parcels being considered in this EA, only one, parcel MTM 105431-F5, has a primitive travel route that extends for ½ mile along its western edge. This route provides some motorized access to the BLM public lands within the parcel. The route is not a high-use route or a main access artery. Its primary use is for ranching access.

3.15 Lands and Realty

Parcel MTM 105431-F5 has two BLM authorized Rights-of-Way (ROW); a twelve inch buried crude oil pipeline held by Phillips 66 and a 12.47 and 7.2 KV overhead electrical power line held by Yellowstone Valley Electric Cooperative. ROW issues were not identified in any other parcels.

3.16 Minerals

3.16.1 Fluid Minerals

It is the policy of the BLM to make mineral resources available for disposal and to encourage development of these resources to meet national, regional, and local needs, consistent with national objectives of an adequate supply of minerals at reasonable prices. At the same time, the BLM strives to assure that mineral development occurs in a manner which minimizes environmental damage and provides for the reclamation of the lands affected.

Currently there are 237 federal oil and gas leases covering approximately 146,538 acres in the Billings Field Office. The number of acres leased and the number of leases can vary on a daily basis as leases are relinquished, expired, or are terminated. Information on numbers and status of wells on these leases and well status and numbers of private and state wells within the external boundary of the field office is displayed in Table 10. Numbers of townships, lease acres within those townships, and development activity for all jurisdictions are summarized in Table 11.

Exploration and development activities would only occur after a lease is issued and the appropriate permit is approved. Exploration and development proposals would require completion of a separate environmental document to analyze specific proposals and site-specific resource concerns before BLM approved the appropriate permit.

Table 10: Existing Development Activity

	Federal Wells	Non-Federal Wells
Drilling Well(s)	0	1
Producing Gas Well(s)	4	244
Producing Oil Well(s)	8	577
Water Injection Well(s)	0	14

Shut-in Well(s)	2	91
Temporarily Abandoned Well(s)	0	43
Gas Storage Wells	0	11
Abandoned Wells	45	2,381

Data source: BLM SDE GIS data, oil and gas surface well location layer data, May 2014

Table 11: Oil and Gas Leasing and Existing Development within Townships Containing Lease Parcels

	Yellowstone County
Number of Townships Containing Lease Parcels	4
Total Acres Within Applicable Township(s)	1282.44
Federal Oil and Gas Minerals	1282.44
Percent of Township(s)	1.3%
Leased Federal Oil and Gas Minerals	0
Percent of Township(s)	0
Leased Federal Oil and Gas Minerals Suspended	0
Percent of Township(s)	0
Federal Wells	Producing Gas Well(s) 0 Producing Oil Well(s) 0 Water Injection Well(s) 0 Shut-in Well(s) 0 Temporarily Abandoned Well(s) 0

	Yellowstone County
Private and State Wells	Producing Gas Well(s) 0 Producing Oil Well(s) 0 Water Injection Well(s) 0 Shut-in Well(s) 17 Temporarily Abandoned Well(s) 0

3.16.2. Solid Minerals

3.16.2.1. Coal

There is no current coal production in the lease parcel areas. Information was verified utilizing the economic coal deposits GIS layer. No proposed lease parcels are lying over any leased coal deposits.

3.16.2.2. Locatable Minerals

Locatable minerals are subject to provisions of the 1872 Mining Law. These generally include metallic minerals such as gold and silver and other materials not subject to lease or sale. There is currently no locatable mineral production or known potential for production in the lease parcel areas.

3.16.2.3. Salable Minerals

Salable minerals (mineral materials) are those common varieties of sand, stone, gravel, cinders, pumice, pumicite, and clay that may be acquired under the Materials Act of 1947. Mineral materials are disposed of by free-use and community/common-use permits granted to municipalities or non-profit entities, respectively. Contracts for sale of mineral materials are offered to private entities on both a competitive and non-competitive basis. Disposal of salable minerals is a discretionary decision of the BLM authorized officer. Future potential resource development conflicts would be avoidable either by not issuing sales contracts in oil and gas development locations or conditioning the APD or salable mineral contracts in a manner to avoid conflicts between operations.

None of the lease parcels proposed to be leased for oil and gas in the Project Area conflict with current permits and contracts for salable minerals awarded on federal lands. Therefore, this subject would not be discussed further in this document.

3.17 Social and Economic Conditions

3.17.1 Social and Environmental Justice

Introduction

Certain existing demographic and economic features influence and define the nature of local economic and social activity. Long-held customs, social cohesion, and history of an area provide valuable insight into how events or changes to the area may affect the livelihood and quality of life of the residents. While linkages exist across various social environments, the affected social environment consists of Yellowstone County, Montana.

Affected Environment
Yellowstone County is located in south-central portion of Montana and had an estimated population of 151,882 residents in 2012, which made it the county with the largest population in the State (US Census 2013a). The county seat of Yellowstone County is Billings had an estimated population of 106,954 residents in 2012 (US Census 2013b). Billings plays an important role as a commercial, transportation, education, and medical services center for a large portion of this part of the state. Yellowstone County also supports considerable agriculture-it had 1,668,346 acres of land in farms and 1,330 farms in 2012 (NASS 2014a). In 2013, the County ranked eleventh for barley production and twelfth for winter wheat production across Montana counties (NASS 2014b). Additionally, in 2012 Yellowstone County ranked ninth in alfalfa hay production and fourth in in cattle and calves across Montana counties (NASS 2013). This information helps highlight the importance of agriculture in the County. Additional information describing the area is found in the Economics section below.

Environmental Justice
Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, states "each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations…" (Executive Order 12989).

Minority populations as defined by Council on Environmental Quality (CEQ) guidance under the National Environmental Policy Act (CEQ 1997) include individuals in the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic. A minority population is identified where "(a) the minority population of the affected area exceeds 50 percent or (b) the minority population percentage of the affected area is meaningfully greater…" (CEQ 1997). Additionally, "[a] minority population also exists if there is more than one minority group present and the minority percentage, as calculated by aggregating all minority persons, meets one of the above-stated thresholds" (CEQ 1997). Low-income populations are determined by the U.S. Census Bureau based upon poverty thresholds developed every year.

U.S. Census data is used to determine whether the populations residing in the study area constitute an "environmental justice population" through meeting either of the following criteria:

- At least one-half of the population is of minority or low-income status; or
- The percentage of population that is of minority or low-income status is at least 10 percentage points higher than for the entire State of Montana.

CEQ guidance does not provide specific criteria for determining low-income populations as it does for minority populations so for this planning effort we will use the criteria for minority populations, which are discussed above, as the criteria for low-income populations. We identify low-income and minority population percentages that are "meaningfully greater" as at least 10 percentage points higher than for the entire State of Montana.

Data for the identification of low-income is from the U.S. Census Bureau, Small Area Income and Poverty Estimates (SAIPE). The SAIPE program produces yearly single year poverty estimates for states, counties, and school districts and is considered the most accurate for these geographic scales, especially for areas with populations of 65,000 or less. Minority populations are identified using the U.S. Census Population Estimates program which provides estimates for the resident population by age, sex, race, and Hispanic origin at the national, state and county scales. Estimates from SAIPE and the Population Estimates program are used in federal funding allocations. The analysis was conducted at the county level due to the availability of the most current data.

Table 12 presents percentages of: a) individuals in poverty and b) the population's race and ethnicity for the State of Montana and Yellowstone County. Table 12 indicates that Yellowstone County does not have an environmental justice minority population since neither the neither minority nor low-income status in the study area meets the above criteria. Therefore no additional analysis is needed for this EA.

Table 12: Percentages of Individuals in Poverty and Race and Ethnicity Percentages for the State of Montana and Yellowstone County based on 2012 Estimates.

	Percent of Population (All Ages)								
		Race[2]						Ethniciy[2]	
	In Poverty[1]	White Alone	Black or African American Alone	American Indian and Alaska Native Alone	Asian Alone	Native Hawaiian and Other Pacific Islander Alone	Two or more races	Hispanic	Aggregated Minority[2,3]
Montana	15.6	89.7	0.6	6.5	0.7	0.1	2.5	3.1	12.8
Yellowstone County	12.7	91.4	0.8	4.3	0.8	0.1	2.6	4.9	12.4

[1]Source: U.S. Census. 2013. 2012 Poverty and Median Household Income Estimates. Small Area Income and Poverty Estimates (SAIPE) Program. Release date: December 2013.
[2]Source: U.S. Census. 2013. Annual Estimates of the Resident Population by Sex, Race, and Hispanic Origin for the United States, States, and Counties. Population Division. Release date: June 2013.
[3] The term "aggregated minority" refers to that part of the total population which is not classified as Non-Hispanic White Only by the U.S. Census Bureau. By using this definition of aggregated minority, the percentage is inclusive of Hispanics, other minority single race categories and multiple race categories that include a minority race category. This definition is most inclusive of populations that may be considered as a minority population under EO 12898.

3.17.2 Economics

Certain existing demographic and economic features influence and define the nature of local economic and social activity. Among these features are the local population, the presence and proximity of cities or regional business centers, longstanding industries, infrastructure, predominant land and water features, and unique area amenities. Several additional parcels in

Yellowstone County have been nominated for leasing in the October 2014 lease sale. While the majority of nominated land is unoccupied there are social and economic linkages which connect nominated parcels to communities in the surrounding area. This is especially true of Billings, where several companies specializing in oil and gas related activities are based out of.

In 2012, Yellowstone County, Montana was estimated to have a total population of 151,882 people, with 66,135 households earning an average annual household income of $94,977 (IMPLAN, 2012). In 2012, the 8-county area economy supported approximately 103,725 jobs in 225 industrial sectors, equating to approximately 1.5 people or 0.6 households per job. The top five industries operating in the local economy included: food service and drinking places, wholesale trade, private hospitals, real estate, and employment services (IMPLAN, 2012). A large share of this economic activity is based out of the city of Billings, which serves as the area's largest business center and the county seat of Yellowstone.

All parcels nominated and being considered for leasing in the October 2014 lease sale are located in the Southern Montana County of Yellowstone. Oil and gas production in Yellowstone has been tapering off and production of the Three Forks Formation in Eastern Montana has ramped up. Although county wide production of oil exceed more than 30,000 bbls and 600 MCF of natural gas on annual average in the early 1990s, average annual production fell to 16.735 bbls of oil and 72 MCF of gas between 2009 and 2013 (Montana Board of Oil and Gas, Annual Production by County 2014). Although minerals administered by the BLM are associated with only a fraction of the county's oil and gas activity, the leasing and development of these minerals supports local employment and income and generates public revenue for many surrounding communities. The economic contributions of Federal fluid minerals are largely influenced by the number of acres leased and estimated levels of production and can be measured in terms of the jobs, income, and public revenue it generates.

Mineral rights can be owned by private individuals, corporations, Indian tribes, or by local, State, or Federal Governments. Typically companies specializing in the development and extraction of oil and gas lease the mineral rights for a particular parcel from the owner of the mineral rights. As of April, 2014, 2,155 acres were leased from the BLM for oil and gas development in Yellowstone County. Federal oil and gas leases are generally issued for 10 years unless drilling activities result in one or more producing wells, or the lease is part of a communitization agreement and incorporated into an existing field or unit. Once production of federal minerals from a lease has begun, the lease is considered to be held by production and the lessee is required to make royalty payments to the Federal Government. Of 2,155 acres leased from the BLM in Yellowstone, only 200 acres were held by production at the time of this analysis.

Leasing mineral rights for the development of Federal minerals generates public revenue through the bonus bids paid at lease auctions and annual rents collected on leased parcels not held by production. Nominated parcels approved for leasing are offered by the BLM at a minimum rate of $2.00 per acre at the lease sale. These sales are competitive and parcels with high potential for oil and gas production command bonus bids in excess of the minimum bid. Between 2009 and 2013, only three parcels totaling 987 acres have been auction for leasing in Yellowstone County. All of which were sold for $2 an acre, generating a total of $1,974 in federal lease revenue over the last five years. In addition to bonus bids, lessees are required to pay rent annually until the lease is classified as held by production, or until the lease expires. These rent payments are equal to $1.50 an acre for the first five years and $2.00 an acre for the second five years of the lease. On annual average, total annual lease bonus and rental revenue to the Federal Government from leasing BLM minerals in Yellowstone County is estimated to be approximately $1,115.

Forty-nine percent of these Federal leasing revenues from public domain minerals are distributed to the State who distributes 25 percent of federal revenue from public domain minerals back to the counties where the leases exist. About 73 percent of the leased BLM minerals within the Billings Field Office are leased on public domain minerals. With federally acquired minerals (acquired under Bankhead Jones authority), 25 percent of Federal revenues are distributed directly to the appropriate counties. Of the $1,115 in federal revenue generated from bonus bids and rent associated with BLM mineral leases in Yellowstone County, $474 is estimated to be distributed back to the state of Montana who then distributes a portion of this revenue back to the county. Between leasing revenue collected from public domain and acquired minerals, Yellowstone County receives about $175 from federal mineral leasing auction and rent revenue on annual average.

As mentioned above, Federal oil and gas production in Montana is subject to production taxes or royalties. The Federal oil and gas royalties on production from public domain minerals equal 12.5 percent of the value of production (43 CFR 3103.3.1). Forty-nine percent of these royalties from public domain minerals are distributed to the State, of which 25 percent is distributed back to the county of production (Title 17-3-240, MCA). If production comes from acquired Federal minerals under the Bankhead Jones authority, 25 percent of the Federal revenues are distributed directly to the counties of production.

The economic contribution of oil and gas related activities to the local economy can be measured by estimating the employment and labor income generated by 1) payments to counties associated with the leasing and rent of Federal minerals, 2) local royalty payments associated with production of Federal oil and gas, and 3) economic activity generated from drilling and associated activities. Activities related to oil and gas leasing, exploration, development, and production form a basic industry that brings money into the State and region and creates jobs in other sectors. As of 2012, the extraction of oil and natural gas (NAICS sector 20), drilling oil and gas wells (NAICS sector 28), and support activities for oil and gas operations (NAICS sector 29) supported an estimated 1,718 jobs[1] and $60 million in employee compensation and proprietor income in Yellowstone County (IMPLAN, 2012).

Currently, the BLM leases 2,155 acres of Federal minerals in Yellowstone County. Total Federal revenues from Federal oil and gas leasing, rents, and royalty payments associated with the leasing of these minerals averages an estimated $5,200. Federal revenues disbursed to the State of Montana on annual average is estimated $2,200 per year and those redistributed back to local governments in Yellowstone County are estimated to be about $800 on annual average. These

[1] IMPLAN job estimates are not full-time equivalents and include all full-time, part-time, and temporary positions supported oil and gas activities within the planning area. These activities may support, or partially support a number of jobs annually. In this respect, 1 job in IMPLAN lasting 12 months = 2 jobs lasting 6 months each = 3 jobs lasting 4 months

revenues help fund traditional county functions such as enforcing laws, administering justice, collecting and disbursing tax funds, providing for orderly elections, maintaining roads and highways, providing fire protection, and/or keeping records. Other county functions that may be funded include administering primary and secondary education and operating clinics/hospitals, county libraries, county airports, local landfills, and county health systems.

On annual average the leasing, development, and extraction of Federal minerals administered by the BLM supports about 30 local jobs (full and part-time) and about $1 million in local labor income. This amounts to less than 1 percent of total employment and income (i.e. wages and proprietor's income) in Yellowstone County.

4.0 ENVIRONMENTAL IMPACTS

4.1 Assumptions and Reasonably Foreseeable Development Scenario Summary

This chapter describes the environmental effects (direct, indirect, and cumulative) that would result from the alternatives. This analysis is tiered to the final environmental impact statement (EIS) for the Billings RMP/ROD. The analysis contained within that RMP/FEIS remains adequate. The RMP determined which areas are available for oil and gas leasing and under what conditions those leases are to be offered and sold.

The act of leasing parcels would not result in any activity that might affect impacts to the various resources. Direct effects of leasing are creation of valid existing right(s) and related to revenue generated by the lease sale receipts.

Potential indirect effects associated with a lease sale would result from any future developments. The BLM assumes there is a high interest in development of any leased parcels but, eEven if lease parcels are leased, it remains unknown and is speculative to assume whether development would actually occur, and if so, it is speculative to assume where specific wells would be drilled and where facilities would be placed. This would not be determined until the BLM receives an application for permit to drill (APD) in which detailed information about proposed wells and facilities would be provided for particular leases. Therefore, this EA discusses potential effects that could occur in the event of development.

Upon receipt of an APD, the BLM would initiate a more site-specific National Environmental Policy Act (NEPA) analysis with public review opportunities to more fully analyze and disclose site-specific effects of specifically identified activities. In all potential exploration and development scenarios, the BLM would require the use of best management practices (BMPs) documented in "Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development" (USDI and USDA 2007), also known as the "Gold Book." The BLM could also identify APD Conditions of Approval (COAs), based on site-specific analysis which could include moving the well location, restrict timing of the project, or require other reasonable measures to minimize adverse impacts (43 CFR 3101.1-2 Surface use rights; Lease Form 3100-11, Section 6) to protect sensitive resources, and to ensure compliance with laws, regulations, and land use plans.

For split-estate leases, the BLM would notify the private landowners that oil and gas exploration or development activities are proposed on their lands and they are encouraged to attend the onsite inspection to discuss the proposed activities. In the event of activity on such split-estate leases, the lessee and/or operator would be responsible for adhering to BLM requirements as well as reaching an agreement with the private surface landowners regarding access, surface disturbance, and reclamation.

This chapter presents the potential environmental, social, and economic effects from the actions described in each alternative in Chapter 2, as well as potential effects from lease exploration and development activities. Environmental consequences are discussed below by alternative to the extent possible at this time for the resources described in Chapter 3. As per NEPA regulations at 40 CFR 1502.14(f), 40 CFR 1502.16(h), and 40 CFR 1508.20, mitigation measures to reduce, avoid, or minimize potential impacts are identified by resource below. The duration of the possible effects is analyzed and described as either short-term or long-term. Short-term effects generally last less than five years and long-term effects generally last more than five years.

The RFD scenario (Appendix B) is based on information contained in the February 2010 Billings Field Office RFD; it is an unpublished report that is available by contacting the Billings Field Office. The RFD scenario contains projections of the number of possible oil and gas wells that could be drilled and produced in the Billings Field Office area and used to analyze projected wells for the 10 nominated lease parcels. The lease parcels are identified within areas of low to moderate development potential. The projected number of wells is used to conduct analysis for economic resources. These well numbers are only an estimate based on historical drilling and mineral resources present, and may change in the future if new technology is developed or new fields and formations are discovered. For the RFD scenario (Appendix B), the lease parcels have been analyzed under the Bull Mountain Basin and Lake Basin Fault Zone areas. This area is identified on Map 3. A detailed description of the RFD forecast in the analysis area is found in Appendix B.

No surface disturbance would occur as a result of issuing leases. The potential number of acres disturbed by exploration and development activities is shown in Table B-1 in Appendix B and were used by cultural resources to determine the number of cultural sites potentially impacted within the nominated lease parcels. The potential acres of disturbance reflect acres typically disturbed by construction, drilling, and production activities, including infrastructure installation throughout the Billings Field Office. Typically exploration and development activities and associated acres of disturbance were used as assumptions for analysis purposes in this EA. Standard terms and conditions as well as special stipulations would apply to the lease parcels. All impacts would be linked to undetermined future levels of lease development.

Given the RFD scenario and recent activity in the Billings Field Office, it is assumed that a maximum of one well pad and associated infrastructure and activities would occur with regard to the parcels being leased. This would result in approximately 3.5 acres of disturbance, including well pad and associated ancillary facilities for an oil well with associated natural gas extraction.

The assumptions were not applied to Alternative A because the lease parcels would not be offered for lease; therefore, no wells would be drilled or produced on the lease parcel, and no surface disturbance would occur on those lands from exploration and development activities.

Environmental consequences are discussed below by alternative to the extent possible at this time for the resources described in Chapter 3. As per NEPA regulations at 40 CFR 1502.14(f), 40 CFR 1502.16(h), and 40 CFR 1508.20, mitigation measures to reduce, avoid, or minimize potential impacts are identified by resource below.

4.2 Alternative A (No Action)

4.2.1 Direct Effects Common to All Resources (not including Economics)

Under Alternative A, zero parcels would be offered for competitive oil and gas lease sale. Under this alternative, the state and private minerals could still be leased in surrounding areas.

There would be no new impacts from oil and gas exploration or production activities on the federal lease parcel lands. No additional natural gas or crude oil would enter the public markets, and no royalties would accrue to the federal or state treasuries from the parcel lands. The No Action Alternative would result in the continuation of the current land and resource uses on the lease parcels.

Except for Economic resources, described below, no further analysis of the No Action Alternative is presented.

4.2.2Economics

4.2.2.1 Direct and Indirect Effects:

The economic contributions of activities associated with oil and gas development on BLM administered Federal minerals are measured in terms of the employment and labor income generated by 1) payments to counties associated with the leasing and rent of Federal minerals, 2) royalty payments associated with production of Federal oil and gas, and 3) economic activity generated from drilling and associated activities. Forward and backward linkages between businesses and people in communities surrounding parcels leased for the development of Federal minerals has enabled the oil and gas industry to attract new revenue to the region, growing the local economy and creating new employment and income opportunities in a wide range of industrial sectors. Table 13 is a summary of local revenues, employment, and labor income impacts of each alternative.

Alternative A is the no action alternative. Under Alternative A, no additional parcels would be leased and no additional public revenue would be generated. The economic contributions of activities associated with oil and gas development would remain consistent with existing conditions described in the Economics section of Chapter 3. Economic effects are summarized and displayed in comparative form in Table 13.

Table 13: Summary Comparison of Estimated Average Annual Economic Impacts

Alternative	Acres Leased	Change in Local Revenue to Counties	Change in Total Employment (full and part-time jobs)	Change in Total Labor Income
A	0	0	0	0
B	1,282	$466	0	$0

*These impacts would be in addition to impacts from existing Federal leases, rents, royalties and related activities.

4.3.1 Direct Effects Common to All Resources

The action of leasing the parcels in Alternative B would, in and of itself, have no direct impact on resources. Any potential effects on resources from the sale of leases would occur during lease exploration and development activities. At the time of this review it is unknown whether a particular lease parcel would be sold and a lease issued.

4.3.2 Indirect Effects Common to All Resources

Oil and gas exploration and development activities such as construction, drilling, production, infrastructure installation, vehicle traffic and reclamation are indirect effects from leasing the parcels in Alternative B. It is unknown when, where, how, or if future surface disturbing activities associated with oil and gas exploration and development such as well sites, roads, facilities, and associated infrastructure would be proposed. It is also not known how many wells, if any, would be drilled and/or completed, the types of technologies and equipment would be used and the types of infrastructure needed for production of oil and gas. Thus, the types, magnitude and duration of potential impacts cannot be precisely quantified at this time, and would vary according to many factors. The potential impacts from exploration and development activities would be analyzed after receipt of an APD or sundry notice.

Typical impacts to resources from oil and gas exploration and development activities such as well sites, roads, facilities, and associated infrastructure are described in the Billings RMP (1984) and its associated environmental impact statement. The Oil & Gas portion of the 1984 Billings RMP was amended by the 1992 Oil & Gas Amendment of the Billings, Powder River, and South Dakota RMPs and Final EIS and the 1994 Record of Decision. The Final Supplement to the Montana Statewide Oil & Gas EIS (2008) and Proposed Amendment of the Powder River and Billings RMPs (FSEIS) amended the 1984 Billings RMP/EIS.

4.3 Alternative B (Proposed Action)

4.3.3 Air Resources

4.3.3.1 Direct and Indirect Effects

4.3.3.1.1 Air Quality

Leasing the parcels would have no direct impacts on air quality. Any potential effects on air quality from sale of lease parcels would occur at the time the leases are developed.

Potential impacts of development could include increased airborne soil particles blown from new well pads or roads; exhaust emissions from drilling equipment, compressors, vehicles, and dehydration and separation facilities, as well as potential releases of GHGs and VOCs during drilling or production activities. The amount of increased emissions cannot be precisely quantified at this time since it is not known for certain how many wells might be drilled, the types of equipment needed if a well were to be completed successfully (e.g., compressor, separator, dehydrator), or what technologies may be employed by a given company for drilling any new wells. The degree of impact would also vary according to the characteristics of the geologic formations from which production occurs, as well as the scope of specific activities proposed in an APD.

Current monitoring data show that criteria pollutant concentrations are well below applicable air quality standards, with the exception of intermittent high localized SO_2 concentrations within 2 kilometers of a refinery in Laurel. The potential level of development and mitigation described below is expected to maintain good air quality in the lease area. Pollutant emissions would be regulated under Montana's oil and gas registration permitting system. SO_2 emissions would be low due to requirements for vehicles and non-road engines to use ultra-low sulfur diesel fuel.

Hazardous air pollutants (HAPs) would also be emitted from oil and gas operations, including well drilling, well completion, and gas and oil production. Recent air quality modeling performed for the BiFO indicates that concentrations of benzene, ethylbenzene, formaldehyde, n-hexane, toluene, and xylene would be less than 11 percent of applicable health-based standards and that the additional risk of cancer would be less than 0.25 in one million (BLM 2013).

4.3.3.1.2 Greenhouse Gas Emissions at the Billings Field Office and Project Scales
Sources of GHGs associated with development of lease parcels may include construction activities, operations, and facility maintenance in the course of oil and gas exploration, development, and production. Estimated GHG emissions are discussed for these specific aspects of oil and gas activity because the BLM has direct involvement in these steps. However, the current proposed activity is to offer parcels for lease. No specific development activities are currently proposed or potentially being decided upon for any parcels being considered in this EA. Potential development activities would be analyzed in a separate NEPA analysis effort if the BLM receives an APD on any of the parcels considered here.

Anticipated GHG emissions presented in this section are taken from the Climate Change SIR, 2010. Data are derived from emissions calculators developed by air quality specialists at the BLM National Operations Center in Denver, Colorado, based on methods described in the Climate Change SIR (2010). Based on the assumptions summarized above for the Billings Field Office RFD, Table 14 discloses projected annual GHG source emissions from BLM-permitted activities associated with the RFD.

Table 14: BLM Projected Annual Emissions of Greenhouse Gases Associated with Oil and Gas Exploration and Development Activity in the Billings Field Office.

Source	BLM Long-Term Greenhouse Gas Emissions in tons/year			Emissions (metric tons/yr)
	CO_2	CH_4	N_2O	CO_2e
Conventional Natural Gas	355	5	0.0	422
*Coal Bed Natural Gas (none forecasted in RFD)	0.0	0	0.0	0.0
Oil	8,353	54	2.3	8,619
Total	**8,708**	**59**	**2.3**	**9,041**

*Currently there is no CBNG production within the Billings Field Office (RFD, February 2010 p-17)

To estimate GHG emissions associated with the action alternatives, the following approach was used:

1. The proportion of each project level action alternative relative to the total RFD was calculated based on total acreage of parcels under consideration for leasing relative to the total acreage of federal mineral acreage available for leasing in the RFD.
2. This ratio was then used as a multiplier with the total estimated GHG emissions for the entire RFD (with the highest year emission output used) to estimate GHG emissions for that particular alternative.

Under Alternative B, approximately 1,602 acres of lease parcels with federal minerals could be leased. These acres constitute approximately 0.18 percent of the total federal mineral estate of approximately 690,000 acres identified in the Billings Field Office RFD scenario. Therefore, based on the approach described above to estimate GHG emissions, 0.18 percent of the total estimated BLM RFD emissions of approximately 9,041 metric tons/year would be approximately 16 metric tons/year of CO_2e if the parcels included in Alternative B were to be developed.

4.3.3.1.3 Climate Change

The assessment of GHG emissions and climate change is in its formative phase. As summarized in the Climate Change SIR, climate change impacts can be predicted with much more certainty over global or continental scales. Existing models have difficulty reliably simulating and attributing observed temperature changes at small scales. On smaller scales, natural climate variability is relatively larger, making it harder to distinguish changes expected due to external forcings (such as contributions from local activities to GHGs). Uncertainties in local forcings and feedbacks also make it difficult to estimate the contribution of GHG increases to observed small-scale temperature changes (Climate Change SIR 2010).

It is currently not possible to know with certainty the net impacts from lease parcel development on climate. The inconsistency in results of scientific models used to predict climate change at the global scale coupled with the lack of scientific models designed to predict climate change on regional or local scales, limits the ability to quantify potential future impacts of decisions made at this level. It is therefore beyond the scope of existing science to relate a specific source of GHG emission or sequestration with the creation or mitigation of any specific climate-related environmental effects. Although the effects of GHG emissions in the global aggregate are well-documented, it is currently impossible to determine what specific effect GHG emissions resulting from a particular activity might have on the environment. For additional information on environmental effects typically attributed to climate change, please refer to the cumulative effects discussion below.

While it is not possible to predict effects on climate change of potential GHG emissions discussed above in the event of lease parcel development for alternatives considered in this EA, the act of leasing does not produce any GHG emissions in and of itself. Releases of GHGs would occur at the exploration/development stage.

4.3.3.2 Mitigation

The BLM encourages industry to incorporate and implement BMPs to reduce impacts to air quality by reducing emissions, surface disturbances, and dust from field production and operations. Measures may also be required as COAs on permits by either the BLM or the applicable state air quality regulatory agency. The BLM also manages venting and flaring of gas from federal wells as described in the provisions of Notice to Lessees (NTL) 4A, Royalty or Compensation for Oil and Gas Lost.

Some of the following measures could be imposed at the development stage:

- flare or incinerate hydrocarbon gases at high temperatures to reduce emissions of incomplete combustion;

- install emission control equipment of a minimum 95 percent efficiency on all condensate storage batteries;
- install emission control equipment of a minimum 95 percent efficiency on dehydration units, pneumatic pumps, produced water tanks;
- operate vapor recovery systems where petroleum liquids are stored;
- use tier II or greater, natural gas or electric drill rig engines;
- operate secondary controls on drill rig engines;
- use no-bleed pneumatic controllers (most effective and cost effective technologies available for reducing VOCs);
- use gas or electric turbines rather than internal combustions engines for compressors;
- operate nitrogen oxides (NO_x) emission controls on all new and replaced internal combustion oil and gas field engines;
- water dirt and gravel roads during periods of high use and control speed limits to reduce fugitive dust emissions;
- implement interim reclamation to re-vegetate areas of the pad not required for production facilities and to reduce the amount of dust from the pads.
- co-locate wells and production facilities to reduce new surface disturbance;
- use directional drilling and horizontal completion technologies whereby one well provides access to petroleum resources that would normally require the drilling of several vertical wellbores;
- operate gas-fired or electrified pump jack engines;
- install velocity tubing strings;
- capture gas during completion activities (i.e. green completions), and other ancillary sources;
- use centralized tank batteries and multi-phase gathering systems to reduce truck traffic;
- use forward looking infrared (FLIR) technology to detect fugitive emissions; and
- monitor ambient air concentrations of NO_x and ozone (O_3).

More specific to reducing GHG emissions, Section 6 of the Climate Change SIR identifies and describes in detail commonly used technologies to reduce methane emissions from natural gas, coal bed natural gas, and oil production operations. Technologies discussed in the Climate Change SIR and as summarized below in Table 15 (reproduced from Table 6-2 in Climate Change SIR 2010), display common methane emission technologies reported under the USEPA Natural Gas STAR Program and associated emission reduction, cost, maintenance and payback data.

Table 15: Selected Methane Emission Reductions Reported Under the USEPA Natural Gas STAR Program [1]

Source Type / Technology	Annual Methane Emission Reduction [1] (Mcf/yr)	Capital Cost Including Installation ($)	Annual Operating and Maintenance Cost ($)	Payback (Years or Months)	Payback Gas Price Basis ($/Mcf)
Wells					
Reduced emission (green) completion	7,000 [2]	$1K – $10K	>$1,000	1 – 3 yr	$3
Plunger lift systems	630	$2.6K – $10K	NR	2 – 14 mo	$7
Gas well smart automation system	1,000	$1.2K	$0.1K – $1K	1 – 3 yr	$3
Gas well foaming	2,520	>$10K	$0.1K – $1K	3 – 10 yr	NR
Tanks					
Vapor recovery units on crude oil tanks	4,900 – 96,000	$35K – $104K	$7K – $17K	3 – 19 mo	$7
Consolidate crude oil production and water storage tanks	4,200	>$10K	<$0.1K	1 – 3 yr	NR
Glycol Dehydrators					
Flash tank separators	237 – 10,643	$5K – $9.8K	Negligible	4 – 51 mo	$7
Reducing glycol circulation rate	394 – 39,420	Negligible	Negligible	Immediate	$7
Zero-emission dehydrators	31,400	>$10K	>$1K	0 – 1 yr	NR
Pneumatic Devices and Controls					
Replace high-bleed devices with low-bleed devices					
End-of-life replacement	50 – 200	$0.2K – $0.3K	Negligible	3 – 8 mo	$7
Early replacement	260	$1.9K	Negligible	13 mo	$7
Retrofit	230	$0.7K	Negligible	6 mo	$7
Maintenance	45 – 260	Negl. to $0.5K	Negligible	0 – 4 mo	$7
Convert to instrument air	20,000 (per facility)	$60K	Negligible	6 mo	$7
Convert to mechanical control systems	500	<$1K	<$0.1K	0 – 1 yr	NR

Table 15: Selected Methane Emission Reductions Reported Under the USEPA Natural Gas STAR Program [1]

Source Type / Technology	Annual Methane Emission Reduction [1] (Mcf/yr)	Capital Cost Including Installation ($)	Annual Operating and Maintenance Cost ($)	Payback (Years or Months)	Payback Gas Price Basis ($/Mcf)
Valves					
Test and repair pressure safety valves	170	NR	$0.1K – $1K	3 – 10 yr	NR
Inspect and repair compressor station blowdown valves	2,000	<$1K	$0.1K – $1K	0 – 1 yr	NR
Compressors					
Install electric compressors	40 – 16,000	>$10K	>$1K	>10 yr	NR
Replace centrifugal compressor wet seals with dry seals	45,120	$324K	Negligible	10 mo	$7
Flare Installation	2,000	>$10K	>$1K	None	NR

Source: Multiple USEPA Natural Gas STAR Program documents. Individual documents are referenced in Climate Change SIR (2010).
[1] Unless otherwise noted, emission reductions are given on a per-device basis (e.g., per well, per dehydrator, per valve, etc.).
[2] Emission reduction is per completion, rather than per year.
K = 1,000
mo = months
Mcf = thousand cubic feet of methane
NR = not reported
yr = year

In the context of the oil sector, additional mitigation measures to reduce GHG emissions include methane reinjection and CO_2 injection. These measures are discussed in more detail in Section 6.0 of the Climate Change SIR (2010).

In an effort to disclose potential future GHG emissions reductions that might be feasible in individual field offices, the BLM estimated GHG emissions reductions based on the RFD for the Miles City Field Office (MCFO). For analysis purposes, the MCFO RFD was selected based on the high potential development scenario. Similar emissions reductions may be possible in the planning area. For emissions sources subject to BLM (federal) jurisdiction, the estimated emissions reduction represent approximately 51 percent reduction in total GHG emissions compared to the estimated MCFO federal GHG emissions inventory (Climate Change SIR, as updated October 2010, Section 6.5 and Table 6-3). The emission reduction technologies and practices are identified as mitigation measures that could be imposed during development. Furthermore, the EPA is expected to promulgate new federal air quality regulations that would require GHG emission reductions from many oil and gas sources.

4.3.4 Soil Resources

4.3.4.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on soil resources. Any potential effects from the sale of lease parcels would occur at the time that the leases are developed. Land uses associated with oil and gas exploration and development could cause surface disturbances. Such acts result in reduced ground cover, soil mixing, compaction, or removal, exposing soils to accelerated erosion by wind and water, resulting in the irretrievable loss of topsoil and nutrients and potentially resulting in mass movement or sedimentation. Surface disturbances also change soil structure, heterogeneity (variable characteristics), temperature regimes, nutrient cycling, biotic richness, and diversity. Along with this, mixed soils have decreased bulk density, and altered porosity, infiltration, air-water relationships, salt content, and pH (Perrow and Davy, 2003; Bainbridge 2007). Soil compaction results in increased bulk density, and reduced porosity, infiltration, moisture, air, nutrient cycling, productivity, and biotic activity (Logan 2001; 2003; 2007). Altering such characteristics reduces the soil system's ability to withstand future disturbances (e.g., wildfire, drought, high precipitation events, etc.).

The probability and magnitude of these effects are dependent upon local site characteristics, climatic events, and the specific mitigation applied to the project. Within 2-5 years following reclamation, vegetative cover and rates of erosion would return to pre-disturbance conditions (FSEIS 2008). Exceptions would be sites poorly suited to reclamation (approximately 44 acres, three percent of the parcels), which would require unconventional and/or site-specific reclamation measures. Prime farmland if irrigated (approximately 6 acres, <1% percent of the parcels) would be avoided or require site-specific reclamation as well.

4.3.4.2 Mitigation

Measures would be taken to reduce, avoid, or minimize potential impacts to soil resources from exploration and development activities. Prior to authorization, proposed actions would be evaluated on a case-by-case basis and would be subject to mitigation measures in order to maintain the soil system. Mitigation could include avoiding areas with low restoration potential, limiting the total area of disturbance, rapid reclamation, erosion/sediment control, soil salvage, decompaction, revegetation, weed control, slope stabilization, surface roughening, and fencing.

Conducting oil and gas development with the following BMPs would enhance soil resilience and reduce soil system fragmentation, accelerated wind and water erosion, and the total area of surface disturbance with the following:

- utilizing plans of development,
- removing vegetation in the smallest area possible,
- co-locating infrastructure,
- using a single trench for utilities and piping,
- employing multiple completions per well bore and directional drilling,
- closed-loop drilling or other pit-less methods,
- ensuring reclamation of all new roads at the end of the life of the well,
- preventing degradation of the watershed from produced water,
- designing impoundments or water disposal methods to minimize impacts to soil; and initiating interim reclamation within 25 days of drilling the well.

4.3.5 Water Resources

4.3.5.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on water resources. Any potential effects to water resources would occur from subsequent exploration/development of the lease parcels.

The magnitude of the impacts to water resources would be dependent on the specific activity, season, proximity to waterbodies, location in the watershed, upland and riparian vegetation condition, effectiveness of mitigation, and the time until reclamation success. Surface disturbance effects typically are localized, short-term, and occur from implementation through vegetation reestablishment. As acres of surface-disturbance increase within a watershed, so could the effects on water resources.

Oil and gas exploration/development of a lease parcel could cause the removal of vegetation, soil compaction, and soil disturbance in uplands within the watershed, 100-year floodplains of non-major streams, and non-riparian, ephemeral waterbodies. The potential effects from these activities could be accelerated erosion, increased overland flow, decreased infiltration, increased water temperature, channelization, and water quality degradation associated with increased sedimentation, turbidity, nutrients, metals, and other pollutants. Erosion potential can be further increased in the long term by soil compaction and low permeability surfacing (e.g. roads and well pads) which increases the energy and amount of overland flow and decreases infiltration, which in turn changes flow characteristics, reduces groundwater recharge, and increases sedimentation and erosion (DEQ 2007).

Spills or produced fluids could potentially impact surface and ground water resources in the long term. Oil and gas exploration/development could contaminate aquifers with salts, drilling fluids, fluids and gases from other formations, detergents, solvents, hydrocarbons, metals, and nutrients; change vertical and horizontal aquifer permeability; and increase hydrologic communication with adjacent aquifers (EPA 2004). Potential groundwater impacts could also result from post development casing failures. These situations are normally mitigated by downhole engineering requirements and inspection at the time of construction, however unforeseen material flaws or pressure conditions may be encountered. Groundwater abstraction would result in a depletion of flow in nearby streams and springs if the aquifer is hydraulically connected to such features. Typically produced water from conventional oil and gas wells is from a depth below useable aquifers or coal seams (FSEIS 2008).

Ground Water: The eventual drilling of the proposed parcels would most likely pass through useable groundwater. Potential impacts to groundwater resources could occur if proper cementing and casing programs are not followed. This could include loss of well integrity, surface spills, or loss of fluids in the drilling and completion process. It is possible for chemical additives used in drilling activities to be introduced into the water producing formations without proper casing and cementing of the well bore. Changes in porosity or other properties of the rock being drilled through can result in the loss of drilling fluids. When this occurs, drilling fluids can be introduced into groundwater without proper cementing and casing. Site specific conditions and drilling practices determine the probability of this occurrence and determine the groundwater resources that could be impacted. In addition to changing the producing formations' physical properties by increasing the flow of water, gas, and/or oil around the well bore; hydraulic fracturing can also introduce chemical additives into the producing formations. Types of chemical additives used in drilling activities may include acids, hydrocarbons, thickening agents, lubricants, and other additives that are operator and location specific. These additives are not always used in these drilling activities and some are likely to be benign such as bentonite clay and sand. Concentrations of these additives also vary considerably since different mixtures can be used for different purposes in oil and gas development and even in the same well bore. If contamination of aquifers from any source occurs, changes in groundwater quality could impact springs and residential wells that are sourced from the affected aquifers. Onshore Order #2 requires that the proposed casing and cementing programs shall be conducted as approved to protect and/or isolate all usable water zones.

Known water bearing zones in the lease area are protected by drilling requirements and, with proper practices, contamination of ground water resources is highly unlikely. Casing along with cement is extended well beyond fresh-water zones to insure that drilling fluids remain within the well bore and do not enter groundwater.

Potential impacts to ground water at site specific locations are analyzed through the NEPA review process at the development stage when the APD is submitted. This process includes geologic and engineering reviews to ensure that cementing and casing programs are adequate to protect all downhole resources.

All water used would have to comply with Montana state water rights regulations and a source of water would need to be secured by industry that would not harm senior water rights holders.

4.3.5.2 Mitigation

In the event of exploration or development, measures would be taken to reduce, avoid, or minimize potential impacts to water resources including application of appropriate mitigation. Mitigation measures that minimize the total area of disturbance, control wind and water erosion, reduce soil compaction, maintain vegetative cover, control nonnative species, and expedite rapid reclamation (including interim reclamation) would maintain water resources. Methods to reduce erosion and sedimentation could include: reducing surface disturbance acres; installing and maintaining adequate erosion control; proper road design, road surfacing, and culvert design; road/infrastructure maintenance; use of low water crossings; and use of isolated or bore crossing (HDD) methods for waterbodies and floodplains. In addition, applying mitigation to maintain adequate, undisturbed, vegetated buffer zones around waterbodies and floodplains could reduce sedimentation and maintain water quality. Appropriate well completion, the use of Spill Prevention Plans, and Underground Injection Control (UIC) regulations would mitigate groundwater impacts. Site-specific mitigation and reclamation measures would be described in the COAs.

4.3.6 Vegetation Resources

4.3.6.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on vegetation resources. Any potential effects on vegetation resources from sale of lease parcels would occur at the time the leases are developed. Impacts to vegetation would depend on the vegetation type/community, soil community and the topography of the lease parcels. Disturbance to vegetation is of concern because protection of soil resources, maintenance of water quality, conservation of wildlife habitat, and livestock production capabilities may be diminished or lost over the long-term through direct loss of vegetation (including direct loss of both plant communities and specific plant species).

Other direct impacts, such as invasive species and noxious weed invasion could result in loss of desirable vegetation. Invasive species and noxious weeds may also reduce livestock grazing forage, wildlife habitat quality, and native species diversity. Cheatgrass is an invasive species well known for completely replacing native vegetation and changing fire regimes.

Additionally, surface disturbing activities directly affect vegetation by destroying habitat, churning soils, impacting biological crusts, disrupting seedbanks, burying individual plants, and generating sites for competitive non-native plants including weedy species. In addition, other vegetation impacts could also be caused from soil erosion and result in loss of the supporting substrate for plants, or from soil compaction resulting in reduced germination rates. Impacts to plants occurring after seed germination but prior to seed set could be particularly harmful as both current and future generations would be affected.

Fugitive dust generated by construction activities and travel along dirt roads can affect nearby plants by depressing photosynthesis, disrupting pollination, and reducing reproductive success. Oil, fuel, wastewater or other chemical spills could contaminate soils as to render them temporarily unsuitable for plant growth until cleanup measures were fully implemented. If cleanup measures were less successful, longer term vegetation damage could be expected.

Oil and gas development activity would reduce BLM's ability to manage livestock grazing while meeting or progressing towards meeting the Standards of Rangeland Health. Development and associated disturbances would reduce available forage or alter livestock distribution leading to overgrazing or other localized excess grazing impacts. Construction of roads, especially in areas of rough topography can cause significant changes in livestock movement and fragment suitable habitat for some plant communities. Where grazing activity contributes to not meeting the Standards for Rangeland Health, the authorized officer must adjust grazing practices or levels of use prior to the next grazing season.

If development activity is reducing vegetative resources for livestock grazing and the grazing activity is resulting in the allotment not meeting the standards for rangeland health, then the authorized officer would have to take action prior to the next grazing season to ensure the BLM lands are progressing towards meeting the standards. This would result in the change of livestock grazing activities in order to improve vegetative conditions.

4.3.6.1.1 Invasive, Non-Native Species (INNS)

At the lease sale stage there are no impacts. Impacts (both direct and indirect) would occur when the lease is developed. The potential impacts would be analyzed on a site-specific basis prior to oil and gas development and during the APD stage of development.

Direct impacts would occur during oil and gas development. Impacts associated with oil and gas development to INNS would include surface disturbance and creating vectors for dispersal. Surface disturbance from drill site development could create suitable site conditions for the introduction of INNS. Vectors create invasive weed seed movement from vehicles and equipment to sites which were not previously infested.

Indirect impacts associated with oil and gas development would include ecological site alterations as a result from the spread of INNS. If appropriate management techniques do not occur and these invasive species becomes established, they could alter the plant community, which would then affect wildlife habitat and upland health.

4.3.6.1.2 Noxious Weeds
At the lease sale stage there are no impacts. Impacts (both direct and indirect) would occur when the lease is developed in the future. The potential impacts would be analyzed on a site-specific basis prior to oil and gas development and during the APD stage of development.

Noxious weed species are highly competitive and could invade plant communities very rapidly. The spread of noxious weeds would have a negative impact on vegetative composition. This negative impact could be both short and long term depending upon the effectiveness and timing of control measures.

The construction of access roads and well pads could unintentionally contribute to the establishment and spread of noxious weeds. Noxious weed seed could be carried to and from the project areas by construction equipment, drilling rigs, and transport vehicles.

The main mechanism for invasive weed seed dispersion on roads and well pads is by equipment and vehicles that were previously used and/or driven across or through other noxious weed infested areas. The potential for the dissemination of invasive and noxious weed seed may be elevated by the use of construction equipment typically contracted out to companies that may be from other geographic areas in the region. Washing and decontaminating equipment prior to transporting from site to site would minimize this impact.

4.3.6.2 Mitigation
Mitigation would be addressed at the site specific APD stage of exploration and development. If needed, COAs would potentially include revegetation with desirable plant species, soil enhancement practices, direct live haul of soil material for seed bank revegetation, reduction of livestock grazing, fencing of reclaimed areas, and the use of seeding strategies consisting of native grasses, forbs, and shrubs, would be identified and addressed at the APD stage. During development, all equipment would be cleaned and free of unwanted plant species, and sites would be monitored for the presence of noxious and invasive species. Small populations of noxious weeds should be eradicated as they appear.

4.3.7 Riparian-Wetland Habitats

4.3.7.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on riparian-wetland habitats. Any potential effects on riparian-wetland habitats from sale of lease parcels would occur at the time the leases are developed.

NSO 11-2 stipulation, applied in parcel MTM 105431-F6, would minimize potential direct impacts to riparian resources. The potential for indirect impacts from the exploration and development of oil and gas within uplands or adjacent to riparian-wetland areas may include reduced riparian/wetland functionality by changing native plant productivity, composition, richness, and diversity; accelerating erosion; increasing sedimentation; and changing hydrologic characteristics. Impacts that reduce the functioning condition of riparian and wetland areas would impair the ability of riparian/wetland areas to reduce nonpoint source pollution (MDEQ 2007) and provide other ecosystem benefits. The magnitude of these effects would be dependent on the specific activity, season, proximity to riparian-wetland areas, location in the watershed, upland and riparian-wetland vegetation condition, mitigation applied, and the time until reclamation success. Erosion increases are typically localized, short term, and occur from implementation through vegetation reestablishment. As acres of surface-disturbance increase within a watershed, so would the effects on riparian-wetland resources. Project planning, design and mitigation measures would ensure riparian functionality would be maintained at current levels. Impacts that reduce the PFC rating of a riparian area would not be allowed.

Given that not all riparian resources are mapped or known by BLM specialists, if riparian areas are discovered during the APD process or development stages, conditions would be applied to conserve riparian resources and riparian functionality.

4.3.7.2 Mitigation

Stipulations addressing steep slopes, waterbodies, streams, 100-year floodplains of major rivers, riparian areas, and wetlands would minimize potential impacts to maintain riparian functional ratings and would be included with the lease when necessary (refer to Appendix A). In the event of exploration or development, site-specific mitigation measures would be identified which would avoid or minimize potential impacts to riparian-wetland areas at the APD stage. Mitigation measures that minimize the total area of disturbance, control wind and water erosion, reduce soil compaction, maintain vegetative cover, control nonnative species, maintain biodiversity, maintain vegetated buffer zones, and expedite rapid reclamation (including interim reclamation) would maintain riparian/wetland resources.

4.3.8 Wildlife and Special Status Species

4.3.8.1 Direct and Indirect Effects

Leasing the 10 parcels would have no direct impacts on wildlife. Any potential effects on wildlife resources from sale of lease parcels would occur at the time the leases are developed.

Indirect impacts to wildlife resources include loss of habitat from development infrastructure, mortalities resulting from collisions with vehicles and power lines, electrocution on power lines, and displacement of wildlife species from initial disturbance caused by human presence. Indirect impacts would include habitat fragmentation and subsequent avoidance due to vehicle traffic, human presence, and other continual development activities.

Based on the RFD scenarios, some direct habitat loss is possible. Initial disturbance would change the occupation of those areas to disturbance-oriented species (i.e. horned larks), or species with more tolerance for disturbances. These changes would also be expected to decrease the diversity of wildlife. Although bladed corridors would be reclaimed after the facilities are constructed, some changes in vegetation would occur along the reclaimed areas. The goal of reclamation is to restore disturbed areas to pre-disturbed conditions. The outcome of reclamation, unlike site restoration, would therefore not always mimic pre-disturbance conditions and offer the same habitat values to wildlife species. Sagebrush obligates, including some species of songbirds, and forest or shrub adapted species, would be most affected by this change because sagebrush, forest, and shrubs may require decades to regrow.

Mule deer (the most common big game animal in the analysis area) would be impacted by development from habitat fragmentation and disturbance. Studies conducted in the Pinedale anticline of Wyoming found that mule deer avoided areas in close proximity to well pads with no evidence of well-pad acclimation during 3 out of 4 years. During year 4 of development habitat selection patterns were influenced more by road density, and not proximity of well pads. The authors attributed this to an unusually severe winter, where movement options and available habitat was limited. Densities of mule deer decreased by an estimated 46% within the developed area over the four years, and indirect impacts were observed out to 2.7-3.7 km of well sites. Mule deer distribution shifted toward less preferred and presumably less suitable habitat. (Sawyer et al, 2005) Similar impacts would be expected from development with this proposal.

The use of standard leasing terms and RMP stipulations on these lands (refer to Appendix A) would minimize, but not preclude impacts to wildlife if development occurs. Oil and gas development which results in surface disturbance could directly and indirectly impact wildlife species. These impacts could include loss or reduction in suitability of habitat, improved habitat for undesirable (non-native) competitors, species or community shift to species or communities more tolerant of disturbances, nest abandonment, mortalities resulting from collisions with vehicles and power lines, electrocutions from power lines, barriers to species migration, habitat fragmentation, increased predation, habitat avoidance, and displacement of wildlife species resulting from human presence. The scale, location, and pace of development, combined with implementation of mitigation measures and the specific tolerance of the species to human disturbance all influence the severity of impacts to wildlife species and habitats, including Threatened, Endangered, Candidate, Proposed, and other special status species.

The reasonably foreseeable development scenario indicates development of the leases resulting in approximately 3.5 acres of surface disturbance (somewhere within the analysis area), which would have minimal impacts on wildlife resources in the analysis area. Overall, this would only result in less than one tenth of one percent of the analysis area being disturbed by the lease parcels being developed (direct habitat alteration/loss).

Stipulations designed to conserve wildlife habitat and minimize disturbance and disruption to wildlife populations have been applied where issues have been identified. These stipulations include timing limitations for activities in big game winter range and near sage-grouse and sharptailed grouse lek sites.

4.3.8.1.1 Threatened, Endangered Proposed, and Candidate Species
Threatened and Endangered Species Consultation

The Biological Opinion from the Billings RMP/EIS ROD -4/23/1984, pg. 100-102; Biological Assessment / Opinion from Miles City District, Oil and Gas RMP/ EIS Amendment -12/1992, pg. 237-243; and Backlog Consultation of 5/8/2008, pg. 1-33 and Biological Opinion 5/20/2008 with US Fish and Wildlife Service address possible effects to T&E Species including grizzly bear, gray wolf, lynx, black-footed ferret, peregrine falcon, and bald eagle within Billings Field Office. Refer to the "Affected Environment, Chapter 3" for the current status of these species.

Summary of determinations for the Billing FO RMP- (5/8/2008-Backlog Consultation)

The following is a summary of the effects determinations on T & E species, developed for each of the Billings RMP management actions (Table 16). Determinations apply to all T&E Species listed in the Billings Field Office unless indicated otherwise.

Table 16: Threatened and Endangered, Proposed and Candidate Wildlife Species Summary of Determinations for the Billings Field Office RMP

T & E Species	Determination
Black-footed ferret	May Affect, Not Likely to Adversely Affect
Gray Wolf	May Affect, Not Likely to Adversely Affect
Grizzly Bear	May Affect, Not Likely to Adversely Affect
Lynx	May Affect, Not Likely to Adversely Affect
Whooping Crane	No Affect

These determinations would remain valid for these species given the stipulations applied, inventories required, and mitigation implemented at the APD stage of development through Conditions of Approval. The project area is not known habitat for any of the listed species.

Whooping Crane:

Whooping crane is listed in Yellowstone County within the Billings Field Office area. BLM has determined that the act of issuing leases within the whooping crane migration corridor would not affect the whooping crane. However, impacts to whooping cranes are possible from subsequent oil and gas development activities that would be permitted at the APD stage. At this time, stipulations do not currently exist to protect any known whooping crane migration staging areas. Line strikes, collisions with vehicles, habitat fragmentation, and other anthropogenic activities can disturb, displace, or cause direct mortality of whooping cranes.

Therefore, if development of these leases is proposed, BLM would consult with the USFWS pursuant to section 7(a)(2) of ESA. An outcome of the consultation process may be that conditions of approval are attached to the permit or the permit may not be approved. Other BMPs would also be developed through consultation, including minimizing disturbance, adherence to Avian Power-line Interaction Committee (APLIC) guidelines, and others as deemed appropriate.

4.3.8.1.2 Other Special Status Species

As noted, any number of the 46 wildlife species that BLM has designated as "Special Status Species" (SSS) have the potential to occur within the parcel areas. Stipulations are not provided for all BLM SSS in the current Resource Management Plans. Stipulations are provided for 10 out of the 46 SSS species. For those species afforded some protections through existing stipulations, impacts would be minimized, but not eliminated. Impacts to BLM sensitive species would be similar to those described above, unless they are afforded protective measures from other regulations such as the Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703.) or the Bald and Golden Eagle Protection Act (BGEPA) (16 U.S.C. 668-668c). BLM does not consult with the USFWS on BLM Sensitive species and likewise would not receive terms and conditions from USFWS requiring additional protections of those species. As mentioned above, any impacts to wildlife resources will be limited to areas outside of the leasing parcels, as NSO stipulations will restrict any surface disturbance or disruptive activities on the parcels. The degree of impact will depend on location and timing of development activities, which will not be disclosed unless an APD is submitted.

Numerous species of birds were identified as inhabitants across the analysis area. With the impacts associated with development, it is reasonable to assume there would be impacts to nesting and migrating bird species. The primary impacts to these species would include disturbance of preferred nesting habitats, improved habitat for undesirable competitors and/or a species shift to disturbance associated species, and increased vehicle collisions.
Research in Sublette County, Wyoming on the effects of natural gas development on sagebrush steppe passerines documented negative impacts to sagebrush obligates such as Brewer's sparrows, sage sparrows, and sage thrashers. (Ingelfinger, 2001) The impacts were reported greatest along roads where traffic volumes are high and within 100 meters of these roads. Sagebrush obligates were reduced within these areas by as much as 60%. Sagebrush obligate density was reduced by 50% within 100 meters of a road even when traffic volumes were less than 12 vehicles /day. It would be expected that similar population declines would occur to this guild of species from similar development proposals within sagebrush habitats.

Stipulations do not exist specifically for the protection of BLM sensitive songbirds. The MBTA prohibits the take, capture or kill of any migratory bird, any part, nest or eggs of any such bird (16 U.S.C 703 (a)). NEPA analysis pursuant to Executive Order 13186 (January 2001) requires BLM to ensure that MBTA compliance and the effects of Bureau actions and agency plans on migratory birds are evaluated, should reduce take of migratory birds and contribute to their conservation.

Effects to migratory birds from oil and gas development at the APD stage could include direct loss of habitat from roads, well pads and other infrastructure, disturbance, powerline strikes and accidental direct mortality, fragmentation of habitat, change in use of habitats, and potential threats and competition from edge species. Field surveys for nesting birds at proposed development sites would be conducted for activities planned between May 1 and August 30. Mitigation measures would be assigned at the APD stage to ensure there would be no measurable negative effect on migratory bird populations, in compliance with Executive Order 13186 and MBTA. These mitigation measures would be required as Conditions of Approval. An NSO stipulation for oil and gas surface disturbing activities in riparian and wetland areas would prohibit any potential oil and gas development in those habitats unless approval was granted through the "Waivers, Exceptions, and Modifications" (WEM) process. BLM would coordinate WEMs with USFWS to assure MBTA compliance. In this case, due to the sensitive nature of riparian and water resources in the lease parcels, it is unlikely WEMs would be granted.

Raptors:
All raptor species known to exist within the analysis area are considered migratory under MBTA. No known raptor nest data exists for the lease parcels from BLM, Montana Natural Heritage, or onsite inventories. Nest surveys would be completed at proposed development sites for activities planned between May 1 and August 30. The timbered and cliff habitats provide potential nesting habitat for raptors. If nest sites are found, mitigation measures would be assigned at the development stage, as Conditions of Approval, to ensure there would be no negative impacts to nesting raptors.

Take of bald and golden eagles and any other migratory raptors is not anticipated through this action; however, take may occur indirectly as a result of vehicle collisions and other related actions associated with development. Field surveys for raptors at proposed development sites would be conducted for activities planned between April 15 and August 30. Mitigation measures would be assigned at the APD stage to ensure there would be negligible effect on raptor populations, including bald and golden eagles. These mitigation measures would be required as Conditions of Approval. The application of stipulations and COAs at the project level is expected to comply with MBTA and BGEPA.

Greater Sage-Grouse:
Suitable habitat within various lease parcels exists to support USFWS Candidate species, Greater Sage-Grouse. Development potential indicates approximately 3.5 acres of surface disturbance would be possible with development associated with this proposed action. The analysis area, which is a loosely drawn polygon surrounding the parcels in Yellowstone County, consists of approximately 76,000 acres. The disturbance of 3.5 acres would result in less than 1/100 of a percent disturbance or habitat alteration. Furthermore, several stipulations are applied to the parcels near sage-grouse leks and in sage-grouse habitat that help conserve habitat qualities and minimize disruptive activities during crucial time periods (lekking and nesting seasons). The overall impact to sage-grouse, with stipulations applied and design features to conserve habitat, would be minimal.

4.3.8.2 Mitigation
Stipulations applied to wildlife resources are designed to provide protections for wildlife species and their habitat, particularly during critical life cycles. Refer to Appendix A for a summary of stipulations that apply to wildlife and habitat. Measures would be taken to prevent, minimize, or mitigate impacts to fish and wildlife animal species from exploration and development activities. Prior to authorization, activities would be evaluated, and the project would be subject to

mitigation measures. Mitigation could include rapid re-vegetation, project relocation, or pre-disturbance wildlife species surveying. If oil and gas development is proposed in suitable habitat for threatened or endangered species, consultation with the USFWS would occur to determine if additional terms and conditions would need to be applied.

Wildlife inventories would be conducted in suitable habitat at APD stage of development to determine the presence or absence of sage-grouse. If sage-grouse are found in the area, Conditions of Approval would be applied for the protection of habitat.

4.3.9 Special Status Plant Species

4.3.9.1 Direct and Indirect Effects

There are no special status plant species identified in the project area or within a two mile radius (the distance it would be feasible to develop a well and directionally drill to the lease's minerals). There will be no direct or indirect effects to this resource. In the event that special status plant species are discovered in the parcels or the development sites, NEPA analysis at the APD stage and mitigation described below would minimize adverse effects.

4.3.9.2 Mitigation

Stipulations applied to wildlife resources, steep slopes, waterbodies, streams, 100-year floodplains of major rivers, riparian areas, and wetlands would likely also provide protections for special status plant species. Additionally stipulation 16-2 applies to all lease parcels. Proposed development would be analyzed on a site-specific basis prior to approval of oil and gas exploration or development activities at the APD stage. Mitigation would also be addressed at the site-specific APD stage. Surveys to determine the existence of federally listed species could occur on BLM-administered surface or minerals prior to approval of exploration and development activities at the APD stage.

4.3.10 Cultural Resources

4.3.10.1 Direct and Indirect Effects

Leasing a nominated parcel gives a basic right to the operator to develop the lease. Leasing would not, however, result in effects to cultural resources. It is only when the lease is developed that there is a potential for cultural resources to be affected by the Proposed Action. That is when the drilling location is known and cultural resource investigations can be centered upon that location and other related developments such as roads, transmission lines, and pipelines.

Indirect effects from surface disturbances associated with exploration and development activities after leasing have the potential to alter the characteristics of a significant cultural or historic property by diminishing the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Other effects to cultural resources from proposed surface disturbance activities include the destruction, damage, or alteration to all or part of the cultural resource and diminishing the property's significant historic features as a result of the introduction of visual, atmospheric, or audible elements. This could include altering or diminishing the elements of a National Register eligible property or damaging an eligible property's eligibility status. Cultural resource investigations associated with development potentially adds to our understanding of the prehistory/history of the area under investigation and discovery of sites that would otherwise remain undiscovered due to burial or omission during review inventories.

Direct and indirect impacts are not anticipated from leasing nominated parcels. It is at the application for permit to drill (APD) stage of development that specific impacts can be correctly assessed. Potential impacts to cultural resources at the APD stage include damage to archaeological sites through construction activities and the possibility of removal of, or damage to, archaeological materials by increased human activity in the area. Conversely, cultural resource inventories associated with development potentially adds to our understanding of the prehistory and history of the area under investigation.

4.3.10.2 Mitigation
The use of standard lease terms, the cultural no surface occupancy (NSO) stipulation, and the cultural lease notice protects vulnerable significant cultural resource values on these lease parcels (refer to Appendix A). The application of these requirements at the leasing phase provide protection to cultural values or at least notification to the lessee that potentially valuable cultural resource values are or are likely to be present on the lease parcels.

Lease Notice 14-2 (which informs the lessee that a cultural resource inventory is required prior to any surface disturbing activity within the lease parcel) and CR 16-1(which informs the lessee that the lease could contain resources important/sacred to Native Americans and should these resources be present, exploration and development proposals could be modified to protect the resources) would be attached to all proposed lease sale parcels.

Lease sale parcels MTM 105431-FB, FE and FA do not contain recorded cultural resources that appear on the site database, but may be within the viewshed of the Nez Perce National Historic Trails which is a nationally significant cultural and historic resource. Stipulations CR 16-1 (above) and CSU 12-4 (pertains to viewshed) would be attached to these parcels. As there is one known and unevaluated cultural resource within MTM 105431-FF lease sale parcel, a No Surface Occupancy (NSO) stipulation (NSO 11-11) would be attached to this parcel, which would inform the lessee that surface occupancy would be prohibited within a portion of the lease sale parcel. Lease Notice (LN 14-9) would also be attached to the same lease sale parcel. This informs the lessee that cultural resources are present within the lease and as a result cultural inventory and mitigation costs may be higher.

Specific mitigation measures, including but not limited to, possible site avoidance, excavation or data recovery would have to be determined when site-specific development proposals are received. However, in most surface-disturbing situations cultural resources would be avoided by project redesign or relocation. Should a cultural property be unavoidable, significant properties would be site-specifically mitigated prior to implementation of a project.

4.3.11 Native American Religious Concerns
4.3.11.1 Direct and Indirect Effects
Leasing the parcels would have no direct impacts on any known, or expressed Native American religious concerns. Any potential effects from the sale of leases would occur at the time the leases are developed.

The BLM WO IM-2005-003 notes that while a lease does not authorize specific on-the-ground activities, no ground disturbance can occur without further authorization from BLM and the surface management agency. Unless proscribed by stipulation, lessees can expect to drill somewhere on a lease unless precluded by law. Leasing would not have an impact on TCPs and/or areas of religious or cultural importance to tribes. A lease sale would not interfere with the performance of traditional ceremonies and rituals pursuant to the American Indian Religious Freedom Act (AIRFA) or EO 13007. It would not prevent tribes from visiting sacred sites or prevent possession of sacred objects. Indirect effects from site specific development proposals could have an impact to Native American religious practices and TCPs.

A review of the lease parcels in Appendix A indicates that no previously reported TCPs would be directly or indirectly impacted, however additional tribal consultation would be required at the APD stage for those parcels containing site types identified by the Nez Perce, Umatilla, Colville, Crow or Northern Cheyenne as being important to the tribes. For those parcels where no inventory data is available or where no information is available for TCPs, BLM is proposing to apply Standard Lease Notice 16-1 and continuing to seek information from tribal authorities on the presence of TCPs that have not been previously reported.

4.3.12 Paleontology

4.3.12.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on paleontological resources. Any potential effects from the sale of leases could occur at the time the leases are developed.

Indirect impacts from the sale of leases would be from the surface disturbances associated with oil and gas exploration and development activities. It is anticipated that most significant fossil resources are located in those geologic units with a Potential Fossil Yield Classification (PFYC) of 3 or higher. However, significant fossil resources could be discovered anywhere. Surface-disturbing activities could potentially alter the characteristics of paleontological resources through damage, fossil destruction, or disturbance of the stratigraphic context in which paleontological resources are located, resulting in the loss of important scientific data. Identified paleontological resources could be avoided by project redesign or relocation before project approval which would negate the need for the implementation of mitigation measures.

Conversely, surface-disturbing activities could potentially lead to the discovery of paleontological localities that would otherwise remain undiscovered due to burial or omission during review inventories. The scientific retrieval and study of these newly discovered resources would expand our understanding of past life and environments of Montana.

4.3.12.2 Mitigation

The application of lease terms, the paleontological no surface occupancy stipulation (NSO 11-12), and the paleontological lease notice (LN 14-12) at leasing, provides protection to paleontological resources during development. The paleontological lease notice is applied to those lease parcels that fall within the PFYC 3 or higher geologic units, requiring a field survey prior to surface disturbance. These inventory requirements could result in the identification of paleontological resources. Avoidance of significant paleontological resources or implementation of mitigation prior to surface disturbance would protect paleontological resources. However, the application of lease terms only allows the relocation of activities up to 200 meters, unless documented in the NEPA document, and cannot result in moving the activity off lease.

Specific mitigation measures could include, but are not limited to, site avoidance or excavation. Avoidance of paleontological properties would be a best management practice. However, should a paleontological locality be unavoidable, significant fossil resources must be mitigated prior to implementation of a project. Also, significant fossil resources could be discovered in areas that had not been surveyed (PFYC of less than 3) during surface disturbance. Those resources must also be professionally mitigated. These mitigation measures and contingencies would be determined when site specific development proposals are received.

No parcels are recommended for the no surface occupancy lease stipulation (NSO 11-12) based upon paleontological resources. See section 3.10 Paleontology for list of parcels.

4.3.13 Visual Resources

4.3.13.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on visual resources. Any potential effects from the sale of leases would occur at the time the leases are developed.

While the act of leasing federal minerals produces no visual impacts, subsequent development (indirect effects) of a lease parcel would result in some level of modification to the existing landscape. This modification would be addressed through site specific planning and mitigation during the APD phase of development.

4.3.13.2 Mitigation

All new oil and gas development would implement, as appropriate for the site, BLM Best Management Practices for VRM, regardless of the VRM class. This includes, but would not be limited to, proper site selection, reduction of visibility, minimizing disturbance, selecting color(s)/color schemes that blend with the background and reclaiming areas that are not in active use. Repetition of form, line, color and texture when designing projects would reduce contrasts between landscape and development. Wherever practical, no new development would be allowed on ridges or mountain tops. Overall, the goal would be to not reduce the visual qualities or scenic value that currently exists. Stipulation CSU 12-4 may be applied to lease parcels MTM 105431-FB, FE and FA if development would enter into the viewshed of the NPNHT or Canyon Creek Battlefield.

4.3.14 Special Designations

4.3.14.1 National Historic Trails

The formally recognized corridor of the Nez Perce National Historic Trail is located on a northwest-southeast diagonal between parcel MTM 105431-FB west of the corridor and MTM 105431-FE and MTM 105431-FA, east of the corridor. Stipulation CR 16-1 would be applied. The topography of the area tends to preclude visual impacts to the NPNHT from development activities on these parcels.

4.3.14.1.1 Mitigation

Specific mitigation measures, including but not limited to, possible site avoidance, excavation or data recovery would have to be determined when site-specific development proposals are received. A visual impact assessment would be conducted within parcels MTM 105431-FB and MTM 105431-FE. If a visual impact is suggested, stipulation CR 16-1 would be applied to reduce visual impacts. However, in most surface-disturbing situations cultural resources would be avoided by project redesign or relocation. Should an adverse impact be unavoidable, significant properties would be site-specifically mitigated prior to implementation of a project.

4.3.15 Livestock Grazing

4.3.15.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on livestock grazing. Any potential effects from the sale of leases would occur at the time the leases are developed.

Oil and gas development could result in a loss of vegetation for livestock grazing (e.g., direct removal, introduction of unpalatable plant species, etc.), decrease the palatability of vegetation due to fugitive dust, disrupt livestock management practices, involve vehicle collisions, and decrease grazing capacity. Direct losses of forage could also result from construction of roads, well pads and associated infrastructure and would vary depending on the extent of development. These impacts could vary from short-term impacts to long-term impacts depending on the type of exploration or development, the success of reclamation, and the type of vegetation removed for the oil and gas activities.

4.3.15.2 Mitigation

Measures would be taken to prevent, minimize, or mitigate impacts to livestock grazing from exploration and development activities. Prior to authorization, activities would be evaluated on a case-by-case basis, and the project would be subject to mitigation measures. Mitigation could potentially include controlling livestock movement by maintaining fence line integrity, fencing of facilities, re-vegetation of disturbed sites, and fugitive dust control. Depending on the degree of development, suspension of a portion of permitted livestock use may be necessary.

4.3.16 Recreation and Travel Management

4.3.16.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on recreation and travel management. Any potential effects from the sale of leases would occur at the time the leases are developed.

Recreation impacts may exist where oil and gas development and recreational user conflicts may occur. In areas where a high level of oil and gas development is likely, there may be user conflicts between motorized recreationists (OHV activities), hunting, target shooting, camping, fishing, river use, picnicking, and winter activities such as snowmobiling and the oil and gas/industrial activities. The intensity of these impacts is moderate and could exist in both the short-term (exploration and construction phases of oil and gas development) and in the long-term (producing wells, maintenance of facilities, etc.). Recreationists would lose some benefit outcomes such as loss of important sense of place, solitude and possible increase of stress.

Where there are other land use activities occurring, including oil and gas development, in areas frequented by recreationists, the public may perceive these areas as inaccessible or unavailable because of the facilities or recreationists may use lease roads to access areas for recreational activities. Potential public safety hazards/risks include: moving equipment, operator vehicles, transport vehicles for oil and gas, oil and gas wells, etc. However, this would be addressed in more detail at the development stage.

As oil and gas development occurs, new routes are created which often attract recreationists seeking additional or new areas to explore for motorized recreational opportunities. Motorized recreational opportunities could be enhanced through the additional opportunities to explore; however, user conflicts and public safety issues could result from the use of the new travel routes. The creation of routes from oil and gas activities could lead to a proliferation of user-created motorized routes, resulting in adverse impacts to the scenic qualities of the area and increased level of surface disturbance. These impacts would be isolated to BLM-administered public lands and could be minimized and avoided through mitigation and reclamation of industrial routes when no longer needed.

For those areas with isolated tracts of BLM public lands that generally do not have existing public access, recreation opportunities that occur in these areas are limited to use with adjacent land owner permission or hunting by an outfitter; therefore, oil and gas activities would have little or no impact on recreational experiences in this area.

Foreseeable changes in recreation use levels include demand for recreational use of public land to increase. Increases could be expected in, but not limited to: hunting, fishing, hiking, camping, wildlife viewing, and dispersed recreational uses. This could increase the incidence of conflict between recreationists involved in motorized activities and non-motorized activities.

The degree of these impacts can only be determined at the APD stage, due to the unknown location of potential development.

4.3.17 Lands and Realty

4.3.17.1 Direct and Indirect Effects

Leasing any of the proposed parcels for this lease sale would have no direct impacts on lands and realty. Any potential effects from the sale of these leases would occur at the time the leases are potentially developed. LN 14-1 will be applied to parcel MT 105431-F5 due to existing ROWs.

4.3.17.2 Mitigation

Measures would need to be taken to avoid disturbance to or impacting existing rights-of-way on federally administered surface in the event that the leased parcels are developed. Potential lease buyers are notified of existing ROWs and potential conflicts with development through the application of LN 14-1 (see Appendix A). Any new or "off-lease" rights-of-way required across federal surface for future exploration and/or development of the parcel would be subject to a separate review and be subject to stipulations to protect other resources as determined by environmental analysis which would be completed on a case-by-case basis.

4.3.18 Minerals

4.3.18.1 Fluid Minerals

4.3.18.1.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on fluid minerals. Any potential effects from the sale of leases would occur at the time the leases are developed.

Issuing a lease provides opportunities to explore for and develop oil and gas. Additional natural gas or crude oil produced from any or all of the two parcels would enter the public markets. The production of oil and gas results in the irreversible and irretrievable loss of these resources. Royalties and taxes would accrue to the federal and state treasuries from the lease parcel lands. There would be a reduction in the known amount of oil and gas resources.

Stipulations applied to various areas with respect to occupancy, timing limitation, and control of surface use could affect oil and gas exploration and development, both on and off the federal parcel. Leases issued with major constraints (NSO stipulations) may decrease some lease values, increase operating costs, and require relocation of well sites, and modification of field development. Leases issued with moderate constraints (timing limitation and controlled surface use (CSU) stipulations) may result in similar but reduced impacts, and delays in operations and uncertainty on the part of operators regarding restrictions.

Under Alternative B, lease parcel F6 would be offered for lease subject to major (NSO) constraints. Six parcels, FA, FB, FC, FD, FE, and FF, would be offered for lease with moderate (CSU) constraints. Three parcels, F3, F5 and F7 would be offered for lease with minor contraints (Timing Limits) and lease notices.

Fracking on BLM Montana Well Sites

Fracturing (known as "fracking" in the oil and gas industry) is a process that uses high pressure pumps to develop pressure at the bottom of a well to crack the hydrocarbon formation. This aids extraction of oil and gas deposits that might be left behind by conventional oil and gas drilling and pumping technology.

Hydraulic fracturing is a 60-year-old process that is now being used more commonly as a result of advanced technology.

Wells are often treated during completion to improve the recovery of hydrocarbons by increasing the rate and volume of hydrocarbons moving from the natural oil and gas reservoir into the wellbore. These processes are known as well-stimulation treatments, which create new fluid passageways in the producing formation or remove blockages within existing passageways. They include fracturing, acidizing, and other mechanical and chemical treatments often used in combination. The results from different treatments are additive and complement each other. This makes it possible to introduce fluids carrying sand, walnut hulls, or other small particles of material into the newly created crevices to keep the fractures open when the pressure is relieved. This process increases the flow rate and volume of reservoir fluids that move from the producing formation into the wellbore. The fracking fluid is typically more than 99 percent water and sand, with small amounts of readily available chemical additives used to control the chemical and mechanical properties of the water and sand mixture.

The State of Montana, Department of Natural Resource and Conservation, Oil and Gas Conservation Division, Board of Oil and Gas Conservation (MBOGC), regulations ensure that all resources including groundwater are protected. The MBOGC regulations require new and existing wells which will be stimulated by hydraulic fracturing must demonstrate suitable and safe mechanical configuration for the stimulation treatment proposed. If the operator proposes hydraulic fracturing through production casing or through intermediate casing, the casing must be tested to the maximum anticipated treating pressure. The MBOGC considers a casing pressure test to be considered successful if the pressure applied has been held for 30 minutes with no more than ten percent pressure loss. A pressure relief valve(s) must be installed on the treating lines between pumps and wellhead to limit the line and the well must be equipped with a remotely controlled shut-in device unless waived by the board administrator. Finally, the surface casing valve must remain open while hydraulic fracturing operations are in progress; the annular space between the fracturing string and the intermediate or production casing must be monitored and may be pressurized to a pressure not to exceed the pressure rating of the lowest rated component that would be exposed to pressure should the fracturing string fail.

To ensure that hydraulic fracturing is conducted in a safe and environmentally sound manner, the BLM approves and regulates all drilling and completion operations, and related surface disturbance on Federal public lands. Operators must submit Applications for Permit to Drill (APDs) to the agency. Prior to approving an APD, the BLM identifies all potential subsurface formations that will be penetrated by the wellbore. This includes all groundwater aquifers and any zones that would present potential safety or health risks that may need special protection measures during drilling, or that may require specific protective well construction measures.

Once the geologic analysis is completed, the BLM reviews the company's proposed casing and cementing programs to ensure the well construction design is adequate to protect the surface and subsurface environment, including the potential risks identified by the geologist and all known or anticipated zones with potential risks.

Before hydraulic fracturing takes place, all surface casing and some deeper, intermediate zones are required to be cemented from the bottom of the cased hole to the surface. The cemented well is pressure tested to ensure there are no leaks and a cement bond log is run to ensure the cement has bonded to the casing and the formation. If the fracturing of the well is considered to be a "non-routine" fracture for the area, the BLM will always be onsite during those operations as well as when abnormal conditions develop during the drilling or completion of a well.

4.3.19.2 Solid Minerals

4.3.19.2.1 Direct and Indirect Effects

Leasing the parcels would have no direct impacts on federal solid minerals. As described in Chapter 3, none of the parcels proposed to be leased for oil and gas in the analysis area conflict with currently active or existing claims, patents, permits or leases for all solid materials issued on federal lands within the analysis area.

4.3.20 Social and Economic Conditions

4.3.20.1 Social and Environmental Justice

Impacts Common to All Alternatives:

Impacts to the social environment of Yellowstone County from this BLM action would be associated with a change in the workforce/employment. Based upon the economics analysis, there would be very little impact to the social qualities, community infrastructure, and community services of Yellowstone County.

4.3.20.1.1 Direct and Indirect Effects

Alt A (No Action)

The No Action alternative would result in the continuation of the current land and resource uses and would cause no additional social impacts. There would be no disproportionate effects to low income or minority populations under this alternative.

Alternative B (Proposed Action)

While the act of leasing Federal minerals itself would result in no social impact, subsequent exploration and development may generate impacts to people living near or using the area in the vicinity of the lease. Exploration, drilling or production could create an inconvenience and affect the quality of life of the people living adjacent to leases due to increased traffic and traffic delays, and light, noise and visual impacts. This could be especially noticeable in rural areas where oil and gas development has not occurred previously. The amount of inconvenience and effect on quality of life would depend on the activity affected, traffic patterns within the area, noise and light levels, length of time and season these activities occur, etc. Until actual well development locations are identified it is difficult to ascertain whether there would be any impacts to property values. As discussed in the Economics section, residents of counties where the development actually occurs would benefit from the additional revenues to counties due to oil and gas leasing and development.

There would be no disproportionate effects to low income or minority populations. Consultation with potentially affected Tribes would occur at the APD stage.

4.20.1.1 Alternative A (No Action)

Economic effects are summarized and displayed in comparative form in Table 13. Under Alternative A none of the nominated parcels would be leased. Consequently, no federal, state, or local revenues would be generated from leasing, rents, or royalties associated with production. No employment or income would be generated if none of the parcels are leased.

Alternative B (Proposed Action)

4.3.20.2 Economics

4.3.20.2.1 Direct and Indirect Effects

Under Alternative B, 10 parcels in Yellowstone County would be made available for leasing at the October 2014 lease auction. The leasing of an additional 1,282 acres of BLM administered minerals in Yellowstone County is not anticipated to generate much additional public revenue, stimulate economic activity, or boost production associated with Federal minerals. It is estimated that the leasing of all minerals nominated for the October auction would generate about $2,500 in one-time bonus bids and $2,200 annually in rent revenue for the Federal government. Forty-nine percent of Federal revenue collected from public domain minerals and 25 percent of Federal revenue from acquired minerals (acquired under Bankhead Jones authority) are redistributed to the State. Montana then distributes 25 percent of public domain revenue and all of acquired mineral revenue back to the counties where the leases exist. Approximately 73 percent of federal leased by the BLM in Yellowstone County are public domain minerals. If these additional parcels were to be leased, an additional $1,000 would be paid to the State of Montana and Yellowstone County would receive an additional $400 to fund schools, roads, and the general government.

Once oil and gas extraction begins, annual rent payments on leased minerals stops and lessees begin to pay royalties equal to 12.5 percent of the value of production (43 CFR 3103.3.1). Although the leasing of these 10 parcels would result in a 60 percent increase in BLM leased minerals in Yellowstone County, the potential for development and production off these lease is very low. Even if production resulted in a 5% increase in oil and gas production on BLM minerals, royalties associated with future development are only estimated to generate an additional $41 annually in federal oil and gas royalties. Of this new federal revenue, an estimated $17 could be disbursed to the State and $6 is estimated to be redistributed back to the Yellowstone County.

The total economic impact of leasing activities proposed under Alternative B is equal to direct and indirect effects of drilling activities, as well as the direct and indirect effects of additional public revenue redistributed back to the five counties. As shown in Table 17, the bonus bids, rents, royalties, and drilling and support activities associated with leasing an additional 1,282 acres of federal minerals is estimated to support no additional jobs and approximately $50 in labor income (IMPLAN, 2012).

Disclosure of the direct, indirect, and cumulative effects of GHG emissions provides information on the potential economic effects of climate change including effects that could be termed the "social cost of carbon" (SCC). The EPA and other federal agencies developed a method for estimating the SCC and a range of estimated values (EPA 2014). The SCC estimates economic damages associated with climate change impacts to net agricultural productivity, human health, property damage, and ecosystems. Using a 3 percent average discount rate and year 2020 values, the incremental SCC is estimated to be $46 per metric ton of annual CO2e increase. Based on the GHG emission estimate provided in Section 4.3.3.1.2, the annual SCC associated with potential development on lease sale parcels is $749 (in 2011 dollars). Estimated SCC is not directly comparable to economic contributions reported above, which recognize certain economic contributions to the local area and governmental agencies but do not include all contributions to private entities at the regional and national scale. Direct comparison of SCC to the economic contributions reported above is also not appropriate because costs associated with climate change are borne by many different entities.

4.3.21 Cumulative Impacts

4.3.21.1 Cumulative Impacts to Economic Conditions Cumulative Effects for Alternative A (No Action)

The lack of measurable direct and indirect effects to economic conditions under the No Action Alternative translates to a lack of measurable cumulative effects. Under this alternative the BLM will not make any additional Federal minerals available for leasing and Federal minerals leased from the Billings Field Office will likely continue at existing levels. Current levels of BLM mineral leasing in Yellowstone County will continue to support jobs and income in the local economy and the economic contributions of oil and gas activities associated with these leases will continue to be similar to those discussed in Chapter 3.

Cumulative economic impacts associated with Federal mineral leasing under the alternatives are shown below in Table 17 and Table 18.

Table 17: Summary Comparison of Cumulative Annual Economic Impacts by Alternative

Activity	A	B
Existing Acres leased	2,155	2,155
Acres that would be leased based on this EA	0	1,282
Total acres leased	2,155	3,437
Acres held by production	1,764	1,764
Total acres leased for which lease rents would be paid	391	1,673
Total average annual Federal lease and rental revenue	$1,115	$3,616
Average annual distribution to State*	$474	$1,538
Average annual distribution to Counties**	$175	567
Average annual oil production (bbl)***	361	365
Average annual gas production (MCF)***	4	4
Total Average annual Federal O&G royalties	$4,090	$4,131
Average annual distribution to State*	$1,739	$1,757
Average annual distribution to Counties**	$642	$648
Total average annual Federal Revenues	$5,206	$7,747
Total average annual State Revenues	$2,213	$3,294
Total average annual revenue distributed to counties	$817	$1,216

*49 percent of Federal revenue from public domain minerals and 25 percent of Federal revenue from acquired minerals are distributed back to the State.
**Montana distributes 25 percent of public domain revenue and all of acquired mineral revenue received from the Federal Government back to the counties where revenue was generated.
***Estimated as BLM's share of Federal minerals production in Yellowstone County.

Table 18: Summary Comparison of Employment and Income Supported by BLM Minerals in Yellowstone County

Industry	Total Jobs Supported		Total Income Supported ($1000)	
	Alt. A	Alt. B	Alt. A	Alt. B
Total Contribution of BLM Minerals	30	30	$1,019,610	$1,019,660

IMPLAN, 2012

4.3.21.2 Cumulative Impacts- Alternative B

Cumulative impacts are those impacts resulting from the incremental impact of an action when added to other past, present, and reasonably foreseeable actions regardless of what agency or person undertakes such other actions. This section describes cumulative impacts associated with this project on resources. The ability to assess the potential cumulative impacts at the leasing stage for this project is limited for many resources due to the lack of site-specific information for potential future activities. Upon receipt of an APD for any of the lease parcels addressed in this document, more site-specific planning would be conducted in which the ability to assess contributions to cumulative impacts in a more detailed manner would be greater due to the availability of more refined site-specific information about proposed activities.

4.3.21.2.1 Past, Present and Reasonably Foreseeable Future Actions

In Yellowstone County, past, present, or reasonably foreseeable future actions that affect the same components of the environment as the Proposed Action are: grazing, dryland and irrigated farming, timber harvest, roads, wildfire and prescribed fire, historical mining, range improvement projects, utility right-of-ways and other items as presented in the Oil and Gas Amendment (1994) of the Billings RMP, as amended. These actions have contributed to habitat loss, habitat fragmentation, impaired water quality, increased erosion, and noxious weed infestations.

Future Actions:

The Bureau of Land Management is not aware of any currently pending applications or proposals for new or different land uses. Currently the Billings Field Office is in the process of writing a new resource management plan (RMP).

Currently there are no BLM proposals for future actions at this time for lands in Yellowstone County.

4.3.21.3 Cumulative Impacts by Resource

Cumulative effects for all resources in the Billings Field Office are described in the 1992 Oil and Gas Amendment of the Billings, Powder River and South Dakota Resource Management Plans and Final Environmental Impact Statement and the 1994 Record of Decision and the 2008 Final Supplement to the Montana Statewide Oil and Gas Environmental Impact with a development alternative for coal bed natural gas production. Anticipated exploration and development activities associated with the lease parcels considered in this EA are within the range of assumptions used and effects described in this cumulative effects analysis for resources other than air, climate, and socio-economics resources. This previous analysis is hereby incorporated by reference for resources other than for air, climate, and socio-economics resources.

4.3.21.3.1 Greenhouse Gas Emissions and Cumulative Impacts on Climate Change

The cumulative effects analysis area is the Billings Field Office, with additional discussion at state-wide, national, and global scales for GHG emissions and climate change.

This section incorporates an analysis of the contributions of the Proposed Action to GHG emissions, followed by a general discussion of potential impacts to climate change. Potential emissions relate to those derived from potential exploration and development of fluid minerals.

Additional emissions beyond the control of the BLM, and outside the scope of this analysis, would also occur during any needed refining processes, as well as end uses of final products.

Projected GHG emissions for this project and the Billings Field Office RFD are compared below with recent, available inventory data at the state, national, and global scales. GHG emissions inventories can vary greatly in their scope and comprehensiveness. State, national, and global inventories are not necessarily consistent in their methods or in the variety of GHG sources that are inventoried (Climate Change SIR 2010). However, comparisons of emissions projected by the BLM for its oil and gas production activities are made with those from inventories at other scales for the sake of providing context for the potential contributions of GHGs associated with this project.

As discussed in the Air Quality section of Chapter 4, total projected BLM GHG emissions from the RFD are 9,673 metric tons/year CO_2e. Potential emissions under Alternative B would be approximately 0.23 percent of this total. Table 19 displays projected GHG emissions from non-BLM activities included in the Billings Field Office RFD. Total projected emissions of non-BLM activities in the RFD are 13,064 metric tons/year of CO_2e. When combined with projected annual BLM emissions, this totals 22,105 metric tons/year CO_2e. Potential GHG emissions under Alternative B would be 0.01 percent of the estimated emissions for the entire RFD. Potential incremental emissions of GHGs from exploration and development of fluid minerals on parcels within Alternative B, would be minor in the context of projected GHG contributions from the entire RFD for the Billings Field Office.

Table 19: Projected non-BLM GHG Emissions Associated with the Billings Field Office Reasonably Foreseeable Development Scenario for Fluid Mineral Exploration and Development.

Source	Non-BLM Projected Greenhouse Gas Emissions in tons/year for Billings Field Office RFD			Emissions (metric tons/yr)
	CO_2	CH_4	N_2O	CO_2e
Conventional Natural Gas	3,947	45	0.01	4,446
Coal Bed Natural Gas (none forecasted in RFD)	0	0	0	0
Oil	8,353	54	0.04	8,619
Total	**12,300**	**99**	**0.06**	**13,064**

Montana's Contribution to U.S. and Global Greenhouse Gases (GHGs)

Montana's GHG inventory (http://www.eia.doe.gov/oiaf/1605/archive/gg04rpt/emission.html, CCS 2007) shows that activities within the state contribute 0.6 percent of U.S and 0.076 percent of global GHG emissions (based on 2004 global GHG emission data from the IPCC, summarized in the Climate Change SIR 2010). Based on 2005 data in the state-wide inventory, the most pronounced source of Montana's emissions is combustion of fossil fuels to generate electricity, which accounts for about 27 percent of Montana's emissions. The next largest contributors are the agriculture and transportation sectors (each at approximately 22 percent) and fossil fuel production (13.6 percent).

GHG emissions from all major sectors in Montana in 2005 added up to a total of approximately 37 million metric tons of CO_2e (CCS 2007). Potential emissions from development of lease parcels in Alternative B of this project represent approximately 4×10^{-5} percent of the state-wide total of GHG emissions based on the 2005 state-wide inventory (CCS 2007).

The EPA published an inventory of U.S. GHG emissions, indicating gross U.S. emissions of 6,702 million metric tons, and net emissions of 5,797 million metric tons (when CO_2 sinks were considered) of CO_2e in 2011 (EPA 2013c). Potential annual emissions under Alternative B of this project would amount to approximately 2.4×10^{-7} percent of gross U.S. total emissions. Global GHG emissions for 2004 (IPCC 2007) indicated approximately 49 gigatonnes (10^9 metric tons) of CO_2e emitted. Potential annual emissions under Alternative B would amount to approximately 3.3×10^{-8} percent of this global total.

As indicated above, although the effects of GHG emissions in the global aggregate are well-documented, it is currently not credibly possible to determine what specific effect GHG emissions resulting from a particular activity might have on climate or the environment. If exploration and development occur on the lease parcels considered under Alternative B, potential GHG emissions described above would incrementally contribute to the total volume of GHGs emitted to the atmosphere, and ultimately to climate change.

Mitigation measures identified in the Chapter 4 Air Quality section above may be in place at the APD stage to reduce GHG emissions from potential oil and gas development on lease parcels under Alternative B. This is likely because many operators working in Montana are currently USEPA Natural Gas STAR Program Partners and future regulations may require GHG emission controls for a variety of industries, including the oil and gas industry (Climate Change SIR 2010).

4.3.21.3.2 Cumulative Impacts of Climate Change

As previously discussed in the Air Quality section of Chapter 4, it is difficult to impossible to identify specific impacts of climate change on specific resources within the analysis area. As summarized in the Climate Change SIR (2010), climate change impacts can be predicted with much more certainty over global or continental scales. Existing models have difficulty reliably simulating and attributing observed temperature changes at small scales. On smaller scales, natural climate variability is relatively larger, making it harder to distinguish changes expected due to external forcings (such as contributions from local activities to GHGs). Uncertainties in local forcings and feedbacks also make it difficult to estimate the contribution of GHG increases to observed small-scale temperature changes (Climate Change SIR 2010). Effects of climate change on resources are described in Chapter 3 of this EA and in the Climate Change SIR (2010).

4.3.21.3.4 Cumulative Impacts to Wildlife

Cumulative impacts are those impacts on the environment which result "from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions." (40 CFR 1508.7). In this case, past and presently on-going actions and activities in the project vicinity include oil and gas development, fire, farming, livestock grazing, traffic, and any other forms of human and natural disturbances.

Construction of roads, production well pads, and other facilities would result in long term (>5 years) loss of habitat and forage in the analysis area. This would be in addition to acres disturbed, or habitats fragmented from various other adjacent activities. As new development occurs, direct and indirect impacts would continue to stress wildlife populations, most likely displacing the larger, mobile animals into adjacent habitat, and increasing competition with existing local populations. Non-mobile animals would be affected by increased habitat fragmentation and interruptions to preferred nesting habitats.

Certain species are localized to some areas and rely on very key habitats during critical times of the year. Disturbance or human activities that would occur in winter range for big game, nesting and brood-rearing habitat for grouse and raptors could displace some or all of the species using a particular area or disrupt the normal life cycles of species. Wildlife and habitat in and around the project would be influenced to different degrees by various human activities. Some species and/or a few individuals from a species group may be able to adapt to these human influences over time.

Conservation Reserve Program (CRP) acreage trends have been reversed since 2007, when enrollment acreage began to decline. This reversal in enrollment trends would have a long-term direct negative impact on species dependent on intact vegetation cover. Source: http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=rns-css

In 2008, the State of Montana designated core sage-grouse habitat areas. These areas were designated to target conservation management practices. Core area 11 is located in Carbon County (Greater Sage-grouse Habitat Conservation Strategy, May, 2009). Core area 11 consists of approximately 284,431 acres, of which 106,503 acres are located on BLM. Currently, there has been limited work in this core area to improve conservation practices. In 2010, the Natural Resource Conservation Service (NRCS) began working with grazing operators to improve grazing management in core area 4 in Musselshell and Golden Valley Counties under the Sage-Grouse Initiative. BLM recently approved applications to construct fences in accordance with ongoing projects with the Sage-Grouse Initiative. As a result of this initiative grazing management would be improved on over 100,000 acres in core area 4.

With the addition of various forms of stipulations, mitigation, and terms and conditions applied during the development stage, the assessed resources of concern are not expected to approach conditions where additional stresses associated with the proposed action and, past, present and future foreseeable actions would have consequential cumulative effects.

As described in the section on impacts to wildlife, given the current RFD, impacts to wildlife species would be negligible or minimal at most. If significantly higher levels of development occur, further NEPA analysis would be required to determine impacts to wildlife resources. Additionally, analysis during the APD phase of development would identify specific impacts that cannot be identified or quantified at this time.

4.3.21.3.5 Cumulative Impacts to Cultural and Native American Religious Concerns
No significant impacts to the cultural resources or Native American Religious Concerns on Federal lands are likely to occur as a result of oil and gas leasing and development under any of the alternatives. For a more detailed discussion on cumulative impacts to cultural resources and Native American Religious Concerns, see Miles City District Final Oil and Gas RMP/EIS Amendment (1992) page 73.

4.3.21.3.6 Cumulative Impacts to Paleontological Resources
Since NSO stipulations for paleontological resources would be applied under all alternatives and paleontological inventories would be required in PFYC 3 or higher areas under all alternatives, there are no significant impacts to paleontological resources. For a more detailed discussion on cumulative impacts to paleontological resources, see Miles City District Final Oil and Gas RMP/EIS Amendment (1992) page 73.

4.3.21.3.7 Cumulative Impacts to Economic Conditions Cumulative Effects for Alternative B (Proposed Action)
The cumulative effects of Alternative B are summarized in Table 17 and Table 18. The leasing of an additional 1,282 acres of Federal minerals by the Billings Field Office would result in a total of 3,437 acres of BLM leased minerals in Yellowstone County. The leasing of these minerals by the BLM would generate about $3,600 in Federal revenue. The redistribution of Federal revenue associated with leasing of these Federal minerals is estimated to generate nearly $1,500 in State revenue for Montana and approximately$500 in local public revenue in Yellowstone County. Federal oil and gas production associated with BLM minerals in Yellowstone may increase slightly, anticipated Federal royalty revenue from production on these minerals is estimated to be approximately $4,100 annually. The redistribution of Federal royalty payments resulting from extraction of BLM minerals in Yellowstone County would provide the State of Montana with $1,700 in public revenue with Yellowstone County receiving roughly $650 from production on BLM minerals within county lines.

Oil and gas related activities associated with Federal minerals leased from the Billings Field Office generates public revenue, stimulates economic activity in the public and private sectors, and can be attributed with supporting employment and income opportunities throughout the local rural economy. Total Federal revenue associated with the leasing and production of BLM administered minerals in Yellowstone County under Alternative B is estimated to exceed $7,700. The redistribution of Federal revenue from these minerals is anticipated to generate nearly $3,300 in State revenue for Montana, and approximately $1,200 will likely be returned to Yellowstone County to fund law enforcement and fire departments, roads and highway maintenance, public education, local clinics/hospitals and county libraries. Public services and infrastructure investments by the State and local municipalities with redistributed Federal dollars supports employment and income in the public sector and in industries providing goods and services to the public sector. The drilling, servicing, and production resulting from BLM leasing of Federal minerals in Yellowstone also stimulates economic activity in the private sector, directly and indirectly supporting local employment and income in nearly every part of the economy. While production is anticipated to increase slightly over the life of these new leases, increased produced will continue to support 30 local jobs and $1 million in local wages and proprietor's income.

The annual SCC associated with oil and gas development within Yellowstone County is $2,072 (in 2011 dollars) based on 3,437 cumulative acres. As noted earlier, the estimated SCC is not directly comparable to economic contributions.

5.0 CONSULTATION AND COORDINATION

5.1 Persons, Agencies, and Organizations Consulted

Coordination with MT FWP and USFWS was conducted for the two lease parcels being reviewed. BLM has coordinated with MT FWP and USFWS in the completion of this EA in order to prepare analysis, identify protective measures, and apply stipulations associated with these parcels being analyzed.

The BLM consults with the State Historic Preservation Office (SHPO) and Native Americans under Section 106 of the National Historic Preservation Act. BLM sent letters to the SHPO, Tribal Chairman/Presidents, and Tribal Historic Perservation Officer (THPO) or other cultural contacts for the Crow Tribe and Northern Cheyenne Tribe in Montana at the beginning of the 15 day scoping period informing them of the potential for the two parcels to be available for lease and inviting them to submit issues and concerns BLM should consider in the environmental analysis. BLM will send a second letter to the SHPO and tribes informing them about the 30 day public comment period for the EA and soliciting any information BLM should consider before making a decision whether to offer any or all of the two parcels for sale. The BLM also sent letters to USDA Forest Service, Nez Perce Trail Foundation, and Nez Perce Tribal representatives in order to identify issues that may arise from the proposed action with regard to the Nez Perce National Historic Trail.

Table 20 lists persons, agencies, and organizations that were consulted during development of this EA along with the findings and conclusions associated with consultations.

Table 20: List of all Persons, Agencies and Organizations Consulted for Purposes of this EA

Name	Purpose & Authorities for Consultation or Coordination	Findings & Conclusions
Montana Fish, Wildlife, and Parks (MT FWP), Region 5	I.M. #MT-2008-008, 2/26/2007; MT FWP and BLM Guidance on Coordination During Oil and Gas Lease Parcel Reviews	Consulted with MT FWP, submitted a list of conditions recommended to protect and conserve sensitive wildlife habitats in and around the leasing parcels.
USFWS	Coordination letter I.M. # MT-2009-039, 2009 Montana/Dakotas special Status Species List.	Consulted with USFWS, no comments were received.
Montana State Historic Preservation Office	Repository for cultural inventory reports and cultural site forms for the State of Montana	Consulted the State Historic Preservation Office CRIS and CRABS databases for information on cultural inventories and cultural sites within the proposed lease sale

		parcels.
Nez Perce Tribal Executive Committee	Section 106 of the National Historic Preservation Act	Expressed interest in being notified/involved with any activity located within proximity to Nez Perce National Historic Trail during 2013 Oil & Gas EA discussions.
Confederated Tribes of the Umatilla Reservation	Section 106 of the National Historic Preservation Act	Comments/response was not received.
Confederated Tribes of the Colville Indian Reservation	Section 106 of the National Historic Preservation Act	Comments/response was not received.
Crow Tribe	Section 106 of the National Historic Preservation Act	Comments/response was not received.
Northern Cheyenne Tribe	Section 106 of the National Historic Preservation Act	Comments/response was not received.

5.2 Summary of Scoping

Public scoping for this project was conducted through a 15-day scoping period advertised on the BLM Montana State Office website and posting on the field office website NEPA notification log. Scoping was initiated March 25, 2013 through April 09, 2013. Surface owner notification letters were also distributed briefly explaining the oil and gas leasing process and planning process. The surface owner notification letter requested written comments regarding any issues or concerns that should be addressed in the environmental analysis.

A total of 27 surface owner notification letters were distributed for the oil and gas leasing analysis process in the Billings Field Office, six of which were for parcels being deferred. The BLM received approximately 40 comment letters/emails and numerous phone calls with regard to split estate development potential and issues.

5.3 List of Preparers

Table 21: List of Preparers

Name	Title	Responsible for the Following Section(s) of this Document
Craig Drake	Assistant Field Manager	Overall review
Susan Bassett	Air Resource Specialist	Air Resources
Sheila Cain	GIS Specialist	GIS
Tom Carroll	Realty Specialist	Lands & Realty (ROWs)
Dustin Crowe	Rangeland Management Specialist	Livestock Grazing, Vegetation, Soils

Jennifer Dobb (FS)	Planning &Environmental Specialist	Economic Analysis
Tim Finger	Outdoor Recreation Planner	Recreation, VRM, Wilderness, Travel Management
Jennifer Macy	Archeologist	Archeology, Paleontology, Special Designations
Jessica Montag	Sociologist	Social Conditions
Ernie McKenzie	Wildlife Biologist	EA Lead, Water, Riparian, Fisheries, Wildlife
Larry Padden	Natural Resource Specialist	Invasive Plant Species and Noxious Weeds

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7.0 DEFINITIONS

The North American Industry Classification System (NAICS) is the standard used by federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS was developed under the auspices of the Office of Management and Budget (OMB), and adopted in 1997 to replace the Standard Industrial Classification (SIC) system and to allow for a high level of comparability in business statistics among the North American countries.

IMPLAN: The IMPLAN Model is the most flexible, detailed and widely used input-output impact model system in the U.S. It provides users with the ability to define industries, economic relationships and projects to be analyzed. It can be customized for any county, region or state, and used to assess "multiplier effects" caused by increasing or decreasing spending in various parts of the economy. This can be used to assess the economic impacts of resource management decisions, facilities, industries, or changes in their level of activity in a given area. The current IMPLAN input-output database and model is maintained and sold by MIG, Inc. (Minnesota IMPLAN Group). The 2010 data set was used in this analysis.

Traditional Cultural Property (TCP) is a property that derives significance from traditional values associated with it by a social or cultural group, such as an Indian tribe or local community. A traditional cultural property may qualify for the National Register of Historic Places if it meets the criteria and criteria exceptions at 36 CFR 60.4. See National Register Bulletin 38.

Appendix A- Lease Parcels and Lease Stipulations
Preliminary Parcel Worksheet
Table A-1

PARCEL NUMBER	PARCEL DESCRIPTION	PROPOSED STIPULATIONS FOR ENTIRE PARCEL IF LEASED	PROPOSED FOR DEFERRAL- NO LEASING
MTM 105431-FA	T. 1 N, R. 23 E, PMM, MT SEC. 24 NE; YELLOWSTONE COUNTY 160.00 AC PD	**CR 16-1** (ALL LANDS) **TES 16-2** (ALL LANDS) **LN 14-2** (ALL LANDS) **CSU 12-1** (ALL LANDS) **CSU 12-4** (ALL LANDS) **LN 14-12** (ALL LANDS)	
MTM 105431-FB	T. 1 N, R. 23 E, PMM, MT SEC. 28 SWSW; YELLOWSTONE COUNTY 40.00 AC PD	**CR 16-1** (ALL LANDS) **TES 16-2** (ALL LANDS) **LN 14-2** (ALL LANDS) **CSU 12-1** (ALL LANDS) **TL 13-1** (ALL LANDS) **CSU 12-4** (ALL LANDS) **LN 14-12** (ALL LANDS)	
MTM 105431-FC	T. 1 N, R. 24 E, PMM, MT SEC. 4 LOTS 1-4; SEC. 8 SE; YELLOWSTONE COUNTY 322.44 AC PD	**CR 16-1** (ALL LANDS) **TES 16-2** (ALL LANDS) **LN 14-2** (ALL LANDS) **CSU 12-1** SEC 8 NWSE, SWSE; **TL 13-1** SEC 8 SE; **LN 14-12** (ALL LANDS)	
MTM 105431-FD	T. 1 N, R. 24 E, PMM, MT SEC. 14 SWSE; YELLOWSTONE COUNTY 40.00 AC PD	**CR 16-1** (ALL LANDS) **TES 16-2** (ALL LANDS) **LN 14-2** (ALL LANDS) **CSU 12-1** (ALL LANDS) **TL 13-1** (ALL LANDS) **LN 14-12** (ALL LANDS)	
MTM 105431-FE	T. 1 N, R. 24 E, PMM, MT SEC. 32 E2SE; YELLOWSTONE COUNTY 80.00 AC PD	**CR 16-1** (ALL LANDS) **TES 16-2** (ALL LANDS) **LN 14-2** (ALL LANDS) **CSU 12-1** (ALL LANDS) **TL 13-1** (ALL LANDS) **LN 14-12** (ALL LANDS)	
MTM 105431-FF	T. 2 N, R. 24 E, PMM, MTSEC. 24 NWSW;YELLOWSTONE COUNTY40.00 ACPD	**CR 16-1** (ALL LANDS) **TES 16-2** (ALL LANDS) **LN 14-2** (ALL LANDS) **TL 13-3** (ALL LANDS) **CSU 12-4** (ALL LANDS) **LN 14-12** (ALL LANDS) **LN 14-11** (ALL LANDS)	

MTM 105431-E9	T. 2 N, R. 25 E, PMM, MT SEC. 28 NENW; YELLOWSTONE COUNTY 40.00 AC PD	**CR 16-1** (ALL LANDS) **TES 16-2** (ALL LANDS) **LN 14-2** (ALL LANDS) **NSO 11-4** (ALL LANDS) **TL 13-1** (ALL LANDS) **TL 13-3** (ALL LANDS) **LN 14-12** (ALL LANDS) **LN 14-11** (ALL LANDS)	**(ALL LANDS)** Entire parcel is within 0.6 miles of a greater sage-grouse lek. The Billings Draft RMP Revision identifies this with a major stipulation, NSO. Deferred until Billings Field Office completes resource management plan revision.
MTM 105431-F3	T. 2 N, R. 26 E, PMM, MT SEC. 3 S2; YELLOWSTONE COUNTY 320.00 AC **50% U.S. MINERAL INTEREST 2/** ACQ	**CR 16-1** (ALL LANDS) **TES 16-2** (ALL LANDS) **LN 14-2** (ALL LANDS) **TL 13-1** SEC 3 SWSE, SESE, NESE; **TL 13-3** SEC 3 SW; **LN 14-12** (ALL LANDS) **LN 14-11** (ALL LANDS)	
MTM 105431-F4	T. 2 N, R. 26 E, PMM, MTSEC. 8 NE, SW;YELLOWSTONE COUNTY320.00 ACACQ	**CR 16-1** (ALL LANDS) **TES 16-2** (ALL LANDS) **LN 14-2** (ALL LANDS) **NSO 11-4** (ALL LANDS) **TL 13-3** (ALL LANDS) **NSO 11-2** SEC 8 SWSW **LN 14-12** (ALL LANDS) **LN 14-11** (ALL LANDS)	SEC. 8 SW, S2NE These portions of this parcel are within 0.6 miles of a greater sage-grouse lek. SEC. 8 (ALL LANDS) This entire parcel falls within 1/2 mile of a sharptail grouse lek.The Billings Draft RMP Revision identifies this with a major stipulation, NSO. Deferred until Billings Field Office completes resource management plan revision.
MTM 105431-F5	T. 2 N, R. 26 E, PMM, MT SEC. 10 NE; YELLOWSTONE COUNTY 160.00 AC ACQ	**CR 16-1** (ALL LANDS) **TES 16-2** (ALL LANDS) **LN 14-2** (ALL LANDS) **TL 13-1** (ALL LANDS) **TL 13-3** SEC 10 W2NE; **LN 14-1** (ALL LANDS) **LN 14-12** (ALL LANDS) **LN 14-11** (ALL LANDS)	

MTM 105431-F6	T. 2 N, R. 26 E, PMM, MT SEC. 14 N2NE; YELLOWSTONE COUNTY 80.00 AC PD	**CR 16-1** (ALL LANDS) **TES 16-2** (ALL LANDS) **LN 14-2** (ALL LANDS) **NSO 11-2** (ALL LANDS) **LN 14-12** (ALL LANDS) **LN 14-11** (ALL LANDS)	
MTM 105431-F7	T. 2 N, R. 26 E, PMM, MT SEC. 22 SWSW; YELLOWSTONE COUNTY 40.00 AC PD	**LN 14-12** (ALL LANDS) **LN 14-11** (ALL LANDS)	
MTM 105431-HW	T. 5 S, R. 16 E, PMM, MTSEC. 13 NWNE;STILLWATER COUNTY40.00 ACPD	**CR 16-1** (ALL LANDS) **TES 16-2** (ALL LANDS) **LN 14-2** (ALL LANDS) **NSO 11-2** (ALL LANDS) **TL 13-1** (ALL LANDS) **LN 14-12** (ALL LANDS)	**ALL LANDS**(Yellowstone Cutthroat trout Suitable Recovery Habitat, Source Water Protection Area, and Unincorporated town within lease parcel. Deferred until Billings Field Office completes resource management plan revision.)

Billings Field Office
October 22, 2013 OG Sale

Table A-2 -Billings Field Office Oil and Gas Leasing Stipulations:

Stipulation Number	Stipulation Name/Brief Description
Bureau of Land Management	
CSU 12-1	**CONTROLLED SURFACE USE STIPULATION** Prior to surface disturbance on slopes over 30 percent, an engineering/reclamation plan must be approved by the authorized officer.
CSU 12-4	**CONTROLLED SURFACE USE STIPULATION** Prior to surface disturbance, a surface use plan of operations (SUPO) for oil and gas activities must be approved for black-footed ferret reintroduction areas by the authorized officer in consultation with the U.S. Fish and Wildlife Service (USFWS).
Cultural 16-1	**CULTURAL RESOURCES LEASE STIPULATION** This lease may be found to contain historic properties and/or resources protected under the National Historic Preservation Act (NHPA), American Indian Religious Freedom Act, Native American Graves Protection and Repatriation Act, E.O. 13007, or other statutes and executive orders. The BLM will not approve any ground disturbing activities that may affect any such properties or resources until it completes its obligations under applicable requirements of the NHPA and other authorities. The BLM may require modification to exploration or development proposals to protect such properties, or disapprove any activity that is likely to result in adverse effects that cannot be successfully avoided, minimized or mitigated.
LN 14-1	**LEASE NOTICE** Land Use Authorizations incorporate specific surface land uses allowed on Bureau of Land Management (BLM) administered lands by authorized officers and those surface uses acquired by BLM on lands administered by other entities. These BLM authorizations include rights-of-way, leases, permits, conservation easements, and Recreation and Public Purpose leases and patents.
LN 14-2	**LEASE NOTICE CULTURAL RESOURCES** The Surface Management Agency is responsible for assuring that the leased Lands are examined to determine if cultural resources are present and to specify mitigation measures.
LN 14-11	**LEASE NOTICE GREATER SAGE-GROUSE HABITAT** The lease may, in part or in total, contain important greater sage grouse habitats as identified by the BLM, either currently or prospectively. The operator may be required to implement specific measures to reduce impacts of oil and gas operations on the greater sage grouse populations and habitat quality. Such measures shall be developed during the application for permit to drill on-site and environmental review process and will be consistent with the lease rights granted.
LN 14-12	**LEASE NOTICE PALEONTOLOGICAL RESOURCE INVENTORY REQUIREMENT** This lease has been identified as being located within geologic units rated as being moderate to very high potential for containing significant paleontological resources. The locations meet the criteria for class 3, 4 and/or 5 as set forth in the Potential Fossil Yield Classification System, WO IM 2008-009, Attachment 2-2. The BLM is responsible for assuring that the

Stipulation Number	Stipulation Name/Brief Description
	leased lands are examined to determine if paleontological resources are present and to specify mitigation measures. Guidance for application of this requirement can be found in WO IM 2008-009 dated October 15, 2007, and WO IM 2009-011 dated October 10, 2008. Prior to undertaking any surface-disturbing activities on the lands covered by this lease, the lessee or project proponent shall contact the BLM to determine if a paleontological resource inventory is required. If an inventory is required, the lessee or project proponent will complete the inventory subject to the following: • the project proponent must engage the services of a qualified paleontologist, acceptable to the BLM, to conduct the inventory. •the project proponent will, at a minimum, inventory a 10-acre area or larger to incorporate possible project relocation which may result from environmental or other resource considerations. •paleontological inventory may identify resources that may require mitigation to the satisfaction of the BLM as directed by WO IM 2009-011.
NSO 11-2	**NO SURFACE OCCUPANCY STIPULATION** Surface occupancy and use is prohibited within riparian areas, 100-year flood plains of major rivers, and on water bodies and streams.
NSO 11-4	**NO SURFACE OCCUPANCY STIPULATION** Surface occupancy and use is prohibited within one-quarter mile of grouse leks.
TES 16-2	**ENDANGERED SPECIES ACT SECTION 7 CONSULTATION STIPULATION** The lease area may now or hereafter contain plants, animals, or their habitats determined to be threatened, endangered, or other special status species. BLM may recommend modifications to exploration and development, and require modifications to or disapprove proposed activity that is likely to result in jeopardy to proposed or listed threatened or endangered species or designated or proposed critical habitat.
TL 13-1	**TIMING LIMITATION STIPULATION** Surface use is prohibited within crucial winter range for wildlife for the time period December 1 to March 31 to protect crucial White-Tailed Deer, Mule Deer, Elk, Antelope, Moose, Bighorn Sheep, and Sage-Grouse winter range from disturbance during the winter use season, and to facilitate long-term maintenance of wildlife populations.
TL 13-3	**TIMING LIMITATION STIPULATION** No surface use is allowed in grouse nesting habitat within two miles of a lek between March 1 and June 15.

Appendix B - RFD Scenario Forecast for Area of Analysis

The reasonably foreseeable development (RFD) scenario is based on information contained in the February 2010 Billings Field Office RFD; it is an unpublished report that is available by contacting the Billings Field Office. The RFD contains projections of the number of possible oil and gas wells that could be drilled and produced in the Billings Field Office area and used to analyze projected wells for the ten nominated lease parcels. The ten lease parcels are identified within moderate and low potential development areas. These well numbers are only an estimate based on historical drilling and mineral resources present, and may change in the future if new technology is developed or new fields and formations are discovered. For the RFD scenario, the ten lease parcels have been analyzed under the Bull Mountain Basin (low potential) and Lake Basin (moderate potential) development zones (Map 3).

All 10 lease parcels are in Yellowstone County and are located in a zone of low to moderate development potential. The RFD scenario for moderate potential zones forecasts up to 20 wells per year with one to four federal wells per year. Assumed disturbance factors are two acres per drill site and 1.5 acres for ancillary facilities and access roads. The parcels total 1,282.44 acres, approximately 1.3 percent of the four townships they are located within.

The potential number of acres disturbed by exploration and development activities is shown in Table B-3. The potential acres of disturbance reflect acres typically disturbed by construction, drilling, and production activities, including infrastructure installation throughout the Billings Field Office. Typical exploration and development activities and associated acres of disturbance were used as assumptions for analysis purposes in this EA. The assumptions were not applied to Alternative A because the lease parcel would not be recommended for lease; therefore, no wells would be drilled or produced on the lease parcel and no surface disturbance would occur on those lands from exploration and development activities.

The expected Billings Field Office total wells drilled per year equals 20 per year with three to four federal wells per year over a 20-year span. These wells could be in one of the three areas identified in table 18. The RFD scenario classified moderate potential lands as having the potential for one to five wells drilled per township per year. Low potential lands have the potential for less than one well per year per township.

Table B-1. RFD Projected Forecast Drilling Depths, and Forecast Surface Disturbance by Basin

Location	Common Drilling Depth in Feet	Likely Product	Size of Drill Site in Acres	Access and Ancillary Facilities in Acres
Central Montana Uplift and Bull Mountain Basin	5,000	Oil with associated gas; CBNG*	2	1.5
Big Horn Basin	7,000	Oil with associated gas; Gas; CBNG*	3	1.5

Crazy Mountain Basin	8,000 – 10,000	Gas	4	1.5

*Currently there is no CBNG production within the Billings Field Office (RFD, February 2010 p-17)

The RFD scenario identified these areas and contains more information about them (Map 2). Total annual disturbance for federal wells is approximately 13.5 acres to 27 acres of short-term disturbance (several years) and 5.5 to 15.5 acres of long-term disturbance for federal wells drilled in the Billings Field Office.

Figure 5: Map 1 - Yellowstone County Lease Parcels October 2014

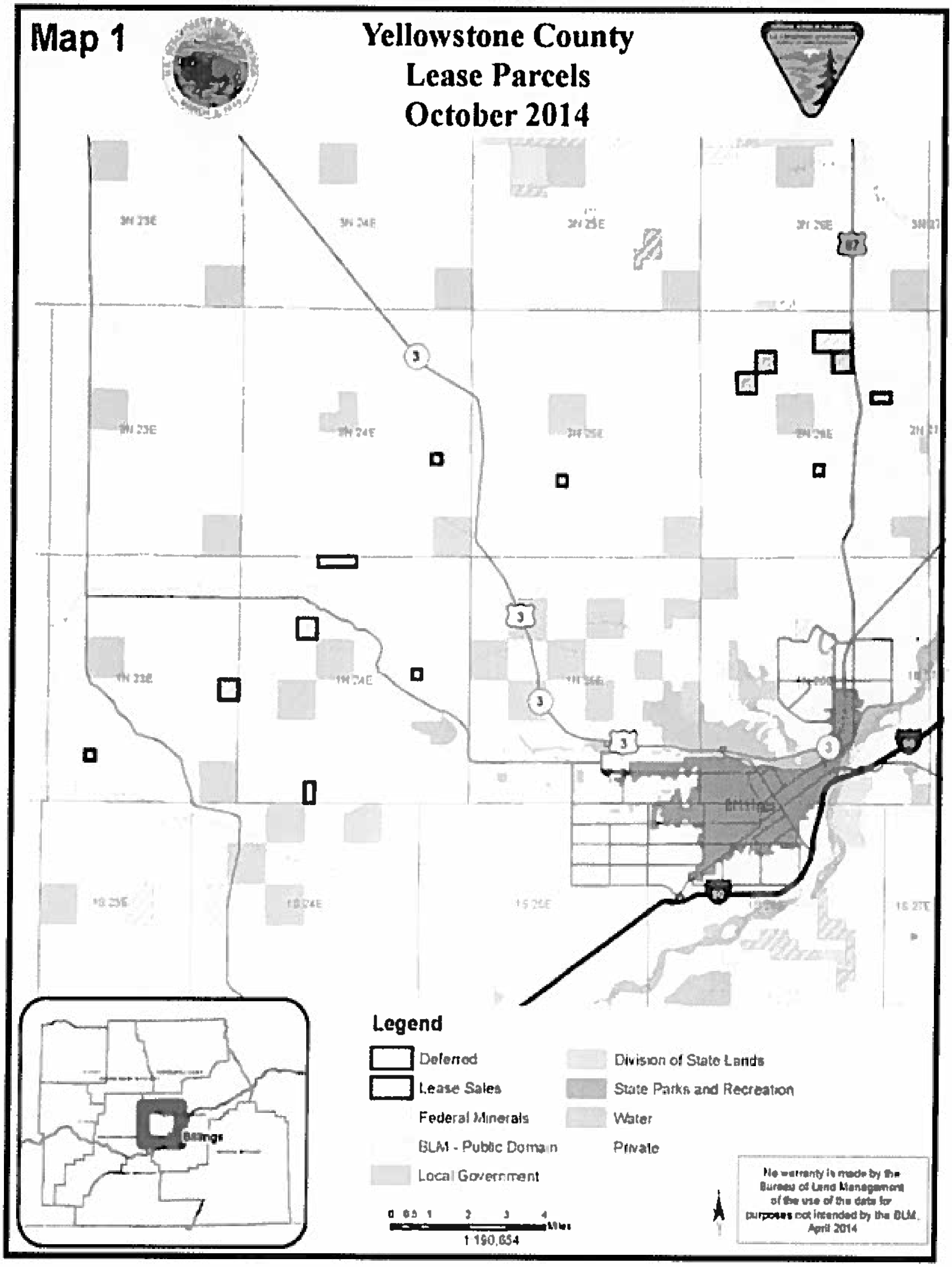


Figure 6: Map 2 - Stillwater County Lease Parcel HW, October 2014

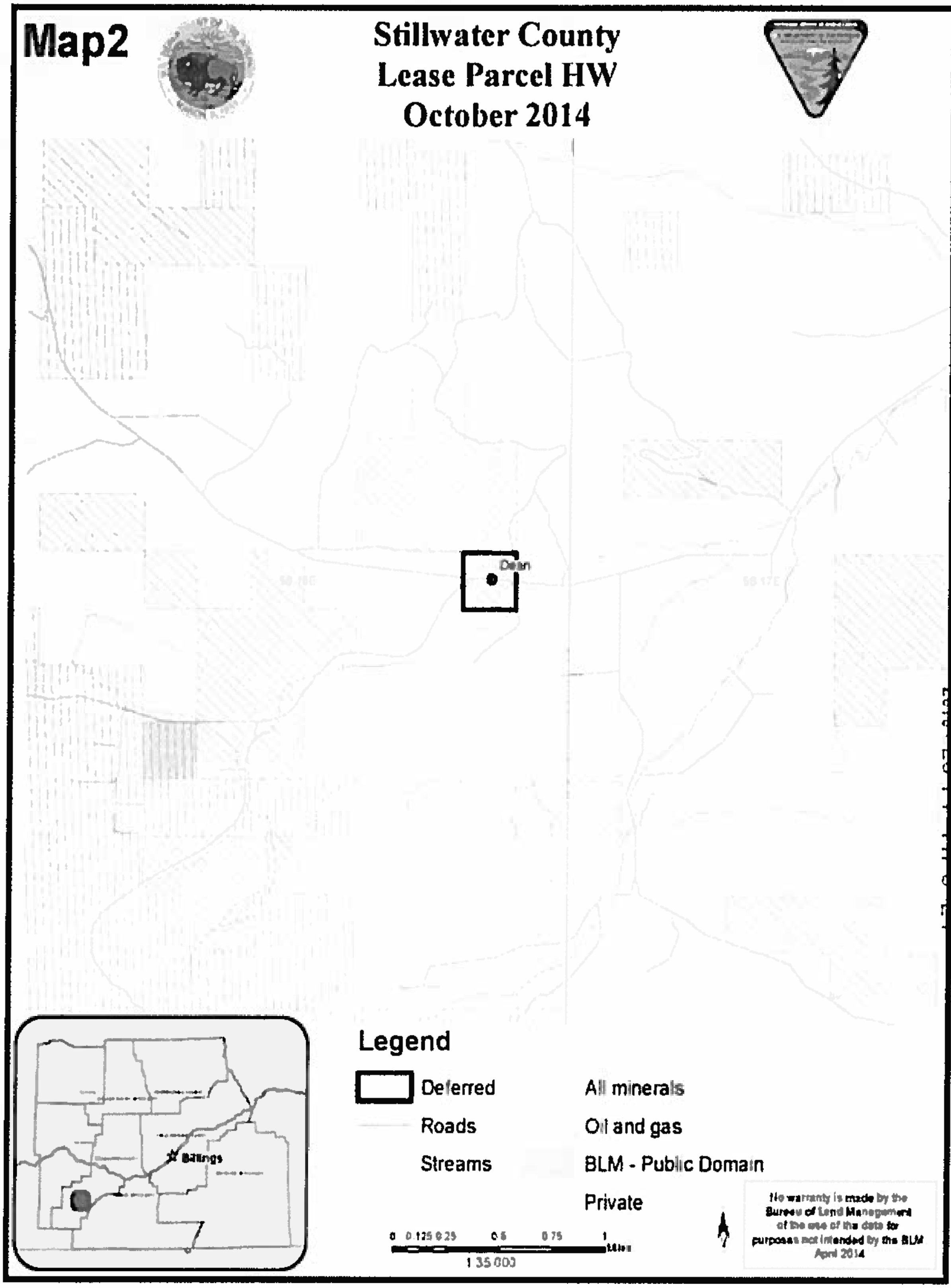


Figure 7: Map 3 - Yellowstone County Oil and Gas Development Potential, October 2014

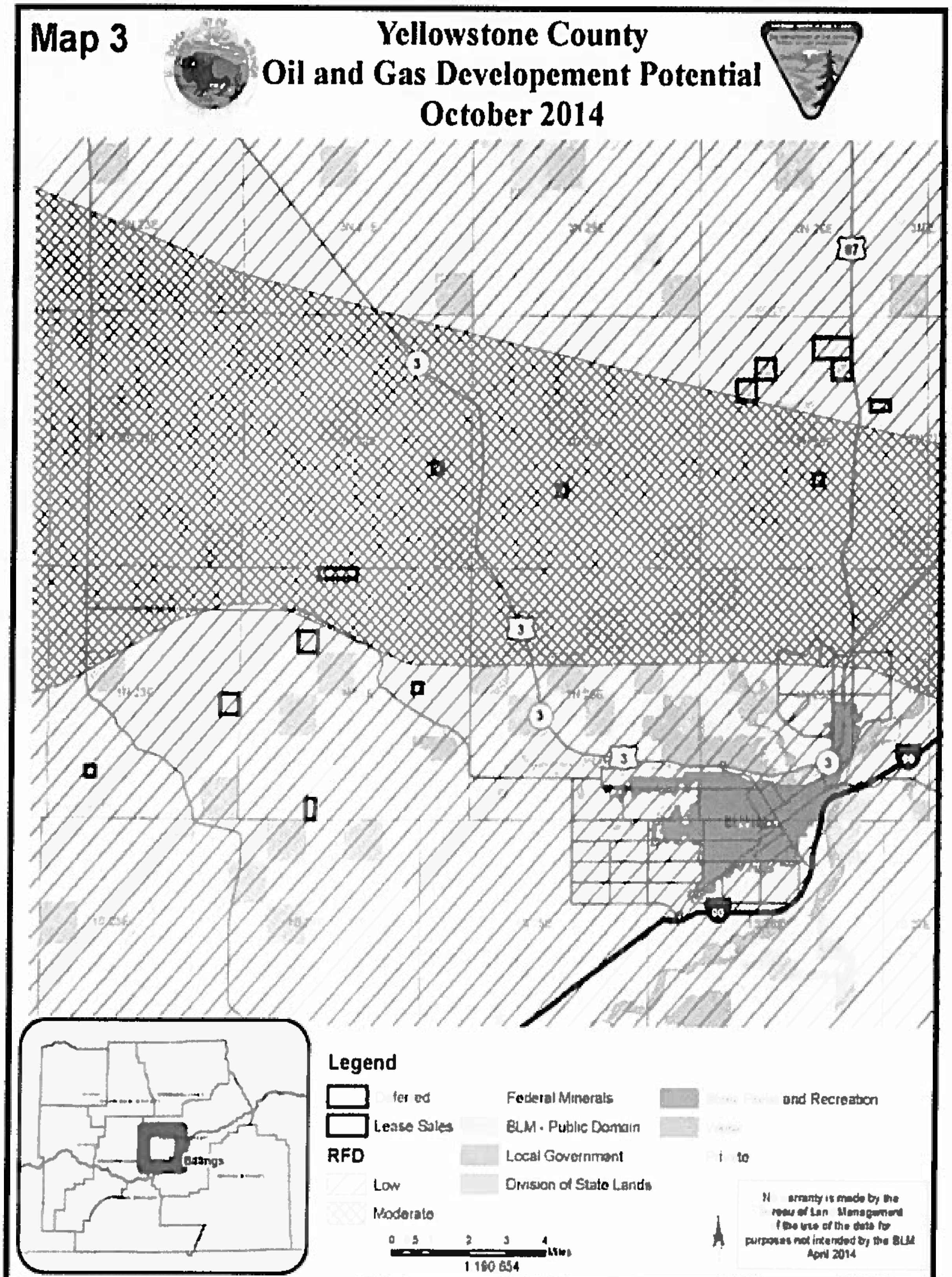


Figure 8: Map 4 - Yellowstone County Lease Parcels / Wildlife, October 2014

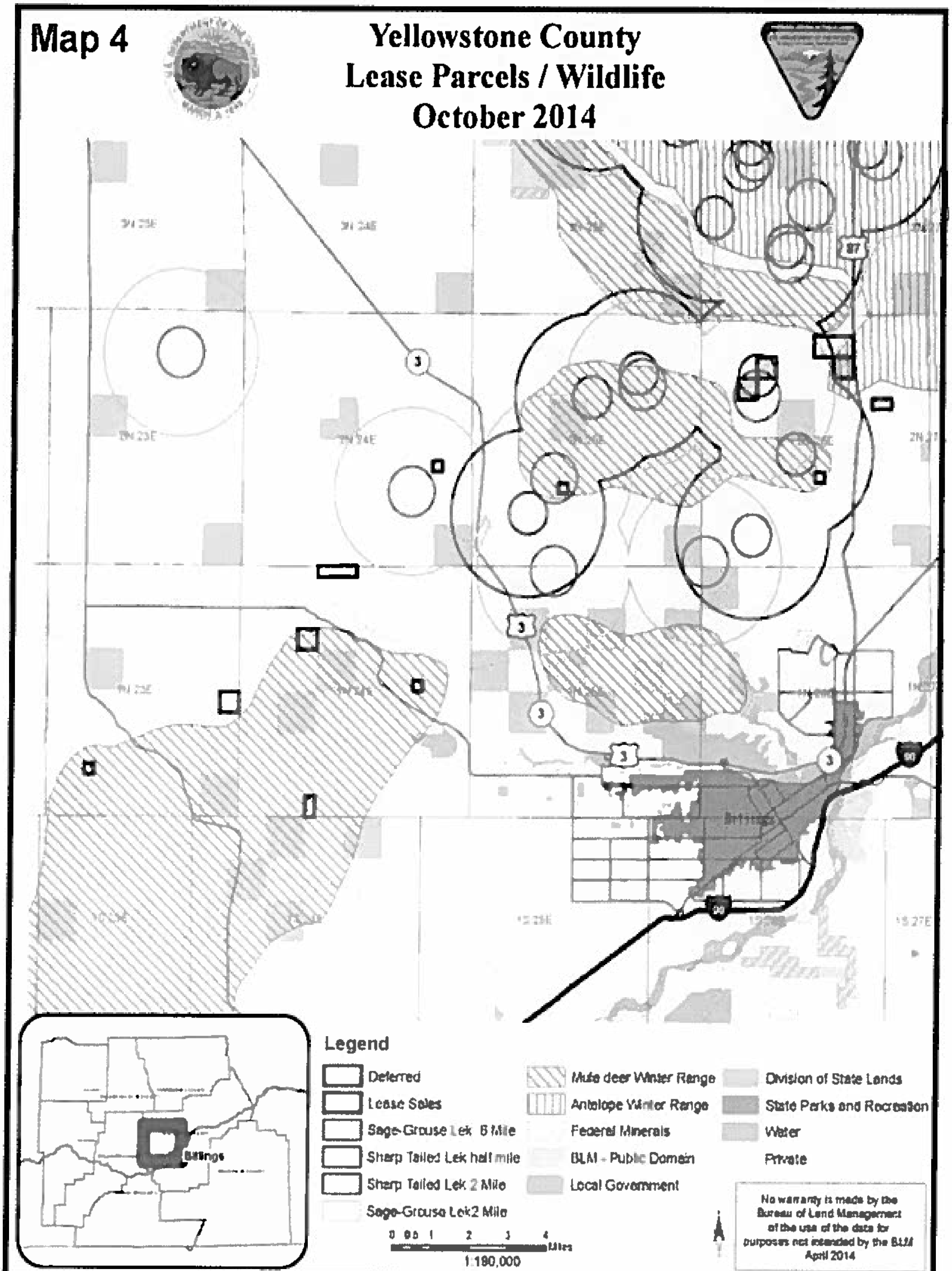
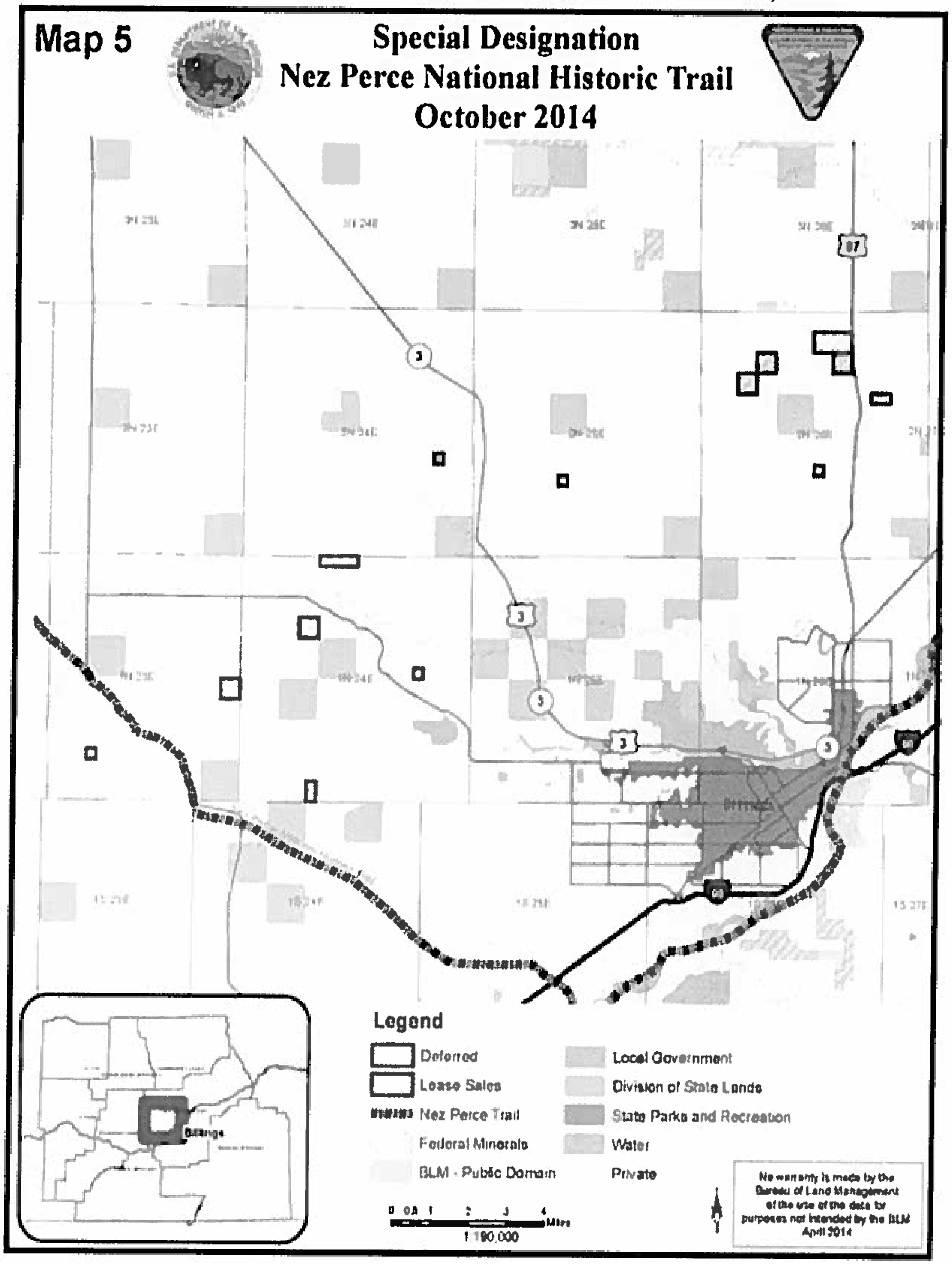


Figure 9: Map 5 - Special Designation Nez Perce National Historic Trail, October 2014



Ex. 3

Attachment F

DRAFT OIL AND GAS AIR EMISSIONS INVENTORY REPORT FOR SEVEN LEASE PARCELS IN THE BLM ROYAL GORGE FIELD OFFICE

Prepared for:

BLM
Colorado State Office and Royal Gorge Field Office
Colorado

Prepared by:

URS

URS Group, Inc.

Program Office:
9901 IH-10, Suite 350
San Antonio, Texas, 78230

URS Project 22243007

July 2013

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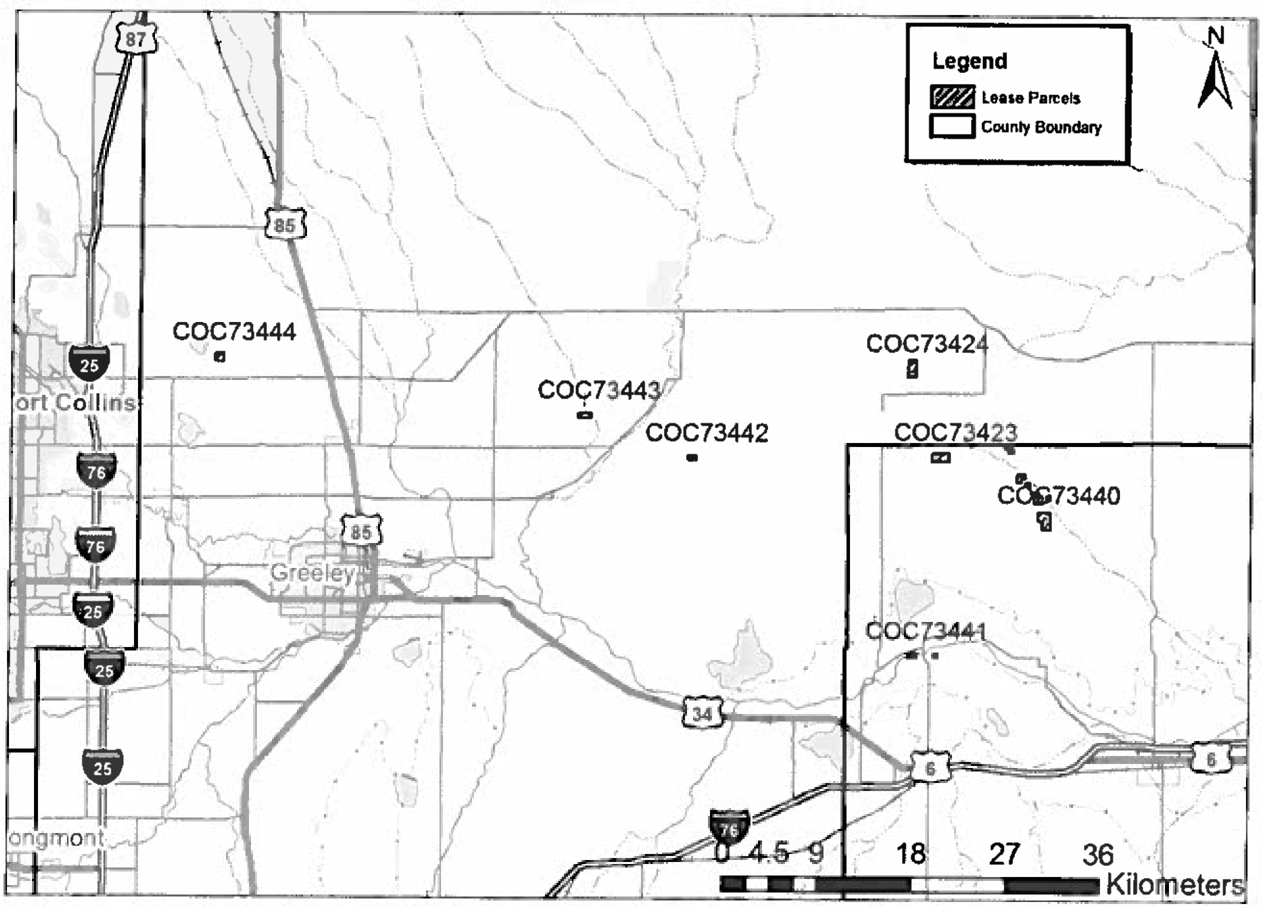
LIST OF ACRONYMS AND ABBREVIATIONS

AP-42	*Compilation of Air Pollutant Emission Factors*
APD	Application for Permit to Drill
API	American Petroleum Institute
bbls	Barrels
BLM	Bureau of Land Management
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
COGCC	Colorado Oil and Gas Conservation Commission
CSO	Colorado State Office
Mscf	Thousands of standard cubic feet
NAA	Non-Attainment Area
NH_3	Ammonia
N_2O	Nitrous oxides
NO_x	Oxides of nitrogen
O&G	Oil and Gas
PM	Particulate matter
PM_{10}	Particulate matter less than or equal to 10 microns in size
$PM_{2.5}$	Particulate matter less than or equal to 2.5 microns in size
PSICC	Pike and San Isabel National Forests and Cimarron and Comanche National Grasslands
RFD	Reasonably foreseeable development
RGFO	Royal Gorge Field Office
SO_2	Sulfur dioxide
tpy	Tons per year
URS	URS Group, Inc.
USEPA	U.S. Environmental Protection Agency
VOC	Volatile organic compound

PROJECT INTRODUCTION AND STUDY AREA

This oil and gas (O&G) emissions inventory report identifies the data and methodologies used in developing air emissions inventories for potential oil and gas development and production activities on seven (7) specific lease parcels in the Bureau of Land Management (BLM) Royal Gorge Field Office (RGFO). These seven parcels are part of the twelve (12) lease parcels in eastern Colorado referred to in the Stipulation and Order entered into by WildEarth Guardians and the BLM (WildEarth 2012) and for this report will further be known as "Study" or "Project". The emissions inventories include quantified potential emissions based on the 2012 BLM RGFO Reasonable Foreseeable Development (RFD) document (BLM 2012).

For emissions inventory domain purposes, the Study Area focuses on the seven lease parcels in the BLM RGFO in Colorado. The RGFO administers over 680,000 surface acres of public land along the Colorado Front Range and 6.8 million sub-surface acres. This Field Office covers approximately the eastern half of Colorado and includes a variety of terrain. The Project emissions inventory development will focus on potential oil and gas activities on the seven lease parcels in the RGFO. A map showing the locations of the seven BLM lease parcels is presented below (Map 1-1).



Map 0-1. Locations of Seven BLM Lease Parcels

The number of active wells for each Township that contains one of the seven lease parcels is shown below in Table 1-1 (data taken from Figure 5b of the RFD [BLM 2012]). Also shown in this table are the number of active wells in the county in 2011, as well as the 2011 oil, gas, and water production for each of the two counties containing the seven lease parcels (COGCC 2013). In order to provide a background of the emissions levels in the area of the lease parcels, Table 1-2 provides county level emissions inventories in tons per year (tpy) for Weld and Morgan counties taken from the 2008 National Emissions Inventory (USEPA 2013).

Table 0-1. Active Wells and Production Values

Parcel Serial #	Township	Number of Active Wells in Township in 2011	County	Number of Active Wells in County in 2011	2011 Average Monthly Oil Production (bbls)	2011 Average Monthly Gas Production (Mscf)	2011 Average Monthly Water Production (bbls)
COC73423	Township 6 North Range 60 West	6					
COC73440	Township 6 North Range 59 West	4	Morgan	252	9,159	10,946	265,862
COC73441	Township 4 North Range 60 West	0					
COC73424	Township 7 North Range 60 West	8					
COC73442	Township 6 North Range 62 West	54					
COC73443	Township 7 North Range 63 West	50	Weld	22,323	2,220,768	19,964,793	954,887
COC73444	Township 7 North Range 67 West	21					

bbls = barrels
Mscf = thousands of standard cubic feet
Source: COGCC 2011 County Production Report

Table 0-2. 2008 County Level Emissions Inventories (tpy)

County	PM_{10}	$PM_{2.5}$	CO	NO_x	SO_2	VOC	CO_2	CH_4	N_2O	NH_3	HAPs
Morgan	6,880	1,529	10,471	9,561	13,466	10,234	306,257	22	10	5,765	2,232
Weld	28,851	5,962	60,876	20,088	352	52,991	1,683,038	137	66	17,042	7,389

PM = Particulate matter
PM_{10} = Particulate matter less than or equal to 10 microns in size
$PM_{2.5}$ = Particulate matter less than or equal to 2.5 microns in size
CO = Carbon monoxide
NO_x = Oxides of nitrogen
SO_2 = Sulfur dioxide
VOC = Volatile organic compounds
CO_2 = Carbon dioxide
CH_4 = Methane
N_2O = Nitrous oxide
NH_3 = Ammonia
HAPs = Hazardous air pollutants
Source: USEPA 2008 NEI

EMISSIONS INVENTORY METHODOLOGY

This section describes the data sources and methods that were used to develop the seven lease parcel-specific emission inventories.

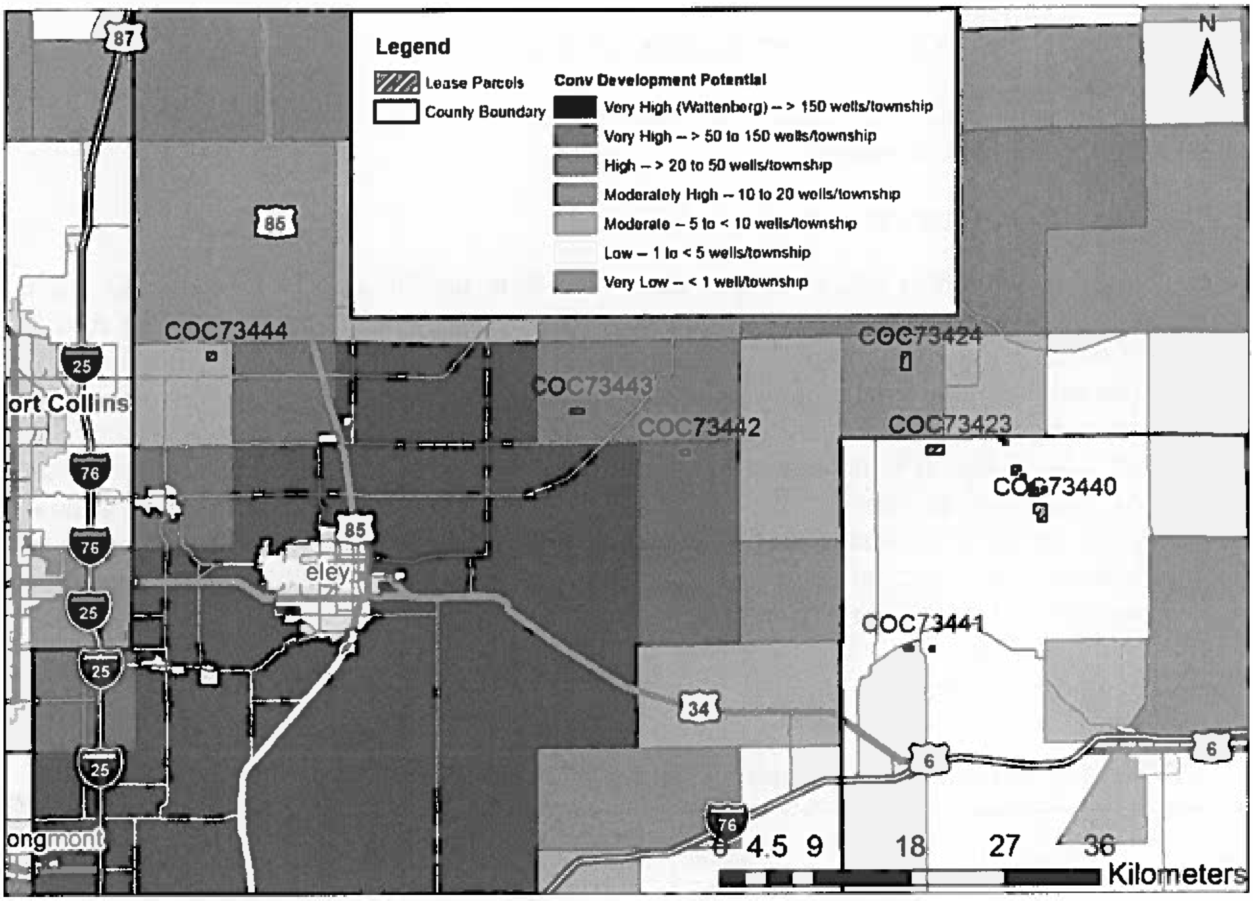
POTENTIAL WELL DEVELOPMENT

Potential well development was estimated using data from the 2012 BLM RGFO RFD and is shown in Table 2-1. Map 2-1 shows oil and gas development potential and projected drilling densities for the years 2011 through 2030 for each Township in the RGFO (Figure 17, 2012 BLM). The minimum and maximum number of potential wells per Township was determined for each lease parcel based on this figure. The average acres disturbed per well was calculated using Table 14a of the RFD document along with the expected percentages of multi-well and single-well pads found on page 31. Parcels must have at least one well in order to retain a lease; therefore, the potential minimum wells developed for each of the lease parcels is one. To determine the potential maximum wells developed for each lease parcel, the area of each parcel in acres was divided by the average acres disturbed for each well. If the result was greater than the maximum wells per Township, the potential maximum was set to the maximum wells per Township; otherwise, the result was used.

Table 0-3. Potential Conventional Well Development for the Seven Lease Parcels

Parcel Serial #	In Non-attainment Area? [1]	Development Category	Minimum Wells per Township	Maximum Wells per Township	Area of Parcel (acres)	Average Acres Disturbed per Well [2]	Potential Minimum Wells Developed in Parcel [3]	Potential Maximum Wells Developed in Parcel [4]
COC73444	Y	Moderate	5	9	160	7.6	1	9
COC73443	Y	High	21	50	123	7.6	1	16
COC73442	Y	Very High	51	150	80	7.6	1	10
COC73424	Y	Moderately High	10	20	320	7.6	1	20
COC73423	N	Low	1	4	320	2.1	1	4
COC73441	N	Low	1	4	120	2.1	1	4
COC73440	N	Low	1	4	879	2.1	1	4

(1) Parcels are either within the Greater Wattenberg Non-Attainment Area (NAA) or to the east of the NAA.
(2) Average acres disturbed is determined from values in the RFD.
(3) Parcels must have at least one well to retain lease.
(4) Potential maximum wells developed is either the number of wells that will fit in the parcel, or the maximum per Township, if the former is greater.



Map 0-2. Conventional O&G Development Potential

POTENTIAL OIL AND GAS ACTIVITIES

Potential oil and gas activities on the lease parcels range from land disturbance from construction and drilling, to well completion activities from venting and flaring, and production activities. Particulate emissions could be generated from the construction of new well pads, roads and pipelines. Construction emissions will also include criteria pollutants from exhaust emissions from construction traffic and drilling engines. At times, during completion, well workovers, or blowdowns, gas may be vented or flared.

Potential oil and gas activity levels for the seven lease parcels were estimated from a variety of sources. Potential oil, gas, condensate, and water produced from wells that could be developed on the lease parcels were estimated by the BLM Colorado State Office (BLM-CSO) from Applications for Permit to Drill (APD) submissions from other sites in the area of the seven lease parcels.

Data requests were sent out to oil and gas operators that work in the area of the seven lease parcels. Only one operator sent back a response. This data was used to supplement the data from the APDs.

Another source of data was the Pike and San Isabel National Forests and Cimarron and Comanche National Grasslands (PSICC) Air Quality Study. The data from this study was used to fill in any data gaps left after the APD and operator data had been entered.

PER-WELL EMISSIONS INVENTORY

The per-well emissions were calculated using the activity data listed in the above section along with emission factors taken from AP-42 (USEPA 1998, 2000, 2006), the American Petroleum Institute's Compendium (API 2009), the USEPA's *Protocol for Equipment Leak Emissions Estimates*, as well as, emissions factors developed for the Piceance Basin in western Colorado.

Emissions calculations took into account all current EPA and Colorado regulations on the oil and gas industry. The latest EPA regulations that affect this project include the following (USEPA 2012):

- High-bleed pneumatic controllers must have a gas bleed limit of 6 cubic feet of gas per hour, and
- Storage tanks with VOC emissions of 6 tons per year or more are required to reduce emissions by at least 95%.

The estimated per-well emissions for the seven lease parcels are listed in Table 2-2 below.

Table 0-4. Per-Well Emissions Estimates

Resource/Phase	PM_{10} tpy	$PM_{2.5}$ tpy	NO_x tpy	SO_2 tpy	CO tpy	VOC tpy	HAPs tpy	CO_2 tpy	CH_4 tpy	N_2O tpy
Oil										
Construction	28.51	3.61	11.16	0.03	2.63	0.75	0.08	1,518.74	0.03	0.01
Operation	15.62	1.64	10.58	0.01	6.26	20.96	2.01	1,149.23	20.86	0.02
Maintenance	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00
Reclamation	0.06	0.01	0.02	0.00	0.01	0.00	0.00	1.73	0.00	0.00
Total	44.27	5.27	21.75	0.03	8.90	21.72	2.09	2,670.32	20.89	0.03
Natural Gas										
Construction	28.62	3.63	11.18	0.03	2.77	0.76	0.08	1,563.51	0.03	0.01
Operation	14.68	1.65	4.53	0.01	8.06	33.30	3.65	1,211.83	31.69	0.01
Maintenance	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00
Reclamation	0.06	0.01	0.02	0.00	0.01	0.00	0.00	1.73	0.00	0.00
Total	43.45	5.30	15.73	0.03	10.84	34.06	3.73	2,777.69	31.72	0.03

SUMMARY

Per-well emissions estimates have been calculated for seven parcels in Weld and Morgan Counties in Colorado. These estimates were calculated using the most current data available and included the most current rules and regulations. Colorado has published recommended modeling thresholds for new sources of emissions (CDPHE 2011). These thresholds are exceeded by the per-well emissions estimates for short-term and long-term PM_{10} and $PM_{2.5}$, and short-term NO_x. Approximately half of the estimated emissions of PM_{10}, $PM_{2.5}$, NO_x and CO_2 come from construction related activities. These activities are expected to last a few weeks per well. The BLM may also require additional controls as conditions of approvals at the permitting stage, which could further reduce emissions. These additional controls may include, but are not limited to, Tier 4 engines and fugitive dust control for construction and traffic.

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Ex. 4

ENVIRON

COLORADO AIR RESOURCE MANAGEMENT MODELING STUDY (CARMMS) 2021 MODELING RESULTS FOR THE HIGH, LOW AND MEDIUM OIL AND GAS DEVELOPMENT SCENARIOS

Final

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1.0 INTRODUCTION

1.1 Background

The Bureau of Land Management (BLM) is in the process of developing new Resource Management Plans (RMPs) for several Field Offices in Colorado. The draft RMP for the Grand Junction Field Office (GJFO) was released in January 2013[1]. In May 2013, a draft RMP for the Dominguez-Escalante National Conservation Area (D-E NCA) was released[2]. The draft RMP for the Uncompahgre Field Office (UFO[3]), the RMP revision for the Royal Gorge Field Office (RGFO[4]), and the Roan Plateau Planning Area Supplemental Environmental Impact Statement (SEIS[5]) are all in preparation, or pre-planning. As part of these RMPs, BLM is estimating the air quality (AQ) and air quality related value (AQRV) impacts due to the projected BLM-authorized mineral development activities. The analysis includes the cumulative AQ and AQRV impacts due to all Reasonable Foreseeable Development (RFD) sources in the region. In the past, individual RMPs have generally performed their own AQ/AQRV analysis for a long-term year (e.g., 20 years out) when the maximum RMP development is projected to occur. This has resulted in inefficiencies and potential inconsistencies in the RMP's AQ/AQRV analysis and a possibility for a failure to adequately assess the effects of cumulative development across all BLM planning areas on AQ/AQRV in the region. In addition, making emissions projections for such a long-term future year results in increased uncertainties and may create potential inconsistencies in the RMP planned and actual development activities. Thus, the BLM GJFO RMP Air Resource Management Plan (ARMP[6]) contains a commitment to perform a unified regional air quality modeling study to address the AQ/AQRV impacts due to development activities within the GJFO planning area as well as all of BLM Colorado's development activities for a short-term year approximately 10 years in the future.

To address this commitment, the BLM has contracted with Environmental Management Planning and Solutions Inc. (EMPSi), and their Subcontractors ENVIRON International Corporation (ENVIRON) and Carter Lake Consulting (CLC), to perform the Colorado Air Resource Management Modeling Study (CARMMS). The first step in the CARMMS air quality modeling was the development of a Photochemical Grid Model (PGM) and far-field dispersion Modeling Protocol (ENVIRON, Carter Lake and EMPSi, 2014). The Modeling Protocol describes procedures for addressing potential AQ and AQRV impacts due to BLM-authorized mineral development and other BLM-authorized activities in Colorado and in particular within the GJFO and other BLM FOs planning areas in Colorado. AQRVs include visibility, sulfur and nitrogen deposition and lake acid neutralizing capacity (ANC).

The BLM New Mexico State Office (NMSO) is also looking at preparing a RMP for oil and gas development within the Mancos Shale development area in northwestern New Mexico that resides

[1] http://www.blm.gov/co/st/en/fo/gjfo/rmp/rmp.html
[2] http://www.blm.gov/co/st/en/nca/denca/denca_rmp.html
[3] http://www.blm.gov/co/st/en/fo/ufo/uncompahgre_rmp.html
[4] http://www.blm.gov/pgdata/etc/medialib/blm/co/field_offices/royal_gorge_field/oil_and_gas.Par.16932.File.dat/RoyalGorgeFinal_RFD_August_2012%20web.pdf
[5] http://www.blm.gov/co/st/en/BLM_Programs/land_use_planning/rmp/roan_plateau.html
[6] http://www.blm.gov/pgdata/etc/medialib/blm/co/field_offices/grand_junction_field/Draft_RMP/appdx.Par.47942.File.dat/ApdxG_Draft%20GJFO%20Air%20Plan_508.pdf

primarily within the BLM New Mexico Farmington Field Office (NMFFO). Given that the Mancos Shale development area is adjacent to some of the Colorado BLM Planning Areas and resides within the CARMMS modeling domain, the BLM decided to add the Mancos Development area to the CARMMS analysis.

The BLM Colorado State Office (COSO) convened an Interagency Air Quality Review Team (IAQRT) that consists of U.S. Environmental Protection Agency (EPA) Region 8, Colorado Department of Health and Environment (CDPHE) Air Pollution Control Division (APCD), National Park Service (NPS), Fish and Wildlife Service (FWS) and United States Forest Service (USFS) to review and comment on the Modeling Protocol in accordance with the June 23, 2011 Memorandum of Understanding (MOU[7]) between the United States Department of Interior (USDOI), United States Department of Agriculture (USDA) and United States Environmental Protection Agency (EPA) on procedures for assessing the AQ and AQRV impacts due to on-land oil and gas development activities on Federal lands under the National Environmental Policy Act (NEPA). With the addition of the NMFFO Mancos Shale development to CARMMS, the IAQRT was expanded to include EPA Region 6 and the New Mexico Environmental Department (NMED).

1.2 Purpose

This document presents the final 2021 modeling results for the CARMMS High, Low and Medium Development Scenarios source apportionment modeling. Presented are the individual AQ and AQRV impacts due to oil and gas (O&G) development on Federal lands within 13 separate Colorado BLM planning areas and the NMFFO Mancos Shale development area as well as the combined assessment of O&G development on Federal and non-Federal lands. In addition, the AQ and AQRV impacts due to mining within the 13 Colorado BLM planning areas and all O&G development within the 4 km CARMMS domain is presented. The 2021 modeling results are compared against National and State Ambient Air Quality Standards (NAAQS and SAAQS) throughout the 4 km modeling domain. The contributions of O&G development to AQ and AQRV at Class I and sensitive Class II areas are presented and compared to PSD increment concentrations and visibility and deposition thresholds of concern.

The CARMMS modeling was performed following procedures documented in a Modeling Protocol. A first draft CARMMS air assessment Modeling Protocol was prepared in August 2013. The BLM and their contractors presented the results of the first draft CARMMS Modeling Protocol to the IAQRT at the BLM COSO office in Denver on October 30, 2013. The IAQRT provided comments on the first draft Modeling Protocol that were incorporated into a draft final Modeling Protocol that was released in January 2014 (ENVIRON, CLC and EMPSi, 2014) along with a Response-to-Comments document that was also dated January 2014. Another meeting with the IAQRT was held at the BLM COSO office on February 28, 2014. IAQRT provided several comments that were addressed in a March 4, 2014 Response-to-Comments document and incorporated into this document. A preliminary draft CARMMS modeling report was prepared in May 2014 that included results for just the 2021 High Development Scenario. Based on comments from BLM, the preliminary draft CARMMS report was updated in an interim draft CARMMS report dated October 2014 that included the 2021 High and Low Development Scenarios modeling results. After

[7] http://www.epa.gov/compliance/resources/policies/nepa/air-quality-analyses-mou-2011.pdf

completion of the 2021 Medium Development Scenario source apportionment modeling this final reported was prepared in December 2014 that includes the 2021 High, Low and Medium Development Scenarios results.

1.3 Overview of Modeling Approach

CARMMS is using a photochemical grid model (PGM) to assess the AQ and AQRV impacts associated with BLM-authorized mineral development on Federal lands within BLM Colorado and the New Mexico Farmington Field Office Planning Areas. CARMMS will not assess the near-source AQ impacts of the O&G and other development activities; that will be addressed at the Project level in the future. The development of a PGM database is quite resources intensive. Thus, to the extent possible, CARMMS has leveraged two studies that have or are developing PGM modeling databases for the western states:

1. The West-wide Jump-start Air Quality Modeling Study (WestJumpAQMS) has performed meteorological, emissions and air quality modeling using a 36 km CONUS, 12 km WESTUS and 4 km Intermountain West modeling domains for the 2008 calendar year. Details on the WestJumpAQMS modeling approach, the PGM 2008 base case modeling and model performance evaluation are available on the WestJumpAQMS website[8] and contained within the WestJumpAQMS Modeling Protocol (ENVIRON, Alpine and UNC, 2013a[9]) and final report (ENVIRON, Alpine and UNC, 2013b[10]).

2. The Three-State Air Quality Study (3SAQS) used the WestJumpAQMS 2008 PGM modeling platform and is developing a new PGM modeling database for the western U.S. and the 2011 calendar year. 3SAQS performed 2020 emissions scenario modeling on the 36/12 CONUS/WESTUS domains using the 2008 modeling platform. 3SAQS is also developing a 2011 modeling platform and performing 2011 and 2020 emission scenario modeling with the 2011 modeling platform. The 3SAQS 2011 modeling platform was not ready in time for the CARMMS modeling.

For CARMMS, WestJumpAQMS developed a stand-alone 2008 4 km CAMx PGM modeling database for the CARMMS 4 km modeling domain shown in Figure 2-1. Boundary Conditions (BCs) for the 4 km CARMMS domain were obtained from a CAMx 2008 36/12 km simulation conducted by WestJumpAQMS. WestJumpAQMS has conducted a model performance evaluation for the WRF 2008 36/12/4 km meteorological simulation and the CAMx 2008 36/12/4 km base case simulation that are summarized for the CARMMS 4 km domain in, respectively, Appendices A and B with more details available on the WestJumpAQMS website[11].

The CARMMS CAMx modeling of the CARMMS 4 km modeling domain (Figure 2-1) for a 2021 future year emission scenario using the WestJumpAQMS 2008 meteorological inputs involved the following activities:

[8] http://www.wrapair2.org/WestJumpAQMS.aspx
[9] http://www.wrapair2.org/pdf/WestJumpAQMS_Modeling_Protocol_and_Source%20Apportionment_Design_FinalMay.pdf
[10] http://www.wrapair2.org/pdf/WestJumpAQMS_FinRpt_Finalv2.pdf
[11] http://www.wrapair2.org/WestJumpAQMS.aspx

- Develop a 2021 Future Year emissions scenario using the CARMMS estimates of oil and gas and other mineral development within the Colorado and northern New Mexico BLM planning areas and the EPA/3SAQS 2020 emission estimates for all other source categories.
    - For O&G emissions in the western Colorado BLM Planning Areas, CARMMS developed emissions calculators (Appendix C) with data specific to each area. BLM COSO provided 2021 oil and gas activity projections for a High, Low and Medium Development Scenarios.
    - 2021 mining emissions within western Colorado BLM Planning Areas were also estimated using CARMMS emissions calculators (Appendix D).
    - O&G emissions for eastern Colorado BLM Planning Areas were developed in a study for the BLM Royal Gorge Field Office (RGFO) and provided by the BLM COSO.
    - The CARMMS emissions calculators were adapted to estimate emissions for the Mancos Shale development area using information provided by the BLM NMFFO.
    - O&G emissions for the Uinta Basin were developed for the Air Resource Management Study (ARMS) and were provided by the BLM Utah State Office (UTSO).
    - O&G emissions for the Wyoming were based on recent future year emission developed for the BLM Wyoming State Office (WYSO) Continental Divide-Creston Draft EIS[12] modeling.
    - O&G emissions for the remainder of the region were based on recent 2020 emission projections developed by the Three State Air Quality Study (3SAQS)
    - Future year anthropogenic emissions for the remainder of the source categories were based on a 2020 emissions inventory developed by EPA for the $PM_{2.5}$ NAAQS rulemaking and updated by 3SAQS.
    - Future year emissions for biogenic sources, fires, windblown dust, sea salt and lightning were kept constant at 2008 levels and were based on the WestJumpAQMS.
- The future year emissions were processed using the SMOKE emissions model to generate 2020/2021 emissions for the WestJumpAQMS 36/12 km domain and 4 km CARMMS domain.
- CAMx modeling was performed for the 36/12 km domains and the 2020/2021 emissions scenario using the 2008 WestJumpAQMS modeling platform.
- 2020/2021 Boundary Condition (BC) inputs for the CARMMS 4 km modeling domain were generated using output from the 36/12 km CAMx model simulation for the 2020/2021 emissions scenario using the 2008 WestJumpAQMS 2008 meteorological inputs.
- CAMx ozone and particulate matter source apportionment simulations were performed for the 2021 High, Low and Medium Development Scenarios and 4 km CARMMS modeling domain using the 2008 CARMMS modeling platform.

[12] http://www.blm.gov/wy/st/en/info/NEPA/documents/rfo/cd_creston.html

- The CAMx 2021 4 km CARMMS domain source apportionment output for the High, Low and Medium Development Scenarios were post-processed to obtain the separate AQ and AQRV impacts due to mineral development activities on Federal lands within each of the 13 Colorado and the northern New Mexico BLM planning areas.
- The CAMx 2021 High, Low and Medium O&G Development Scenarios output was also post-processed to obtain the cumulative AQ and AQRV impacts due to mineral development on Federal and non-Federal lands within all of the Colorado and the northern New Mexico BLM planning areas as well as O&G development throughout the CARMMS 4 km modeling domain.

- The AQ and AQRV impacts of BLM-authorized oil and gas development on Federal lands within each BLM Colorado planning areas alone and cumulative impacts across all planning areas for the 2021 High, Low and Medium Development Scenarios are summarized in this final report.

1.4 Air Quality Standards and AQRV Thresholds

1.4.1 Federal and State Air Quality Standards and PSD Increments

EPA sets National Ambient Air Quality Standards (NAAQS) for six pollutants, which are called criteria air pollutants (CAPs). The CAPs are: ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), suspended Particle Pollution (particulate matter with a mean aerodynamic diameter of less than or equal to 10 and 2.5 microns; PM_{10} and $PM_{2.5}$), sulfur dioxide (SO_2) and lead (Pb). States may also set their own ambient air quality standards, which must be as stringent as the NAAQS but may be more stringent.

Federal air quality regulations adopted and enforced by the states limit incremental emission increases to specific levels defined by the classification of air quality in an area. The Prevention of Significant Deterioration (PSD) Program is designed to limit the incremental increase of specific air pollutant concentrations above a legally defined baseline level. Incremental increases in PSD Class I areas are strictly limited, while increases allowed in Class II areas are less strict. PSD Class I and Class II increments are defined for NO_2, PM_{10}, $PM_{2.5}$ and SO_2. Please note the PSD increments are project level thresholds, and are not an appropriate metric for reference against field office level impacts.

Table 1-1 summarizes the NAAQS, the Colorado Ambient and Quality Standards (CAAQS) and the New Mexico Ambient Air Quality Standards (NMAAQS). PSD Class I and Class II increments are also shown in Table 1-1.

Table 1-1. Applicable National and State Ambient Air Quality Standards and PSD concentration increments.

Pollutant/Averaging Time	NAAQS	CAAQS[13]	NMAAQS[14]	PSD Class I Increment[1]	PSD Class II Increment[1]
		CO			
1-hour[2]	35 ppm	--	13.1 ppm	--	--
8-hour[2]	9 ppm	--	8.7ppm	--	--
		NO_2			
1-hour[3]	100 ppb	--	--	--	--
24-hour	--	--	0.10 ppm	--	--
Annual[4]	53 ppb	--	0.05 ppm	2.5	25
		O_3[15]			
8-hour[5]	0.075 ppm	--	--	--	--
		PM_{10}			
24-hour[6]	150 µg/m^3	--	--	8	30
Annual[7]	--	--	--	4	17
		$PM_{2.5}$			
24-hour[8]	35 µg/m^3	--	--	2	9
Annual[9]	12 µg/m^3	--	--	1	4
SO_2					
1-hour[10]	75 ppb	--	--		
3-hour[11]	0.5 ppm	700 µg/m^3	--	25	512
24-hour[12]	--	--	0.10 ppm	5	91
Annual[4]	--	--	0.02 ppm	2	20

1. The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis.
2. No more than one exceedance per calendar year; for MAAQS - No more than one exceedance per consecutive 12 months
3. 98th percentile, averaged over 3 year; for MAAQS - not to be exceeded more than once over any 12 consecutive months
4. Annual mean not to be exceeded; for MAAQS - arithmetic average over any four consecutive quarters not to be exceeded
5. Fourth-highest daily maximum 8-hour ozone concentrations in a year, averaged over 3 years
6. Not to be exceeded more than once per calendar year on average over 3 years.
7. 3 year average of the arithmetic means over a calendar year
8. 98th percentile, averaged over 3 years
9. Annual mean, averaged over 3 years, NAAQS promulgated December 14, 2012
10. 99th percentile of daily maximum 1-hour concentrations in a year, averaged over 3 years
11. No more than one exceedance per calendar year (secondary NAAQS) and no more than one exceedance in 12 consecutive months (CAAQS)
12. For areas in New Mexico not within 3.5 miles of the Chino Mines Company
13. http://www.colorado.gov/cs/Satellite/CDPHE-Main/CBON/1251601911433
14. http://www.nmcpr.state.nm.us/nmac/parts/title20/20.002.0003.htm
15. In December 2014 EPA proposed a new primary 8-hour ozone NAAQS that would lower the threshold to somewhere in the 65-70 ppb range that will be promulgated in October 2015.

1.4.2 Air Quality Related Value (AQRV) Thresholds

The impacts of each BLM authorized oil and gas and other activities within each BLM Planning area, as well as cumulative impacts of all activities together, at Class I and sensitive Class II areas will be assessed for three AQRVs: visibility, deposition and acid neutralizing capacity (ANC). The June 23, 2011 MOU between EPA, USDOI and USDA states that the project and cumulative AQRV impacts at Class I and sensitive Class II areas should be assessed by comparing against thresholds of concern defined by the Federal Land Manager (FLM) for the given Class I or sensitive Class II area in question. In the CARMMS first draft Modeling Protocol and at the October 30, 2013 meeting with the Interagency Air Quality Review Team (IAQRT) we presented the following threshold of concern for AQRVs in Class I and sensitive Class II areas and there were no disagreements in the comments received from the IAQRT:

- Visibility impacts for BLM-authorized oil and gas sources within each BLM Planning Area are assessed using the FLAG (2010) procedures that use the new IMPROVE equation, annual average natural visibility background and monthly relative humidity adjustment factors [f(RH)] (see Section 4.6.1). The visibility impacts from mineral development on Federal lands within each separate BLM planning area are compared against a 0.5 and 1.0 change in deciview (dv) haze index threshold of concern and any exceedances will be reported. Please note the dv thresholds are project level thresholds, and not an appropriate metric to reference against field office level or cumulative impacts.
- Cumulative sources visibility impacts from multiple BLM Planning Areas are assessed using a new visibility approach and metrics developed by the FLMs based on the regional haze rule visibility metrics for the best and worst 20% visibility days as discussed in Section 4.6.2.
- Acid deposition impacts due to mineral development on Federal lands within each separate BLM Planning Area for annual total sulfur (S) and total nitrogen (N) deposition are compared against the 0.005 kg/ha/yr Deposition Analysis Threshold (DAT) for the western states. Please note the DAT is a project level threshold, and not an appropriate metric to reference against field office level or cumulative impacts.
- Total N and S deposition impacts due to all emissions in the 2008 and 2021 emissions scenarios (i.e., cumulative) are compared to Critical Load values of 2.2 kg/ha/yr for N in Wyoming, 2.3 kg/ha/yr for N in Colorado except for Dinosaur National Monument where a 3.0 kg/ha/yr Critical Load value for N is used. For S, a 5.0 kg/ha/yr critical load value is used everywhere (see Section 4.7).
- The predicted annual deposition fluxes of sulfur and nitrogen at sensitive lake receptors due to Federal O&G development from individual BLM Planning Areas are used to estimate the change in ANC in accordance with the January 2000, USFS Rocky Mountain Region's Screening Methodology for Calculating ANC Change to High Elevation Lakes, User's Guide (USFS, 2000). The predicted changes in ANC are compared with the USFS's Level of Acceptable Change (LAC) thresholds of 10% for lakes with ANC values greater than 25 μeq/l and 1 μeq/l for lakes with background ANC values of 25 μeq/l and less (see Section 4.8). Please note the LAC is a project level threshold, and not an appropriate metric to reference against field office level or cumulative impacts.

2.0 CARMMS DATABASE DEVELOPMENT

2.1 Modeling System

The CARMMS 2008 modeling database was based on the WestJumpAQMS so the same modeling system was adopted. The justification for the model selection is given in the CARMMS Modeling Protocol (ENVIRON, Cater Lake and EMPSi, 2014). Table 2-1 lists the main models selected for the BLM CARMMS modeling with a brief summary of the reasons for their selection as follows:

- The WRF meteorological model was selected because it contains more recent updates and features compared to the MM5 alternative that is no longer supported by its developer.
- The SMOKE emissions model is the most current and up-to-date emissions modeling system and has performance improvements over the alternatives.
- The MOVES on-road mobile emissions modeling system is the recommended modeling system by the EPA.
- The MEGAN biogenic emissions model has been updated by WRAP specifically for simulating biogenic emissions in the western states.
- The CAMx photochemical grid model (PGM) includes a source apportionment capability that is critically important for the CARMMS and was not available in the version of CMAQ PGM alternative at the time the study was initiated.

Table 2-1. Summary of models selected for the BLM CARMMS modeling.

Model Type	Selected Model
Meteorological Model	Weather Research Forecasting (WRF)
Emissions Model	Sparse Matrix Operator Kernel Emissions (SMOKE)
Emissions Model – On Road Sources	Motor Vehicle Emissions Simulator (MOVES2010)
Emissions Model – Biogenic Sources	Model for Emissions of Gases and Aerosols in Nature (MEGAN)
Photochemical Grid Model	Comprehensive Air-quality Model with extensions (CAMx)

2.2 Episode Selection

Since the CARMMS will need to address annual average air quality issues (e.g., $PM_{2.5}$) and deposition issues, a full year is selected for modeling. Due to computational requirements and resource constraints, a single meteorological baseline year will be modeled. The entire 2008 calendar year was selected for the CARMMS modeling because it satisfied the most episode selection criteria of recent years:

1. The entire 2008 calendar year includes a variety of meteorological conditions. The year appears to have higher than average photochemical production potential so was not an atypical low year for secondary ozone and PM formation.

2. 2008 had observed ozone and $PM_{2.5}$ concentrations that were close to and even above the ozone and $PM_{2.5}$ Design Values in Colorado.

3. The 2008 year did not include any special study data in Colorado. Note that enhanced monitoring of the Front Range region and vicinity was collected for the summer of 2014, but that was after most of the CARMMS modeling was completed.

4. By modeling a full year (366 days) there should be sufficient number of days to calculated Relative Response Factors (RRFs) following EPA's guidance document (EPA, 2007).

5. The 2008 calendar year was already modeled as part of the Denver ozone modeling and in the WestJumpAQMS and 3SAQS. In particular, the ability to leverage the CARMMS database development off of WestJumpAQMS is critical to the success of the study.

6. Ozone nonattainment areas under the March 2008 0.075 ppm 8-hour ozone NAAQS were designated using 2008-2010 observations, which includes the selected 2008 modeling period.

7. The entire 2008 calendar year dataset includes both weekdays and weekend days.

8. Of the recent years, 2008 fulfills more of the episode selection criteria than other recent years available at the time the project was initiated.

2.3 CARMMS Modeling Domains

To leverage modeling data from other studies, the CARMMS adopted the so-called RPO Lambert projection that uses a longitude/latitude origin at (-97, 40) and standard latitude parallels of 33 and 45 degrees. Figure 2-1 displays the 4 km modeling domain used in the CARMMS emissions and photochemical modeling. An initial 4 km modeling domain was identified by including all Class I areas for which any part of the Class I area is within 200 km of a western Colorado BLM Field Office Planning Area. While developing the Modeling Protocol, the BLM New Mexico State Office (NMSO) indicated that they would like to include their Mancos Shale Oil development in the CARMMS modeling. The Mancos Shale Oil development area would be within the New Mexico BLM Farmington Field Office area, but would primarily reside in San Juan County with portions potentially stretching into neighboring Rio Arriba, Sandoval and McKinley Counties. Thus, the CARMMS 4 km domain was extended southward to include all Class I areas within 300 km of the Mancos Shale development area.

Figure 2-1 also shows the Class I areas throughout the domain that were analyzed for air quality and AQRV impacts. More details on the Class I and sensitive Class II areas where the AQ and AQRV impacts due to oil and gas and other activities within the BLM planning areas will be assessed is given in Chapter 4.

The CAMx vertical domain definitions will depend on the definition of the WRF vertical layer structure. WRF was run with 37 vertical levels (36 vertical layers using CAMx definition of layer thicknesses) from the surface up to 50 mb (~19-km high above mean sea level) (ENVIRON and Alpine, 2012[13]). The WRF model employs a terrain following coordinate system defined by pressure, using multiple layers that extend from the surface to 50 mb (approximately 19 km

[13] http://www.wrapair2.org/pdf/WestJumpAQMS_2008_Annual_WRF_Final_Report_February29_2012.pdf

above mean sea level). CARMMS is adopting the same layer collapsing strategy as used by WestJumpAQMS whereby multiple WRF layers are combined into one CAMx layer to reduce the air quality model computational time. Table 2-2 displays the approach for collapsing the WRF 36 vertical layers to 25 vertical layers in CAMx for CARMMS and WestJumpAQMS. The WRF layer collapsing scheme in Table 2-2 is collapsing two WRF layers into one CAMx/CMAQ layer for the lowest four layers in CAMx/CMAQ. In the past, the lowest layers of MM5/WRF were mapped directly into CAMx/CMAQ with no layer collapsing. However, in those applications the MM5/WRF layer 1 was much thicker (20-40 m) than used in this WRF application (12 m). Use of a 12 m lowest layer may trap emissions in a too shallow layer and may result in overstated surface concentrations. For example, NO_X emissions are caused by combustion so are buoyant and have plume rise that in reality could take them out of the first layer if it is defined too shallow.

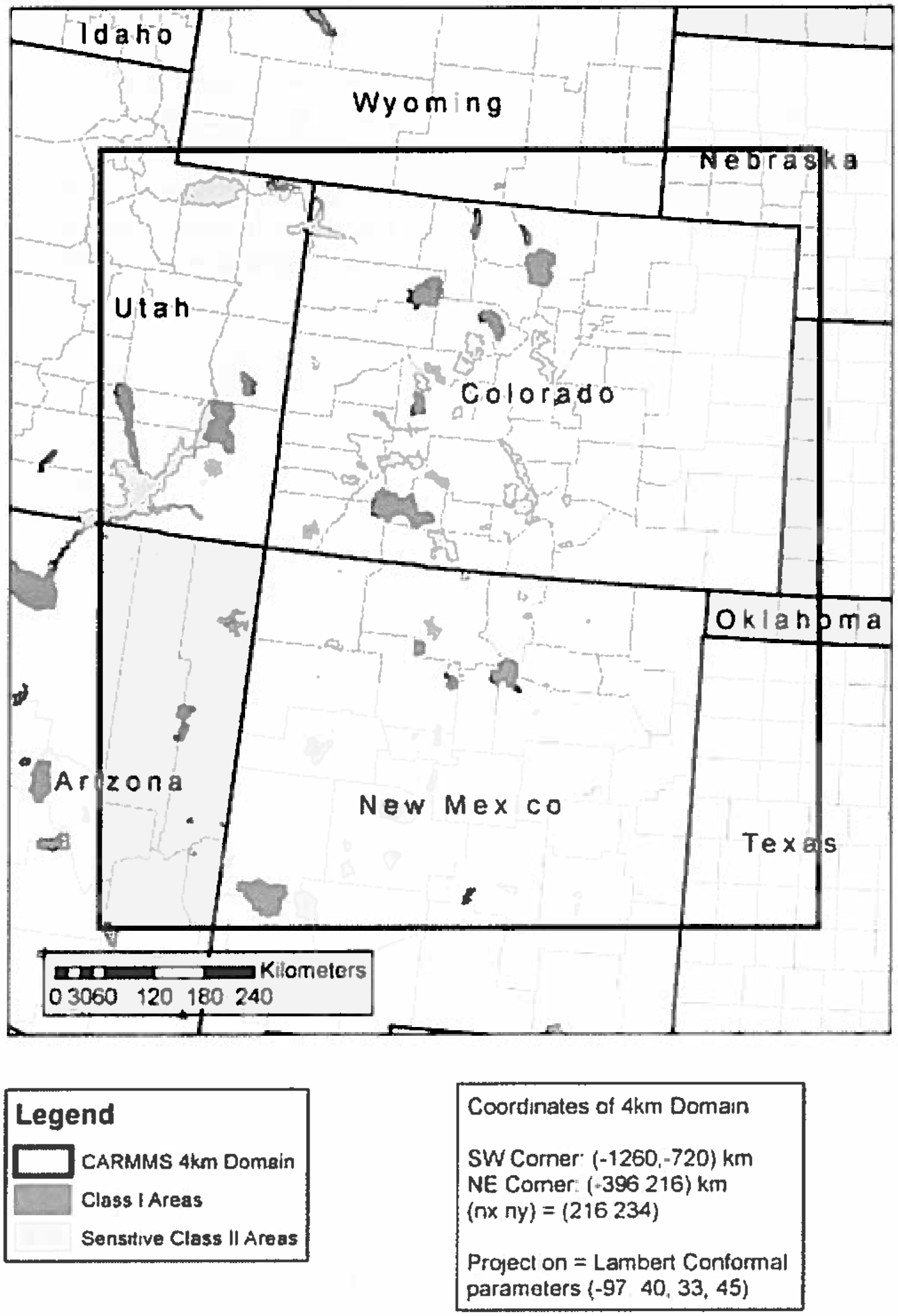

Figure 2-1. 4 km modeling domain used in the Colorado Air Resource Management Modeling Study (CARMMS).

Table 2-2. 37 Vertical layer interface definition for WRF simulations (left most columns), and approach for reducing to 25 vertical layers for CAMx by collapsing multiple WRF layers (right columns).

WRF Meteorological Model					CAMx Air Quality Model		
WRF Layer	Sigma	Pressure (mb)	Height (m)	Thickness (m)	CAMx Layer	Height (m)	Thickness (m)
37	0.0000	50.00	19260	2055	25	19260.0	3904.9
36	0.0270	75.65	17205	1850			
35	0.0600	107.00	15355	1725	24	15355.1	3425.4
34	0.1000	145.00	13630	1701			
33	0.1500	192.50	11930	1389	23	11929.7	2569.6
32	0.2000	240.00	10541	1181			
31	0.2500	287.50	9360	1032	22	9360.1	1952.2
30	0.3000	335.00	8328	920			
29	0.3500	382.50	7408	832	21	7407.9	1591.8
28	0.4000	430.00	6576	760			
27	0.4500	477.50	5816	701	20	5816.1	1352.9
26	0.5000	525.00	5115	652			
25	0.5500	572.50	4463	609	19	4463.3	609.2
24	0.6000	620.00	3854	461	18	3854.1	460.7
23	0.6400	658.00	3393	440	17	3393.4	439.6
22	0.6800	696.00	2954	421	16	2953.7	420.6
21	0.7200	734.00	2533	403	15	2533.1	403.3
20	0.7600	772.00	2130	388	14	2129.7	387.6
19	0.8000	810.00	1742	373	13	1742.2	373.1
18	0.8400	848.00	1369	271	12	1369.1	271.1
17	0.8700	876.50	1098	177	11	1098.0	176.8
16	0.8900	895.50	921	174	10	921.2	173.8
15	0.9100	914.50	747	171	9	747.5	170.9
14	0.9300	933.50	577	84	8	576.6	168.1
13	0.9400	943.00	492	84			
12	0.9500	952.50	409	83	7	408.6	83.0
11	0.9600	962.00	326	82	6	325.6	82.4
10	0.9700	971.50	243	82	5	243.2	81.7
9	0.9800	981.00	162	41	4	161.5	64.9
8	0.9850	985.75	121	24			
7	0.9880	988.60	97	24	3	96.6	40.4
6	0.9910	991.45	72	16			
5	0.9930	993.35	56	16	2	56.2	32.2
4	0.9950	995.25	40	16			
3	0.9970	997.15	24	12	1	24.1	24.1
2	0.9985	998.58	12	12			
1	1.0000	1000	0			0	

2.4 Meteorological Modeling Approach

The CARMMS meteorological inputs for the CAMx modeling are based on the WRF modeling performed as part of the WestJumpAQMS. The WRF computational domains were defined to be slightly larger than the CAMx and SMOKE modeling domains to eliminate the occurrence of boundary artifacts in the CAMx meteorological inputs. Such boundary artifacts can occur when the boundary conditions (BCs) for the meteorological variables come into dynamic balance with WRF's atmospheric equations and numerical methods.

The WRF model contains many different physics options, and achieving the best model performance for any particular year and region is accomplished by performing model sensitivity tests using different options. As part of the post-2008 Denver ozone SIP modeling, Alpine Geophysics, LLC and ENVIRON conducted numerous WRF meteorological sensitivity simulations to determine the best performing configuration for simulating meteorology in the Inter-Mountain West region (Morris et al., 2011). The final WRF configuration was used for the 2008 Denver ozone modeling as well as for the WestJumpAQMS WRF modeling results that are used in CARMMS.

2.4.1 2008 WRF Modeling Methodology

The WestJumpAQMS 2008 WRF modeling methodology is described below. More details are provided in the WestJumpAQMS WRF Application/Evaluation report (ENVIRON and Alpine, 2012[14]).

Horizontal Domain Definition: The computational domain on which WRF was applied for WestJumpAQMS included a 36 km CONUS, 12 km WESTUS and 4 km Inter-Mountain West Domain (IMWD). The 4 km domain includes the 4 km CARMMS domain shown in Figure 2-1. The grid projection is Lambert Conformal with a pole of projection of 40 degrees North, -97 degrees East and standard parallels of 33 and 45 degrees, the so-called RPO projection. The datum (size and shape of earth) is a perfect sphere with radius 6370.0 km.

Vertical Domain Definition: The WRF modeling was based on 37 vertical layers with an approximately 12 meter deep surface layer. The vertical domain is presented in both sigma and height coordinates in Table 2-2.

Topographic Inputs: Topographic information for WRF were developed using the standard WRF terrain databases. The 36 km domain is based on the 10 minute (18 km) global data. The 12 km domain is based on the 2 minute (~4 km) data. The 4 km domain is based on 30 second (~900 m) data.

Vegetation Type and Land Use Inputs: Vegetation type and land use information were developed using the most recently released WRF databases provided with the WRF distribution. Standard WRF surface characteristics corresponding to each land use category were employed.

Atmospheric Data Inputs: The first guess fields were taken from the 12 km North American Model (NAM) database.

[14] http://www.wrapair2.org/pdf/WestJumpAQMS_2008_Annual_WRF_Final_Report_February29_2012.pdf

Diffusion Options: Horizontal Smagorinsky first-order closure (km_opt = 4) with sixth-order numerical diffusion and suppressed up-gradient diffusion (diff_6th_opt = 2) were used.

Lateral Boundary Conditions: Lateral boundary conditions were specified from the initialization dataset (12 km NAM) on the 36 km domain with continuous updates nested from the 36 km domain to the 12 km domain and continuous updates nested from the 12 km domain to the 4 km domain, using one-way nesting (feedback = 0).

Top and Bottom Boundary Conditions: The top boundary condition was selected as an implicit Rayleigh dampening for the vertical velocity. Consistent with the model application for non-idealized cases, the bottom boundary condition was selected as physical, not free-slip.

Water Temperature Inputs: The water temperature data were taken from the National Centers for Environmental Prediction (NCEP) Real Time Global (RTG) global one-twelfth degree analysis[15].

FDDA Data Assimilation: The WRF model was run with a combination of analysis and observation nudging (i.e., Four Dimensional Data assimilation [FDDA]). Analysis nudging was used on the 36 km and 12 km domain using the 12 km NAM dataset. For winds and temperature, analysis nudging coefficients of $5x10^{-4}$ and $3.0x10^{-4}$ were used on the 36 km and 12 km domains, respectively. For mixing ratio, an analysis nudging coefficient of $1.0x10^{-5}$ was used for both the 36 km and 12 km domains. The nudging uses both surface and aloft nudging with nudging for temperature and mixing ratio not performed in the lower atmosphere (i.e., within the boundary layer and at the surface). Observation nudging was performed on the 4 km grid domain using the Meteorological Assimilation Data Ingest System (MADIS)[16] observation archive. The MADIS archive includes the National Climatic Data Center (NCDC)[17] observations and the National Data Buoy Center (NDBC) Coastal-Marine Automated Network C-MAN[18] stations. The observational nudging coefficients for winds, temperatures and mixing ratios were $1.0x10^{-4}$, $1.0x10^{-4}$, and $1.0x10^{-5}$, respectively and the radius of influence was set to 50 km.

Physics Options: The WRF model contains many different physics options. The physics options chosen for the WestJumpAQMS application are presented in Table 2-3.

Application Methodology: The WRF model was executed in 5½ day blocks initialized at 12Z every 5 days. Model results were output every 60 minutes. The first twelve (12) hours of each 5 ½ day block is used for model spin-up and not used in the PGM model inputs or in the WRF model performance evaluation. WRF was configured to run in distributed memory parallel mode.

[15] Real-time, global, sea surface temperature (RTG-SST) analysis. http://polar.ncep.noaa.gov/sst/oper/Welcome.html
[16] Meteorological Assimilation Data Ingest System. http://madis.noaa.gov/
[17] National Climatic Data Center. http://lwf.ncdc.noaa.gov/oa/ncdc.html
[18] National Data Buoy Center. http://www.ndbc.noaa.gov/cman.php

Table 2-3. Physics options used in the WestJumpAQMS WRF 2008 simulation modeling.

WRF Treatment	Option Selected	Notes
Microphysics	Thompson scheme	New with WRF 3.1.
Longwave Radiation	RRTMG	Rapid Radiative Transfer Model for GCMs includes random cloud overlap and improved efficiency over RRTM.
Shortwave Radiation	RRTMG	Same as above, but for shortwave radiation.
Land Surface Model (LSM)	NOAH	Two-layer scheme with vegetation and sub-grid tiling.
Planetary Boundary Layer (PBL) scheme	YSU	Yonsie University (Korea) Asymmetric Convective Model with non-local upward mixing and local downward mixing.
Cumulus parameterization	Kain-Fritsch in the 36 km and 12 km domains. None in the 4 km domain.	4 km can explicitly simulate cumulus convection so parameterization not needed.
Analysis nudging	Nudging applied to winds, temperature and moisture in the 36 km and 12 km domains	Temperature and moisture nudged above PBL only.
Observation Nudging	Nudging applied to surface wind only in the 4 km domain	Surface temperature and moisture observation nudging can introduce instabilities.
Initialization Dataset	12 km North American Model (NAM)	Also used in analysis nudging

2.4.2 Meteorological Model Performance Evaluation

The WestJumpAQMS performed a comprehensive and detailed model performance evaluation of the 2008 WRF 36/12/4 km model simulation. The WestJumpAQMS WRF model performance evaluation is documented in a WRF Application/Evaluation report that is available on its website (ENVIRON and Alpine, 2012[19]). The WRF evaluation consisted of the following:

- Evaluation against surface meteorological observations of wind direction, wind speed, temperature and water vapor mixing ratio (humidity) with monthly performance statistics calculated using the METSTAT program:
  - Surface meteorological performance statistics were calculated across the 36 km CONUS, 12 km WESTUS and 4 km Inter-Mountain West domains, across each individual western state and at individual monitoring sites within each western state, including Colorado[20] that is the main focus of the CARMMS.
  - The surface meteorological model performance statistics were compared against model performance evaluation benchmarks in order to help interpret the WRF model performance and compare it with other studies that were used to develop the benchmarks. The 2008 WRF model performance was compared against both the

[19] http://www.wrapair2.org/pdf/WestJumpAQMS_2008_Annual_WRF_Final_Report_February29_2012.pdf
[20] http://www.wrapair2.org/pdf/westjump.wrf.site.co.2012-04-04.pdf

simple (simple terrain and/or simple meteorological conditions) and complex (complex terrain and/or more complex meteorological conditions) model performance benchmarks.

- The WRF 2008 precipitation estimates were compared with monthly analysis fields generated by the Climate Prediction Center (CPC) in a qualitative evaluation.

Appendix A summarizes some of the WestJumpAQMS WRF model performance evaluation products as they relate to WRF performance within the CARMMS 4 km modeling domain. The WestJumpAQMS 2008 WRF model performance within the CARMMS region is as good or better than meteorological model performance seen in past photochemical modeling studies of the region (e.g., WRAP regional haze modeling and Denver 2008 ozone State Implementation Plan modeling). Thus, the WestJumpAQMS 2008 WRF meteorological fields were judged to be appropriate for use in the CARMMS.

2.5 2008 BASE CASE EMISSIONS

The 2008 Base Case emissions were developed by the WestJumpAQMS. The primary source for the 2008 Base Case emissions is Version 2.0 of the National Emissions Inventory (NEIv2.0[21]). For most source categories, the SMOKE emissions modeling system was used to process the emissions into the hourly gridded speciated emissions needed as input for CAMx. The comprehensive and detailed documentation for the WestJumpAQMS 2008 Base Case emissions inventory is available on the WestJumpAQMS website[22] and includes a final report (ENVIRON, Alpine and UNC, 2013) and 16 Emissions Technical Memorandums that provide details on the 2008 emissions for each source category as well as for the parameters used in the emissions modeling.

2.5.1 Source of 2008 Base Case Emissions

Table 2-4 summarizes the emission models and sources of 2008 Base Case emissions that are based primarily on the 2008 NEIv2.0 with the following enhancements:

- Major (≥25 MW) Electrical Generating Units (EGUs) point source SO_2 and NO_X emissions used Continuous Emissions Monitor (CEM) measurement data that are available online from the EPA Clean Air Markets Division (CAMD[23]). These data are hour-specific for SO_2, NO_x and heat input. The temporal variability of other pollutant emissions (e.g., PM) for the CEM sources were estimated using the hourly CEM heat input data to allocate the annual emissions from the NEIv2.0 to each hour of the year. Emissions, locations and stack parameters for point sources without CEM devices were based on the 2008 NEIv2.0.
- The WRAP-IPAMS Phase III 2006 oil and gas emission inventories were projected to 2008 for all Phase III basins that were available at the time of the WestJumpAQMS 2008 emissions development. In addition, under WestJumpAQMS new oil and gas emissions

[21] http://www.epa.gov/ttnchie1/net/2008inventory.html
[22] http://www.wrapair2.org/WestJumpAQMS.aspx
[23] http://www.epa.gov/airmarkets/

inventory was developed for the Permian Basin in southeastern New Mexico/northwestern Texas.

- On-road mobile source emissions were based on the MOVES2010[24] model with county-specific weekday and weekend day VMT and monthly meteorology for the 2008 base case modeling year.
- The WRAP windblown dust (WBD) model [25] was used to generate WBD emissions using day-specific hourly meteorology from the 2008 WRF simulation.
- Sea salt and lightning emissions were generated using the 2008 WRF model hourly gridded output.
- Emissions from fires (wildfires, prescribed burns and agricultural burning) are based on the 2008 fire emissions inventory developed in the Joint Fire Sciences Program (JFSP) Deterministic and Empirical Assessment of Smoke's Contribution to Ozone (DEASCO3[26]) study.
- Biogenic emissions were generated using an enhanced version of the Model of Emissions of Gases and Aerosols in Nature (MEGAN[27]) that was updated by WRAP to better represent biogenic emissions for the western states.
- Mexico emissions were based on the 2008 projections from the 1999 Mexico national emissions inventory.
- The Environment Canada 2006 emissions inventory based on the National Pollutant Release Inventory (NPRI) was used for Canada.
- New spatial surrogates for the emissions were developed using the latest 2010 Census and other data that are now available and includes population and housing statistics for 2010. Details on the new spatial surrogates used for allocating county-level emissions to the 4 km grid cells can be found in the WestJumpAQMS Emissions Technical Memorandum Number 13[28].

[24] http://www.epa.gov/otaq/models/moves/
[25] http://www.wrapair.org/forums/dejf/fderosion.html
[26] https://www.firescience.gov/projects/11-1-6-6/proposal/11-1-6-6_11-1-6_attachment_1_primary.pdf
[27] http://acd.ucar.edu/~guenther/MEGAN/MEGAN.htm
[28] http://www.wrapair2.org/pdf/Memo13_Parameters_Sep30_2013.pdf

Table 2-4. Summary of sources of emissions and emission models used to generate 2008 base case emissions for use in CARMMS.

Emissions Component	Configuration	Details
Model Code	SMOKE Version 3.1	http://www.smoke-model.org/index.cfm
Oil and Gas Emissions	Update WRAP Phase III 2006 to 2008	Seven WRAP Phase III Basins in CO, NM, UT and WY plus add 2008 Permian Basin O&G Emissions
Area Source Emissions	2008 NEI Version 2.0	Western state updates, then SMOKE processing of http://www.epa.gov/ttn/chief/net/2008inventory.html
On-Road Mobile Sources	MOVES2010	County specific emissions run for monthly weekday and weekend days. California based on EMFAC2011.
Point Sources	2008 CEM and Non-CEM Sources	Use 2008 day-specific hourly measured CEM for SO_2 and NO_x emissions for CEM sources, 2008 NEIv2.0 for other pollutants and non-CEM sources
Off-Road Mobile Sources	2008 NEIv2.0	Based on EPA NONROAD model http://www.epa.gov/oms/nonrdmdl.htm
Wind Blown Dust Emissions	WRAP Wind Blown Dust (WBD)	WRAP WBD Model with 2008 WRF meteorology adjusted to be consistent with 2002 WBD modeling
Ammonia Emissions	NEIv2.0	Based on CMU Ammonia Model. Review and update spatial allocation if appropriate.
Biogenic Sources	MEGAN	Enhanced version of MEGAN Version 2.1 from WRAP Biogenics study http://www.wrapair2.org/pdf/WGA_BiogEmisInv_FinalReport_March20_2012.pdf
Fires	2008 DEASCO3	2008 DEASCO3 fire inventory used. http://www.wrapair2.org/pdf/JSFP_DEASCO3_TechnicalProposal_November19_2010.pdf
Temporal Adjustments	Seasonal, day, hour	Based on latest collected information
Chemical Speciation	CB05 Chemical Speciation	CB6 considered but was too new at time study was initiated.
Gridding	Spatial Surrogates based on landuse	Develop new spatial surrogates using 2010 census data and other data
Quality Assurance	SMOKE QA Tools; PAVE, VERDI plots; Summary reports	Follow WRAP emissions QA/QC plan.

2.5.2 On-Road Mobile Sources

The Motor Vehicle Emissions Simulator (MOVES[29]) is EPA's current tool to construct on-road mobile source emissions estimates for national, state, and county level inventories of criteria air pollutants, greenhouse gas emissions, and some mobile source air toxics from highway vehicles. In addition, MOVES can make projections for energy consumption (total, petroleum-based, and fossil-based). EPA requires that all new regulatory modeling studies use the MOVES model for mobile source emissions and MOVES is also recommended for NEPA studies (EPA, 2012c).

The CARMMS/WestJumpAQMS 2008 on-road mobile source emission modeling was conducted using MOVES2010 (EPA, 2012a). On July 31, 2014, EPA released a new version of MOVES (MOVES2014; EPA, 2014a,b). The CARMMS mobile source emissions modeling was conducted in 2013 using MOVES2010, well before the release of MOVES2014. As stated in EPA's MOVES2014 Policy Guidance (EPA, 2014c) "All states other than California should use MOVES2014 for future SIPs in order to take full advantage of the improvements incorporated in this version. However, state and local agencies that have already completed significant work on a SIP with MOVES2010 can continue to use it"[30] (EPA, 2014c).

The WestJumpAQMS ran MOVES2010 configured to estimate 2008 mobile source emissions directly (i.e., emissions inventory mode) at a county level basis by month using the monthly average diurnally varying 2008 WRF meteorological conditions. However, the 3SAQS updated the 2008 and 2020 mobile source emissions using MOVES2010 in the emissions factor mode to generate a lookup table of emissions factors that was used with SMOKE-MOVES and the 2008 WRF gridded hourly meteorological data to generate day-specific hourly gridded on-road mobile source emission inputs. The CARMMS 2021 High, Low and Medium Development Scenarios CAMx source apportionment modeling used the 3SAQS 2020 SMOKE-MOVES on-road mobile source emissions. SMOKE-MOVES spatially allocated the mobile source activity data to the 36/12/4 km modeling domains using spatial surrogates developed using the 2010 census and other data. This includes new spatial surrogate categories specific to new source categories in MOVES (e.g., heavy duty truck idling at rest stops. SMOKE-MOVES also chemically speciated the emissions to the CB05 chemical mechanism using CB05 chemical speciation profiles based on the SPECIATE4.3 database. More details on the 2008 on-road mobile source emissions can be found in the 3SAQS 2008 base case modeling report (Adelman, Shanker, Yang and Morris, 2014).

2.5.3 Area and Non-Road Mobile Sources

The 2008 NEIv2.0 area and non-road emissions were processed using the SMOKE emissions model with new 2010 census spatial surrogates and default temporal and CB05 speciation adjustments. Several source categories within the area and non-road category were removed from the NEIv2.0 so that they could be replaced or updated and separately processed, which allows a more thorough QA/QC analysis. The source categories that were extracted from the NEIv2.0 area and non-road sources for separate treatment or replacement were as follows:

[29] http://www.epa.gov/otaq/models/moves/

[30] http://www.epa.gov/otaq/models/moves/documents/420b14008.pdf

- Oil and gas (O&G) exploration and production sources for locations covered by most of the WRAP Phase III O&G Basins and the Permian Basin were removed from the 2008 NEIv2. They were replaced by the WRAP Phase III 2006 emissions projected to 2008 (see Section 2.5.4). New 2008 O&G emissions were developed for the Permian Basin in southeastern New Mexico/northwestern Texas. The 2008 NEIv2.0 O&G emissions were used for the remainder of the U.S. locations, which includes the Williston and Great Plains Basins (North Dakota and Montana) whose WRAP Phase III emissions were not available at the time of the 2008 emissions inventory development.
- Ammonia emissions due to livestock and fertilizer sources were removed from the NEIv2.0 and processed separately.
- Aircraft, locomotive and marine (ALM) sources were processed separately as their own source group in the emissions modeling. The marine sources do not include large ocean going (Class 3) vessels (Commercial Marine Vessels, CMV) that were processed under the off-shore shipping category.
- Fire emissions were removed from the NEIv2.0 and were replaced by 2008 fire emissions developed as part of the DEASCO3 study.
- Fugitive dust emissions were removed from the NEIv2.0 for separate processing.

Below we summarize the processing area and non-road emissions used from the 2008 NEIv2 in the CARMMS 2008 base case, more details can be found in WestJumpAQMS Technical Memorandum No.2 Area and Non-Road Emissions (Loomis, Morris and Adelman, 2013[31]).

2.5.3.1 Area Sources

The NEI Area (or Non-Point) data category contains emission estimates for sources which individually are too small in magnitude or too numerous to inventory as individual point sources, and which can often be estimated more accurately as a single aggregate source for a County or Tribal area. Area source (non-point) emissions are emissions sources that are summed over a geographic region, rather than specifically located. Examples of area sources include small industrial, residential, consumer product, and agricultural emissions. For emissions modeling purposes, these types of emissions are defined by state and county (or tribal) identifiers, and SCC codes. After extracting the area source categories from the NEIv2.0 as indicated above, the remaining area sources in the NEIv2.0 were processed by SMOKE as their own source category.

2.5.3.2 Non-Road Sources

The NEI Non-Road data categories contain mobile sources which are estimated for version 2.0 of the 2008 NEI using the EPA NONROAD[32] model, run within the National Mobile Inventory Model (NMIM[33]). The non-road emissions have been compiled as both annual total emissions, and average day emissions by month. In order to take the best advantage of the monthly and seasonal variability of the non-road emissions sources, we used the monthly options for SMOKE modeling inputs.

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[31] http://www.wrapair2.org/pdf/Memo_2_Area_Jan22_2013%20review%20draft.pdf
[32] http://www.epa.gov/otaq/nonrdmdl.htm
[33] http://www.epa.gov/otaq/nmim.htm

Note that emissions data for aircraft, locomotives, and commercial marine vessels are not included in the NEI non-road data category starting with the 2008 NEI. These three non-road mobile source categories were handled as special cases, with separate input processing streams. Aircraft engine emissions occurring during Landing and Takeoff Operations (LTO) and the Ground Support Equipment (GSE) and Auxiliary Power Units (APU) associated with the aircraft are now included in the point data category at individual airports in the 2008 NEI. Emissions from locomotives that occur at rail yards are also included in the point data category. In-flight aircraft emissions, locomotive emissions outside of the rail yards, and commercial marine vessel emissions (both underway and port emissions) are included in the Non-Point data category.

2.5.4 2008 Oil and Gas Emissions

For Basins covered by the WRAP-IPAMS Phase III 2006 oil and gas (O&G) emissions available at the time of the 2008 base case emissions development, the WRAP Phase III O&G 2006 emissions were projected to 2008. WestJumpAQMS also developed new 2008 O&G emissions for the Permian Basin in southeastern New Mexico/northwestern Texas. For all other Basins in the U.S. (including Williston and Great Plains Basins whose WRAP Phase III emissions were not available at the time of the 2008 base case development) the 2008 O&G emissions from the NEIv2.0 were used and processed as area and point sources.

2.5.4.1 2008 Phase III O&G Emissions Update

The WRAP Phase III 2006 baseline O&G inventories were projected to 2008 for the following eight WRAP Phase III Basins:

- Denver-Julesburg Basin (CO)
- Piceance Basin (CO)
- Uinta Basin (UT)
- North San Juan Basin (CO)
- South San Juan Basin (NM)
- Wind River Basin (WY)
- Powder River Basin (WY)
- Greater Green River Basin (WY)

The 2008 O&G emission update for the WRAP Phase III and Permian Basins used 2008 O&G production statistics from the Enerdeq database published by IHS Global, also referred to as the "PI Dwight's" database. This database contains production statistics that are consistent and typically of higher quality than the primary data in individual state O&G Commission databases.

Processing of the IHS data for the 2008 projections followed the same methodology as used in the WRAP Phase III study[34]. Summaries of production statistics were extracted from the IHS database, including well count by well type and location, spud count, production of gas by well type and well location, production of liquid petroleum (oil or condensate) by well type and well

[34] http://www.wrapair2.org/PhaseIII.aspx

location, and production of water by well type and well location. All data were summarized at the county and basin level, for tribal and non-tribal land separately as applicable to each basin. No new survey work was conducted for the 2008 O&G emissions update so the analysis did not include any updates of company-specific production statistics as was done in the development of the Phase III 2006 O&G emission inventories. The resulting production statistics data were summarized at the county, tribal and basin levels for all basins including the Permian Basin.

The 2008 production statistics from the IHS database were used to project the Phase III baseline 2006 O&G inventories. The projections will be developed as scaling factors that represented the ratio of the value of a specific activity parameter in 2008 to the value in 2006. The scaling factors were developed at the county and tribal levels for all basins. Scaling factors were then matched to all source categories considered as part of the Phase III inventories, using the same cross-referencing analysis conducted as part of the midterm (2012) projections in the Phase III study. The 2008 to 2006 scaling factors were used to adjust the activity data for the oil and gas emissions.

Where specific scaling factors are estimated to be less than one (1), indicating a reduction in an activity parameter from 2006 to 2008, all emissions factors and activity data will be assumed to be identical in 2008 as in 2006 and the 2006 emissions will be reduced and no emission controls assessment is needed (i.e., when activity is reduced between 2006 and 2008 we are assuming that the same equipment is being used in the field, it is just producing less). In this case, the 2008 emissions will be developed assuming the direct application of the scaling factor with no additional controls.

Where scaling factors are estimated to be greater than one (1), it is assumed that some growth in activity has occurred in the 2006-2008 time period and that new equipment may have been deployed in the field. A controls analysis was conducted specific to each basin and utilizing the control measures identified as part of the WRAP Phase III midterm O&G projections work. The controls analysis only considered broad control factors, rather than detailed analyses as conducted in the Phase III midterm projections. Where no significant impact of controls from federal or state regulations are anticipated in the 2006-2008 time period, no control factors for the specific source category will be assumed.

For Colorado Basins, the permitted O&G 2008 emissions were based on the CDPHE 2008 APEN database rather than projected from the WRAP Phase III 2006 O&G emissions, whose permitted O&G emissions were based on the CDPHE 2006 APEN database. In addition, the Colorado Department of Health and Development (CDPHE) has determined that not all condensate flash VOC emissions that were assumed to be controlled 95% by flares make it to the flare and are instead vented to the atmosphere. Thus, CDPHE has introduced the concept of a Capture Efficiency (CE) for condensate flare control that assumes only 75% of the condensate flash VOC emissions are actually controlled by the flare and the other 25% is released directly to the atmosphere. The CDPHE 75% CE assumption was adopted in the CARMMS/WestJumpAQMS 2008 base case O&G emissions in Colorado. The WRAP Phase III 2006 unpermitted condensate tank O&G emissions are either projected to 2008 (D-J Basin) or the 2008 APEN condensate tank emissions are reduced (Piceance Basin) in order for the total 2008 condensate production in the inventory to match the 2008 IHS database production statistics.

Details on the development of the 2008 O&G emissions for the Colorado Basins, the Uinta and South San Juan Basins and the Wyoming Basins can be found in three WestJumpAQMS Technical Memorandums by, respectively, Bar-Ilan and Morris (2012a[35]), Bar-Ilan and Morris (2012b[36]) and Bar-Ilan and Morris (2012c[37]).

2.5.4.2 2008 Emission Inventory for the Permian Basin

A study prepared by Applied EnviroSolutions, Inc. (AES) on 2007 O&G emissions in the New Mexico portion of the Permian Basin along with 2008 O&G emissions from the Texas Commission on Environmental Quality (TCEQ) was used to develop a comprehensive O&G emissions inventory of the Permian Basin. The Permian Basin lies outside of the CARMMS modeling domain, although Permian Basin emissions are used in the CAMx 36/12 km modeling to provide BCs for the CARMMS 4 km domain. Details on the development of the 2008 O&G emissions for the Permian Basin can be found in WestJumpAQMS Emissions Technical Memorandum Number 4d (Bar-Ilan and Morris, 2013[38]).

2.5.4.3 2008 O&G Emissions for the Remainder of the U.S.

The WRAP Phase III Basins and Permian Basin O&G emissions described above covers most of an area including northwestern TX, NM, CO, UT and WY and all of the 4 km CARMMS domain. For areas within these states not covered by the WRAP Phase III and Permian Basins, and O&G emissions outside of this region, the O&G emissions from the 2008 NEIv2.0 were used. Details on the O&G emissions used in the 2008 base case not covered by the WRAP Phase III Basins can be found in WestJumpAQMS Technical Memorandum No. 4e (Loomis, Adelman, Morris and Bar-Ilan, 2013[39]).

2.5.5 Fire Emissions

2008 emissions from wild fires, prescribed burns and agricultural burning were based on the comprehensive 2008 fire emissions inventory developed as part of the DEASCO3[40] project sponsored by the Joint Fire Science Program (JFSP). The WestJumpAQMS emissions Technical Memorandum Number 5 (Morris, Tai, Loomis and Adelman, 2012[41]) discusses and compares available fire emissions data for 2008. Details on the DEASCO3 fire emissions development methodology[42] and the methodology for fire plume rise and speciation[43] is available on the DEASCO3 website.

2.5.6 Ammonia Emissions

Ammonia emissions were based on the 2008 NEIv2.0 emissions inventory. A vast majority of the ammonia emissions in the 2008 NEIv2.0 were from livestock and fertilizer application that

[35] http://www.wrapair2.org/pdf/Memo_4a_OG_Jun06_2012_Final.pdf
[36] http://www.wrapair2.org/pdf/Memo_4b_OG_June06_2012_Final.pdf
[37] http://www.wrapair2.org/pdf/Memo_4c_OG_Jan23_2013_RevisedFinal.pdf
[38] http://www.wrapair2.org/pdf/Memo_4d_OG_Apr24_2013_Final.pdf
[39] http://www.wrapair2.org/pdf/Final_Memo_4e_RemainderOG_Mar6_2013.pdf
[40] http://www.wrapair2.org/pdf/JSFP_DEASCO3_TechnicalProposal_November19_2010.pdf
[41] http://www.wrapair2.org/pdf/Memo_5_Fires_Apr27_2012_Final.pdf
[42] https://wraptools.org/pdf/ei_methodology_20130930.pdf
[43] https://wraptools.org/pdf/DEASCO3_Plume_Rise_Memo_20131210.pdf

were based on the CMU ammonia model[44]. Updated spatial surrogates for locations of Concentrated Animal Feeding Operations (CAFOs) in Colorado developed as part of the NPS ROMANS study were used to spatially allocate the NEIv2.0 livestock ammonia emissions in Colorado, which greatly improves the ammonia emissions within the CARMMS domain. Details on the development of the ammonia emissions used in the CARMMS 2008 base case can be found in the WestJumpAQMS Technical Memorandum No. 8 (Loomis, Wilkinson, Adelman and Morris, 2013[45]).

2.5.7 Ocean Going Vessels

The 2008 off-shore shipping emissions inventory was based on the 2008 NEIv2.0. These emissions are developed and carried as point sources, rather than the area-level files generally used for off-road mobiles sources, including marine emissions sources. Details on the Off-Shore Shipping emissions are provided in a report "Documentation for the Commercial Marine Vessel Component of the National Emissions Inventory – Methodology" prepared by Eastern Research Group (ERG, 2010[46]) dated March 30, 2010. The WestJumpAQMS emissions Technical Memorandum Number 7 (Loomis, Morris and Adelman, 2012[47]) describes the off-shore shipping emissions and how they were processed for input into the photochemical grid model.

2.5.8 Biogenic Emissions

WRAP performed a Western Biogenic Emissions Update Study that enhanced the MEGAN biogenic emissions model to better simulate biogenic emissions in the western U.S. The CARMMS used the new enhanced version of MEGAN along with the 2008 WRF 36/12/4 km data to generate hourly gridded speciated biogenic emission inputs for 2008 and the CARMMS 4 km domain. Details on the WRAP Biogenic Emissions Update Study can be found in the study's final report (Sakulyanontvittaya, Yarwood and Guenther, 2012[48]) with a summary provided in the WestJumpAQMS emissions Technical Memorandum Number 9 on biogenic emissions (Sakulyanontvittaya et al., 2012[49]).

2.5.9 Spatial Allocation

New spatial allocation surrogates were developed at 4 km resolution for the CONUS domain using the latest 2010 CENSUS and other new data. The 4 km surrogate distributions were used directly for disaggregating the county-level emissions to the 4 km grid cells in the CARMMS modeling domain, as well as collapsed to 36 and 12 km resolution for spatial allocation to the 36 km CONUS and 12 km WESTUS domains used in WestJumpAQMS modeling. Table 2-5 summarizes the spatial surrogates to be used for spatial allocation in the CARMMS/WestJumpAQMS SMOKE emissions modeling. More details are provided in the WestJumpAQMS emissions Technical Memorandum Number 13 on SMOKE modeling parameters (Adelman, Loomis and Morris, 2013[50]).

[44] http://www.cmu.edu/ammonia/
[45] http://www.wrapair2.org/pdf/Memo8_AmmoniaSources_Feb28_2013review_draft.pdf
[46] http://www.epa.gov/ttn/chief/net/nei08_alm_popup.html
[47] http://www.wrapair2.org/pdf/OffshoreShippingEmissionsMemo_7WestJumpAQMS_Jan23_2012.pdf
[48] http://www.wrapair2.org/pdf/WGA_BiogEmisInv_FinalReport_March20_2012.pdf
[49] http://www.wrapair2.org/pdf/Memo_9_Biogenics_May9_2012_Final.pdf
[50] http://www.wrapair2.org/pdf/Memo13_Parameters_Feb28_2013review_draft.pdf

Table 2-5. Spatial surrogate distributions to be used in the SMOKE emissions modeling spatial allocations.

Shapefile	Description	Type	Year	Source
cty_pophu2k_revised	U.S. County Boundaries	Polygon	2005	U.S. Census Bureau
pophu_bg2010	Population/ Housing	Polygon	2010	U.S. Census Bureau
rd_ps_tiger2010	Roadways	Line	2010	U.S. Census Bureau
waterway_ntad2011	Waterways	Line	2010	U.S. Bureau of Transport Statistics
rail_tiger2010	Railways	Line	2010	U.S. Census Bureau
exits**	Highway Exits	Point	2010	ESRI
mjrrds**	Major Roads	Line	2010	ESRI
transterm**	Transportation Terminals	Point	2010	ESRI
fema_bsf_2002bnd	Building footprints	Polygon	2010	FEMA
heating_fuels_acs0510_c2010	Home heating fuels	Polygon	2010	U.S. Census Bureau

2.5.10 Temporal Allocation

Temporal profiles are available from the U.S. EPA for a wide range of emissions sources. While the majority of the temporal profiles available from the EPA represent nationally averaged emissions sources, state-specific monthly profiles exist for prescribed fires, wildfires, livestock, and some mobile sources. For most sources the emissions modeling temporal allocations were based on the U.S. EPA temporal profiles distributed with the 2008 NEIv2.0[51] (filename: amptpro_2008aa_us_can_revised_06oct2011_v0.txt). Several source categories use episode emissions that already have hourly emissions so will not use the temporal allocation profiles. These emissions categories include: large point sources with measured hourly CEM emissions; on-road mobile sources that use the MOVES monthly weekday/weekend day hourly emissions; biogenic emissions from MEGAN; and fire emissions from DEASCO3. The EPA default cross walk file between SCC codes and temporal allocations is available on the NEIv2.0 website[52].

2.5.11 Chemical Speciation

The U.S. EPA develops speciation profiles from information stored in the SPECIATE database[53]. The SPECIATE database is the official repository of volatile organic compound (VOC) and particulate matter (PM) emissions source profiles for different categories of emissions sources. CARMMS SMOKE emissions modeling used the SPECIATE Version 4.3 database released in September 2011 that contains 5,592 profiles of chemical mass fractions from source testing conducted by EPA, state agencies, or published in the literature since the 1970's. Of the profiles in SPECIATE V4.3, 3,570 are for PM sources, 1,775 are for VOC sources, and 247 are for other gases, such as mercury. The most recent update to the SPECIATE database occurred with the release of version 4.4 in February 2014 that includes 5,728 speciation profiles for VOC, PM and mercury. SPECIATE 4.4 was released after CARMMS conducted most of its emissions modeling.

Part of the speciation process for VOCs includes converting inventory reactive organic gases (ROG) to total organic gases (TOG). This step is required because inventoried VOC excludes ethane and methane in the mass of total VOC while the speciation profiles include ethane and

[51] http://www.epa.gov/ttnchie1/net/2008inventory.html
[52] ftp://ftp.epa.gov/EmisInventory/2008v2/doc/scc_eissector_xwalk_2008neiv2.xlsx
[53] http://www.epa.gov/ttnchie1/software/speciate/

methane. Before the speciation profiles can be applied to the inventory, the inventory VOC must be scaled up to account for the missing methane mass. SCC-specific ROG-to-TOG conversion factors are included with the speciation profiles to prepare the inventories for speciation.

The CARMMS CAMx photochemical grid modeling used the Carbon Bond version 05 (CB05) chemical mechanism (Yarwood et al., 2005[54]). The SMOKE emissions modeling was performed using CB05 speciation profiles, based on the SPECIATE V4.3 database, and ROG-to-TOG conversion factors. The Speciation Tool is an interface to the SPECIATE database that develops CB05 VOC speciation profiles for use in the SMOKE emissions modeling. The exception to using the SPECIATE V4.3 VOC speciation profiles was for the WRAP Phase III Basins where Basin-specific CB05 VOC speciation profiles were used for O&G VOC emissions.

2.5.12 Emissions Quality Assurance and Quality Control

The emissions modeling quality assurance (QA) and quality control (QC) procedures developed as part of the WRAP Regional Modeling Center are being used in the CARMMS and WestJumpAQMS emissions modeling (Adelman, 2004). The 2008 base case emissions are processed by major source category in several different "streams" of emissions modeling. This is done in order to assist in the QA/QC of the emissions modeling as it is much easier to identify potential issues in the emissions fields when analyzing single source categories at a time. Each stream of emissions modeling generates a pre-merged CAMx-ready emissions model input with all pre-merged emissions inputs merged together to generate the final CAMx-ready two-dimensional gridded low-level (layer 1) and point source emission inputs. Table 2-6 lists an example of separate streams of emissions modeling by source category that can be used. Also shown in Table 2-6 are the source of the emissions, processing comments and the temporal allocation strategy whose options are as follows:

- Single day per year (aveday_yr)
- Single day per month (aveday_mon)
- Typical Monday, Weekday, Saturday, Sunday per year (mwdss_yr)
- Typical Monday, Weekday, Saturday, Sunday per month (mwdss_mon)
- Emissions estimated for each model simulation day (daily)
- Emissions estimated for each model simulation day with temporal profiles generated with average daily meteorology (daily met)
- Emissions estimated for each model simulation day with temporal profiles generated with hourly meteorology (hourly met)

[54] http://www.camx.com/publ/pdfs/cb05_final_report_120805.aspx

Table 2-6. Emissions processing categories and temporal allocation approach for 2008 Base Case emissions modeling.

No.	Emissions Processing Category (Abbr)	Inventory Source	Temporal	Processing Comments
1	Nonpoint/Area (nonpt)	NEI	mwdss_mon	Remove oil & gas, agricultural NH3, and dust,; includes commercial marine and rail
2	Livestock NH3 (lv)	NEI	mwdss_mon	Do not apply met-based temporal profiles; separate out for possible sensitivity later
3	Fertilizer NH3 (ft)	NEI	mwdss_mon	Group with lv as a full agricultural NH3 sector (ag)
4	Fugitive and Road Dust (fd)	NEI	mwdss_mon	Includes paved and unpaved road dust; apply transport factors but not met factors
5	Residential Wood Combustion (rwc)	NEI	mwdss_mon	Do not apply met-based temporal profiles; separate out for possible sensitivity later
6	Area Oil & Gas from P3 (ogp3)	WRAP P3	mwdss_mon	Basin specific speciation profiles and spatial surrogates (includes Permian Basin)
7	Area Oil and Gas from NEI (ognei)	NEI	MWDSS_mon	Use default speciation and allocations
8	Nonroad mobile (nr)	NEI	mwdss_mon	Includes NMIM commercial marine and rail
9	MOVES RPD (rpd)	MOVES	hourly met	
10	CEM Point (ptcem)	NEI08/CAMD	daily	Anomalies removed from 2008 CAMD data
11	Non-CEM Point (ptncem)	NEI08	mwdss_mon	Removed oil & gas sources from NEI and transferred to ptognei sector
12	Point Oil & Gas from P3 (ptogp3)	WRAP P3	mwdss_mon	WRAP Phase III inventory and Permian Basin
13	Point Oil & Gas from NEI (ptognei)	WRAP NEI	mwdss_mon	Remove NEI oil and gas emissions for counties in WRAP P3/Permian Basins
14	Point Fires (ptfire)	FINN or SMARTFIRE	daily	
15	Commercial Marine (ptseca)	NEI	aveday_mon	Latest version from Emissions Control Area (ECA) rule
16	Lightning NO_x (lnox)		hourly met	Gridded hourly NO emissions tied to WRF convective rainfall (optional)
17	Sea salt (ss)		hourly met	Surf zone and open ocean PM emissions (Optional)
18	Windblown Dust (wbd)	TBD	hourly met	WRAP WBD model one option
19	MEGAN Biogenic (bg)	MEGAN2.1	hourly met	Use new versions of MEGAN V2.10 updated by WRAP for the western U.S.
20	Mexico Area (mexar)	Mexico NEI	mwdss_mon	Mexico inventory projected from 1999 to 2008
21	Mexico Point (mexpt)	Mexico NEI	mwdss_mon	Mexico inventory projected from 1999 to 2013
22	Mexico Mobile (mexmb)	Mexico NEI	mwdss_mon	Mexico inventory projected from 1999 to 2013
23	Canada Area (canar)	Canada NPRI	mwdss_mon	Latest Environment Canada Inventory
24	Canada Point (canpt)	Canada NPRI	mwdss_mon	Latest Environment Canada Inventory
25	Canada Mobile (canmb)	Canada NPRI	mwdss_mon	Latest Environment Canada Inventory
26+	BLM Planning Areas	BLM	Mwdss_mon	Separate processing of O&G and mining emissions in each BLM Planning Area

Separate QA/QC is performed for each separate stream of emissions processing and in each step. SMOKE includes advanced quality assurance features that include error logs when emissions are dropped or added. The QA/QC procedures developed under the WRAP RMC will be used (Adelman, 2004) that includes visual displays that such as:

- Spatial plots of the hourly emissions for each major species (e.g., NO_X, VOC, some speciated VOC, SO_2, NH_3, PM and CO);
- Vertical average emissions plots for major species and each of the grids;
- Diurnal plots of total emissions by major species and by state; and
- Summary tables of emissions for major species for each grid and by major source category.

This QA information will be examined against the original point and area source data and summarized in an overall QA/QC assessment.

Scripts to perform the emissions merging of the appropriate biogenic, on-road, non-road, area, low-level, fire, and point emission files were written to generate the CAMx-ready two-dimensional day-specific hourly speciated gridded emission inputs. The point source and, as available, elevated fire emissions were processed into the day-specific hourly speciated emissions in the CAMx-ready point source format.

The resultant CAMx model-ready emissions were subjected to a final QA using spatial maps, vertical plots and diurnal plots to assure that: (1) the emissions were merged properly; (2) CAMx inputs contain the same total emissions; and (3) to provide additional QA/QC information.

2.6 2008 Base Case Modeling and Model Performance Evaluation

WestJumpAQMS performed a CAMx 2008 4 km Base Case simulation for the CARMMS 4 km modeling domain and conducted a model performance evaluation. The CARMMS model performance evaluation was documented in Section 4.5.3 in the WestJumpAQMS final report (ENVIRON, Alpine and UNC, 2013[55]). The CARMMS study intended to rely on the WestJumpAQMS CAMx model performance evaluation that focused on monthly and annual model performance statistics across the 4 km CARMMS domain for ozone, $PM_{2.5}$ and related species. However, when presenting the CARMMS 2008 Base Case modeling and model performance evaluation results to the IAQRT at a February 28, 2014 meeting, the IAQRT requested that more model performance information be provided. In particular, the IAQRT requested that ozone model performance statistics be calculated using a 60 ppb observed ozone cut-off concentration instead of 40 ppb as used by WestJumpAQMS, and that model performance statistics be provided down to an individual monitoring site. Thus, CARMMS calculated additional ozone model performance statistics using the 60 ppb ozone cut-off and packaged up all of the WestJumpAQMS model performance products for the 4 km CARMMS domain and 2008 Base Case simulation. The result was a 72 Mb zipped file of model performance products that had over 4,500 model performance statistics and displays that

[55] http://www.wrapair2.org/pdf/WestJumpAQMS_FinRpt_Finalv2.pdf

summarized model performance down to the individual monitoring site for each month and for each day of 2008 across the 4 km CARMMS domain. The zipped file of model performance products was provided to the IAQRT.

Appendix B summarizes the CARMMS CAMx 2008 Base Case simulation and model performance evaluation across the 4 km CARMMS domain, including ozone model performance statistics using a 60 ppb observed ozone cut-off threshold as recommended by EPA. The CARMMS CAMx Base Case simulation achieved EPA's ozone model performance goals, except in the winter months (Jan, Feb, Nov and Dec) when a 60 ppb observed ozone cut-off is used. The highest winter ozone events in the CARMMS 4 km domain occur during the winter ozone episodes in the Uinta Basin under cold pool shallow inversion conditions or stratospheric ozone intrusions events that the CARMMS modeling system was either not configured to simulate or has difficulty simulating, respectively. The CARMMS CAMx Base Case simulation also mostly achieved the PM Model Performance Criteria. More details on the CARMMS 2008 4 km base case simulation and model performance evaluation are provided in Appendix B.

3.0 FUTURE YEAR EMISSIONS

The meteorological base year for the CARMMS modeling is 2008. The development of the 2008 Base Case modeling database and emissions scenario was described in Chapter 2. In this section, we describe the development of the future year emissions scenario. The future year emissions scenario modeled is 2021. Projecting future year oil and gas (O&G) emissions has many uncertainties as it depends on economic conditions (e.g., price of natural gas and oil), identification of new O&G plays, availability of exploration and development equipment and regulatory requirements. For CARMMS, future year O&G emissions were developed for a range of potential outcomes that would hopefully bound the actual future year O&G development in the region. CARMMS developed three levels of 2021 future year O&G development within the BLM Colorado Planning Areas:

- High Development Scenario;
- Low Development Scenario; and
- Medium Development Scenario, which is a mitigated version of the High Development Scenario.

There are four general types of future year emissions addressed in CARMMS:

1. BLM-authorized (Federal lands) and other (non-Federal lands) oil and gas and mining emissions within the Colorado BLM planning areas (as well as the BLM Farmington Field Office in northern New Mexico);
2. Oil and gas and other development areas outside of Colorado/northern New Mexico BLM Planning Areas;
3. Remainder future year anthropogenic emissions; and
4. Emissions related to the 2008 base year that remained unchanged in the future year scenarios.

3.1 Western Colorado BLM Planning Area Oil and Gas Emissions

To address emissions from future BLM-authorized (Federal lands) and non-BLM-authorized (non-Federal lands) oil and gas development in the western Colorado planning areas, CARMMS has developed several emission calculators. Existing emissions calculators were improved under CARMMS and representative calculators for "typical" crude oil, conventional gas (with condensate), coal bed natural gas (CBNG), and shale gas within the region have been developed. New information has been incorporated for drilling times; engine configurations; condensate and produced water production; well pad versus offsite gas treatment and storage; well-head, infield, and pipeline compression; and gas/oil production. The ability to readily modify input assumptions, such as production parameters, emission control assumptions, and wellhead equipment configurations, has also been incorporated into the calculators.

The refined emission calculators were used to develop the 2021 future-year O&G emissions inventories for the eight western Colorado BLM planning areas. The O&G emission calculators were also updated using information provided by the BLM New Mexico Farmington Field Office (FFO) petroleum engineers to estimate future year O&G emissions for the Mancos Shale Development area in northern New Mexico.

The following sections summarize the emission calculators used to estimate the O&G and mining emissions for western Colorado and northern New Mexico. Details on the emission calculators are provide in two Technical Memorandums (Grant, Zapert and Morris, 2013a,b) that are included as Appendices C and D.

3.1.1 Overview of Calculators

Emission calculators have been developed for each of the following well types.

- Conventional gas
- Conventional oil
- Shale gas
- Coalbed natural gas (CBNG)

For each well type, a separate self-contained emission calculator spreadsheet contains all of the inputs and calculations need to generate well site emissions.

Additionally, a calculator has been developed to estimate midstream emissions for each area. The midstream emission calculator draws upon Colorado Department of Public Health (CDPHE) Air Pollutant Emission Notice (APEN) emissions for base year emission estimates. Future year midstream emission projections are dependent on the change in oil and gas production in a given planning area which can be updated based on linkages to the by well type emission calculators.

3.1.2 Pollutants

The emission calculators include estimates of emissions of criteria air pollutants (CAPs), greenhouse gases (GHGs), and hazardous air pollutants (HAPs) as follows:

- Criteria Pollutants
  - Carbon monoxide (CO)
  - Nitrogen oxides (NO_X)
  - Particulate matter less than or equal to 10 microns in diameter (PM_{10})
  - Particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$)
  - Sulfur dioxide (SO_2)
  - Volatile Organic Compounds (VOCs)
- Greenhouse Gases[56]
  - Carbon dioxide (CO_2)
  - Methane (CH_4)
  - Nitrous oxide (N_2O)
- Hazardous Air Pollutants (HAPs)[57]

[56] Note that the CARMMS PGM modeling does not use Greenhouse Gas (GHG) emissions, but the emission calculators provide GHG emission estimates so they can be reported in the RMPs.

While lead (Pb) is a criteria pollutant, emissions of lead in the BLM western Colorado planning areas due to O&G and mining activities are extremely low and are therefore not included in this analysis.

HAP emissions were estimated for each emissions source. For oil and gas emissions sources, HAP emissions from venting and combustion source categories were estimated for formaldehyde, n-hexane, benzene, toluene, ethylbenzene, and xylenes (BTEX).

Anthropogenic greenhouse gas emission inventories typically include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. Fluorinated gases are not expected to be emitted in appreciable quantities by any category considered in this emission inventory and were therefore not included in this analysis.

Although the CARMMS emissions calculators calculate HAP and GHG emissions for oil and gas sources, the CARMMS PGM modeling do not use these emissions so they are not included in this report.

3.1.3 Temporal

The calculators estimate annual emissions associated with oil and gas exploration. Baseline emissions are estimated for 2011 with annual emission forecasts made for every year out to 10 years (2021).

3.1.4 Calculator Inputs

The emission calculator for each well type allows for specification of the following inputs.

- Base year oil and gas activity (gas production, oil production, spud counts, active well counts)
- Well decline estimates
- Level of control by source category
- Gas composition
- Equipment configurations (e.g. drill rigs, fracing rigs)
- Gas venting activity (e.g. completions, blowdowns)

The midstream emission calculator includes estimates of base year 2011 gas plant and compressor station emissions are taken from CDPHE APEN data. Base year midstream emissions are projected to future years based upon the gas production in each planning area.

3.1.5 Emission Calculations

Emission calculations for all emission-generating activities were developed based on typical emission inventory methodology. Methods used to estimate emissions from each source category are explained in detail in Appendix C (Grant, Zapert and Morris, 2013a). For each source category, emissions for the 2011 baseline were estimated. Emissions were then

[57] Note that the CARMMS PGM modeling does not use HAPs emissions, but the emission calculators provide HAPs emission estimates so they can be reported in the RMPs.

forecasted to future years, accounting for activity growth and for applicable sources emissions controls.

The methodologies described here are used consistently in all four calculators by well type; however the input data of each calculator was selected to best reflect the operational characteristics of each well type (oil, gas, CBNG, and shale gas) and thus obtained from literature sources including the following Air Quality Technical Support Documents (AQTSD) from Colorado field office planning areas and BLM emission calculators:

- White River AQTSD (URS, 2012a)
- Colorado River Valley AQTSD (URS, 2012b)
- Grand Junction AQTSD (BLM, 2012b)
- Uncompahgre AQTSD (in preparation)
- BLM Crude Oil Well Gas Emission Calculator
- BLM Coalbed Natural Gas Well Emission Calculator

Emissions are generated in three main phases of oil and gas systems:

- Emissions from Well Construction and Development
- Emissions from the Production Phase (occurring at-or-nearby the well pad)
- Emissions from Midstream Sources (Central Gas Compression and Processing)

The methodologies implemented to estimate base year and future year emissions from oil and gas sources are explained in Appendix C (Grant, Zapert and Morris, 2013a) and covered the following source categories:

- Well pad construction and development:
    - Well pad, access road and pipeline construction equipment;
    - Well pad, access road and pipeline construction traffic;
    - Drilling and completion equipment;
    - Fracing equipment;
    - Refracing equipment;
    - Drilling and well completion traffic;
    - Well pad, access road and pipeline construction wind erosion; and
    - Well completion venting.
- Production phase emissions:
    - Well workover equipment;
    - Production traffic;
    - Blowdown venting;
    - Well recompletion venting;
    - Pneumatic devices and fugitive components;

- Water injection pumps;
- Compressor station maintenance traffic exhaust and fugitive dust;
- Condensate or oil tanks flashing and working and breathing losses;
- Loading emissions from condensate and oil tanks;
- Haul trucks traffic emissions;
- Heaters; and
- Dehydrators;

- Midstream sources:
  - Natural gas processing facilities;
  - Natural gas compressor stations; and
  - Gas sweetening.

The oil and gas emission calculators are designed to estimate emissions from both BLM-authorized and non-BLM-authorized activities within the western Colorado BLM planning areas. Emissions were also estimated for coal and uranium mines on federal lands in the western Colorado BLM planning areas. However, unlike the oil and gas emissions, emissions from mines not on federal lands were not estimated and were obtained from the EPA 2020 projections. The emissions for mines on federal lands were estimated for the baseline (2011) and future years and were based on the CDPHE APEN database and available EISs and EAs. Details on the mining emissions are given in Appendix D (Grant, Zapert and Morris, 2013b). Emissions were estimated for the following mines (BLM field office in parenthesis):

- Book Cliffs Area (Grand Junction).
- McClane (Grand Junction).
- Oak Mesa Area (Uncompahgre).
- King (Tres Rios).
- Foidel (Kremmling).
- Deserado (White River).
- Trapper (Little Snake).
- Colowyo (Little Snake).
- Sage Creek (Little Snake).
- West Elk (Uncompahgre).
- Elk Creek (Uncompahgre).

3.2 Oil and Gas Emissions outside of the BLM Western Colorado Planning Areas

The following three sections describe the procedures for estimating baseline and future year oil and gas emissions for areas within the CARMMS 4 km modeling domain but outside of the western Colorado BLM planning areas.

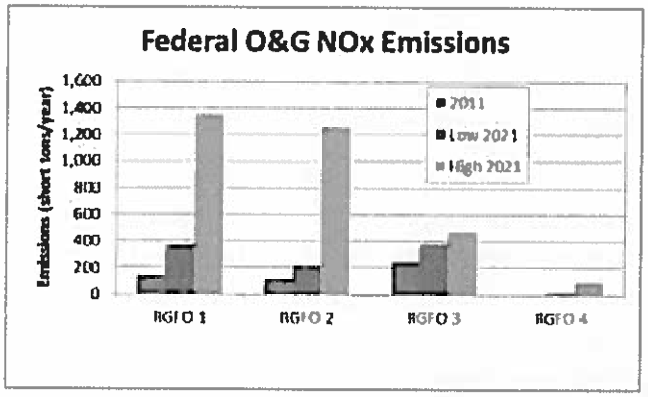
3.2.1 Colorado Royal Gorge Field Office

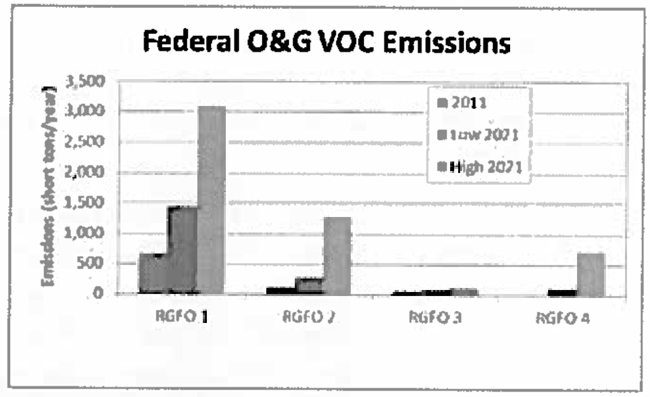
Baseline and future year oil and gas emissions for the BLM Royal Gorge Field Office[58] (RGFO) planning area in eastern Colorado were developed by the BLM COSO using RGFO specific oil and gas RFD estimates and air pollutant emissions calculators designed specifically for eastern Colorado oil and gas development / operations. Due to the geographic size and diversity of the RGFO, the RGFO was divided into four unique geographic areas and baseline and projected emissions inventories were developed for each RGFO area. Future year 2021 oil and gas emissions estimates were developed for future "permitted" and "non-permitted" activities. To develop the year 2021 "permitted" oil and gas emissions estimates, the year 2011 APENs emissions for each RGFO area was scaled using the year 2011 oil and gas production data with projected year 2021 oil and gas production data. The APENs based projections account for all permitted source types but do not include non-permitted sources such as pneumatics, small tanks and some fugitives. To account for "non-permitted" activities in the DJ Basin, WRAP Phase III emissions inventories for non-permitted sources and production data were used to develop production average emissions factors for non-permitted sources / activities and these emissions factors were then used with future projected year 2021 production rates to develop a future year 2021 non-permitted oil and gas emissions inventory for the DJ Basin. For eastern and southeastern portions of the RGFO, a CENRAP oil and gas emissions inventory report was used with projected future year 2021 production data to develop future non-permitted oil and gas emissions estimates similar to what was completed for the DJ Basin. For the Raton Basin, oil and gas operators were specifically queried for operations / activities that are not routinely permitted and future projected year 2021 non-permitted emissions estimates for these activities were made using that information. In addition to the "permitted" and "non-permitted" RGFO emissions inventories described above, oil and gas development and production related traffic emissions were developed for year 2021. The "RFD / High" and "Low" emissions scenarios assumed on-the-books controls and the "RFD-Controlled / Medium" scenario assumes the following enhanced emissions controls for future projected Federal oil and gas: no venting during blow-downs, 30% electrification, Tier 4 drill and completion engines, 80% dust control to unpaved roads, 50% dust controls for well-pad and road construction disturbed areas and 50% of small non-permitted condensate tanks are assumed controlled.

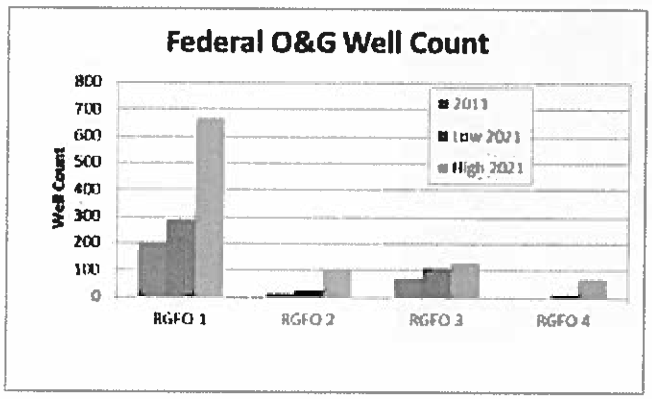
The following charts show year 2011 and projected year 2021 RGFO NOx and VOC emissions estimates and well counts for the CARMMS Low and High modeling scenarios. As shown in the plots, projected year 2021 Federal O&G related emissions for the RFD / High Scenario are higher than projected year 2021 Federal O&G emissions estimates for the Low scenario. For the cumulative plots, future year 2021 cumulative (Federal and non-Federal) emission estimates for the Low Scenario (projected development based on recent development rates) are higher than the RFD / High Scenario and are being driven by the non-Federal oil and gas projection estimates. The current annual non-Federal oil and gas development rates are higher than the

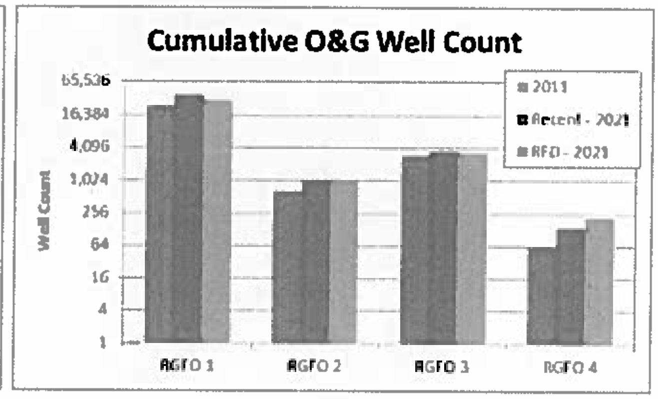
[58] http://www.blm.gov/co/st/en/fo/rgfo.html

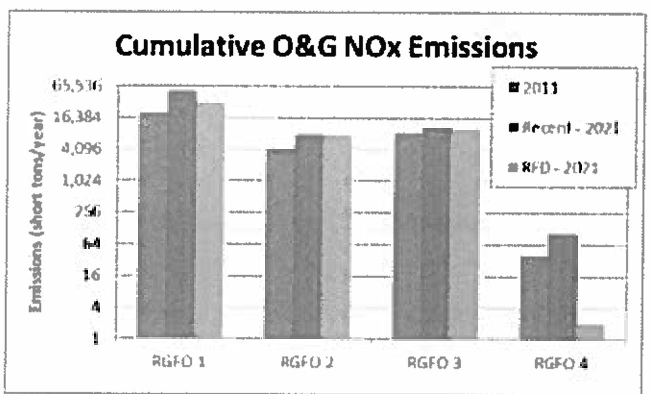
RFD projected estimates primarily because the RFD analysis assumes that current annual non-Federal development rates are not sustainable.

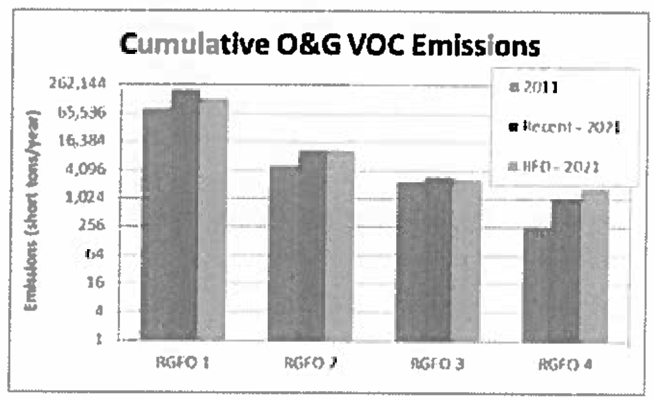












3.2.2 South San Juan Basin, New Mexico

Oil and gas emissions for the New Mexico BLM Farmington Field Office in the South San Juan Basin that includes San Juan, Rio Arriba, Sandoval and McKinley Counties were estimated based on oil and gas activity provided by the New Mexico BLM State and Farmington Field Office for the Mancos Shale Play and 2012 WRAP Phase III inventories for oil and gas emissions in the South San Juan basin. Figure 3-1 displays the Mancos Shale oil and gas development area in northwestern New Mexico in relation to BLM Planning Areas (note that the Mancos Shale extends into southern Colorado Tres Rios Field Office Planning Area). Figure 3-2 displays a detailed map of the Mancos Shale development area; the formation is split into an oil prone area in the south and a gas prone area to the north. The oil development is expected to occur at a rate of approximately 200 wells per year starting around 2015. The development of the gas prone area to the north (dry gas with little or no fluids) is dependent on the price of natural gas and is expected to be intensively developed starting approximately four years after the oil prone area (~2019).

70% of the new O&G emissions due to the Mancos Shale development are assumed to occur on Federal lands (i.e., BLM-authorized) and these emissions will be attributed to the New Mexico BLM Farmington Field Office even though there are small amounts of emissions within the BLM Colorado Tres Rios Field Office Planning Area.

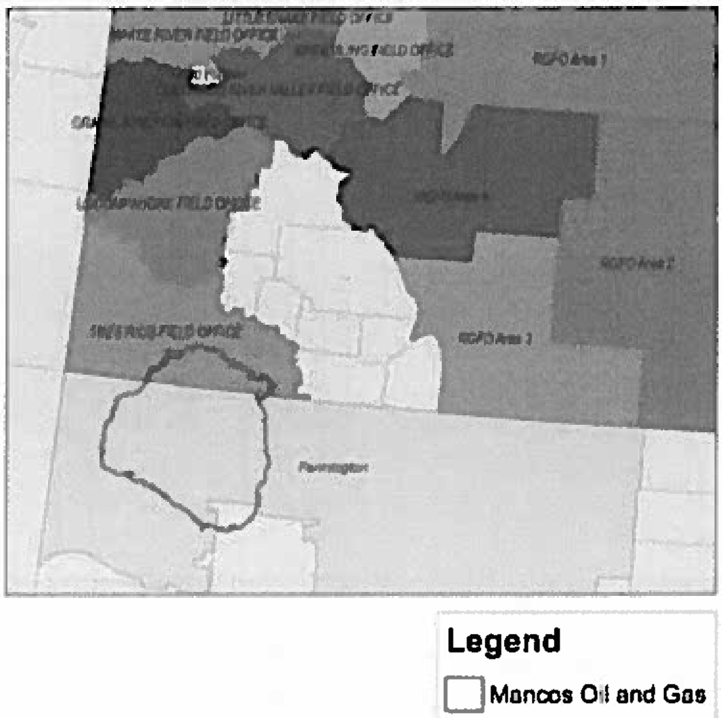


Figure 3-1. Mancos Shale development area (shown with other oil and gas source areas from CARMMS).

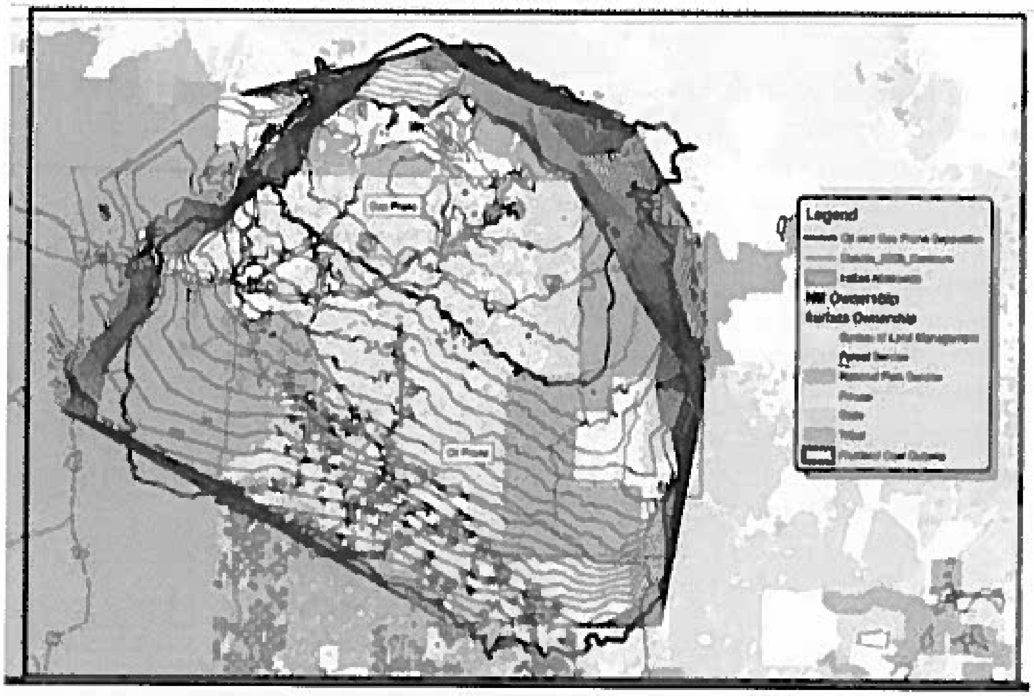


Figure 3-2. Map of oil and gas prone development areas within the Mancos Shale Oil formation primarily in the New Mexico BLM FFO planning area.

To address emissions from future BLM-authorized (Federal lands) and non-BLM-authorized (non-Federal lands) oil and gas development in the South San Juan Basin, BLM commissioned development of Mancos Shale emission calculators. CARMMS emission calculators were modified and adapted to develop two new Mancos Shale emission calculators, one for oil wells and another for gas wells drilled in the Mancos Shale formation. Mancos Shale oil and gas well information has been incorporated for all phases of well development and production emissions to the extent that Mancos Shale specific data was available based on information provided by the BLM New Mexico Farmington Field Office (FFO) petroleum engineers. The ability to readily modify input assumptions, such as production parameters, emission control assumptions, and wellhead equipment configurations, has also been incorporated into the calculators.

The Mancos Shale emission calculators were used to develop the 2021 future-year O&G emissions inventories for oil and gas activity associated with the Mancos Shale formation. The oil and gas emission calculators are designed to estimate emissions from both BLM-authorized and non-BLM-authorized activities for the Mancos Shale formation emissions.

Pollutants included in the Mancos Shale calculators, temporal considerations, and calculator inputs are all consistent with the CARMMS calculators as described in Sections 3.1.2, 3.1.3, and 3.1.4, respectively.

3.2.2.1 Emission Calculations

Emission calculations for all Mancos Shale emission-generating activities were developed based on typical emission inventory methodology. Methods used to estimate emissions from each source category are consistent with the CARMMS Western Colorado Planning Area calculators explained in detail in Appendix C (Grant, Zapert and Morris, 2013a). For each source category, emissions were estimated for all years of activity, accounting for activity growth and for applicable sources, emissions controls.

The methodologies described here are used consistently in both oil well and gas well Mancos Shale calculators; however the input data of each calculator was selected to best reflect the operational characteristics of each well type (oil and gas) and thus obtained from either BLM New Mexico Farmington Field Office (FFO) petroleum engineers provided well characteristics data or from CARMMS Western Colorado oil and gas calculators.

Emissions are generated in three main phases of oil and gas systems:

- Emissions from Well Construction and Development
- Emissions from the Production Phase (occurring at-or-nearby the well pad)
- Emissions from Midstream Sources (Central Gas Compression and Processing)

The methodologies implemented to estimate base year and future year emissions from oil and gas sources are explained in Appendix C (Grant, Zapert and Morris, 2013a) using the emissions calculators for source categories discussed in Section 3.1.5.

Recent trends in gas production in the South San Juan Basin show consistent decline since 2006 (Figure 3-3). Average decline over the 2006 to 2013 period is about 42 billion cubic-feet (BCF) per year, with the largest drop in production occurring from 2012 to 2013 (64 BCF). Over the ten year period from 2011 to 2021, the average annual historical rate of decline would result in a loss of 420 BCF and the most recent, maximum rate of annual decline would result in a loss of 640 BCF. The total gas production estimated to be added to 2021 for the Mancos Shale for the high development scenario is about 510 BCF per year. Given existing midstream capacity and recent declines in gas production in the South San Juan Basin, additional emissions at midstream sources (i.e. compressor stations and gas plants) were assumed negligible for the Mancos Shale development.

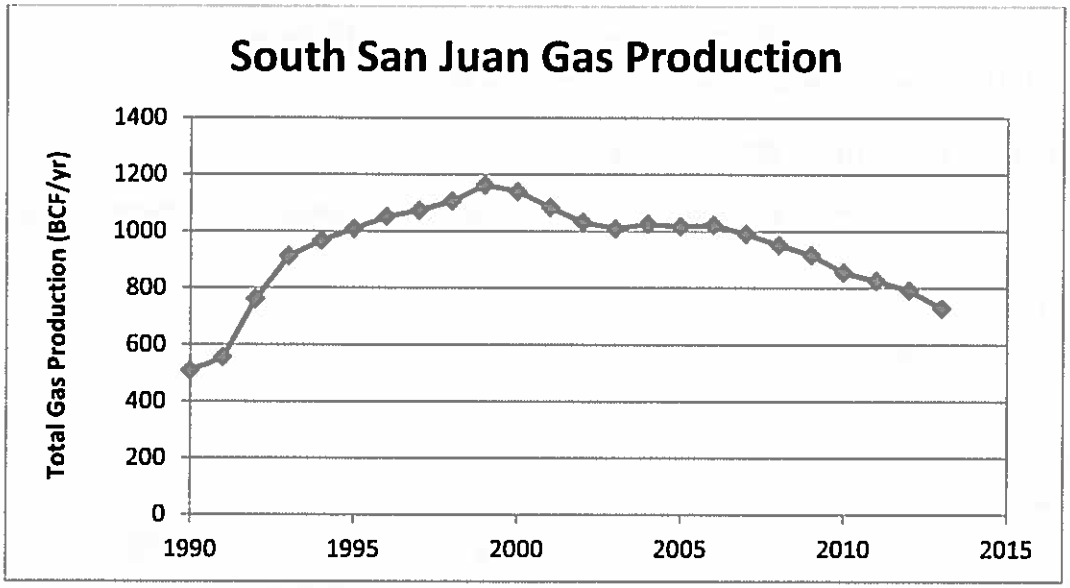


Figure 3-3. Historical gas production in the South San Juan Basin (including Rio Arriba, San Juan, Sandoval, and McKinley Counties).

3.2.3 Uinta Basin, Utah

Baseline and future year emissions associated with oil and gas development in the Uinta Basin have been estimated by AECOM for the BLM Utah State Office (UTSO[59]) under the UTSO Air Resource Management Study (ARMS). The UTSO ARMS is using a 2010 baseline year. More details on the oil and gas emissions for the Uinta Basin are available in the UTSO ARMS documentation (AECOM, 2013[60]).

3.2.4 Southwestern Wyoming

Oil and gas development emissions for southwestern Wyoming were based on recent BLM Environmental Impact Statements (EISs), including those compiled as part of the draft EIS for the Continental Divide-Creston Natural Gas Project[61].

3.3 Other Anthropogenic Emissions

Other anthropogenic emissions (i.e., non O&G and BLM authorized mining sources) for the 2021 future year were based on 2020 emission projections compiled by the 3SAQS that were based on EPA's 2020 projections used in the $PM_{2.5}$ NAAQS rulemaking, which used EPA's 2007v5 modeling platform[62]. Emissions associated with oil and gas emissions within the western Colorado, Royal Gorge, North San Juan Basin, Uinta Basin and southwest Wyoming Basin described in Section 3.2 above were removed from the 2020 3SAQS/NEI to avoid double counting. Similarly, mining emissions on federal lands in the western Colorado BLM planning areas were also removed from the 2020 NEIs and replaced by estimates from the CARMMS calculators.

[59] http://www.blm.gov/ut/st/en.html
[60] http://www.blm.gov/pgdata/etc/medialib/blm/ut/natural_resources/airQuality.Par.34346.File.dat/UTSO_EmissionsTSD121913.pdf
[61] http://www.blm.gov/wy/st/en/info/NEPA/documents/rfo/cd_creston.html
[62] http://www.epa.gov/ttnchie1/emch/

Details on the development of the 2020 NEI can be found in the 2020 Emissions Technical Support Document (TSD) for the $PM_{2.5}$ NAAQS rule (EPA, 2012d[63]).

3.4 Emissions that Remain at 2008 Levels

The following emission categories from the 2008 Base Case emissions scenario (see Section 2.5) were assumed to remain unchanged for the 2021 future year emission scenarios:

- Biogenic emissions.
- Wildfires, Prescribed Burns and Agricultural Burning emissions.
- Lightning emissions.
- Sea Salt emissions.
- Windblown Dust emissions.
- Emissions from Canada, Mexico and offshore sources (used in the 2021 36/12 km simulation used to provide boundary conditions for the 4 km CARMMS domain).

3.5 Western Colorado BLM Planning Area Oil and Gas Emissions

The emission calculators were used to generate O&G emissions for the eleven-year period of 2011-2021 for 8 western Colorado BLM Planning Areas:

- Roan Plateau portion of the Colorado River Valley Field Office (CRVFO)
- CRVFO outside of the Roan Plateau
- Grand Junction Field Office (GJFO)
- Kremmling Field Office (KFO)
- Little Snake Field Office (LSFO)
- Tres Rios Field Office (TRFO)
- Uncompahgre Field Office (UFO)
- White River Field Office (WRFO)

For each year between 2011-2021, the emissions calculators were used to estimate O&G emissions for upstream (well site) and midstream emission sources and for O&G development on Federal and non-Federal lands within in each of the 8 western Colorado BLM Planning Areas listed above.

3.5.1 2021 High, Low and Medium Development Scenarios

The emissions calculators were used to generate O&G emissions within the 8 western Colorado BLM Planning Areas for 2021 High, Low and Medium Development Scenarios. The High Development Scenario is based on BLM COSOs estimates of RFD O&G future development within these 8 BLM Planning Areas. The Low Development Scenario is based on historical 5-year average O&G development over the 2008-2012 period that was used to grow O&G

[63] http://epa.gov/ttn/chief/emch/2007v5/2007v5_2020base_EmisMod_TSD_13dec2012.pdf

emissions to each year between 2011-2021. Applicable State and Federal controls are applied to the O&G emissions starting in the year that they are required.

The Low Development Scenario assumes 25,710 total active wells in 2021 within the 8 western Colorado BLM Planning Areas with 8,121 wells (32%) on Federal and 17,589 wells (68%) on non-Federal lands. The High Development Scenario assumes 41,033 total active wells, 1.6 times higher than the Low Development Scenario, that are split as 18,347 on Federal (45%) and 22,686 (55%) on non-Federal lands. The 2021 Medium Development Scenario has the same number of wells as the High Development Scenario but assumes additional levels of controls beyond the application of existing state and federal requirements. The Medium Development Scenario assumes additional control of engine and fugitive emission sources for all phases of well-site operation for wells drilled on Federal land after 2015 as follows:

- All development (drilling / completion / fracing) engines will be Tier 4. Tier 4 gen-set standards will be applied for all engines with a horsepower >750; final Tier 4 standards will be applied to all engines with horsepower <750.
- All condensate tank, oil tank, and dehydrator emissions are captured and controlled by VRUs (assumed 95% control efficiency attained by vapor recovery).
- All pneumatic devices are low-bleed or no bleed. Assumed 50% of devices are low-bleed (6 cfh) and 50% of devices are no-bleed.
- Assume that 30% of production engines are powered by electricity (applies to all well-site engines).
- Assume 80% dust control for unpaved road traffic.
- All truck loading emissions are captured and controlled by VRU.

Table 3-1 and Figure 3-4 compare the total emissions from the 8 western Colorado BLM Planning Areas for the 2021 High, Low and Medium Development emission scenarios.

Table 3-1. Comparison of oil and gas emissions (tons per year, TPY) from the 8 western Colorado BLM Planning Areas for 2021 High, Low and Medium Development emission scenarios.

Scenario	VOC	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2
All Wells						
Low	44,025	22,715	25,078	4,425	1,270	259
Medium	78,654	45,453	51,983	7,224	2,355	1,145
High	95,427	46,014	56,666	9,482	2,714	1,145
Federal Emissions						
Low	13,950	7,369	7,939	1,233	424	190
Medium	30,254	22,811	26,003	2,763	1,118	971
High	47,007	23,371	29,879	4,996	1,452	972
Non-Federal Emissions						
Low	30,075	15,346	17,139	3,191	846	69
Medium	48,399	22,642	25,979	4,461	1,237	174
High	48,420	22,642	26,787	4,486	1,262	174

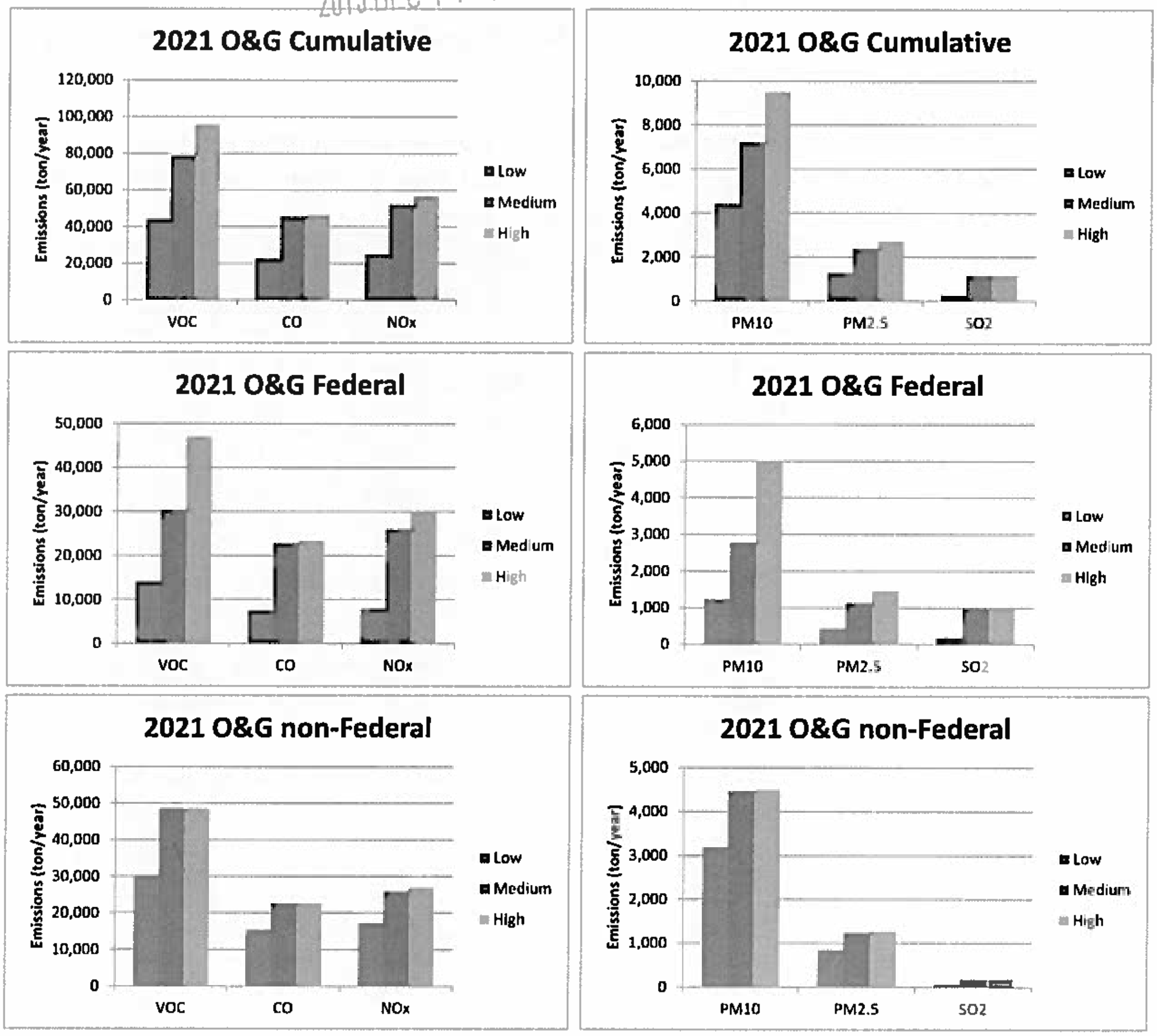


Figure 3-4. Comparison of total oil and gas emissions from the 8 western Colorado BLM Planning Areas for the 2021 High, Low and Medium Development Scenarios.

3.5.2 2021 High, Low and Medium Development Scenarios

The CARMMS air quality modeling results for the 2021 High, Low and Medium Development Scenarios are presented in Chapter 5. In this section we summarize the emissions for the 8 western Colorado BLM Planning Areas and the three 2021 emission scenarios. Figure 3-5 and Table 3-2 display the NO_X and VOC O&G emissions for the 8 western Colorado BLM Planning Areas and the 2011 current year emissions and the three 2021 emission scenarios stratified by O&G emissions on Federal and non-Federal lands. Summary spreadsheets (not shown) also include emissions stratified by upstream vs. midstream and provide emissions per well. Across the 8 Colorado Planning Areas, the 2021 High Development Scenario O&G NO_X and VOC emissions are, respectively, 2.6 and 2.7 times greater than in 2011, whereas the 2021 Low Development Scenario are 1.1 and 1.3 times greater than 2011, so the 2021 Low Development Scenario emissions are very similar to 2011 O&G emission levels. The controls assumed in the

2021 Medium Development Scenario reduce O&G NO_X and VOC emissions by -8.2% and -17.6% from the 2021 High Development Scenario.

Table 3-2a. Summary of oil and gas NO_X and VOC emissions within the 8 western Colorado BLM Planning Areas for the 2011 current year and 2021 High Development emission scenarios (2021 emissions include both existing and new O&G sources).

2011	NO_X Emissions (TPY)			VOC Emissions (TPY)		
BLM Area	Federal	non-Fed	Total	Federal	non-Fed	Total
CRVFO (No Roan)	1,036	3,575	4,611	2,596	10,407	13,003
Roan (CRVFO)	1,280	2,158	3,438	1,962	3,356	5,318
GJFO	535	2,976	3,511	634	4,032	4,665
KFO	69	40	108	150	138	288
LSFO	741	189	930	1,493	415	1,907
TRFO	879	4,551	5,431	837	3,243	4,080
UFO	61	76	137	55	65	120
WRFO	3,296	736	4,032	4,433	1,052	5,485
Grand Total	7,896	14,301	22,198	12,159	22,708	34,867
2021 High Scenario	**NO_X Emissions (TPY)**			**VOC Emissions (TPY)**		
BLM Area	**Federal**	**non-Fed**	**Total**	**Federal**	**non-Fed**	**Total**
CRVFO (No Roan)	1,679	4,639	6,318	5,070	14,287	19,357
Roan (CRVFO)	1,835	1,856	3,692	2,971	3,425	6,395
GJFO	7,670	10,291	17,961	13,744	20,230	33,974
KFO	236	221	458	424	326	750
LSFO	2,320	1,723	4,042	3,334	2,349	5,683
TRFO	3,386	5,096	8,482	2,289	3,861	6,150
UFO	612	1,067	1,679	620	1,082	1,702
WRFO	12,141	1,893	14,034	18,556	2,859	21,415
Grand Total	29,879	26,787	56,666	47,007	48,420	95,427
Difference	**NO_X Emissions (TPY)**			**VOC Emissions (TPY)**		
BLM Area	**Federal**	**non-Fed**	**Total**	**Federal**	**non-Fed**	**Total**
CRVFO (No Roan)	62%	30%	37%	95%	37%	49%
Roan (CRVFO)	43%	-14%	7%	51%	2%	20%
GJFO	1333%	246%	412%	2069%	402%	628%
KFO	244%	455%	322%	183%	136%	160%
LSFO	213%	813%	335%	123%	467%	198%
TRFO	285%	12%	56%	173%	19%	51%
UFO	903%	1302%	1124%	1025%	1565%	1317%
WRFO	268%	157%	248%	319%	172%	290%
Grand Total	278%	87%	155%	287%	113%	174%

Table 3-2b. Summary of oil and gas NO_X and VOC emissions within the 8 western Colorado BLM Planning Areas for the 2011 current year and 2021 Medium Development emission scenarios (2021 emissions include both existing and new O&G sources).

2011	NO_X Emissions (TPY)			VOC Emissions (TPY)		
BLM Area	Federal	non-Fed	Total	Federal	non-Fed	Total
CRVFO (No Roan)	1,036	3,575	4,611	2,596	10,407	13,003
Roan (CRVFO)	1,280	2,158	3,438	1,962	3,356	5,318
GJFO	535	2,976	3,511	634	4,032	4,666
KFO	69	40	109	150	138	288
LSFO	741	189	930	1,493	415	1,908
TRFO	879	4,551	5,430	837	3,243	4,080
UFO	61	76	137	55	65	120
WRFO	3,296	736	4,032	4,433	1,052	5,485
Grand Total	7,896	14,301	22,197	12,159	22,708	34,867
2021 Medium Scenario	**NO_X Emissions (TPY)**			**VOC Emissions (TPY)**		
BLM Area	Federal	non-Fed	Total	Federal	non-Fed	Total
CRVFO (No Roan)	1,428	4,459	5,887	3,174	14,283	17,457
Roan (CRVFO)	1,613	1,820	3,433	2,438	3,424	5,862
GJFO	6,517	9,927	16,444	6,158	20,221	26,379
KFO	197	213	410	245	326	571
LSFO	2,092	1,680	3,772	2,690	2,348	5,038
TRFO	2,984	5,033	8,017	1,876	3,860	5,735
UFO	486	1,012	1,498	531	1,081	1,611
WRFO	10,686	1,835	12,522	13,142	2,857	15,999
Grand Total	26,003	25,979	51,983	30,254	48,399	78,654
Difference	**NO_X Emissions (TPY)**			**VOC Emissions (TPY)**		
BLM Area	Federal	non-Fed	Total	Federal	non-Fed	Total
CRVFO (No Roan)	38%	25%	28%	22%	37%	34%
Roan (CRVFO)	26%	-16%	0%	24%	2%	10%
GJFO	1118%	234%	368%	871%	402%	465%
KFO	185%	433%	276%	63%	136%	98%
LSFO	182%	789%	306%	80%	466%	164%
TRFO	239%	11%	48%	124%	19%	41%
UFO	696%	1232%	993%	865%	1563%	1243%
WRFO	224%	149%	211%	196%	172%	192%
Grand Total	229%	82%	134%	149%	113%	126%

Table 3-2c. Summary of oil and gas NO_X and VOC emissions within the 8 western Colorado BLM Planning Areas for the 2011 current year and 2021 Low Development emission scenarios (2021 emissions include both existing and new O&G sources).

2011	NO_X Emissions (TPY)			VOC Emissions (TPY)		
BLM Area	**Federal**	**non-Fed**	**Total**	**Federal**	**non-Fed**	**Total**
CRVFO (No Roan)	1,036	3,575	4,611	2,596	10,407	13,003
Roan (CRVFO)	1,280	2,158	3,438	1,962	3,356	5,318
GJFO	535	2,976	3,511	634	4,032	4,666
KFO	69	40	109	150	138	288
LSFO	741	189	930	1,493	415	1,908
TRFO	879	4,551	5,430	837	3,243	4,080
UFO	61	76	137	55	65	120
WRFO	3,296	736	4,032	4,433	1,052	5,485
Grand Total	7,896	14,301	22,197	12,159	22,708	34,867
2021 Low Scenario	**NO_X Emissions (TPY)**			**VOC Emissions (TPY)**		
BLM Area	**Federal**	**non-Fed**	**Total**	**Federal**	**non-Fed**	**Total**
CRVFO (No Roan)	1,212	3,334	4,546	3,701	10,456	14,157
Roan (CRVFO)	1,248	1,856	3,104	2,208	3,425	5,633
GJFO	819	5,229	6,049	1,203	10,107	11,310
KFO	80	94	175	127	145	272
LSFO	592	389	980	972	536	1,508
TRFO	1,051	5,261	6,313	782	3,931	4,712
UFO	176	127	303	200	140	340
WRFO	2,760	849	3,609	4,758	1,336	6,093
Grand Total	7,939	17,139	25,078	13,950	30,075	44,025
Difference	**NO_X Emissions (TPY)**			**VOC Emissions (TPY)**		
BLM Area	**Federal**	**non-Fed**	**Total**	**Federal**	**non-Fed**	**Total**
CRVFO (No Roan)	17%	-7%	-1%	43%	0%	9%
Roan (CRVFO)	-3%	-14%	-10%	13%	2%	6%
GJFO	53%	76%	72%	90%	151%	142%
KFO	16%	136%	60%	-16%	5%	-6%
LSFO	-20%	106%	5%	-35%	29%	-21%
TRFO	20%	16%	16%	-7%	21%	15%
UFO	189%	67%	121%	264%	116%	184%
WRFO	-16%	15%	-11%	7%	27%	11%
Grand Total	1%	20%	13%	15%	32%	26%

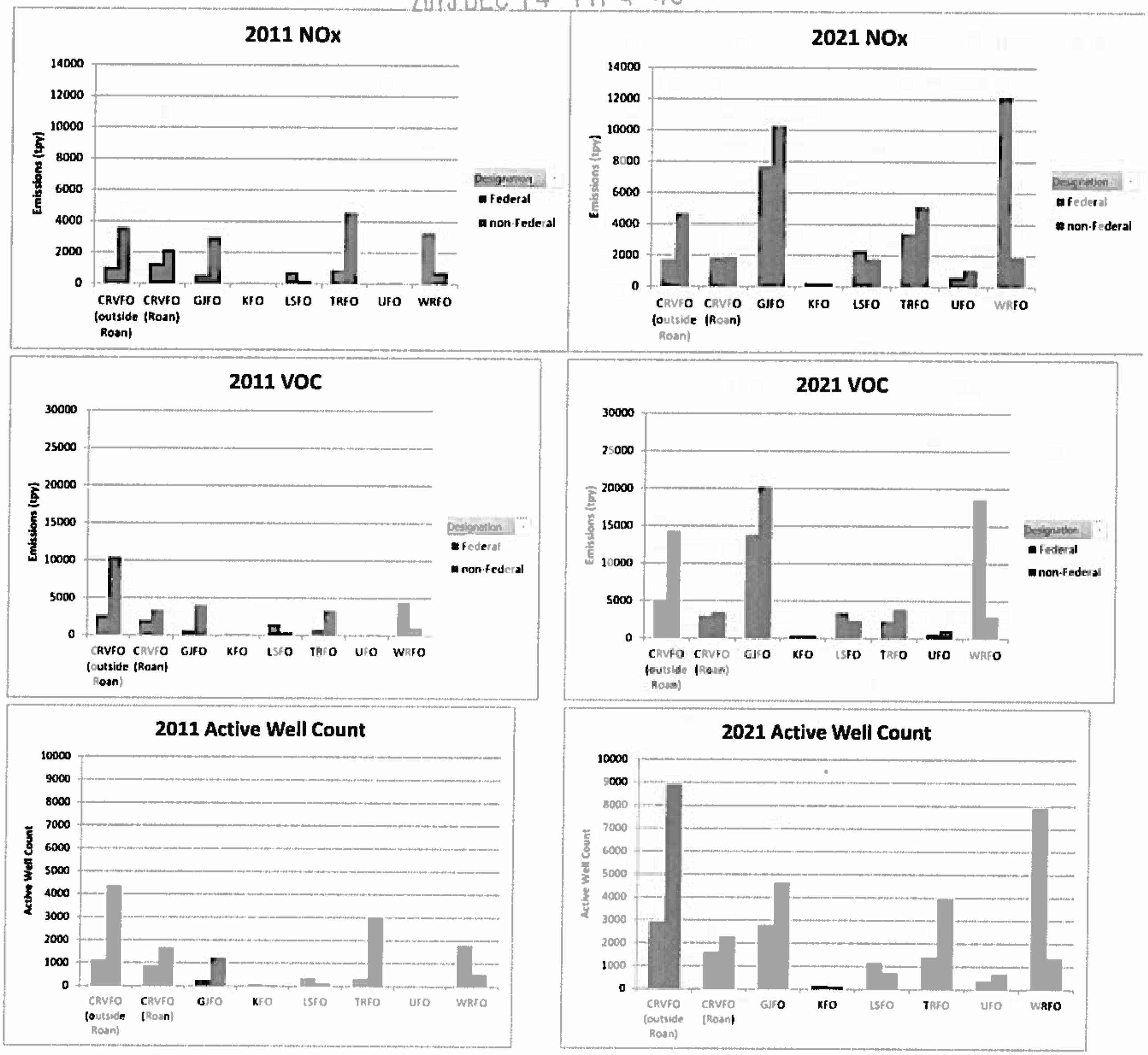


Figure 3-5. NO_X and VOC emissions and well counts from oil and gas development within the 8 western Colorado BLM Planning Areas and for the 2011 current (left) and 2021 High Development Scenario (right) emissions scenarios.

3.6 Future Year Emissions Modeling Procedures

The 2021 future year emissions were processed using the SMOKE emissions model in a similar manner as used for the 2008 Base Case emissions scenario described in Section 2.5. One difference in the 2021 SMOKE emissions modeling was that each source category for which separate ozone and particulate matter contributions are needed was processed in a separate stream in the SMOKE emissions modeling. This resulted in many different streams of SMOKE emissions processing for the three 2021 emission scenarios to provide separate source groups so that the AQ/AQRV impacts can be isolated in the source apportionment modeling.

3.6.1 Non-Oil and Gas Future-Year Emissions Data

For most of the inventory sectors, the 2020 inventory and ancillary emissions data were obtained directly from the 3SAQS modeling platform, which in turn uses data from EPA's 2007v5 modeling platform (EPA, 2012d). Developed by EPA for use in the $PM_{2.5}$ NAAQS RIA, the 2020 inventory represent the best estimate of future year emissions without the implementation of any new controls necessary to attain the current $PM_{2.5}$ annual and 24-hr (35 $\mu g/m^3$ and 15 $\mu g/m^3$) and ozone 8-hr (75 ppb) standards (EPA, 2012d). These emissions reflect rule promulgated or under reconsideration as of July 2012.

A summary of the 2007v5 modeling platform 2020 inventory is provided below and additional details are available from EPA (EPA, 2012d).

CEM Point: For Electric Generating Units (EGUs) with Continuous Emissions Monitors (CEMs), EGU-specific emissions estimates were obtained from the Integrated Planning Model (IPM®[64]), version 4.10 accounting for controls from the Cross-State Air Pollution Rule (CSAPR[65]) and Mercury and Air Toxics Standard (MATS[66]) rulemakings.

Non-CEM Point: Projection factors and percent reductions reflect CSAPR comments and emission reductions due to national rules, control programs, plant closures, consent decrees and settlements and 1997 and 2001 ozone State Implementation Plans in NY, CT, and VA. EPA used projection approaches for corn ethanol and biodiesel plants, refineries and upstream impacts from the Energy Independence and Security Act of 2007 (EISA). Terminal area forecast (TAF) data aggregated to the national level were used for aircraft to account for projected changes in landing/takeoff activity.

Nonpoint/Area: Agricultural sector projection factors for livestock estimates based on expected changes in animal population from 2005 Department of Agriculture data, updated based on personal communication with EPA experts in July 2012; fertilizer application NH_3 emissions projections include upstream impacts EISA. Fugitive dust projection factors for dust categories related to livestock estimates based on expected changes in animal population and upstream impacts from EISA. Other nonpoint source projection factors that implement CSAPR comments and reflect emission reductions due to control programs. Residential wood combustion projections are based on growth in lower-emitting stoves and a reduction in higher emitting stoves. PFC projection factors reflecting impact of the final Mobile Source Air Toxics (MSAT 2) rule. Upstream impacts from EISA, including post-2007 cellulosic ethanol plants are also reflected.

Off-road Mobile: Other than for California, this sector uses data from a run of NMIM that utilized NONROAD2008a, using future-year equipment population estimates and control programs to the year 2020 and using national level inputs. Final controls from the final locomotive-marine and small spark ignition OTAQ rules are included. California-specific data were provided by California Air Resources Board (CARB).

[64] http://www.icfi.com/insights/products-and-tools/ipm
[65] http://www.epa.gov/crossstaterule/
[66] http://www.epa.gov/mats/

Aircraft/locomotive/marine: For all states except California, projection factors for Class 1 and Class 2 commercial marine and locomotives, which reflect final locomotive-marine controls. California projected year-2020 inventory data were provided by CARB.

Offshore shipping: Base-year 2007 emissions grown and controlled to 2020, incorporating controls based on Emissions Control Area (ECA) and International Marine Organization (IMO) global NO_X and SO_2 controls.

On-road Mobile, not including refueling: MOVES2010b emissions factors for year 2020 were developed using the same representative counties, state-supplied data, meteorology, and procedures that were used to produce the 2007 emission factors. California-specific data were provided by CARB. Other than California, this sector includes all non-refueling on-road mobile emissions (exhaust, evaporative, evaporative permeation, brake wear and tire wear modes).

On-road Refueling: Uses the same projection and processing approach as the on-road sector, except for California where EPA projected using MOVES2010b and did not include CARB data.

Canada Sources: Held constant and 2006 levels.

Mexico Sources: Projections from 1999 to 2018.

The ancillary data (spatial/temporal/chemical) were held unchanged from the 3SAQS platform for preparing the 2021 emissions for CAMx. In the 3SAQS platform, the base sets of ancillary data were taken directly from the EPA 2007v5 modeling platform. The 3SAQS made targeted improvements to the ancillary files for counties in the 3-state study region (Figure 3-6). The improvements were focused on the assignments of spatial/chemical/temporal profiles to inventory sources and on developing profiles that best represent the emissions patterns in the 3-state study region.

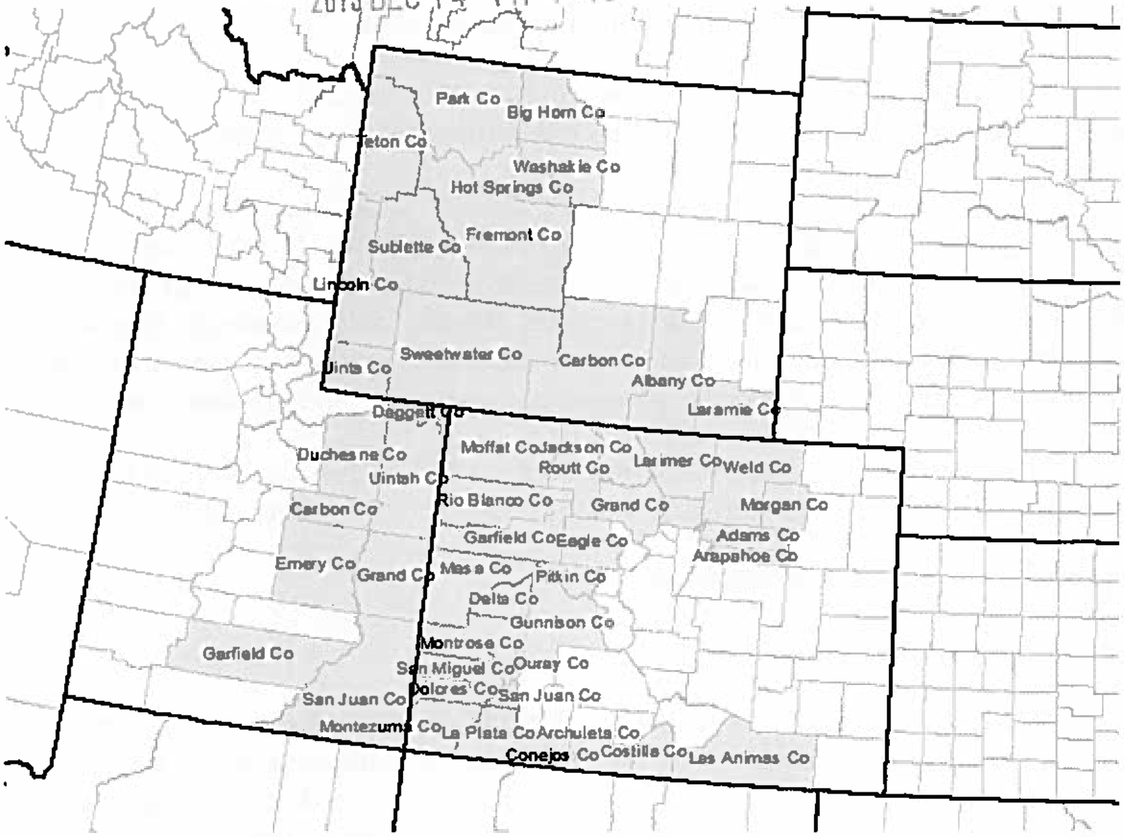


Figure 3-6. List of counties where the 3SAQS made targeted emission improvements to the EPA NEI.

The 3SAQS improvements over the EPA 2008, 2011 and 2020 National Emissions Inventory (NEI) for the CO/UT/WY counties include the following:

Utah

- Updated the 2007v5 spatial surrogates for land cover and building square footage with NLCD2006 and FEMA-HAZUS data
- Changed the ATV/ORV/Snowmobile surrogate assignment from rural land area to forest land
- Changed the livestock surrogate assignment from total agricultural land to pasture land
- Changed the fertilizer surrogate assignment from total agricultural land to crop land
- Created a state-specific, year 2011 monthly temporal profile for residential natural gas heating fuel use with Energy Information Administration data (Figure 3-7).
- Used point locations of rest areas and truck stops to allocation MOVES extended idling emissions to the modeling grid

Colorado

- Updated the 2007v5 spatial surrogates for land cover and building square footage with NLCD2006 and FEMA-HAZUS data
- Changed the ATV/ORV/Snowmobile surrogate assignment from rural land area to forest land
- Created CAFO spatial surrogates from data provided by CDPHE for livestock ammonia sources
- Changed the livestock surrogate assignment from total agricultural land to pasture land
- Changed the fertilizer surrogate assignment from total agricultural land to crop land
- Created a state-specific, year 2011 monthly temporal profile for residential natural gas heating fuel use with Energy Information Administration data (Figure 3-7).
- Developed 2008 vehicle miles traveled (VMT)-based spatial surrogates for on-road mobile sources. Figure 3-8 compares the U.S. Census year 2010 TIGER line roadway data with link-based VMT data from CO.
- Used point locations of rest areas and truck stops to allocation MOVES extended idling emissions to the modeling grid

Wyoming

- Updated the NEI08v2 spatial surrogates for land cover and building square footage with NLCD2006 and FEMA-HAZUS data
- Changed the ATV/ORV/Snowmobile surrogate assignment from rural land area to forest land
- Changed the livestock surrogate assignment from total agricultural land to pasture land
- Changed the fertilizer surrogate assignment from total agricultural land to crop land
- Created a state-specific, year 2011 monthly temporal profile for residential natural gas heating fuel use with Energy Information Administration data (Figure 3-7).
- Developed confined animal feeding operation (CAFO) spatial surrogates for livestock sources. The CAFOs locations data were provided by the state of Wyoming (Figure 3-9). The 3SAQS generated WY livestock surrogates for cattle, poultry, and swine.
- Used point locations of rest areas and truck stops to allocation MOVES extended idling emissions to the modeling grid

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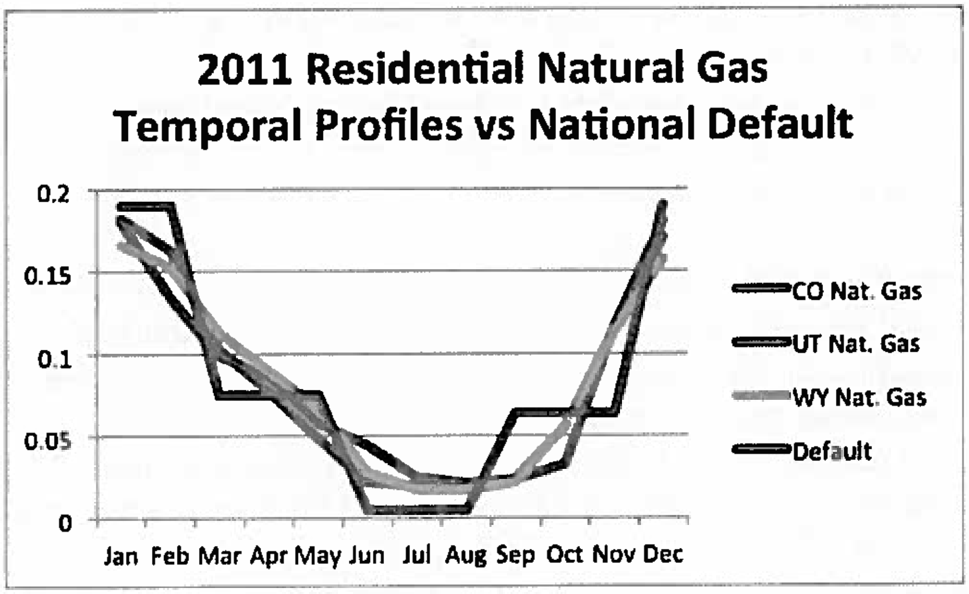


Figure 3-7. 3SAQS 2011 residential natural gas consumption monthly temporal profiles.

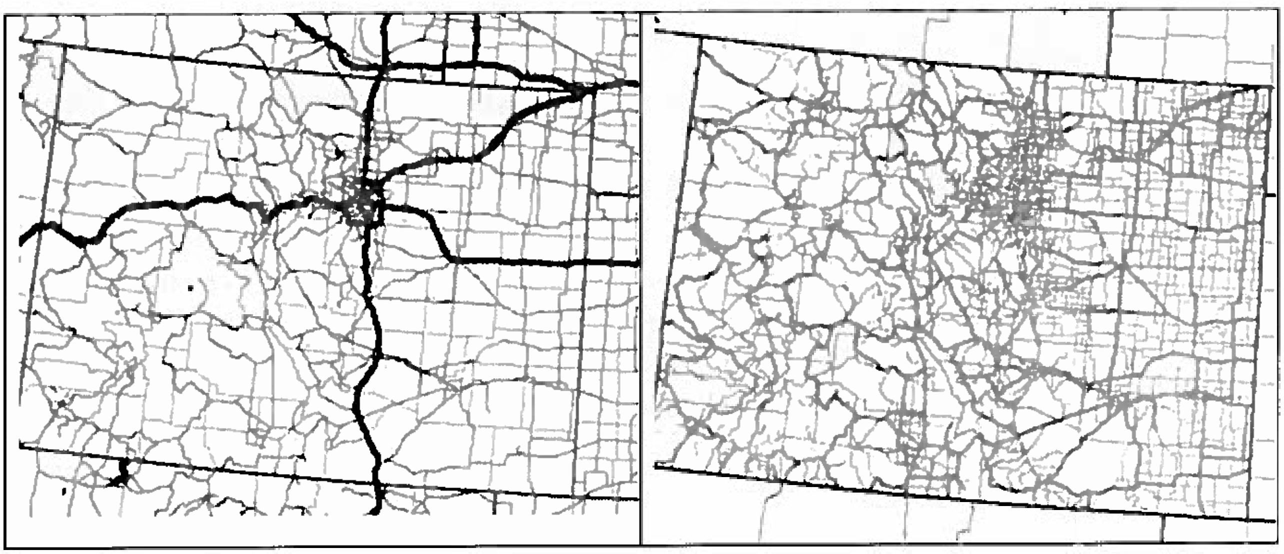


Figure 3-8. Colorado roadway spatial data improvement plots. Left: TIGER 2010 Shapefile of urban/rural primary/secondary roads. Right: CO 2008 VMT-based roadways.

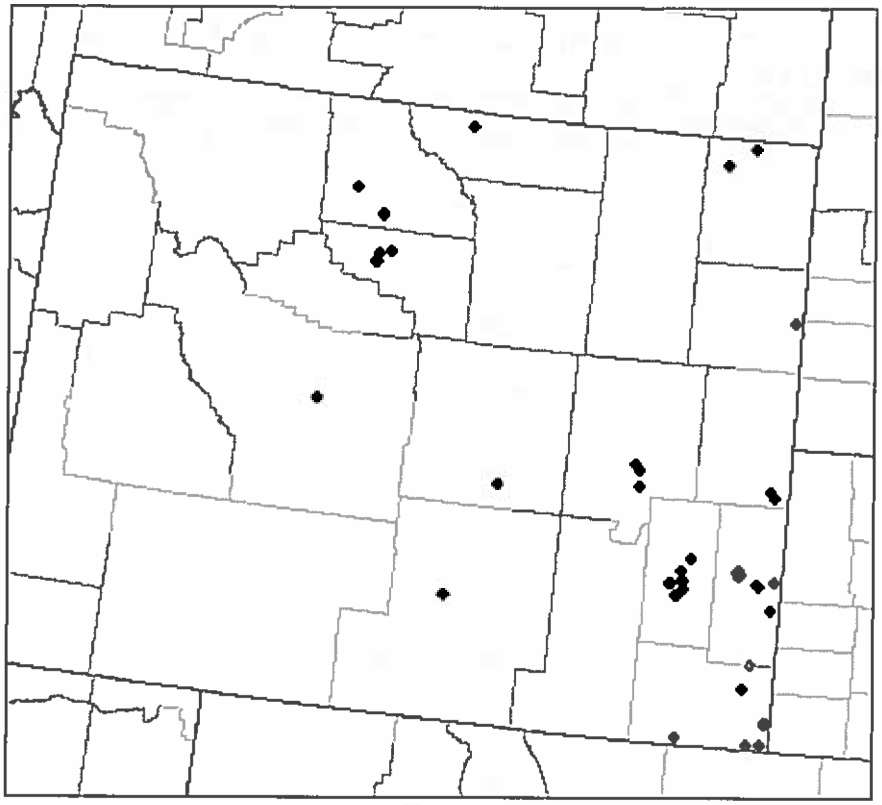


Figure 3-9. Wyoming CAFO locations.

3.6.2 Oil and Gas Future-Year Emissions Data

For oil and gas sources, ENVIRON developed emissions inventories for the western Colorado BLM planning areas as described in Section 3.1 and South San Juan basin, NM as described in Section 3.2.2. The oil and gas emissions for all other planning areas were provided by BLM as described in Section 3.2.

Oil and gas sources within 14 BLM planning areas, emissions were divided into existing and RFD (new) source categories to facilitate CAMx source apportionment processing. The RFD sources were further divided into oil and gas development on the BLM-authorized land (Federal) and other (non-Federal) lands. The South San Juan basin existing emissions were obtained from the WRAP Phase III midterm projection.

For processing oil and gas emissions, we developed ancillary data (spatial/temporal/chemical) specific to planning areas. The area-specific spatial allocation profiles were developed from the data provided by BLM and chemical speciation profiles were prepared from the gas composition available in the emission calculator. Table 3-3 provides a list of speciation and gridding profiles developed by planning areas. The conventional (CG) and CBM gas speciation profile are assigned to source categories associated with the respective well type. For spatial allocation, gridding profiles were developed for each well type (i.e., conventional, CBM) and land type (Federal, non-Federal) combination.

Table 3-3. Source of VOC speciation profile and spatial surrogates used for gridding oil and gas emissions in the 14 CO/NM BLM Planning Areas.

Source Region	Speciation Profiles	Gridding Profiles
Colorado		
Colorado River Valley, without Roan	CRV(CG)	CRVFO {CG}(Fed,non-Fed}
Grand Junction FO	GJ {CBM,CG,SG}	GJFO {CG,CBM}(Fed,non-Fed}
Kremmling FO	K {CBM,CG,CO}	KFO shapefile
Little Snake FO	LS {CG,CO}	CRVFO {CG}(Fed,non-Fed}
Roan Plateau	CRV(CG}	CRVFO_Roan_Plateau.
Tres Rios FO	TR {CBM,CG,CO,SHL}	TRFO {CG,CBM}(Fed,non-Fed}
Uncompahgre FO	U {CBM,CG}	UFO {CG,CBM}(Fed,non-Fed}
White River FO	WR {CG,CO}	WRVFO {CG}(Fed,non-Fed}
Pawnee National Grasslands	DJ{FLA ,VNT}	RGFO {CG}(Fed}
Royal Gorge FO Area1	DJ{FLA ,VNT}	RGFO {CG}(Fed,non-Fed}
Royal Gorge FO Area2	DJ{FLA ,VNT}	RGFO {CG}(Fed,non-Fed)
Royal Gorge FO Area3	DJ{FLA ,VNT}	RGFO {CG}(Fed,non-Fed}
Royal Gorge FO Area4	DJ{FLA ,VNT}	RGFO {CG}(Fed,non-Fed)
New Mexico		
Farmington FO	MAN{SG, SO}	Shapefile

3.6.3 Mining Future-Year Emissions Data

For mining sources, emissions were estimated for coal and uranium mines on Federal lands in the western Colorado BLM Planning Areas. The emissions for mines on Federal lands were estimated based on the CDPHE APEN database and available EISs and EAs. The mining emissions not on federal lands were obtained from the 2020 EPA/3SAQS inventory. EPA default chemical speciation profiles were used in the SMOKE emissions modeling for mining.

The estimated coal mining sources were consolidated with the 2020 EPA/3SAQS inventory to avoid potential double counting. The western Colorado uranium mining emissions were modeled as "area" and spatially allocated using spatial surrogates developed from the data provided by BLM in a shapefile format.

3.7 Emissions Modeling Results

Table 3-4 lists the total NO_X, VOC, SO_2 and $PM_{2.5}$ emissions for the 20 Source Categories used in the CAMx 2021 High Development Scenario source apportionment simulation (see Section 4.1 and Table 4-1) plus three combined O&G source groups as well as total anthropogenic and all emissions within the 4 km CARMMS domain. These emissions were obtained from CAMx source apportionment diagnostic output file for each day of the annual simulation that were summed to obtain total annual emissions. The emissions in Table 3-4 differ from the ones presented earlier in Tables 3-1 and 3-2 in that they represent emissions after processing by SMOKE emissions model that performs spatial and temporal allocation and chemical speciation. Another important differences in the emissions presented in Table 3-4 from those in Tables 3-1 and 3-2 is that for the BLM Planning Areas (Numbers 1-14) the emissions are in Table 3-4 are just for new O&G emissions on Federal lands, whereas Tables 3-1 and 3-2 Federal O&G emissions are for new and existing sources. For VOC, the differences in emissions between Tables 3-2 and Table 3-4 are even greater because SMOKE also does chemical speciation of the VOCs into the CB05 chemical mechanism that drops the unreactive portions of VOCs that do not participate in photochemistry.

For new Federal O&G within the 14 BLM Planning Areas and the 2021 High Development Scenario, the WRFO has the highest NO_X emissions (11,264 tons per year, TPY) followed by GJFO (7,293 TPY), FFO (3,321 TPY) and TRFO (2,665 TPY). Total 2021 O&G NO_X emissions in the 14 BLM Planning Areas is 178,447 TPY that is split 18 percent new Federal (32,566 TPY), 37 percent new non-Federal (65,713 TPY) and 45 percent existing O&G emissions (81,168 TPY). Outside of the 14 BLM Planning Areas, there is an additional 61,220 TPY O&G NO_X emissions for a total 2021 High Development Scenario O&G NO_X emissions across the entire 4 km CARMMS domain of 240,667 TPY that represents 34 percent of the total anthropogenic and 30 percent of the total (anthropogenic plus natural) NO_X emissions in the 4 km domain.

Total O&G VOC emissions in the 4 km CARMMS domain for the 2021 High Development Scenario are 835,785 TPY that represents 73 percent of the total anthropogenic and 39 percent of the total anthropogenic plus natural VOC emissions across the domain. Natural VOC emissions represent 46 percent of the annual VOC emissions across the 4 km CARMMS domain. Note that biogenic emissions are highly day-specific with higher emissions under warmer temperatures and higher light intensity. Thus, the contributions of biogenic VOC emissions to the total annual VOC emissions (46 percent) would be expected to be lower on cooler and higher on warmer days. Also note that the VOC emissions in Table 3-4 were obtained from the Carbon Bond chemical mechanism species that will be different than the VOC species input into the SMOKE emissions modeling system (for example, includes ethane and excludes nonreactive carbon in VOCs).

With one exception, SO_2 emissions from Federal O&G within the 14 BLM Planning Areas are fairly low (< 20 TPY). The exception is the WRFO Planning Area where the 904 TPY SO_2 emissions represent 95 percent of the 950 TPY SO_2 emissions from all 14 BLM Planning Areas combined in the 2021 High Development Scenario. A majority of the 2021 SO_2 emissions in the WRFO Planning Area come from two gas plants: the Enterprise Gas Proc – Meeker Gas Plant and the Williams Field – Willow Creek Gas Plant. These gas plant emissions were based on the CDPHE 2008 Air Pollution Emission Notice (APEN) database grown to 2021 using the change in gas production between 2008 and 2021 for the 2021 High, Low and Medium Development Scenarios. Total O&G SO_2 emissions across the CARMMS domain is 6,071 TPY that is primarily (75 percent) due to O&G from outside of the 14 BLM Planning Areas, these areas in the 4 km CARMMS domain outside of the 14 BLM Planning Areas includes the Uinta Basin where sour gas reserves occur.

Total $PM_{2.5}$ emissions from O&G in the 14 BLM Planning Areas and the 2021 High Development Scenario is 7,849 TPY of which over half (58 percent) is due to new non-Federal O&G and the rest approximately split equally between new Federal and existing O&G. Mining within the 14 BLM Planning Areas contributes 6,957 TPY. By far the largest contribution of primary $PM_{2.5}$ emissions is the other (non O&G and mining) anthropogenic emissions category that contributes 74 percent of the region-wide total with natural emissions (mostly due to wildfires) contributing most of the rest (23 percent).

Table 3-5a is like Table 3-4 only for the 2021 Low Development Scenario, with the percent reductions of emissions between the Low and High development Scenarios shown in Table 3-5b. The total new Federal O&G NO_X emissions across the 14 BLM Planning Areas for the low scenario (8,385 TPY) is 74% lower than the high scenario (32,566 TPY). Similar reductions are seen for the other species (-63 to -83 percent). The annual emissions for the 2021 Medium Development Scenario are shown in Table 3-6a with the percent reduction from the 2021 High Development Scenario given in Table 3-6b. Total O&G NO_X emissions across the 14 BLM Planning Areas for the 2021 Medium Development Scenario is 27,071 TPY that is -17% lower than the 201 High Development Scenario (Table 3-6b). Similarly, 2021 Medium Development Scenario O&G VOC emissions across the 14 BLM Planning Areas are 35% lower than the 2021 High Development Scenario.

Table 3-4. Total emissions (tons per year) for each Source Category (see Table 4-1) and combinations of Source Categories for the 2021 High Development Scenario from the CAMx source apportionment diagnostic output files after processing by SMOKE.

CARMMS 2021 High Development Scenario (tpy)						
Number	**Group**	**NO_X**	**VOC**	**SO_2**	**$PM_{2.5}$**	**PM_{10}**
19	Natural (Biogenics + Fires)	113,165	992,560	1,132	79,453	574,255
1	LSFO	2,007	4,648	13	73	170
2	WRFO	11,264	27,258	904	597	1,368
3	CRVFO	1,311	6,076	2	71	250
4	RPPA	1,245	2,739	1	48	135
5	GJFO	7,293	18,108	15	310	1,496
6	UFO	586	870	1	35	140
7	TRFO	2,665	1,715	2	125	855
8	KFO	177	412	0	10	50
9	RGFO #1	303	875	1	29	225
10	PGPA	930	2,682	3	90	689
11	RGFO #2	1,151	1,526	1	22	58
12	RGFO #3	224	77	0	3	16
13	RGFO #4	90	944	0	16	134
14	FFO	3,321	8,747	5	314	1,824
15	New O&G from non-Fed BLM PAs	65,713	228,655	297	4,548	30,790
16	Existing O&G from BLM PAs	81,169	228,749	252	1,558	2,838
17	Mining from BLM PAs	686	46	8	6,957	6,977
18	All O&G outside 14 BLM PAs	61,220	301,705	4,572	2,680	2,822
20	Remaining anthro emissions	459,907	312,498	95,720	242,828	1,400,504
	14 BLM PAs Fed O&G	32,566	76,676	950	1,744	7,409
	14 PAs Total O&G	179,447	534,080	1,499	7,849	41,038
	Total O&G	240,667	835,785	6,071	10,530	43,859
	Total Anthropogenic	701,260	1,148,329	101,799	260,315	1,451,340
	Total All Emissions	814,425	2,140,889	102,931	339,768	2,025,594

Table 3-5a. Total emissions (tons per year) for each Source Category (see Table 4-1) and combinations of Source Categories for the 2021 Low Development Scenario from the CAMx source apportionment diagnostic output files after processing by SMOKE.

CARMMS 2021 Low Development Scenario (tpy)						
Number	Group	NO_X	VOC	SO_2	$PM_{2.5}$	PM_{10}
19	Natural (Biogenics + Fires)	113,165	992,560	1,132	79,453	574,255
1	LSFO	275	638	2	10	23
2	WRFO	1,861	4,502	149	99	226
3	CRVFO	844	3,916	1	46	161
4	RPPA	656	1,552	1	26	70
5	GJFO	425	965	1	20	72
6	UFO	150	270	0	10	45
7	TRFO	326	227	0	16	89
8	KFO	21	34	0	1	5
9	RGFO #1	61	262	0	5	42
10	PGPA	188	804	1	17	129
11	RGFO #2	104	191	0	2	6
12	RGFO #3	141	51	0	2	11
13	RGFO #4	14	135	0	2	20
14	FFO	3,321	8,747	5	314	1,824
15	New O&G from non-Fed BLM PAs	31,247	104,163	113	2,057	13,769
16	Existing O&G from BLM PAs	81,169	228,749	252	1,558	2,838
17	Mining from BLM PAs	686	46	8	6,957	6,977
18	All O&G outside 14 BLM PAs	61,220	301,705	4,572	2,680	2,822
20	Remaining anthro emissions	459,907	312,498	95,720	242,828	1,400,504
	14 BLM PAs Fed O&G	8,385	22,294	161	570	2,723
	14 PAs Total O&G	120,801	355,207	527	4,185	19,331
	Total O&G	182,021	656,912	5,099	6,865	22,152
	Total Anthropogenic	642,614	969,456	100,827	256,651	1,429,633
	Total All Emissions	755,779	1,962,016	101,958	336,104	2,003,888

Table 3-5b. Percent difference in 2021 High and Low Development Scenario emissions (High – Low) for each Source Category (see Table 4-1) and combinations of Source Categories from the CAMx source apportionment diagnostic output after processing by SMOKE.

CARMMS 2021 Low Scenario Percent Change from High Scenario (%)						
Number	Group	NO_X	VOC	SO_2	$PM_{2.5}$	PM_{10}
19	Natural (Biogenics + Fires)	0.0%	0.0%	0.0%	0.0%	0.0%
1	LSFO	-86.3%	-86.3%	-86.4%	-86.3%	-86.4%
2	WRFO	-83.5%	-83.5%	-83.5%	-83.5%	-83.5%
3	CRVFO	-35.6%	-35.5%	-35.7%	-35.2%	-35.5%
4	RPPA	-47.3%	-43.3%	-46.8%	-46.3%	-48.2%
5	GJFO	-94.2%	-94.7%	-94.1%	-93.6%	-95.2%
6	UFO	-74.5%	-69.0%	-76.5%	-70.6%	-67.7%
7	TRFO	-87.8%	-86.8%	-83.8%	-87.1%	-89.6%
8	KFO	-88.2%	-91.7%	-88.8%	-89.2%	-89.8%
9	RGFO #1	-79.8%	-70.0%	-81.9%	-81.6%	-81.3%
10	PGPA	-79.8%	-70.0%	-81.9%	-81.2%	-81.2%
11	RGFO #2	-91.0%	-87.5%	-90.8%	-90.5%	-89.3%
12	RGFO #3	-37.0%	-34.0%	-37.5%	-33.0%	-31.0%
13	RGFO #4	-85.0%	-85.7%	-85.0%	-85.4%	-85.4%
14	FFO	0.0%	0.0%	0.0%	0.0%	0.0%
15	New O&G from non-Fed BLM PAs	-52.4%	-54.4%	-61.8%	-54.8%	-55.3%
16	Existing O&G from BLM PAs	0.0%	0.0%	0.0%	0.0%	0.0%
17	Mining from BLM PAs	0.0%	0.0%	0.0%	0.0%	0.0%
18	All O&G outside 14 BLM PAs	0.0%	0.0%	0.0%	0.0%	0.0%
20	Remaining anthro emissions	0.0%	0.0%	0.0%	0.0%	0.0%
	14 BLM PAs Fed O&G	-74.3%	-70.9%	-83.1%	-67.3%	-63.2%
	14 PAs Total O&G	-32.7%	-33.5%	-64.9%	-46.7%	-52.9%
	Total O&G	-24.4%	-21.4%	-16.0%	-34.8%	-49.5%
	Total Anthropogenic	-8.4%	-15.6%	-1.0%	-1.4%	-1.5%
	Total All Emissions	-7.2%	-8.4%	-0.9%	-1.1%	-1.1%

Table 3-6a. Total emissions (tons per year) for each Source Category (see Table 4-1) and combinations of Source Categories for the 2021 Medium Development Scenario from the CAMx source apportionment diagnostic output files after processing by SMOKE.

CARMMS 2021 Medium Development Scenario (tpy)						
Number	Group	NO_X	VOC	SO_2	$PM_{2.5}$	PM_{10}
19	Natural (Biogenics + Fires)	113,165	992,560	1,132	79,453	574,255
1	LSFO	1,779	3,633	13	58	98
2	WRFO	9,809	18,803	904	500	810
3	CRVFO	1,060	3,253	2	51	123
4	RPPA	1,023	1,848	1	35	70
5	GJFO	6,149	8,345	15	196	673
6	UFO	460	733	1	24	66
7	TRFO	2,263	1,253	2	65	361
8	KFO	137	210	0	6	23
9	RGFO #1	193	679	1	10	52
10	PGPA	593	2,081	3	29	158
11	RGFO #2	846	1,468	1	15	25
12	RGFO #3	156	54	0	2	5
13	RGFO #4	51	679	0	5	30
14	FFO	2,552	6,808	4	185	745
15	New O&G from non-Fed BLM PAs	64,849	227,796	297	4,517	30,722
16	Existing O&G from BLM PAs	81,169	228,749	252	1,558	2,838
17	Mining from BLM PAs	686	46	8	6,957	6,977
18	All O&G outside 14 BLM PAs	61,220	301,705	4,572	2,680	2,822
20	Remaining anthro emissions	459,907	312,498	95,720	242,828	1,400,504
	14 BLM PAs Fed O&G	27,071	49,849	947	1,180	3,239
	14 PAs Total O&G	173,089	506,394	1,496	7,254	36,800
	Total O&G	234,309	808,100	6,068	9,935	39,621
	Total Anthropogenic	694,902	1,120,643	101,796	259,720	1,447,102
	Total All Emissions	808,067	2,113,203	102,928	339,173	2,021,356

Table 3-6b. Percent difference in 2021 High and Medium Development Scenario emissions (High – Medium) for each Source Category (see Table 4-1) and combinations of Source Categories from the CAMx source apportionment diagnostic output files after processing by SMOKE.

CARMMS 2021 Medium Scenario Percent Change from High Scenario (%)						
Number	Group	NO_X	VOC	SO_2	$PM_{2.5}$	PM_{10}
19	Natural (Biogenics + Fires)	0.0%	0.0%	0.0%	0.0%	0.0%
1	LSFO	-11.3%	-21.8%	-1.4%	-20.7%	-42.7%
2	WRFO	-12.9%	-31.0%	0.0%	-16.4%	-40.8%
3	CRVFO	-19.1%	-46.5%	-0.4%	-27.9%	-50.6%
4	RPPA	-17.9%	-32.5%	-0.3%	-26.9%	-48.1%
5	GJFO	-15.7%	-53.9%	-0.6%	-36.8%	-55.0%
6	UFO	-21.5%	-15.7%	-5.2%	-32.4%	-52.5%
7	TRFO	-15.1%	-26.9%	-4.1%	-47.9%	-57.8%
8	KFO	-22.5%	-48.9%	-7.2%	-40.1%	-55.3%
9	RGFO #1	-36.2%	-22.4%	-20.6%	-67.0%	-77.0%
10	PGPA	-36.2%	-22.4%	-20.6%	-67.2%	-77.0%
11	RGFO #2	-26.5%	-3.8%	-24.8%	-33.2%	-56.2%
12	RGFO #3	-30.2%	-29.8%	-28.3%	-50.5%	-68.3%
13	RGFO #4	-43.5%	-28.0%	-1.0%	-71.0%	-77.4%
14	FFO	-23.1%	-22.2%	-21.4%	-41.0%	-59.2%
15	New O&G from non-Fed BLM PAs	-1.3%	-0.4%	-0.1%	-0.7%	-0.2%
16	Existing O&G from BLM PAs	0.0%	0.0%	0.0%	0.0%	0.0%
17	Mining from BLM PAs	0.0%	0.0%	0.0%	0.0%	0.0%
18	All O&G outside 14 BLM PAs	0.0%	0.0%	0.0%	0.0%	0.0%
20	Remaining anthro emissions	0.0%	0.0%	0.0%	0.0%	0.0%
	14 BLM PAs Fed O&G	-16.9%	-35.0%	-0.3%	-32.3%	-56.3%
	14 PAs Total O&G	-3.5%	-5.2%	-0.2%	-7.6%	-10.3%
	Total O&G	-2.6%	-3.3%	-0.1%	-5.7%	-9.7%
	Total Anthropogenic	-0.9%	-2.4%	0.0%	-0.2%	-0.3%
	Total All Emissions	-0.8%	-1.3%	0.0%	-0.2%	-0.2%

Figure 3-10 displays spatial maps of NO_X, VOC and $PM_{2.5}$ emissions across the 4 km CARMMS domain by different source types for the 2021 High Development Scenario. The spatial maps for the Low and Medium Development Scenarios have the same locations as the High Development Scenario just with lower intensity. Figure 3-10a displays the total new Federal and new non-Federal O&G emissions across the 14 CO/NM BLM Planning Areas that shows a mixture of Federal and non-Federal O&G emissions in the western Colorado Planning Areas. Most of the new O&G emissions in the eastern Colorado Planning Areas (e.g., Weld County) are due to non-Federal O&G, except for the development within the Pawnee Grassland Planning Area. The differences in the new Federal and non-Federal O&G emissions for the Mancos Shale

Development area in northern New Mexico reflects the assumption that new O&G was split 70 percent Federal and 30 percent non-Federal.

Figure 3-10b top panel displays the spatial distribution of emissions that combines the existing O&G within the 14 CO/NM BLM Planning Areas with the remainder O&G (new Federal and non-Federal plus existing) within the 4 km CARMMS domain but outside of the 14 CO/NM BLM Planning Areas. In addition to the familiar Basins within the 14 CO/NM Planning Areas (Denver-Julesburg, Piceance and North and South San Juan), the Uinta Basin is clearly evident along with O&G emissions in southwest Wyoming and in the Texas panhandle. Mining within the Colorado BLM Planning Areas consist of mainly isolated grid cells that can have very high $PM_{2.5}$ emissions (Figure 3-10b, bottom panel). Figure 3-10c displays the other (remainder) anthropogenic emissions and natural emissions. Roadways and the major urban areas of Denver, Salt Lake City, Colorado Springs and Albuquerque are clearly evident in the other anthropogenic emissions NO_X and VOC maps. Whereas the spatial maps of other anthropogenic $PM_{2.5}$ emissions is more reflective of agricultural sources. Natural VOC emissions are dominated by forested areas, whereas the natural NO_X emissions are higher in agricultural areas and the locations of fires in 2008.

3.7.1 Mining PM Speciation Issues

The EPA default PM speciation profiles as provided with the SMOKE emissions modeling system were used to speciate PM emissions for mining sources. These PM speciation profiles convert total $PM_{2.5}$ emissions into particulate SO4, NO3, NH4, EC, OA and OPM2.5 (other $PM_{2.5}$) for the PGM modeling. In analyzing the AQ and AQRV impacts associated with mining on Federal lands in the CARMMS 2021 modeling results, we noticed sulfur deposition impacts and visibility impairment impacts due to SO4 that were higher than expected given the low SO_2 emissions from mining for the 2021 emission scenarios (8 TPY, see Tables 3-4 through 3-6). These higher than expected sulfur impacts from mining were due to primary SO4 emissions. Of the 6,957 TPY $PM_{2.5}$ emissions from mining (Table 3-4), 874 TPY (12.5%) is due to primary SO4 emissions.

Table 3-7 lists the mining source categories and emissions by Source Classification Code (SCC) and the PM speciation profile code used in the SMOKE modeling system that is used to speciate the mining PM emissions using a cross-reference with the SCC number. SMOKE speciates most of the mining PM emissions using the 92047 PM speciation profile that is for "Mineral Products – Avg – Simplified." Table 3-8 lists the $PM_{2.5}$ speciation profiles for the three profiles used to speciate the mining emissions in SMOKE. For the dominant 92047 PM profile for mining, 14.1% of the $PM_{2.5}$ emissions are speciated as primary SO4. The reference for the 92047 PM speciation profile in the SPECIATE database is "Shareef, G.S. Engineering Judgment, Radian Corporation. September 1987." In our search we could not find this reference.

For some types of above ground mining that uses blasting, higher sulfur emissions may be expected. However, in Colorado most of the mining is underground that would not include blasting so would be expected to have lower sulfur emissions, which is reflected in the low mining SO_2 emissions. Thus, it appears that mining primary SO4 emissions are overstated in the CARMMS 2021 modeling, which would result in overstated sulfur deposition and visibility impacts associated with mining. This issue will be discussed with EPA so that the SMOKE emissions modeling system can be updated in the future.

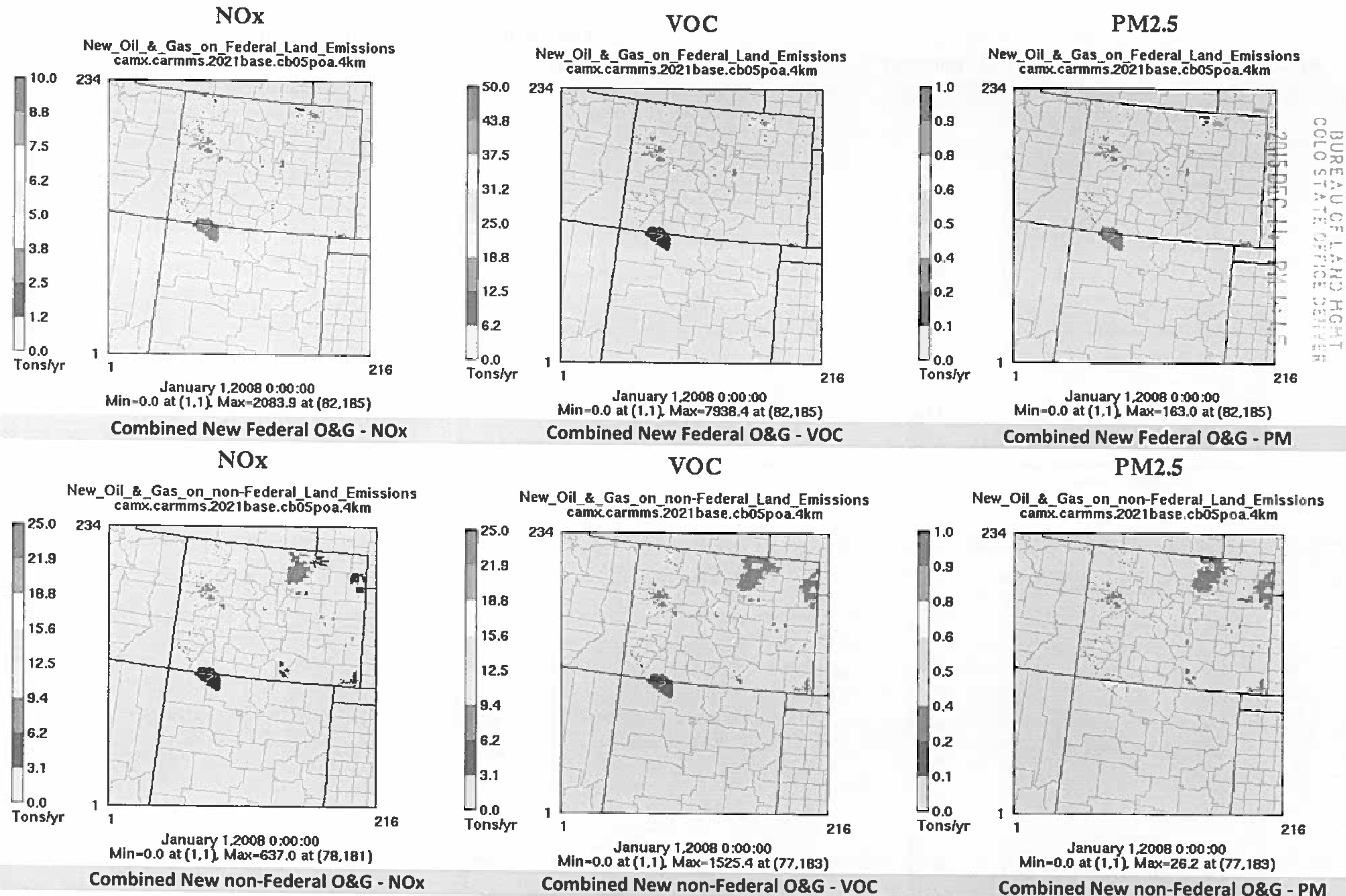


Figure 3-10a. Spatial distribution of Federal (top) and non-Federal oil and gas NO_X, VOC and $PM_{2.5}$ emissions (tons per year) for the 14 BLM Planning Areas and the 2021 High Development Scenario.

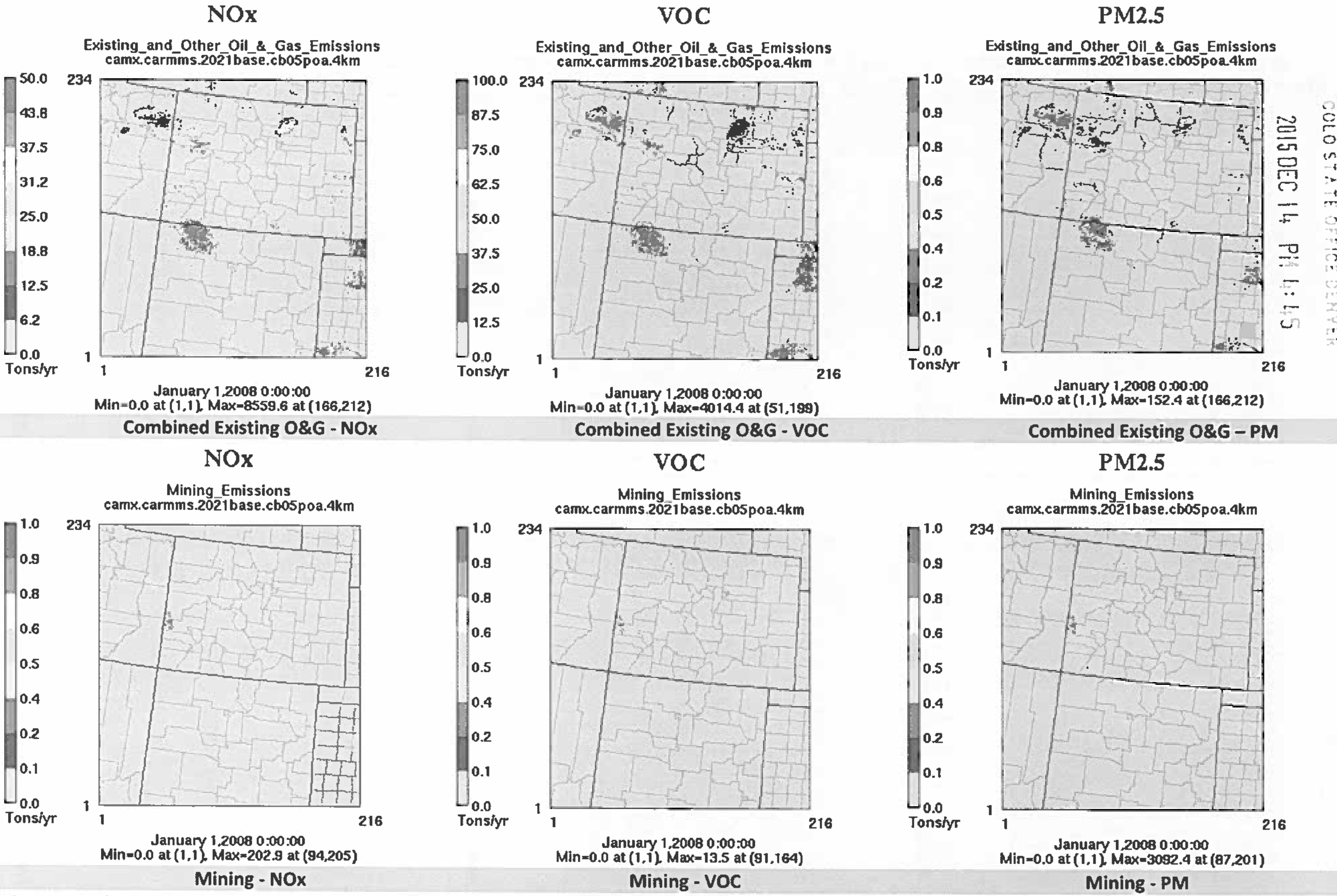
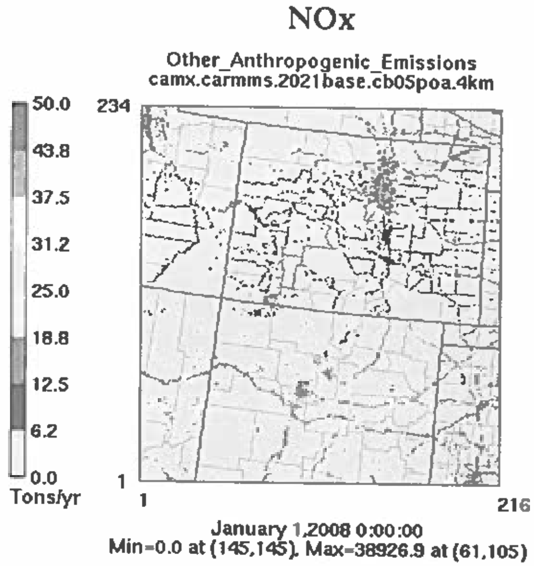
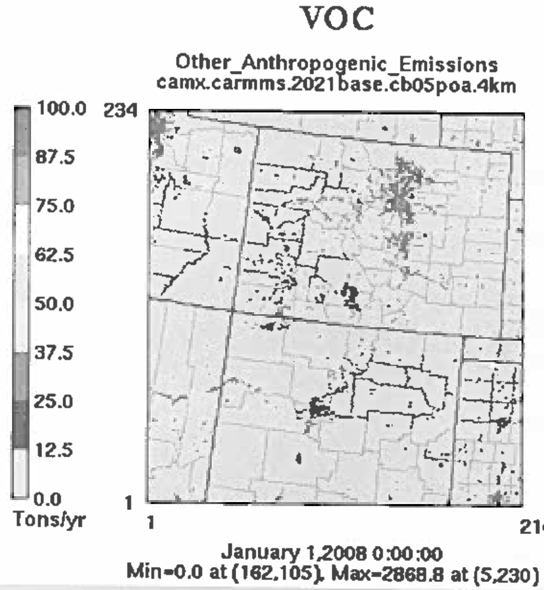


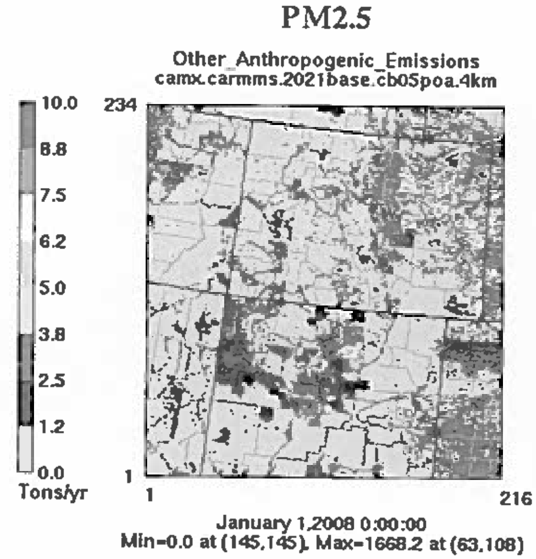
Figure 3-10b. Spatial distribution of Existing oil and gas (top) and mining on Federal lands NO_X, VOC and $PM_{2.5}$ emissions (tons per year) for the 14 BLM Planning Areas and the 2021 High Development Scenario.



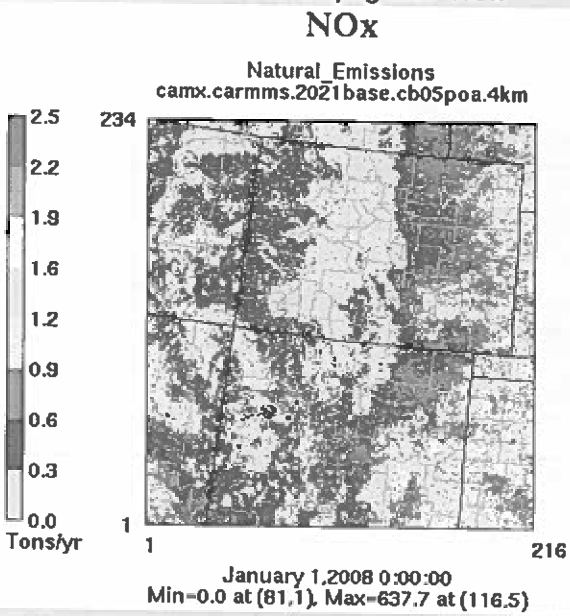
Other Anthropogenic - NOx



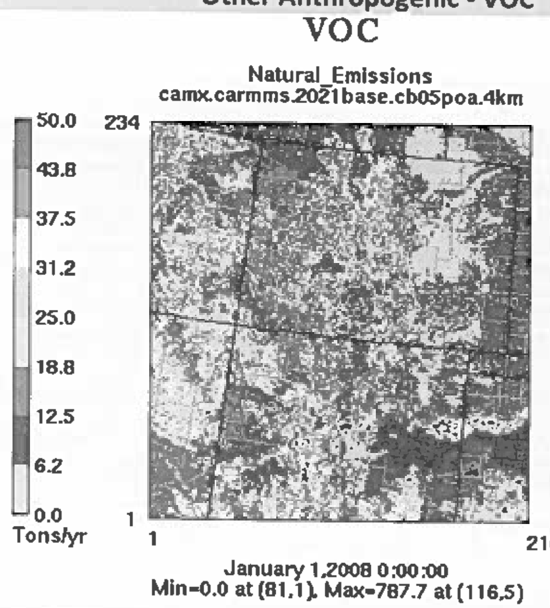
Other Anthropogenic - VOC



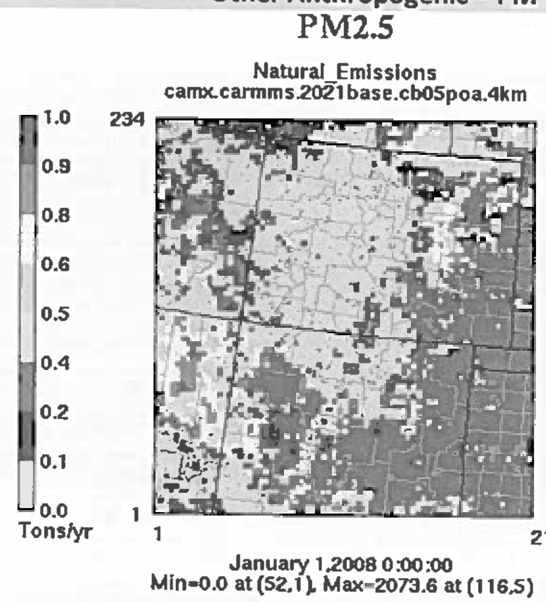
Other Anthropogenic – PM



Natural - NOx



Natural - VOC



Natural - PM

Figure 3-10c. Spatial distribution of other anthropogenic (top) and natural (biogenic, fires, lightning, sea salt and windblown dust) NO_X, VOC and $PM_{2.5}$ emissions (tons per year) for the 14 BLM Planning Areas and the 2021 High Development Scenario.

Table 3-7. SCC number and description, $PM_{2.5}$ speciation profile code and name, and PM emissions for 95% of the mining emissions on Federal lands used in the CARMMS 2021 modeling

SCC	SCC Description	Profile	Profile name	PM2.5 (tpy)
30501099	Coal Mining, Cleaning & Material Handling /Other Not Classified	92047	Mineral Products - Avg - Simplified	1,717
30501022	Coal Mining, Cleaning & Material Handling /Drilling/Blasting	92047	Mineral Products - Avg - Simplified	1,460
30501011	Coal Mining, Cleaning & Material Handling /Coal Transfer	92047	Mineral Products - Avg - Simplified	1,449
30501015	Coal Mining, Cleaning & Material Handling /Loading	92047	Mineral Products - Avg - Simplified	457
30501049	Coal Mining, Cleaning & Material Handling /Wind Erosion: Exposed Areas	92022	Crustal Material - Simplified	403
30501038	Coal Mining, Cleaning & Material Handling /Truck Loading: Coal	92047	Mineral Products - Avg - Simplified	333
30501043	Coal Mining, Cleaning & Material Handling /Open Storage Pile: Coal	92047	Mineral Products - Avg - Simplified	113
30501024	Coal Mining, Cleaning & Material Handling /Hauling	92047	Mineral Products - Avg - Simplified	105
30504010	Mining & Quarrying Nonmetallic Minerals /Underground Ventilation	92073	Sand & Gravel - Simplified	72
30501040	Coal Mining, Cleaning & Material Handling /Truck Unloading: End Dump – Coal	92047	Mineral Products - Avg - Simplified	68
30501046	Coal Mining, Cleaning & Material Handling /Bulldozing: Coal	92047	Mineral Products - Avg - Simplified	67
30501009	Coal Mining, Cleaning & Material Handling /Raw Coal Storage	92047	Mineral Products - Avg - Simplified	61

Table 3-8. $PM_{2.5}$ speciation profiles used to speciate the mining PM emissions.

Profile	Pol	Species	Fraction
Mineral Products - Avg - Simplified			
92047	PM2_5	POA	7.4%
92047	PM2_5	PEC	1.5%
92047	PM2_5	PNO3	0.3%
92047	PM2_5	PSO4	14.1%
92047	PM2_5	PMFINE	76.8%
Crustal Material - Simplified			
92022	PM2_5	POA	7.5%
92022	PM2_5	PEC	0.2%
92022	PM2_5	PNO3	0.1%
92022	PM2_5	PSO4	0.2%
92022	PM2_5	PMFINE	92.0%
Sand & Gravel - Simplified			
92073	PM2_5	POA	0.0%
92073	PM2_5	PEC	0.0%
92073	PM2_5	PNO3	0.1%
92073	PM2_5	PSO4	0.3%
92073	PM2_5	PMFINE	99.7%

4.0 FUTURE YEAR MODELING APPROACH

The CAMx source apportionment tool was used to obtain separate contributions of BLM authorized oil and gas development on Federal lands within 13 Colorado BLM Planning Areas plus the Mancos Shale Development area in northwestern New Mexico. This final report addresses the contributions to air quality (AQ) and air quality related value (AQRV) impacts associated with the 2021 High, Low and Medium Development Scenarios. The following sections describe how the CARMMS 2021 CAMx source apportionment modeling was conducted for the three scenarios and analyzed with the results presented in Chapter 5.

4.1 CARMMS Source Apportionment Modeling Approach

The CAMx Anthropogenic Precursor Culpability Assessment (APCA) version of the Ozone Source Apportionment Technology (OSAT) and the Particulate Source Apportionment Technology (PSAT) were used to obtain separate AQ and AQRV contributions due to BLM-authorized new oil and gas development on Federal lands for each of the 13 Colorado BLM Planning Areas and the Mancos Shale O&G development area within the New Mexico BLM Farmington Field Office (NMFFO) Planning Area (i.e., the 14 BLM Planning Areas). Separate source apportionment contributions from new oil and gas emissions on non-Federal lands and existing oil and gas within the combined 14 BLM Planning Areas was also obtained. Separate source apportionment of AQ/AQRV impacts associated with the 10 mines located within Colorado BLM Planning Areas discussed at the end of Section 3.1.5 was also obtained. Separate source apportionment contributions was also obtained for oil and gas emissions within the 4 km CARMMS domain outside of the 14 BLM Planning Areas, remainder anthropogenic emissions and natural emissions (i.e., biogenic sources, fires, lightning, windblown dust and sea salt).

4.1.1 Overview of Source Apportionment Tools

The CAMx OSAT/APCA ozone and PSAT PM source apportionment tools use reactive tracers that are released from each Source Group for which contributions are desired. These reactive tracers operate in parallel to the host photochemical grid model accessing the model's transport, dispersion, chemistry and deposition algorithms. For example, the OSAT/APCA ozone source apportionment tools represents each Source Group's ozone contributions using four reactive tracers that represent the Source Groups VOC emissions (V), NO_X emissions (N) and ozone attributed to the Source Group that is formed under more VOC-limited (O3V) and NO_X-limited (O3N) conditions. At each time step and in each grid cell, ozone formed is allocated to the Source Groups based on the Source Groups relative contribution of VOC or more NO_X emissions to the total VOC or NO_X concentrations after determination of whether ozone formation is more VOC-limited or more NO_X-limited. The APCA ozone source apportionment tool differs from OSAT in that it recognizes that some precursor emissions are not controllable so redirects ozone formed from the uncontrollable to the controllable Source Group. For example, when ozone is formed under VOC-limited conditions due to the interaction between biogenic VOC and anthropogenic NO_X emissions, a case OSAT would assign the ozone formed to the biogenic emissions Source Group, APCA redirects the ozone formed to the anthropogenic emissions Source Group recognizing that biogenic VOC emissions are not controllable and without the anthropogenic NO_X the ozone would not have been generated. In a CAMx APCA source apportionment run, the first Source Category specified in the run is assumed to be the uncontrollable Source Group (typically natural emissions) and ozone will only be allocated to natural emissions when it is due to natural VOC and NO_X emissions interacting with each other (e.g., ozone formed due to reactions between biogenic VOC and biogenic NOx). For the CARMMS modeling, the natural emissions Source Group included biogenic, fires (wildfires, prescribed burns and agricultural burning), lightning, windblown dust and sea salt emissions. Although one could argue that emissions from prescribed burns and agricultural burning are not natural, emissions from wildfires dominate the fire emissions especially within the CARMMS 4 km domain.

For the CAMx PSAT PM source apportionment tool there are several families of PM source apportionment tracers that can be run separately or together that track the different components of PM. Each of these families has a different number of reactive tracers to track the pathway from the PM precursor emissions to the ultimate PM compounds. The five different families of PSAT source apportionment are as follows (number of tracers in parenthesis): Sulfate-SO4 (2); Nitrate/Ammonium-NO3/NH4 (7); Primary PM (6); Secondary Organic Aerosol-SOA (20) and Mercury-Hg (3). For CARMMS, we used the SO4, NO3/NH4 and Primary PM PSAT families of tracers so that 15 total reactive tracers are needed to track PM contribution for each Source Group. The Hg PSAT family was not used because mercury is not a focus of CARMMS and O&G sources have negligible Hg emissions. There are five SOA precursors treated in CAMx: toluene and xylene (aromatics), isoprene, terpene and sesquiterpene with biogenic sources contributing a majority of the SOA. O&G VOC emissions are dominated by light VOCs that do not form any SOA. We examined the speciation of the O&G emissions and found the five VOC species that are SOA precursors account for approximately 0.1 percent of the O&G VOC emissions. Thus, O&G emission VOCs would have a negligible contribution to SOA so the SOA family of PSAT source apportionment tracers was not used. The CARMMS annual source apportionment runs take over a month to complete and use of the SOA PSAT family would have more than doubled the number of tracers.

Thus, SOA is not included in the $PM_{2.5}$ and visibility impacts associated with Source Groups A through V that are based on the PSAT source apportionment modeling results. But SOA is included in the $PM_{2.5}$ and visibility impacts of Source Groups W and X that represents total emissions from the 2021 and 2008 emission scenarios.

4.1.2 CARMMS Source Apportionment Configuration

The APCA version of the OSAT and the SO4, NO3/NH4 and Primary PM (i.e., no SOA) families of PSAT source apportionment was used to track the AQ/AQRV contributions of new O&G development on Federal lands in 14 separate BLM Planning Areas for the 2021 High, Low and Medium Development Scenarios using the CARMMS 2008 4 km modeling platform. The 14 BLM Planning Areas where separate AQ/AQRV impacts due to new O&G development on Federal lands were simulated are shown in Figure 4-1. In total, the 2021 CAMx source apportionment modeling tracked AQ/AQRV contributions for 20 separate Source Categories in the order listed in Table 4-1. Because the APCA version of OSAT is being used, the first Source Category has to be natural emissions. The 2nd through 15th Source Categories correspond to new O&G emissions on Federal lands within the 13 Colorado BLM planning areas and the Mancos Shale development area within the BLM NMFFO lands (the 14 BLM Planning Areas).

The 16^{th} Source Category is the combined emissions from all new O&G within the 14 BLM Planning Areas on non-Federal lands. The 17^{th} and 18^{th} Source Categories are, respectively, existing O&G within the 14 BLM Planning Areas and mining on Federal lands within the 14 BLM Planning Areas[67]. The 19^{th} Source Category is all O&G emissions (existing, new Federal and new non-Federal) outside of the 14 BLM Planning Areas (i.e., the yellow area in Figure 4-1). And the final (20^{th}) Source Category is remaining anthropogenic emissions (e.g., point, mobile and area sources that are not O&G everywhere or mining on Federal lands within the 14 BLM Planning Areas).

Table 4-1. Ordering of the 20 Source Categories used in the CAMx 2021 source apportionment modeling.

1	Natural emissions (combined biogenic, fires, lightning, sea salt and WBD).
2	Little Snake FO
3	White River FO
4	Colorado River Valley FO (CRVFO)
5	Roan Plateau Planning area portion of CRVFO
6	Grand Junction FO
7	Uncompahgre FO
8	Tres Rios FO
9	Kremmling FO
10	Royal Gorge FO Area#1 (RGFO#1) -- North
11	Pawnee Grasslands portion of RGFO#1
12	RGFO#2 – West-Central/South
13	RGFO#3 – South
14	RGFO#4 – East-Central
15	New Mexico Farmington Field Office
16	Combined New O&G from non-Federal lands within the 14 BLM Planning Areas
17	Combined Existing O&G from 14 BLM Planning Areas
18	Mining from 14 BLM Planning Areas
19	All O&G (existing and new on Federal and non-Federal lands) in 4 km domain outside of the 14 BLM Planning Areas (see yellow region in Figure 1)
20	Remaining anthropogenic emissions (on-road and non-road mobile, point and area sources everywhere in 4 km domain)

[67] There were no mining emissions within the northern New Mexico Mancos Shale development area.

4.2 Post-Processing of the CAMx 2021 Source Apportionment Modeling Results

The CAMx 2021 total concentrations results were post-processed for comparisons to the applicable ambient air quality standards as listed in Table 4-3. With the exception of ozone, where results will be reported in concentration units of part per billion by volume (ppb), all concentrations will be reported in units of micrograms per cubic meter ($\mu g/m^3$). Gas-phase species were converted from parts per million (ppm) to $\mu g/m^3$ using the conversion factor recommended in the Colorado Department of Health and Environment (CDPHE) air permit modeling guidance[68]. The incremental AQ and AQRV impacts due to each of the 24 Source Groups listed in Table 4-2 are reported. These 24 Source Groups are labeled A through X consist of the following sources:

(A - N) New Federal O&G from each of the 14 BLM Planning Areas as shown in Figure 4-1 and listed as Source Categories No. 2 through 15 in Table 4-1.

(O) Total Federal O&G from the CRVFO that combines the Roan Plateau and non-Roan Plateau portions of the CRVFO.

(P) Total Federal O&G from the RGFO that combines the four RGFO subregions plus the Pawnee Grassland portion of the RGFO.

(Q) Mining on Federal land within the 13 Colorado BLM Planning Areas.

(R) Combined O&G and mining development on Federal lands within all of the 13 Colorado BLM Planning Areas.

(S) Combined new O&G and mining development on Federal lands and new O&G development non-Federal lands within the 13 Colorado BLM Planning Areas.

(T) The Cumulative Emissions scenario that includes new O&G development on Federal and non-Federal lands and mining development on Federal lands within the 13 Colorado BLM Planning areas plus new O&G development for the Mancos Shale area in northern New Mexico.

(U) Emissions from all O&G development throughout the 4 km CARMMS domain (new Federal and non-Federal O&G through the domain plus Federal mining in Colorado).

(V) Natural emissions (biogenic, fires, lightning, WBD and sea salt).

(W) All emissions from the 2021 CAMx simulation (total concentrations).

(X) All emissions from the 2008 CAMx base case simulation (total concentrations).

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[68] C [ppm] = C [$\mu g/m^3$] / (40.9 x MW), where MW = molecular weight in g/mole. This formula assumes 1 atmosphere pressure and 298 K temperature. http://www.colorado.gov/airquality/permits/guide.pdf

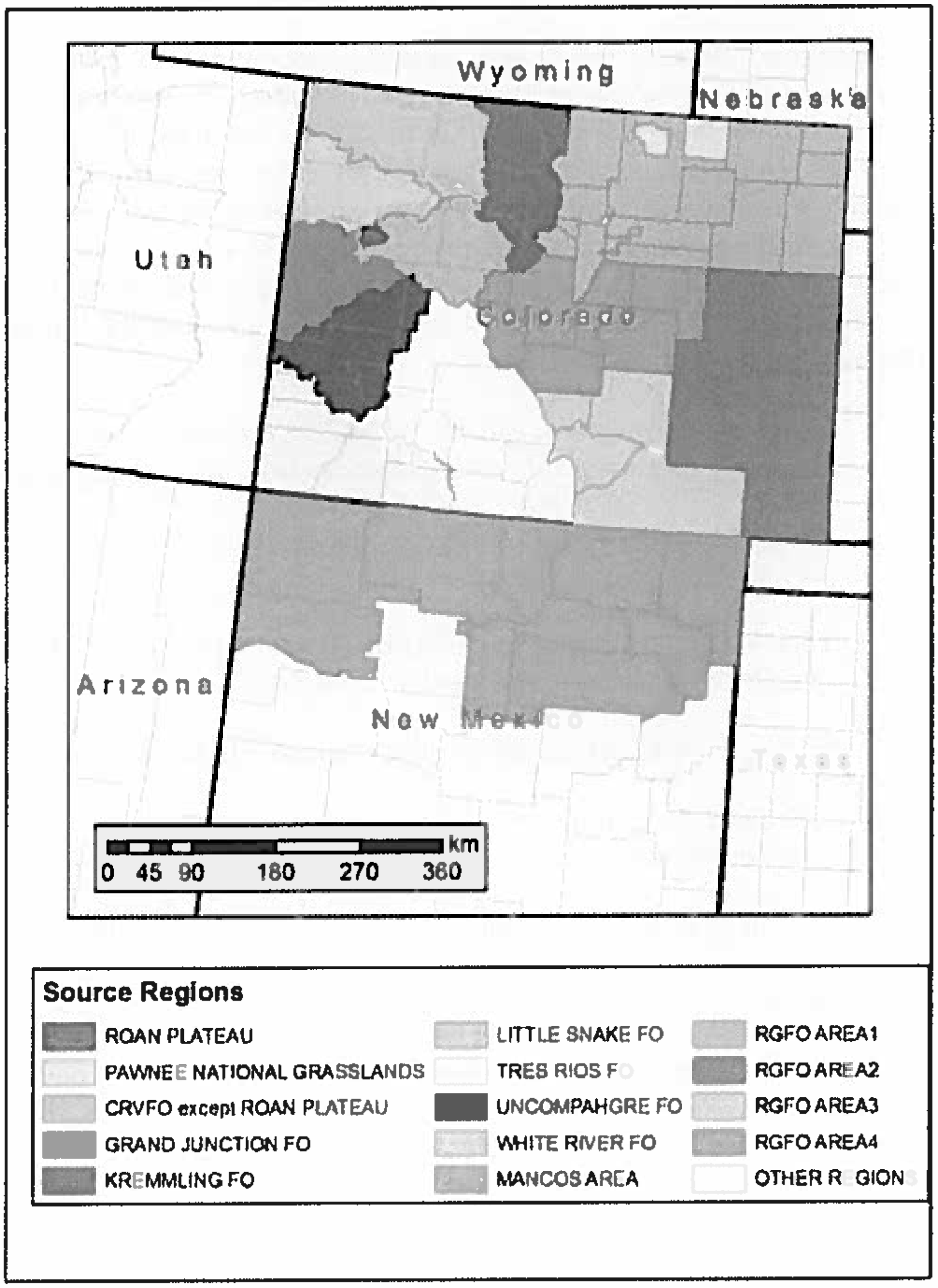

Figure 4-1. 13 Colorado and New Mexico BLM planning areas (the 14 BLM Planning Areas) where separate contributions of new O&G development on Federal lands was obtain for 2021 source apportionment modeling.

Table 4-2. 24 Source apportionment post-processing Source Groups that separate AQ/AQRV impacts at Class I and sensitive Class II areas will be disclosed for the 2021 emission scenarios and 2008 base case.

Processing Source Group	Source Group Name	Source Category No. (See Table 4-1)
A through N	See Table 4-1 for names of the new Federal O&G from the 14 BLM Planning Areas Source Categories #2 through #15	Separately #2 - #15
O	Total Colorado River Field Office	#4 and #5
P	Total Royal Gorge Field Office	#10, #11, #12 #13 and #14
Q	Mining from 13 Colorado BLM Planning Areas	#18
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	#2 -#14 and #18
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	#2 - #14 plus #16 and #18
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	#2 - #16 and #18
U	Combined O&G and Mining in 4 km domain	#2 - #19
V	Natural Emissions	#1
W	2021 All Emissions	#1 - #20
X	2008 Base Case All Emissions	--

Table 4-3. Applicable National and State Ambient Air Quality Standards and PSD concentration increments (bold indicates units in which standard was defined, conversion to ppm/ppb following CDPHE modeling guidance and with the exception of ozone that will be reported in ppb, all modeled concentrations will be reported in µg/m³).

Pollutant/Averaging Time	NAAQS	CAAQS[13]	NMAAQS[14]	PSD Class I Increment[1]	PSD Class II Increment[1]
CO					
1-hour[2]	**35 ppm** 40,000 µg/m³	--	**13.1 ppm** 1,100 µg/m³	--	--
8-hour[2]	**9 ppm** 10,000 µg/m³	--	**8.7 ppm** 10,000 µg/m³	--	--
NO_2					
1-hour[3]	**100 ppb** 188 µg/m³	--	--	--	--
24-hour	--	--	**0.10 ppm** 1,953 µg/m³	--	--
Annual[4]	**53 ppb** 100 µg/m³	--	**0.05 ppm** 98 µg/m³	2.5 µg/m³	25 µg/m³
O_3					
8-hour[5]	**0.075 ppm** 147 µg/m³	--	--	--	--
PM_{10}					
24-hour[6]	**150 µg/m³**	--	--	8 µg/m³	30 µg/m³
Annual[7]	--	--	--	4 µg/m³	17 µg/m³
$PM_{2.5}$					
24-hour[8]	**35 µg/m³**	--	--	2 µg/m³	9 µg/m³
Annual[9]	**12 µg/m³**	--	--	1 µg/m³	4 µg/m³
SO_2					
1-hour[10]	**75 ppb** 196 µg/m³	--	--		
3-hour[11]	**0.5 ppm** 1,300 µg/m³	**700 µg/m³**	--	25 µg/m³	512 µg/m³
24-hour[12]	--	--	**0.10 ppm** 262 µg/m³	5 µg/m³	91 µg/m³
Annual[4]	--	--	**0.02 ppm** 52 µg/m³	2 µg/m³	20 µg/m³

1. The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis.
2. No more than one exceedance per calendar year; for NMAAQS - No more than one exceedance per consecutive 12 months
3. 98th percentile, averaged over 3 year; for NMAAQS - not to be exceeded more than once over any 12 consecutive months
4. Annual mean not to be exceeded; for NMAAQS - arithmetic average over any four consecutive quarters not to be exceeded
5. Fourth-highest daily maximum 8-hour ozone concentrations in a year, averaged over 3 years
6. Not to be exceeded more than once per calendar year on average over 3 years.
7. 3 year average of the arithmetic means over a calendar year
8. 98th percentile, averaged over 3 years
9. Annual mean, averaged over 3 years, NAAQS promulgated December 14, 2012
10. 99th percentile of daily maximum 1-hour concentrations in a year, averaged over 3 years
11. No more than one exceedance per calendar year (secondary NAAQS) and no more than one exceedance in 12 consecutive months (CAAQS)
12. For areas in New Mexico not within 3.5 miles of the Chino Mines Company
13. http://www.colorado.gov/cs/Satellite/CDPHE-Main/CBON/1251601911433
14. http://www.nmcpr.state.nm.us/nmac/parts/title20/20.002.0003.htm

4.3 Class I and Sensitive Class II Areas for Analysis

The BLM COSO and NMSO and their contractors worked with the IAQRT to identify the Class I and sensitive Class II areas where the AQ/AQRV impacts due to O&G development on Federal lands within the Colorado BLM Planning Areas would be assessed. With the addition of the Mancos Shale development area in northwest New Mexico in the CARMMS analysis, the BLM NMSO reached out to the IAQRT to assist in identifying additional Class I and sensitive Class II areas to analyze in the analysis. Responses were received from NPS, USFS and FWS and a Technical Memorandum was prepared dated September 2, 2014 (Parker and Morris, 2014) for the NMSO that identified the Class I and sensitive Class II areas for the CARMMS analysis. Although the Class I area list did not change, several additional sensitive Class II areas were added to the CARMMS post-processing list that were within 300 km of the Mancos Shale development area.

The Class I and sensitive Class II areas were also analyzed and a few areas that overlapped or were adjacent were consolidated. In addition, new shapefiles of the Class I/II areas were acquired and GIS analysis was performed to define the grid cell definition of the Class I/II areas. This resulted in changes to the grid cell definitions of the Class I/II areas (i.e., receptors) from what was used in the CARMMS May 2014 preliminary draft report. Section 4.3.1 describes the procedures used and examples on how the grid cell definitions of the Class II/II areas were performed.

4.3.1 Final Class I and Sensitive Class II Areas

The Class I areas where air quality and AQRV impacts were calculated within the 4 km CARMMS modeling domain are displayed in Figure 4-2 and listed in Table 4-4. The sensitive Class II areas used in the CARMMS post-processing are displayed in Figure 4-3 by FLM ownership and listed in Table 4-5. Note that several of the Class I areas are portions of a sensitive Class II area. In total, the CARMMS modeling results were post-processed using 26-27 and 58 Class I and sensitive Class II areas, respectively. Details on how the sensitive Class II areas were defined are provided in Parker and Morris (2014). Note that the Colorado side of Dinosaur National Monument is considered PSD Class I for just SO_2. Sensitive lakes in the region where acid neutralizing capacity (ANC) calculations will be made are listed in Table 4-6.

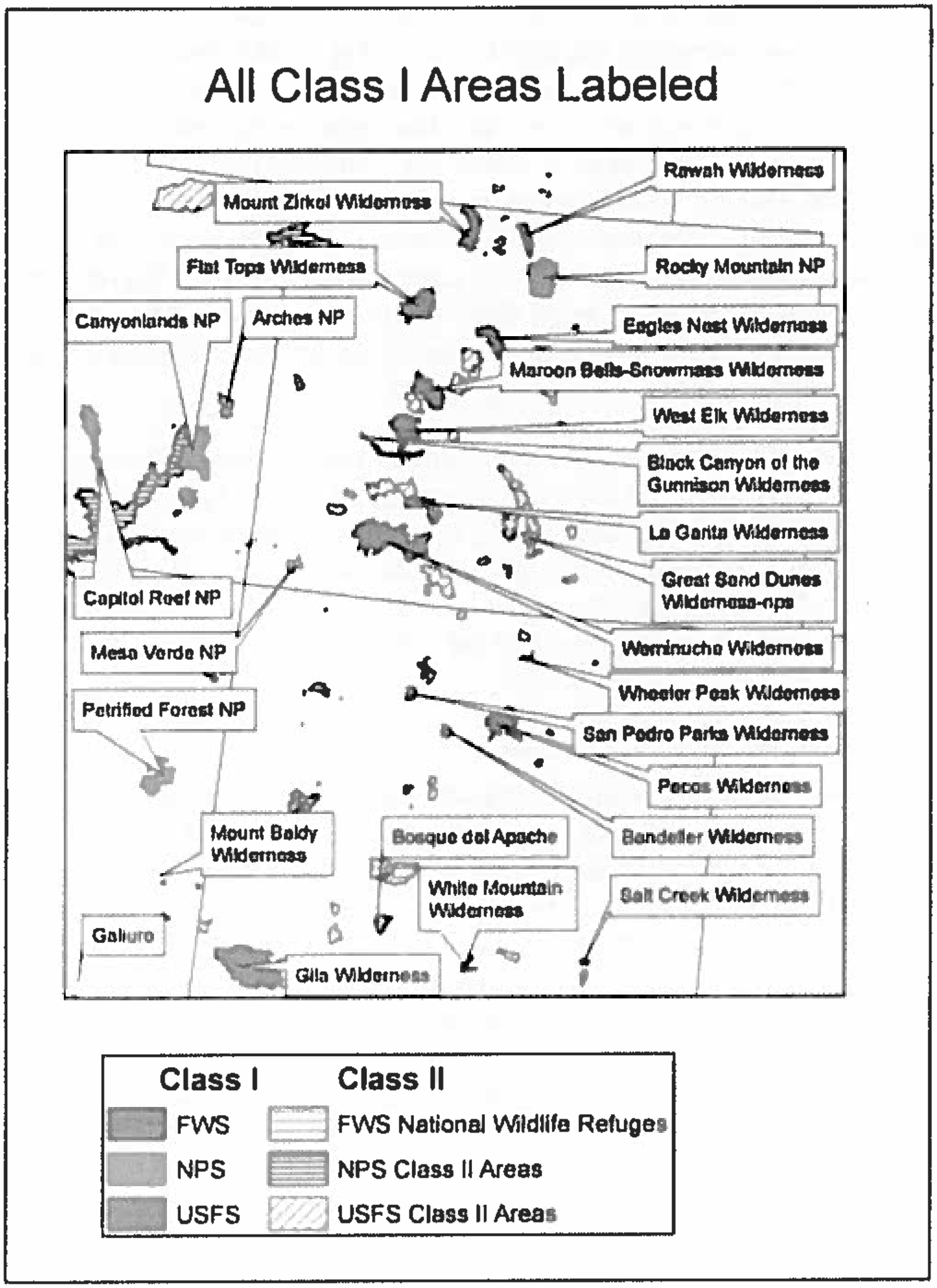

Figure 4-2. Locations of Class I (dark green) and sensitive Class II (light green) areas where air quality and AQRV impacts were assessed as well as sensitive lakes (blue dots) where ANC calculations will be made (Class I areas are labeled).

Table 4-4. List of Class I Areas for Impact Analysis

Class I Area	State	FLM
Arches NP	UT	NPS
Bandelier Wilderness	NM	NPS
Black Canyon of the Gunnison National Park	CO	NPS
Bosque del Apache Wilderness	NM	FWS
Canyonlands NP	UT	NPS
Capitol Reef NP	UT	NPS
Eagles Nest Wilderness	CO	USFS
Flat Tops Wilderness	CO	USFS
Galiuro Wilderness	AZ	USFS
Gila Wilderness	NM	USFS
Great Sand Dunes Wilderness-NPS	CO	NPS
La Garita Wilderness	CO	USFS
Maroon Bells-Snowmass Wilderness	CO	USFS
Mesa Verde NP	CO	NPS
Mount Baldy Wilderness	AZ	USFS
Mount Zirkel Wilderness	CO	USFS
Pecos Wilderness	NM	USFS
Petrified Forest NP	AZ	NPS
Rawah Wilderness	CO	USFS
Rocky Mountain NP	CO	NPS
Salt Creek Wilderness	NM	FWS
San Pedro Parks Wilderness	NM	USFS
Weminuche Wilderness	CO	USFS
West Elk Wilderness	CO	USFS
Wheeler Peak Wilderness	NM	USFS
White Mountain Wilderness	NM	USFS
Dinosaur NM[1]	UT & CO	NPS
1. The Colorado side of Dinosaur NM is PSD Class I for SO_2		

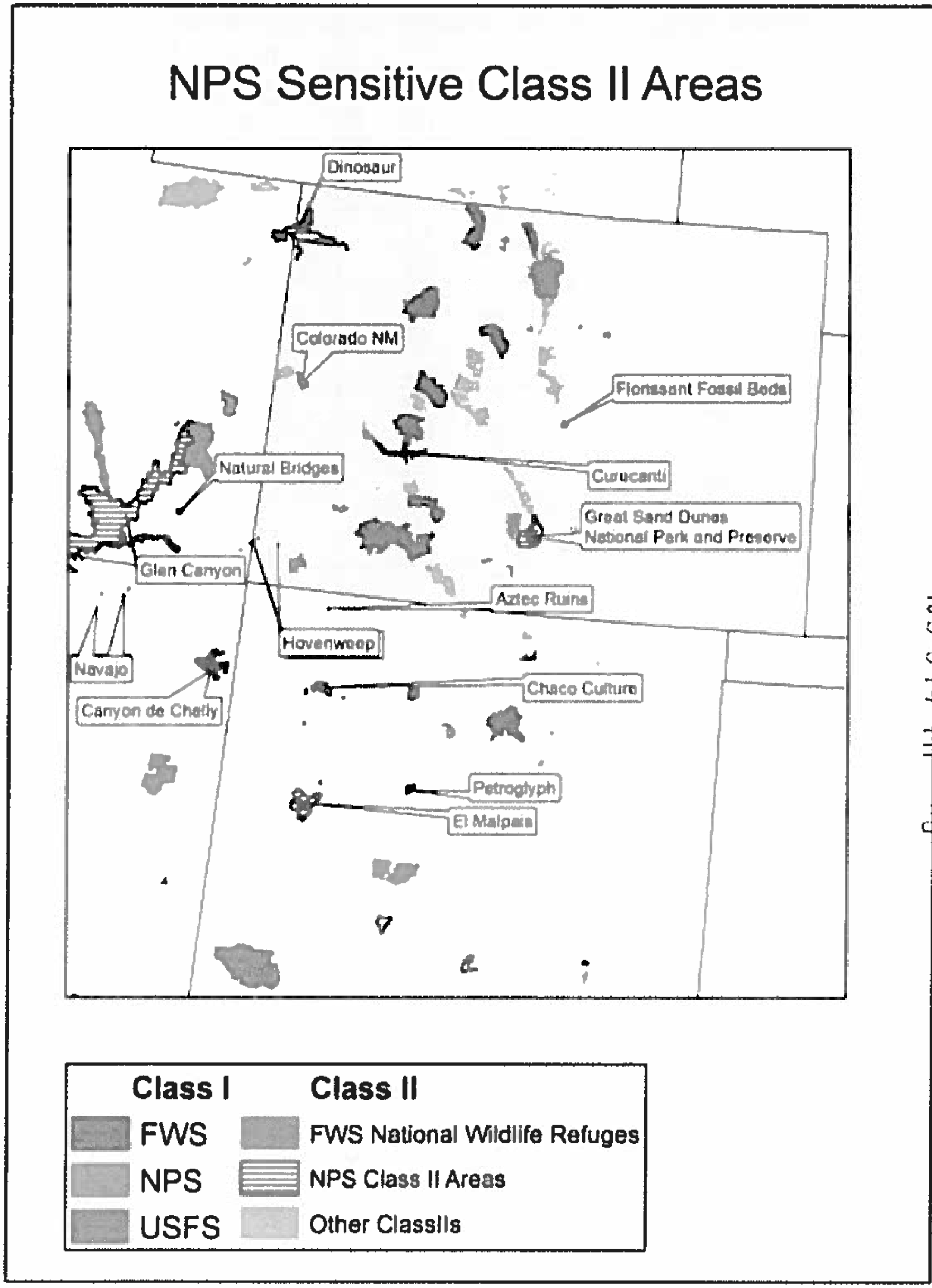

Figure 4-3a. NPS sensitive Class II areas for the CARMMS analysis labeled. Class I areas and non-NPS sensitive Class II areas unlabeled.

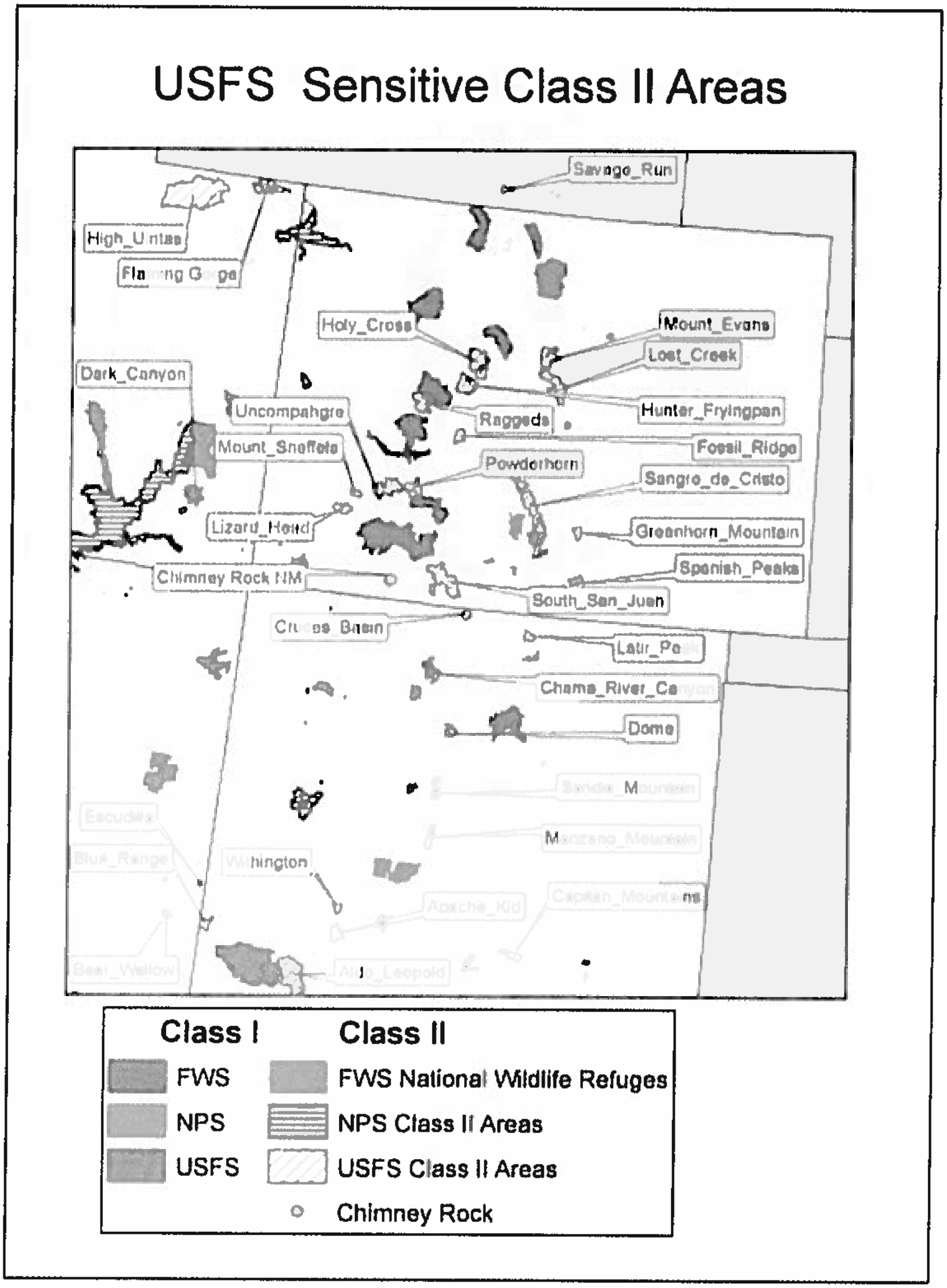

Figure 4-3b. USFS sensitive Class II areas for the CARMMS analysis labeled. Class I area and non-USFS Class II areas displayed but not labeled.

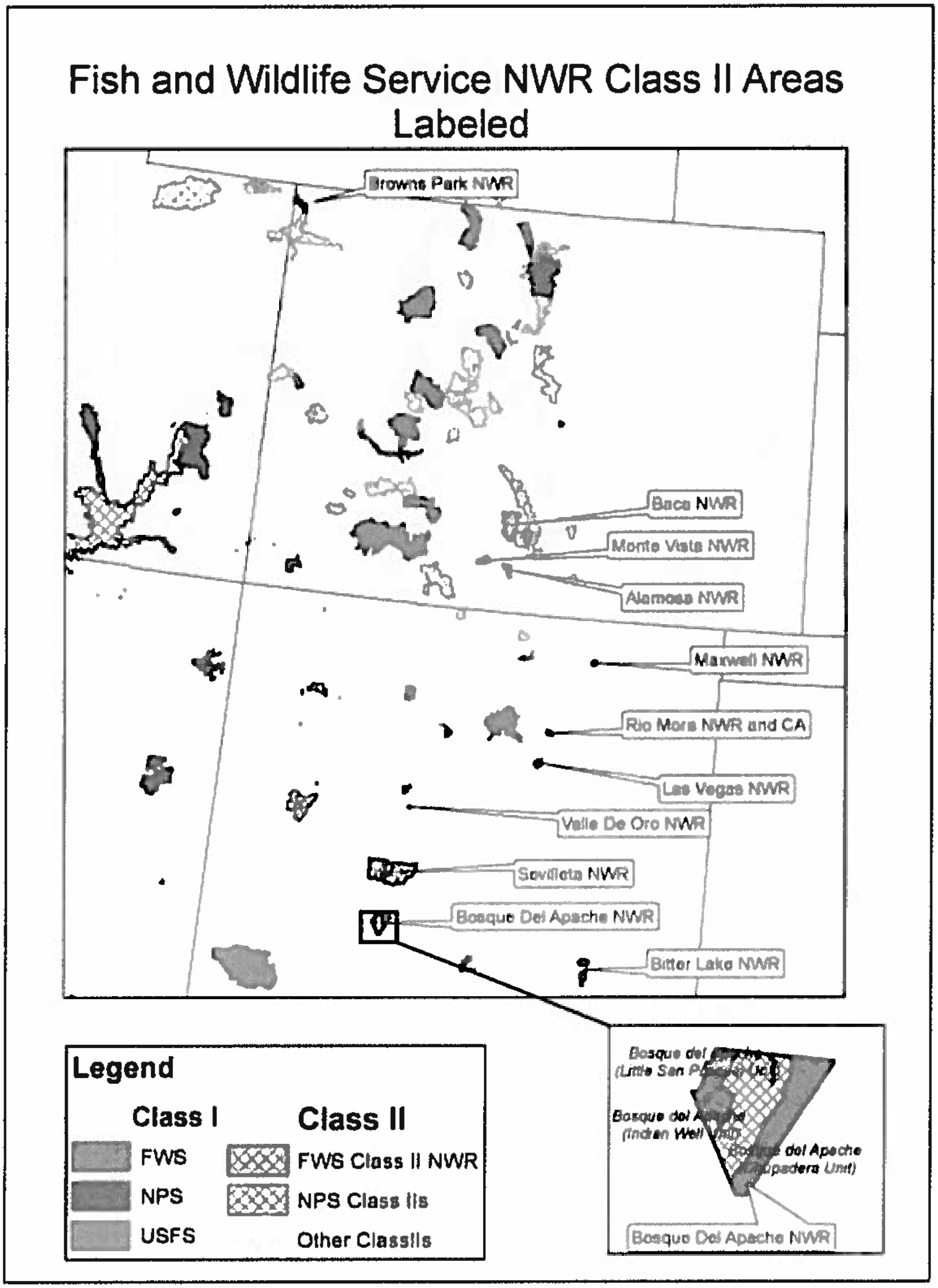

Figure 4-3c. FWS sensitive Class II areas for the CARMMS analysis labeled. Class I areas and non-FWS areas shown but not labeled.

Table 4-5. Sensitive Class II areas where air quality and AQRV impacts were assessed.

Sensitive Class II Area	State	FLM
Alamosa NWR	CO	FWS
Aldo Leopold Wilderness	NM	USFS
Apache Kid Wilderness	NM	USFS
Aztec Ruins NM	NM	NPS
Baca NWR	CO	FWS
Bear Wallow Wilderness	AZ	USFS
Bitter Lake NWR	NM	FWS
Blue Range Wilderness	NM	USFS
Bosque Del Apache NWR	NM	FWS
Browns Park NWR	CO	FWS
Canyon de Chelly NM	AZ	NPS
Capitan Mountains Wilderness	NM	USFS
Chaco Culture NHP	NM	NPS
Chama River Canyon Wilderness	NM	USFS
Chimney Rock NM	CO	USFS
Colorado NM	CO	NPS
Cruces Basin Wilderness	NM	USFS
Curecanti NRA	CO	NPS
Dark Canyon Wilderness	UT	USFS
Dinosaur NM	CO	NPS
Dome Wilderness	NM	USFS
El Malpais NM	NM	NPS
Escudilla Wilderness	AZ	USFS
Flaming Gorge	UT	USFS
Florissant Fossil Beds NM	CO	NPS
Fossil Ridge Wilderness	CO	USFS
Glen Canyon NRA	UT	NPS
Great Sand Dunes National Park	CO	NPS
Great Sand Dunes National Preserve	CO	NPS
Greenhorn Mountain Wilderness	CO	USFS
High Uintas Wilderness	UT	USFS
Holy Cross Wilderness	CO	USFS
Hovenweep NM	CO	NPS
Hunter-Fryingpan Wilderness	CO	USFS
Las Vegas NWR	NM	FWS
Latir Peak Wilderness	NM	USFS
Lizard Head Wilderness	CO	USFS
Lost Creek Wilderness	CO	USFS
Manzano Mountain Wilderness	NM	USFS
Maxwell NWR	NM	FWS
Monte Vista NWR	CO	FWS
Mount Evans Wilderness	CO	USFS
Mount Sneffels Wilderness	CO	USFS
Natural Bridges NM	UT	NPS
Navajo NM	AZ	NPS

Table 4-6. Sensitive lakes where ANC calculations were made.

Lake	National Forest Name	Wilderness Name
Walk Up Lake	Ashley National Forest	
Tabor Lake	White River National Forest	Collegiate Peaks Wilderness
Brooklyn Lake	White River National Forest	Collegiate Peaks Wilderness
Booth Lake	White River National Forest	Eagles Nest Wilderness
Upper Willow Lake	White River National Forest	Eagles Nest Wilderness
Upper Ned Wilson Lake	White River National Forest	Flat Tops Wilderness
Lower Nwl Packtrail Pothole	White River National Forest	Flat Tops Wilderness
Ned Wilson Lake	White River National Forest	Flat Tops Wilderness
Upper Nwl Packtrail Pothole	White River National Forest	Flat Tops Wilderness
Dean Lake	Ashley National Forest	High Uintas Wilderness
No Name (Utah; Duchesne - 4d2-039)	Ashley National Forest	High Uintas Wilderness
Fish Lake	Wasatch-Cache National Forest	High Uintas Wilderness
Bluebell	ASHLEY NATIONAL FOREST	HIGH UINTAS WILDERNESS
Upper Coffin	Ashley National Forest	High Uintas Wilderness
Blodgett Lake, Colorado	White River National Forest	Holy Cross Wilderness
Upper Turquoise Lake	White River National Forest	Holy Cross Wilderness
Upper West Tennessee Lake	San Isabel National Forest	Holy Cross Wilderness
Blue Lake (Colorado; Boulder - 4e1-040)	Arapaho And Roosevelt National Forests	Indian Peaks Wilderness
No Name (Colorado; Boulder - 4e1-055)	Arapaho And Roosevelt National Forests	Indian Peaks Wilderness
King Lake (Colorado; Grand - 4e1-049)	Arapaho And Roosevelt National Forests	Indian Peaks Wilderness
Crater Lake (Colorado; Grand - 4e1-041)	Arapaho And Roosevelt National Forests	Indian Peaks Wilderness
Upper Lake	Arapaho And Roosevelt National Forests	Indian Peaks Wilderness
Small Lake Above U-Shaped Lake	Rio Grande National Forest	La Garita Wilderness
U-Shaped Lake	Rio Grande National Forest	La Garita Wilderness
Moon Lake (Upper)	White River National Forest	Maroon Bells-Snowmass Wilderness
Avalanche Lake	White River National Forest	Maroon Bells-Snowmass Wilderness
Capitol Lake	White River National Forest	Maroon Bells-Snowmass Wilderness
Upper Middle Beartrack Lake	Arapaho And Roosevelt National Forests	Mount Evans Wilderness
South Lake (Colorado)	Pike And San Isabel National Forests	Mount Evans Wilderness
Abyss Lake	Pike And San Isabel National Forests	Mount Evans Wilderness
North Lake (Colorado)	Pike And San Isabel National Forests	Mount Evans Wilderness
Frozen Lake	Pike And San Isabel National Forests	Mount Evans Wilderness
Seven Lakes (Lg.East)	Medicine Bow-Routt National Forest	Mount Zirkel Wilderness
Summit Lake (Colorado;	Medicine Bow-Routt National Forest	Mount Zirkel Wilderness

Lake	National Forest Name	Wilderness Name
Jackson - 4e2-060)		
Lake Elbert	Medicine Bow-Routt National Forest	Mount Zirkel Wilderness
Deep Creek Lake, Colorado	Gunnison National Forest	Raggeds Wilderness
Rawah Lake #4	Arapaho And Roosevelt National Forests	Rawah Wilderness
Island Lake	Arapaho And Roosevelt National Forests	Rawah Wilderness
Kelly Lake (Colorado)	Arapaho And Roosevelt National Forests	Rawah Wilderness
Upper Stout Lake	San Isabel National Forest	Sangre De Cristo Wilderness
Upper Little Sand Creek Lake	San Isabel National Forest	Sangre De Cristo Wilderness
Lower Stout Lake	San Isabel National Forest	Sangre De Cristo Wilderness
Crater Lake (Sangre De Cristo)	Rio Grande National Forest	Sangre De Cristo Wilderness
Lake South Of Blue Lakes	San Juan-Rio Grande National Forest	South San Juan Wilderness
Glacier Lake (Colorado)	San Juan-Rio Grande National Forest	South San Juan Wilderness
Little Eldorado Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
White Dome Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Lake Due South Of Ute Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Big Eldorado Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Small Pond Above Trout Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Upper Sunlight Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Upper Grizzly Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
West Snowdon Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Middle Ute Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Little Granite Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Lower Sunlight Lake	San Juan-Rio Grande National Forest	Weminuche Wilderness
Four Mile Pothole	San Juan-Rio Grande National Forest	Weminuche Wilderness
South Golden Lake	Grand Mesa, Uncompahgre And Gunnison National Forests	West Elk Wilderness

4.3.2 Class I and Sensitive Class II Area Grid Cell Assignments

The list of CAMx grid cells that represent each Class I/II area changed slightly between the preliminary analysis as documented in the May 2014 report and the final analysis reported here. For some of the Class I/II areas, the CAMx grid cells used to represent the areas are identical in the preliminary and final analyses, these areas include Galiuro Wilderness, Mt Baldy Wilderness and Colorado NM. For some other Class I/II areas, the CAMx grid cells used to represent the areas differ by a single grid cell (of about 100 total grid cells). The final results for these areas are usually expected to be very close to the preliminary results, those areas include Canyonlands National Park and Rocky Mountain National Park. Some of the other Class I/II areas have more grid cell differences between the preliminary and final analysis.

Determining the grid cells that represent the Class I/II areas is achieved with Graphical Information System (GIS) software, and is performed by intersecting the CAMx model grid cells with GIS shapefiles that define the Class I/II boundaries. Different GIS tools are available to perform the intersection that assigns a Class I/II designation to each grid cell, and different input shapefiles defining the boundaries are also available.

To generate the grid cells for the final analysis, we used official Class I boundary shapefiles that are available for download from the NPS website[69]. The GIS tool "spatial join" was used to assign a Class I/II area to each CAMx grid cell if any part of the Class I/II area intersects the grid cell, even if the Class I/II area only covers a small fraction of the grid cell. For example, Figure 4-4 displays the La Garita Wilderness Class I area boundary and grid cells (receptors) representing that area, the numbers displayed in the grid cells are the i and j coordinates of the CARMMS 4 km domain modeling grid. In Figure 4-4 it can be seen that many of the grid cells covering the boundary of La Garita have more than 50% of the grid cell area outside of the La Garita boundary, these grid cells may not have been used in the preliminary analysis. In fact there are numerous grid cells assigned to the La Garita Wilderness where the Class I area covers less than 10 percent of the grid cell. The inclusion of any grid cell that intersects any part of the Class I area no matter how small introduces conservatisms in the analysis. In addition, for the final processing, attention was paid to grid cells that cover more than one Class I/II area, in those cases, a particular grid cell was used twice to represent 2 different neighboring Class I/II areas. Figure 4-5 provides an example of a grid cell (56_153) that is used to represent both Black Canyon of the Gunnison Class I area and Curecanti NPS Class II area. Figure 4-6 displays a quality assurance (QA) plot showing all the Class I areas (including the Colorado side of Dinosaur NM, since it is considered a Class I area for SO_2), overlaid with the grid cells used to represent the Class I/II areas in the final analysis.

[69] http://www.nature.nps.gov/air/maps/classiloc.cfm

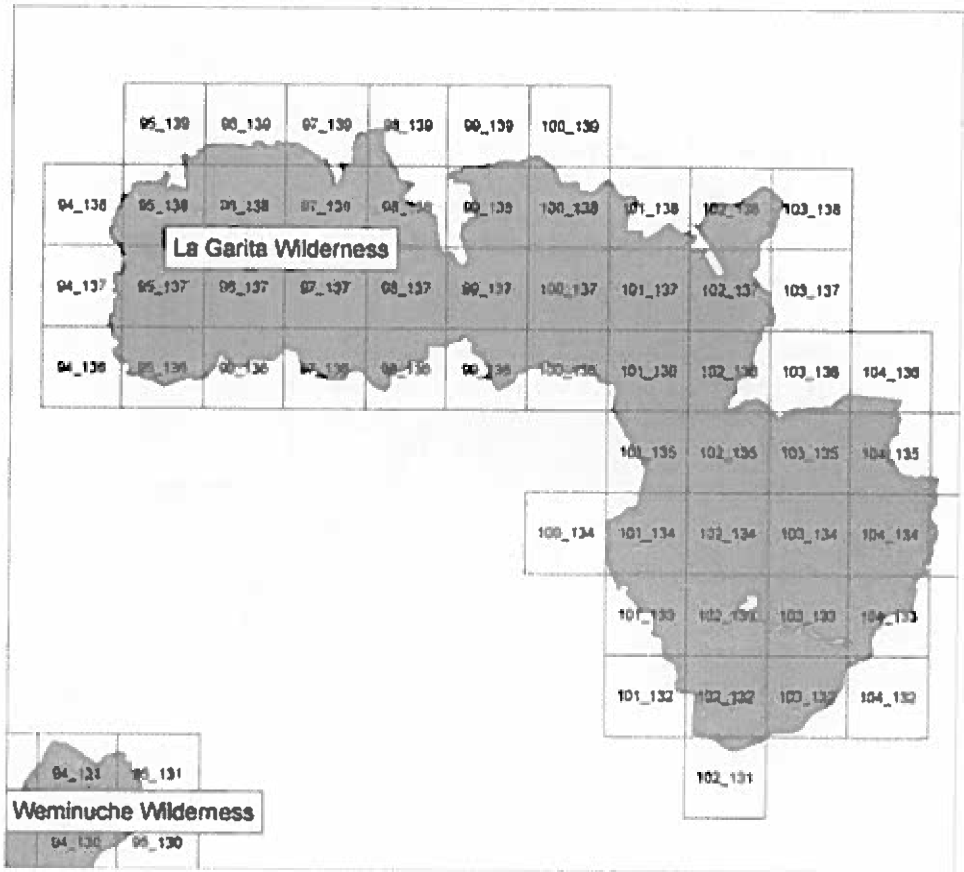

Figure 4-4. La Garita Wilderness Area represented by 4 km grid cells.

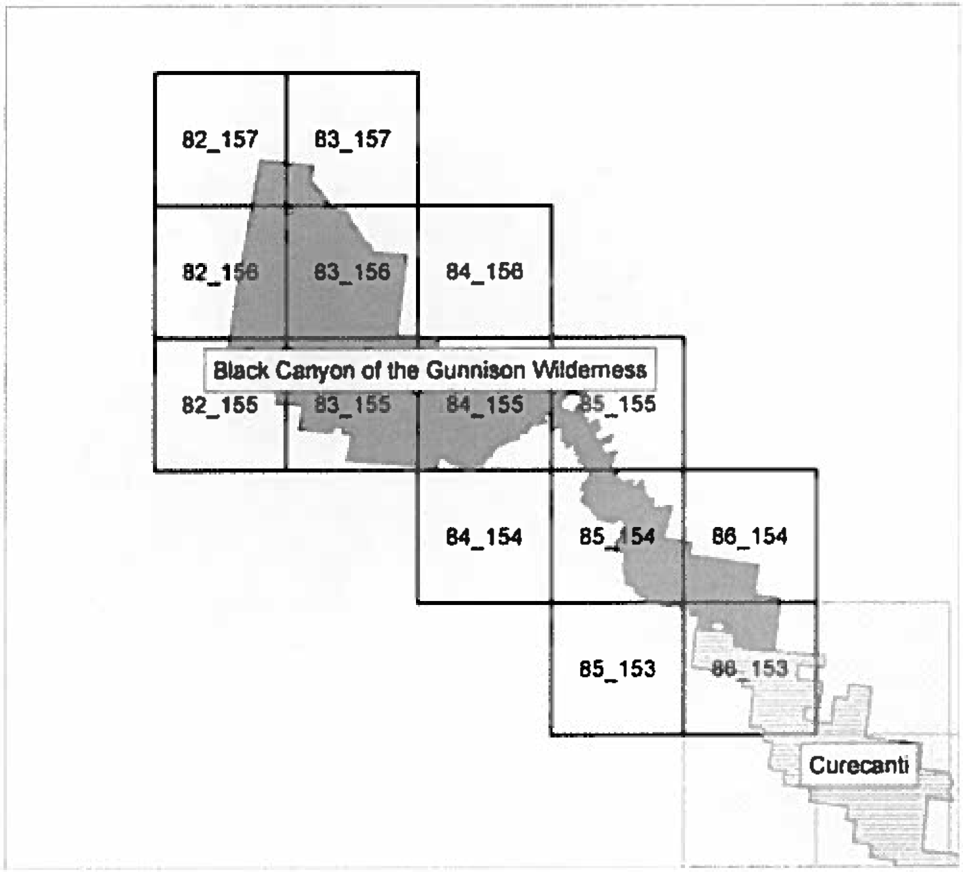

Figure4-5. Example of Black Canyon of the Gunnison Class I area grid cell overlap with Curecanti Class II area.

Class I Areas with Grid Cells

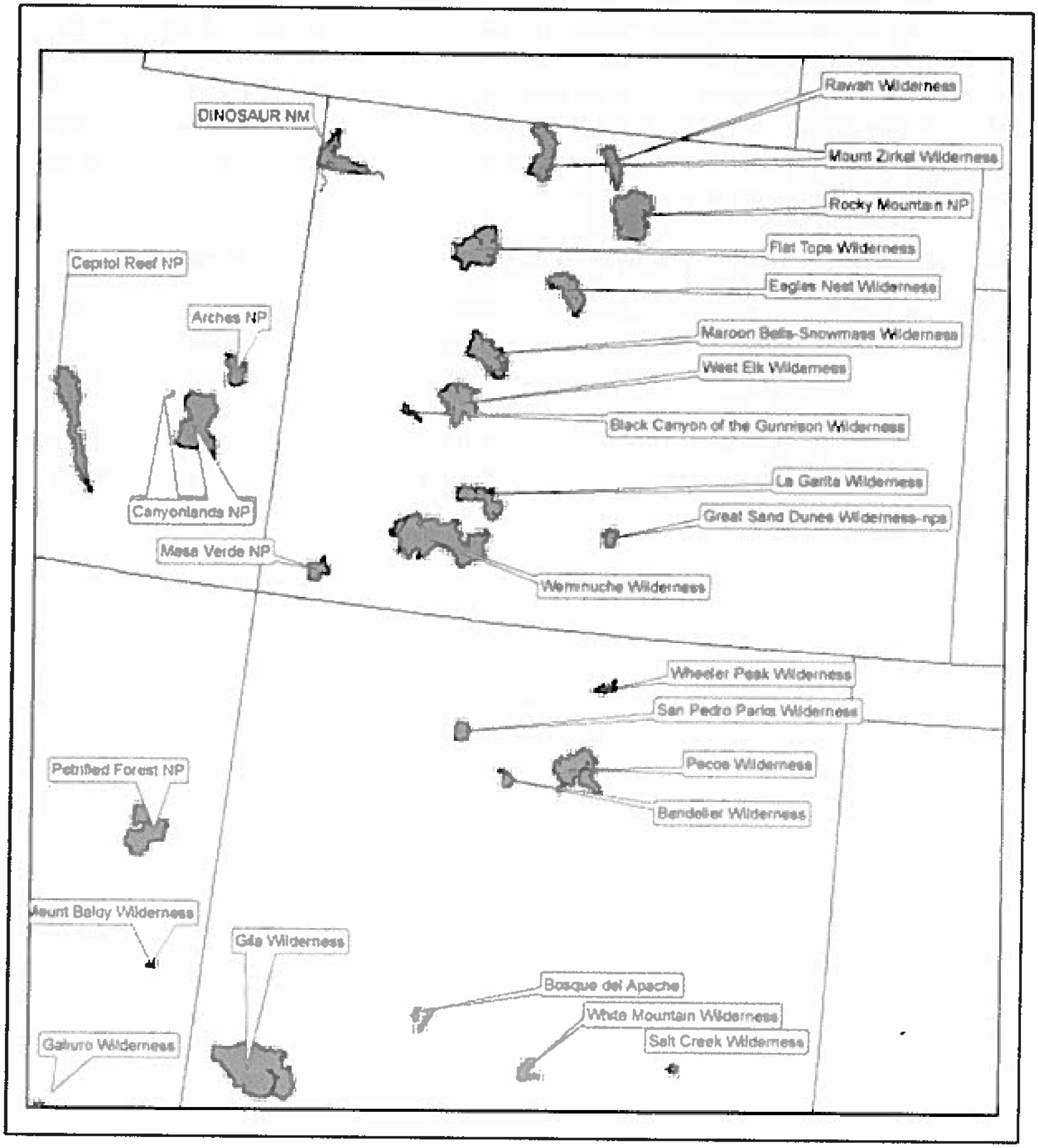

Figure 4-6. QA Plot showing all Class I Areas and CARMMS 4 km grid cell receptors that represent the areas.

4.4 Ambient Concentration Analysis using Absolute Modeling Results

Modeled concentrations predicted by the CAMx due to all sources were compared against national and state standards (NAAQS, CAAQS and NMAAQS, see Table 4-3) throughout the 4 km modeling domain. When exceedances of the ozone or $PM_{2.5}$ NAAQS are estimated, the APCA and PSAT source apportionment results was used to determine the contribution of emissions from each of the Source Groups to determine the major cause of the modeled exceedance. The incremental air quality concentration contribution due to emissions from oil and gas on Federal lands at Class I and sensitive Class II areas for each BLM planning area were compared to applicable PSD increments (see Table 4-3). The PSD demonstrations are for information only and are not regulatory PSD Increment consumption analyses, which would be completed as necessary by the relevant state or other agency.

4.5 Ambient Concentration Analysis using Relative Modeling Results

EPA's modeling guidance recommends using the PGM modeling results in a relative fashion when comparing future year modeling results to the ozone and $PM_{2.5}$ NAAQS (EPA, 2007). The relative change in the PGM concentrations between the current and future year simulations are used to scale the observed current year ozone or $PM_{2.5}$ Design Value (DVC) to obtain a projected future year Design Value (DVF). The model derived scaling factors are called Relative Response Factors (RRFs) and are based on the ratio of future year to current year modeling results:

$$DVF = DVC \times RRF$$

EPA's PGM modeling guidance provides recommended procedures for calculating DVCs and RRFs (EPA, 2007) that have been implemented in EPA's Modeled Attainment Test Software (MATS[70]; Abt, 2012). The MATS projection tool was used with the CAMx 2008 Base Case and 2021 High, Low and Medium Development Scenarios modeling results to project future year ozone DVFs that were compared to the NAAQS. MATS also has a capability of projecting $PM_{2.5}$ DVFs but there is much less observed $PM_{2.5}$ data in the region so such projections would be extremely limited, so MATS was not used for $PM_{2.5}$. The MATS default settings for making future year ozone projections were used that includes using a current year Design Value (DVC) based on an average of three-years of Design Values (DVs) centered on the Base Case modeling year (2008) and constructing RRFs using at least 10 days of modeling results. As the Base Case year is 2008, then this means using a DVC based on DVs from the following 3-year periods, 2006-2008, 2007-2009 and 2008-2010.

4.6 Visibility Analysis

Visibility impacts were calculated for new oil and gas emissions on Federal lands within each BLM Planning Areas as well as for cumulative emissions sources. The approach used the incremental concentrations as quantified by the CAMx PSAT tool simulation of oil and gas and mining activities within each BLM planning area. Changes in light extinction from CAMx model

[70] http://www.epa.gov/ttn/scram/modelingapps_mats.htm

concentration increments due to emissions from oil and gas and other activity emissions were calculated for each day at grid cells that intersect Class I and sensitive Class II areas within the 4 km modeling domain (see Section 4.3.2). The FLAG (2010) procedures were used in the incremental BLM planning area-specific visibility assessment analysis.

The visibility evaluation metric used in this analysis is based on the Haze Index which is measured in deciview (dv) units and is defined as follows:

$$HI = 10 \times \ln[b_{ext}/10] .$$

b_{ext} is the atmospheric light extinction measured in inverse megameters (Mm^{-1}) and is calculated primarily from atmospheric concentrations of particulates. A more intuitive measure of haze is visual range (VR), which is defined as the distance at which a large black object just disappears from view, and is measured in km. Visual range is related to b_{ext} by the formula VR = 3912 / b_{ext}. Visual range will not be used as a threshold in the analysis, but could be back-calculated from extinction to give a more easily understood visibility metric.

The incremental concentrations due to BLM planning area emissions were added to background concentrations in the extinction equation (b_{ext}) and the difference between the Haze Index with added BLM planning area concentrations to the Haze Index based solely on background concentrations is calculated. This quantity is the change in Haze Index, which is referred to as "delta deciview" (Δdv) :

$$\Delta dv = 10 \times \ln[b_{ext(BLM+background)}/10] - 10 \times \ln[b_{ext(background)}/10]$$

$$\Delta dv = 10 \times \ln[b_{ext(BLM+background)}/b_{ext(background)}]$$

Here $b_{ext(BLM+background)}$ refers to atmospheric light extinction due to oil and gas and other activities in each BLM planning area plus background concentrations, and $b_{ext(background)}$ refers to atmospheric light extinction due to background concentrations only.

For each individual BLM Planning Areas, the estimated visibility degradation at the Class I areas and sensitive Class II areas due to new O&G emissions on Federal lands are presented in terms of the number of days that exceed a threshold change in deciview (Δdv) relative to background conditions. In the next section we describe the method for calculating the extinction, b_{ext}.

4.6.1 IMPROVE Reconstructed Mass Extinction Equations

The FLAG (2010) procedures for evaluating visibility impacts at Class I areas use the revised IMPROVE reconstructed mass extinction equation to convert PM species in μgm^{-3} to light extinction (b_{ext}) in inverse megameters (Mm^{-1}) as follows:

$$b_{ext} = b_{SO4} + b_{NO3} + b_{EC} + b_{OCM} + b_{Soil} + b_{PMC} + b_{SeaSalt} + b_{Rayleigh} + b_{NO2}$$

where

$$b_{SO4} = 2.2 \times f_S(RH) \times [\text{Small Sulfate}] + 4.8 \times f_L(RH) \times [\text{Large Sulfate}]$$

$$b_{NO3} = 2.4 \times f_S(RH) \times [\text{Small Nitrate}] + 5.1 \times f_L(RH) \times [\text{Large Nitrate}]$$

$$b_{OCM} = 2.8 \times [\text{Small Organic Mass}] + 6.1 \times [\text{Large Organic Mass}]$$

$$b_{EC} = 10 \times [\text{Elemental Carbon}]$$

$$b_{Soil} = 1 \times [\text{Fine Soil}]$$

$$b_{CM} = 0.6 \times [\text{Coarse Mass}]$$

$$b_{SeaSalt} = 1.7 \times f_{SS}(RH) \times [\text{Sea Salt}]$$

$$b_{Rayleigh} = \text{Rayleigh Scattering (Site-specific)}$$

$$b_{NO2} = 0.33 \times [NO_2\ (\text{ppb})]\ \{\text{or as: } 0.1755 \times [NO_2\ (\mu g/m^3)]\}.$$

f(RH) are relative humidity adjustment factors that account for the fact that sulfate, nitrate and sea salt aerosols are hygroscopic and are more effective at scattering radiation at higher relative humidity. FLAG (2010) recommends using monthly average f(RH) values rather than the hourly averages recommended in the previous FLAG (2000) guidance document in order to moderate the effects of extreme weather events on the visibility results.

The revised IMPROVE equation treats "large sulfate" and "small sulfate" separately because large and small aerosols affect an incoming beam of light differently. However, the IMPROVE measurements do not separately measure large and small sulfate; they measure only the total $PM_{2.5}$ sulfate. Similarly, CAMx writes out a single concentration of particulate sulfate for each grid cell. Part of the definition of the new IMPROVE equation is a procedure for calculating the large and small sulfate contributions based on the magnitude of the model output sulfate concentrations; the procedure is documented in FLAG (2010). The sulfate concentration magnitude is used as a surrogate for distinguishing between large and small sulfate concentrations. For a given grid cell, the large and small sulfate contributions are calculated from the model output sulfate (which is the "Total Sulfate" referred to in the FLAG (2010) guidance) as:

For Total Sulfate < 20 $\mu g/m^3$:

$$[\text{Large Sulfate}] = ([\text{Total Sulfate}] / 20\ \mu g/m^3) \times [\text{Total Sulfate}]$$

For Total Sulfate ≥ 20 $\mu g/m^3$:

$$[\text{Large Sulfate}] = [\text{Total Sulfate}]$$

For all values of Total Sulfate:

$$[\text{Small Sulfate}] = [\text{Total Sulfate}] - [\text{Large Sulfate}]$$

The procedure is identical for nitrate and organic mass. Sulfate, nitrate and organic mass concentrations for the western U.S. are expected to be mainly in the small fraction.

The PSAT source apportionment algorithm does not separately track NO_2 concentrations but instead tracks total reactive nitrogen (RGN) that consistent mainly of NO plus NO_2. Thus for each hour and each grid cell representing a Class I/II area, a Source Group's incremental PSAT RGN contribution is converted to NO_2 by multiplying by the total (all emissions) CAMx model NO_2/RGN concentration ratio, which is then used in the IMPROVE visibility equation.

Although sodium and particulate chloride are treated in the CAMx core model, these species are not carried in the CAMx PSAT tool; neglecting sea salt in the visibility calculations in the 4 km CARMMS impact assessment domains does not compromise the accuracy of the analysis as IMPROVE measurements show that sea salt concentrations are negligible in this inland area and there would be no sea salt associated with any of the O&G emissions.

Predicted daily average modeled concentrations due to each BLM planning area for grid cells containing Class I and sensitive Class II area receptors were processed using the revised IMPROVE reconstructed mass extinction equation FLAG (2010) to obtain changes in b_{ext} at each sensitive receptor area that are converted to deciview and reported.

The FLAG (2010) method was used to estimate the visibility impacts from each Colorado and northern New Mexico BLM Planning Area. This method used the revised IMPROVE equation together with annual average natural conditions (see Table 6 in FLAG, 2010) and monthly relative humidity factors for each Class I area (see Tables 7-9 in FLAG, 2010). The Δdv was calculated for each grid cell that overlaps a Class I or sensitive Class II area for each day of the annual CAMx run. The highest Δdv across all grid cells overlapping a Class I or sensitive Class II area was selected to represent the daily value at that Class I/II area. Visibility impacts due to new O&G emissions on Federal lands within each BLM Planning Areas that are more than 0.5 and 1.0 dv will be reported.

4.6.2 Cumulative Visibility

The cumulative visibility impacts due to the development of oil and gas and other (e.g., mining) activities on all BLM Planning Areas were assessed following the recommendations from the FWS and NPS that was outlined in their February 10, 2012 letter to the Wyoming Department of Environmental Quality on recommended cumulative visibility method for the Continental Divide-Creston gas infill development EIS (FWS and NPS, 2012) and subsequent conversations with the FLMs. This approach is based on an abbreviated regional haze rule method that estimates the future year visibility at Class I and sensitive Class II areas for the average of the Worst 20% (W20%) and Best 20% (B20%) visibility days with and without the effects of the cumulative emissions on visibility impairment. The cumulative visibility impacts used CAMx model output from the 2008 Base Case and 2021 emissions scenarios in conjunction with monitoring data to produce cumulative visibility impacts at each Class I area in the CARMMS domain. EPA's Modeled Attainment Test Software (MATS[71]) was used to make the 2021 visibility projections for the W20% and B20% days. The basic steps in the recommended cumulative visibility method are as follows (FWS and NPS, 2012):

[71] http://www.epa.gov/ttn/scram/modelingapps_mats.htm

1. Calculate the observed average 2008 current year cumulative visibility impact using the Haze Index (HI, in deciviews) at each Class I or associated sensitive Class II area to determine the 20% of days with the worst and 20% of days with the best visibility. The intent is to incorporate 5 years of monitoring data surrounding the 2008 Base Case year, which would include 2006-2010. MATS uses the IMPROVE data associate with each Class I area and modeling results at the location of the IMPROVE monitoring site will be used.

2. Estimate the relative response factors (RRFs) for each component of $PM_{2.5}$ and for coarse mass (CM) corresponding to the new IMPROVE visibility algorithm using the CAMx 2008 and 2021 model output.

3. Using the RRFs and ambient data, calculate 2021 future-year daily concentration data for the B20% and W20% days using the CAMx 2008 Base Case and 2021 standard model concentration estimates and PSAT source apportionment modeling results two ways:

    a. <u>2021 Total Emissions</u>: Use total 2021 High, Low and Medium Development Scenario CAMx concentration results due to all emissions;

    b. <u>2021 No Cumulative Emissions</u>: Use PSAT source apportionment results to eliminate contributions of PM concentrations associated with combined emission scenarios corresponding to Source Groups R,S,T and U in Table 4-2.

4. Use the information in step 3 to calculate the average 2021 visibility for the 20% Best and 20% Worst visibility days and the 2021 emissions.

5. Assess the average differences in cumulative visibility impacts for the four combined scenarios and also compare with the current observed Baseline visibility conditions.

4.7 Sulfur and Nitrogen Deposition

CAMx-predicted wet and dry fluxes of sulfur- and nitrogen-containing species were processed to estimate total annual sulfur (S) and nitrogen (N) deposition values at each Class I and sensitive Class II area as well as at each acid sensitive lake. The Maximum annual S and N deposition values from any grid cell that intersects a Class I or sensitive Class II receptor area was used to represent deposition for that area, in addition to the Average annual deposition values of all grid cells that intersect a Class I or sensitive Class II receptor area. Maximum and Average predicted S and N deposition impacts were estimated separately for each BLM planning area and together across all BLM planning areas using the Source Groups in Table 4-2.

Nitrogen deposition impacts were calculated by taking the sum of the nitrogen contained in the fluxes of all nitrogen species modeled by CAMx PSAT source apportionment tool. CAMx species used in the nitrogen deposition flux calculation are: reactive gaseous nitrate species, RGN (NO, NO_2, NO_3 radical, HONO, N_2O_5), TPN (PAN, PANX, PNA), organic nitrates (NTR), particulate nitrate formed from primary emissions plus secondarily formed particulate nitrate (NO_3), gaseous nitric acid (HNO_3), gaseous ammonia (NH_3) and particulate ammonium (NH_4). CAMx species used in the sulfur deposition calculation are primarily sulfur dioxide emissions (SO_2) and particulate sulfate ion from primary emissions plus secondarily formed sulfate (SO_4).

FLAG (2010) recommends that applicable sources assess impacts of nitrogen and sulfur deposition at Class I areas. This guidance recognizes the importance of establishing critical deposition loading values ("Critical Loads") for each specific Class I area as these Critical Loads are completely dependent on local atmospheric, aquatic and terrestrial conditions and chemistry. Critical Load thresholds are essentially a level of atmospheric pollutant deposition below which negative ecosystem effects are not likely to occur. FLAG (2010) does not include any Critical Load levels for specific Class I areas and refers to site-specific critical load information on FLM websites for each area of concern. This guidance does, however recommend the use of deposition analysis thresholds (DATs[72]) developed by the National Park Service and the Fish and Wildlife Service. The DATs represent screening level values for nitrogen and sulfur deposition for individual projects with deposition impacts below the DATS considered negligible. DAT have been established for both nitrogen and sulfur deposition and in western Class I areas they are 0.005 kilograms per hectare per year (kg/ha/yr) for both nitrogen and sulfur deposition. As a screening analysis, results for oil and gas and mining activities for each BLM planning area, which is Source Groups A through P were separately compared to the DATs. Comparison of deposition impacts from combined Source Groups to the DAT is not appropriate.

For the combined Source Groups and total 2008 and 2021 emissions Source Groups W and X, the annual nitrogen and sulfur deposition were compared against Critical Load values established for the Rocky Mountain region to assess total deposition impacts. The NPS has provided recent information on nitrogen critical load values applicable for Wyoming and Colorado Class I and sensitive Class II areas (NPS, 2014). For Class I and sensitive Class II areas in Wyoming a critical load value of 2.2 kg/ha/yr for nitrogen deposition (estimated from a wet deposition critical load value of 1.4 kg N/ha/yr) is applicable, based on research conducted by Saros et. al.(2010) in the eastern Sierra Nevada and Greater Yellowstone ecosystems. This is a critical load value that is protective of high elevation surface waters. For Colorado Class I and sensitive Class II areas (with the exception of Dinosaur National Monument) a critical load value 2.3 kg N/ha/yr is applicable for total nitrogen deposition, based on research conducted by Jill Baron (Baron 2006) that estimated 1.5 kg/ha/yr as a critical loading value for wet nitrogen deposition for high-elevation lakes in Rocky Mountain National Park, Colorado. For Dinosaur National Monument, which is an arid region, a nitrogen deposition critical load value is based on research conducted by Pardo et al. (2011) which concluded that the cumulative critical load necessary to protect shrublands and lichen communities in Dinosaur NM is 3 kg N/ha/year.

For sulfur deposition, the critical load threshold published by Fox et al. (Fox 1989) for total sulfur deposition of 5 kg/ha/yr, for the Bob Marshall Wilderness Area in Montana and Bridger Wilderness Area in Wyoming, was used as critical load threshold for each of the Class I and sensitive Class II areas.

In summary, we will compare the total annual sulfur and nitrogen deposition amounts for the cumulative Source Groups Q through X to the following Critical Load values:

[72] http://www.nature.nps.gov/air/Pubs/pdf/flag/nsDATGuidance.pdf

Nitrogen

- Wyoming – 2.2 kg/ha/yr
- Colorado – 2.3 kg/ha/yr, except for Dinosaur Monument that will use 3.0 kg/ha/yr

Sulfur

- 5.0 kg/ha/yr – all areas

4.8 Acid Neutralizing Capacity

In addition to calculation of total deposition fluxes, an additional analysis was performed to assess the change in water chemistry associated with atmospheric deposition from BLM oil and gas and mining activities and cumulative sources for each of the sensitive lakes listed in Table 4-5. This analysis assesses the change in the acid neutralizing capacity (ANC) of sensitive lakes. An estimate of potential changes in ANC was made by following the procedure developed by the USFS Rocky Mountain Region (USFS, 2000). Predicted changes in ANC are compared with the threshold (10 percent change in ANC for lakes with background ANC values greater than 25 micro equivalents per liter [µeq/L], and no more than a 1 µeq/L change in ANC for lakes with background ANC values equal to or less than 25 µeq/L). A list of sensitive lakes was obtained from the USFS (Table 4-5). The most recent lake chemistry background ANC data was obtained from the VIEWS website for each of the sensitive lakes in the 4 km CARMMS modeling domain.

5.0 2021 MODELING RESULTS

In this Chapter we present the CARMMS modeling results for the 2021 High, Low and Medium Development Scenarios following the procedures given in Chapter 4 using examples from the 24 Source Group contributions given in Table 4-2. Electronic attachments are provided that contain modeling results for all of the Source Groups with summaries provided in this Chapter. In this Chapter we present results for several Source Groups as examples given below, results for the rest of the Source Groups are provided in the interactive electronic attachments:

(E) New O&G on Federal lands within the BLM Grand Junction Field Office (GJFO) Planning Area;

(F) New O&G on Federal lands in the BLM Uncompahgre Field Office (UFO) Planning Area;

(J) New O&G on Federal lands within the U.S. Forest Service Pawnee Grasslands Planning Area(USFS-PG);

(R) New O&G and mining on Federal lands within the 13 Colorado Planning Areas;

(T) New O&G on Federal and non-Federal lands and mining on Federal lands within the 14 BLM Planning Areas (Colorado and northern New Mexico BLM Planning Areas0; and

(U) All O&G (new Federal and non-Federal as well as existing) and Federal mining in Colorado within the 4 km CARMMS domain.

5.1 PSD Pollutant Concentration Impacts at Class I and Sensitive Class II Areas

Attachment A-1, A-2 and A-3 are three Excel spreadsheets that contain the contributions of emissions from each Source Group listed in Table 4-2 to pollutant concentrations at the 27 Class I (Table 4-4) and 58 sensitive Class II (Table 4-5) areas for the, respectively, 2021 High, Low and Medium Development Scenarios. Results are presented for each PSD pollutant and averaging time given in Table 4-3. Attachment A contains two pivot table sheets:

The first pivot table sheet is "Summary" that lists the impacts of a user selected Source Group to all PSD pollutants across all Class I/II areas. It is controlled by selecting the Source Group in cell B1 and whether contributions of the maximum receptor or average across all receptors in a Class I/II area is desired in cell B2; we always select the "Maximum" option. If a concentration at a Class I or sensitive Class II area is above the, respectively, PSD Class I or II Increments, the cell is shaded yellow.

The second pivot table sheet is "MaxImpact" and for a user-selected PSD pollutant it lists the maximum concentration impact at any Class I and sensitive Class II area due to emissions from each Source Group along with the percentage the concentration is of the PSD Increment and the Class I and II area where the maximum occurs. The pivot table is controlled by selecting the pollutant and averaging time in cell B1 and whether maximum or average concentrations across the Class I/II area is desired in cell B2.

The sheet "Readme" has a brief explanation of the sheets in the spreadsheet and maps for the locations of the Class I and sensitive Class II areas.

The PSD incremental concentrations are reported for informational purposes only and the analyses presented in this section are not a comprehensive PSD increment consumption assessment, which must be performed by the appropriate state or federal agency.

5.1.1 Maximum PSD Concentration Impacts at any Class I or II Area

EPA has defined PSD Concentrations Increments for Class I and II areas for 8 different pollutant concentration/averaging time combinations (see Table 4-3). In this section we present the "Maximum" PSD concentration impacts at Class I and sensitive Class II areas due to each of the relevant 24 Source Groups from Table 4-2 (i.e., from the MaxImpact sheet in Attachments A-1 and A-2). The modeled impacts are based on the CAMx PSAT source apportionment contributions. For short-term averaging times (i.e., not annual), the highest second high concentration at each Class I/II area is selected for comparison with the PSD increment.

5.1.1.1 Annual NO_2 PSD Concentrations

The maximum (highest 2nd high) contribution to annual NO_2 concentrations at any Class I or sensitive Class II area due to emissions from the 24 Source Groups for the 2021 High, Low and Medium Development Scenarios are shown in Table 5-1, which was obtained from the MaxImpact sheet in Attachments A-1, A-2 and A-3. The Class I and II PSD Increments for annual NO_2 are 2.5 and 25 $\mu g/m^3$, respectively. The annual NO_2 contributions from each of the individual BLM Planning Areas in Colorado and northern New Mexico (i.e., Source Groups A through P) are all below the annual NO_2 PSD Increment in all Class I and sensitive Class II areas for all three 2021 emission scenarios. The BLM Planning Area with the highest annual NO_2 concentration contribution to any Class I area is the BLM Colorado Tres Rios Field Office (TRFO) Planning Area whose annual NO_2 concentration contribution at Mesa Verde National Park for the 2021 High Development Scenarios is 1.97 $\mu g/m^3$, which represents 79% of the Class I area Increment. The mitigation in the 2021 Medium Development Scenario reduces this impact by -16% to 1.66 $\mu g/m^3$, which represents 66% of the PSD Class I area annual NO_2 increment. The corresponding TRFO annual NO_2 impact for the Low Development Scenario is 0.24 $\mu g/m^3$, which represents 9% of the Class I increment. The maximum annual NO_2 contribution at any Class I area from any other of the 14 BLM Planning Areas are less than 5% of the Class I area NO_2 PSD Increment. The highest annual NO_2 concentration at any sensitive Class II area due to new O&G emissions on Federal lands in any of the 14 BLM Planning Areas is the New Mexico Farmington Field Office (NMFFO) with a 2.0 $\mu g/m^3$ annual NO_2 at the Aztec Ruins Class II area that represents 8% of the PSD Class II area Increment; recall that the same high emissions scenario was used for the BLM NMFFO Planning Area for both the CARMMS 2021 High and Low Development Scenarios. The NMFFO Planning Area new Federal O&G annual NO2 impacts at Mesa Verde for the 2021 Medium Development Scenario is 1.6 $\mu g/m^3$ that is -23% lower than seen for the 2021 High Development Scenario.

The maximum annual NO_2 contribution due to all new O&G and mining on Federal lands within the 13 Colorado BLM Planning Areas combined (i.e., Source Group R) for the High, Low and Medium Development Scenarios are, respectively, 1.98, 0.24 and 1.67 $\mu g/m^3$ at Mesa Verde National Park, which represents 79%, 10% and 67% of the NO_2 PSD Class I increment and is primarily due to Federal O&G emissions from the TRFO Planning Area as discussed above. For the Cumulative Emissions Scenario that represents all new O&G on both Federal and non-Federal lands and mining within the 14 CO/NM BLM Planning Areas (Source Group T) the maximum NO_2 contribution are 4.5, 2.9 and 4.1 $\mu g/m^3$ for the High, Low and Medium Development Scenarios, respectively, that are above the annual NO_2 PSD Class I Increment (2.5 $\mu g/m^3$). The maximum contribution of the Cumulative Emissions Scenario (T) to annual NO_2 at any sensitive Class II area is 4.1 $\mu g/m^3$ for the High Scenario at the South San Juan Class II area, 3.0 $\mu g/m^3$ at the Aztec Ruins Class II area for the Low Scenario and 3.7 $\mu g/m^3$ for the Medium Development Scenario all of which are below the Class II area annual NO_2 PSD Increment. Finally, the maximum annual NO_2 contribution at any Class I area due to the combined effects of all O&G development in the 4 km CARMS domain plus Federal mining in Colorado (Source Group U) is 4.8 $\mu g/m^3$ for the High, 3.1 $\mu g/m^3$ for the Low and 4.4 $\mu g/m^3$ for the Medium Development Scenarios both occurring at Mesa Verde.

Table 5-1a. Maximum annual NO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Choose	NO2, Annual	μg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2.5	0.019	0.8%	Mount_Zirkel	25	0.031	0.1%	Dinosaur_all
B	White River FO	2.5	0.117	4.7%	Flat_Tops	25	0.451	1.8%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2.5	0.025	1.0%	Flat_Tops	25	0.010	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	2.5	0.025	1.0%	Flat_Tops	25	0.009	0.0%	Holy_Cross
E	Grand Junction FO	2.5	0.079	3.2%	Arches	25	0.149	0.6%	Colorado
F	Uncompahgre FO	2.5	0.105	4.2%	Maroon_Bells	25	0.164	0.7%	Raggeds
G	Tres Rios FO	2.5	1.968	78.7%	Mesa_Verde	25	1.921	7.7%	South_San_Juan
H	Kremmling FO	2.5	0.036	1.4%	Rawah	25	0.011	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2.5	0.000	0.0%	Rocky_Mountain	25	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2.5	0.001	0.0%	Rocky_Mountain	25	0.001	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2.5	0.000	0.0%	Salt_Creek	25	0.001	0.0%	Maxwell_NWR
L	RGFO#3 – South	2.5	0.003	0.1%	Great_Sand_Dunes	25	0.190	0.8%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2.5	0.000	0.0%	Eagles_Nest	25	0.015	0.1%	Lost_Creek
N	New Mexico Farmington District	2.5	0.042	1.7%	Mesa_Verde	25	2.041	8.2%	Aztec_Ruins
O	Total Colorado River Field Office	2.5	0.050	2.0%	Flat_Tops	25	0.020	0.1%	Holy_Cross
P	Total Royal Gorge Field Office	2.5	0.003	0.1%	Great_Sand_Dunes	25	0.191	0.8%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2.5	0.011	0.4%	West_Elk	25	0.017	0.1%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2.5	1.979	79.1%	Mesa_Verde	25	1.927	7.7%	South_San_Juan
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2.5	4.477	179.1%	Mesa_Verde	25	4.033	16.1%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2.5	4.498	179.9%	Mesa_Verde	25	4.086	16.3%	South_San_Juan
U	Combined O&G and Mining in 4 km domain	2.5	4.779	191.2%	Mesa_Verde	25	20.535	82.1%	Aztec_Ruins
V	Natural Emissions	2.5	2.698	107.9%	Bandelier	25	1.226	4.9%	Dome
W	2021 All Emissions	2.5	6.100	244.0%	Mesa_Verde	25	26.453	105.8%	Aztec_Ruins
X	2008 All Emissions	2.5	15.638	625.5%	Eagles_Nest	25	23.759	95.0%	Aztec_Ruins

Table 5-1b. Maximum annual NO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Choose	NO2_Annual	μg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2.5	0.003	0.1%	Mount_Zirkel	25	0.004	0.0%	Dinosaur_all
B	White River FO	2.5	0.019	0.8%	Flat_Tops	25	0.071	0.3%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2.5	0.016	0.6%	Flat_Tops	25	0.006	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	2.5	0.013	0.5%	Flat_Tops	25	0.005	0.0%	Holy_Cross
E	Grand Junction FO	2.5	0.004	0.2%	Maroon_Bells	25	0.008	0.0%	Colorado
F	Uncompahgre FO	2.5	0.031	1.2%	Maroon_Bells	25	0.050	0.2%	Raggeds
G	Tres Rios FO	2.5	0.236	9.4%	Mesa_Verde	25	0.236	0.9%	South_San_Juan
H	Kremmling FO	2.5	0.004	0.2%	Rawah	25	0.001	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2.5	0.000	0.0%	Rocky_Mountain	25	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2.5	0.000	0.0%	Rocky_Mountain	25	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2.5	0.000	0.0%	Salt_Creek	25	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	2.5	0.002	0.1%	Great_Sand_Dunes	25	0.118	0.5%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2.5	0.000	0.0%	Eagles_Nest	25	0.002	0.0%	Lost_Creek
N	New Mexico Farmington District	2.5	0.042	1.7%	Mesa_Verde	25	2.040	8.2%	Aztec_Ruins
O	Total Colorado River Field Office	2.5	0.029	1.2%	Flat_Tops	25	0.011	0.0%	Holy_Cross
P	Total Royal Gorge Field Office	2.5	0.002	0.1%	Great_Sand_Dunes	25	0.118	0.5%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2.5	0.011	0.4%	West_Elk	25	0.017	0.1%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2.5	0.239	9.6%	Mesa_Verde	25	0.238	1.0%	South_San_Juan
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2.5	2.850	114.0%	Mesa_Verde	25	2.500	10.0%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2.5	2.870	114.8%	Mesa_Verde	25	2.971	11.9%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	2.5	3.146	125.8%	Mesa_Verde	25	20.491	82.0%	Aztec_Ruins
V	Natural Emissions	2.5	2.698	107.9%	Bandelier	25	1.226	4.9%	Dome
W	2021 All Emissions	2.5	5.620	224.8%	Petrified_Forest	25	26.407	105.6%	Aztec_Ruins
X	2008 All Emissions	2.5	15.638	625.5%	Eagles_Nest	25	23.759	95.0%	Aztec_Ruins

Table 5-1c. Maximum annual NO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Choose	NO2_Annual	μg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2.5	0.016	0.6%	Mount_Zirkel	25	0.027	0.1%	Dinosaur_all
B	White River FO	2.5	0.089	3.6%	Flat_Tops	25	0.424	1.7%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2.5	0.019	0.8%	Flat_Tops	25	0.008	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	2.5	0.020	0.8%	Flat_Tops	25	0.008	0.0%	Holy_Cross
E	Grand Junction FO	2.5	0.075	3.0%	Arches	25	0.137	0.5%	Colorado
F	Uncompahgre FO	2.5	0.071	2.9%	Maroon_Bells	25	0.111	0.4%	Raggeds
G	Tres Rios FO	2.5	1.660	66.4%	Mesa_Verde	25	1.627	6.5%	South_San_Juan
H	Kremmling FO	2.5	0.031	1.2%	Eagles_Nest	25	0.007	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2.5	0.000	0.0%	Rocky_Mountain	25	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2.5	0.001	0.0%	Rocky_Mountain	25	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2.5	0.000	0.0%	Salt_Creek	25	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	2.5	0.002	0.1%	Great_Sand_Dunes	25	0.132	0.5%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2.5	0.000	0.0%	Eagles_Nest	25	0.008	0.0%	Lost_Creek
N	New Mexico Farmington District	2.5	0.033	1.3%	Mesa_Verde	25	1.573	6.3%	Aztec_Ruins
O	Total Colorado River Field Office	2.5	0.040	1.6%	Flat_Tops	25	0.016	0.1%	Holy_Cross
P	Total Royal Gorge Field Office	2.5	0.002	0.1%	Great_Sand_Dunes	25	0.132	0.5%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2.5	0.011	0.4%	West_Elk	25	0.017	0.1%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2.5	1.669	66.8%	Mesa_Verde	25	1.631	6.5%	South_San_Juan
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2.5	4.087	163.5%	Mesa_Verde	25	3.679	14.7%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2.5	4.103	164.1%	Mesa_Verde	25	3.720	14.9%	South_San_Juan
U	Combined O&G and Mining in 4 km domain	2.5	4.383	175.3%	Mesa_Verde	25	20.080	80.3%	Aztec_Ruins
V	Natural Emissions	2.5	2.698	107.9%	Bandelier	25	1.226	4.9%	Dome
W	2021 All Emissions	2.5	5.703	228.1%	Mesa_Verde	25	26.011	104.0%	Aztec_Ruins
X	2008 All Emissions	2.5	15.638	625.5%	Eagles_Nest	25	23.759	95.0%	Aztec_Ruins

5.1.1.2 SO₂ PSD Concentrations

Tables 5-2 through 5-4 presents the comparison of the, respectively, maximum annual, 24-hour and 3-hour SO_2 concentrations at Class I/II areas with the PSD SO_2 increments for the 24 Source Groups. Note that the Colorado portion of the Dinosaur National Monument is Class I for SO_2 only, so it is included in the Class I area grouping in these Tables. None of the Source Groups exceed the annual PSD Class I Increment at any Class I/II area (Table 5-2). For 24-hour and 3-hour SO_2 contributions, there are wildfires that cause exceedances of the PSD Class I increment at the Bandelier Class I area for the Natural, total 2021 and total 2008 (Source Groups V, X and W) emission groups, but none of the other Source Groups exhibit any exceedances of the 24-hour and 3-hour SO_2 PSD Increments at any Class I or sensitive Class II area. Note that PSD Increments are not applicable for Natural or Total emissions. The contributions of the 14 BLM Planning Areas to SO_2 concentrations at Class I/II areas are extremely small, mostly much less than 1% of the PSD Increments. Of the 14 BLM Planning Areas, Federal O&G from the White River Field Office (WRFO) Planning Area has by far the largest contribution to annual, 24-hour and 3-hour SO_2 concentrations at any Class I area with maximum contributions of 5, 8 and 5 percent of the PSD Increment for the High and Medium Development Scenarios (the mitigation in the Medium Development Scenario did not address SO_2 emissions) and approximately 1 percent of the PSD Increment for the Low Development Scenarios that occurs at the Colorado portion of Dinosaur National Monument.

Table 5-2a. Maximum annual SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Choose	SO2, Annual	µg/m3
Across grid cells	Maximum	

Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2	0.000	0.0%	Mount_Zirkel	20	0.000	0.0%	Dinosaur_all
B	White River FO	2	0.089	4.5%	Dinosaur_CO	20	0.089	0.4%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
E	Grand Junction FO	2	0.000	0.0%	Arches	20	0.001	0.0%	Colorado
F	Uncompahgre FO	2	0.000	0.0%	Maroon_Bells	20	0.000	0.0%	Raggeds
G	Tres Rios FO	2	0.001	0.1%	Mesa_Verde	20	0.001	0.0%	South_San_Juan
H	Kremmling FO	2	0.000	0.0%	Rawah	20	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2	0.000	0.0%	Salt_Creek	20	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	2	0.000	0.0%	Great_Sand_Dunes	20	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2	0.000	0.0%	Eagles_Nest	20	0.000	0.0%	Lost_Creek
N	New Mexico Farmington District	2	0.000	0.0%	Mesa_Verde	20	0.003	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
P	Total Royal Gorge Field Office	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2	0.000	0.0%	West_Elk	20	0.000	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2	0.090	4.5%	Dinosaur_CO	20	0.090	0.4%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2	0.102	5.1%	Dinosaur_CO	20	0.102	0.5%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2	0.102	5.1%	Dinosaur_CO	20	0.102	0.5%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	2	0.108	5.4%	Dinosaur_CO	20	0.108	0.5%	Dinosaur_all
V	Natural Emissions	2	0.410	20.5%	Bandelier	20	0.171	0.9%	Dome
W	2021 All Emissions	2	1.857	92.8%	Galiuro	20	0.968	4.8%	Bitter_Lake_NWR
X	2008 All Emissions	2	1.240	62.0%	Petrified_Forest	20	1.143	5.7%	Aztec_Ruins

Table 5-2b. Maximum annual SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Choose	SO2, Annual	μg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2	0.000	0.0%	Mount_Zirkel	20	0.000	0.0%	Dinosaur_all
B	White River FO	2	0.014	0.7%	Dinosaur_CO	20	0.014	0.1%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
E	Grand Junction FO	2	0.000	0.0%	Arches	20	0.000	0.0%	Colorado
F	Uncompahgre FO	2	0.000	0.0%	Maroon_Bells	20	0.000	0.0%	Raggeds
G	Tres Rios FO	2	0.000	0.0%	Mesa_Verde	20	0.000	0.0%	South_San_Juan
H	Kremmling FO	2	0.000	0.0%	Rawah	20	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2	0.000	0.0%	Pecos	20	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	2	0.000	0.0%	Great_Sand_Dunes	20	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2	0.000	0.0%	Eagles_Nest	20	0.000	0.0%	Lost_Creek
N	New Mexico Farmington District	2	0.000	0.0%	Mesa_Verde	20	0.003	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
P	Total Royal Gorge Field Office	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2	0.000	0.0%	West_Elk	20	0.000	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2	0.014	0.7%	Dinosaur_CO	20	0.014	0.1%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2	0.018	0.9%	Dinosaur_CO	20	0.018	0.1%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2	0.018	0.9%	Dinosaur_CO	20	0.018	0.1%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	2	0.024	1.2%	Dinosaur_CO	20	0.083	0.4%	Aztec_Ruins
V	Natural Emissions	2	0.410	20.5%	Bandelier	20	0.171	0.9%	Dome
W	2021 All Emissions	2	1.857	92.8%	Galiuro	20	0.968	4.8%	Bitter_Lake_NWR
X	2008 All Emissions	2	1.240	62.0%	Petrified_Forest	20	1.143	5.7%	Aztec_Ruins

Table 5-2c. Maximum annual SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Choose	SO2, Annual	μg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2	0.000	0.0%	Mount_Zirkel	20	0.000	0.0%	Dinosaur_all
B	White River FO	2	0.089	4.5%	Dinosaur_CO	20	0.089	0.4%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
E	Grand Junction FO	2	0.000	0.0%	Arches	20	0.001	0.0%	Colorado
F	Uncompahgre FO	2	0.000	0.0%	Maroon_Bells	20	0.000	0.0%	Raggeds
G	Tres Rios FO	2	0.001	0.1%	Mesa_Verde	20	0.001	0.0%	South_San_Juan
H	Kremmling FO	2	0.000	0.0%	Rawah	20	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2	0.000	0.0%	Salt_Creek	20	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	2	0.000	0.0%	Great_Sand_Dunes	20	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2	0.000	0.0%	Eagles_Nest	20	0.000	0.0%	Lost_Creek
N	New Mexico Farmington District	2	0.000	0.0%	Mesa_Verde	20	0.003	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	2	0.000	0.0%	Flat_Tops	20	0.000	0.0%	Holy_Cross
P	Total Royal Gorge Field Office	2	0.000	0.0%	Rocky_Mountain	20	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2	0.000	0.0%	West_Elk	20	0.000	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2	0.090	4.5%	Dinosaur_CO	20	0.090	0.4%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2	0.102	5.1%	Dinosaur_CO	20	0.102	0.5%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2	0.102	5.1%	Dinosaur_CO	20	0.102	0.5%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	2	0.108	5.4%	Dinosaur_CO	20	0.108	0.5%	Dinosaur_all
V	Natural Emissions	2	0.410	20.5%	Bandelier	20	0.171	0.9%	Dome
W	2021 All Emissions	2	1.857	92.8%	Galiuro	20	0.968	4.8%	Bitter_Lake_NWR
X	2008 All Emissions	2	1.240	62.0%	Petrified_Forest	20	1.143	5.7%	Aztec_Ruins

Table 5-3a. Maximum 24-hour SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	5	0.002	0.0%	Dinosaur_CO	91	0.002	0.0%	Dinosaur_all
B	White River FO	5	0.412	8.2%	Dinosaur_CO	91	0.412	0.5%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
D	Roan Plateau Planning area portion of CRVFO	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
E	Grand Junction FO	5	0.002	0.0%	Arches	91	0.003	0.0%	Colorado
F	Uncompahgre FO	5	0.001	0.0%	Maroon_Bells	91	0.001	0.0%	Raggeds
G	Tres Rios FO	5	0.003	0.1%	Mesa_Verde	91	0.003	0.0%	South_San_Juan
H	Kremmling FO	5	0.000	0.0%	Rawah	91	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	5	0.000	0.0%	Pecos	91	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	5	0.000	0.0%	Great_Sand_Dunes	91	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	5	0.000	0.0%	Eagles_Nest	91	0.000	0.0%	Lost_Creek
N	New Mexico Farmington District	5	0.001	0.0%	Mesa_Verde	91	0.009	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
P	Total Royal Gorge Field Office	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	5	0.001	0.0%	West_Elk	91	0.002	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	5	0.412	8.2%	Dinosaur_CO	91	0.412	0.5%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	5	0.469	9.4%	Dinosaur_CO	91	0.469	0.5%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	5	0.469	9.4%	Dinosaur_CO	91	0.469	0.5%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	5	0.487	9.7%	Dinosaur_CO	91	0.565	0.6%	Aztec_Ruins
V	Natural Emissions	5	50.751	1015.0%	Bandelier	91	20.045	22.0%	Dome
W	2021 All Emissions	5	51.160	1023.2%	Bandelier	91	20.791	22.8%	Dome
X	2008 All Emissions	5	50.921	1018.4%	Bandelier	91	20.894	23.0%	Dome

Table 5-3b. Maximum 24-hour SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Choose	SO2, 24-hour	μg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	5	0.000	0.0%	Dinosaur_CO	91	0.000	0.0%	Dinosaur_all
B	White River FO	5	0.067	1.3%	Dinosaur_CO	91	0.067	0.1%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
D	Roan Plateau Planning area portion of CRVFO	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
E	Grand Junction FO	5	0.000	0.0%	Arches	91	0.000	0.0%	Colorado
F	Uncompahgre FO	5	0.000	0.0%	Maroon_Bells	91	0.000	0.0%	Raggeds
G	Tres Rios FO	5	0.001	0.0%	Mesa_Verde	91	0.001	0.0%	South_San_Juan
H	Kremmling FO	5	0.000	0.0%	Rawah	91	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	5	0.000	0.0%	Pecos	91	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	5	0.000	0.0%	Great_Sand_Dunes	91	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	5	0.000	0.0%	Eagles_Nest	91	0.000	0.0%	Lost_Creek
N	New Mexico Farmington District	5	0.001	0.0%	Mesa_Verde	91	0.009	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
P	Total Royal Gorge Field Office	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	5	0.001	0.0%	West_Elk	91	0.002	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	5	0.067	1.3%	Dinosaur_CO	91	0.067	0.1%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	5	0.085	1.7%	Dinosaur_CO	91	0.085	0.1%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	5	0.085	1.7%	Dinosaur_CO	91	0.085	0.1%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	5	0.125	2.5%	Mesa_Verde	91	0.561	0.6%	Aztec_Ruins
V	Natural Emissions	5	50.751	1015.0%	Bandelier	91	20.045	22.0%	Dome
W	2021 All Emissions	5	51.158	1023.2%	Bandelier	91	20.790	22.8%	Dome
X	2008 All Emissions	5	50.921	1018.4%	Bandelier	91	20.894	23.0%	Dome

Table 5-3c. Maximum 24-hour SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Choose	SO2, 24-hour	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	5	0.002	0.0%	Dinosaur_CO	91	0.002	0.0%	Dinosaur_all
B	White River FO	5	0.412	8.2%	Dinosaur_CO	91	0.412	0.5%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
D	Roan Plateau Planning area portion of CRVFO	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
E	Grand Junction FO	5	0.002	0.0%	Arches	91	0.003	0.0%	Colorado
F	Uncompahgre FO	5	0.001	0.0%	Maroon_Bells	91	0.001	0.0%	Raggeds
G	Tres Rios FO	5	0.003	0.1%	Mesa_Verde	91	0.003	0.0%	South_San_Juan
H	Kremmling FO	5	0.000	0.0%	Rawah	91	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	5	0.000	0.0%	Pecos	91	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	5	0.000	0.0%	Great_Sand_Dunes	91	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	5	0.000	0.0%	Eagles_Nest	91	0.000	0.0%	Lost_Creek
N	New Mexico Farmington District	5	0.001	0.0%	Mesa_Verde	91	0.007	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	5	0.000	0.0%	Flat_Tops	91	0.000	0.0%	Colorado
P	Total Royal Gorge Field Office	5	0.000	0.0%	Rocky_Mountain	91	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	5	0.001	0.0%	West_Elk	91	0.002	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	5	0.412	8.2%	Dinosaur_CO	91	0.412	0.5%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	5	0.468	9.4%	Dinosaur_CO	91	0.468	0.5%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	5	0.468	9.4%	Dinosaur_CO	91	0.468	0.5%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	5	0.487	9.7%	Dinosaur_CO	91	0.563	0.6%	Aztec_Ruins
V	Natural Emissions	5	50.751	1015.0%	Bandelier	91	20.045	22.0%	Dome
W	2021 All Emissions	5	51.160	1023.2%	Bandelier	91	20.791	22.8%	Dome
X	2008 All Emissions	5	50.921	1018.4%	Bandelier	91	20.894	23.0%	Dome

Table 5-4a. Maximum 3-hour SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Choose	SO2, 3-hour	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	25	0.005	0.0%	Dinosaur_CO	512	0.005	0.0%	Dinosaur_all
B	White River FO	25	1.262	5.0%	Dinosaur_CO	512	1.262	0.2%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	25	0.001	0.0%	Flat_Tops	512	0.000	0.0%	Colorado
D	Roan Plateau Planning area portion of CRVFO	25	0.001	0.0%	Flat_Tops	512	0.000	0.0%	Colorado
E	Grand Junction FO	25	0.003	0.0%	Arches	512	0.006	0.0%	Colorado
F	Uncompahgre FO	25	0.002	0.0%	Maroon_Bells	512	0.002	0.0%	Raggeds
G	Tres Rios FO	25	0.006	0.0%	Mesa_Verde	512	0.005	0.0%	South_San_Juan
H	Kremmling FO	25	0.000	0.0%	Rawah	512	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	25	0.000	0.0%	Rocky_Mountain	512	0.000	0.0%	Lost_Creek
J	Pawnee Grasslands portion of RGFO#1	25	0.001	0.0%	Rocky_Mountain	512	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	25	0.000	0.0%	Pecos	512	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	25	0.000	0.0%	Great_Sand_Dunes	512	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	25	0.000	0.0%	Eagles_Nest	512	0.000	0.0%	Lost_Creek
N	New Mexico Farmington District	25	0.002	0.0%	Mesa_Verde	512	0.015	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	25	0.001	0.0%	Flat_Tops	512	0.001	0.0%	Colorado
P	Total Royal Gorge Field Office	25	0.001	0.0%	Rocky_Mountain	512	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	25	0.004	0.0%	West_Elk	512	0.008	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	25	1.262	5.0%	Dinosaur_CO	512	1.262	0.2%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	25	1.435	5.7%	Dinosaur_CO	512	1.435	0.3%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	25	1.435	5.7%	Dinosaur_CO	512	1.435	0.3%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	25	1.495	6.0%	Dinosaur_CO	512	1.495	0.3%	Dinosaur_all
V	Natural Emissions	25	95.970	383.9%	Bandelier	512	64.686	12.6%	Dome
W	2021 All Emissions	25	96.160	384.6%	Bandelier	512	65.144	12.7%	Dome
X	2008 All Emissions	25	96.190	384.8%	Bandelier	512	65.161	12.7%	Dome

Table 5-4b. Maximum 3-hour SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Choose	SO2, 3-hour	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	25	0.001	0.0%	Dinosaur_CO	512	0.001	0.0%	Dinosaur_all
B	White River FO	25	0.189	0.8%	Dinosaur_CO	512	0.189	0.0%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	25	0.000	0.0%	Flat_Tops	512	0.000	0.0%	Colorado
D	Roan Plateau Planning area portion of CRVFO	25	0.000	0.0%	Flat_Tops	512	0.000	0.0%	Colorado
E	Grand Junction FO	25	0.000	0.0%	Arches	512	0.000	0.0%	Colorado
F	Uncompahgre FO	25	0.001	0.0%	Maroon_Bells	512	0.001	0.0%	Raggeds
G	Tres Rios FO	25	0.001	0.0%	Mesa_Verde	512	0.001	0.0%	South_San_Juan
H	Kremmling FO	25	0.000	0.0%	Rawah	512	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	25	0.000	0.0%	Rocky_Mountain	512	0.000	0.0%	Lost_Creek
J	Pawnee Grasslands portion of RGFO#1	25	0.000	0.0%	Rocky_Mountain	512	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	25	0.000	0.0%	Pecos	512	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	25	0.000	0.0%	Great_Sand_Dunes	512	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	25	0.000	0.0%	Eagles_Nest	512	0.000	0.0%	Lost_Creek
N	New Mexico Farmington District	25	0.002	0.0%	Mesa_Verde	512	0.015	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	25	0.001	0.0%	Flat_Tops	512	0.000	0.0%	Colorado
P	Total Royal Gorge Field Office	25	0.000	0.0%	Rocky_Mountain	512	0.000	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	25	0.004	0.0%	West_Elk	512	0.008	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	25	0.189	0.8%	Dinosaur_CO	512	0.189	0.0%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	25	0.240	1.0%	Dinosaur_CO	512	0.240	0.0%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	25	0.240	1.0%	Dinosaur_CO	512	0.240	0.0%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	25	0.497	2.0%	Mesa_Verde	512	1.328	0.3%	Aztec_Ruins
V	Natural Emissions	25	95.970	383.9%	Bandelier	512	64.688	12.6%	Dome
W	2021 All Emissions	25	96.160	384.6%	Bandelier	512	65.140	12.7%	Dome
X	2008 All Emissions	25	96.190	384.8%	Bandelier	512	65.161	12.7%	Dome

Table 5-4c. Maximum 3-hour SO_2 concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Choose	SO2, 3-hour	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	25	0.005	0.0%	Dinosaur_CO	512	0.005	0.0%	Dinosaur_all
B	White River FO	25	1.262	5.0%	Dinosaur_CO	512	1.262	0.2%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	25	0.001	0.0%	Flat_Tops	512	0.000	0.0%	Colorado
D	Roan Plateau Planning area portion of CRVFO	25	0.001	0.0%	Flat_Tops	512	0.000	0.0%	Colorado
E	Grand Junction FO	25	0.003	0.0%	Arches	512	0.006	0.0%	Colorado
F	Uncompahgre FO	25	0.002	0.0%	Maroon_Bells	512	0.002	0.0%	Raggeds
G	Tres Rios FO	25	0.006	0.0%	Mesa_Verde	512	0.005	0.0%	South_San_Juan
H	Kremmling FO	25	0.000	0.0%	Rawah	512	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	25	0.000	0.0%	Rocky_Mountain	512	0.000	0.0%	Lost_Creek
J	Pawnee Grasslands portion of RGFO#1	25	0.000	0.0%	Rocky_Mountain	512	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	25	0.000	0.0%	Pecos	512	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	25	0.000	0.0%	Great_Sand_Dunes	512	0.000	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	25	0.000	0.0%	Eagles_Nest	512	0.000	0.0%	Lost_Creek
N	New Mexico Farmington District	25	0.001	0.0%	Mesa_Verde	512	0.012	0.0%	Aztec_Ruins
O	Total Colorado River Field Office	25	0.001	0.0%	Flat_Tops	512	0.001	0.0%	Colorado
P	Total Royal Gorge Field Office	25	0.000	0.0%	Rocky_Mountain	512	0.000	0.0%	Lost_Creek
Q	Mining from 13 Colorado BLM Planning Areas	25	0.004	0.0%	West_Elk	512	0.008	0.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	25	1.262	5.0%	Dinosaur_CO	512	1.262	0.2%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	25	1.435	5.7%	Dinosaur_CO	512	1.435	0.3%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	25	1.435	5.7%	Dinosaur_CO	512	1.435	0.3%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	25	1.495	6.0%	Dinosaur_CO	512	1.495	0.3%	Dinosaur_all
V	Natural Emissions	25	95.970	383.9%	Bandelier	512	64.686	12.6%	Dome
W	2021 All Emissions	25	96.160	384.6%	Bandelier	512	65.144	12.7%	Dome
X	2008 All Emissions	25	96.190	384.8%	Bandelier	512	65.161	12.7%	Dome

5.1.1.3 $PM_{2.5}$ PSD Concentrations

Tables 5-5 and 5-6 displays the, respectively, maximum annual and 24-hour $PM_{2.5}$ concentrations due the Source Groups at any Class I and II area and compares them with the PSD $PM_{2.5}$ Increments for the 2021 High, Low and Medium Development Scenarios. $PM_{2.5}$ concentrations due to emissions from Federal O&G within any of the 14 BLM Planning Areas do not come close to exceeding any of the PSD $PM_{2.5}$ Increments. The BLM Planning Area with the largest Federal O&G $PM_{2.5}$ contribution at any Class I area is the TRFO Planning Area that contributes $PM_{2.5}$ concentrations of 9 and 15 percent for the High, 5 and 9 percent for the Medium and 1 and 2 percent for the Low Development Scenarios to the, respectively, annual and 24-hour $PM_{2.5}$ Class I PSD Increments at the Mesa Verde Class I area. Mining on Federal land within all of the 13 Colorado BLM Planning Areas (Source Group Q) contributes a maximum of 0.16 $\mu g/m^3$ for annual $PM_{2.5}$ at Mount Zirkel and 0.79 $\mu g/m^3$ for 24-hour $PM_{2.5}$ at Flat Tops that represents 16% and 39% of the PSD Class I Increments, respectively, for all three of the 2021 Scenarios (BLM mining emissions were not altered in the three 2021 scenarios).

The maximum contribution at any Class I area to annual $PM_{2.5}$ due to all Federal O&G and mining in the 13 Colorado BLM Planning Areas (Source Group R), the Cumulative Emissions scenario of all Federal O&G and mining and non-Federal O&G in the 14 CO/NM Planning Areas (Source Group T) and all O&G emissions throughout the 4 km CARMMS domain are, respectively, 0.18 to 0.22 $\mu g/m^3$ that represents 18 to 22 percent of the Class I area increment for the High Development Scenario with similar results seen for the Medium and slightly lower values seen for the Low Development Scenarios. Similar results are seen for 24-hour $PM_{2.5}$ with the Source Groups R, S, T and U contributing 42 to 58 percent of the 24-hour $PM_{2.5}$ Class I Increment for the High and Medium and 40 to 43 percent of the Increment for the Low Development Scenario at Rocky Mountain National Park.

Extremely high maximum annual and 24-hour $PM_{2.5}$ contributions are seen due to natural emissions (Source Group V) that are also reflected in the total 2021 (W) and 2008 (X) Source Groups that are due to wildfires that occurred in 2008 for which the PSD Increments are not applicable.

Note that PSD increments are not applicable to natural emissions or existing sources, thus results from Source Groups U, V, W and X are not appropriate for comparison with PSD increments.

Table 5-5a. Maximum Annual $PM_{2.5}$ concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Choose	PM2.5, Annual	μg/m3							
Across grid cells	Maximum								
Group	**Group Name**	**PSD Class I Increment**	**Max @ any Class I area**	**Percent of PSD Class I Increment**	**Class I Area where Max occurred**	**PSD Class II Increment**	**Max @ any Class II area**	**Percent of PSD Class II Increment**	**Class II Area where Max occurred**
A	Little Snake FO	1	0.003	0.3%	Mount_Zirkel	4	0.003	0.1%	Dinosaur_all
B	White River FO	1	0.021	2.1%	Flat_Tops	4	0.046	1.2%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	1	0.003	0.3%	Flat_Tops	4	0.002	0.1%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	1	0.003	0.3%	Flat_Tops	4	0.002	0.0%	Holy_Cross
E	Grand Junction FO	1	0.011	1.1%	Maroon_Bells	4	0.023	0.6%	Colorado
F	Uncompahgre FO	1	0.012	1.2%	Maroon_Bells	4	0.017	0.4%	Raggeds
G	Tres Rios FO	1	0.087	8.7%	Mesa_Verde	4	0.084	2.1%	South_San_Juan
H	Kremmling FO	1	0.004	0.4%	Rawah	4	0.002	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	1	0.000	0.0%	Rocky_Mountain	4	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	1	0.001	0.1%	Rocky_Mountain	4	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	1	0.000	0.0%	Pecos	4	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	1	0.000	0.0%	Great_Sand_Dunes	4	0.003	0.1%	Greenhorn_Mounta
M	RGFO#4 – East-Central	1	0.000	0.0%	Eagles_Nest	4	0.003	0.1%	Lost_Creek
N	New Mexico Farmington District	1	0.007	0.7%	Weminuche	4	0.205	5.1%	Aztec_Ruins
O	Total Colorado River Field Office	1	0.006	0.6%	Flat_Tops	4	0.004	0.1%	Holy_Cross
P	Total Royal Gorge Field Office	1	0.001	0.1%	Rocky_Mountain	4	0.003	0.1%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	1	0.164	16.4%	Mount_Zirkel	4	0.168	4.2%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	1	0.182	18.2%	Mount_Zirkel	4	0.195	4.9%	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	1	0.216	21.6%	Mesa_Verde	4	0.224	5.6%	Raggeds
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	1	0.220	22.0%	Mesa_Verde	4	0.319	8.0%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	1	0.252	25.2%	Mesa_Verde	4	0.699	17.5%	Aztec_Ruins
V	Natural Emissions	1	9.730	973.0%	Bandelier	4	4.249	106.2%	Dome
W	2021 All Emissions	1	14.610	1461.0%	Bandelier	4	14.412	360.3%	Valle_De_Oro_NWR
X	2008 All Emissions	1	14.217	1421.7%	Bandelier	4	12.072	301.8%	Petroglyph

Table 5-5b. Maximum Annual $PM_{2.5}$ concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Choose	PM2.5, Annual	μg/m3							
Across grid cells	Maximum								
Group	**Group Name**	**PSD Class I Increment**	**Max @ any Class I area**	**Percent of PSD Class I Increment**	**Class I Area where Max occurred**	**PSD Class II Increment**	**Max @ any Class II area**	**Percent of PSD Class II Increment**	**Class II Area where Max occurred**
A	Little Snake FO	1	0.000	0.0%	Mount_Zirkel	4	0.000	0.0%	Dinosaur_all
B	White River FO	1	0.004	0.4%	Flat_Tops	4	0.008	0.2%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	1	0.002	0.2%	Flat_Tops	4	0.001	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	1	0.002	0.2%	Flat_Tops	4	0.001	0.0%	Holy_Cross
E	Grand Junction FO	1	0.001	0.1%	Maroon_Bells	4	0.001	0.0%	Colorado
F	Uncompahgre FO	1	0.004	0.4%	Maroon_Bells	4	0.005	0.1%	Raggeds
G	Tres Rios FO	1	0.011	1.1%	Mesa_Verde	4	0.011	0.3%	South_San_Juan
H	Kremmling FO	1	0.000	0.0%	Rawah	4	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	1	0.000	0.0%	Rocky_Mountain	4	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	1	0.000	0.0%	Rocky_Mountain	4	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	1	0.000	0.0%	Pecos	4	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	1	0.000	0.0%	Great_Sand_Dunes	4	0.002	0.1%	Greenhorn_Mounta
M	RGFO#4 – East-Central	1	0.000	0.0%	Eagles_Nest	4	0.000	0.0%	Lost_Creek
N	New Mexico Farmington District	1	0.007	0.7%	Weminuche	4	0.205	5.1%	Aztec_Ruins
O	Total Colorado River Field Office	1	0.004	0.4%	Flat_Tops	4	0.002	0.1%	Holy_Cross
P	Total Royal Gorge Field Office	1	0.000	0.0%	Rocky_Mountain	4	0.002	0.1%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	1	0.164	16.4%	Mount_Zirkel	4	0.168	4.2%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	1	0.167	16.7%	Mount_Zirkel	4	0.175	4.4%	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	1	0.173	17.3%	Mount_Zirkel	4	0.185	4.6%	Raggeds
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	1	0.173	17.3%	Mount_Zirkel	4	0.311	7.8%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	1	0.199	19.9%	Mount_Zirkel	4	0.692	17.3%	Aztec_Ruins
V	Natural Emissions	1	9.730	973.0%	Bandelier	4	4.249	106.2%	Dome
W	2021 All Emissions	1	14.608	1460.8%	Bandelier	4	14.409	360.2%	Valle_De_Oro_NWR
X	2008 All Emissions	1	14.217	1421.7%	Bandelier	4	12.072	301.8%	Petroglyph

Table 5-5c. Maximum Annual $PM_{2.5}$ concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Choose	PM2.5, Annual	µg/m3						
Across grid cells	Maximum							
Group	**Group Name**	**PSD Class I Increment**	**Max @ any Class I area**	**Percent of PSD Class I Increment**	**Class I Area where Max occurred**	**PSD Class II Increment**	**Max @ any Class II area**	**Percent of PSD Class II Increment**	**Class II Area where Max occurred**
A	Little Snake FO	1	0.002	0.2%	Mount_Zirkel	4	0.002	0.1%	Dinosaur_all
B	White River FO	1	0.018	1.8%	Flat_Tops	4	0.044	1.1%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	1	0.002	0.2%	Flat_Tops	4	0.002	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	1	0.002	0.2%	Flat_Tops	4	0.001	0.0%	Holy_Cross
E	Grand Junction FO	1	0.008	0.8%	Arches	4	0.020	0.5%	Colorado
F	Uncompahgre FO	1	0.008	0.8%	Maroon_Bells	4	0.011	0.3%	Raggeds
G	Tres Rios FO	1	0.048	4.8%	Mesa_Verde	4	0.045	1.1%	South_San_Juan
H	Kremmling FO	1	0.002	0.2%	Rawah	4	0.001	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	1	0.000	0.0%	Rocky_Mountain	4	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	1	0.000	0.0%	Rocky_Mountain	4	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	1	0.000	0.0%	Pecos	4	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	1	0.000	0.0%	Great_Sand_Dunes	4	0.002	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	1	0.000	0.0%	Eagles_Nest	4	0.001	0.0%	Lost_Creek
N	New Mexico Farmington District	1	0.005	0.5%	Weminuche	4	0.122	3.1%	Aztec_Ruins
O	Total Colorado River Field Office	1	0.004	0.4%	Flat_Tops	4	0.003	0.1%	Holy_Cross
P	Total Royal Gorge Field Office	1	0.000	0.0%	Rocky_Mountain	4	0.002	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	1	0.164	16.4%	Mount_Zirkel	4	0.168	4.2%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	1	0.179	17.9%	Mount_Zirkel	4	0.188	4.7%	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	1	0.191	19.1%	Mount_Zirkel	4	0.216	5.4%	Raggeds
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	1	0.191	19.1%	Mount_Zirkel	4	0.230	5.7%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	1	0.216	21.6%	Mount_Zirkel	4	0.611	15.3%	Aztec_Ruins
V	Natural Emissions	1	9.730	973.0%	Bandelier	4	4.249	106.2%	Dome
W	2021 All Emissions	1	14.609	1460.9%	Bandelier	4	14.411	360.3%	Valle_De_Oro_NWR
X	2008 All Emissions	1	14.217	1421.7%	Bandelier	4	12.072	301.8%	Petroglyph

Table 5-6a. Maximum 24-Hour $PM_{2.5}$ concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Choose	PM2.5, 24-hour	µg/m3							
Across grid cells	Maximum								
Group	**Group Name**	**PSD Class I Increment**	**Max @ any Class I area**	**Percent of PSD Class I Increment**	**Class I Area where Max occurred**	**PSD Class II Increment**	**Max @ any Class II area**	**Percent of PSD Class II Increment**	**Class II Area where Max occurred**
A	Little Snake FO	2	0.031	1.6%	Mount_Zirkel	9	0.030	0.3%	Dinosaur_all
B	White River FO	2	0.133	6.6%	Flat_Tops	9	0.293	3.3%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2	0.015	0.7%	Flat_Tops	9	0.026	0.3%	Colorado
D	Roan Plateau Planning area portion of CRVFO	2	0.012	0.6%	Flat_Tops	9	0.025	0.3%	Colorado
E	Grand Junction FO	2	0.094	4.7%	Arches	9	0.242	2.7%	Colorado
F	Uncompahgre FO	2	0.060	3.0%	Maroon_Bells	9	0.062	0.7%	Raggeds
G	Tres Rios FO	2	0.302	15.1%	Mesa_Verde	9	0.260	2.9%	Hovenweep
H	Kremmling FO	2	0.011	0.5%	Mount_Zirkel	9	0.008	0.1%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2	0.004	0.2%	Rocky_Mountain	9	0.002	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2	0.018	0.9%	Rocky_Mountain	9	0.007	0.1%	Mount_Evans
K	RGFO#2 – West-Central/South	2	0.003	0.1%	Pecos	9	0.005	0.1%	Greenhorn_Mounta
L	RGFO#3 – South	2	0.003	0.1%	Great_Sand_Dunes	9	0.023	0.3%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2	0.002	0.1%	Eagles_Nest	9	0.011	0.1%	Lost_Creek
N	New Mexico Farmington District	2	0.053	2.6%	Mesa_Verde	9	0.799	8.9%	Aztec_Ruins
O	Total Colorado River Field Office	2	0.027	1.3%	Flat_Tops	9	0.050	0.6%	Colorado
P	Total Royal Gorge Field Office	2	0.023	1.1%	Rocky_Mountain	9	0.023	0.3%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2	0.787	39.3%	Flat_Tops	9	1.075	11.9%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2	0.842	42.1%	Flat_Tops	9	1.191	13.2%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2	0.884	44.2%	Rocky_Mountain	9	1.248	13.9%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2	0.886	44.3%	Rocky_Mountain	9	1.249	13.9%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	2	1.164	58.2%	Rocky_Mountain	9	3.535	39.3%	Dinosaur_all
V	Natural Emissions	2	1224.900	61245.0%	Bandelier	9	481.211	5346.8%	Dome
W	2021 All Emissions	2	1228.190	61409.5%	Bandelier	9	486.073	5400.8%	Dome
X	2008 All Emissions	2	1227.070	61353.5%	Bandelier	9	485.583	5395.4%	Dome

Table 5-6b. Maximum 24-Hour $PM_{2.5}$ concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Choose	PM2.5, 24-hour	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2	0.004	0.2%	Mount_Zirkel	9	0.005	0.1%	Dinosaur_all
B	White River FO	2	0.026	1.3%	Flat_Tops	9	0.056	0.6%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2	0.011	0.6%	Flat_Tops	9	0.018	0.2%	Colorado
D	Roan Plateau Planning area portion of CRVFO	2	0.008	0.4%	Flat_Tops	9	0.013	0.1%	Colorado
E	Grand Junction FO	2	0.006	0.3%	Black_Canyon	9	0.014	0.2%	Colorado
F	Uncompahgre FO	2	0.021	1.0%	Maroon_Bells	9	0.020	0.2%	Raggeds
G	Tres Rios FO	2	0.041	2.0%	Mesa_Verde	9	0.034	0.4%	Hovenweep
H	Kremmling FO	2	0.001	0.1%	Mount_Zirkel	9	0.001	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2	0.001	0.0%	Rocky_Mountain	9	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2	0.004	0.2%	Rocky_Mountain	9	0.001	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2	0.000	0.0%	Pecos	9	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	2	0.002	0.1%	Great_Sand_Dunes	9	0.015	0.2%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2	0.000	0.0%	Eagles_Nest	9	0.002	0.0%	Lost_Creek
N	New Mexico Farmington District	2	0.053	2.6%	Mesa_Verde	9	0.800	8.9%	Aztec_Ruins
O	Total Colorado River Field Office	2	0.019	1.0%	Flat_Tops	9	0.031	0.3%	Colorado
P	Total Royal Gorge Field Office	2	0.005	0.2%	Rocky_Mountain	9	0.015	0.2%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2	0.787	39.4%	Flat_Tops	9	1.081	12.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2	0.804	40.2%	Flat_Tops	9	1.094	12.2%	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2	0.830	41.5%	Flat_Tops	9	1.110	12.3%	Raggeds
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2	0.835	41.7%	Flat_Tops	9	1.181	13.1%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	2	0.852	42.6%	Flat_Tops	9	3.524	39.2%	Dinosaur_all
V	Natural Emissions	2	1224.890	61244.5%	Bandelier	9	481.209	5346.8%	Dome
W	2021 All Emissions	2	1228.160	61408.0%	Bandelier	9	486.060	5400.7%	Dome
X	2008 All Emissions	2	1227.070	61353.5%	Bandelier	9	485.583	5395.4%	Dome

Table 5-6c. Maximum 24-Hour $PM_{2.5}$ concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Choose	PM2.5, 24-hour	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	2	0.027	1.4%	Mount_Zirkel	9	0.024	0.3%	Dinosaur_all
B	White River FO	2	0.132	6.6%	Flat_Tops	9	0.272	3.0%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	2	0.012	0.6%	Maroon_Bells	9	0.021	0.2%	Colorado
D	Roan Plateau Planning area portion of CRVFO	2	0.010	0.5%	Flat_Tops	9	0.020	0.2%	Colorado
E	Grand Junction FO	2	0.092	4.6%	Arches	9	0.207	2.3%	Colorado
F	Uncompahgre FO	2	0.039	1.9%	Maroon_Bells	9	0.041	0.5%	Raggeds
G	Tres Rios FO	2	0.186	9.3%	Mesa_Verde	9	0.188	2.1%	Hovenweep
H	Kremmling FO	2	0.007	0.3%	Eagles_Nest	9	0.005	0.1%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	2	0.002	0.1%	Rocky_Mountain	9	0.001	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	2	0.010	0.5%	Rocky_Mountain	9	0.004	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	2	0.002	0.1%	Pecos	9	0.004	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	2	0.002	0.1%	Great_Sand_Dunes	9	0.015	0.2%	Greenhorn_Mounta
M	RGFO#4 – East-Central	2	0.001	0.0%	Eagles_Nest	9	0.004	0.0%	Lost_Creek
N	New Mexico Farmington District	2	0.033	1.7%	Mesa_Verde	9	0.494	5.5%	Aztec_Ruins
O	Total Colorado River Field Office	2	0.022	1.1%	Eagles_Nest	9	0.042	0.5%	Colorado
P	Total Royal Gorge Field Office	2	0.013	0.6%	Rocky_Mountain	9	0.015	0.2%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	2	0.787	39.3%	Flat_Tops	9	1.076	12.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2	0.841	42.1%	Flat_Tops	9	1.175	13.1%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2	0.878	43.9%	Rocky_Mountain	9	1.231	13.7%	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2	0.879	43.9%	Rocky_Mountain	9	1.232	13.7%	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	2	1.152	57.6%	Rocky_Mountain	9	3.533	39.3%	Dinosaur_all
V	Natural Emissions	2	1224.900	61245.0%	Bandelier	9	481.211	5346.8%	Dome
W	2021 All Emissions	2	1228.190	61409.5%	Bandelier	9	486.069	5400.8%	Dome
X	2008 All Emissions	2	1227.070	61353.5%	Bandelier	9	485.583	5395.4%	Dome

5.1.1.4 PM_{10} PSD Concentrations

The results of the comparisons against the PM_{10} PSD increments is very similar to $PM_{2.5}$ with none of the Source Groups, except Natural Emissions (Source Group V) that are also included in the total 2021 and 2008 Source Groups, showing any exceedances of the annual or 24-hour PM_{10} PSD increment (Tables 5-7 and 5-8). Wildfires within the Natural Emissions Source Group can produce very high PM concentrations.

Of the BLM Planning Areas, Federal O&G from the TRFO has the largest annual and 24-hour PM_{10} concentrations at any Class I area with maximum values that of 12 and 16 percent for the High, 5 and 7 percent for the Medium and 1 and 2 percent for the Low Development Scenarios of the PSD PM_{10} increment. The combined Source Groups R, S, T and U PM_{10} impacts at any Class I area are 36% or less of the PM_{10} PSD increments.

Table 5-7a. Maximum Annual PM_{10} concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Choose	PM10, Annual	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	4	0.004	0.1%	Mount_Zirkel	17	0.004	0.0%	Dinosaur_all
B	White River FO	4	0.034	0.8%	Flat_Tops	17	0.054	0.3%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	4	0.007	0.2%	Flat_Tops	17	0.003	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	4	0.004	0.1%	Flat_Tops	17	0.002	0.0%	Holy_Cross
E	Grand Junction FO	4	0.025	0.6%	Maroon_Bells	17	0.036	0.2%	Colorado
F	Uncompahgre FO	4	0.034	0.9%	Maroon_Bells	17	0.054	0.3%	Raggeds
G	Tres Rios FO	4	0.473	11.8%	Mesa_Verde	17	0.522	3.1%	South_San_Juan
H	Kremmling FO	4	0.015	0.4%	Rawah	17	0.005	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	4	0.000	0.0%	Rocky_Mountain	17	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	4	0.001	0.0%	Rocky_Mountain	17	0.001	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	4	0.000	0.0%	Pecos	17	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	4	0.000	0.0%	Great_Sand_Dunes	17	0.009	0.1%	Greenhorn_Mounta
M	RGFO#4 – East-Central	4	0.000	0.0%	Eagles_Nest	17	0.013	0.1%	Lost_Creek
N	New Mexico Farmington District	4	0.024	0.6%	Weminuche	17	0.900	5.3%	Aztec_Ruins
O	Total Colorado River Field Office	4	0.011	0.3%	Flat_Tops	17	0.005	0.0%	Holy_Cross
P	Total Royal Gorge Field Office	4	0.002	0.0%	Rocky_Mountain	17	0.014	0.1%	Lost_Creek
Q	Mining from 13 Colorado BLM Planning Areas	4	0.164	4.1%	Mount_Zirkel	17	0.168	1.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	4	0.492	12.3%	Mesa_Verde	17	0.530	3.1%	South_San_Juan
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	4	1.058	26.4%	Mesa_Verde	17	1.077	6.3%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	4	1.071	26.8%	Mesa_Verde	17	1.330	7.8%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	4	1.108	27.7%	Mesa_Verde	17	1.796	10.6%	Aztec_Ruins
V	Natural Emissions	4	10.653	266.3%	Bandelier	17	5.251	30.9%	Sevilleta_NWR
W	2021 All Emissions	4	21.754	543.8%	Wheeler_Peak	17	65.725	386.6%	Valle_De_Oro_NWR
X	2008 All Emissions	4	17.449	436.2%	Bandelier	17	51.874	305.1%	Petroglyph

Table 5-7b. Maximum Annual PM_{10} concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Choose	PM10, Annual	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	4	0.001	0.0%	Mount_Zirkel	17	0.001	0.0%	Dinosaur_all
B	White River FO	4	0.006	0.1%	Flat_Tops	17	0.010	0.1%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	4	0.004	0.1%	Flat_Tops	17	0.002	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	4	0.002	0.1%	Flat_Tops	17	0.001	0.0%	Holy_Cross
E	Grand Junction FO	4	0.001	0.0%	Maroon_Bells	17	0.002	0.0%	Colorado
F	Uncompahgre FO	4	0.011	0.3%	Maroon_Bells	17	0.019	0.1%	Raggeds
G	Tres Rios FO	4	0.049	1.2%	Mesa_Verde	17	0.055	0.3%	South_San_Juan
H	Kremmling FO	4	0.002	0.0%	Rawah	17	0.000	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	4	0.000	0.0%	Rocky_Mountain	17	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	4	0.000	0.0%	Rocky_Mountain	17	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	4	0.000	0.0%	Pecos	17	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	4	0.000	0.0%	Great_Sand_Dunes	17	0.006	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	4	0.000	0.0%	Eagles_Nest	17	0.002	0.0%	Lost_Creek
N	New Mexico Farmington District	4	0.024	0.6%	Weminuche	17	0.900	5.3%	Aztec_Ruins
O	Total Colorado River Field Office	4	0.007	0.2%	Flat_Tops	17	0.003	0.0%	Holy_Cross
P	Total Royal Gorge Field Office	4	0.000	0.0%	Rocky_Mountain	17	0.007	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	4	0.164	4.1%	Mount_Zirkel	17	0.168	1.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	4	0.169	4.2%	Mount_Zirkel	17	0.183	1.1%	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	4	0.688	17.2%	Mesa_Verde	17	0.672	4.0%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	4	0.701	17.5%	Mesa_Verde	17	1.315	7.7%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	4	0.738	18.5%	Mesa_Verde	17	1.781	10.5%	Aztec_Ruins
V	Natural Emissions	4	10.653	266.3%	Bandelier	17	5.251	30.9%	Sevilleta_NWR
W	2021 All Emissions	4	21.747	543.7%	Wheeler_Peak	17	65.719	386.6%	Valle_De_Oro_NWR
X	2008 All Emissions	4	17.449	436.2%	Bandelier	17	51.874	305.1%	Petroglyph

Table 5-7c. Maximum Annual PM_{10} concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Choose	PM10, Annual	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	4	0.003	0.1%	Mount_Zirkel	17	0.003	0.0%	Dinosaur_all
B	White River FO	4	0.023	0.6%	Flat_Tops	17	0.047	0.3%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	4	0.004	0.1%	Flat_Tops	17	0.002	0.0%	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	4	0.003	0.1%	Flat_Tops	17	0.002	0.0%	Holy_Cross
E	Grand Junction FO	4	0.014	0.3%	Maroon_Bells	17	0.025	0.1%	Colorado
F	Uncompahgre FO	4	0.017	0.4%	Maroon_Bells	17	0.027	0.2%	Raggeds
G	Tres Rios FO	4	0.203	5.1%	Mesa_Verde	17	0.222	1.3%	South_San_Juan
H	Kremmling FO	4	0.007	0.2%	Rawah	17	0.002	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	4	0.000	0.0%	Rocky_Mountain	17	0.000	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	4	0.000	0.0%	Rocky_Mountain	17	0.000	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	4	0.000	0.0%	Pecos	17	0.000	0.0%	Maxwell_NWR
L	RGFO#3 – South	4	0.000	0.0%	Great_Sand_Dunes	17	0.004	0.0%	Greenhorn_Mounta
M	RGFO#4 – East-Central	4	0.000	0.0%	Eagles_Nest	17	0.003	0.0%	Lost_Creek
N	New Mexico Farmington District	4	0.011	0.3%	Weminuche	17	0.380	2.2%	Aztec_Ruins
O	Total Colorado River Field Office	4	0.007	0.2%	Flat_Tops	17	0.004	0.0%	Holy_Cross
P	Total Royal Gorge Field Office	4	0.001	0.0%	Rocky_Mountain	17	0.004	0.0%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	4	0.164	4.1%	Mount_Zirkel	17	0.168	1.0%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	4	0.219	5.5%	Mesa_Verde	17	0.229	1.3%	South_San_Juan
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	4	0.776	19.4%	Mesa_Verde	17	0.772	4.5%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	4	0.782	19.6%	Mesa_Verde	17	0.786	4.6%	South_San_Juan
U	Combined O&G and Mining in 4 km domain	4	0.819	20.5%	Mesa_Verde	17	1.241	7.3%	Aztec_Ruins
V	Natural Emissions	4	10.653	266.3%	Bandelier	17	5.251	30.9%	Sevilleta_NWR
W	2021 All Emissions	4	21.748	543.7%	Wheeler_Peak	17	65.722	386.6%	Valle_De_Oro_NWR
X	2008 All Emissions	4	17.449	436.2%	Bandelier	17	51.874	305.1%	Petroglyph

Table 5-8a. Maximum 24-Hour PM_{10} concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 High Development Scenario.

Choose	PM10, 24-hour	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	8	0.036	0.4%	Mount_Zirkel	30	0.042	0.1%	Dinosaur_all
B	White River FO	8	0.161	2.0%	Flat_Tops	30	0.327	1.1%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	8	0.029	0.4%	Flat_Tops	30	0.031	0.1%	Colorado
D	Roan Plateau Planning area portion of CRVFO	8	0.019	0.2%	Flat_Tops	30	0.027	0.1%	Colorado
E	Grand Junction FO	8	0.130	1.6%	Arches	30	0.295	1.0%	Colorado
F	Uncompahgre FO	8	0.160	2.0%	Maroon_Bells	30	0.168	0.6%	Raggeds
G	Tres Rios FO	8	1.249	15.6%	Mesa_Verde	30	1.160	3.9%	South_San_Juan
H	Kremmling FO	8	0.038	0.5%	Rawah	30	0.020	0.1%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	8	0.009	0.1%	Rocky_Mountain	30	0.003	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	8	0.035	0.4%	Rocky_Mountain	30	0.012	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	8	0.003	0.0%	Pecos	30	0.005	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	8	0.004	0.1%	Great_Sand_Dunes	30	0.035	0.1%	Greenhorn_Mounta
M	RGFO#4 – East-Central	8	0.006	0.1%	Eagles_Nest	30	0.053	0.2%	Lost_Creek
N	New Mexico Farmington District	8	0.176	2.2%	Mesa_Verde	30	2.778	9.3%	Aztec_Ruins
O	Total Colorado River Field Office	8	0.049	0.6%	Flat_Tops	30	0.058	0.2%	Colorado
P	Total Royal Gorge Field Office	8	0.044	0.6%	Rocky_Mountain	30	0.053	0.2%	Lost_Creek
Q	Mining from 13 Colorado BLM Planning Areas	8	0.787	9.8%	Flat_Tops	30	1.075	3.6%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	8	1.284	16.1%	Mesa_Verde	30	1.234	4.1%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	8	2.746	34.3%	Mesa_Verde	30	2.372	7.9%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	8	2.773	34.7%	Mesa_Verde	30	4.063	13.5%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	8	2.880	36.0%	Mesa_Verde	30	6.475	21.6%	Aztec_Ruins
V	Natural Emissions	8	1310.760	16384.5%	Bandelier	30	512.681	1708.9%	Dome
W	2021 All Emissions	8	1318.400	16480.0%	Bandelier	30	522.924	1743.1%	Dome
X	2008 All Emissions	8	1314.400	16430.0%	Bandelier	30	520.280	1734.3%	Dome

Table 5-8b. Maximum 24-Hour PM_{10} concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Low Development Scenario.

Choose	PM10, 24-hour	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	8	0.005	0.1%	Mount_Zirkel	30	0.006	0.0%	Dinosaur_all
B	White River FO	8	0.029	0.4%	Flat_Tops	30	0.062	0.2%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	8	0.020	0.3%	Flat_Tops	30	0.022	0.1%	Colorado
D	Roan Plateau Planning area portion of CRVFO	8	0.011	0.1%	Flat_Tops	30	0.015	0.1%	Colorado
E	Grand Junction FO	8	0.007	0.1%	Black_Canyon	30	0.017	0.1%	Colorado
F	Uncompahgre FO	8	0.056	0.7%	Maroon_Bells	30	0.054	0.2%	Raggeds
G	Tres Rios FO	8	0.133	1.7%	Mesa_Verde	30	0.121	0.4%	South_San_Juan
H	Kremmling FO	8	0.004	0.0%	Rawah	30	0.002	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	8	0.002	0.0%	Rocky_Mountain	30	0.001	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	8	0.007	0.1%	Rocky_Mountain	30	0.002	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	8	0.000	0.0%	Pecos	30	0.000	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	8	0.003	0.0%	Great_Sand_Dunes	30	0.023	0.1%	Greenhorn_Mounta
M	RGFO#4 – East-Central	8	0.001	0.0%	Eagles_Nest	30	0.008	0.0%	Lost_Creek
N	New Mexico Farmington District	8	0.176	2.2%	Mesa_Verde	30	2.778	9.3%	Aztec_Ruins
O	Total Colorado River Field Office	8	0.031	0.4%	Flat_Tops	30	0.038	0.1%	Colorado
P	Total Royal Gorge Field Office	8	0.009	0.1%	Rocky_Mountain	30	0.023	0.1%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	8	0.787	9.8%	Flat_Tops	30	1.081	3.6%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	8	0.808	10.1%	Flat_Tops	30	1.114	3.7%	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	8	1.788	22.3%	Mesa_Verde	30	1.483	4.9%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	8	1.815	22.7%	Mesa_Verde	30	4.038	13.5%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	8	1.925	24.1%	Mesa_Verde	30	6.458	21.5%	Aztec_Ruins
V	Natural Emissions	8	1310.760	16384.5%	Bandelier	30	512.679	1708.9%	Dome
W	2021 All Emissions	8	1318.360	16479.5%	Bandelier	30	522.909	1743.0%	Dome
X	2008 All Emissions	8	1314.400	16430.0%	Bandelier	30	520.280	1734.3%	Dome

Table 5-8c. Maximum 24-Hour PM_{10} concentration at any Class I or sensitive Class II area due to the different Source Groups for the 2021 Medium Development Scenario.

Choose	PM10, 24-hour	µg/m3							
Across grid cells	Maximum								
Group	Group Name	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
A	Little Snake FO	8	0.029	0.4%	Mount_Zirkel	30	0.029	0.1%	Dinosaur_all
B	White River FO	8	0.132	1.7%	Flat_Tops	30	0.286	1.0%	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	8	0.017	0.2%	Flat_Tops	30	0.023	0.1%	Colorado
D	Roan Plateau Planning area portion of CRVFO	8	0.012	0.2%	Flat_Tops	30	0.022	0.1%	Colorado
E	Grand Junction FO	8	0.096	1.2%	Arches	30	0.223	0.7%	Colorado
F	Uncompahgre FO	8	0.079	1.0%	Maroon_Bells	30	0.081	0.3%	Raggeds
G	Tres Rios FO	8	0.561	7.0%	Mesa_Verde	30	0.492	1.6%	South_San_Juan
H	Kremmling FO	8	0.017	0.2%	Rawah	30	0.010	0.0%	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	8	0.003	0.0%	Rocky_Mountain	30	0.001	0.0%	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	8	0.014	0.2%	Rocky_Mountain	30	0.005	0.0%	Mount_Evans
K	RGFO#2 – West-Central/South	8	0.002	0.0%	Pecos	30	0.004	0.0%	Greenhorn_Mounta
L	RGFO#3 – South	8	0.002	0.0%	Great_Sand_Dunes	30	0.018	0.1%	Greenhorn_Mounta
M	RGFO#4 – East-Central	8	0.001	0.0%	Eagles_Nest	30	0.012	0.0%	Lost_Creek
N	New Mexico Farmington District	8	0.077	1.0%	Mesa_Verde	30	1.234	4.1%	Aztec_Ruins
O	Total Colorado River Field Office	8	0.028	0.4%	Flat_Tops	30	0.045	0.2%	Colorado
P	Total Royal Gorge Field Office	8	0.017	0.2%	Rocky_Mountain	30	0.019	0.1%	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	8	0.787	9.8%	Flat_Tops	30	1.076	3.6%	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	8	0.842	10.5%	Flat_Tops	30	1.192	4.0%	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	8	2.028	25.3%	Mesa_Verde	30	1.706	5.7%	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	8	2.042	25.5%	Mesa_Verde	30	2.405	8.0%	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	8	2.150	26.9%	Mesa_Verde	30	4.742	15.8%	Aztec_Ruins
V	Natural Emissions	8	1310.760	16384.5%	Bandelier	30	512.681	1708.9%	Dome
W	2021 All Emissions	8	1318.390	16479.9%	Bandelier	30	522.916	1743.1%	Dome
X	2008 All Emissions	8	1314.400	16430.0%	Bandelier	30	520.280	1734.3%	Dome

5.1.2 PSD Concentration across All Class I and Sensitive Class II Areas

In this section we present examples of the contributions of PSD pollutant concentrations across all PSD Class I and sensitive Class II areas for the BLM GJFO Planning Areas as well as several of the combined Planning Area Source Groups. The tables below were obtained from the "Summary" sheet of Attachments A-1, A-2 and A-3 Excel spreadsheet that contains results for all of the Source Groups.

5.1.2.1 Individual BLM Planning Area PSD Contributions

Table 5-9 displays the contributions of new oil and gas emissions on Federal lands to PSD pollutant concentrations at all Class I and sensitive Class II areas in the CARMMS 4 km domain for the BLM Grand Junction Field Office (GJFO) Planning Area. All of the PSD pollutant concentrations at Class I areas due to new O&G on Federal lands within the BLM GJFO Planning Area (as well as the other 14 BLM other Planning Areas) are well below the Class I and II PSD concentration increments. Similar Tables of concentrations contributions at all of the Class I and sensitive Class II areas from each of the 24 Source Groups and the High and Low Development Scenarios can be found in Attachments A-1, A-2 and A-3.

Table 5-9a. Contributions of new oil and gas emissions on Federal lands within the BLM Grand Junction Field Office Planning Area to PSD pollutant concentrations at Class I and sensitive Class II areas for the 2021 High Development Scenario.

Group	G_E	Grand Junction FO								
Across grid cells	Maximum	Max								
		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		SO_2 (µg/m³)		
		Averaging Time	Annual	24-hour	Annual	24-hour	Annual	3-hour	24-hour	Annual
Class I	State	Owner	PSD Class I Increment							
			2.5	8	4	2	1	25	5	2
Arches NP	UT	NPS	0.079	0.130	0.014	0.094	0.010	0.003	0.002	0.000
Bandelier NM	NM	NPS	0.001	0.014	0.001	0.010	0.001	0.000	0.000	0.000
Black Canyon of the Gunnison NM	CO	NPS	0.029	0.129	0.013	0.091	0.008	0.001	0.001	0.000
Bosque del Apache Wilderness	NM	FWS	0.000	0.008	0.000	0.005	0.000	0.000	0.000	0.000
Canyonlands NP	UT	NPS	0.012	0.073	0.004	0.043	0.002	0.001	0.001	0.000
Capitol Reef NP	UT	NPS	0.001	0.016	0.001	0.011	0.000	0.000	0.000	0.000
Eagles Nest Wilderness	CO	FS	0.038	0.086	0.016	0.051	0.008	0.001	0.001	0.000
Flat Tops Wilderness	CO	FS	0.062	0.081	0.019	0.045	0.009	0.003	0.001	0.000
Galiuro Wilderness	AZ	FS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Gila Wilderness	NM	FS	0.000	0.005	0.000	0.003	0.000	0.000	0.000	0.000
Great Sand Dunes NM	CO	NPS	0.004	0.042	0.005	0.034	0.003	0.000	0.000	0.000
La Garita Wilderness	CO	FS	0.007	0.043	0.005	0.030	0.003	0.000	0.000	0.000
Maroon Bells-Snowmass Wilderness	CO	FS	0.067	0.121	0.025	0.065	0.011	0.002	0.001	0.000
Mesa Verde NP	CO	NPS	0.004	0.035	0.003	0.023	0.001	0.001	0.000	0.000
Mount Baldy Wilderness	AZ	FS	0.000	0.005	0.000	0.005	0.000	0.000	0.000	0.000
Mount Zirkel Wilderness	CO	FS	0.014	0.036	0.006	0.023	0.003	0.001	0.000	0.000
Pecos Wilderness	NM	FS	0.001	0.017	0.001	0.012	0.001	0.000	0.000	0.000
Petrified Forest NP	AZ	NPS	0.000	0.008	0.000	0.005	0.000	0.000	0.000	0.000
Rawah Wilderness	CO	FS	0.009	0.032	0.005	0.022	0.003	0.001	0.000	0.000
Rocky Mountain NP	CO	NPS	0.016	0.056	0.008	0.037	0.005	0.001	0.000	0.000
Salt Creek Wilderness	NM	FWS	0.000	0.008	0.000	0.005	0.000	0.000	0.000	0.000
San Pedro Parks Wilderness	NM	FS	0.001	0.014	0.001	0.010	0.001	0.000	0.000	0.000
Weminuche Wilderness	CO	FS	0.005	0.031	0.003	0.021	0.002	0.001	0.000	0.000
West Elk Wilderness	CO	FS	0.011	0.084	0.013	0.059	0.007	0.001	0.001	0.000
Wheeler Peak Wilderness	NM	FS	0.002	0.021	0.002	0.017	0.001	0.000	0.000	0.000
White Mountain Wilderness	NM	FS	0.000	0.005	0.000	0.003	0.000	0.000	0.000	0.000
Dinosaur NM[3]	CO	NPS	NA	NA	NA	NA	NA	0.003	0.001	0.000
Class II	State	Owner	PSD Class II Increment							
			25	30	17	9	4	512	91	20
Alamosa NWR	CO	FWS	0.003	0.041	0.004	0.033	0.003	0.000	0.000	0.000
Aldo Leopold Wilderness	NM	USFS	0.000	0.005	0.000	0.004	0.000	0.000	0.000	0.000
Apache Kid Wilderness	NM	USFS	0.000	0.007	0.000	0.005	0.000	0.000	0.000	0.000
Aztec Ruins NM	NM	NPS	0.002	0.017	0.002	0.012	0.001	0.000	0.000	0.000
Baca NWR	CO	FWS	0.005	0.045	0.005	0.039	0.004	0.000	0.000	0.000
Bear Wallow Wilderness	AZ	USFS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000
Bitter Lake NWR	NM	FWS	0.000	0.008	0.000	0.005	0.000	0.000	0.000	0.000
Blue Range Wilderness	NM	USFS	0.000	0.004	0.000	0.003	0.000	0.000	0.000	0.000
Bosque Del Apache NWR	NM	FWS	0.000	0.008	0.000	0.005	0.000	0.000	0.000	0.000
Browns Park NWR	CO	FWS	0.002	0.014	0.001	0.009	0.001	0.001	0.000	0.000
Canyon de Chelly NM	AZ	NPS	0.001	0.014	0.001	0.009	0.000	0.000	0.000	0.000
Capitan Mountains Wilderness	NM	USFS	0.000	0.005	0.000	0.003	0.000	0.000	0.000	0.000
Chaco Culture NHP	NM	NPS	0.002	0.010	0.001	0.006	0.000	0.000	0.000	0.000
Chama River Canyon Wilderness	NM	USFS	0.001	0.014	0.001	0.011	0.001	0.000	0.000	0.000
Chimney Rock NM	CO	USFS	0.003	0.016	0.002	0.013	0.001	0.000	0.000	0.000
Colorado NM	CO	NPS	0.149	0.295	0.036	0.242	0.023	0.006	0.003	0.001
Cruces Basin Wilderness	NM	USFS	0.002	0.018	0.002	0.013	0.001	0.000	0.000	0.000
Curecanti NRA	CO	NPS	0.018	0.081	0.010	0.058	0.006	0.001	0.001	0.000
Dark Canyon Wilderness	UT	USFS	0.002	0.020	0.001	0.014	0.001	0.001	0.000	0.000
Dinosaur NM	CO	NPS	0.021	0.054	0.004	0.031	0.002	0.003	0.001	0.000
Dome Wilderness	NM	USFS	0.001	0.014	0.001	0.009	0.001	0.000	0.000	0.000
El Malpais NM	NM	NPS	0.001	0.011	0.001	0.006	0.000	0.000	0.000	0.000
Escudilla Wilderness	AZ	USFS	0.000	0.005	0.000	0.003	0.000	0.000	0.000	0.000
Flaming Gorge	UT	USFS	0.001	0.010	0.000	0.008	0.000	0.000	0.000	0.000
Florissant Fossil Beds NM	CO	NPS	0.006	0.037	0.004	0.025	0.003	0.001	0.000	0.000
Fossil Ridge Wilderness	CO	USFS	0.015	0.051	0.008	0.036	0.004	0.001	0.000	0.000
Glen Canyon NRA	UT	NPS	0.009	0.051	0.003	0.035	0.002	0.001	0.001	0.000
Great Sand Dunes National Park	CO	NPS	0.004	0.043	0.005	0.035	0.003	0.000	0.000	0.000
Great Sand Dunes National Preserve	CO	NPS	0.004	0.034	0.004	0.027	0.002	0.000	0.000	0.000
Greenhorn Mountain Wilderness	CO	USFS	0.003	0.021	0.002	0.016	0.001	0.000	0.000	0.000
High Uintas Wilderness	UT	USFS	0.000	0.006	0.000	0.003	0.000	0.000	0.000	0.000
Holy Cross Wilderness	CO	USFS	0.038	0.089	0.016	0.053	0.008	0.001	0.001	0.000
Hovenweep NM	CO	NPS	0.004	0.025	0.003	0.016	0.002	0.001	0.000	0.000
Hunter-Fryingpan Wilderness	CO	USFS	0.033	0.081	0.014	0.050	0.007	0.001	0.000	0.000
Las Vegas NWR	NM	FWS	0.001	0.015	0.001	0.012	0.001	0.000	0.000	0.000
Latir Peak Wilderness	NM	USFS	0.002	0.027	0.002	0.021	0.001	0.000	0.000	0.000
Lizard Head Wilderness	CO	USFS	0.006	0.042	0.004	0.023	0.002	0.001	0.000	0.000
Lost Creek Wilderness	CO	USFS	0.013	0.039	0.006	0.026	0.003	0.001	0.000	0.000
Manzano Mountain Wilderness	NM	USFS	0.001	0.011	0.001	0.007	0.000	0.000	0.000	0.000
Maxwell NWR	NM	FWS	0.001	0.017	0.001	0.012	0.001	0.000	0.000	0.000
Monte Vista NWR	CO	FWS	0.003	0.036	0.004	0.029	0.003	0.000	0.000	0.000
Mount Evans Wilderness	CO	USFS	0.014	0.042	0.007	0.027	0.004	0.001	0.000	0.000
Mount Sneffels Wilderness	CO	USFS	0.009	0.054	0.006	0.041	0.003	0.001	0.000	0.000
Natural Bridges NM	UT	NPS	0.001	0.016	0.001	0.010	0.001	0.000	0.000	0.000
Navajo NM	AZ	NPS	0.001	0.017	0.001	0.010	0.000	0.000	0.000	0.000
Petroglyph NM	NM	NPS	0.001	0.012	0.001	0.006	0.000	0.000	0.000	0.000
Powderhorn Wilderness	CO	USFS	0.008	0.044	0.005	0.030	0.003	0.001	0.000	0.000
Raggeds Wilderness	CO	USFS	0.046	0.097	0.017	0.054	0.008	0.001	0.001	0.000
Rio Mora NWR and CA	NM	FWS	0.001	0.014	0.001	0.010	0.001	0.000	0.000	0.000
Sandia Mountain Wilderness	NM	USFS	0.001	0.013	0.001	0.008	0.000	0.000	0.000	0.000
Sangre de Cristo Wilderness	CO	USFS	0.007	0.040	0.005	0.030	0.003	0.000	0.000	0.000
Savage Run Wilderness	WY	USFS	0.006	0.025	0.003	0.015	0.002	0.001	0.000	0.000
Sevilleta NWR	NM	FWS	0.000	0.015	0.001	0.011	0.000	0.000	0.000	0.000
South San Juan Wilderness	CO	USFS	0.003	0.024	0.002	0.016	0.001	0.000	0.000	0.000
Spanish Peaks Wilderness	CO	USFS	0.003	0.024	0.002	0.018	0.001	0.000	0.000	0.000
Uncompahgre Wilderness	CO	USFS	0.009	0.059	0.006	0.039	0.004	0.001	0.000	0.000
Valle De Oro NWR	NM	FWS	0.001	0.014	0.001	0.010	0.001	0.000	0.000	0.000
Withington Wilderness	NM	USFS	0.000	0.007	0.000	0.005	0.000	0.000	0.000	0.000

Table 5-9b. Contributions of new oil and gas emissions on Federal lands within the BLM Grand Junction Field Office Planning Area to PSD pollutant concentrations at Class I and sensitive Class II areas for the 2021 Low Development Scenario.

Group	G_E	Grand Junction FO								
Across grid cells	Maximum	Max								
		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		SO_2 (µg/m³)		
		Averaging Time	Annual[2]	24-hour[3]	Annual[1]	24-hour[4]	Annual[1]	3-hour[3]	24-hour[3]	Annual[1]
Class I	State	Owner	PSD Class I Increment[1]							
			2.5	8	4	2	1	25	5	2
Arches NP	UT	NPS	0.004	0.007	0.001	0.006	0.001	0.000	0.000	0.000
Bandelier NM	NM	NPS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Black Canyon of the Gunnison NM	CO	NPS	0.002	0.007	0.001	0.006	0.000	0.000	0.000	0.000
Bosque del Apache Wilderness	NM	FWS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Canyonlands NP	UT	NPS	0.001	0.004	0.000	0.003	0.000	0.000	0.000	0.000
Capitol Reef NP	UT	NPS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Eagles Nest Wilderness	CO	FS	0.002	0.005	0.001	0.004	0.001	0.000	0.000	0.000
Flat Tops Wilderness	CO	FS	0.004	0.004	0.001	0.003	0.001	0.000	0.000	0.000
Galiuro Wilderness	AZ	FS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gila Wilderness	NM	FS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Great Sand Dunes NM	CO	NPS	0.000	0.002	0.000	0.002	0.000	0.000	0.000	0.000
La Garita Wilderness	CO	FS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000
Maroon Bells-Snowmass Wilderness	CO	FS	0.004	0.007	0.001	0.005	0.001	0.000	0.000	0.000
Mesa Verde NP	CO	NPS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Mount Baldy Wilderness	AZ	FS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mount Zirkel Wilderness	CO	FS	0.001	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Pecos Wilderness	NM	FS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Petrified Forest NP	AZ	NPS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rawah Wilderness	CO	FS	0.001	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Rocky Mountain NP	CO	NPS	0.001	0.003	0.000	0.002	0.000	0.000	0.000	0.000
Salt Creek Wilderness	NM	FWS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
San Pedro Parks Wilderness	NM	FS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Weminuche Wilderness	CO	FS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000
West Elk Wilderness	CO	FS	0.002	0.005	0.001	0.004	0.000	0.000	0.000	0.000
Wheeler Peak Wilderness	NM	FS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
White Mountain Wilderness	NM	FS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	0.000	0.000	0.000
Class II	State	Owner	PSD Class II Increment[1]							
			25	30	17	9	4	512	91	20
Alamosa NWR	CO	FWS	0.000	0.002	0.000	0.002	0.000	0.000	0.000	0.000
Aldo Leopold Wilderness	NM	USFS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Apache Kid Wilderness	NM	USFS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Aztec Ruins NM	NM	NPS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Baca NWR	CO	FWS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000
Bear Wallow Wilderness	AZ	USFS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bitter Lake NWR	NM	FWS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blue Range Wilderness	NM	USFS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bosque Del Apache NWR	NM	FWS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Browns Park NWR	CO	FWS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Canyon de Chelly NM	AZ	NPS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Capitan Mountains Wilderness	NM	USFS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Chaco Culture NHP	NM	NPS	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Chama River Canyon Wilderness	NM	USFS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Chimney Rock NM	CO	USFS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Colorado NM	CO	NPS	0.008	0.017	0.002	0.014	0.001	0.000	0.000	0.000
Cruces Basin Wilderness	NM	USFS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Curecanti NRA	CO	NPS	0.001	0.005	0.001	0.004	0.000	0.000	0.000	0.000
Dark Canyon Wilderness	UT	USFS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Dinosaur NM	CO	NPS	0.001	0.003	0.000	0.002	0.000	0.000	0.000	0.000
Dome Wilderness	NM	USFS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
El Malpais NM	NM	NPS	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Escudilla Wilderness	AZ	USFS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Flaming Gorge	UT	USFS	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Florissant Fossil Beds NM	CO	NPS	0.000	0.002	0.000	0.002	0.000	0.000	0.000	0.000
Fossil Ridge Wilderness	CO	USFS	0.001	0.003	0.000	0.002	0.000	0.000	0.000	0.000
Glen Canyon NRA	UT	NPS	0.000	0.001	0.000	0.002	0.000	0.000	0.000	0.000
Great Sand Dunes National Park	CO	NPS	0.000	0.002	0.000	0.002	0.000	0.000	0.000	0.000
Great Sand Dunes National Preserve	CO	NPS	0.000	0.002	0.000	0.002	0.000	0.000	0.000	0.000
Greenhorn Mountain Wilderness	CO	USFS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
High Uintas Wilderness	UT	USFS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Holy Cross Wilderness	CO	USFS	0.002	0.005	0.001	0.004	0.001	0.000	0.000	0.000
Hovenweep NM	CO	NPS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Hunter-Fryingpan Wilderness	CO	USFS	0.002	0.005	0.001	0.004	0.000	0.000	0.000	0.000
Las Vegas NWR	NM	FWS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Latir Peak Wilderness	NM	USFS	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000
Lizard Head Wilderness	CO	USFS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000
Lost Creek Wilderness	CO	USFS	0.001	0.002	0.000	0.002	0.000	0.000	0.000	0.000
Manzano Mountain Wilderness	NM	USFS	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Maxwell NWR	NM	FWS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Monte Vista NWR	CO	FWS	0.000	0.002	0.000	0.002	0.000	0.000	0.000	0.000
Mount Evans Wilderness	CO	USFS	0.001	0.002	0.000	0.002	0.000	0.000	0.000	0.000
Mount Sneffels Wilderness	CO	USFS	0.001	0.003	0.000	0.003	0.000	0.000	0.000	0.000
Natural Bridges NM	UT	NPS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Navajo NM	AZ	NPS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Petroglyph NM	NM	NPS	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Powderhorn Wilderness	CO	USFS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000
Raggeds Wilderness	CO	USFS	0.003	0.006	0.001	0.004	0.001	0.000	0.000	0.000
Rio Mora NWR and CA	NM	FWS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Sandia Mountain Wilderness	NM	USFS	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Sangre de Cristo Wilderness	CO	USFS	0.000	0.002	0.000	0.002	0.000	0.000	0.000	0.000
Savage Run Wilderness	WY	USFS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Sevilleta NWR	NM	FWS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
South San Juan Wilderness	CO	USFS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Spanish Peaks Wilderness	CO	USFS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Uncompahgre Wilderness	CO	USFS	0.000	0.003	0.000	0.003	0.000	0.000	0.000	0.000
Valle De Oro NWR	NM	FWS	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Withington Wilderness	NM	USFS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 5-9c. Contributions of new oil and gas emissions on Federal lands within the BLM Grand Junction Field Office Planning Area to PSD pollutant concentrations at Class I and sensitive Class II areas for the 2021 Medium Development Scenario.

Group	G_E	Grand Junction FO								
Across grid cells	Maximum	Max								
		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		SO_2 (µg/m³)		
		Averaging Time	Annual[1]	24-hour[2]	Annual[1]	24-hour[4]	Annual[1]	3-hour[2]	24-hour[2]	Annual[1]
Class I	State	Owner	PSD Class I Increment[1]							
			2.5	8	4	2	1	25	5	2
Arches NP	UT	NPS	0.075	0.096	0.010	0.092	0.008	0.003	0.002	0.000
Bandelier NM	NM	NPS	0.001	0.010	0.001	0.008	0.001	0.000	0.000	0.000
Black Canyon of the Gunnison NM	CO	NPS	0.026	0.082	0.009	0.078	0.007	0.001	0.001	0.000
Bosque del Apache Wilderness	NM	FWS	0.000	0.005	0.000	0.004	0.000	0.000	0.000	0.000
Canyonlands NP	UT	NPS	0.011	0.051	0.003	0.033	0.002	0.001	0.001	0.000
Capitol Reef NP	UT	NPS	0.001	0.011	0.000	0.009	0.000	0.000	0.000	0.000
Eagles Nest Wilderness	CO	FS	0.031	0.054	0.009	0.041	0.006	0.001	0.001	0.000
Flat Tops Wilderness	CO	FS	0.050	0.044	0.011	0.036	0.007	0.003	0.001	0.000
Galiuro Wilderness	AZ	FS	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Gila Wilderness	NM	FS	0.000	0.003	0.000	0.003	0.000	0.000	0.000	0.000
Great Sand Dunes NM	CO	NPS	0.003	0.031	0.003	0.028	0.003	0.000	0.000	0.000
La Garita Wilderness	CO	FS	0.006	0.032	0.003	0.025	0.002	0.000	0.000	0.000
Maroon Bells-Snowmass Wilderness	CO	FS	0.054	0.073	0.014	0.050	0.008	0.002	0.001	0.000
Mesa Verde NP	CO	NPS	0.004	0.023	0.002	0.019	0.001	0.001	0.000	0.000
Mount Baldy Wilderness	AZ	FS	0.000	0.004	0.000	0.004	0.000	0.000	0.000	0.000
Mount Zirkel Wilderness	CO	FS	0.012	0.022	0.004	0.019	0.002	0.001	0.000	0.000
Pecos Wilderness	NM	FS	0.001	0.012	0.001	0.010	0.001	0.000	0.000	0.000
Petrified Forest NP	AZ	NPS	0.000	0.005	0.000	0.004	0.000	0.000	0.000	0.000
Rawah Wilderness	CO	FS	0.008	0.023	0.003	0.018	0.002	0.001	0.000	0.000
Rocky Mountain NP	CO	NPS	0.013	0.035	0.005	0.029	0.004	0.001	0.000	0.000
Salt Creek Wilderness	NM	FWS	0.000	0.005	0.000	0.004	0.000	0.000	0.000	0.000
San Pedro Parks Wilderness	NM	FS	0.001	0.010	0.001	0.009	0.000	0.000	0.000	0.000
Weminuche Wilderness	CO	FS	0.004	0.021	0.002	0.017	0.002	0.001	0.000	0.000
West Elk Wilderness	CO	FS	0.025	0.059	0.008	0.049	0.005	0.001	0.001	0.000
Wheeler Peak Wilderness	NM	FS	0.001	0.015	0.001	0.014	0.001	0.000	0.000	0.000
White Mountain Wilderness	NM	FS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000
Dinosaur NM[1]	CO	NPS	NA	NA	NA	NA	NA	0.003	0.001	0.000
Class II	State	Owner	PSD Class II Increment[1]							
			25	30	17	9	4	512	91	20
Alamosa NWR	CO	FWS	0.003	0.030	0.003	0.028	0.002	0.000	0.000	0.000
Aldo Leopold Wilderness	NM	USFS	0.000	0.003	0.000	0.003	0.000	0.000	0.000	0.000
Apache Kid Wilderness	NM	USFS	0.000	0.005	0.000	0.004	0.000	0.000	0.000	0.000
Aztec Ruins NM	NM	NPS	0.002	0.011	0.001	0.009	0.001	0.000	0.000	0.000
Baca NWR	CO	FWS	0.004	0.034	0.004	0.032	0.003	0.000	0.000	0.000
Bear Wallow Wilderness	AZ	USFS	0.000	0.002	0.000	0.002	0.000	0.000	0.000	0.000
Bitter Lake NWR	NM	FWS	0.000	0.005	0.000	0.004	0.000	0.000	0.000	0.000
Blue Range Wilderness	NM	USFS	0.000	0.003	0.000	0.002	0.000	0.000	0.000	0.000
Bosque Del Apache NWR	NM	FWS	0.000	0.005	0.000	0.004	0.000	0.000	0.000	0.000
Browns Park NWR	CO	FWS	0.002	0.009	0.001	0.008	0.000	0.001	0.000	0.000
Canyon de Chelly NM	AZ	NPS	0.001	0.009	0.000	0.007	0.000	0.000	0.000	0.000
Capitan Mountains Wilderness	NM	USFS	0.000	0.003	0.000	0.003	0.000	0.000	0.000	0.000
Chaco Culture NHP	NM	NPS	0.001	0.006	0.000	0.005	0.000	0.000	0.000	0.000
Chama River Canyon Wilderness	NM	USFS	0.001	0.010	0.001	0.009	0.000	0.000	0.000	0.000
Chimney Rock NM	CO	USFS	0.002	0.012	0.001	0.010	0.001	0.000	0.000	0.000
Colorado NM	CO	NPS	0.137	0.223	0.025	0.207	0.020	0.006	0.003	0.001
Cruces Basin Wilderness	NM	USFS	0.002	0.013	0.001	0.011	0.001	0.000	0.000	0.000
Curecanti NRA	CO	NPS	0.016	0.057	0.007	0.048	0.005	0.001	0.001	0.000
Dark Canyon Wilderness	UT	USFS	0.002	0.014	0.001	0.012	0.001	0.001	0.000	0.000
Dinosaur NM	CO	NPS	0.018	0.035	0.002	0.022	0.002	0.003	0.001	0.000
Dome Wilderness	NM	USFS	0.001	0.009	0.001	0.008	0.000	0.000	0.000	0.000
El Malpais NM	NM	NPS	0.001	0.006	0.000	0.005	0.000	0.000	0.000	0.000
Escudilla Wilderness	AZ	USFS	0.000	0.003	0.000	0.003	0.000	0.000	0.000	0.000
Flaming Gorge	UT	USFS	0.001	0.007	0.000	0.007	0.000	0.000	0.000	0.000
Florissant Fossil Beds NM	CO	NPS	0.005	0.024	0.003	0.020	0.002	0.001	0.000	0.000
Fossil Ridge Wilderness	CO	USFS	0.012	0.034	0.005	0.030	0.003	0.001	0.000	0.000
Glen Canyon NRA	UT	NPS	0.008	0.035	0.002	0.028	0.002	0.001	0.001	0.000
Great Sand Dunes National Park	CO	NPS	0.003	0.032	0.003	0.029	0.003	0.000	0.000	0.000
Great Sand Dunes National Preserve	CO	NPS	0.003	0.025	0.003	0.022	0.002	0.000	0.000	0.000
Greenhorn Mountain Wilderness	CO	USFS	0.003	0.015	0.001	0.013	0.001	0.000	0.000	0.000
High Uintas Wilderness	UT	USFS	0.000	0.003	0.000	0.003	0.000	0.000	0.000	0.000
Holy Cross Wilderness	CO	USFS	0.030	0.053	0.009	0.042	0.006	0.001	0.001	0.000
Hovenweep NM	CO	NPS	0.004	0.017	0.002	0.012	0.001	0.001	0.000	0.000
Hunter-Fryingpan Wilderness	CO	USFS	0.026	0.050	0.008	0.040	0.005	0.001	0.000	0.000
Las Vegas NWR	NM	FWS	0.001	0.011	0.001	0.010	0.001	0.000	0.000	0.000
Latir Peak Wilderness	NM	USFS	0.002	0.020	0.001	0.017	0.001	0.000	0.000	0.000
Lizard Head Wilderness	CO	USFS	0.005	0.026	0.002	0.018	0.002	0.001	0.000	0.000
Lost Creek Wilderness	CO	USFS	0.011	0.026	0.004	0.021	0.003	0.001	0.000	0.000
Manzano Mountain Wilderness	NM	USFS	0.001	0.007	0.000	0.005	0.000	0.000	0.000	0.000
Maxwell NWR	NM	FWS	0.001	0.011	0.001	0.009	0.001	0.000	0.000	0.000
Monte Vista NWR	CO	FWS	0.003	0.026	0.003	0.024	0.003	0.000	0.000	0.000
Mount Evans Wilderness	CO	USFS	0.011	0.027	0.004	0.021	0.003	0.001	0.000	0.000
Mount Sneffels Wilderness	CO	USFS	0.008	0.040	0.004	0.035	0.003	0.001	0.000	0.000
Natural Bridges NM	UT	NPS	0.001	0.010	0.001	0.008	0.000	0.000	0.000	0.000
Navajo NM	AZ	NPS	0.001	0.010	0.000	0.008	0.000	0.000	0.000	0.000
Petroglyph NM	NM	NPS	0.001	0.007	0.001	0.004	0.000	0.000	0.000	0.000
Powderhorn Wilderness	CO	USFS	0.007	0.030	0.003	0.025	0.002	0.001	0.000	0.000
Raggeds Wilderness	CO	USFS	0.038	0.060	0.010	0.044	0.006	0.001	0.001	0.000
Rio Mora NWR and CA	NM	FWS	0.001	0.010	0.001	0.009	0.001	0.000	0.000	0.000
Sandia Mountain Wilderness	NM	USFS	0.001	0.008	0.000	0.006	0.000	0.000	0.000	0.000
Sangre de Cristo Wilderness	CO	USFS	0.006	0.028	0.003	0.024	0.003	0.000	0.000	0.000
Savage Run Wilderness	WY	USFS	0.005	0.016	0.002	0.012	0.001	0.000	0.000	0.000
Sevilleta NWR	NM	FWS	0.000	0.010	0.000	0.009	0.000	0.000	0.000	0.000
South San Juan Wilderness	CO	USFS	0.003	0.017	0.002	0.013	0.001	0.000	0.000	0.000
Spanish Peaks Wilderness	CO	USFS	0.002	0.017	0.002	0.015	0.001	0.000	0.000	0.000
Uncompahgre Wilderness	CO	USFS	0.007	0.040	0.004	0.033	0.003	0.001	0.000	0.000
Valle De Oro NWR	NM	FWS	0.000	0.010	0.001	0.008	0.000	0.000	0.000	0.000
Withington Wilderness	NM	USFS	0.000	0.005	0.000	0.004	0.000	0.000	0.000	0.000

5.1.2.2 Combined BLM Planning Area PSD Contributions

Below we examine the contributions of emissions to concentrations at Class I areas for three of the combination Source Groups: (R) Federal O&G and mining within the 13 Colorado BLM Planning Areas; (T) the Cumulative Emissions Scenario that includes new O&G and mining on Federal lands and new O&G on non-Federal lands within the 14 NM BLM Planning Areas; and (U) all O&G (new Federal and non-Federal and existing) throughout the 4 km CARMMS domain plus Federal mining. Results for the other Source Groups as well as results for the sensitive Class II areas are contained in Attachments A-1, A-2 and A-3.

Source Group R represents mining and new O&G development on Federal lands within the 13 Colorado BLM Planning Areas so represents potential new emissions that may be mitigated by the BLM COSO. The PSD contributions of Source Group R are below the Class I and Class II PSD increments at all Class I and sensitive Class II areas, respectively, for all PSD pollutants and averaging times and the 2021 High, Low and Medium Scenarios (Table 5-10). As a percentage of a PSD increment, the largest contribution at any Class I area due to Source Group R is 79% (1.979 $\mu g/m^3$), 10% (0.239 $\mu g/m^3$) and 67% (1.669 $\mu g/m^3$) of the 2.5 $\mu g/m^3$ annual NO_2 PSD Class I increment for the, respectively, High, Low and Medium Development Scenarios and occurs at the Mesa Verde National Park. These NO_2 impacts are primarily (99%) due to new Federal O&G emissions from the TRFO Planning Area.

Source Group T is the Cumulative Emissions Scenario that includes new Federal and non-Federal oil and gas and Federal mining within the 14 BLM Colorado and Northern New Mexico Planning Areas whose PSD pollutant concentrations for the 2021 High and Low Development Scenarios are shown in Table 5-11. With one exception, the contribution of the Cumulative Emissions Scenario to PSD concentrations at all Class I and sensitive Class II areas are below the PSD Class I and II concentrations increments. The exception is for annual NO_2 at the Mesa Verde Class I area where the 2021 High, Low and Medium Development Scenario estimate an annual NO_2 contributions of, respectively, 4.50, 4.11 and 2.87 $\mu g/m^3$ that exceed the 2.5 $\mu g/m^3$ annual NO_2 PSD Class I area increment. Note that new Federal O&G emissions from the TRFO Planning Area contributed 1.97 $\mu g/m^3$ (High Scenario), 0.24 $\mu g/m^3$ (Low Scenario) and 1.66 $\mu g/m^3$ (Medium Scenario) to the maximum annual NO_2 at Mesa Verde and the split between new Federal and non-Federal O&G in the TRFO planning Area is 40% and 60%, respectively (see Table 3-2). Thus, the Cumulative Emissions Source Group T annual NO_2 contribution at Mesa Verde is mainly due to new Federal and non-Federal O&G development within the TRFO Planning Area.

The contributions of all O&G within the 4 km CARMMS domain plus Federal mining in Colorado (Source Group U) to PSD pollutants at Class I areas for the two 2021 emission scenarios are shown in Table 5-12. Again, with one exception, the contributions of all O&G emissions throughout the 4 km CARMMS domain produce PSD pollutant concentrations at all Class I and sensitive Class II areas that are below the PSD Class I and II area increments, respectively. The exception is the annual NO_2 at Mesa Verde Class I area where Source Group U contributes 4.78, 3.15 and 4.38 $\mu g/m^3$ for the High, Low and Medium Development Scenarios, respectively.

Table 5-10a. Contributions of new oil and gas and mining on Federal lands within the 13 Colorado BLM Planning Areas to PSD pollutant concentrations at Class I areas (Source Group R) for the 2021 High Development Scenario.

Group	G_R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas								
Across grid cells	Maximum	Max								
		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		SO_2 (µg/m³)		
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]
Class I	State	Owner	PSD Class I Increment[1]							
			2.5	8	4	2	1	25	5	2
Arches NP	UT	NPS	0.117	0.248	0.040	0.213	0.033	0.087	0.037	0.003
Bandelier NM	NM	NPS	0.006	0.080	0.009	0.069	0.006	0.011	0.005	0.000
Black Canyon of the Gunnison NM	CO	NPS	0.064	0.380	0.057	0.327	0.046	0.071	0.043	0.004
Bosque del Apache Wilderness	NM	FWS	0.002	0.047	0.003	0.036	0.002	0.010	0.004	0.000
Canyonlands NP	UT	NPS	0.037	0.177	0.019	0.138	0.014	0.062	0.026	0.002
Capitol Reef NP	UT	NPS	0.003	0.060	0.003	0.047	0.003	0.021	0.007	0.000
Eagles Nest Wilderness	CO	FS	0.091	0.244	0.072	0.202	0.057	0.076	0.022	0.003
Flat Tops Wilderness	CO	FS	0.225	0.844	0.160	0.842	0.133	0.356	0.132	0.013
Galiuro Wilderness	AZ	FS	0.000	0.006	0.000	0.005	0.000	0.002	0.000	0.000
Gila Wilderness	NM	FS	0.001	0.025	0.001	0.020	0.001	0.009	0.003	0.000
Great Sand Dunes NM	CO	NPS	0.015	0.128	0.023	0.111	0.019	0.023	0.009	0.001
La Garita Wilderness	CO	FS	0.019	0.147	0.022	0.116	0.017	0.045	0.014	0.001
Maroon Bells-Snowmass Wilderness	CO	FS	0.202	0.534	0.157	0.442	0.118	0.096	0.030	0.005
Mesa Verde NP	CO	NPS	1.979	1.284	0.492	0.339	0.104	0.047	0.018	0.002
Mount Baldy Wilderness	AZ	FS	0.000	0.030	0.001	0.026	0.001	0.005	0.002	0.000
Mount Zirkel Wilderness	CO	FS	0.092	0.753	0.190	0.741	0.182	0.150	0.054	0.008
Pecos Wilderness	NM	FS	0.005	0.064	0.008	0.054	0.006	0.014	0.005	0.000
Petrified Forest NP	AZ	NPS	0.001	0.039	0.002	0.034	0.002	0.007	0.003	0.000
Rawah Wilderness	CO	FS	0.076	0.344	0.084	0.314	0.068	0.080	0.024	0.004
Rocky Mountain NP	CO	NPS	0.053	0.297	0.075	0.282	0.066	0.072	0.017	0.003
Salt Creek Wilderness	NM	FWS	0.001	0.038	0.002	0.032	0.002	0.005	0.002	0.000
San Pedro Parks Wilderness	NM	FS	0.008	0.077	0.009	0.057	0.006	0.019	0.007	0.000
Weminuche Wilderness	CO	FS	0.019	0.111	0.017	0.088	0.013	0.051	0.014	0.001
West Elk Wilderness	CO	FS	0.121	0.678	0.172	0.659	0.151	0.079	0.031	0.003
Wheeler Peak Wilderness	NM	FS	0.006	0.077	0.011	0.065	0.008	0.019	0.006	0.001
White Mountain Wilderness	NM	FS	0.001	0.028	0.002	0.022	0.002	0.008	0.003	0.000
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	1.262	0.412	0.090

Table 5-10b. Contributions of new oil and gas and mining on Federal lands within the 13 Colorado BLM Planning Areas to PSD pollutant concentrations at Class I areas (Source Group R) for the 2021 Low Development Scenario.

Group	G_R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas								
Across grid cells	Maximum	Max								
		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		SO_2 (µg/m³)		
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]
Class I	State	Owner	PSD Class I Increment[1]							
			2.5	8	4	2	1	25	5	2
Arches NP	UT	NPS	0.017	0.141	0.020	0.131	0.019	0.014	0.005	0.001
Bandelier NM	NM	NPS	0.001	0.038	0.004	0.037	0.004	0.002	0.001	0.000
Black Canyon of the Gunnison NM	CO	NPS	0.010	0.211	0.031	0.204	0.030	0.011	0.006	0.001
Bosque del Apache Wilderness	NM	FWS	0.000	0.028	0.002	0.027	0.001	0.002	0.001	0.000
Canyonlands NP	UT	NPS	0.006	0.107	0.009	0.102	0.009	0.009	0.004	0.000
Capitol Reef NP	UT	NPS	0.000	0.039	0.002	0.037	0.002	0.004	0.001	0.000
Eagles Nest Wilderness	CO	FS	0.020	0.149	0.043	0.148	0.041	0.011	0.003	0.001
Flat Tops Wilderness	CO	FS	0.051	0.808	0.110	0.804	0.105	0.053	0.021	0.002
Galiuro Wilderness	AZ	FS	0.000	0.003	0.000	0.003	0.000	0.000	0.000	0.000
Gila Wilderness	NM	FS	0.000	0.016	0.001	0.015	0.001	0.001	0.001	0.000
Great Sand Dunes NM	CO	NPS	0.004	0.066	0.011	0.063	0.011	0.004	0.002	0.000
La Garita Wilderness	CO	FS	0.004	0.110	0.011	0.108	0.011	0.007	0.002	0.000
Maroon Bells-Snowmass Wilderness	CO	FS	0.054	0.380	0.105	0.356	0.095	0.014	0.005	0.001
Mesa Verde NP	CO	NPS	0.239	0.160	0.063	0.130	0.031	0.007	0.003	0.000
Mount Baldy Wilderness	AZ	FS	0.000	0.012	0.001	0.012	0.000	0.001	0.000	0.000
Mount Zirkel Wilderness	CO	FS	0.022	0.714	0.169	0.712	0.167	0.022	0.008	0.001
Pecos Wilderness	NM	FS	0.001	0.035	0.004	0.034	0.004	0.002	0.001	0.000
Petrified Forest NP	AZ	NPS	0.000	0.022	0.001	0.022	0.001	0.001	0.001	0.000
Rawah Wilderness	CO	FS	0.013	0.303	0.057	0.300	0.056	0.013	0.004	0.001
Rocky Mountain NP	CO	NPS	0.011	0.257	0.054	0.256	0.053	0.012	0.003	0.001
Salt Creek Wilderness	NM	FWS	0.000	0.020	0.001	0.020	0.001	0.001	0.000	0.000
San Pedro Parks Wilderness	NM	FS	0.001	0.040	0.004	0.037	0.004	0.003	0.001	0.000
Weminuche Wilderness	CO	FS	0.003	0.080	0.008	0.076	0.008	0.007	0.002	0.000
West Elk Wilderness	CO	FS	0.034	0.646	0.139	0.642	0.134	0.011	0.005	0.001
Wheeler Peak Wilderness	NM	FS	0.001	0.046	0.006	0.044	0.005	0.003	0.001	0.000
White Mountain Wilderness	NM	FS	0.000	0.020	0.001	0.019	0.001	0.001	0.000	0.000
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	0.189	0.067	0.014

Table 5-10c. Contributions of new oil and gas and mining on Federal lands within the 13 Colorado BLM Planning Areas to PSD pollutant concentrations at Class I areas (Source Group R) for the 2021 Medium Development Scenario.

Group	G_R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas							
Across grid cells	Maximum	Max							
		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		SO_2 (µg/m³)	
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]
Class I	State	Owner	PSD Class I Increment[1]							
			2.5	8	4	2	1	25	5	2
Arches NP	UT	NPS	0.111	0.212	0.034	0.197	0.031	0.087	0.037	0.003
Bandelier NM	NM	NPS	0.005	0.066	0.007	0.062	0.006	0.011	0.005	0.000
Black Canyon of the Gunnison NM	CO	NPS	0.056	0.321	0.047	0.300	0.042	0.071	0.043	0.004
Bosque del Apache Wilderness	NM	FWS	0.001	0.036	0.002	0.032	0.002	0.010	0.004	0.000
Canyonlands NP	UT	NPS	0.033	0.143	0.015	0.128	0.013	0.062	0.026	0.002
Capitol Reef NP	UT	NPS	0.002	0.049	0.003	0.044	0.002	0.021	0.007	0.000
Eagles Nest Wilderness	CO	FS	0.078	0.194	0.059	0.183	0.053	0.076	0.022	0.003
Flat Tops Wilderness	CO	FS	0.176	0.842	0.137	0.841	0.126	0.356	0.132	0.013
Galiuro Wilderness	AZ	FS	0.000	0.005	0.000	0.004	0.000	0.002	0.000	0.000
Gila Wilderness	NM	FS	0.001	0.021	0.001	0.018	0.001	0.009	0.003	0.000
Great Sand Dunes NM	CO	NPS	0.012	0.103	0.018	0.097	0.017	0.023	0.009	0.001
La Garita Wilderness	CO	FS	0.016	0.117	0.018	0.113	0.016	0.045	0.014	0.001
Maroon Bells-Snowmass Wilderness	CO	FS	0.150	0.454	0.126	0.414	0.110	0.096	0.030	0.005
Mesa Verde NP	CO	NPS	1.669	0.597	0.219	0.221	0.064	0.047	0.018	0.002
Mount Baldy Wilderness	AZ	FS	0.000	0.025	0.001	0.024	0.001	0.005	0.002	0.000
Mount Zirkel Wilderness	CO	FS	0.079	0.743	0.182	0.739	0.179	0.150	0.053	0.008
Pecos Wilderness	NM	FS	0.005	0.052	0.006	0.048	0.005	0.014	0.005	0.000
Petrified Forest NP	AZ	NPS	0.001	0.034	0.002	0.032	0.002	0.007	0.003	0.000
Rawah Wilderness	CO	FS	0.056	0.318	0.071	0.310	0.065	0.080	0.024	0.004
Rocky Mountain NP	CO	NPS	0.043	0.279	0.066	0.272	0.063	0.072	0.017	0.003
Salt Creek Wilderness	NM	FWS	0.001	0.031	0.002	0.029	0.002	0.005	0.002	0.000
San Pedro Parks Wilderness	NM	FS	0.007	0.058	0.007	0.050	0.005	0.019	0.007	0.000
Weminuche Wilderness	CO	FS	0.017	0.093	0.013	0.084	0.011	0.051	0.014	0.001
West Elk Wilderness	CO	FS	0.094	0.662	0.154	0.654	0.146	0.079	0.031	0.003
Wheeler Peak Wilderness	NM	FS	0.005	0.064	0.008	0.060	0.007	0.019	0.006	0.001
White Mountain Wilderness	NM	FS	0.001	0.023	0.002	0.021	0.002	0.007	0.003	0.000
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	1.262	0.412	0.090

Table 5-11a. Contributions of new oil and gas and mining on Federal lands and new oil and gas on non-Federal lands within the 14 BLM Planning Areas to PSD pollutant concentrations at Class I and sensitive Class II areas (Source Group T) for the 2021 High Development Scenario.

Group	G_T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Are							
Across grid cells	Maximum	Max							
		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		SO_2 (µg/m³)	
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]
Class I	State	Owner	PSD Class I Increment[1]							
			2.5	8	4	2	1	25	5	2
Arches NP	UT	NPS	0.233	0.443	0.063	0.345	0.049	0.103	0.044	0.004
Bandelier NM	NM	NPS	0.028	0.200	0.027	0.138	0.014	0.013	0.006	0.000
Black Canyon of the Gunnison NM	CO	NPS	0.424	0.691	0.171	0.511	0.078	0.083	0.050	0.004
Bosque del Apache Wilderness	NM	FWS	0.004	0.083	0.007	0.051	0.004	0.012	0.004	0.000
Canyonlands NP	UT	NPS	0.069	0.249	0.032	0.178	0.021	0.072	0.031	0.002
Capitol Reef NP	UT	NPS	0.011	0.090	0.009	0.069	0.005	0.025	0.009	0.000
Eagles Nest Wilderness	CO	FS	0.185	0.391	0.105	0.312	0.077	0.088	0.026	0.004
Flat Tops Wilderness	CO	FS	0.387	0.974	0.201	0.856	0.156	0.405	0.150	0.015
Galiuro Wilderness	AZ	FS	0.000	0.022	0.000	0.010	0.000	0.002	0.001	0.000
Gila Wilderness	NM	FS	0.001	0.039	0.002	0.031	0.002	0.011	0.004	0.000
Great Sand Dunes NM	CO	NPS	0.037	0.218	0.047	0.187	0.033	0.027	0.011	0.001
La Garita Wilderness	CO	FS	0.044	0.240	0.038	0.179	0.026	0.052	0.016	0.002
Maroon Bells-Snowmass Wilderness	CO	FS	0.377	0.709	0.214	0.528	0.144	0.110	0.034	0.006
Mesa Verde NP	CO	NPS	4.498	2.773	1.071	0.726	0.220	0.054	0.021	0.004
Mount Baldy Wilderness	AZ	FS	0.001	0.045	0.002	0.039	0.001	0.006	0.002	0.000
Mount Zirkel Wilderness	CO	FS	0.154	0.800	0.212	0.758	0.194	0.173	0.061	0.009
Pecos Wilderness	NM	FS	0.025	0.144	0.024	0.102	0.012	0.017	0.006	0.001
Petrified Forest NP	AZ	NPS	0.004	0.076	0.005	0.048	0.003	0.009	0.004	0.000
Rawah Wilderness	CO	FS	0.141	0.410	0.117	0.328	0.082	0.091	0.028	0.004
Rocky Mountain NP	CO	NPS	0.187	1.612	0.183	0.886	0.094	0.083	0.020	0.004
Salt Creek Wilderness	NM	FWS	0.004	0.068	0.007	0.048	0.004	0.005	0.003	0.000
San Pedro Parks Wilderness	NM	FS	0.038	0.201	0.029	0.095	0.013	0.023	0.009	0.001
Weminuche Wilderness	CO	FS	0.081	0.199	0.056	0.128	0.025	0.059	0.017	0.001
West Elk Wilderness	CO	FS	0.234	0.736	0.214	0.684	0.172	0.091	0.036	0.004
Wheeler Peak Wilderness	NM	FS	0.025	0.127	0.028	0.095	0.016	0.022	0.007	0.001
White Mountain Wilderness	NM	FS	0.003	0.059	0.005	0.036	0.003	0.009	0.003	0.000
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	1.435	0.469	0.102

Table 5-11b. Contributions of new oil and gas and mining on Federal lands and new oil and gas on non-Federal lands within the 14 BLM Planning Areas to PSD pollutant concentrations at Class I and sensitive Class II areas (Source Group T) for the 2021 Low Development Scenario.

Group	G_T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Are								
Across grid cells	Maximum	Max								
		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		SO_2 (µg/m³)		
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]
Class I	State	Owner	PSD Class I Increment[1]							
			2.5	8	4	2	1	25	5	2
Arches NP	UT	NPS	0.071	0.198	0.033	0.171	0.028	0.019	0.008	0.001
Bandelier NM	NM	NPS	0.021	0.157	0.021	0.095	0.010	0.003	0.001	0.000
Black Canyon of the Gunnison NM	CO	NPS	0.070	0.297	0.051	0.261	0.040	0.015	0.009	0.001
Bosque del Apache Wilderness	NM	FWS	0.002	0.057	0.004	0.035	0.003	0.002	0.001	0.000
Canyonlands NP	UT	NPS	0.028	0.148	0.019	0.119	0.013	0.012	0.006	0.000
Capitol Reef NP	UT	NPS	0.008	0.072	0.007	0.046	0.004	0.005	0.002	0.000
Eagles Nest Wilderness	CO	FS	0.064	0.191	0.062	0.174	0.052	0.015	0.005	0.001
Flat Tops Wilderness	CO	FS	0.142	0.837	0.134	0.835	0.118	0.068	0.027	0.003
Galiuro Wilderness	AZ	FS	0.000	0.013	0.000	0.007	0.000	0.000	0.000	0.000
Gila Wilderness	NM	FS	0.001	0.023	0.001	0.018	0.001	0.002	0.001	0.000
Great Sand Dunes NM	CO	NPS	0.018	0.096	0.027	0.083	0.019	0.005	0.002	0.000
La Garita Wilderness	CO	FS	0.021	0.118	0.023	0.113	0.017	0.009	0.003	0.000
Maroon Bells-Snowmass Wilderness	CO	FS	0.111	0.444	0.127	0.396	0.106	0.018	0.006	0.001
Mesa Verde NP	CO	NPS	2.870	1.815	0.701	0.512	0.148	0.010	0.005	0.002
Mount Baldy Wilderness	AZ	FS	0.000	0.028	0.001	0.018	0.001	0.001	0.000	0.000
Mount Zirkel Wilderness	CO	FS	0.046	0.728	0.179	0.719	0.173	0.029	0.011	0.002
Pecos Wilderness	NM	FS	0.019	0.112	0.018	0.063	0.009	0.003	0.001	0.000
Petrified Forest NP	AZ	NPS	0.002	0.045	0.003	0.035	0.002	0.002	0.001	0.000
Rawah Wilderness	CO	FS	0.038	0.314	0.072	0.306	0.062	0.016	0.005	0.001
Rocky Mountain NP	CO	NPS	0.068	0.679	0.090	0.397	0.062	0.016	0.004	0.001
Salt Creek Wilderness	NM	FWS	0.002	0.042	0.004	0.029	0.002	0.001	0.001	0.000
San Pedro Parks Wilderness	NM	FS	0.029	0.169	0.023	0.066	0.010	0.004	0.002	0.000
Weminuche Wilderness	CO	FS	0.066	0.177	0.047	0.091	0.020	0.010	0.003	0.000
West Elk Wilderness	CO	FS	0.072	0.661	0.157	0.650	0.144	0.015	0.007	0.001
Wheeler Peak Wilderness	NM	FS	0.016	0.097	0.020	0.058	0.011	0.004	0.001	0.000
White Mountain Wilderness	NM	FS	0.002	0.040	0.003	0.023	0.002	0.002	0.001	0.000
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	0.240	0.085	0.018

Table 5-11c. Contributions of new oil and gas and mining on Federal lands and new oil and gas on non-Federal lands within the 14 BLM Planning Areas to PSD pollutant concentrations at Class I and sensitive Class II areas (Source Group T) for the 2021 Medium Development Scenario.

Group	G_T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Are								
Across grid cells	Maximum	Max								
		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		SO_2 (µg/m³)		
		Averaging Time	Annual[3]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]
Class I	State	Owner	PSD Class I Increment[1]							
			2.5	8	4	2	1	25	5	2
Arches NP	UT	NPS	0.226	0.388	0.056	0.321	0.046	0.103	0.044	0.004
Bandelier NM	NM	NPS	0.024	0.158	0.020	0.120	0.012	0.013	0.006	0.000
Black Canyon of the Gunnison NM	CO	NPS	0.384	0.636	0.160	0.469	0.074	0.083	0.050	0.004
Bosque del Apache Wilderness	NM	FWS	0.003	0.066	0.005	0.047	0.004	0.012	0.004	0.000
Canyonlands NP	UT	NPS	0.064	0.207	0.026	0.168	0.019	0.072	0.031	0.002
Capitol Reef NP	UT	NPS	0.009	0.075	0.006	0.060	0.004	0.025	0.009	0.000
Eagles Nest Wilderness	CO	FS	0.171	0.331	0.090	0.283	0.072	0.088	0.026	0.004
Flat Tops Wilderness	CO	FS	0.330	0.868	0.177	0.852	0.148	0.405	0.150	0.015
Galiuro Wilderness	AZ	FS	0.000	0.018	0.000	0.008	0.000	0.002	0.001	0.000
Gila Wilderness	NM	FS	0.001	0.034	0.002	0.028	0.002	0.011	0.004	0.000
Great Sand Dunes NM	CO	NPS	0.032	0.189	0.039	0.168	0.029	0.027	0.011	0.001
La Garita Wilderness	CO	FS	0.039	0.205	0.032	0.163	0.024	0.052	0.016	0.002
Maroon Bells-Snowmass Wilderness	CO	FS	0.314	0.627	0.182	0.494	0.135	0.110	0.035	0.006
Mesa Verde NP	CO	NPS	4.103	2.042	0.782	0.600	0.176	0.054	0.021	0.004
Mount Baldy Wilderness	AZ	FS	0.001	0.039	0.002	0.035	0.001	0.006	0.002	0.000
Mount Zirkel Wilderness	CO	FS	0.138	0.777	0.203	0.755	0.191	0.172	0.061	0.009
Pecos Wilderness	NM	FS	0.022	0.112	0.018	0.090	0.011	0.016	0.006	0.001
Petrified Forest NP	AZ	NPS	0.003	0.067	0.004	0.045	0.003	0.009	0.004	0.000
Rawah Wilderness	CO	FS	0.116	0.368	0.103	0.324	0.078	0.091	0.028	0.004
Rocky Mountain NP	CO	NPS	0.180	1.594	0.178	0.879	0.092	0.083	0.020	0.004
Salt Creek Wilderness	NM	FWS	0.003	0.055	0.006	0.044	0.003	0.005	0.003	0.000
San Pedro Parks Wilderness	NM	FS	0.033	0.137	0.021	0.085	0.011	0.022	0.009	0.001
Weminuche Wilderness	CO	FS	0.069	0.141	0.039	0.117	0.021	0.059	0.017	0.001
West Elk Wilderness	CO	FS	0.200	0.712	0.195	0.679	0.166	0.091	0.036	0.004
Wheeler Peak Wilderness	NM	FS	0.022	0.106	0.022	0.087	0.014	0.022	0.007	0.001
White Mountain Wilderness	NM	FS	0.003	0.054	0.004	0.033	0.003	0.009	0.003	0.000
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	1.435	0.468	0.102

Table 5-12a. Contributions of new Federal and non-Federal and existing oil and gas throughout the CARMMS 4 km domain and mining on Federal lands in Colorado to PSD pollutant concentrations at Class I areas (Source Group U) for the 2021 High Development Scenario.

Group	G_U	Combined O&G and Mining in 4 km domain								
Across grid cells	Maximum	Max								

		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		SO_2 (µg/m³)		
		Averaging Time	Annual[1]	24-hour[2]	Annual[1]	24-hour[4]	Annual[1]	3-hour[2]	24-hour[2]	Annual[1]
Class I	State	Owner	PSD Class I Increment[1]							
			2.5	8	4	2	1	25	5	2
Arches NP	UT	NPS	0.357	0.577	0.096	0.430	0.080	0.107	0.046	0.006
Bandelier NM	NM	NPS	0.348	0.611	0.063	0.561	0.048	0.106	0.039	0.005
Black Canyon of the Gunnison NM	CO	NPS	0.481	0.763	0.199	0.617	0.104	0.086	0.052	0.006
Bosque del Apache Wilderness	NM	FWS	0.022	0.152	0.013	0.126	0.010	0.047	0.019	0.001
Canyonlands NP	UT	NPS	0.160	0.356	0.052	0.288	0.041	0.176	0.070	0.006
Capitol Reef NP	UT	NPS	0.083	0.171	0.019	0.166	0.014	0.162	0.054	0.004
Eagles Nest Wilderness	CO	FS	0.246	0.566	0.131	0.485	0.099	0.093	0.029	0.005
Flat Tops Wilderness	CO	FS	0.515	1.093	0.241	0.882	0.189	0.422	0.157	0.017
Galiuro Wilderness	AZ	FS	0.001	0.038	0.001	0.027	0.001	0.008	0.002	0.000
Gila Wilderness	NM	FS	0.004	0.072	0.004	0.064	0.004	0.016	0.006	0.000
Great Sand Dunes NM	CO	NPS	0.117	0.331	0.078	0.297	0.063	0.057	0.016	0.003
La Garita Wilderness	CO	FS	0.135	0.341	0.059	0.293	0.045	0.074	0.024	0.004
Maroon Bells-Snowmass Wilderness	CO	FS	0.447	0.824	0.241	0.587	0.167	0.114	0.036	0.007
Mesa Verde NP	CO	NPS	4.779	2.880	1.108	0.833	0.252	0.497	0.130	0.016
Mount Baldy Wilderness	AZ	FS	0.003	0.080	0.004	0.066	0.003	0.017	0.006	0.000
Mount Zirkel Wilderness	CO	FS	0.228	0.893	0.240	0.822	0.219	0.179	0.065	0.010
Pecos Wilderness	NM	FS	0.195	0.337	0.046	0.272	0.033	0.096	0.040	0.005
Petrified Forest NP	AZ	NPS	0.028	0.112	0.008	0.089	0.007	0.137	0.018	0.001
Rawah Wilderness	CO	FS	0.210	0.492	0.148	0.379	0.103	0.095	0.029	0.005
Rocky Mountain NP	CO	NPS	0.240	1.882	0.207	1.164	0.116	0.087	0.021	0.005
Salt Creek Wilderness	NM	FWS	0.027	0.120	0.012	0.097	0.009	0.176	0.038	0.002
San Pedro Parks Wilderness	NM	FS	0.433	0.329	0.058	0.230	0.041	0.175	0.066	0.011
Weminuche Wilderness	CO	FS	0.446	0.494	0.097	0.459	0.062	0.171	0.046	0.006
West Elk Wilderness	CO	FS	0.289	0.790	0.238	0.706	0.193	0.095	0.037	0.005
Wheeler Peak Wilderness	NM	FS	0.145	0.251	0.052	0.207	0.038	0.072	0.021	0.004
White Mountain Wilderness	NM	FS	0.015	0.116	0.010	0.095	0.008	0.025	0.010	0.001
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	1.495	0.487	0.108

Table 5-12b. Contributions of new Federal and non-Federal and existing oil and gas throughout the CARMMS 4 km domain and mining on Federal lands in Colorado to PSD pollutant concentrations at Class I areas (Source Group U) for the 2021 Low Development Scenario.

Group	G_U	Combined O&G and Mining in 4 km domain								
Across grid cells	Maximum	Max								

		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		SO_2 (µg/m³)		
		Averaging Time	Annual[1]	24-hour[2]	Annual[1]	24-hour[4]	Annual[1]	3-hour[2]	24-hour[2]	Annual[1]
Class I	State	Owner	PSD Class I Increment[1]							
			2.5	8	4	2	1	25	5	2
Arches NP	UT	NPS	0.192	0.372	0.068	0.311	0.060	0.066	0.032	0.003
Bandelier NM	NM	NPS	0.342	0.531	0.057	0.495	0.045	0.105	0.038	0.005
Black Canyon of the Gunnison NM	CO	NPS	0.124	0.431	0.080	0.382	0.068	0.040	0.014	0.003
Bosque del Apache Wilderness	NM	FWS	0.021	0.129	0.011	0.112	0.009	0.047	0.019	0.001
Canyonlands NP	UT	NPS	0.138	0.320	0.040	0.249	0.033	0.175	0.070	0.006
Capitol Reef NP	UT	NPS	0.080	0.168	0.017	0.163	0.013	0.160	0.054	0.003
Eagles Nest Wilderness	CO	FS	0.128	0.401	0.090	0.360	0.076	0.020	0.014	0.002
Flat Tops Wilderness	CO	FS	0.269	0.856	0.176	0.852	0.154	0.082	0.033	0.005
Galiuro Wilderness	AZ	FS	0.000	0.029	0.001	0.023	0.000	0.008	0.002	0.000
Gila Wilderness	NM	FS	0.003	0.058	0.003	0.052	0.003	0.015	0.005	0.000
Great Sand Dunes NM	CO	NPS	0.099	0.298	0.059	0.263	0.049	0.057	0.016	0.002
La Garita Wilderness	CO	FS	0.118	0.283	0.044	0.260	0.036	0.074	0.024	0.003
Maroon Bells-Snowmass Wilderness	CO	FS	0.193	0.518	0.156	0.449	0.130	0.029	0.012	0.003
Mesa Verde NP	CO	NPS	3.146	1.925	0.738	0.621	0.181	0.497	0.125	0.015
Mount Baldy Wilderness	AZ	FS	0.002	0.066	0.003	0.051	0.003	0.017	0.006	0.000
Mount Zirkel Wilderness	CO	FS	0.119	0.797	0.209	0.781	0.199	0.035	0.015	0.003
Pecos Wilderness	NM	FS	0.189	0.235	0.040	0.203	0.030	0.096	0.039	0.004
Petrified Forest NP	AZ	NPS	0.026	0.102	0.007	0.084	0.006	0.136	0.017	0.001
Rawah Wilderness	CO	FS	0.106	0.391	0.103	0.337	0.083	0.020	0.007	0.002
Rocky Mountain NP	CO	NPS	0.119	0.998	0.115	0.715	0.082	0.020	0.009	0.002
Salt Creek Wilderness	NM	FWS	0.025	0.103	0.010	0.085	0.008	0.176	0.038	0.002
San Pedro Parks Wilderness	NM	FS	0.425	0.299	0.052	0.229	0.038	0.174	0.064	0.010
Weminuche Wilderness	CO	FS	0.431	0.494	0.088	0.459	0.057	0.171	0.046	0.006
West Elk Wilderness	CO	FS	0.126	0.680	0.183	0.667	0.167	0.034	0.011	0.003
Wheeler Peak Wilderness	NM	FS	0.137	0.223	0.044	0.193	0.033	0.072	0.021	0.003
White Mountain Wilderness	NM	FS	0.014	0.105	0.008	0.090	0.007	0.022	0.008	0.001
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	0.294	0.103	0.024

Table 5-12c. Contributions of new Federal and non-Federal and existing oil and gas throughout the CARMMS 4 km domain and mining on Federal lands in Colorado to PSD pollutant concentrations at Class I areas (Source Group U) for the 2021 Medium Development Scenario.

Group	G_U	Combined O&G and Mining in 4 km domain								
Across grid cells	Maximum	Max								
		Pollutant	NO_2 (µg/m³)	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		SO_2 (µg/m³)		
		Averaging Time	Annual[1]	24-hour[2]	Annual[3]	24-hour[4]	Annual[3]	3-hour[2]	24-hour[2]	Annual[3]
Class I	State	Owner	PSD Class I Increment[1]							
			2.5	8	4	2	1	25	5	2
Arches NP	UT	NPS	0.349	0.505	0.089	0.414	0.077	0.107	0.046	0.006
Bandelier NM	NM	NPS	0.344	0.579	0.056	0.545	0.046	0.106	0.039	0.005
Black Canyon of the Gunnison NM	CO	NPS	0.440	0.710	0.189	0.571	0.100	0.086	0.052	0.006
Bosque del Apache Wilderness	NM	FWS	0.022	0.140	0.012	0.123	0.010	0.047	0.019	0.001
Canyonlands NP	UT	NPS	0.155	0.314	0.047	0.278	0.039	0.176	0.070	0.006
Capitol Reef NP	UT	NPS	0.082	0.166	0.016	0.163	0.014	0.162	0.054	0.004
Eagles Nest Wilderness	CO	FS	0.222	0.512	0.117	0.463	0.094	0.093	0.028	0.005
Flat Tops Wilderness	CO	FS	0.458	0.959	0.218	0.878	0.182	0.421	0.157	0.017
Galluro Wilderness	AZ	FS	0.001	0.034	0.001	0.026	0.001	0.008	0.002	0.000
Gila Wilderness	NM	FS	0.003	0.067	0.004	0.061	0.003	0.016	0.006	0.000
Great Sand Dunes NM	CO	NPS	0.113	0.303	0.071	0.279	0.060	0.057	0.016	0.003
La Garita Wilderness	CO	FS	0.130	0.316	0.052	0.282	0.043	0.074	0.024	0.004
Maroon Bells-Snowmass Wilderness	CO	FS	0.392	0.701	0.209	0.560	0.158	0.115	0.036	0.007
Mesa Verde NP	CO	NPS	4.383	2.150	0.819	0.709	0.208	0.497	0.130	0.015
Mount Baldy Wilderness	AZ	FS	0.003	0.072	0.004	0.063	0.003	0.017	0.006	0.000
Mount Zirkel Wilderness	CO	FS	0.212	0.858	0.232	0.821	0.216	0.179	0.065	0.010
Pecos Wilderness	NM	FS	0.192	0.324	0.040	0.266	0.032	0.096	0.040	0.005
Petrified Forest NP	AZ	NPS	0.027	0.097	0.008	0.084	0.006	0.137	0.018	0.001
Rawah Wilderness	CO	FS	0.185	0.447	0.134	0.367	0.099	0.095	0.029	0.005
Rocky Mountain NP	CO	NPS	0.234	1.850	0.201	1.152	0.114	0.087	0.021	0.005
Salt Creek Wilderness	NM	FWS	0.026	0.108	0.011	0.092	0.009	0.176	0.038	0.002
San Pedro Parks Wilderness	NM	FS	0.429	0.266	0.050	0.225	0.039	0.175	0.066	0.010
Weminuche Wilderness	CO	FS	0.434	0.470	0.080	0.449	0.058	0.171	0.046	0.006
West Elk Wilderness	CO	FS	0.255	0.746	0.219	0.695	0.188	0.095	0.037	0.005
Wheeler Peak Wilderness	NM	FS	0.142	0.234	0.046	0.201	0.036	0.072	0.021	0.004
White Mountain Wilderness	NM	FS	0.015	0.105	0.009	0.093	0.007	0.025	0.010	0.001
Dinosaur NM[5]	CO	NPS	NA	NA	NA	NA	NA	1.495	0.487	0.108

5.2 Visibility Impacts at Class I/II Areas using FLAG (2010)

Attachments B-1, B-2 and B-3 are interactive Excel spreadsheets that contain the visibility impacts at Class I and sensitive Class II areas due to emissions from the 24 Source Groups using the FLAG (2010) procedures as described in Section 4.6. There are four interactive sheets in Attachment B:

"Table1" shows maximum change in (delta) visibility (Δdv), the day of maximum Δdv and number of days that Δdv exceed the 0.5 and 1.0 dv thresholds for all Class I/II areas and a user selected Source Group that is controlled in cell B1.

"Table2" shows the temporal distribution (i.e., maximum and minimum and 98th, 80th and 20th percentiles) of Δdv by user selected Source Group (controlled by cell B1) for all Class I and II areas.

"Table3" shows maximum (or 98th, 80th, 20th or minimum controlled by cell B1) impact of Δdv from all Source Groups across all Class I, all Class II and combined all Class I and II areas.

"Table4" shows the maximum number of days that Δdv is greater than the 0.5 and 1.0 dv thresholds at any Class I or II area for all 24 Source Groups.

"Table 5" shows the number of days that Δdv is greater than the 0.5 and 1.0 dv thresholds and the maximum Δdv at each Class I and sensitive Class II area for a user-selected Source Group controlled by cell B1.

Addition information describing the Attachment B-1 and B-2 spreadsheets are contained in sheets "Readme" and "Ref."

5.2.1 Maximum Visibility Impacts at any Class I Area for all Source Groups

Table 5-13 displays the Class I and II areas where the maximum number of days Δdv exceeds the 0.5 and 1.0 thresholds occurred for each of the 24 Source Groups and the 2021 High Development Scenario. Tables 5-14 and 5-15 show the same information only for the 2021 Low and Medium Development Scenarios, respectively. These Tables were obtained from "Table4" in Attachments B-1, B-2 and B-3. The maximum Δdv impact at any Class I and II area due to each the 24 Source Groups for the 2021 High, Low and Medium Development Scenarios are shown in Table 5-16.

Of the 14 BLM Colorado and New Mexico Planning Areas (Source Groups A through N) plus the total CRFO (Source Group O) and RGFO (Source Group P) Planning Areas, only three have Federal O&G with Δdv visibility impacts at any Class I area that exceed the 0.5 dv threshold for the 2021 High Development Scenario as follows (Table 5-13a):

- WRFO with 6 days of Δdv > 0.5 and no days with Δdv > 1.0 (Table 5-13a) and max Δdv of 0.789 at Flats Tops Wilderness Area (Table 5-16a).
- GRFO with 2 days of Δdv > 0.5 and no days with Δdv > 1.0 and max Δdv of 0.900 at Arches National Park.
- TRFO with 35 days of Δdv > 0.5 and 4 days with Δdv > 1.0 and max Δdv of 1.42 at Mesa Verde National Park.

The individual Source Groups A through P of Federal O&G emissions in BLM Planning have no days with Δdv > 0.5 at any Class I area for the 2021 Low Development Scenario (Table 5-14a). The maximum Δdv at any Class I area for Federal O&G within an individual BLM Planning Area and the 2021 Low Development Scenario is 0.31 from the Farmington Field Office (Mancos Shale Development) (Table 5-16b).

Results for the 2021 Medium Development Scenario are similar but lower than the High Development Scenario with WRFO, GRFO and TRFO having 4, 2 and 5 days with Δdv > 0.5 at any Class I area with TRFO having 1 day with Δdv > 1.0 at any Class I area (Table 5-15a).

When looking at the 2021 High Development Scenario visibility impacts at Class II areas, there are four of the 18 BLM Planning Areas (Source Groups A through P) that have maximum Δdv that exceeds the 0.5 threshold, WRFO, GJFO and TRFO, as seen for Class I areas, but also NMFFO for the Class II areas (Tables 5-13b and 5-16a).

- WRFO with 40 days of Δdv > 0.5 and 5 days with Δdv > 1.0 and max Δdv of 1.43 at Dinosaur National Monument.

- GRFO with 23 days of $\Delta dv > 0.5$ and 3 days with $\Delta dv > 1.0$ and max Δdv of 1.46 at Colorado National Monument.
- TRFO with 16 days of $\Delta dv > 0.5$ and 3 days with $\Delta dv > 1.0$ and max Δdv of 2.46 at Hovenweep National Monument.
- NMFFO with 210 days of $\Delta dv > 0.5$ and 50 days with $\Delta dv > 1.0$ and max Δdv of 2.46 at Aztec Ruins National Monument.

For the 2021 Low Development Scenario, there is only one individual BLM Planning Area that has visibility impacts greater than 0.5 dv at any Class II area and that is for the NMFFO that has the exact same impacts as listed in the above bullet for the 2021 High Development Scenario (Table 5-14b). This is because the same high O&G development emissions were used for the Mancos Shale Development area in the 2021 High and Low Development Scenario because the contract from the BLM NMSO for developing emissions for the Mancos Shale Development area came in after the CARMMS 2021 Low Development Scenario source apportionment simulation was performed.

New O&G development on Federal lands result in exceedances of the 0.5 dv visibility threshold at Class II areas for the 2021 Medium Development Scenario for the same four BLM Planning Areas as seen for the 2021 High Development Scenarios only with lower number of days (Tables 5-15b and 5-16c).

- WRFO with 38 days of $\Delta dv > 0.5$ and 5 days with $\Delta dv > 1.0$ and max Δdv of 1.34 at Dinosaur National Monument.
- GRFO with 19 days of $\Delta dv > 0.5$ and 3 days with $\Delta dv > 1.0$ and max Δdv of 1.28 at Colorado National Monument.
- TRFO with 5 days of $\Delta dv > 0.5$ and 1 day with $\Delta dv > 1.0$ and max Δdv of 1.18 at Hovenweep National Monument.
- NMFFO with 77 days of $\Delta dv > 0.5$ and 3 days with $\Delta dv > 1.0$ and max Δdv of 1.60 at Aztec Ruins National Monument.

Not surprisingly, when looking at visibility impacts using the FLAG (2010) approach at Class I/II areas due to O&G emissions across combined BLM Planning Areas there are greater visibility impacts than for any individual BLM Planning Area. The FLMs have developed a Cumulative Visibility approach using the regional haze Worst 20 percent days (W20%) and Best 20 percent days (B20%) regional haze rule metric that is used to assess the visibility impacts for these combined Source Groups that is discussed in Section 5.3. The combined Source Group visibility impacts at Class I/II areas using the FLAG (2010) method in Figures 5-13 through 5-15 are provided for information only.

Table 5-13a. Class I area where each of the 24 Source Groups have the maximum number of days that Δdv exceeds the 0.5 and 1.0 dv thresholds for the High Development Scenario.

Source Group	Group Name	>0.5		>1.0	
		Max # of Day @ Class I	Class I (Max Occurs)	Max # of Day @ Class I	Class I (Max Occurs)
A	Little Snake FO	0	NA	0	NA
B	White River FO	6	CI_Flat_Tops	0	NA
C	Colorado River Valley FO (CRVFO)	0	NA	0	NA
D	Roan Plateau Planning area portion of CRVFO	0	NA	0	NA
E	Grand Junction FO	2	CI_Arches	0	NA
F	Uncompahgre FO	0	NA	0	NA
G	Tres Rios FO	35	CI_Mesa_Verde	4	CI_Mesa_Verde
H	Kremmling FO	0	NA	0	NA
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0	NA	0	NA
J	Pawnee Grasslands portion of RGFO#1	0	NA	0	NA
K	RGFO#2 – West-Central/South	0	NA	0	NA
L	RGFO#3 – South	0	NA	0	NA
M	RGFO#4 – East-Central	0	NA	0	NA
N	New Mexico Farmington District	0	NA	0	NA
O	Total Colorado River Field Office	0	NA	0	NA
P	Total Royal Gorge Field Office	0	NA	0	NA
Q	Mining from 13 Colorado BLM Planning Areas	48	CI_Mount_Zirkel	5	CI_Flat_Tops
R	Combined new Federal O&G and Mining from the 13 Colo	72	CI_Mount_Zirkel	12	CI_Mount_Zirkel
S	Combined new Federal and non-Federal O&G and Mining	281	CI_Mesa_Verde	55	CI_Mesa_Verde
T	Cumulative Emissions Scenario – New Federal and non-Fe	285	CI_Mesa_Verde	62	CI_Mesa_Verde
U	Combined O&G and Mining in 4 km domain	312	CI_Mesa_Verde	105	CI_Mesa_Verde
V	Natural Emissions	192	CI_Bosque	139	CI_Bosque
W	2021 All Emissions	365	CI_Arches	365	CI_Arches
X	2008 All Emissions	365	CI_Arches	365	CI_Arches

Table 5-13b. Sensitive Class II area where each of the 24 Source Groups has the maximum number of days that Δdv exceeds the 0.5 and 1.0 dv thresholds for the High Development Scenario.

Source Group	Group Name	>0.5		>1.0	
		Max # of Day @ Class II	Class II (Max Occurs)	Max # of Day @ Class II	Class II (Max Occurs)
A	Little Snake FO	0	NA	0	NA
B	White River FO	40	CII_Dinosaur_all	5	CII_Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0	NA	0	NA
D	Roan Plateau Planning area portion of CRVFO	0	NA	0	NA
E	Grand Junction FO	23	CII_Colorado	3	CII_Colorado
F	Uncompahgre FO	0	NA	0	NA
G	Tres Rios FO	16	CII_South_San_Juan	3	CII_Hovenweep
H	Kremmling FO	0	NA	0	NA
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0	NA	0	NA
J	Pawnee Grasslands portion of RGFO#1	0	NA	0	NA
K	RGFO#2 – West-Central/South	0	NA	0	NA
L	RGFO#3 – South	0	NA	0	NA
M	RGFO#4 – East-Central	0	NA	0	NA
N	New Mexico Farmington District	210	CII_Aztec_Ruins	50	CII_Aztec_Ruins
O	Total Colorado River Field Office	0	NA	0	NA
P	Total Royal Gorge Field Office	0	NA	0	NA
Q	Mining from 13 Colorado BLM Planning Areas	39	CII_Raggeds	8	CII_Dinosaur_all
R	Combined new Federal O&G and Mining from the 13 Colo	110	CII_Dinosaur_all	27	CII_Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining	288	CII_South_San_Juan	43	CII_Colorado
T	Cumulative Emissions Scenario – New Federal and non-Fe	299	CII_South_San_Juan	133	CII_Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	350	CII_Aztec_Ruins	278	CII_Aztec_Ruins
V	Natural Emissions	246	CII_Sevilleta_NWR	202	CII_Sevilleta_NWR
W	2021 All Emissions	365	CII_Alamosa_NWR	365	CII_Alamosa_NWR
X	2008 All Emissions	365	CII_Alamosa_NWR	365	CII_Alamosa_NWR

Table 5-14a. Class I area where each of the 24 Source Groups have the maximum number of days that Δdv exceeds the 0.5 and 1.0 dv thresholds for the Low Development Scenario.

Source Group	Group Name	>0.5		>1.0	
		Max # of Day @ Class I	Class I (Max Occurs)	Max # of Day @ Class I	Class I (Max Occurs)
A	Little Snake FO	0	NA	0	NA
B	White River FO	0	NA	0	NA
C	Colorado River Valley FO (CRVFO)	0	NA	0	NA
D	Roan Plateau Planning area portion of CRVFO	0	NA	0	NA
E	Grand Junction FO	0	NA	0	NA
F	Uncompahgre FO	0	NA	0	NA
G	Tres Rios FO	0	NA	0	NA
H	Kremmling FO	0	NA	0	NA
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0	NA	0	NA
J	Pawnee Grasslands portion of RGFO#1	0	NA	0	NA
K	RGFO#2 – West-Central/South	0	NA	0	NA
L	RGFO#3 – South	0	NA	0	NA
M	RGFO#4 – East-Central	0	NA	0	NA
N	New Mexico Farmington District	0	NA	0	NA
O	Total Colorado River Field Office	0	NA	0	NA
P	Total Royal Gorge Field Office	0	NA	0	NA
Q	Mining from 13 Colorado BLM Planning Areas	48	CI_Mount_Zirkel	5	CI_Flat_Tops
R	Combined new Federal O&G and Mining from the 13 Colo	51	CI_Mount_Zirkel	6	CI_Flat_Tops
S	Combined new Federal and non-Federal O&G and Mining	135	CI_Mesa_Verde	10	CI_Mesa_Verde
T	Cumulative Emissions Scenario – New Federal and non-Fe	143	CI_Mesa_Verde	11	CI_Mesa_Verde
U	Combined O&G and Mining in 4 km domain	201	CI_Mesa_Verde	44	CI_Mesa_Verde
V	Natural Emissions	192	CI_Bosque	139	CI_Bosque
W	2021 All Emissions	365	CI_Arches	365	CI_Arches
X	2008 All Emissions	365	CI_Arches	365	CI_Arches

Table 5-14b. Sensitive Class II area where each of the 24 Source Groups has the maximum number of days that Δdv exceeds the 0.5 and 1.0 dv thresholds for the Low Development Scenario.

Source Group	Group Name	>0.5		>1.0	
		Max # of Day @ Class II	Class II (Max Occurs)	Max # of Day @ Class II	Class II (Max Occurs)
A	Little Snake FO	0	NA	0	NA
B	White River FO	0	NA	0	NA
C	Colorado River Valley FO (CRVFO)	0	NA	0	NA
D	Roan Plateau Planning area portion of CRVFO	0	NA	0	NA
E	Grand Junction FO	0	NA	0	NA
F	Uncompahgre FO	0	NA	0	NA
G	Tres Rios FO	0	NA	0	NA
H	Kremmling FO	0	NA	0	NA
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0	NA	0	NA
J	Pawnee Grasslands portion of RGFO#1	0	NA	0	NA
K	RGFO#2 – West-Central/South	0	NA	0	NA
L	RGFO#3 – South	0	NA	0	NA
M	RGFO#4 – East-Central	0	NA	0	NA
N	New Mexico Farmington District	210	CII_Aztec_Ruins	50	CII_Aztec_Ruins
O	Total Colorado River Field Office	0	NA	0	NA
P	Total Royal Gorge Field Office	0	NA	0	NA
Q	Mining from 13 Colorado BLM Planning Areas	39	CII_Raggeds	8	CII_Dinosaur_all
R	Combined new Federal O&G and Mining from the 13 Colo	46	CII_Raggeds	9	CII_Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining	91	CII_South_San_Juan	16	CII_Hovenweep
T	Cumulative Emissions Scenario – New Federal and non-Fe	278	CII_Aztec_Ruins	127	CII_Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	349	CII_Aztec_Ruins	275	CII_Aztec_Ruins
V	Natural Emissions	246	CII_Sevilleta_NWR	202	CII_Sevilleta_NWR
W	2021 All Emissions	365	CII_Alamosa_NWR	365	CII_Alamosa_NWR
X	2008 All Emissions	365	CII_Alamosa_NWR	365	CII_Alamosa_NWR

Table 5-15a. Class I area where each of the 24 Source Groups have the maximum number of days that Δdv exceeds the 0.5 and 1.0 dv thresholds for the Medium Development Scenario.

Source Group	Group Name	>0.5		>1.0	
		Max # of Day @ Class I	Class I (Max Occurs)	Max # of Day @ Class I	Class I (Max Occurs)
A	Little Snake FO	0	NA	0	NA
B	White River FO	4	CI_Flat_Tops	0	NA
C	Colorado River Valley FO (CRVFO)	0	NA	0	NA
D	Roan Plateau Planning area portion of CRVFO	0	NA	0	NA
E	Grand Junction FO	2	CI_Arches	0	NA
F	Uncompahgre FO	0	NA	0	NA
G	Tres Rios FO	5	CI_Mesa_Verde	1	CI_Mesa_Verde
H	Kremmling FO	0	NA	0	NA
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0	NA	0	NA
J	Pawnee Grasslands portion of RGFO#1	0	NA	0	NA
K	RGFO#2 – West-Central/South	0	NA	0	NA
L	RGFO#3 – South	0	NA	0	NA
M	RGFO#4 – East-Central	0	NA	0	NA
N	New Mexico Farmington District	0	NA	0	NA
O	Total Colorado River Field Office	0	NA	0	NA
P	Total Royal Gorge Field Office	0	NA	0	NA
Q	Mining from 13 Colorado BLM Planning Areas	48	CI_Mount_Zirkel	5	CI_Flat_Tops
R	Combined new Federal O&G and Mining from the 13 Colo	69	CI_Mount_Zirkel	12	CI_Mount_Zirkel
S	Combined new Federal and non-Federal O&G and Mining	209	CI_Mesa_Verde	28	CI_Rocky_Mountain
T	Cumulative Emissions Scenario – New Federal and non-Fe	213	CI_Mesa_Verde	28	CI_Rocky_Mountain
U	Combined O&G and Mining in 4 km domain	265	CI_Mesa_Verde	64	CI_Mesa_Verde
V	Natural Emissions	192	CI_Bosque	139	CI_Bosque
W	2021 All Emissions	365	CI_Arches	365	CI_Arches
X	2008 All Emissions	365	CI_Arches	365	CI_Arches

Table 5-15b. Sensitive Class II area where each of the 24 Source Groups has the maximum number of days that Δdv exceeds the 0.5 and 1.0 dv thresholds for the Medium Development Scenario.

Source Group	Group Name	>0.5		>1.0	
		Max # of Day @ Class II	Class II (Max Occurs)	Max # of Day @ Class II	Class II (Max Occurs)
A	Little Snake FO	0	NA	0	NA
B	White River FO	38	CII_Dinosaur_all	5	CII_Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0	NA	0	NA
D	Roan Plateau Planning area portion of CRVFO	0	NA	0	NA
E	Grand Junction FO	19	CII_Colorado	3	CII_Colorado
F	Uncompahgre FO	0	NA	0	NA
G	Tres Rios FO	5	CII_Hovenweep	1	CII_Hovenweep
H	Kremmling FO	0	NA	0	NA
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0	NA	0	NA
J	Pawnee Grasslands portion of RGFO#1	0	NA	0	NA
K	RGFO#2 – West-Central/South	0	NA	0	NA
L	RGFO#3 – South	0	NA	0	NA
M	RGFO#4 – East-Central	0	NA	0	NA
N	New Mexico Farmington District	77	CII_Aztec_Ruins	3	CII_Aztec_Ruins
O	Total Colorado River Field Office	0	NA	0	NA
P	Total Royal Gorge Field Office	0	NA	0	NA
Q	Mining from 13 Colorado BLM Planning Areas	39	CII_Raggeds	8	CII_Dinosaur_all
R	Combined new Federal O&G and Mining from the 13 Colo	102	CII_Dinosaur_all	26	CII_Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining	163	CII_South_San_Juan	38	CII_Colorado
T	Cumulative Emissions Scenario – New Federal and non-Fe	226	CII_Aztec_Ruins	57	CII_Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	342	CII_Aztec_Ruins	240	CII_Aztec_Ruins
V	Natural Emissions	246	CII_Sevilleta_NWR	202	CII_Sevilleta_NWR
W	2021 All Emissions	365	CII_Alamosa_NWR	365	CII_Alamosa_NWR
X	2008 All Emissions	365	CII_Alamosa_NWR	365	CII_Alamosa_NWR

Table 5-16a. Maximum Δdv impact at any Class I and sensitive Class II area due to each of the 24 Source Groups for the 2021 High Development Scenario.

Source Group	Group Name	Max dv @ Class I	Class I (Max Occurs)	Max dv @ Class II	Class II (Max Occurs)
A	Little Snake FO	0.21939	CI_Mount_Zirkel	0.22310	CII_Dinosaur_all
B	White River FO	0.78870	CI_Flat_Tops	1.43427	CII_Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.10714	CI_Eagles_Nest	0.15269	CII_Colorado
D	Roan Plateau Planning area portion of CRVFO	0.09446	CI_Maroon_Bells	0.14267	CII_Colorado
E	Grand Junction FO	0.90007	CI_Arches	1.46046	CII_Colorado
F	Uncompahgre FO	0.21822	CI_Maroon_Bells	0.26247	CII_Raggeds
G	Tres Rios FO	1.41540	CI_Mesa_Verde	1.46604	CII_Hovenweep
H	Kremmling FO	0.07991	CI_Eagles_Nest	0.05406	CII_Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.02253	CI_Rocky_Mountain	0.01337	CII_Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	0.12545	CI_Rocky_Mountain	0.05321	CII_Mount_Evans
K	RGFO#2 – West-Central/South	0.02275	CI_Pecos	0.03937	CII_Greenhorn_Mounta
L	RGFO#3 – South	0.01940	CI_Great_Sand_Dunes	0.11458	CII_Greenhorn_Mounta
M	RGFO#4 – East-Central	0.00772	CI_Eagles_Nest	0.04298	CII_Lost_Creek
N	New Mexico Farmington District	0.30608	CI_Weminuche	2.45884	CII_Aztec_Ruins
O	Total Colorado River Field Office	0.19924	CI_Eagles_Nest	0.29345	CII_Colorado
P	Total Royal Gorge Field Office	0.14801	CI_Rocky_Mountain	0.11458	CII_Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	1.27398	CI_Flat_Tops	1.90579	CII_Dinosaur_all
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	1.63971	CI_Flat_Tops	2.63206	CII_Colorado
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	4.19030	CI_Rocky_Mountain	4.59771	CII_Colorado
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	4.19144	CI_Rocky_Mountain	4.60319	CII_Colorado
U	Combined O&G and Mining in 4 km domain	5.53454	CI_Rocky_Mountain	11.71349	CII_Dinosaur_all
V	Natural Emissions	61.82309	CI_Bandelier	57.86500	CII_Dome
W	2021 All Emissions	81.23828	CI_Pecos	57.91427	CII_Dome
X	2008 All Emissions	123.70431	CI_Bandelier	115.81325	CII_Dome

Table 5-16b. Maximum Δdv impact at any Class I and sensitive Class II area due to each of the 24 Source Groups for the 2021 Low Development Scenario.

Source Group	Group Name	Max dv @ Class I	Class I (Max Occurs)	Max dv @ Class II	Class II (Max Occurs)
A	Little Snake FO	0.03379	CI_Mount_Zirkel	0.03217	CII_Dinosaur_all
B	White River FO	0.17342	CI_Flat_Tops	0.35529	CII_Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.08399	CI_Eagles_Nest	0.10547	CII_Colorado
D	Roan Plateau Planning area portion of CRVFO	0.06573	CI_Maroon_Bells	0.08541	CII_Colorado
E	Grand Junction FO	0.06394	CI_Arches	0.10458	CII_Colorado
F	Uncompahgre FO	0.09830	CI_Maroon_Bells	0.08642	CII_Raggeds
G	Tres Rios FO	0.21039	CI_Mesa_Verde	0.20104	CII_Hovenweep
H	Kremmling FO	0.00866	CI_Eagles_Nest	0.00657	CII_Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.00538	CI_Rocky_Mountain	0.00288	CII_Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	0.02803	CI_Rocky_Mountain	0.01093	CII_Mount_Evans
K	RGFO#2 – West-Central/South	0.00197	CI_Pecos	0.00361	CII_Greenhorn_Mounta
L	RGFO#3 – South	0.01214	CI_Great_Sand_Dunes	0.07568	CII_Greenhorn_Mounta
M	RGFO#4 – East-Central	0.00116	CI_Eagles_Nest	0.00677	CII_Lost_Creek
N	New Mexico Farmington District	0.30611	CI_Weminuche	2.45923	CII_Aztec_Ruins
O	Total Colorado River Field Office	0.14638	CI_Maroon_Bells	0.19010	CII_Colorado
P	Total Royal Gorge Field Office	0.03345	CI_Rocky_Mountain	0.07568	CII_Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	1.27455	CI_Flat_Tops	1.90811	CII_Dinosaur_all
R	Combined new Federal O&G and Mining from the 13 Colo	1.32779	CI_Flat_Tops	1.92664	CII_Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining	2.33257	CI_Mesa_Verde	2.89740	CII_Hovenweep
T	Cumulative Emissions Scenario – New Federal and non-Fe	2.34277	CI_Mesa_Verde	3.43746	CII_Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	3.86495	CI_Rocky_Mountain	11.69008	CII_Dinosaur_all
V	Natural Emissions	61.82309	CI_Bandelier	57.86496	CII_Dome
W	2021 All Emissions	81.23822	CI_Pecos	57.91372	CII_Dome
X	2008 All Emissions	123.70431	CI_Bandelier	115.81325	CII_Dome

Table 5-16c. Maximum Δdv impact at any Class I and sensitive Class II area due to each of the 24 Source Groups for the 2021 Medium Development Scenario.

Source Group	Group Name	Max dv @ Class I	Class I (Max Occurs)	Max dv @ Class II	Class II (Max Occurs)
A	Little Snake FO	0.18773	CI_Mount_Zirkel	0.18619	CII_Dinosaur_all
B	White River FO	0.78275	CI_Flat_Tops	1.33901	CII_Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.08876	CI_Eagles_Nest	0.12445	CII_Colorado
D	Roan Plateau Planning area portion of CRVFO	0.08081	CI_Maroon_Bells	0.12163	CII_Colorado
E	Grand Junction FO	0.83689	CI_Arches	1.28333	CII_Colorado
F	Uncompahgre FO	0.14666	CI_Maroon_Bells	0.17131	CII_Raggeds
G	Tres Rios FO	1.02858	CI_Mesa_Verde	1.18014	CII_Hovenweep
H	Kremmling FO	0.07964	CI_Eagles_Nest	0.03373	CII_Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.01231	CI_Rocky_Mountain	0.00764	CII_Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	0.07521	CI_Rocky_Mountain	0.03252	CII_Mount_Evans
K	RGFO#2 – West-Central/South	0.01639	CI_Pecos	0.02875	CII_Greenhorn_Mounta
L	RGFO#3 – South	0.01298	CI_Great_Sand_Dunes	0.07842	CII_Greenhorn_Mounta
M	RGFO#4 – East-Central	0.00366	CI_Eagles_Nest	0.01837	CII_Lost_Creek
N	New Mexico Farmington District	0.22871	CI_Weminuche	1.60245	CII_Aztec_Ruins
O	Total Colorado River Field Office	0.16619	CI_Eagles_Nest	0.24274	CII_Colorado
P	Total Royal Gorge Field Office	0.08758	CI_Rocky_Mountain	0.07842	CII_Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	1.27401	CI_Flat_Tops	1.90580	CII_Dinosaur_all
R	Combined new Federal O&G and Mining from the 13 Colo	1.60208	CI_Flat_Tops	2.32929	CII_Colorado
S	Combined new Federal and non-Federal O&G and Mining	4.14160	CI_Rocky_Mountain	4.32611	CII_Colorado
T	Cumulative Emissions Scenario – New Federal and non-Fe	4.14242	CI_Rocky_Mountain	4.33038	CII_Colorado
U	Combined O&G and Mining in 4 km domain	5.49465	CI_Rocky_Mountain	11.71799	CII_Dinosaur_all
V	Natural Emissions	61.82309	CI_Bandelier	57.86499	CII_Dome
W	2021 All Emissions	81.23827	CI_Pecos	57.91420	CII_Dome
X	2008 All Emissions	123.70431	CI_Bandelier	115.81325	CII_Dome

5.2.2 Individual Planning Area Contributions to Visibility Impairment at Class I and II Areas using FLAG (2010)

Below we present the visibility impacts at Class I areas due to Federal O&G in five BLM Planning Areas: WRFO, GJFO, TRFO, NMFFO and USFS-PG and the 2021 High, Low and Medium Development Scenarios. The first four BLM Planning Areas were selected because they were the ones that had Δdv impacts of greater than 0.5 at any Class I or II area (see Table 5-15), whereas USFS-PG was selected as it is one of our example Planning Areas. Tables 5-17 through 5-21 displays the maximum Δdv and number of days Δdv exceeds the 0.5 and 1.0 thresholds for all Class I areas due to emissions from Federal O&G development within the WRFO, GJFO, TRFO, NMFFO and USFS-PG Planning Areas, respectively. These Tables were obtained from sheet "Table1" in Attachments B-1, B-2 and B-3. The visibility results for the 2021 High, Low and Medium Development Scenario and these five BLM Planning Areas are summarized as follows, results for the other Source Groups and for sensitive Class II areas can be found in Attachments B-1, B-2 and B-3:

- Federal O&G from the WRFO Planning Area and the 2021 High Development Scenario results in 6 days at Flat Tops, 1 day at Eagles Nest and 2 days at Maroon Bells-Snowmass Class I areas with Δdv > 0.5 and no days > 1.0 and maximum Δdv of 0.789, 0.538 and 0.559 at these three Class I areas, respectively (Table 5-17a). The mitigation in the 2021 Medium Development Scenario reduces these values to 4, 0 and 0 days with Δdv > 0.5 and 0.782, 0.439 and 0.479 maximum Δdv at Flat Tops, Eagles Nest and Maroon-Bells Class I areas, respectively (Table 5-17c). For the 2021 Low Development Scenario new Federal O&G from the WRFO Planning Are have no days with Δdv > 0.5 with maximum

Δdv at Flat Tops, Eagles Nest and Maroon Bells-Snowmass of 0.173, 0.107 and 0.122, respectively (Table 5-16b).

- For the 2021 High and Medium Development Scenarios, the GJFO Planning Area has two Class I areas where new Federal O&G emissions result in Δdv greater than 0.5 with 2 days at Arches and 1 day at Black Canyon of the Gunnison that have maximum Δdv of 0.900/0.837 (High/Medium) and 0.580/0.500 (High/Medium), respective (Table 5-18a,c). There are no days with Δdv > 0.5 at any Class I area due to new Federal O&G emissions within the GJFO Planning area for the 2021 Low Development Scenario (Table 5-18b).
- For new Federal O&G within the TRFO Planning Area the 2021 High Development Scenario has 35 days with Δdv > 0.5 and 4 days with Δdv > 1.0 at just the Mesa Verde Class I area (Table 5-19a). These values are reduced to 5 days with Δdv > 0.5 and 1 day with Δdv > 1.0 at the Mesa Verde Class I area due to the mitigation in the 2021 Medium Development Scenario (Table 5-19c). There are no days greater than these thresholds for the 2021 Low Development Scenario (Table 5-19b). The maximum Δdv due to the TRFO at Mesa Verde are 1.412, 0.210 and 1.029 for the 2021 High, Low and Medium Development Scenario, respectively.
- There are no days with Δdv > 0.5 at any Class I area due to Federal O&G emissions from the NMFFO Mancos Shale Development area for all three 2021 emission scenarios (Table 5-20). However, as shown in Attachments B-1, B-2 and B-3, there are 210, 210 and 77 days with Δdv > 0.5 and 50, 50 and 3 days with Δdv > 1.0 at the Aztec Ruins sensitive Class II area for the 2021 High, Low and Medium Development Scenarios. Note that the CARMMS 2021 High and Low Development Scenarios both ran with the same High Development Scenario emissions for the NMFFO Mancos Shale O&G emissions since the Low Scenario emissions were not available at the time of the CARMMS 2021 Low Development Scenario CAMx source apportionment simulation.
- New Federal O&G from the USFS-PG Planning Area has no days with Δdv > 0.5 at any Class I or sensitive Class II area for all three 2021 emissions scenarios (Table 5-21). The maximum Δdv impact due to new Federal O&G development in the USGS-PG Planning Area is 0.125, 0.028 and 0.075 at Rocky Mountain National Park for the, respectively, 2021 High, Low and Medium Development Scenarios (Table 5-21).

Table 5-17a. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the WRFO Planning Area (2021 High Development Scenario).

White River FO					
Short Name	Class I&IIName	Δdv	Date	Number of Day	
				> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.43533	1/14/2008	0	0
CI_Bandelier	Bandelier NM	0.11148	1/17/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.47587	2/17/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.03747	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.26536	1/14/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.07285	2/15/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.53773	1/12/2008	0	1
CI_Flat_Tops	Flat Tops Wilderness	0.78870	1/22/2008	0	6
CI_Galiuro	Galiuro Wilderness	0.00336	5/14/2008	0	0
CI_Gila	Gila Wilderness	0.02166	1/17/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.20730	2/17/2008	0	0
CI_La_Garita	La Garita Wilderness	0.14817	3/6/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.55850	1/12/2008	0	2
CI_Mesa_Verde	Mesa Verde NP	0.17805	3/6/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.04517	1/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.32817	1/12/2008	0	0
CI_Pecos	Pecos Wilderness	0.08404	4/13/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.04465	3/23/2008	0	0
CI_Rawah	Rawah Wilderness	0.22532	12/17/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.20118	3/27/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.03710	5/19/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.07923	3/7/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.12011	5/14/2008	0	0
CI_West_Elk	West Elk Wilderness	0.32166	1/12/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.09681	5/20/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.02573	1/14/2008	0	0

Table 5-17b. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the WRFO Planning Area (2021 Low Development Scenario).

White River FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.09570	1/14/2008	0	0
CI_Bandelier	Bandelier NM	0.01819	1/17/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.08959	2/17/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.00606	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.05029	1/14/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.01199	2/15/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.10731	1/12/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.17342	1/22/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00057	5/14/2008	0	0
CI_Gila	Gila Wilderness	0.00357	1/14/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.03269	1/12/2008	0	0
CI_La_Garita	La Garita Wilderness	0.02915	3/6/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.12272	1/12/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.02813	3/6/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00755	1/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.06246	1/12/2008	0	0
CI_Pecos	Pecos Wilderness	0.01509	4/13/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.00758	3/23/2008	0	0
CI_Rawah	Rawah Wilderness	0.03847	3/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.03799	3/27/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.00666	5/19/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.01379	3/7/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.02257	3/6/2008	0	0
CI_West_Elk	West Elk Wilderness	0.06922	1/12/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.01743	5/20/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.00433	1/14/2008	0	0

Table 5-17c. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the WRFO Planning Area (2021 Medium Development Scenario).

White River FO					
Short Name	Class I&II Name	Δdv	Date	Number of Day > 1.0	Number of Day > 0.5
Class I					
CI_Arches	Arches NP	0.38770	1/14/2008	0	0
CI_Bandelier	Bandelier NM	0.09901	1/17/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.46855	2/17/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.03146	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.23310	1/14/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.06555	2/15/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.43903	1/12/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.78275	1/12/2008	0	4
CI_Galiuro	Galiuro Wilderness	0.00308	5/14/2008	0	0
CI_Gila	Gila Wilderness	0.01893	1/17/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.18367	2/17/2008	0	0
CI_La_Garita	La Garita Wilderness	0.12817	3/6/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.47918	11/11/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.15716	3/6/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.03930	1/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.32707	1/12/2008	0	0
CI_Pecos	Pecos Wilderness	0.07481	4/13/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.04403	3/23/2008	0	0
CI_Rawah	Rawah Wilderness	0.18687	12/17/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.19646	3/27/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.03306	5/19/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.06799	3/7/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.10672	5/14/2008	0	0
CI_West_Elk	West Elk Wilderness	0.30428	2/17/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.08643	5/20/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.02139	1/14/2008	0	0

Table 5-18a. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the GJFO Planning Area (2021 High Development Scenario).

Grand Junction FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.90007	1/13/2008	0	2
CI_Bandelier	Bandelier NM	0.07374	1/17/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.58026	2/16/2008	0	1
CI_Bosque	Bosque del Apache Wilderness	0.02721	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.34965	1/13/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.13423	1/2/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.29818	1/22/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.34568	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00199	5/18/2008	0	0
CI_Gila	Gila Wilderness	0.01637	1/14/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.18116	1/12/2008	0	0
CI_La_Garita	La Garita Wilderness	0.15510	1/12/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.43962	1/12/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.14631	1/17/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.02719	1/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.28359	5/25/2008	0	0
CI_Pecos	Pecos Wilderness	0.07952	1/13/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.02661	3/9/2008	0	0
CI_Rawah	Rawah Wilderness	0.14821	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.16054	3/24/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.02422	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.05123	3/6/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.09183	3/5/2008	0	0
CI_West_Elk	West Elk Wilderness	0.40600	1/12/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.10652	1/12/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.01722	1/14/2008	0	0

Table 5-18b. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the GJFO Planning Area (2021 Low Development Scenario).

Grand Junction FO					
Short Name	Class I&II Name	Δdv	Date	Number of Day > 1.0	Number of Day > 0.5
Class I					
CI_Arches	Arches NP	0.06394	1/13/2008	0	0
CI_Bandelier	Bandelier NM	0.00426	1/17/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.03463	2/16/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.00157	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.02204	1/13/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.00678	1/2/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.02113	1/22/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.01884	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00012	5/18/2008	0	0
CI_Gila	Gila Wilderness	0.00099	1/14/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.01113	1/13/2008	0	0
CI_La_Garita	La Garita Wilderness	0.01015	3/22/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.03801	1/12/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.00879	1/17/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00165	1/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.01705	5/25/2008	0	0
CI_Pecos	Pecos Wilderness	0.00503	1/13/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.00157	3/9/2008	0	0
CI_Rawah	Rawah Wilderness	0.00923	4/22/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.01079	3/24/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.00146	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.00328	3/6/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.00642	3/5/2008	0	0
CI_West_Elk	West Elk Wilderness	0.03084	1/12/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.00653	1/13/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.00101	1/14/2008	0	0

Table 5-18c. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the GJFO Planning Area (2021 Medium Development Scenario).

Grand Junction FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.83689	1/13/2008	0	2
CI_Bandelier	Bandelier NM	0.06171	1/17/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.50011	2/16/2008	0	1
CI_Bosque	Bosque del Apache Wilderness	0.02177	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.32464	1/13/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.11614	1/2/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.24399	1/22/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.27841	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00155	5/18/2008	0	0
CI_Gila	Gila Wilderness	0.01337	1/14/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.15145	1/12/2008	0	0
CI_La_Garita	La Garita Wilderness	0.13364	1/12/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.36723	1/12/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.12182	1/17/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.02259	1/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.23447	5/25/2008	0	0
CI_Pecos	Pecos Wilderness	0.06703	1/13/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.02307	3/9/2008	0	0
CI_Rawah	Rawah Wilderness	0.11926	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.13008	3/24/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.02030	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.04261	3/6/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.07837	3/5/2008	0	0
CI_West_Elk	West Elk Wilderness	0.34239	1/12/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.08939	1/12/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.01405	1/14/2008	0	0

Table 5-19a. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the TRFO Planning Area (2021 High Development Scenario).

Tres Rios FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.08112	2/10/2008	0	0
CI_Bandelier	Bandelier NM	0.08282	1/18/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.15138	2/11/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.03171	1/13/2008	0	0
CI_Canyonlands	Canyonlands NP	0.14171	12/21/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.02766	1/3/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.06000	5/24/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.08493	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00177	3/23/2008	0	0
CI_Gila	Gila Wilderness	0.01053	4/13/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.03540	11/19/2008	0	0
CI_La_Garita	La Garita Wilderness	0.05190	3/21/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.08297	5/24/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	1.41540	2/10/2008	4	35
CI_Mount_Baldy	Mount Baldy Wilderness	0.01073	3/23/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.07637	5/25/2008	0	0
CI_Pecos	Pecos Wilderness	0.03618	3/11/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.03174	1/14/2008	0	0
CI_Rawah	Rawah Wilderness	0.05117	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.03678	5/24/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.01197	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.06324	1/12/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.06845	3/21/2008	0	0
CI_West_Elk	West Elk Wilderness	0.07588	12/20/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.02479	2/8/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.01629	1/13/2008	0	0

Table 5-19b. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the TRFO Planning Area (2021 Low Development Scenario).

Tres Rios FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.01083	2/10/2008	0	0
CI_Bandelier	Bandelier NM	0.00987	1/18/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.01743	2/11/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.00383	1/13/2008	0	0
CI_Canyonlands	Canyonlands NP	0.01906	12/21/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.00330	1/3/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.00728	5/24/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.01074	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00021	3/23/2008	0	0
CI_Gila	Gila Wilderness	0.00133	4/13/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.00413	11/19/2008	0	0
CI_La_Garita	La Garita Wilderness	0.00642	3/21/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.00984	5/24/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.21039	2/10/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00130	3/23/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.00984	5/25/2008	0	0
CI_Pecos	Pecos Wilderness	0.00427	3/11/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.00384	1/14/2008	0	0
CI_Rawah	Rawah Wilderness	0.00634	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.00465	5/24/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.00149	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.00768	1/12/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.00834	3/21/2008	0	0
CI_West_Elk	West Elk Wilderness	0.00900	12/20/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.00302	2/8/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.00201	1/13/2008	0	0

Table 5-19c. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the TRFO Planning Area (2021 Medium Development Scenario).

Tres Rios FO					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.06784	2/10/2008	0	0
CI_Bandelier	Bandelier NM	0.06815	1/18/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.12458	2/11/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.02502	1/13/2008	0	0
CI_Canyonlands	Canyonlands NP	0.11730	12/21/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.02288	1/3/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.04997	5/24/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.07172	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00146	3/23/2008	0	0
CI_Gila	Gila Wilderness	0.00855	4/13/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.02765	3/21/2008	0	0
CI_La_Garita	La Garita Wilderness	0.04270	3/21/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.06869	5/24/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	1.02858	2/10/2008	1	5
CI_Mount_Baldy	Mount Baldy Wilderness	0.00885	3/23/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.06459	5/25/2008	0	0
CI_Pecos	Pecos Wilderness	0.02941	3/11/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.02271	1/14/2008	0	0
CI_Rawah	Rawah Wilderness	0.04288	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.03083	5/24/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.00975	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.05047	1/12/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.05626	3/21/2008	0	0
CI_West_Elk	West Elk Wilderness	0.06237	12/20/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.02032	2/8/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.01354	1/13/2008	0	0

Table 5-20a. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the NMFFO Planning Area (2021 High Development Scenario).

New Mexico Farmington District					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.05561	11/25/2008	0	0
CI_Bandelier	Bandelier NM	0.15626	1/18/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.12266	5/25/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.02491	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.08824	12/30/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.08109	1/3/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.07141	5/25/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.07557	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00596	5/17/2008	0	0
CI_Gila	Gila Wilderness	0.01445	5/18/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.12535	12/8/2008	0	0
CI_La_Garita	La Garita Wilderness	0.15074	5/24/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.09903	5/25/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.19519	1/1/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.01094	5/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.04961	5/26/2008	0	0
CI_Pecos	Pecos Wilderness	0.08594	3/11/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.07565	1/14/2008	0	0
CI_Rawah	Rawah Wilderness	0.03416	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.03444	5/25/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.02992	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.13503	3/18/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.30608	5/24/2008	0	0
CI_West_Elk	West Elk Wilderness	0.11344	5/25/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.07107	3/24/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.02660	1/13/2008	0	0

Table 5-20b. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the NMFFO Planning Area (2021 Low Development Scenario).

New Mexico Farmington District					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.05560	11/25/2008	0	0
CI_Bandelier	Bandelier NM	0.15753	1/18/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.12277	5/25/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.02532	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.08843	12/30/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.08074	1/3/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.07157	5/25/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.07693	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00600	5/17/2008	0	0
CI_Gila	Gila Wilderness	0.01454	5/18/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.12514	12/8/2008	0	0
CI_La_Garita	La Garita Wilderness	0.15069	5/24/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.09914	5/25/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.19566	1/1/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.01103	5/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.05047	5/26/2008	0	0
CI_Pecos	Pecos Wilderness	0.08613	3/11/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.07619	1/14/2008	0	0
CI_Rawah	Rawah Wilderness	0.03453	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.03407	5/25/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.03084	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.13617	3/18/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.30611	5/24/2008	0	0
CI_West_Elk	West Elk Wilderness	0.11343	5/25/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.07176	3/24/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.02696	1/13/2008	0	0

Table 5-20c. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the NMFFO Planning Area (2021 Medium Development Scenario).

New Mexico Farmington District					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.03949	11/25/2008	0	0
CI_Bandelier	Bandelier NM	0.11621	1/18/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.09211	5/25/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.01757	3/7/2008	0	0
CI_Canyonlands	Canyonlands NP	0.06564	12/30/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.06059	1/3/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.05397	5/25/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.05739	5/25/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00370	5/17/2008	0	0
CI_Gila	Gila Wilderness	0.00984	5/18/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.09241	12/8/2008	0	0
CI_La_Garita	La Garita Wilderness	0.11350	5/24/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.07456	5/25/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.14509	12/30/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00702	5/17/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.03725	5/26/2008	0	0
CI_Pecos	Pecos Wilderness	0.06296	3/11/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.04816	1/14/2008	0	0
CI_Rawah	Rawah Wilderness	0.02590	5/25/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.02598	5/25/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.02222	1/13/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.08660	3/18/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.22871	5/24/2008	0	0
CI_West_Elk	West Elk Wilderness	0.08529	5/25/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.04916	2/8/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.01987	1/13/2008	0	0

Table 5-21a. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the USFS-PG Planning Area (2021 High Development Scenario).

Pawnee Grasslands portion of RGFO#1					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.00006	9/30/2008	0	0
CI_Bandelier	Bandelier NM	0.00242	12/9/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.00137	3/17/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.00144	11/15/2008	0	0
CI_Canyonlands	Canyonlands NP	0.00007	7/10/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.00004	7/10/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.00630	3/9/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.00154	3/17/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00008	5/17/2008	0	0
CI_Gila	Gila Wilderness	0.00096	5/17/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.00676	11/27/2008	0	0
CI_La_Garita	La Garita Wilderness	0.00159	4/17/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.00261	3/17/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.00030	3/17/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00039	5/16/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.00255	5/26/2008	0	0
CI_Pecos	Pecos Wilderness	0.00395	11/24/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.00056	5/16/2008	0	0
CI_Rawah	Rawah Wilderness	0.02765	5/26/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.12545	11/20/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.00225	5/18/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.00120	5/16/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.00183	4/17/2008	0	0
CI_West_Elk	West Elk Wilderness	0.00204	3/17/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.00246	5/15/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.00268	5/18/2008	0	0

Table 5-21b. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the USFS-PG Planning Area (2021 Low Development Scenario).

Pawnee Grasslands portion of RGFO#1					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.00001	12/30/2008	0	0
CI_Bandelier	Bandelier NM	0.00048	12/9/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.00032	3/17/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.00028	11/15/2008	0	0
CI_Canyonlands	Canyonlands NP	0.00008	12/30/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.00001	7/10/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.00130	3/9/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.00031	3/17/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00002	5/17/2008	0	0
CI_Gila	Gila Wilderness	0.00019	5/17/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.00139	11/27/2008	0	0
CI_La_Garita	La Garita Wilderness	0.00035	3/17/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.00055	3/17/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.00007	3/17/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00008	5/16/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.00054	5/26/2008	0	0
CI_Pecos	Pecos Wilderness	0.00074	11/24/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.00011	5/16/2008	0	0
CI_Rawah	Rawah Wilderness	0.00556	5/26/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.02803	11/20/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.00047	5/18/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.00023	5/16/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.00038	4/17/2008	0	0
CI_West_Elk	West Elk Wilderness	0.00046	3/17/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.00049	5/15/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.00056	5/18/2008	0	0

Table 5-21c. Maximum Δdv and number of days Δdv exceeds 0.5 and 1.0 for each Class I area due to emissions from Federal O&G within the USFS-PG Planning Area (2021 Medium Development Scenario).

Pawnee Grasslands portion of RGFO#1					
				Number of Day	
Short Name	Class I&II Name	Δdv	Date	> 1.0	> 0.5
Class I					
CI_Arches	Arches NP	0.00002	9/30/2008	0	0
CI_Bandelier	Bandelier NM	0.00146	12/9/2008	0	0
CI_Black_Canyon	Black Canyon of the Gunnison NM	0.00086	3/17/2008	0	0
CI_Bosque	Bosque del Apache Wilderness	0.00079	11/15/2008	0	0
CI_Canyonlands	Canyonlands NP	0.00003	7/10/2008	0	0
CI_Capitol_Reef	Capitol Reef NP	0.00002	7/10/2008	0	0
CI_Eagles_Nest	Eagles Nest Wilderness	0.00369	3/9/2008	0	0
CI_Flat_Tops	Flat Tops Wilderness	0.00091	3/17/2008	0	0
CI_Galiuro	Galiuro Wilderness	0.00003	5/17/2008	0	0
CI_Gila	Gila Wilderness	0.00047	5/17/2008	0	0
CI_Great_Sand_Dunes	Great Sand Dunes NM	0.00371	11/27/2008	0	0
CI_La_Garita	La Garita Wilderness	0.00099	3/17/2008	0	0
CI_Maroon_Bells	Maroon Bells-Snowmass Wilderness	0.00158	3/17/2008	0	0
CI_Mesa_Verde	Mesa Verde NP	0.00018	3/17/2008	0	0
CI_Mount_Baldy	Mount Baldy Wilderness	0.00019	5/16/2008	0	0
CI_Mount_Zirkel	Mount Zirkel Wilderness	0.00155	5/26/2008	0	0
CI_Pecos	Pecos Wilderness	0.00234	11/24/2008	0	0
CI_Petrified_Forest	Petrified Forest NP	0.00024	5/16/2008	0	0
CI_Rawah	Rawah Wilderness	0.01687	5/26/2008	0	0
CI_Rocky_Mountain	Rocky Mountain NP	0.07521	11/20/2008	0	0
CI_Salt_Creek	Salt Creek Wilderness	0.00124	2/18/2008	0	0
CI_San_Pedro	San Pedro Parks Wilderness	0.00066	11/24/2008	0	0
CI_Weminuche	Weminuche Wilderness	0.00106	4/17/2008	0	0
CI_West_Elk	West Elk Wilderness	0.00126	3/17/2008	0	0
CI_Wheeler_Peak	Wheeler Peak Wilderness	0.00135	5/15/2008	0	0
CI_White_Mountain	White Mountain Wilderness	0.00146	5/18/2008	0	0

5.3 Cumulative Visibility Impacts at Class I Areas

The visibility impacts due to new oil and gas emissions from combined BLM Planning Areas were examined following the procedures provided by the FWS and NPS (FWS and NPS, 2012) and described in Section 4.6.2. These procedures use EPA's Modeled Attainment Test Software (MATS) to project current year observed visibility impairment for the observed best 20 percent (B20%) and worst 20 percent (W20%) visibility days to the future year using the CAMx 2008 Base Case and 2021 High, Low and Medium Development Scenarios modeling results with and without emissions from each of the combined emission Source Groups. The cumulative visibility analysis was conducted for the following four combined Source Groups:

- Source Group R: New oil and gas and mining on Federal lands within the 13 Colorado BLM Planning Areas;
- Source Group S: New oil and gas on Federal and non-Federal lands and mining on Federal lands within the 13 Colorado BLM Planning Areas;

- Source Group T: Cumulative Emissions Scenario of new oil and gas on Federal and non-Federal lands and mining on Federal lands within the 14 Colorado and northern New Mexico BLM Planning Areas;
- Source Group U: Existing and New Federal and non-Federal oil and gas throughout the 4 km CARMMS domain plus mining on Federal land within the 13 Colorado BLM Planning Areas.

Attachments C-1, C-2 and C-3 contain the 2008 observed and 2021 projected visibility for the W20% and B20% days at Class I and sensitive Class II areas for the, respectively, High, Low and Medium Development Scenarios with and without each of the combined Source Groups. Tables 5-22 through 5-27 from Attachments C-1, C-2 and C-3 displays the cumulative visibility results at Class I areas for the 2021 High, Low and Medium Development Scenarios, the four combined emission Source Groups listed above and the W20% and B20% days. MATS uses observed PM species concentrations and monthly average relative humidity from IMPROVE monitoring sites to calculate daily visibility impairment from which the W20% and B20% visibility days metrics are determined. Not all Class I areas have a co-located IMPROVE monitoring site. Thus, IMPROVE observations were mapped to nearby Class I areas that did not include an IMPROVE monitor. In Tables 5-22 through 5-27, the Class I area of interest is shown in the first column and the IMPROVE site used to represent observed visibility at the Class I area is shown in the third column. For example, the IMPROVE data from Canyonlands National Park was used to represent observed visibility for both the Canyonlands and Arches National Parks. The MATS includes the IMPROVE site to Class I area mappings. However, MATS does not include mappings between IMPROVE sites and sensitive Class II areas. Thus, we assigned an IMPROVE monitoring site to each sensitive Class II area based mainly on proximity so that MATS could calculate cumulative visibility impacts for the W20%/B20% days at sensitive Class II areas. Tables 5-22 through 5-26 include cumulative visibility impacts for just the Class I areas, the results for the sensitive Class II areas are included in Attachments C-1, C-2 and C-3.

Table 5-22a displays the observed W20% visibility metric for the current year (2008) and the projected W20% metric for the 2021 High Development Scenario with and without each of the four combined Source Groups with differences in the W20% visibility metric shown in Table 5-22b. From the 2008 current year to the 2021 High Development Scenario future year, the W20% visibility metric is estimated to improve at 24 and degrade at 2 of the 26 Class I areas. The biggest improvement in W20% visibility between 2008 and 2021 High Scenario is a reduction of 0.89 dv that occurs at Rocky Mountain National Park that goes from 12.04 dv in 2008 to 11.15 dv in the 2021 High Development Scenario. The two Class I areas with degradation are Salt Creek (0.22 dv increase) and White Mountain (0.23 dv increase).

There are even more improvements in the W20% visibility between 2008 and 2021 for the Low Development Scenario (Table 5-23). Again the Class I area with the biggest improvement between 2008 and 2021 Low Scenario is a reduction of 0.92 dv at Rocky Mountain National Park. Again 24 of the 26 Class I areas see W20% visibility improvements between 2008 and 2021 Low Scenario with the same two Class I areas showing W20% visibility degradation in the High and Low Development Scenarios. The results for the 2021 Medium Development Scenario are similar with 24 of 26 Class I areas showing improvements in the W20% visibility metric with the largest improvement (0.89 dv decrease) occurring at Rocky Mountain National Park (Table 5-24).

The Source Group R (new Federal O&G and mining in Colorado) contribution to 2021 W20% visibility ranges from a minimum of zero to maximums of 0.12 (High), 0.10 (Low) and 0.12 (Medium) dv (Tables 5-22b, 5-23b and 5-24b). Whereas, the contributions of all O&G emissions in the 4 km CARMMS domain (Source Group U) to the W20% days is always positive with maximum values of 0.50, 0.40 and 0.45 dv for the High, Low and Medium Development Scenarios, respectively.

The results for the B20% visibility days and High, Low and Medium Development Scenarios are shown in Tables 5-25 through 5-27. Between 2008 and 2021 the B20% visibility improves for approximately half and degrades for the other half of the Class I areas for all three 2021 emission scenarios. The largest improvement in B20% visibility for the High, Low and Medium Development Scenarios are 0.16, 0.20 and 0.17 dv and the largest degradation in B20% visibility is 0.61, 0.57 and 0.61 dv, respectively. The Source Groups' R, S, T and U contributions to the B20% visibility range from zero to 0.16, 0.33, 0.40 and 0.80 dv for the High and zero to 0.13, 0.16, 0.23 and 0.75 dv for the Low Development Scenarios with the 2021 Medium Development scenario results falling between the High and Low Development Scenarios.

Table 5-22a. Cumulative visibility results for W20% visibility days at Class I areas for current year (2008) and 2021 High Development Scenario using all emissions and without Source Groups R, S, T and U.

Class I Name	State	IMPROVE Site	2008 Base	2021 High	2021 High w/o R	2021 High w/o S	2021 High w/o T	2021 High w/o U
Arches NP	UT	CANY1	11.02	10.37	10.34	10.26	10.26	10.19
Mount Baldy Wilderness	AZ	BALD1	11.10	10.56	10.56	10.55	10.55	10.54
Bandelier NM	NM	BAND1	11.33	10.88	10.83	10.80	10.79	10.44
Black Canyon of the Gunnison NM	CO	WEMI1	9.95	9.31	9.30	9.11	9.11	9.05
Bosque del Apache	NM	BOAP1	12.72	12.31	12.30	12.30	12.30	12.27
Canyonlands NP	UT	CANY1	12.49	11.98	11.96	11.91	11.91	11.86
Capitol Reef NP	UT	CAPI1	12.92	12.72	12.71	12.65	12.65	12.61
Eagles Nest Wilderness	CO	WHRI1	8.68	7.87	7.85	7.78	7.78	7.70
Flat Tops Wilderness	CO	WHRI1	8.68	8.07	8.06	7.89	7.89	7.85
Galiuro Wilderness[1]	AZ	CHIR1	11.58	11.19	11.19	11.19	11.19	11.18
Gila Wilderness	NM	GICL1	11.58	11.54	11.54	11.54	11.54	11.54
Great Sand Dunes NM	CO	GRSA1	10.90	10.78	10.73	10.70	10.70	10.66
La Garita Wilderness	CO	WEMI1	9.95	9.36	9.35	9.34	9.33	9.31
Maroon Bells-Snowmass Wilderness	CO	WHRI1	8.68	7.91	7.89	7.84	7.84	7.80
Mesa Verde NP	CO	MEVE1	11.20	10.82	10.79	10.77	10.76	10.71
Mount Zirkel Wilderness	CO	MOZI1	9.36	8.54	8.53	8.45	8.45	8.42
Pecos Wilderness[2]	NM	BAND1	11.33	10.86	10.80	10.76	10.75	10.51
Petrified Forest NP	AZ	PEFO1	12.49	12.06	12.04	12.02	12.02	11.89
Rawah Wilderness	CO	MOZI1	9.36	8.53	8.52	8.44	8.44	8.39
Rocky Mountain NP	CO	ROMO1	12.04	11.15	11.14	11.09	11.09	11.03
Salt Creek	NM	SACR1	16.87	17.09	17.08	17.08	17.08	17.06
San Pedro Parks Wilderness	NM	SAPE1	9.43	8.72	8.60	8.58	8.58	8.54
West Elk Wilderness	CO	WHRI1	8.68	8.08	8.06	8.01	8.01	7.97
Weminuche Wilderness	CO	WEMI1	9.95	9.49	9.46	9.45	9.45	9.42
Wheeler Peak Wilderness[2]	NM	BAND1	11.33	10.86	10.75	10.59	10.52	10.36
White Mountain Wilderness	NM	WHIT1	12.92	13.15	13.15	13.15	13.15	13.13

Table 5-22b. Differences in cumulative visibility results for W20% visibility days at Class I areas between current year (2008) and 2021 High Development Scenario (2008-2021) and contributions of Source Groups R, S, T and U to 2021 W20% day's visibility.

Class I Name	State	IMPROVE Site	2021 High Improvement from 2008	Contribution from R	Contribution from S	Contribution from T	Contribution from U
Arches NP	UT	CANY1	0.65	0.03	0.11	0.11	0.18
Mount Baldy Wilderness	AZ	BALD1	0.54	0.00	0.01	0.01	0.02
Bandelier NM	NM	BAND1	0.45	0.05	0.08	0.09	0.44
Black Canyon of the Gunnison NM	CO	WEMI1	0.64	0.01	0.20	0.20	0.26
Bosque del Apache	NM	BOAP1	0.41	0.01	0.01	0.01	0.04
Canyonlands NP	UT	CANY1	0.51	0.02	0.07	0.07	0.12
Capitol Reef NP	UT	CAPI1	0.20	0.01	0.07	0.07	0.11
Eagles Nest Wilderness	CO	WHRI1	0.81	0.02	0.09	0.09	0.17
Flat Tops Wilderness	CO	WHRI1	0.61	0.01	0.18	0.18	0.22
Galiuro Wilderness[1]	AZ	CHIR1	0.39	0.00	0.00	0.00	0.01
Gila Wilderness	NM	GICL1	0.04	0.00	0.00	0.00	0.00
Great Sand Dunes NM	CO	GRSA1	0.12	0.05	0.08	0.08	0.12
La Garita Wilderness	CO	WEMI1	0.59	0.01	0.02	0.03	0.05
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.77	0.02	0.07	0.07	0.11
Mesa Verde NP	CO	MEVE1	0.38	0.03	0.05	0.06	0.11
Mount Zirkel Wilderness	CO	MOZI1	0.82	0.01	0.09	0.09	0.12
Pecos Wilderness[2]	NM	BAND1	0.47	0.06	0.10	0.11	0.35
Petrified Forest NP	AZ	PEFO1	0.43	0.02	0.04	0.04	0.17
Rawah Wilderness	CO	MOZI1	0.83	0.01	0.09	0.09	0.14
Rocky Mountain NP	CO	ROMO1	0.89	0.01	0.06	0.06	0.12
Salt Creek	NM	SACR1	-0.22	0.01	0.01	0.01	0.03
San Pedro Parks Wilderness	NM	SAPE1	0.71	0.12	0.14	0.14	0.18
West Elk Wilderness	CO	WHRI1	0.60	0.02	0.07	0.07	0.11
Weminuche Wilderness	CO	WEMI1	0.46	0.03	0.04	0.04	0.07
Wheeler Peak Wilderness[2]	NM	BAND1	0.47	0.11	0.27	0.34	0.50
White Mountain Wilderness	NM	WHIT1	-0.23	0.00	0.00	0.00	0.02

Table 5-23a. Cumulative visibility results for W20% visibility days at Class I areas for current year (2008) and 2021 Low Development Scenario using all emissions and without Source Groups R, S, T and U.

Class I Name	State	IMPROVE Site	2008 Base	2021 Low	2021 Low w/o R	2021 Low w/o S	2021 Low w/o T	2021 Low w/o U
Arches NP	UT	CANY1	11.02	10.33	10.32	10.28	10.28	10.21
Mount Baldy Wilderness	AZ	BALD1	11.10	10.56	10.56	10.55	10.55	10.54
Bandelier NM	NM	BAND1	11.33	10.85	10.83	10.81	10.81	10.45
Black Canyon of the Gunnison NM	CO	WEMI1	9.95	9.21	9.20	9.12	9.12	9.06
Bosque del Apache	NM	BOAP1	12.72	12.31	12.31	12.30	12.30	12.27
Canyonlands NP	UT	CANY1	12.49	11.95	11.94	11.92	11.91	11.87
Capitol Reef NP	UT	CAPI1	12.92	12.69	12.69	12.66	12.66	12.62
Eagles Nest Wilderness	CO	WHRI1	8.68	7.83	7.82	7.79	7.79	7.71
Flat Tops Wilderness	CO	WHRI1	8.68	8.00	7.99	7.91	7.91	7.86
Galluro Wilderness[1]	AZ	CHIR1	11.58	11.19	11.19	11.19	11.19	11.18
Gila Wilderness	NM	GICL1	11.58	11.54	11.54	11.54	11.54	11.54
Great Sand Dunes NM	CO	GRSA1	10.90	10.76	10.73	10.72	10.71	10.67
La Garita Wilderness	CO	WEMI1	9.95	9.35	9.35	9.34	9.34	9.31
Maroon Bells-Snowmass Wilderness	CO	WHRI1	8.68	7.88	7.87	7.85	7.85	7.81
Mesa Verde NP	CO	MEVE1	11.20	10.81	10.79	10.78	10.78	10.72
Mount Zirkel Wilderness	CO	MOZI1	9.36	8.49	8.49	8.45	8.45	8.42
Pecos Wilderness[2]	NM	BAND1	11.33	10.82	10.80	10.78	10.77	10.52
Petrified Forest NP	AZ	PEFO1	12.49	12.04	12.04	12.02	12.02	11.89
Rawah Wilderness	CO	MOZI1	9.36	8.48	8.47	8.44	8.44	8.39
Rocky Mountain NP	CO	ROMO1	12.04	11.12	11.12	11.09	11.09	11.03
Salt Creek	NM	SACR1	16.87	17.09	17.08	17.08	17.08	17.06
San Pedro Parks Wilderness	NM	SAPE1	9.43	8.70	8.60	8.59	8.59	8.55
West Elk Wilderness	CO	WHRI1	8.68	8.05	8.04	8.02	8.01	7.98
Weminuche Wilderness	CO	WEMI1	9.95	9.48	9.46	9.46	9.45	9.43
Wheeler Peak Wilderness[2]	NM	BAND1	11.33	10.75	10.70	10.61	10.55	10.38
White Mountain Wilderness	NM	WHIT1	12.92	13.15	13.15	13.15	13.15	13.13

Table 5-23b. Differences in cumulative visibility results for W20% visibility days at Class I areas between current year (2008) and 2021 Low Development Scenario (2008-2021) and contributions of Source Groups R, S, T and U to 2021 W20% day's visibility.

Class I Name	State	IMPROVE Site	2021 Low Improvement from 2008	Contribution from R	Contribution from S	Contribution from T	Contribution from U
Arches NP	UT	CANY1	0.69	0.01	0.05	0.05	0.12
Mount Baldy Wilderness	AZ	BALD1	0.54	0.00	0.01	0.01	0.02
Bandelier NM	NM	BAND1	0.48	0.02	0.04	0.04	0.40
Black Canyon of the Gunnison NM	CO	WEMI1	0.74	0.01	0.09	0.09	0.15
Bosque del Apache	NM	BOAP1	0.41	0.00	0.01	0.01	0.04
Canyonlands NP	UT	CANY1	0.54	0.01	0.03	0.04	0.08
Capitol Reef NP	UT	CAPI1	0.23	0.00	0.03	0.03	0.07
Eagles Nest Wilderness	CO	WHRI1	0.85	0.01	0.04	0.04	0.12
Flat Tops Wilderness	CO	WHRI1	0.68	0.01	0.09	0.09	0.14
Galiuro Wilderness[1]	AZ	CHIR1	0.39	0.00	0.00	0.00	0.01
Gila Wilderness	NM	GICL1	0.04	0.00	0.00	0.00	0.00
Great Sand Dunes NM	CO	GRSA1	0.14	0.03	0.04	0.05	0.09
La Garita Wilderness	CO	WEMI1	0.60	0.00	0.01	0.01	0.04
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.80	0.01	0.03	0.03	0.07
Mesa Verde NP	CO	MEVE1	0.39	0.02	0.03	0.03	0.09
Mount Zirkel Wilderness	CO	MOZI1	0.87	0.00	0.04	0.04	0.07
Pecos Wilderness[2]	NM	BAND1	0.51	0.02	0.04	0.05	0.30
Petrified Forest NP	AZ	PEFO1	0.45	0.00	0.02	0.02	0.15
Rawah Wilderness	CO	MOZI1	0.88	0.01	0.04	0.04	0.09
Rocky Mountain NP	CO	ROMO1	0.92	0.00	0.03	0.03	0.09
Salt Creek	NM	SACR1	-0.22	0.01	0.01	0.01	0.03
San Pedro Parks Wilderness	NM	SAPE1	0.73	0.10	0.11	0.11	0.15
West Elk Wilderness	CO	WHRI1	0.63	0.01	0.03	0.04	0.07
Weminuche Wilderness	CO	WEMI1	0.47	0.02	0.02	0.03	0.05
Wheeler Peak Wilderness[2]	NM	BAND1	0.58	0.05	0.14	0.20	0.37
White Mountain Wilderness	NM	WHIT1	-0.23	0.00	0.00	0.00	0.02

Table 5-24a. Cumulative visibility results for W20% visibility days at Class I areas for current year (2008) and 2021 Medium Development Scenario using all emissions and without Source Groups R, S, T and U.

Class I Name	State	IMPROVE Site	2008 Base	2021 Medium	2021 Med w/o R	2021 Med w/o S	2021 Med w/o T	2021 Med w/o U
Arches NP	UT	CANY1	11.02	10.36	10.35	10.26	10.26	10.19
Mount Baldy Wilderness	AZ	BALD1	11.10	10.56	10.56	10.55	10.55	10.54
Bandelier NM	NM	BAND1	11.33	10.87	10.83	10.80	10.79	10.44
Black Canyon of the Gunnison NM	CO	WEMI1	9.95	9.31	9.30	9.11	9.11	9.05
Bosque del Apache	NM	BOAP1	12.72	12.31	12.30	12.30	12.30	12.27
Canyonlands NP	UT	CANY1	12.49	11.98	11.96	11.91	11.91	11.86
Capitol Reef NP	UT	CAPI1	12.92	12.72	12.71	12.65	12.65	12.61
Eagles Nest Wilderness	CO	WHRI1	8.68	7.86	7.85	7.78	7.78	7.70
Flat Tops Wilderness	CO	WHRI1	8.68	8.07	8.06	7.89	7.89	7.85
Galiuro Wilderness[1]	AZ	CHIR1	11.58	11.19	11.19	11.19	11.19	11.18
Gila Wilderness	NM	GICL1	11.58	11.54	11.54	11.54	11.54	11.54
Great Sand Dunes NM	CO	GRSA1	10.90	10.77	10.73	10.71	10.70	10.66
La Garita Wilderness	CO	WEMI1	9.95	9.36	9.35	9.33	9.33	9.31
Maroon Bells-Snowmass Wilderness	CO	WHRI1	8.68	7.90	7.89	7.85	7.84	7.80
Mesa Verde NP	CO	MEVE1	11.20	10.82	10.79	10.77	10.77	10.71
Mount Zirkel Wilderness	CO	MOZI1	9.36	8.54	8.53	8.45	8.45	8.42
Pecos Wilderness[2]	NM	BAND1	11.33	10.84	10.80	10.76	10.75	10.51
Petrified Forest NP	AZ	PEFO1	12.49	12.06	12.04	12.02	12.02	11.89
Rawah Wilderness	CO	MOZI1	9.36	8.53	8.52	8.44	8.44	8.39
Rocky Mountain NP	CO	ROMO1	12.04	11.15	11.14	11.09	11.09	11.03
Salt Creek	NM	SACR1	16.87	17.09	17.08	17.08	17.08	17.06
San Pedro Parks Wilderness	NM	SAPE1	9.43	8.72	8.60	8.58	8.58	8.54
West Elk Wilderness	CO	WHRI1	8.68	8.08	8.06	8.01	8.01	7.97
Weminuche Wilderness	CO	WEMI1	9.95	9.48	9.46	9.45	9.45	9.42
Wheeler Peak Wilderness[2]	NM	BAND1	11.33	10.81	10.72	10.56	10.53	10.36
White Mountain Wilderness	NM	WHIT1	12.92	13.15	13.15	13.15	13.15	13.13

Table 5-24b. Differences in cumulative visibility results for W20% visibility days at Class I areas between current year (2008) and 2021 Medium Development Scenario (2008-2021) and contributions of Source Groups R, S, T and U to 2021 W20% day's visibility.

Class I Name	State	IMPROVE Site	2021 Med Improvement from 2008	Contribution from R	Contribution from S	Contribution from T	Contribution from U
Arches NP	UT	CANY1	0.66	0.01	0.10	0.10	0.17
Mount Baldy Wilderness	AZ	BALD1	0.54	0.00	0.01	0.01	0.02
Bandelier NM	NM	BAND1	0.46	0.04	0.07	0.08	0.43
Black Canyon of the Gunnison NM	CO	WEMI1	0.64	0.01	0.20	0.20	0.26
Bosque del Apache	NM	BOAP1	0.41	0.01	0.01	0.01	0.04
Canyonlands NP	UT	CANY1	0.51	0.02	0.07	0.07	0.12
Capitol Reef NP	UT	CAPI1	0.20	0.01	0.07	0.07	0.11
Eagles Nest Wilderness	CO	WHRI1	0.82	0.01	0.08	0.08	0.16
Flat Tops Wilderness	CO	WHRI1	0.61	0.01	0.18	0.18	0.22
Galiuro Wilderness[1]	AZ	CHIR1	0.39	0.00	0.00	0.00	0.01
Gila Wilderness	NM	GICL1	0.04	0.00	0.00	0.00	0.00
Great Sand Dunes NM	CO	GRSA1	0.13	0.04	0.06	0.07	0.11
La Garita Wilderness	CO	WEMI1	0.59	0.01	0.03	0.03	0.05
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.78	0.01	0.05	0.06	0.10
Mesa Verde NP	CO	MEVE1	0.38	0.03	0.05	0.05	0.11
Mount Zirkel Wilderness	CO	MOZI1	0.82	0.01	0.09	0.09	0.12
Pecos Wilderness[2]	NM	BAND1	0.49	0.04	0.08	0.09	0.33
Petrified Forest NP	AZ	PEFO1	0.43	0.02	0.04	0.04	0.17
Rawah Wilderness	CO	MOZI1	0.83	0.01	0.09	0.09	0.14
Rocky Mountain NP	CO	ROMO1	0.89	0.01	0.06	0.06	0.12
Salt Creek	NM	SACR1	-0.22	0.01	0.01	0.01	0.03
San Pedro Parks Wilderness	NM	SAPE1	0.71	0.12	0.14	0.14	0.18
West Elk Wilderness	CO	WHRI1	0.60	0.02	0.07	0.07	0.11
Weminuche Wilderness	CO	WEMI1	0.47	0.02	0.03	0.03	0.06
Wheeler Peak Wilderness[2]	NM	BAND1	0.52	0.09	0.25	0.28	0.45
White Mountain Wilderness	NM	WHIT1	-0.23	0.00	0.00	0.00	0.02

Table 5-25a. Cumulative visibility results for B20% visibility days at Class I areas for current year (2008) and 2021 High Development Scenario using all emissions and without Source Groups R, S, T and U.

Class I Name		IMPROVE Site	2008 Base	2021 High	2021 High w/o R	2021 High w/o S	2021 High w/o T	2021 High w/o U
Arches NP	UT	CANY1	2.86	2.86	2.85	2.81	2.81	2.78
Mount Baldy Wilderness	AZ	BALD1	2.86	2.84	2.83	2.83	2.83	2.80
Bandelier NM	NM	BAND1	4.01	4.62	4.57	4.53	4.51	3.82
Black Canyon of the Gunnison NM	CO	WEMI1	2.25	2.18	2.17	2.07	2.07	2.04
Bosque del Apache	NM	BOAP1	5.50	5.42	5.42	5.42	5.42	5.41
Canyonlands NP	UT	CANY1	4.54	4.72	4.69	4.62	4.62	4.57
Capitol Reef NP	UT	CAPI1	3.33	3.43	3.41	3.37	3.36	3.33
Eagles Nest Wilderness	CO	WHRI1	0.69	0.55	0.54	0.50	0.50	0.48
Flat Tops Wilderness	CO	WHRI1	0.69	0.55	0.53	0.41	0.41	0.38
Galiuro Wilderness[1]	AZ	GICL1	2.58	2.87	2.86	2.86	2.86	2.86
Gila Wilderness	NM	CHIR1	2.58	2.89	2.89	2.89	2.89	2.89
Great Sand Dunes NM	CO	GRSA1	3.58	3.82	3.77	3.75	3.74	3.70
La Garita Wilderness	CO	WEMI1	2.25	2.29	2.27	2.26	2.26	2.22
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.69	0.53	0.51	0.49	0.49	0.47
Mesa Verde NP	CO	MEVE1	3.12	3.28	3.24	3.21	3.21	3.14
Mount Zirkel Wilderness	CO	MOZI1	0.95	0.84	0.83	0.72	0.72	0.68
Pecos Wilderness[2]	NM	PEFO1	4.54	4.65	4.60	4.57	4.56	4.21
Petrified Forest NP	AZ	BAND1	4.01	4.51	4.45	4.40	4.39	3.94
Rawah Wilderness	CO	MOZI1	0.95	0.87	0.86	0.75	0.75	0.71
Rocky Mountain NP	CO	ROMO1	1.91	1.87	1.86	1.82	1.82	1.80
Salt Creek	NM	SACR1	6.81	7.00	7.00	7.00	7.00	6.99
San Pedro Parks Wilderness	NM	SAPE1	1.28	1.32	1.18	1.16	1.16	1.11
West Elk Wilderness	CO	WHRI1	0.69	0.57	0.56	0.54	0.54	0.52
Weminuche Wilderness	CO	WEMI1	2.25	2.43	2.40	2.38	2.38	2.35
Wheeler Peak Wilderness[2]	NM	BAND1	4.01	4.37	4.21	4.04	3.97	3.75
White Mountain Wilderness	NM	WHIT1	3.33	3.32	3.32	3.32	3.32	3.29

Table 5-25b. Differences in cumulative visibility results for B20% visibility days at Class I areas between current year (2008) and 2021 High Development Scenario (2008-2021) and contributions of Source Groups R, S, T and U to 2021 W20% day's visibility.

Class I Name		IMPROVE Site	2021 High Improvement from 2008	Contribution from R	Contribution from S	Contribution from T	Contribution from U
Arches NP	UT	CANY1	0.00	0.01	0.05	0.05	0.08
Mount Baldy Wilderness	AZ	BALD1	0.02	0.01	0.01	0.01	0.04
Bandelier NM	NM	BAND1	-0.61	0.05	0.09	0.11	0.80
Black Canyon of the Gunnison NM	CO	WEMI1	0.07	0.01	0.11	0.11	0.14
Bosque del Apache	NM	BOAP1	0.08	0.00	0.00	0.00	0.01
Canyonlands NP	UT	CANY1	-0.18	0.03	0.10	0.10	0.15
Capitol Reef NP	UT	CAPI1	-0.10	0.02	0.06	0.07	0.10
Eagles Nest Wilderness	CO	WHRI1	0.14	0.01	0.05	0.05	0.07
Flat Tops Wilderness	CO	WHRI1	0.14	0.02	0.14	0.14	0.17
Galiuro Wilderness[1]	AZ	GICL1	-0.29	0.01	0.01	0.01	0.01
Gila Wilderness	NM	CHIR1	-0.31	0.00	0.00	0.00	0.00
Great Sand Dunes NM	CO	GRSA1	-0.24	0.05	0.07	0.08	0.12
La Garita Wilderness	CO	WEMI1	-0.04	0.02	0.03	0.03	0.07
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.16	0.02	0.04	0.04	0.06
Mesa Verde NP	CO	MEVE1	-0.16	0.04	0.07	0.07	0.14
Mount Zirkel Wilderness	CO	MOZI1	0.11	0.01	0.12	0.12	0.16
Pecos Wilderness[2]	NM	PEFO1	-0.11	0.05	0.08	0.09	0.44
Petrified Forest NP	AZ	BAND1	-0.50	0.06	0.11	0.12	0.57
Rawah Wilderness	CO	MOZI1	0.08	0.01	0.12	0.12	0.16
Rocky Mountain NP	CO	ROMO1	0.04	0.01	0.05	0.05	0.07
Salt Creek	NM	SACR1	-0.19	0.00	0.00	0.00	0.01
San Pedro Parks Wilderness	NM	SAPE1	-0.04	0.14	0.16	0.16	0.21
West Elk Wilderness	CO	WHRI1	0.12	0.01	0.03	0.03	0.05
Weminuche Wilderness	CO	WEMI1	-0.18	0.03	0.05	0.05	0.08
Wheeler Peak Wilderness[2]	NM	BAND1	-0.36	0.16	0.33	0.40	0.62
White Mountain Wilderness	NM	WHIT1	0.01	0.00	0.00	0.00	0.03

Table 5-26a. Cumulative visibility results for B20% visibility days at Class I areas for current year (2008) and 2021 Low Development Scenario using all emissions and without Source Groups R, S, T and U.

Class I Name		IMPROVE Site	2008 Base	2021 Low	2021 Low w/o R	2021 Low w/o S	2021 Low w/o T	2021 Low w/o U
Arches NP	UT	CANY1	2.86	2.84	2.84	2.82	2.82	2.79
Mount Baldy Wilderness	AZ	BALD1	2.86	2.83	2.83	2.83	2.83	2.80
Bandelier NM	NM	BAND1	4.01	4.58	4.56	4.54	4.53	3.83
Black Canyon of the Gunnison NM	CO	WEMI1	2.25	2.13	2.12	2.08	2.08	2.05
Bosque del Apache	NM	BOAP1	5.50	5.42	5.42	5.42	5.42	5.41
Canyonlands NP	UT	CANY1	4.54	4.69	4.67	4.64	4.64	4.59
Capitol Reef NP	UT	CAPI1	3.33	3.41	3.40	3.37	3.37	3.34
Eagles Nest Wilderness	CO	WHRI1	0.69	0.53	0.53	0.51	0.51	0.48
Flat Tops Wilderness	CO	WHRI1	0.69	0.49	0.49	0.42	0.42	0.39
Galiuro Wilderness[1]	AZ	GICL1	2.58	2.86	2.86	2.86	2.86	2.86
Gila Wilderness	NM	CHIR1	2.58	2.89	2.89	2.89	2.89	2.89
Great Sand Dunes NM	CO	GRSA1	3.58	3.80	3.77	3.76	3.75	3.70
La Garita Wilderness	CO	WEMI1	2.25	2.28	2.27	2.26	2.26	2.22
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.69	0.51	0.51	0.50	0.50	0.48
Mesa Verde NP	CO	MEVE1	3.12	3.25	3.24	3.22	3.22	3.14
Mount Zirkel Wilderness	CO	MOZI1	0.95	0.79	0.78	0.73	0.73	0.69
Pecos Wilderness[2]	NM	PEFO1	4.54	4.61	4.60	4.58	4.57	4.21
Petrified Forest NP	AZ	BAND1	4.01	4.46	4.44	4.41	4.40	3.95
Rawah Wilderness	CO	MOZI1	0.95	0.82	0.82	0.77	0.77	0.72
Rocky Mountain NP	CO	ROMO1	1.91	1.85	1.84	1.82	1.82	1.80
Salt Creek	NM	SACR1	6.81	7.00	7.00	7.00	7.00	6.99
San Pedro Parks Wilderness	NM	SAPE1	1.28	1.30	1.17	1.17	1.17	1.12
West Elk Wilderness	CO	WHRI1	0.69	0.56	0.55	0.54	0.54	0.52
Weminuche Wilderness	CO	WEMI1	2.25	2.41	2.40	2.39	2.39	2.35
Wheeler Peak Wilderness[2]	NM	BAND1	4.01	4.22	4.16	4.06	3.99	3.76
White Mountain Wilderness	NM	WHIT1	3.33	3.32	3.32	3.32	3.32	3.29

Table 5-26b. Differences in cumulative visibility results for B20% visibility days at Class I areas between current year (2008) and 2021 Low Development Scenario (2008-2021) and contributions of Source Groups R, S, T and U to 2021 W20% day's visibility.

Class I Name		IMPROVE Site	2021 Low Improvement from 2008	Contribution from R	Contribution from S	Contribution from T	Contribution from U
Arches NP	UT	CANY1	0.02	0.00	0.02	0.02	0.05
Mount Baldy Wilderness	AZ	BALD1	0.03	0.00	0.00	0.00	0.03
Bandelier NM	NM	BAND1	-0.57	0.02	0.04	0.05	0.75
Black Canyon of the Gunnison NM	CO	WEMI1	0.12	0.01	0.05	0.05	0.08
Bosque del Apache	NM	BOAP1	0.08	0.00	0.00	0.00	0.01
Canyonlands NP	UT	CANY1	-0.15	0.02	0.05	0.05	0.10
Capitol Reef NP	UT	CAPI1	-0.08	0.01	0.04	0.04	0.07
Eagles Nest Wilderness	CO	WHRI1	0.16	0.00	0.02	0.02	0.05
Flat Tops Wilderness	CO	WHRI1	0.20	0.00	0.07	0.07	0.10
Galiuro Wilderness[1]	AZ	GICL1	-0.28	0.00	0.00	0.00	0.00
Gila Wilderness	NM	CHIR1	-0.31	0.00	0.00	0.00	0.00
Great Sand Dunes NM	CO	GRSA1	-0.22	0.03	0.04	0.05	0.10
La Garita Wilderness	CO	WEMI1	-0.03	0.01	0.02	0.02	0.06
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.18	0.00	0.01	0.01	0.03
Mesa Verde NP	CO	MEVE1	-0.13	0.01	0.03	0.03	0.11
Mount Zirkel Wilderness	CO	MOZI1	0.16	0.01	0.06	0.06	0.10
Pecos Wilderness[2]	NM	PEFO1	-0.07	0.01	0.03	0.04	0.40
Petrified Forest NP	AZ	BAND1	-0.45	0.02	0.05	0.06	0.51
Rawah Wilderness	CO	MOZI1	0.13	0.00	0.05	0.05	0.10
Rocky Mountain NP	CO	ROMO1	0.06	0.01	0.03	0.03	0.05
Salt Creek	NM	SACR1	-0.19	0.00	0.00	0.00	0.01
San Pedro Parks Wilderness	NM	SAPE1	-0.02	0.13	0.13	0.13	0.18
West Elk Wilderness	CO	WHRI1	0.13	0.01	0.02	0.02	0.04
Weminuche Wilderness	CO	WEMI1	-0.16	0.01	0.02	0.02	0.06
Wheeler Peak Wilderness[2]	NM	BAND1	-0.21	0.06	0.16	0.23	0.46
White Mountain Wilderness	NM	WHIT1	0.01	0.00	0.00	0.00	0.03

Table 5-27a. Cumulative visibility results for B20% visibility days at Class I areas for current year (2008) and 2021 Medium Development Scenario using all emissions and without Source Groups R, S, T and U.

Class I Name		IMPROVE Site	2008 Base	2021 Medium	2021 Med w/o R	2021 Med w/o S	2021 Med w/o T	2021 Med w/o U
Arches NP	UT	CANY1	2.86	2.86	2.85	2.81	2.81	2.78
Mount Baldy Wilderness	AZ	BALD1	2.86	2.83	2.83	2.83	2.83	2.80
Bandelier NM	NM	BAND1	4.01	4.62	4.57	4.52	4.52	3.82
Black Canyon of the Gunnison NM	CO	WEMI1	2.25	2.18	2.17	2.07	2.07	2.04
Bosque del Apache	NM	BOAP1	5.50	5.42	5.42	5.42	5.42	5.41
Canyonlands NP	UT	CANY1	4.54	4.72	4.69	4.62	4.62	4.58
Capitol Reef NP	UT	CAPI1	3.33	3.43	3.41	3.37	3.36	3.33
Eagles Nest Wilderness	CO	WHRI1	0.69	0.55	0.54	0.50	0.50	0.48
Flat Tops Wilderness	CO	WHRI1	0.69	0.54	0.53	0.41	0.41	0.38
Galiuro Wilderness[1]	AZ	GICL1	2.58	2.87	2.86	2.86	2.86	2.86
Gila Wilderness	NM	CHIR1	2.58	2.89	2.89	2.89	2.89	2.89
Great Sand Dunes NM	CO	GRSA1	3.58	3.81	3.77	3.75	3.75	3.70
La Garita Wilderness	CO	WEMI1	2.25	2.29	2.27	2.26	2.26	2.22
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.69	0.52	0.51	0.49	0.49	0.47
Mesa Verde NP	CO	MEVE1	3.12	3.27	3.24	3.21	3.21	3.14
Mount Zirkel Wilderness	CO	MOZI1	0.95	0.83	0.83	0.72	0.72	0.68
Pecos Wilderness[2]	NM	PEFO1	4.54	4.64	4.60	4.57	4.56	4.21
Petrified Forest NP	AZ	BAND1	4.01	4.50	4.44	4.40	4.39	3.94
Rawah Wilderness	CO	MOZI1	0.95	0.87	0.86	0.75	0.75	0.71
Rocky Mountain NP	CO	ROMO1	1.91	1.87	1.86	1.82	1.82	1.80
Salt Creek	NM	SACR1	6.81	7.00	7.00	7.00	7.00	6.99
San Pedro Parks Wilderness	NM	SAPE1	1.28	1.32	1.18	1.16	1.16	1.11
West Elk Wilderness	CO	WHRI1	0.69	0.57	0.56	0.54	0.54	0.52
Weminuche Wilderness	CO	WEMI1	2.25	2.43	2.40	2.38	2.38	2.35
Wheeler Peak Wilderness[2]	NM	BAND1	4.01	4.32	4.19	4.02	3.97	3.75
White Mountain Wilderness	NM	WHIT1	3.33	3.32	3.32	3.32	3.32	3.29

Table 5-27b. Differences in cumulative visibility results for B20% visibility days at Class I areas between current year (2008) and 2021 Medium Development Scenario (2008-2021) and contributions of Source Groups R, S, T and U to 2021 W20% day's visibility.

Class I Name		IMPROVE Site	2021 Med Improvement from 2008	Contribution from R	Contribution from S	Contribution from T	Contribution from U
Arches NP	UT	CANY1	0.00	0.01	0.05	0.05	0.08
Mount Baldy Wilderness	AZ	BALD1	0.03	0.00	0.00	0.00	0.03
Bandelier NM	NM	BAND1	-0.61	0.05	0.10	0.10	0.80
Black Canyon of the Gunnison NM	CO	WEMI1	0.07	0.01	0.11	0.11	0.14
Bosque del Apache	NM	BOAP1	0.08	0.00	0.00	0.00	0.01
Canyonlands NP	UT	CANY1	-0.18	0.03	0.10	0.10	0.14
Capitol Reef NP	UT	CAPI1	-0.10	0.02	0.06	0.07	0.10
Eagles Nest Wilderness	CO	WHRI1	0.14	0.01	0.05	0.05	0.07
Flat Tops Wilderness	CO	WHRI1	0.15	0.01	0.13	0.13	0.16
Galiuro Wilderness[1]	AZ	GICL1	-0.29	0.01	0.01	0.01	0.01
Gila Wilderness	NM	CHIR1	-0.31	0.00	0.00	0.00	0.00
Great Sand Dunes NM	CO	GRSA1	-0.23	0.04	0.06	0.06	0.11
La Garita Wilderness	CO	WEMI1	-0.04	0.02	0.03	0.03	0.07
Maroon Bells-Snowmass Wilderness	CO	WHRI1	0.17	0.01	0.03	0.03	0.05
Mesa Verde NP	CO	MEVE1	-0.15	0.03	0.06	0.06	0.13
Mount Zirkel Wilderness	CO	MOZI1	0.12	0.00	0.11	0.11	0.15
Pecos Wilderness[2]	NM	PEFO1	-0.10	0.04	0.07	0.08	0.43
Petrified Forest NP	AZ	BAND1	-0.49	0.06	0.10	0.11	0.56
Rawah Wilderness	CO	MOZI1	0.08	0.01	0.12	0.12	0.16
Rocky Mountain NP	CO	ROMO1	0.04	0.01	0.05	0.05	0.07
Salt Creek	NM	SACR1	-0.19	0.00	0.00	0.00	0.01
San Pedro Parks Wilderness	NM	SAPE1	-0.04	0.14	0.16	0.16	0.21
West Elk Wilderness	CO	WHRI1	0.12	0.01	0.03	0.03	0.05
Weminuche Wilderness	CO	WEMI1	-0.18	0.03	0.05	0.05	0.08
Wheeler Peak Wilderness[2]	NM	BAND1	-0.31	0.13	0.30	0.35	0.57
White Mountain Wilderness	NM	WHIT1	0.01	0.00	0.00	0.00	0.03

5.4 Sulfur and Nitrogen Deposition at Class I and Sensitive Class II Areas

Attachments D-1, D-2 and D-3 are interactive Excel spreadsheets that display Maximum and Average sulfur and nitrogen deposition due to emissions from each of the 24 Source Groups shown in Table 4-2. As for the PSD concentrations Attachment A spreadsheet, there is a "Summary" sheet that displays the sulfur and nitrogen deposition across all Class I and sensitive Class II areas for a user selected Source Group that is controlled by a drop down menu in cell B5. And a "MaxImpact" sheet that gives the highest sulfur or nitrogen deposition that occurred at any Class I area or sensitive Class II area that is controlled by cell B3 to select Sulfur or Nitrogen and cell B4 to select either Maximum or Average. Here Maximum represents the maximum deposition in any grid cell covering the Class I/II area, whereas Average provides the average of deposition across all grid cells covering a Class I/II area. Although the convention in the past has been to report the Maximum deposition in any receptor in a Class I/II area, since deposition relates to the total amount deposited across an entire watershed, the Average metric is probably a more relevant parameter for evaluating potential environment effects. Both Maximum and Average deposition metrics are reported.

For the deposition impacts associated with Federal O&G within each of the individual BLM Planning Areas (i.e., Source Groups A through P), the sulfur and nitrogen deposition amounts are compared against the 0.005 kg/ha/yr Deposition Analysis Threshold (DAT) for the western U.S.. The DAT is a screening threshold where if a Project's deposition amount is below the DAT then its deposition impacts is considered insignificant. The deposition due to the total emission scenarios, that is Source Groups W (2021) and X (2008), are compared against the Critical Load Values, which for nitrogen is 2.2 kg/ha/yr in Wyoming and 2.3 kg/ha/yr in Colorado except for 3.0 kg/ha/yr for Dinosaur NM and for sulfur is 5.0 kg/ha/yr everywhere.

5.4.1 Highest Deposition Impacts at Class I/II Areas

Tables 5-29 through 5-31 display the highest Maximum and Average nitrogen and sulfur deposition in any Class I or sensitive Class II area due to emissions from each of the 24 Source Groups for the, respectively 2021 High, Low and Medium Development Scenarios. The results for the GJFO, UFO and USFS-PG Planning Areas are summarized in Table 5-28.

5.4.1.1 Individual BLM Planning Area Comparison to DATs

Individual BLM Planning Area (i.e., Source Groups A through P) annual nitrogen and sulfur deposition are compared against the 0.005 kg/ha/yr western U.S. Deposition Analysis Threshold (DAT). The two BLM Planning Area with Federal O&G having the highest annual nitrogen deposition impact are the TRFO and WRFO with Maximum values of 0.126 and 0.108 and Average values of 0.043 and 0.068 for the High, Maximum values of 0.106 and 0.134 and Average values of 0.036 and 0.056 for the Medium, and Maximum values of 0.015 and 0.017 and Average values of 0.005 and 0.011 for the Low Development Scenarios all of which are above the DAT (Tables 5-29 through 5-31).

Table 5-28 summarizes the Average and Maximum nitrogen and sulfur deposition results for new Federal O&G emissions from the Grand Junction Field Office (GJFO), Uncompahgre Field Office (UFO) and Pawnee Grassland (USFS-PG) Planning Areas and the 2021 High, Low and Medium Development Scenarios. For the 2021 High Development Scenario, the highest

Maximum and Average nitrogen deposition at any Class I area due to GJFO (0.0679 and 0.0416 kg/ha/yr) and UFO (0.0240 and 0.0104 kg/ha/yr) that are above the DAT. However, for USFS-PG Planning Area, its highest Maximum and Average nitrogen deposition at any Class I area is below the DAT (0.0017 and 0.0006 kg/ha/yr) for the 2021 High Development Scenario. For the 2021 Low Development Scenario, the Maximum and Average nitrogen deposition for GJFO (0.0037 and 0.0023 kg/ha/yr) are below the DAT. And for UFO the Maximum value (0.0065 kg/ha/yr) is above but the Average value (0.0027 kg/ha/yr) is below the DAT. The nitrogen deposition results for the Medium Scenario falls between the High and Low Scenarios.

The annual sulfur deposition from new Federal O&G in the BLM Planning Areas tends to be much lower than seen for the nitrogen deposition so results for just the 2021 High Development Scenario and Maximum sulfur deposition metric are presented in Table 5-32 with the other results provided in Attachments D-1, D-2 and D-3. The only individual BLM Planning Area whose new Federal O&G emissions results in its sulfur deposition exceeding the DAT is the WRFO and that is just for the Maximum (0.011 kg/ha/yr) and Average (0.008 kg/ha/yr) 2021 High Development Scenario. The Maximum (0.021 kg/ha/yr) and Average (0.008 kg/ha/yr) sulfur deposition due to WRFO for the 2021 Medium Development Scenario are also above the DAT. However, the highest WRFO sulfur deposition for the Maximum (0.002 kg/ha/yr) and Average (0.001 kg/ha/yr) metrics and the 2021 Low Development Scenario are below the DAT. The sulfur deposition results for all the other individual BLM Planning areas are below the DAT. For example, Table 5-28b displays the highest Maximum and Average sulfur deposition results at any Class I or II area due to new Federal O&G emissions from the GJFO, UFO and USFS-PG Planning Areas and all values are approximately a factor of 10 or more below the DAT.

Table 5-28a. Highest maximum and average nitrogen deposition (kg/ha/yr) at any Class I or sensitive Class II area due to new Federal oil and gas emissions from the BLM Grand Junction Field Office and Uncompahgre Field Office and the USFS Pawnee Grassland Planning Areas for the 2021 High, Low and Medium Development Scenarios.

Source Group	Class I Areas			Sensitive Class II Areas		
	Max	Avg	Area	Max	Avg	Area
2021 High Development Scenario						
GJFO	0.0679	0.0416	Maroon-B	0.0679	0.0543	Colorado NM
UFO	0.0240	0.0104	Maroon-B	0.0347	0.0151	Raggeds
USFS-PG	0.0017	0.006	Rocky Mtn	0.0013	0.0007	Mt. Evans
2021 Low Development Scenario						
GJFO	0.0037	0.0023	Maroon-B	0.0037	0.0029	Colorado NM
UFO	0.0065	0.0027	Maroon-B	0.0100	0.0400	Raggeds Gun
USFS-PG	0.0004	0.0001	Rocky Mtn	0.0003	0.0002	Mt. Evans
2021 Medium Development Scenario						
GJFO	0.0558	0.0344	Maroon-B	0.06071	0.0483	Colorado NM
UFO	0.0167	0.0076	Maroon-B	0.0241	0.0109	Raggeds Gun
USFS-PG	0.0011	0.0004	Rocky Mtn	0.0008	0.0005	Mt. Evans

Table 5-28b. Highest maximum and average sulfur deposition (kg/ha/yr) at any Class I or sensitive Class II area due to new Federal oil and gas emissions from the BLM Grand Junction Field Office and Uncompahgre Field Office and the USFS Pawnee Grassland Planning Areas for the 2021 High, Low and Medium Development Scenarios.

Source Group	Class I Areas			Sensitive Class II Areas		
	Max	Avg	Area	Max	Avg	Area
2021 High Development Scenario						
GJFO	0.0006	0.0004	Maroon-B	0.0005	0.0003	Raggeds
UFO	0.0004	0.0002	Maroon-B	0.0008	0.0003	Raggeds
USFS-PG	0.0000	0.0000	Rocky Mtn	0.0000	0.0000	Lost Creek
2021 Low Development Scenario						
GJFO	0.0001	0.0000	Maroon-B	0.0000	0.0000	Raggeds
UFO	0.0001	0.0001	Maroon-B	0.0002	0.0001	Raggeds
USFS-PG	0.0000	0.0000	Rocky Mtn	0.0000	0.0000	Lost Creek
2021 Medium Development Scenario						
GJFO	0.0005	0.0003	Maroon-B	0.0004	0.0002	Raggeds
UFO	0.0003	0.0001	Maroon-B	0.0006	0.0002	Raggeds
USFS-PG	0.0000	0.0000	Rocky Mtn	0.0000	0.0000	Lost Creek

Table 5-29a. Highest nitrogen deposition at any Class I area or sensitive Class II area for each of the 24 Source Groups and the 2021 High Development Scenario using the Maximum deposition in any receptor in the Class I/II area.

Choose	Nitrogen				
Across grid cells	Maximum				
Group	Group Name	Max @ any Class I area	Class I Area where Max occurred	Max @ any Class II area	Class II Area where Max occurred
A	Little Snake FO	0.0169	Mount_Zirkel	0.0136	Dinosaur_all
B	White River FO	0.1083	Flat_Tops	0.1418	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.0198	Flat_Tops	0.0118	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	0.0200	Flat_Tops	0.0107	Holy_Cross
E	Grand Junction FO	0.0679	Maroon_Bells	0.0679	Colorado
F	Uncompahgre FO	0.0240	Maroon_Bells	0.0347	Raggeds
G	Tres Rios FO	0.1256	Mesa_Verde	0.1448	South_San_Juan
H	Kremmling FO	0.0065	Rawah	0.0022	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0004	Rocky_Mountain	0.0003	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	0.0017	Rocky_Mountain	0.0013	Mount_Evans
K	RGFO#2 – West-Central/South	0.0005	Pecos	0.0008	Las_Vegas_NWR
L	RGFO#3 – South	0.0017	Great_Sand_Dunes	0.0272	Greenhorn_Mounta
M	RGFO#4 – East-Central	0.0002	Eagles_Nest	0.0028	Lost_Creek
N	New Mexico Farmington District	0.0371	Weminuche	0.1607	Aztec_Ruins
O	Total Colorado River Field Office	0.0398	Flat_Tops	0.0225	Holy_Cross
P	Total Royal Gorge Field Office	0.0024	Rocky_Mountain	0.0279	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.0086	Mount_Zirkel	0.0062	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.2120	Flat_Tops	0.1762	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	0.3660	Flat_Tops	0.3388	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	0.3680	Flat_Tops	0.3746	South_San_Juan
U	Combined O&G and Mining in 4 km domain	0.5946	Mesa_Verde	1.9374	Aztec_Ruins
V	Natural Emissions	6.6543	Bandelier	1.4498	Chama_River_Cany
W	All 2021 Emissions	8.4676	Bandelier	11.2607	Valle_De_Oro_NWR
X	All 2008 Emissions	9.0012	Bandelier	12.6927	Bitter_Lake_NWR

Table 5-29b. Highest nitrogen deposition at any Class I area or sensitive Class II area for each of the 24 Source Groups and the 2021 High Development Scenario using the Average deposition in any receptor in the Class I/II area.

Choose	Nitrogen				
Across grid cells	Average				
Group	Group Name	Max @ any Class I area	Class I Area where Max occurred	Max @ any Class II area	Class II Area where Max occurred
A	Little Snake FO	0.0133	Mount_Zirkel	0.0079	Savage_Run
B	White River FO	0.0680	Flat_Tops	0.0390	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.0120	Flat_Tops	0.0082	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	0.0120	Flat_Tops	0.0075	Holy_Cross
E	Grand Junction FO	0.0416	Maroon_Bells	0.0543	Colorado
F	Uncompahgre FO	0.0104	Maroon_Bells	0.0151	Raggeds
G	Tres Rios FO	0.0428	Mesa_Verde	0.0466	Hovenweep
H	Kremmling FO	0.0031	Rawah	0.0015	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0001	Rocky_Mountain	0.0002	Lost_Creek
J	Pawnee Grasslands portion of RGFO#1	0.0006	Rocky_Mountain	0.0007	Lost_Creek
K	RGFO#2 – West-Central/South	0.0003	Salt_Creek	0.0006	Maxwell_NWR
L	RGFO#3 – South	0.0011	Great_Sand_Dunes	0.0133	Greenhorn_Mounta
M	RGFO#4 – East-Central	0.0001	Eagles_Nest	0.0017	Lost_Creek
N	New Mexico Farmington District	0.0242	Mesa_Verde	0.1501	Aztec_Ruins
O	Total Colorado River Field Office	0.0241	Flat_Tops	0.0157	Holy_Cross
P	Total Royal Gorge Field Office	0.0014	Great_Sand_Dunes	0.0147	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.0051	Mount_Zirkel	0.0050	Colorado
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.1454	Flat_Tops	0.1160	Colorado
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	0.2550	Flat_Tops	0.2191	Colorado
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	0.2566	Flat_Tops	0.2552	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	0.4902	Mesa_Verde	1.9175	Aztec_Ruins
V	Natural Emissions	0.7876	Bandelier	0.4469	Dome
W	All 2021 Emissions	3.1160	Mount_Zirkel	8.8528	Valle_De_Oro_NWR
X	All 2008 Emissions	5.3938	Salt_Creek	10.0402	Valle_De_Oro_NWR

Table 5-30a. Highest nitrogen deposition at any Class I area or sensitive Class II area for each of the 24 Source Groups and the 2021 Low Development Scenario using the Maximum deposition in any receptor in the Class I/II area.

Choose	Nitrogen				
Across grid cells	Maximum				
Group	**Group Name**	**Max @ any Class I area**	**Class I Area where Max occurred**	**Max @ any Class II area**	**Class II Area where Max occurred**
A	Little Snake FO	0.0023	Mount_Zirkel	0.0018	Dinosaur_all
B	White River FO	0.0169	Flat_Tops	0.0228	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.0122	Flat_Tops	0.0072	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	0.0101	Flat_Tops	0.0053	Holy_Cross
E	Grand Junction FO	0.0037	Maroon_Bells	0.0037	Colorado
F	Uncompahgre FO	0.0065	Maroon_Bells	0.0100	Raggeds
G	Tres Rios FO	0.0153	Mesa_Verde	0.0182	South_San_Juan
H	Kremmling FO	0.0007	Rawah	0.0002	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0001	Rocky_Mountain	0.0001	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	0.0004	Rocky_Mountain	0.0003	Mount_Evans
K	RGFO#2 – West-Central/South	0.0000	Pecos	0.0001	Las_Vegas_NWR
L	RGFO#3 – South	0.0011	Great_Sand_Dunes	0.0169	Greenhorn_Mounta
M	RGFO#4 – East-Central	0.0000	Eagles_Nest	0.0004	Lost_Creek
N	New Mexico Farmington District	0.0371	Weminuche	0.1605	Aztec_Ruins
O	Total Colorado River Field Office	0.0223	Flat_Tops	0.0125	Holy_Cross
P	Total Royal Gorge Field Office	0.0011	Great_Sand_Dunes	0.0170	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.0085	Mount_Zirkel	0.0061	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.0434	Flat_Tops	0.0315	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	0.2000	Mesa_Verde	0.2128	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	0.2156	Mesa_Verde	0.2487	South_San_Juan
U	Combined O&G and Mining in 4 km domain	0.5434	Mesa_Verde	1.9167	Aztec_Ruins
V	Natural Emissions	6.6543	Bandelier	1.4498	Chama_River_Cany
W	All 2021 Emissions	8.4513	Bandelier	11.2549	Valle_De_Oro_NWR
X	All 2008 Emissions	9.0012	Bandelier	12.6927	Bitter_Lake_NWR

Table 5-30b. Highest nitrogen deposition at any Class I area or sensitive Class II area for each of the 24 Source Groups and the 2021 Low Development Scenario using the Average deposition in any receptor in the Class I/II area.

Choose	Nitrogen
Across grid cells	Average

Group	Group Name	Max @ any Class I area	Class I Area where Max occurred	Max @ any Class II area	Class II Area where Max occurred
A	Little Snake FO	0.0018	Mount_Zirkel	0.0011	Savage_Run
B	White River FO	0.0107	Flat_Tops	0.0061	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.0074	Flat_Tops	0.0050	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	0.0060	Flat_Tops	0.0037	Holy_Cross
E	Grand Junction FO	0.0023	Flat_Tops	0.0029	Colorado
F	Uncompahgre FO	0.0027	Maroon_Bells	0.0040	Raggeds
G	Tres Rios FO	0.0052	Mesa_Verde	0.0056	Hovenweep
H	Kremmling FO	0.0003	Rawah	0.0002	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0000	Rocky_Mountain	0.0000	Lost_Creek
J	Pawnee Grasslands portion of RGFO#1	0.0001	Rocky_Mountain	0.0002	Lost_Creek
K	RGFO#2 – West-Central/South	0.0000	Salt_Creek	0.0001	Maxwell_NWR
L	RGFO#3 – South	0.0007	Great_Sand_Dunes	0.0083	Greenhorn_Mounta
M	RGFO#4 – East-Central	0.0000	Eagles_Nest	0.0002	Lost_Creek
N	New Mexico Farmington District	0.0242	Mesa_Verde	0.1499	Aztec_Ruins
O	Total Colorado River Field Office	0.0134	Flat_Tops	0.0087	Holy_Cross
P	Total Royal Gorge Field Office	0.0007	Great_Sand_Dunes	0.0085	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.0051	Mount_Zirkel	0.0049	Colorado
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.0303	Flat_Tops	0.0216	Raggeds
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	0.0841	Flat_Tops	0.0973	Hovenweep
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	0.1058	Mesa_Verde	0.2348	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	0.4345	Mesa_Verde	1.8948	Aztec_Ruins
V	Natural Emissions	0.7876	Bandelier	0.4469	Dome
W	All 2021 Emissions	2.9682	Mount_Zirkel	8.8463	Valle_De_Oro_NWR
X	All 2008 Emissions	5.3938	Salt_Creek	10.0402	Valle_De_Oro_NWR

Table 5-31a. Highest nitrogen deposition at any Class I area or sensitive Class II area for each of the 24 Source Groups and the 2021 Medium Development Scenario using the Maximum deposition in any receptor in the Class I/II area.

Choose	Nitrogen				
Across grid cells	Maximum				

Group	Group Name	Max @ any Class I area	Class I Area where Max occurred	Max @ any Class II area	Class II Area where Max occurred
A	Little Snake FO	0.0153	Mount_Zirkel	0.0118	Dinosaur_all
B	White River FO	0.1343	Dinosaur_CO	0.1343	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.0156	Flat_Tops	0.0097	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	0.0163	Flat_Tops	0.0089	Holy_Cross
E	Grand Junction FO	0.0558	Maroon_Bells	0.0607	Colorado
F	Uncompahgre FO	0.0167	Maroon_Bells	0.0241	Raggeds
G	Tres Rios FO	0.1062	Mesa_Verde	0.1230	South_San_Juan
H	Kremmling FO	0.0040	Rawah	0.0015	Mount_Evans
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0003	Rocky_Mountain	0.0002	Mount_Evans
J	Pawnee Grasslands portion of RGFO#1	0.0011	Rocky_Mountain	0.0008	Mount_Evans
K	RGFO#2 – West-Central/South	0.0004	Pecos	0.0006	Las_Vegas_NWR
L	RGFO#3 – South	0.0012	Great_Sand_Dunes	0.0190	Greenhorn_Mounta
M	RGFO#4 – East-Central	0.0001	Eagles_Nest	0.0016	Lost_Creek
N	New Mexico Farmington District	0.0285	Weminuche	0.1236	Aztec_Ruins
O	Total Colorado River Field Office	0.0320	Flat_Tops	0.0186	Holy_Cross
P	Total Royal Gorge Field Office	0.0015	Rocky_Mountain	0.0195	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.0086	Mount_Zirkel	0.0062	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.1739	Flat_Tops	0.1639	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	0.3200	Flat_Tops	0.3105	South_San_Juan
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	0.3216	Flat_Tops	0.3380	South_San_Juan
U	Combined O&G and Mining in 4 km domain	0.6433	Dinosaur_CO	1.8955	Aztec_Ruins
V	Natural Emissions	6.6543	Bandelier	1.4498	Chama_River_Cany
W	All 2021 Emissions	8.4636	Bandelier	11.2595	Valle_De_Oro_NWR
X	All 2008 Emissions	9.0012	Bandelier	12.6927	Bitter_Lake_NWR

Table 5-31b. Highest nitrogen deposition at any Class I area or sensitive Class II area for each of the 24 Source Groups and the 2021 Medium Development Scenario using the Average deposition in any receptor in the Class I/II area.

Choose	Nitrogen				
Across grid cells	Average				

Group	Group Name	Max @ any Class I area	Class I Area where Max occurred	Max @ any Class II area	Class II Area where Max occurred
A	Little Snake FO	0.0120	Mount_Zirkel	0.0070	Savage_Run
B	White River FO	0.0559	Flat_Tops	0.0374	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.0095	Flat_Tops	0.0068	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	0.0098	Flat_Tops	0.0062	Holy_Cross
E	Grand Junction FO	0.0344	Maroon_Bells	0.0483	Colorado
F	Uncompahgre FO	0.0076	Maroon_Bells	0.0109	Raggeds
G	Tres Rios FO	0.0363	Mesa_Verde	0.0396	Hovenweep
H	Kremmling FO	0.0020	Rawah	0.0010	Mount_Evans
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0001	Rocky_Mountain	0.0001	Lost_Creek
J	Pawnee Grasslands portion of RGFO#1	0.0004	Rocky_Mountain	0.0005	Lost_Creek
K	RGFO#2 – West-Central/South	0.0003	Salt_Creek	0.0004	Maxwell_NWR
L	RGFO#3 – South	0.0008	Great_Sand_Dunes	0.0093	Greenhorn_Mounta
M	RGFO#4 – East-Central	0.0000	Eagles_Nest	0.0009	Lost_Creek
N	New Mexico Farmington District	0.0185	Mesa_Verde	0.1154	Aztec_Ruins
O	Total Colorado River Field Office	0.0193	Flat_Tops	0.0129	Holy_Cross
P	Total Royal Gorge Field Office	0.0010	Great_Sand_Dunes	0.0102	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.0051	Mount_Zirkel	0.0050	Colorado
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.1199	Flat_Tops	0.1027	Colorado
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	0.2240	Flat_Tops	0.2027	Colorado
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	0.2253	Flat_Tops	0.2145	Aztec_Ruins
U	Combined O&G and Mining in 4 km domain	0.4729	Mesa_Verde	1.8770	Aztec_Ruins
V	Natural Emissions	0.7876	Bandelier	0.4469	Dome
W	All 2021 Emissions	3.0955	Mount_Zirkel	8.8515	Valle_De_Oro_NWR
X	All 2008 Emissions	5.3938	Salt_Creek	10.0402	Valle_De_Oro_NWR

Table 5-32. Highest sulfur deposition at any Class I area or sensitive Class II area for each of the 24 Source Groups and the 2021 High Development Scenario using the Maximum deposition in any receptor in the Class I/II area.

Choose	Sulfur				
Across grid cells	Maximum				
Group	Group Name	Max @ any Class I area	Class I Area where Max occurred	Max @ any Class II area	Class II Area where Max occurred
A	Little Snake FO	0.0003	Mount_Zirkel	0.0001	Savage_Run
B	White River FO	0.0111	Flat_Tops	0.0212	Dinosaur_all
C	Colorado River Valley FO (CRVFO)	0.0003	Flat_Tops	0.0001	Holy_Cross
D	Roan Plateau Planning area portion of CRVFO	0.0002	Flat_Tops	0.0001	Holy_Cross
E	Grand Junction FO	0.0006	Maroon_Bells	0.0005	Raggeds
F	Uncompahgre FO	0.0004	Maroon_Bells	0.0008	Raggeds
G	Tres Rios FO	0.0006	Mesa_Verde	0.0012	South_San_Juan
H	Kremmling FO	0.0001	Rawah	0.0000	Savage_Run
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0000	Rocky_Mountain	0.0000	Lost_Creek
J	Pawnee Grasslands portion of RGFO#1	0.0000	Rocky_Mountain	0.0000	Lost_Creek
K	RGFO#2 – West-Central/South	0.0000	Pecos	0.0000	Greenhorn_Mounta
L	RGFO#3 – South	0.0000	Great_Sand_Dunes	0.0001	Greenhorn_Mounta
M	RGFO#4 – East-Central	0.0000	Eagles_Nest	0.0000	Lost_Creek
N	New Mexico Farmington District	0.0009	Weminuche	0.0019	Aztec_Ruins
O	Total Colorado River Field Office	0.0004	Flat_Tops	0.0002	Holy_Cross
P	Total Royal Gorge Field Office	0.0000	Rocky_Mountain	0.0001	Greenhorn_Mounta
Q	Mining from 13 Colorado BLM Planning Areas	0.0235	Mount_Zirkel	0.0078	Raggeds
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.0323	Mount_Zirkel	0.0229	Dinosaur_all
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	0.0345	Mount_Zirkel	0.0259	Dinosaur_all
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	0.0345	Mount_Zirkel	0.0260	Dinosaur_all
U	Combined O&G and Mining in 4 km domain	0.0411	Mount_Zirkel	0.0300	Dinosaur_all
V	Natural Emissions	0.1642	Bandelier	0.0497	Dome
W	All 2021 Emissions	1.7369	Mount_Baldy	1.4079	South_San_Juan
X	All 2008 Emissions	2.3428	Mount_Zirkel	2.1000	South_San_Juan

5.4.1.2 Comparisons Against Critical Loads

In this section we compare the total sulfur and nitrogen deposition from all sources in the 2008 Base Case and 2021 High, Low and Medium Development Scenarios with Critical Load values. It is unclear what the sulfur and nitrogen for the combined Source Groups Q through U should be compared against given that the DAT and Critical Load LOCs were designed for single Projects and total emissions, respectively. The total nitrogen and sulfur deposition amounts for the combined Source Groups Q through U are much lower than the Critical Load values (Attachments D-1, D-2 and D-3).

Tables 5-33 and 5-34 display the total nitrogen and sulfur deposition, respectively, at Class I areas for the 2021 High, Low and Medium Development Scenarios, the 2008 Base Case, the differences between the three2021 scenarios and the 2008 Base Case (2021 minus 2008) and the difference between the three 2021 scenarios and the natural emissions (Source Group V). As seen in Table 5-29a the Class I area with the highest Maximum nitrogen deposition in the 2021 High Development Scenario is 8.47 kg/ha/yr at the Bandelier Class I area in New Mexico that is over 3 times the nitrogen Critical Load value (2.3 kg/ha/yr). However, most of this (6.65 kg/ha/yr) is due to natural emissions (Source Group V in Table 5-29a) and when natural emission contributions are removed the value at Bandelier for the 2021 scenarios (1.80-1.81

kg/ha/yr) is reduced to below the nitrogen Critical Load value (2.3 kg/ha/yr) (Table 5-33). When removing natural emission contributions the Maximum nitrogen deposition exceeds the 2.3 kg/ha/yr Critical Load value at approximately half (14) of the 26 Class I areas for all three 2021 emission scenarios with the highest value of 4.23, 4.04 and 4.20 kg/ha/yr at the Mount Zirkel Wilderness Area and the 2021 High, Low and Medium Development Scenarios, respectively. When examining the Average annual nitrogen deposition across Class I areas, approximately a quarter of the Class I areas exceed the 2.3 kg/ha/yr nitrogen Critical Load value for the 2021 emission scenarios..

With one exception, all 26 Class I areas exhibit a reduction in annual nitrogen deposition from 2008 to 2021 with the largest reduction occurring at Salt Creek (-5.5 kg/ha/yr) and the second largest reduction occurring at Bosque del Apache (-2.6 kg/ha/yr). The exception is the Great Sand Dunes NM that saw essentially no change in nitrogen deposition between 2008 and 2021 for the three 2021 emissions scenarios (changes of -0.02 to +0.07 kg/ha/yr).

The total sulfur deposition at all of the Class I areas for the 2008 and three 2021 emission scenarios are all well below the sulfur Critical Load of 5 kg/ha/yr (Table 5-34). Sulfur deposition is reduced by 5% to 50% across the Class I areas between the 2008 and 2021 emissions scenarios. The highest sulfur deposition at any Class I area for the three 2021 emission scenarios is 1.7 kg/ha/yr at Mt. Baldy that is approximately a factor of three below the sulfur deposition Critical Load (5.0 kg/ha/yr) (Table 5-34).

Additional results, including those for sensitive Class II areas and all Source Groups, are found in Attachments D-1, D-2 and D-3.

Table 5-33a. Total annual nitrogen deposition at Class I areas for the 2021 High Development Scenario, 2008 Base Case, their differences (2021 High minus 2008) and 2021 High Development Scenario without the contributions of natural emissions (e.g., wildfires).

Class I Area	2021 High N-Max (kg/ha)	2021 High N-Avg (kg/ha)	2008 Base N-Max (kg/ha)	2008 Base N-Avg (kg/ha)	2021 High - 2008 N-Max (kg/ha)	2021 High - 2008 N-Avg (kg/ha)	2021 Hi - Natural N-Max (kg/ha)	2021 Hi - Natural N-Avg (kg/ha)
Arches NP	1.67	1.56	2.20	1.81	-0.53	-0.25	1.64	1.52
Bandelier NM	8.47	2.51	9.00	2.96	-0.53	-0.45	1.81	1.72
Black Canyon NP	2.85	2.30	2.99	2.57	-0.14	-0.27	2.79	2.25
Bosque del Apache WA	2.49	1.64	5.08	2.46	-2.60	-0.82	2.26	1.51
Canyonlands NP	1.89	1.43	2.31	1.77	-0.42	-0.34	1.84	1.39
Capitol Reef NP	3.22	1.54	3.37	1.90	-0.15	-0.36	3.20	1.52
Eagles Nest WA	2.79	2.08	3.59	2.94	-0.79	-0.85	2.73	2.03
Flat Tops WA	3.00	2.39	3.71	3.09	-0.71	-0.70	2.90	2.34
Galiuro WA	2.39	2.29	2.97	2.83	-0.57	-0.54	2.38	2.28
Gila WA	2.07	1.36	2.69	1.68	-0.63	-0.31	1.98	1.31
Great Sand Dunes NM	2.77	1.97	2.70	1.95	0.07	0.02	2.66	1.89
La Garita WA	1.97	1.55	2.75	2.11	-0.78	-0.56	1.88	1.48
Maroon Bells-Snowmass	3.01	2.18	3.81	2.94	-0.80	-0.77	2.93	2.12
Mesa Verde NP	2.92	2.53	3.14	2.76	-0.21	-0.22	2.86	2.47
Mount Baldy WA	2.38	1.94	3.24	2.69	-0.86	-0.75	2.05	1.70
Mount Zirkel WA	4.29	3.12	5.13	3.95	-0.84	-0.84	4.23	3.07
Pecos WA	2.98	2.27	3.95	2.99	-0.97	-0.72	2.19	2.09
Petrified Forest NP	2.04	1.72	2.66	2.16	-0.62	-0.44	1.99	1.68
Rawah WA	3.23	2.51	4.07	3.27	-0.84	-0.76	3.14	2.45
Rocky Mountain NP	3.41	2.58	4.49	3.50	-1.08	-0.92	3.31	2.51
Salt Creek WA	2.70	2.43	8.21	5.39	-5.51	-2.96	2.64	2.38
San Pedro Parks WA	2.70	2.33	3.36	2.93	-0.67	-0.60	2.25	2.15
Weminuche WA	3.03	2.14	3.80	2.84	-0.78	-0.70	2.89	2.06
West Elk WA	2.58	1.98	3.34	2.63	-0.76	-0.66	2.27	1.91
Wheeler Peak WA	3.10	2.55	4.11	3.44	-1.02	-0.88	2.90	2.41
White Mountain WA	3.09	2.42	3.73	2.85	-0.65	-0.42	2.57	2.14

Table 5-33b. Total annual nitrogen deposition at Class I areas for the 2021 Low Development Scenario, 2008 Base Case, their differences (2021 Low minus 2008) and 2021 Low Development Scenario without the contributions of natural emissions (e.g., wildfires).

Class I Area	2021 Low		2008 Base		2021 Low - 2008		2021 Low - Natural	
	N-Max (kg/ha)	N-Avg (kg/ha)	N-Max (kg/ha)	N-Avg (kg/ha)	N-Max (kg/ha)	N-Avg (kg/ha)	N-Max (kg/ha)	N-Avg (kg/ha)
Arches NP	1.59	1.48	2.20	1.81	-0.62	-0.33	1.55	1.44
Bandelier NM	8.45	2.49	9.00	2.96	-0.55	-0.47	1.80	1.70
Black Canyon NP	2.72	2.19	2.99	2.57	-0.26	-0.38	2.67	2.14
Bosque del Apache WA	2.48	1.63	5.08	2.46	-2.60	-0.83	2.26	1.51
Canyonlands NP	1.86	1.40	2.31	1.77	-0.45	-0.37	1.81	1.37
Capitol Reef NP	3.22	1.54	3.37	1.90	-0.15	-0.37	3.19	1.52
Eagles Nest WA	2.61	1.95	3.59	2.94	-0.98	-0.99	2.54	1.90
Flat Tops WA	2.75	2.20	3.71	3.09	-0.96	-0.89	2.66	2.15
Galiuro WA	2.39	2.29	2.97	2.83	-0.58	-0.55	2.38	2.28
Gila WA	2.06	1.36	2.69	1.68	-0.63	-0.31	1.98	1.31
Great Sand Dunes NM	2.72	1.93	2.70	1.95	0.02	-0.02	2.62	1.86
La Garita WA	1.91	1.51	2.75	2.11	-0.83	-0.60	1.82	1.44
Maroon Bells-Snowmass	2.82	2.02	3.81	2.94	-0.99	-0.92	2.73	1.97
Mesa Verde NP	2.86	2.47	3.14	2.76	-0.27	-0.28	2.80	2.41
Mount Baldy WA	2.37	1.94	3.24	2.69	-0.86	-0.75	2.05	1.69
Mount Zirkel WA	4.10	2.97	5.13	3.95	-1.03	-0.98	4.04	2.92
Pecos WA	2.96	2.25	3.95	2.99	-0.99	-0.74	2.17	2.07
Petrified Forest NP	2.03	1.72	2.66	2.16	-0.63	-0.44	1.98	1.67
Rawah WA	3.09	2.39	4.07	3.27	-0.98	-0.88	3.00	2.33
Rocky Mountain NP	3.22	2.44	4.49	3.50	-1.26	-1.06	3.12	2.37
Salt Creek WA	2.69	2.42	8.21	5.39	-5.52	-2.97	2.63	2.37
San Pedro Parks WA	2.68	2.31	3.36	2.93	-0.69	-0.62	2.23	2.13
Weminuche WA	3.00	2.11	3.80	2.84	-0.81	-0.73	2.86	2.03
West Elk WA	2.44	1.87	3.34	2.63	-0.90	-0.76	2.13	1.80
Wheeler Peak WA	3.06	2.52	4.11	3.44	-1.05	-0.91	2.87	2.38
White Mountain WA	3.08	2.42	3.73	2.85	-0.65	-0.43	2.56	2.14

Table 5-33c. Total annual nitrogen deposition at Class I areas for the 2021 Medium Development Scenario, 2008 Base Case, their differences (2021 Medium minus 2008) and 2021 Medium Development Scenario without the contributions of natural emissions (e.g., wildfires).

	2021 High		2008 Base		2021 High - 2008		2021 Hi - Natural	
Class I Area	N-Max (kg/ha)	N-Avg (kg/ha)	N-Max (kg/ha)	N-Avg (kg/ha)	N-Max (kg/ha)	N-Avg (kg/ha)	N-Max (kg/ha)	N-Avg (kg/ha)
Arches NP	1.67	1.55	2.20	1.81	-0.54	-0.26	1.63	1.52
Bandelier NM	8.46	2.50	9.00	2.96	-0.54	-0.46	1.81	1.72
Black Canyon NP	2.83	2.29	2.99	2.57	-0.16	-0.29	2.78	2.23
Bosque del Apache WA	2.49	1.64	5.08	2.46	-2.60	-0.83	2.26	1.51
Canyonlands NP	1.89	1.43	2.31	1.77	-0.42	-0.35	1.83	1.39
Capitol Reef NP	3.22	1.54	3.37	1.90	-0.15	-0.36	3.20	1.52
Eagles Nest WA	2.76	2.06	3.59	2.94	-0.83	-0.88	2.70	2.01
Flat Tops WA	2.95	2.35	3.71	3.09	-0.75	-0.73	2.86	2.31
Galiuro WA	2.39	2.29	2.97	2.83	-0.57	-0.54	2.38	2.28
Gila WA	2.07	1.36	2.69	1.68	-0.63	-0.31	1.98	1.31
Great Sand Dunes NM	2.76	1.96	2.70	1.95	0.06	0.01	2.66	1.89
La Garita WA	1.96	1.54	2.75	2.11	-0.79	-0.57	1.87	1.47
Maroon Bells-Snowmass	2.98	2.15	3.81	2.94	-0.84	-0.79	2.89	2.09
Mesa Verde NP	2.90	2.51	3.14	2.76	-0.23	-0.24	2.84	2.46
Mount Baldy WA	2.38	1.94	3.24	2.69	-0.86	-0.75	2.05	1.69
Mount Zirkel WA	4.27	3.10	5.13	3.95	-0.86	-0.86	4.20	3.05
Pecos WA	2.98	2.27	3.95	2.99	-0.97	-0.72	2.19	2.08
Petrified Forest NP	2.04	1.72	2.66	2.16	-0.62	-0.44	1.98	1.68
Rawah WA	3.21	2.49	4.07	3.27	-0.86	-0.78	3.12	2.43
Rocky Mountain NP	3.39	2.56	4.49	3.50	-1.10	-0.93	3.29	2.49
Salt Creek WA	2.69	2.43	8.21	5.39	-5.52	-2.97	2.64	2.38
San Pedro Parks WA	2.69	2.33	3.36	2.93	-0.67	-0.61	2.24	2.14
Weminuche WA	3.01	2.13	3.80	2.84	-0.79	-0.71	2.88	2.05
West Elk WA	2.56	1.96	3.34	2.63	-0.78	-0.67	2.25	1.89
Wheeler Peak WA	3.09	2.55	4.11	3.44	-1.03	-0.89	2.89	2.40
White Mountain WA	3.09	2.42	3.73	2.85	-0.65	-0.42	2.57	2.14

Table 5-34a. Total annual sulfur deposition at Class I areas for the 2021 High Development Scenario, 2008 Base Case, their differences (2021 High minus 2008) and 2021 High Development Scenario without the contributions of natural emissions (e.g., wildfires).

Class I Area	2021 High		2008 Base		2021 High - 2008		2021 Hi - Natural	
	S-Max (kg/ha)	S-Avg (kg/ha)	S-Max (kg/ha)	S-Avg (kg/ha)	S-Max (kg/ha)	S-Avg (kg/ha)	S-Max (kg/ha)	S-Avg (kg/ha)
Arches NP	0.22	0.20	0.36	0.33	-0.14	-0.13	0.22	0.22
Bandelier NM	0.77	0.47	1.12	0.71	-0.34	-0.24	0.61	0.77
Black Canyon NP	0.36	0.31	0.62	0.53	-0.26	-0.22	0.36	0.36
Bosque del Apache WA	0.38	0.35	0.41	0.36	-0.03	-0.02	0.38	0.38
Canyonlands NP	0.35	0.22	0.60	0.35	-0.25	-0.13	0.35	0.35
Capitol Reef NP	0.40	0.22	0.55	0.33	-0.15	-0.11	0.40	0.40
Eagles Nest WA	0.92	0.56	1.56	1.10	-0.64	-0.54	0.92	0.92
Flat Tops WA	1.04	0.71	1.72	1.33	-0.69	-0.61	1.04	1.04
Galiuro WA	1.31	1.17	1.12	1.02	0.19	0.15	1.31	1.31
Gila WA	1.32	0.58	1.61	0.72	-0.29	-0.13	1.32	1.32
Great Sand Dunes NM	0.57	0.33	0.94	0.56	-0.38	-0.23	0.57	0.57
La Garita WA	0.67	0.43	1.25	0.88	-0.58	-0.45	0.67	0.67
Maroon Bells-Snowmass	1.14	0.70	1.86	1.33	-0.71	-0.64	1.14	1.14
Mesa Verde NP	0.58	0.49	0.91	0.80	-0.33	-0.32	0.58	0.58
Mount Baldy WA	1.74	1.13	2.06	1.52	-0.33	-0.38	1.72	1.74
Mount Zirkel WA	1.48	0.93	2.34	1.73	-0.86	-0.80	1.48	1.48
Pecos WA	1.42	0.83	1.95	1.30	-0.53	-0.46	1.40	1.42
Petrified Forest NP	0.58	0.47	0.80	0.68	-0.22	-0.21	0.58	0.58
Rawah WA	1.01	0.65	1.77	1.29	-0.77	-0.64	1.00	1.01
Rocky Mountain NP	1.11	0.68	1.91	1.35	-0.80	-0.66	1.11	1.11
Salt Creek WA	0.69	0.61	0.73	0.66	-0.04	-0.05	0.69	0.69
San Pedro Parks WA	1.11	0.77	1.61	1.24	-0.51	-0.47	1.10	1.11
Weminuche WA	1.50	0.80	2.06	1.36	-0.56	-0.56	1.50	1.50
West Elk WA	0.90	0.53	1.48	1.01	-0.58	-0.48	0.89	0.90
Wheeler Peak WA	1.54	1.07	2.23	1.66	-0.69	-0.59	1.53	1.54
White Mountain WA	1.61	0.97	1.85	1.11	-0.24	-0.14	1.59	1.61

Table 5-34b. Total annual sulfur deposition at Class I areas for the 2021 Low Development Scenario, 2008 Base Case, their differences (2021 Low minus 2008) and 2021 Low Development Scenario without the contributions of natural emissions (e.g., wildfires).

	2021 Low		2008 Base		2021 Low - 2008		2021 Low - Natural	
Class I Area	S-Max (kg/ha)	S-Avg (kg/ha)	S-Max (kg/ha)	S-Avg (kg/ha)	S-Max (kg/ha)	S-Avg (kg/ha)	S-Max (kg/ha)	S-Avg (kg/ha)
Arches NP	0.22	0.20	0.36	0.33	-0.15	-0.13	0.22	0.20
Bandelier NM	0.77	0.47	1.12	0.71	-0.34	-0.24	0.61	0.45
Black Canyon NP	0.36	0.31	0.62	0.53	-0.26	-0.22	0.36	0.31
Bosque del Apache WA	0.38	0.35	0.41	0.36	-0.03	-0.02	0.38	0.35
Canyonlands NP	0.35	0.22	0.60	0.35	-0.25	-0.13	0.35	0.22
Capitol Reef NP	0.40	0.22	0.55	0.33	-0.15	-0.11	0.40	0.22
Eagles Nest WA	0.92	0.56	1.56	1.10	-0.64	-0.54	0.92	0.56
Flat Tops WA	1.03	0.71	1.72	1.33	-0.69	-0.62	1.03	0.71
Galiuro WA	1.31	1.17	1.12	1.02	0.19	0.15	1.31	1.17
Gila WA	1.32	0.58	1.61	0.72	-0.29	-0.13	1.32	0.58
Great Sand Dunes NM	0.57	0.33	0.94	0.56	-0.38	-0.23	0.57	0.33
La Garita WA	0.67	0.43	1.25	0.88	-0.58	-0.45	0.67	0.43
Maroon Bells-Snowmass	1.14	0.69	1.86	1.33	-0.72	-0.64	1.14	0.69
Mesa Verde NP	0.58	0.49	0.91	0.80	-0.33	-0.32	0.58	0.49
Mount Baldy WA	1.74	1.13	2.06	1.52	-0.33	-0.38	1.72	1.13
Mount Zirkel WA	1.47	0.93	2.34	1.73	-0.87	-0.80	1.47	0.93
Pecos WA	1.42	0.83	1.95	1.30	-0.53	-0.47	1.40	0.83
Petrified Forest NP	0.58	0.47	0.80	0.68	-0.22	-0.21	0.58	0.47
Rawah WA	1.00	0.65	1.77	1.29	-0.77	-0.64	1.00	0.65
Rocky Mountain NP	1.11	0.68	1.91	1.35	-0.80	-0.67	1.10	0.68
Salt Creek WA	0.69	0.61	0.73	0.66	-0.04	-0.05	0.69	0.61
San Pedro Parks WA	1.11	0.76	1.61	1.24	-0.51	-0.47	1.10	0.76
Weminuche WA	1.50	0.80	2.06	1.36	-0.56	-0.56	1.50	0.80
West Elk WA	0.90	0.53	1.48	1.01	-0.58	-0.48	0.89	0.53
Wheeler Peak WA	1.54	1.07	2.23	1.66	-0.69	-0.59	1.53	1.07
White Mountain WA	1.61	0.97	1.85	1.11	-0.24	-0.14	1.59	0.96

Table 5-34c. Total annual sulfur deposition at Class I areas for the 2021 Medium Development Scenario, 2008 Base Case, their differences (2021 Medium minus 2008) and 2021 Medium Development Scenario without the contributions of natural emissions (e.g., wildfires).

Class I Area	2021 High		2008 Base		2021 High - 2008		2021 Hi - Natural	
	S-Max (kg/ha)	S-Avg (kg/ha)	S-Max (kg/ha)	S-Avg (kg/ha)	S-Max (kg/ha)	S-Avg (kg/ha)	S-Max (kg/ha)	S-Avg (kg/ha)
Arches NP	0.22	0.20	0.36	0.33	-0.14	-0.13	0.22	0.20
Bandelier NM	0.77	0.47	1.12	0.71	-0.34	-0.24	0.61	0.45
Black Canyon NP	0.36	0.31	0.62	0.53	-0.26	-0.22	0.36	0.31
Bosque del Apache WA	0.38	0.35	0.41	0.36	-0.03	-0.02	0.38	0.35
Canyonlands NP	0.35	0.22	0.60	0.35	-0.25	-0.13	0.35	0.22
Capitol Reef NP	0.40	0.22	0.55	0.33	-0.15	-0.11	0.40	0.22
Eagles Nest WA	0.92	0.56	1.56	1.10	-0.64	-0.54	0.92	0.56
Flat Tops WA	1.04	0.71	1.72	1.33	-0.69	-0.61	1.04	0.71
Galiuro WA	1.31	1.17	1.12	1.02	0.19	0.15	1.31	1.17
Gila WA	1.32	0.58	1.61	0.72	-0.29	-0.13	1.32	0.58
Great Sand Dunes NM	0.57	0.33	0.94	0.56	-0.38	-0.23	0.57	0.33
La Garita WA	0.67	0.43	1.25	0.88	-0.58	-0.45	0.67	0.43
Maroon Bells-Snowmass	1.14	0.70	1.86	1.33	-0.71	-0.64	1.14	0.70
Mesa Verde NP	0.58	0.49	0.91	0.80	-0.33	-0.32	0.58	0.49
Mount Baldy WA	1.74	1.13	2.06	1.52	-0.33	-0.38	1.72	1.13
Mount Zirkel WA	1.48	0.93	2.34	1.73	-0.86	-0.80	1.48	0.93
Pecos WA	1.42	0.83	1.95	1.30	-0.53	-0.46	1.40	0.83
Petrified Forest NP	0.58	0.47	0.80	0.68	-0.22	-0.21	0.58	0.47
Rawah WA	1.01	0.65	1.77	1.29	-0.77	-0.64	1.00	0.65
Rocky Mountain NP	1.11	0.68	1.91	1.35	-0.80	-0.66	1.11	0.68
Salt Creek WA	0.69	0.61	0.73	0.66	-0.04	-0.05	0.69	0.61
San Pedro Parks WA	1.11	0.77	1.61	1.24	-0.51	-0.47	1.10	0.76
Weminuche WA	1.50	0.80	2.06	1.36	-0.56	-0.56	1.50	0.80
West Elk WA	0.90	0.53	1.48	1.01	-0.58	-0.48	0.89	0.53
Wheeler Peak WA	1.54	1.07	2.23	1.66	-0.69	-0.59	1.53	1.07
White Mountain WA	1.61	0.97	1.85	1.11	-0.24	-0.14	1.59	0.96

5.5 Acid Neutralizing Capacity (ANC) at Sensitive Lakes

Acid Neutralizing Capacity (ANC) at sensitive lakes was calculated for each Source Group following the procedures given in Section 4.8. For a Project, the USFS ANC Level of Acceptable Change (LAC) threshold is no change greater than 10% for lakes with base ANC > 25 μeq/l and no change greater than 1 μeq/l for lakes with base ANC values < 25 μeq/l. Attachments E-1, E-2 and E-3 are interactive Excel spreadsheet that displays the change in ANC at the sensitive lakes due to emissions from each of the 24 Source Groups and the, respectively, High, Low and Medium Development Scenarios. The Source Group to be displayed is controlled by cell B3 with the resultant change in ANC (Delta ANC) shown as a percent in Column N and as μeq/l in Column O with an indication of whether it is below the USFS LAC value given in Column P. Although ANC is presented for each Source Group, the ANC results for the Source Groups with existing sources (U, V, W and X) are not meaningful since their effects are contained within both the 10 percentile baseline lake acidity as well as the incremental acidity added to the baseline.

5.5.1 ANC Calculations for Individual BLM Planning Areas

For new Federal O&G from each of the 14 BLM Planning Areas (Source Groups A through P) the change in ANC were below the USFS LAC significance thresholds at all of the sensitive lakes. For example, Table 5-35 displays ANC results from Attachment E-1 (2021 High Development Scenario) for the GJFO, UFO and USFS-PG Planning Areas (Source Groups E, F and J). For new Federal O&G from the GJFO Planning Area and the 2021 High Scenario, the maximum change in ANC at any sensitive lake is 3.22% at the White Dome Lake in the Weminuche National Forest. This change is below both of the USFS LAC values (Table 5-35a). Note that Attachment D contains more information on the sensitive lakes than presented in Table 5-35 including the lake chemistry parameters. For new Federal O&G within the UFO Planning Area and the 2021 High Scenario, the maximum change in ANC at any sensitive lake is 1.02% at Deep Creek Lake in the Raggeds Wilderness Area - Gunnison National Forest that is below the USFS LAC thresholds (Table 5-35b). New Federal O&G development within the USFS Pawnee Grassland Planning Area has almost no effect on acidification at the sensitive lakes with maximum change in ANC values of 0.02% (Table 5-35c). ANC results for the other BLM Planning Areas and the 2021 Low and Medium Development Scenario are contained in Attachments E-1, E-2 and E-3.

Table 5-35a. ANC calculations at sensitive lakes for new Federal oil and gas development within the BLM Grand Junction Field Office Planning Area (Source Group E) and the 2021 High Development Scenario.

Lake	10th Percentile Lowest ANC Value (μeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	101.7	0.0003	0.0277	0.898	0.33%	0.3316	<10%	yes	101.3
Tabor Lake	112.4	0.0003	0.0289	0.860	0.32%	0.3617	<10%	yes	112.0
Booth Lake	86.8	0.0004	0.0442	0.844	0.65%	0.5621	<10%	yes	86.2
Upper Willow Lake	134.1	0.0002	0.0295	0.741	0.32%	0.4278	<10%	yes	133.7
Ned Wilson Lake	39.0	0.0004	0.0438	1.158	1.04%	0.4059	<10%	yes	38.6
Upper Ned Wilson Lake	12.9	0.0004	0.0438	1.158	3.15%	0.4059	<1(μeq/L)	yes	12.5
Lower NWL Packtrail Pothole	29.7	0.0004	0.0438	1.158	1.37%	0.4059	<10%	yes	29.2
Upper NWL Packtrail Pothole	48.7	0.0004	0.0438	1.158	0.83%	0.4059	<10%	yes	48.3
Walk Up Lake	55.2	0.0000	0.0008	0.878	0.02%	0.0101	<10%	yes	55.2
Bluebell Lake	55.5	0.0000	0.0005	0.883	0.01%	0.0066	<10%	yes	55.5
Dean Lake	48.9	0.0000	0.0005	1.061	0.01%	0.0050	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	67.0	0.0000	0.0008	0.844	0.02%	0.0105	<10%	yes	67.0
Upper Coffin Lake	64.9	0.0000	0.0006	0.960	0.01%	0.0070	<10%	yes	64.8
Fish Lake	105.8	0.0000	0.0008	0.869	0.01%	0.0101	<10%	yes	105.7
Blodgett Lake, Colorado	47.7	0.0004	0.0471	0.928	1.14%	0.5446	<10%	yes	47.1
Upper Turquoise Lake	104.0	0.0004	0.0475	0.809	0.61%	0.6316	<10%	yes	103.4
Upper West Tennessee Lake	114.2	0.0003	0.0374	0.904	0.39%	0.4440	<10%	yes	113.8
Blue Lake (Colorado; Boulder - 4E1-040)	19.3	0.0003	0.0360	1.128	1.78%	0.3424	<1(μeq/L)	yes	18.9
Crater Lake	53.1	0.0003	0.0314	1.071	0.59%	0.3144	<10%	yes	52.8
King Lake (Colorado; Grand - 4E1-049)	52.3	0.0002	0.0331	0.959	0.71%	0.3699	<10%	yes	51.9
No Name Lake (Colorado; Boulder - 4E1-055)	25.6	0.0003	0.0370	1.126	1.38%	0.3531	<10%	yes	25.3
Upper Lake	69.0	0.0003	0.0340	1.139	0.46%	0.3204	<10%	yes	68.7
Small Lake Above U-Shaped Lake	59.9	0.0001	0.0100	0.927	0.19%	0.1153	<10%	yes	59.8
U-Shaped Lake	81.4	0.0001	0.0100	0.927	0.14%	0.1153	<10%	yes	81.2
Avalanche Lake	158.8	0.0006	0.0526	1.282	0.28%	0.4419	<10%	yes	158.4
Capitol Lake	154.4	0.0006	0.0519	1.110	0.33%	0.5030	<10%	yes	153.9
Moon Lake (Upper)	53.0	0.0006	0.0519	1.110	0.95%	0.5030	<10%	yes	52.5
Upper Middle Beartrack Lake	50.9	0.0002	0.0209	0.869	0.51%	0.2583	<10%	yes	50.6
Abyss Lake	81.1	0.0001	0.0218	0.896	0.32%	0.2613	<10%	yes	80.8
Frozen Lake	93.3	0.0001	0.0218	0.896	0.28%	0.2613	<10%	yes	93.0
North Lake	80.9	0.0001	0.0218	0.896	0.32%	0.2613	<10%	yes	80.7
South Lake	66.7	0.0001	0.0218	0.896	0.39%	0.2613	<10%	yes	66.5
Lake Elbert	56.6	0.0003	0.0299	1.726	0.33%	0.1859	<10%	yes	56.4
Seven Lakes (LG East)	36.2	0.0002	0.0246	1.546	0.47%	0.1713	<10%	yes	36.1
Summit Lake	48.0	0.0003	0.0290	1.449	0.45%	0.2153	<10%	yes	47.8
Deep Creek Lake	20.6	0.0003	0.0409	0.887	2.40%	0.4949	<1(μeq/L)	yes	20.1
Island Lake	71.0	0.0002	0.0222	1.079	0.31%	0.2215	<10%	yes	70.8
Kelly Lake	179.9	0.0002	0.0222	1.079	0.12%	0.2215	<10%	yes	179.6
Rawah Lake #4	41.3	0.0002	0.0225	1.098	0.53%	0.2206	<10%	yes	41.1
Crater Lake (Sangre de Cristo)	162.9	0.0001	0.0097	0.959	0.07%	0.1084	<10%	yes	162.8
Lower Stout Lake	145.2	0.0001	0.0123	0.671	0.14%	0.1975	<10%	yes	145.0
Upper Little Sand Creek Lake	129.5	0.0001	0.0092	1.064	0.07%	0.0926	<10%	yes	129.4
Upper Stout Lake	76.3	0.0001	0.0123	0.671	0.26%	0.1975	<10%	yes	76.1
Glacier Lake (Colorado)	63.4	0.0000	0.0042	1.145	0.06%	0.0398	<10%	yes	63.4
Lake South of Blue Lakes	16.9	0.0000	0.0050	1.312	0.24%	0.0406	<1(μeq/L)	yes	16.9
Big Eldorado Lake	19.6	0.0000	0.0070	1.128	0.34%	0.0664	<1(μeq/L)	yes	19.6
Four Mile Pothole	123.4	0.0001	0.0069	1.173	0.05%	0.0633	<10%	yes	123.3
Lake Due South of Ute Lake	13.2	0.0000	0.0059	1.067	0.45%	0.0597	<1(μeq/L)	yes	13.1
Little Eldorado	-3.3	0.0000	0.0070	1.128	2.01%	0.0664	<1(μeq/L)	yes	-3.4
Little Granite Lake	80.7	0.0000	0.0069	0.830	0.11%	0.0890	<10%	yes	80.6
Lower Sunlight Lake	80.9	0.0001	0.0073	1.177	0.08%	0.0670	<10%	yes	80.8
Middle Ute Lake	42.8	0.0000	0.0059	1.052	0.14%	0.0603	<10%	yes	42.7
Small Pond Above Trout Lake	25.5	0.0000	0.0069	1.087	0.27%	0.0682	<10%	yes	25.4
Upper Grizzly Lake	29.9	0.0001	0.0075	1.177	0.23%	0.0689	<10%	yes	29.8
Upper Sunlight Lake	28.0	0.0001	0.0075	1.177	0.25%	0.0689	<10%	yes	27.9
West Snowdon Lake	39.4	0.0000	0.0070	0.978	0.20%	0.0772	<10%	yes	39.3
White Dome Lake	2.1	0.0000	0.0070	1.128	3.22%	0.0664	<1(μeq/L)	yes	2.0
South Golden Lake	111.4	0.0002	0.0317	0.984	0.31%	0.3456	<10%	yes	111.1

* USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC

Table 5-35b. ANC calculations at sensitive lakes for new Federal oil and gas development within the BLM Uncompahgre Field Office Planning Area (Source Group F) and the 2021 High Development Scenario.

Lake	10th Percentile Lowest ANC Value (μeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	101.7	0.0001	0.0045	0.898	0.05%	0.0543	<10%	yes	101.6
Tabor Lake	112.4	0.0001	0.0044	0.860	0.05%	0.0559	<10%	yes	112.3
Booth Lake	86.8	0.0000	0.0030	0.844	0.04%	0.0389	<10%	yes	86.7
Upper Willow Lake	134.1	0.0000	0.0022	0.741	0.02%	0.0325	<10%	yes	134.1
Ned Wilson Lake	39.0	0.0000	0.0015	1.158	0.04%	0.0137	<10%	yes	39.0
Upper Ned Wilson Lake	12.9	0.0000	0.0015	1.158	0.11%	0.0137	<1(μeq/L)	yes	12.9
Lower NWL Packtrail Pothole	29.7	0.0000	0.0015	1.158	0.05%	0.0137	<10%	yes	29.6
Upper NWL Packtrail Pothole	48.7	0.0000	0.0015	1.158	0.03%	0.0137	<10%	yes	48.7
Walk Up Lake	55.2	0.0000	0.0000	0.878	0.00%	0.0003	<10%	yes	55.2
Bluebell Lake	55.5	0.0000	0.0000	0.883	0.00%	0.0002	<10%	yes	55.5
Dean Lake	48.9	0.0000	0.0000	1.061	0.00%	0.0001	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	67.0	0.0000	0.0000	0.844	0.00%	0.0003	<10%	yes	67.0
Upper Coffin Lake	64.9	0.0000	0.0000	0.960	0.00%	0.0002	<10%	yes	64.8
Fish Lake	105.8	0.0000	0.0000	0.869	0.00%	0.0003	<10%	yes	105.8
Blodgett Lake, Colorado	47.7	0.0001	0.0044	0.928	0.11%	0.0518	<10%	yes	47.6
Upper Turquoise Lake	104.0	0.0001	0.0038	0.809	0.05%	0.0506	<10%	yes	103.9
Upper West Tennessee Lake	114.2	0.0001	0.0041	0.904	0.04%	0.0492	<10%	yes	114.2
Blue Lake (Colorado; Boulder - 4E1-040)	19.3	0.0000	0.0025	1.128	0.12%	0.0235	<1(μeq/L)	yes	19.2
Crater Lake	53.1	0.0000	0.0021	1.071	0.04%	0.0211	<10%	yes	53.1
King Lake (Colorado; Grand - 4E1-049)	52.3	0.0000	0.0021	0.959	0.05%	0.0236	<10%	yes	52.2
No Name Lake (Colorado; Boulder - 4E1-055)	25.6	0.0000	0.0025	1.126	0.09%	0.0240	<10%	yes	25.6
Upper Lake	69.0	0.0000	0.0024	1.139	0.03%	0.0230	<10%	yes	69.0
Small Lake Above U-Shaped Lake	59.9	0.0000	0.0013	0.927	0.03%	0.0154	<10%	yes	59.9
U-Shaped Lake	81.4	0.0000	0.0013	0.927	0.02%	0.0154	<10%	yes	81.3
Avalanche Lake	158.8	0.0004	0.0147	1.282	0.08%	0.1250	<10%	yes	158.7
Capitol Lake	154.4	0.0003	0.0132	1.110	0.08%	0.1299	<10%	yes	154.3
Moon Lake (Upper)	53.0	0.0003	0.0132	1.110	0.25%	0.1299	<10%	yes	52.9
Upper Middle Beartrack Lake	50.9	0.0000	0.0017	0.869	0.04%	0.0205	<10%	yes	50.9
Abyss Lake	81.1	0.0000	0.0018	0.896	0.03%	0.0211	<10%	yes	81.1
Frozen Lake	93.3	0.0000	0.0018	0.896	0.02%	0.0211	<10%	yes	93.2
North Lake	80.9	0.0000	0.0018	0.896	0.03%	0.0211	<10%	yes	80.9
South Lake	66.7	0.0000	0.0018	0.896	0.03%	0.0211	<10%	yes	66.7
Lake Elbert	56.6	0.0000	0.0011	1.726	0.01%	0.0066	<10%	yes	56.6
Seven Lakes (LG East)	36.2	0.0000	0.0007	1.546	0.01%	0.0052	<10%	yes	36.2
Summit Lake	48.0	0.0000	0.0011	1.449	0.02%	0.0084	<10%	yes	48.0
Deep Creek Lake	20.6	0.0003	0.0173	0.887	1.02%	0.2107	<1(μeq/L)	yes	20.4
Island Lake	71.0	0.0000	0.0014	1.079	0.02%	0.0141	<10%	yes	71.0
Kelly Lake	179.9	0.0000	0.0014	1.079	0.01%	0.0141	<10%	yes	179.8
Rawah Lake #4	41.3	0.0000	0.0014	1.098	0.03%	0.0137	<10%	yes	41.3
Crater Lake (Sangre de Cristo)	162.9	0.0000	0.0012	0.959	0.01%	0.0134	<10%	yes	162.9
Lower Stout Lake	145.2	0.0000	0.0019	0.671	0.02%	0.0308	<10%	yes	145.2
Upper Little Sand Creek Lake	129.5	0.0000	0.0012	1.064	0.01%	0.0118	<10%	yes	129.5
Upper Stout Lake	76.3	0.0000	0.0019	0.671	0.04%	0.0308	<10%	yes	76.3
Glacier Lake (Colorado)	63.4	0.0000	0.0005	1.145	0.01%	0.0044	<10%	yes	63.4
Lake South of Blue Lakes	16.9	0.0000	0.0005	1.312	0.02%	0.0042	<1(μeq/L)	yes	16.9
Big Eldorado Lake	19.6	0.0000	0.0007	1.128	0.03%	0.0065	<1(μeq/L)	yes	19.6
Four Mile Pothole	123.4	0.0000	0.0006	1.173	0.00%	0.0057	<10%	yes	123.4
Lake Due South of Ute Lake	13.2	0.0000	0.0006	1.067	0.04%	0.0057	<1(μeq/L)	yes	13.2
Little Eldorado	-3.3	0.0000	0.0007	1.128	0.20%	0.0065	<1(μeq/L)	yes	-3.3
Little Granite Lake	80.7	0.0000	0.0007	0.830	0.01%	0.0092	<10%	yes	80.7
Lower Sunlight Lake	80.9	0.0000	0.0007	1.177	0.01%	0.0063	<10%	yes	80.9
Middle Ute Lake	42.8	0.0000	0.0006	1.052	0.01%	0.0059	<10%	yes	42.8
Small Pond Above Trout Lake	25.5	0.0000	0.0007	1.087	0.03%	0.0071	<10%	yes	25.5
Upper Grizzly Lake	29.9	0.0000	0.0007	1.177	0.02%	0.0063	<10%	yes	29.9
Upper Sunlight Lake	28.0	0.0000	0.0007	1.177	0.02%	0.0063	<10%	yes	28.0
West Snowdon Lake	39.4	0.0000	0.0007	0.978	0.02%	0.0074	<10%	yes	39.3
White Dome Lake	2.1	0.0000	0.0007	1.128	0.32%	0.0065	<1(μeq/L)	yes	2.1
South Golden Lake	111.4	0.0001	0.0090	0.984	0.09%	0.0989	<10%	yes	111.3

* USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC

Table 5-35c. ANC calculations at sensitive lakes for new Federal oil and gas development within the USFS Pawnee Grasslands Planning Area (Source Group J) and the 2021 High Development Scenario.

Lake	10th Percentile Lowest ANC Value (µeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (µeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (µeq/L)
Brooklyn Lake	101.7	0.0000	0.0000	0.898	0.00%	0.0005	<10%	yes	101.7
Tabor Lake	112.4	0.0000	0.0000	0.860	0.00%	0.0005	<10%	yes	112.4
Booth Lake	86.8	0.0000	0.0001	0.844	0.00%	0.0006	<10%	yes	86.8
Upper Willow Lake	134.1	0.0000	0.0001	0.741	0.00%	0.0015	<10%	yes	134.1
Ned Wilson Lake	39.0	0.0000	0.0000	1.158	0.00%	0.0001	<10%	yes	39.0
Upper Ned Wilson Lake	12.9	0.0000	0.0000	1.158	0.00%	0.0001	<1(µeq/L)	yes	12.9
Lower NWL Packtrail Pothole	29.7	0.0000	0.0000	1.158	0.00%	0.0001	<10%	yes	29.6
Upper NWL Packtrail Pothole	48.7	0.0000	0.0000	1.158	0.00%	0.0001	<10%	yes	48.7
Walk Up Lake	55.2	0.0000	0.0000	0.878	0.00%	0.0000	<10%	yes	55.2
Bluebell Lake	55.5	0.0000	0.0000	0.883	0.00%	0.0000	<10%	yes	55.5
Dean Lake	48.9	0.0000	0.0000	1.061	0.00%	0.0000	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	67.0	0.0000	0.0000	0.844	0.00%	0.0000	<10%	yes	67.0
Upper Coffin Lake	64.9	0.0000	0.0000	0.960	0.00%	0.0000	<10%	yes	64.8
Fish Lake	105.8	0.0000	0.0000	0.869	0.00%	0.0000	<10%	yes	105.8
Blodgett Lake, Colorado	47.7	0.0000	0.0000	0.928	0.00%	0.0003	<10%	yes	47.7
Upper Turquoise Lake	104.0	0.0000	0.0000	0.809	0.00%	0.0005	<10%	yes	104.0
Upper West Tennessee Lake	114.2	0.0000	0.0000	0.904	0.00%	0.0006	<10%	yes	114.2
Blue Lake (Colorado; Boulder - 4E1-040)	19.3	0.0000	0.0003	1.128	0.02%	0.0032	<1(µeq/L)	yes	19.2
Crater Lake	53.1	0.0000	0.0003	1.071	0.01%	0.0027	<10%	yes	53.1
King Lake (Colorado; Grand - 4E1-049)	52.3	0.0000	0.0004	0.959	0.01%	0.0042	<10%	yes	52.3
No Name Lake (Colorado; Boulder - 4E1-055)	25.6	0.0000	0.0005	1.126	0.02%	0.0044	<10%	yes	25.6
Upper Lake	69.0	0.0000	0.0003	1.139	0.00%	0.0024	<10%	yes	69.0
Small Lake Above U-Shaped Lake	59.9	0.0000	0.0000	0.927	0.00%	0.0004	<10%	yes	59.9
U-Shaped Lake	81.4	0.0000	0.0000	0.927	0.00%	0.0004	<10%	yes	81.4
Avalanche Lake	158.8	0.0000	0.0000	1.282	0.00%	0.0001	<10%	yes	158.8
Capitol Lake	154.4	0.0000	0.0000	1.110	0.00%	0.0002	<10%	yes	154.4
Moon Lake (Upper)	53.0	0.0000	0.0000	1.110	0.00%	0.0002	<10%	yes	53.0
Upper Middle Beartrack Lake	50.9	0.0000	0.0005	0.869	0.01%	0.0064	<10%	yes	50.9
Abyss Lake	81.1	0.0000	0.0004	0.896	0.01%	0.0044	<10%	yes	81.1
Frozen Lake	93.3	0.0000	0.0004	0.896	0.00%	0.0044	<10%	yes	93.3
North Lake	80.9	0.0000	0.0004	0.896	0.01%	0.0044	<10%	yes	80.9
South Lake	66.7	0.0000	0.0004	0.896	0.01%	0.0044	<10%	yes	66.7
Lake Elbert	56.6	0.0000	0.0000	1.726	0.00%	0.0002	<10%	yes	56.6
Seven Lakes (LG East)	36.2	0.0000	0.0000	1.546	0.00%	0.0002	<10%	yes	36.2
Summit Lake	48.0	0.0000	0.0000	1.449	0.00%	0.0002	<10%	yes	48.0
Deep Creek Lake	20.6	0.0000	0.0000	0.887	0.00%	0.0002	<1(µeq/L)	yes	20.6
Island Lake	71.0	0.0000	0.0001	1.079	0.00%	0.0012	<10%	yes	71.0
Kelly Lake	179.9	0.0000	0.0001	1.079	0.00%	0.0012	<10%	yes	179.8
Rawah Lake #4	41.3	0.0000	0.0002	1.098	0.00%	0.0015	<10%	yes	41.3
Crater Lake (Sangre de Cristo)	162.9	0.0000	0.0002	0.959	0.00%	0.0024	<10%	yes	162.9
Lower Stout Lake	145.2	0.0000	0.0003	0.671	0.00%	0.0042	<10%	yes	145.2
Upper Little Sand Creek Lake	129.5	0.0000	0.0002	1.064	0.00%	0.0025	<10%	yes	129.5
Upper Stout Lake	76.3	0.0000	0.0003	0.671	0.01%	0.0042	<10%	yes	76.3
Glacier Lake (Colorado)	63.4	0.0000	0.0001	1.145	0.00%	0.0005	<10%	yes	63.4
Lake South of Blue Lakes	16.9	0.0000	0.0001	1.312	0.00%	0.0005	<1(µeq/L)	yes	16.9
Big Eldorado Lake	19.6	0.0000	0.0000	1.128	0.00%	0.0001	<1(µeq/L)	yes	19.6
Four Mile Pothole	123.4	0.0000	0.0000	1.173	0.00%	0.0003	<10%	yes	123.4
Lake Due South of Ute Lake	13.2	0.0000	0.0000	1.067	0.00%	0.0001	<1(µeq/L)	yes	13.2
Little Eldorado	-3.3	0.0000	0.0000	1.128	0.00%	0.0001	<1(µeq/L)	yes	-3.3
Little Granite Lake	80.7	0.0000	0.0000	0.830	0.00%	0.0003	<10%	yes	80.7
Lower Sunlight Lake	80.9	0.0000	0.0000	1.177	0.00%	0.0001	<10%	yes	80.9
Middle Ute Lake	42.8	0.0000	0.0000	1.052	0.00%	0.0001	<10%	yes	42.8
Small Pond Above Trout Lake	25.5	0.0000	0.0000	1.087	0.00%	0.0003	<10%	yes	25.5
Upper Grizzly Lake	29.9	0.0000	0.0000	1.177	0.00%	0.0001	<10%	yes	29.9
Upper Sunlight Lake	28.0	0.0000	0.0000	1.177	0.00%	0.0001	<10%	yes	28.0
West Snowdon Lake	39.4	0.0000	0.0000	0.978	0.00%	0.0001	<10%	yes	39.3
White Dome Lake	2.1	0.0000	0.0000	1.128	0.01%	0.0001	<1(µeq/L)	yes	2.1
South Golden Lake	111.4	0.0000	0.0000	0.984	0.00%	0.0002	<10%	yes	111.4

* USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC

5.5.2 ANC Calculations for Combined BLM Planning Areas

The Attachment E-1, E-2 and E-3 spreadsheets also contain ANC calculations for the combined BLM Planning Area Source Groups Q through T of new emission sources. Below we provide results for Source Group R (new Federal O&G and mining within 13 CO BLM Planning Areas) and the Cumulative Emissions Scenario (Source Group T) that also adds new O&G and O&G emissions from the Mancos Shale development in northern New Mexico.

Table 5-36 displays the ANC results at the 58 sensitive lakes for the combined new Federal O&G and mining within the 13 Colorado BLM Planning Areas (Source Group R) and the 2021 High, Low and Medium Development Scenarios. For the lakes that have base ANC values > 25 µeq/l the maximum percent change in ANC is always below the USFS LAC 10% threshold for all three 2021 emission scenarios. However, for the 8 lakes with base ANC < 25 µeq/l, three have changes in ANC greater than the 1 µeq/l USFS LAC threshold for the 2021 High Development Scenario (Table 5-36a): Upper Ned Wilson Lake (1.61 µeq/l); Blue Lake (1.11 µeq/l) and Deep Creek Lake (1.47 µeq/l). The mitigation in the 2021 Medium Development scenario is sufficient to reduce the change in ANC value at Blue Lake (0.94 µeq/l) to below the 1 µeq/l LAC threshold, but the change in ANC values at Upper Ned Wilson (1.36 µeq/l) and Deep Creek (1.21 µeq/l) lakes remain above the LAC threshold. For these same three lakes the change in ANC values are below the 1 µeq/l USFS LAC threshold for the 2021 Low Development Scenario (0.3887, 0.2611 and 0.3577 µeq/l).

The ANC results for the Cumulative Emissions Scenario (Source Group T) and the 2021 High and Low Emissions Scenario are shown in Table 5-37. Since this Source Group contains Source Group R then the same three sensitive lakes with ANC < 25 µeq/l have changes in ANC greater than the 1 µeq/l USFS LAC threshold for the 2021 High Development Scenario (Table 5-37a): Upper Ned Wilson Lake (2.7137 µeq/l); Blue Lake (2.4663 µeq/l) and Deep Creek Lake (2.6909 µeq/l). However, in addition there is one sensitive lake with base ANC > 25 µeq/l whose change in ANC exceeds the USFS 10% LAC threshold for the 2021 High Development Scenario and Source Group T: No Name Lake (10.50%). The mitigation in the 2021 Medium Development Scenario is sufficient to reduce the change in ANC at No Name Lake (9.67%) to below the 10% LAC threshold but not to reduce it at the other three lakes with base ANC < 25 µeq/l to below the 1 µeq/l LAC threshold (Table 5-37c). For the 2021 Low Development Scenario and Source Group T, all sensitive lakes have change in ANC below the LAC thresholds (Table 5-37b).

Note that the USFS ANC LAC thresholds were developed for evaluating potential lake acidification for individual Projects, not for quasi-cumulative emission source groups of new O&G development across an entire state as in Source Groups R and T. In addition, the USFS ANC LAC thresholds were developed for evaluating potential lake acidification for individual Projects (i.e. new emissions since baseline lake chemistry data was monitored), not for cumulative emissions scenarios that include all existing O&G since the baseline ANC values that are used in the ANC calculations would already account for impacts from existing emissions sources.

Table 5-36a. ANC calculations at sensitive lakes for new Federal oil and gas development and mining within the 13 Colorado BLM Planning Areas (Source Group R) and 2021 High Development Scenario.

Lake	10th Percentile Lowest ANC Value (μeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	101.7	0.0061	0.0783	0.898	0.98%	0.9924	<10%	yes	100.7
Tabor Lake	112.4	0.0060	0.0808	0.860	0.95%	1.0663	<10%	yes	111.3
Booth Lake	86.8	0.0076	0.1114	0.844	1.72%	1.4898	<10%	yes	85.3
Upper Willow Lake	134.1	0.0062	0.0783	0.741	0.90%	1.2051	<10%	yes	132.9
Ned Wilson Lake	39.0	0.0195	0.1577	1.158	4.13%	1.6089	<10%	yes	37.4
Upper Ned Wilson Lake	12.9	0.0195	0.1577	1.158	12.49%	1.6089	<1(μeq/L)	no	11.3
Lower NWL Packtrail Pothole	29.7	0.0195	0.1577	1.158	5.43%	1.6089	<10%	yes	28.0
Upper NWL Packtrail Pothole	48.7	0.0195	0.1577	1.158	3.30%	1.6089	<10%	yes	47.1
Walk Up Lake	55.2	0.0003	0.0035	0.878	0.08%	0.0453	<10%	yes	55.2
Bluebell Lake	55.5	0.0001	0.0020	0.883	0.05%	0.0259	<10%	yes	55.5
Dean Lake	48.9	0.0001	0.0018	1.061	0.04%	0.0188	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	67.0	0.0003	0.0043	0.844	0.09%	0.0580	<10%	yes	67.0
Upper Coffin Lake	64.9	0.0002	0.0024	0.960	0.04%	0.0284	<10%	yes	64.8
Fish Lake	105.8	0.0003	0.0034	0.869	0.04%	0.0443	<10%	yes	105.7
Blodgett Lake, Colorado	47.7	0.0081	0.1146	0.928	2.93%	1.3978	<10%	yes	46.3
Upper Turquoise Lake	104.0	0.0094	0.1221	0.809	1.65%	1.7194	<10%	yes	102.3
Upper West Tennessee Lake	114.2	0.0059	0.0912	0.904	0.99%	1.1363	<10%	yes	113.1
Blue Lake (Colorado; Boulder - 4E1-040)	19.3	0.0115	0.1069	1.128	5.75%	1.1064	<1(μeq/L)	no	18.1
Crater Lake	53.1	0.0122	0.0963	1.071	2.01%	1.0659	<10%	yes	52.1
King Lake (Colorado; Grand - 4E1-049)	52.3	0.0120	0.1027	0.959	2.41%	1.2580	<10%	yes	51.0
No Name Lake (Colorado; Boulder - 4E1-055)	25.6	0.0124	0.1104	1.126	4.48%	1.1479	<10%	yes	24.5
Upper Lake	69.0	0.0128	0.1031	1.139	1.55%	1.0700	<10%	yes	67.9
Small Lake Above U-Shaped Lake	59.9	0.0018	0.0295	0.927	0.60%	0.3574	<10%	yes	59.5
U-Shaped Lake	81.4	0.0018	0.0295	0.927	0.44%	0.3574	<10%	yes	81.0
Avalanche Lake	158.8	0.0117	0.1349	1.282	0.76%	1.2069	<10%	yes	157.6
Capitol Lake	154.4	0.0116	0.1325	1.110	0.89%	1.3695	<10%	yes	153.0
Moon Lake (Upper)	53.0	0.0116	0.1325	1.110	2.58%	1.3695	<10%	yes	51.6
Upper Middle Beartrack Lake	50.9	0.0053	0.0593	0.869	1.54%	0.7841	<10%	yes	50.1
Abyss Lake	81.1	0.0050	0.0611	0.896	0.96%	0.7790	<10%	yes	80.3
Frozen Lake	93.3	0.0050	0.0611	0.896	0.84%	0.7790	<10%	yes	92.5
North Lake	80.9	0.0050	0.0611	0.896	0.96%	0.7790	<10%	yes	80.2
South Lake	66.7	0.0050	0.0611	0.896	1.17%	0.7790	<10%	yes	66.0
Lake Elbert	56.6	0.0290	0.1501	1.726	1.92%	1.0843	<10%	yes	55.5
Seven Lakes (LG East)	36.2	0.0205	0.1239	1.546	2.70%	0.9779	<10%	yes	35.3
Summit Lake	48.0	0.0323	0.1501	1.449	2.73%	1.3118	<10%	yes	46.7
Deep Creek Lake	20.6	0.0096	0.1135	0.887	7.11%	1.4652	<1(μeq/L)	no	19.1
Island Lake	71.0	0.0140	0.0931	1.079	1.47%	1.0406	<10%	yes	70.0
Kelly Lake	179.9	0.0140	0.0931	1.079	0.58%	1.0406	<10%	yes	178.8
Rawah Lake #4	41.3	0.0135	0.0951	1.098	2.51%	1.0384	<10%	yes	40.3
Crater Lake (Sangre de Cristo)	162.9	0.0025	0.0311	0.959	0.23%	0.3696	<10%	yes	162.6
Lower Stout Lake	145.2	0.0029	0.0388	0.671	0.45%	0.6568	<10%	yes	144.5
Upper Little Sand Creek Lake	129.5	0.0027	0.0311	1.064	0.26%	0.3347	<10%	yes	129.2
Upper Stout Lake	76.3	0.0029	0.0388	0.671	0.86%	0.6568	<10%	yes	75.7
Glacier Lake (Colorado)	63.4	0.0013	0.0186	1.145	0.29%	0.1835	<10%	yes	63.2
Lake South of Blue Lakes	16.9	0.0013	0.0236	1.312	1.19%	0.2011	<1(μeq/L)	yes	16.7
Big Eldorado Lake	19.6	0.0014	0.0246	1.128	1.24%	0.2442	<1(μeq/L)	yes	19.4
Four Mile Pothole	123.4	0.0015	0.0232	1.173	0.18%	0.2229	<10%	yes	123.2
Lake Due South of Ute Lake	13.2	0.0012	0.0206	1.067	1.65%	0.2170	<1(μeq/L)	yes	12.9
Little Eldorado	-3.3	0.0014	0.0246	1.128	7.40%	0.2442	<1(μeq/L)	yes	-3.5
Little Granite Lake	80.7	0.0011	0.0229	0.830	0.38%	0.3068	<10%	yes	80.4
Lower Sunlight Lake	80.9	0.0018	0.0267	1.177	0.32%	0.2561	<10%	yes	80.6
Middle Ute Lake	42.8	0.0012	0.0206	1.052	0.51%	0.2192	<10%	yes	42.6
Small Pond Above Trout Lake	25.5	0.0012	0.0231	1.087	0.93%	0.2369	<10%	yes	25.2
Upper Grizzly Lake	29.9	0.0020	0.0272	1.177	0.88%	0.2623	<10%	yes	29.6
Upper Sunlight Lake	28.0	0.0020	0.0272	1.177	0.94%	0.2623	<10%	yes	27.7
West Snowdon Lake	39.4	0.0010	0.0246	0.978	0.71%	0.2781	<10%	yes	39.1
White Dome Lake	2.1	0.0014	0.0246	1.128	11.85%	0.2442	<1(μeq/L)	yes	1.8
South Golden Lake	111.4	0.0045	0.0872	0.984	0.89%	0.9872	<10%	yes	110.4

* USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC

Table 5-36b. ANC calculations at sensitive lakes for new Federal oil and gas development and mining within the 13 Colorado BLM Planning Areas (Source Group R) and 2021 Low Development Scenario.

Lake	10th Percentile Lowest ANC Value (μeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	101.7	0.0033	0.0157	0.898	0.22%	0.2204	<10%	yes	101.5
Tabor Lake	112.4	0.0033	0.0161	0.860	0.21%	0.2353	<10%	yes	112.2
Booth Lake	86.8	0.0043	0.0223	0.844	0.38%	0.3290	<10%	yes	86.5
Upper Willow Lake	134.1	0.0037	0.0157	0.741	0.20%	0.2731	<10%	yes	133.8
Ned Wilson Lake	39.0	0.0113	0.0323	1.158	1.00%	0.3887	<10%	yes	38.6
Upper Ned Wilson Lake	12.9	0.0113	0.0323	1.158	3.02%	0.3887	<1(μeq/L)	yes	12.5
Lower NWL Packtrail Pothole	29.7	0.0113	0.0323	1.158	1.31%	0.3887	<10%	yes	29.3
Upper NWL Packtrail Pothole	48.7	0.0113	0.0323	1.158	0.80%	0.3887	<10%	yes	48.3
Walk Up Lake	55.2	0.0001	0.0007	0.878	0.02%	0.0091	<10%	yes	55.2
Bluebell Lake	55.5	0.0000	0.0004	0.883	0.01%	0.0052	<10%	yes	55.5
Dean Lake	48.9	0.0000	0.0003	1.061	0.01%	0.0037	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	67.0	0.0001	0.0008	0.844	0.02%	0.0113	<10%	yes	67.0
Upper Coffin Lake	64.9	0.0001	0.0005	0.960	0.01%	0.0058	<10%	yes	64.8
Fish Lake	105.8	0.0001	0.0006	0.869	0.01%	0.0090	<10%	yes	105.8
Blodgett Lake, Colorado	47.7	0.0045	0.0223	0.928	0.63%	0.3009	<10%	yes	47.4
Upper Turquoise Lake	104.0	0.0053	0.0244	0.809	0.37%	0.3831	<10%	yes	103.6
Upper West Tennessee Lake	114.2	0.0033	0.0175	0.904	0.21%	0.2404	<10%	yes	114.0
Blue Lake (Colorado; Boulder - 4E1-040)	19.3	0.0078	0.0208	1.128	1.36%	0.2611	<1(μeq/L)	yes	19.0
Crater Lake	53.1	0.0086	0.0188	1.071	0.49%	0.2626	<10%	yes	52.9
King Lake (Colorado; Grand - 4E1-049)	52.3	0.0084	0.0202	0.959	0.59%	0.3066	<10%	yes	52.0
No Name Lake (Colorado; Boulder - 4E1-055)	25.6	0.0085	0.0216	1.126	1.07%	0.2746	<10%	yes	25.3
Upper Lake	69.0	0.0084	0.0200	1.139	0.37%	0.2562	<10%	yes	68.7
Small Lake Above U-Shaped Lake	59.9	0.0009	0.0056	0.927	0.12%	0.0743	<10%	yes	59.8
U-Shaped Lake	81.4	0.0009	0.0056	0.927	0.09%	0.0743	<10%	yes	81.3
Avalanche Lake	158.8	0.0074	0.0262	1.282	0.17%	0.2716	<10%	yes	158.5
Capitol Lake	154.4	0.0071	0.0258	1.110	0.20%	0.3079	<10%	yes	154.1
Moon Lake (Upper)	53.0	0.0071	0.0258	1.110	0.58%	0.3079	<10%	yes	52.7
Upper Middle Beartrack Lake	50.9	0.0031	0.0118	0.869	0.35%	0.1779	<10%	yes	50.7
Abyss Lake	81.1	0.0029	0.0121	0.896	0.22%	0.1744	<10%	yes	80.9
Frozen Lake	93.3	0.0029	0.0121	0.896	0.19%	0.1744	<10%	yes	93.1
North Lake	80.9	0.0029	0.0121	0.896	0.22%	0.1744	<10%	yes	80.8
South Lake	66.7	0.0029	0.0121	0.896	0.26%	0.1744	<10%	yes	66.6
Lake Elbert	56.6	0.0212	0.0320	1.726	0.55%	0.3124	<10%	yes	56.3
Seven Lakes (LG East)	36.2	0.0135	0.0250	1.546	0.70%	0.2535	<10%	yes	36.0
Summit Lake	48.0	0.0250	0.0329	1.449	0.84%	0.4029	<10%	yes	47.6
Deep Creek Lake	20.6	0.0066	0.0240	0.887	1.74%	0.3577	<1(μeq/L)	yes	20.2
Island Lake	71.0	0.0094	0.0191	1.079	0.38%	0.2698	<10%	yes	70.8
Kelly Lake	179.9	0.0094	0.0191	1.079	0.15%	0.2698	<10%	yes	179.6
Rawah Lake #4	41.3	0.0090	0.0194	1.098	0.64%	0.2653	<10%	yes	41.0
Crater Lake (Sangre de Cristo)	162.9	0.0013	0.0063	0.959	0.05%	0.0825	<10%	yes	162.8
Lower Stout Lake	145.2	0.0015	0.0077	0.671	0.10%	0.1427	<10%	yes	145.1
Upper Little Sand Creek Lake	129.5	0.0014	0.0067	1.064	0.06%	0.0794	<10%	yes	129.4
Upper Stout Lake	76.3	0.0015	0.0077	0.671	0.19%	0.1427	<10%	yes	76.2
Glacier Lake (Colorado)	63.4	0.0006	0.0034	1.145	0.06%	0.0368	<10%	yes	63.4
Lake South of Blue Lakes	16.9	0.0006	0.0041	1.312	0.22%	0.0379	<1(μeq/L)	yes	16.9
Big Eldorado Lake	19.6	0.0006	0.0045	1.128	0.24%	0.0479	<1(μeq/L)	yes	19.6
Four Mile Pothole	123.4	0.0007	0.0043	1.173	0.04%	0.0446	<10%	yes	123.3
Lake Due South of Ute Lake	13.2	0.0006	0.0039	1.067	0.33%	0.0435	<1(μeq/L)	yes	13.1
Little Eldorado	-3.3	0.0006	0.0045	1.128	1.45%	0.0479	<1(μeq/L)	yes	-3.3
Little Granite Lake	80.7	0.0005	0.0043	0.830	0.07%	0.0601	<10%	yes	80.7
Lower Sunlight Lake	80.9	0.0008	0.0049	1.177	0.06%	0.0510	<10%	yes	80.8
Middle Ute Lake	42.8	0.0005	0.0038	1.052	0.10%	0.0435	<10%	yes	42.7
Small Pond Above Trout Lake	25.5	0.0006	0.0043	1.087	0.18%	0.0469	<10%	yes	25.4
Upper Grizzly Lake	29.9	0.0010	0.0050	1.177	0.18%	0.0533	<10%	yes	29.8
Upper Sunlight Lake	28.0	0.0010	0.0050	1.177	0.19%	0.0533	<10%	yes	27.9
West Snowdon Lake	39.4	0.0004	0.0044	0.978	0.13%	0.0519	<10%	yes	39.3
White Dome Lake	2.1	0.0006	0.0045	1.128	2.33%	0.0479	<1(μeq/L)	yes	2.0
South Golden Lake	111.4	0.0028	0.0170	0.984	0.19%	0.2100	<10%	yes	111.2

* USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC

Table 5-36c. ANC calculations at sensitive lakes for new Federal oil and gas development and mining within the 13 Colorado BLM Planning Areas (Source Group R) and 2021 Medium Development Scenario.

Lake	10th Percentile Lowest ANC Value (µeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (µeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Med Predicted 10th Percentile Lowest ANC Value (µeq/L)
Brooklyn Lake	101.7	0.0060	0.0641	0.898	0.81%	0.8229	<10%	yes	100.9
Tabor Lake	112.4	0.0059	0.0661	0.860	0.79%	0.8827	<10%	yes	111.5
Booth Lake	86.8	0.0074	0.0913	0.844	1.42%	1.2346	<10%	yes	85.5
Upper Willow Lake	134.1	0.0061	0.0645	0.741	0.75%	1.0042	<10%	yes	133.1
Ned Wilson Lake	39.0	0.0193	0.1306	1.158	3.48%	1.3575	<10%	yes	37.6
Upper Ned Wilson Lake	12.9	0.0193	0.1306	1.158	10.54%	1.3575	<1(µeq/L)	no	11.5
Lower NWL Packtrail Pothole	29.7	0.0193	0.1306	1.158	4.58%	1.3575	<10%	yes	28.3
Upper NWL Packtrail Pothole	48.7	0.0193	0.1306	1.158	2.79%	1.3575	<10%	yes	47.3
Walk Up Lake	55.2	0.0003	0.0032	0.878	0.08%	0.0420	<10%	yes	55.2
Bluebell Lake	55.5	0.0001	0.0019	0.883	0.04%	0.0239	<10%	yes	55.5
Dean Lake	48.9	0.0001	0.0016	1.061	0.04%	0.0173	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	67.0	0.0003	0.0040	0.844	0.08%	0.0543	<10%	yes	67.0
Upper Coffin Lake	64.9	0.0002	0.0022	0.960	0.04%	0.0263	<10%	yes	64.8
Fish Lake	105.8	0.0002	0.0031	0.869	0.04%	0.0411	<10%	yes	105.7
Blodgett Lake, Colorado	47.7	0.0079	0.0939	0.928	2.43%	1.1578	<10%	yes	46.5
Upper Turquoise Lake	104.0	0.0092	0.1000	0.809	1.37%	1.4249	<10%	yes	102.6
Upper West Tennessee Lake	114.2	0.0057	0.0746	0.904	0.82%	0.9392	<10%	yes	113.3
Blue Lake (Colorado; Boulder - 4E1-040)	19.3	0.0114	0.0898	1.128	4.90%	0.9429	<1(µeq/L)	yes	18.3
Crater Lake	53.1	0.0121	0.0811	1.071	1.72%	0.9128	<10%	yes	52.2
King Lake (Colorado; Grand - 4E1-049)	52.3	0.0118	0.0865	0.959	2.06%	1.0769	<10%	yes	51.2
No Name Lake (Colorado; Boulder - 4E1-055)	25.6	0.0123	0.0928	1.126	3.83%	0.9801	<10%	yes	24.6
Upper Lake	69.0	0.0126	0.0869	1.139	1.33%	0.9175	<10%	yes	68.1
Small Lake Above U-Shaped Lake	59.9	0.0017	0.0250	0.927	0.51%	0.3049	<10%	yes	59.6
U-Shaped Lake	81.4	0.0017	0.0250	0.927	0.37%	0.3049	<10%	yes	81.1
Avalanche Lake	158.8	0.0114	0.1105	1.282	0.63%	1.0020	<10%	yes	157.8
Capitol Lake	154.4	0.0113	0.1087	1.110	0.74%	1.1389	<10%	yes	153.3
Moon Lake (Upper)	53.0	0.0113	0.1087	1.110	2.15%	1.1389	<10%	yes	51.8
Upper Middle Beartrack Lake	50.9	0.0052	0.0492	0.869	1.30%	0.6592	<10%	yes	50.2
Abyss Lake	81.1	0.0049	0.0507	0.896	0.81%	0.6542	<10%	yes	80.4
Frozen Lake	93.3	0.0049	0.0507	0.896	0.70%	0.6542	<10%	yes	92.6
North Lake	80.9	0.0049	0.0507	0.896	0.81%	0.6542	<10%	yes	80.3
South Lake	66.7	0.0049	0.0507	0.896	0.98%	0.6542	<10%	yes	66.1
Lake Elbert	56.6	0.0288	0.1301	1.726	1.70%	0.9594	<10%	yes	55.6
Seven Lakes (LG East)	36.2	0.0203	0.1071	1.546	2.38%	0.8618	<10%	yes	35.4
Summit Lake	48.0	0.0321	0.1301	1.449	2.42%	1.1640	<10%	yes	46.8
Deep Creek Lake	20.6	0.0094	0.0927	0.887	5.89%	1.2130	<1(µeq/L)	no	19.4
Island Lake	71.0	0.0138	0.0792	1.079	1.27%	0.9025	<10%	yes	70.1
Kelly Lake	179.9	0.0138	0.0792	1.079	0.50%	0.9025	<10%	yes	178.9
Rawah Lake #4	41.3	0.0134	0.0808	1.098	2.18%	0.8984	<10%	yes	40.4
Crater Lake (Sangre de Cristo)	162.9	0.0024	0.0258	0.959	0.19%	0.3108	<10%	yes	162.6
Lower Stout Lake	145.2	0.0028	0.0324	0.671	0.38%	0.5539	<10%	yes	144.6
Upper Little Sand Creek Lake	129.5	0.0026	0.0258	1.064	0.22%	0.2813	<10%	yes	129.2
Upper Stout Lake	76.3	0.0028	0.0324	0.671	0.73%	0.5539	<10%	yes	75.8
Glacier Lake (Colorado)	63.4	0.0013	0.0158	1.145	0.25%	0.1572	<10%	yes	63.2
Lake South of Blue Lakes	16.9	0.0013	0.0200	1.312	1.02%	0.1717	<1(µeq/L)	yes	16.7
Big Eldorado Lake	19.6	0.0014	0.0211	1.128	1.08%	0.2113	<1(µeq/L)	yes	19.4
Four Mile Pothole	123.4	0.0015	0.0198	1.173	0.16%	0.1916	<10%	yes	123.2
Lake Due South of Ute Lake	13.2	0.0012	0.0178	1.067	1.43%	0.1881	<1(µeq/L)	yes	13.0
Little Eldorado	-3.3	0.0014	0.0211	1.128	6.40%	0.2113	<1(µeq/L)	yes	-3.5
Little Granite Lake	80.7	0.0011	0.0196	0.830	0.33%	0.2645	<10%	yes	80.5
Lower Sunlight Lake	80.9	0.0018	0.0230	1.177	0.27%	0.2220	<10%	yes	80.6
Middle Ute Lake	42.8	0.0012	0.0177	1.052	0.44%	0.1900	<10%	yes	42.6
Small Pond Above Trout Lake	25.5	0.0012	0.0197	1.087	0.80%	0.2038	<10%	yes	25.3
Upper Grizzly Lake	29.9	0.0020	0.0234	1.177	0.76%	0.2277	<10%	yes	29.7
Upper Sunlight Lake	28.0	0.0020	0.0234	1.177	0.81%	0.2277	<10%	yes	27.8
West Snowdon Lake	39.4	0.0010	0.0212	0.978	0.61%	0.2404	<10%	yes	39.1
White Dome Lake	2.1	0.0014	0.0211	1.128	10.26%	0.2113	<1(µeq/L)	yes	1.8
South Golden Lake	111.4	0.0044	0.0719	0.984	0.74%	0.8204	<10%	yes	110.6

Table 5-37a. ANC calculations at sensitive lakes for new Federal oil and gas development and mining and new non-Federal oil and gas within the 14 Colorado and northern New Mexico BLM Planning Areas (Source Group T) and the 2021 High Development Scenario.

Lake	10th Percentile Lowest ANC Value (μeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	101.7	0.0073	0.1527	0.898	1.86%	1.8877	<10%	yes	99.8
Tabor Lake	112.4	0.0071	0.1557	0.860	1.79%	2.0080	<10%	yes	110.4
Booth Lake	86.8	0.0090	0.2179	0.844	3.29%	2.8510	<10%	yes	83.9
Upper Willow Lake	134.1	0.0072	0.1589	0.741	1.77%	2.3766	<10%	yes	131.7
Ned Wilson Lake	39.0	0.0220	0.2756	1.158	6.96%	2.7137	<10%	yes	36.3
Upper Ned Wilson Lake	12.9	0.0220	0.2756	1.158	21.07%	2.7137	<1(μeq/L)	no	10.2
Lower NWL Packtrail Pothole	29.7	0.0220	0.2756	1.158	9.15%	2.7137	<10%	yes	26.9
Upper NWL Packtrail Pothole	48.7	0.0220	0.2756	1.158	5.57%	2.7137	<10%	yes	46.0
Walk Up Lake	55.2	0.0003	0.0061	0.878	0.14%	0.0780	<10%	yes	55.1
Bluebell Lake	55.5	0.0002	0.0039	0.883	0.09%	0.0484	<10%	yes	55.5
Dean Lake	48.9	0.0001	0.0034	1.061	0.07%	0.0347	<10%	yes	48.8
No Name (Utah, Duchesne - 4D2-039)	67.0	0.0004	0.0075	0.844	0.15%	0.0989	<10%	yes	66.9
Upper Coffin Lake	64.9	0.0002	0.0044	0.960	0.08%	0.0503	<10%	yes	64.8
Fish Lake	105.8	0.0003	0.0059	0.869	0.07%	0.0758	<10%	yes	105.7
Blodgett Lake, Colorado	47.7	0.0097	0.2231	0.928	5.58%	2.6596	<10%	yes	45.0
Upper Turquoise Lake	104.0	0.0112	0.2361	0.809	3.12%	3.2422	<10%	yes	100.8
Upper West Tennessee Lake	114.2	0.0070	0.1798	0.904	1.92%	2.1922	<10%	yes	112.0
Blue Lake (Colorado; Boulder - 4E1-040)	19.3	0.0134	0.2491	1.128	12.81%	2.4663	<1(μeq/L)	no	16.8
Crater Lake	53.1	0.0139	0.2157	1.071	4.27%	2.2690	<10%	yes	50.9
King Lake (Colorado; Grand - 4E1-049)	52.3	0.0136	0.2374	0.959	5.31%	2.7724	<10%	yes	49.5
No Name Lake (Colorado; Boulder - 4E1-055)	25.6	0.0148	0.2713	1.126	10.50%	2.6909	<10%	no	22.9
Upper Lake	69.0	0.0147	0.2274	1.139	3.26%	2.2504	<10%	yes	66.7
Small Lake Above U-Shaped Lake	59.9	0.0023	0.0717	0.927	1.41%	0.8472	<10%	yes	59.1
U-Shaped Lake	81.4	0.0023	0.0717	0.927	1.04%	0.8472	<10%	yes	80.5
Avalanche Lake	158.8	0.0138	0.2629	1.282	1.44%	2.2877	<10%	yes	156.5
Capitol Lake	154.4	0.0139	0.2581	1.110	1.68%	2.5949	<10%	yes	151.8
Moon Lake (Upper)	53.0	0.0139	0.2581	1.110	4.90%	2.5949	<10%	yes	50.4
Upper Middle Beartrack Lake	50.9	0.0070	0.1670	0.869	4.17%	2.1247	<10%	yes	48.8
Abyss Lake	81.1	0.0063	0.1566	0.896	2.38%	1.9289	<10%	yes	79.2
Frozen Lake	93.3	0.0063	0.1566	0.896	2.07%	1.9289	<10%	yes	91.3
North Lake	80.9	0.0063	0.1566	0.896	2.38%	1.9289	<10%	yes	79.0
South Lake	66.7	0.0063	0.1566	0.896	2.89%	1.9289	<10%	yes	64.8
Lake Elbert	56.6	0.0314	0.2514	1.726	3.04%	1.7227	<10%	yes	54.9
Seven Lakes (LG East)	36.2	0.0224	0.2067	1.546	4.31%	1.5610	<10%	yes	34.7
Summit Lake	48.0	0.0345	0.2513	1.449	4.31%	2.0711	<10%	yes	45.9
Deep Creek Lake	20.6	0.0111	0.2214	0.887	13.48%	2.7769	<1(μeq/L)	no	17.8
Island Lake	71.0	0.0155	0.1711	1.079	2.57%	1.8257	<10%	yes	69.2
Kelly Lake	179.9	0.0155	0.1711	1.079	1.02%	1.8257	<10%	yes	178.0
Rawah Lake #4	41.3	0.0151	0.1772	1.098	4.48%	1.8487	<10%	yes	39.4
Crater Lake (Sangre de Cristo)	162.9	0.0034	0.0932	0.959	0.66%	1.0691	<10%	yes	161.9
Lower Stout Lake	145.2	0.0038	0.1045	0.671	1.18%	1.7122	<10%	yes	143.5
Upper Little Sand Creek Lake	129.5	0.0035	0.0905	1.064	0.72%	0.9369	<10%	yes	128.6
Upper Stout Lake	76.3	0.0038	0.1045	0.671	2.24%	1.7122	<10%	yes	74.6
Glacier Lake (Colorado)	63.4	0.0023	0.0741	1.145	1.12%	0.7081	<10%	yes	62.7
Lake South of Blue Lakes	16.9	0.0025	0.0965	1.312	4.74%	0.8013	<1(μeq/L)	yes	16.1
Big Eldorado Lake	19.6	0.0021	0.0637	1.128	3.15%	0.6190	<1(μeq/L)	yes	19.0
Four Mile Pothole	123.4	0.0029	0.0926	1.173	0.70%	0.8647	<10%	yes	122.5
Lake Due South of Ute Lake	13.2	0.0020	0.0617	1.067	4.82%	0.6346	<1(μeq/L)	yes	12.5
Little Eldorado	-3.3	0.0021	0.0637	1.128	18.76%	0.6190	<1(μeq/L)	yes	-3.9
Little Granite Lake	80.7	0.0019	0.0729	0.830	1.19%	0.9583	<10%	yes	79.8
Lower Sunlight Lake	80.9	0.0027	0.0734	1.177	0.85%	0.6867	<10%	yes	80.2
Middle Ute Lake	42.8	0.0019	0.0589	1.052	1.43%	0.6132	<10%	yes	42.2
Small Pond Above Trout Lake	25.5	0.0021	0.0746	1.087	2.94%	0.7494	<10%	yes	24.7
Upper Grizzly Lake	29.9	0.0031	0.0766	1.177	2.40%	0.7182	<10%	yes	29.2
Upper Sunlight Lake	28.0	0.0031	0.0766	1.177	2.57%	0.7182	<10%	yes	27.3
West Snowdon Lake	39.4	0.0015	0.0616	0.978	1.74%	0.6863	<10%	yes	38.7
White Dome Lake	2.1	0.0021	0.0637	1.128	30.05%	0.6190	<1(μeq/L)	yes	1.4
South Golden Lake	111.4	0.0053	0.1712	0.984	1.71%	1.9060	<10%	yes	109.5

* USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC

Table 5-37b. ANC calculations at sensitive lakes for new Federal oil and gas development and mining and new non-Federal oil and gas within the 14 Colorado and northern New Mexico BLM Planning Areas (Source Group T) and the 2021 Low Development Scenario.

Lake	10th Percentile Lowest ANC Value (μeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	101.7	0.0039	0.0528	0.898	0.66%	0.6663	<10%	yes	101.0
Tabor Lake	112.4	0.0038	0.0529	0.860	0.62%	0.6973	<10%	yes	111.7
Booth Lake	86.8	0.0050	0.0745	0.844	1.15%	0.9959	<10%	yes	85.8
Upper Willow Lake	134.1	0.0042	0.0544	0.741	0.62%	0.8349	<10%	yes	133.3
Ned Wilson Lake	39.0	0.0123	0.0913	1.158	2.41%	0.9397	<10%	yes	38.1
Upper Ned Wilson Lake	12.9	0.0123	0.0913	1.158	7.30%	0.9397	<1(μeq/L)	yes	11.9
Lower NWL Packtrail Pothole	29.7	0.0123	0.0913	1.158	3.17%	0.9397	<10%	yes	28.7
Upper NWL Packtrail Pothole	48.7	0.0123	0.0913	1.158	1.93%	0.9397	<10%	yes	47.8
Walk Up Lake	55.2	0.0001	0.0023	0.878	0.05%	0.0293	<10%	yes	55.2
Bluebell Lake	55.5	0.0001	0.0016	0.883	0.04%	0.0203	<10%	yes	55.5
Dean Lake	48.9	0.0000	0.0013	1.061	0.03%	0.0139	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	67.0	0.0001	0.0029	0.844	0.06%	0.0383	<10%	yes	67.0
Upper Coffin Lake	64.9	0.0001	0.0017	0.960	0.03%	0.0197	<10%	yes	64.8
Fish Lake	105.8	0.0001	0.0022	0.869	0.03%	0.0283	<10%	yes	105.7
Blodgett Lake, Colorado	47.7	0.0052	0.0757	0.928	1.93%	0.9220	<10%	yes	46.7
Upper Turquoise Lake	104.0	0.0061	0.0804	0.809	1.09%	1.1299	<10%	yes	102.9
Upper West Tennessee Lake	114.2	0.0038	0.0606	0.904	0.66%	0.7537	<10%	yes	113.4
Blue Lake (Colorado; Boulder - 4E1-040)	19.3	0.0086	0.0832	1.128	4.45%	0.8574	<1(μeq/L)	yes	18.4
Crater Lake	53.1	0.0093	0.0713	1.071	1.49%	0.7904	<10%	yes	52.3
King Lake (Colorado; Grand - 4E1-049)	52.3	0.0091	0.0791	0.959	1.85%	0.9676	<10%	yes	51.3
No Name Lake (Colorado; Boulder - 4E1-055)	25.6	0.0095	0.0922	1.126	3.71%	0.9507	<10%	yes	24.7
Upper Lake	69.0	0.0092	0.0751	1.139	1.13%	0.7789	<10%	yes	68.2
Small Lake Above U-Shaped Lake	59.9	0.0013	0.0341	0.927	0.68%	0.4050	<10%	yes	59.5
U-Shaped Lake	81.4	0.0013	0.0341	0.927	0.50%	0.4050	<10%	yes	81.0
Avalanche Lake	158.8	0.0083	0.0864	1.282	0.49%	0.7788	<10%	yes	158.0
Capitol Lake	154.4	0.0081	0.0855	1.110	0.58%	0.8892	<10%	yes	153.5
Moon Lake (Upper)	53.0	0.0081	0.0855	1.110	1.68%	0.8892	<10%	yes	52.1
Upper Middle Beartrack Lake	50.9	0.0038	0.0610	0.869	1.55%	0.7890	<10%	yes	50.1
Abyss Lake	81.1	0.0035	0.0561	0.896	0.87%	0.7037	<10%	yes	80.4
Frozen Lake	93.3	0.0035	0.0561	0.896	0.75%	0.7037	<10%	yes	92.6
North Lake	80.9	0.0035	0.0561	0.896	0.87%	0.7037	<10%	yes	80.2
South Lake	66.7	0.0035	0.0561	0.896	1.05%	0.7037	<10%	yes	66.0
Lake Elbert	56.6	0.0221	0.0776	1.726	1.06%	0.5989	<10%	yes	56.0
Seven Lakes (LG East)	36.2	0.0142	0.0627	1.546	1.43%	0.5180	<10%	yes	35.7
Summit Lake	48.0	0.0258	0.0770	1.449	1.53%	0.7325	<10%	yes	47.3
Deep Creek Lake	20.6	0.0072	0.0713	0.887	4.53%	0.9324	<1(μeq/L)	yes	19.7
Island Lake	71.0	0.0100	0.0541	1.079	0.87%	0.6214	<10%	yes	70.4
Kelly Lake	179.9	0.0100	0.0541	1.079	0.35%	0.6214	<10%	yes	179.2
Rawah Lake #4	41.3	0.0096	0.0563	1.098	1.52%	0.6284	<10%	yes	40.7
Crater Lake (Sangre de Cristo)	162.9	0.0019	0.0460	0.959	0.32%	0.5292	<10%	yes	162.4
Lower Stout Lake	145.2	0.0019	0.0459	0.671	0.52%	0.7565	<10%	yes	144.4
Upper Little Sand Creek Lake	129.5	0.0019	0.0437	1.064	0.35%	0.4542	<10%	yes	129.0
Upper Stout Lake	76.3	0.0019	0.0459	0.671	0.99%	0.7565	<10%	yes	75.6
Glacier Lake (Colorado)	63.4	0.0014	0.0524	1.145	0.79%	0.4991	<10%	yes	62.9
Lake South of Blue Lakes	16.9	0.0016	0.0695	1.312	3.41%	0.5762	<1(μeq/L)	yes	16.3
Big Eldorado Lake	19.6	0.0011	0.0348	1.128	1.72%	0.3385	<1(μeq/L)	yes	19.3
Four Mile Pothole	123.4	0.0019	0.0647	1.173	0.49%	0.6038	<10%	yes	122.8
Lake Due South of Ute Lake	13.2	0.0012	0.0375	1.067	2.93%	0.3854	<1(μeq/L)	yes	12.8
Little Eldorado	-3.3	0.0011	0.0348	1.128	10.26%	0.3385	<1(μeq/L)	yes	-3.6
Little Granite Lake	80.7	0.0012	0.0454	0.830	0.74%	0.5965	<10%	yes	80.1
Lower Sunlight Lake	80.9	0.0015	0.0424	1.177	0.49%	0.3963	<10%	yes	80.5
Middle Ute Lake	42.8	0.0010	0.0347	1.052	0.84%	0.3608	<10%	yes	42.4
Small Pond Above Trout Lake	25.5	0.0012	0.0465	1.087	1.83%	0.4667	<10%	yes	25.0
Upper Grizzly Lake	29.9	0.0018	0.0450	1.177	1.41%	0.4219	<10%	yes	29.5
Upper Sunlight Lake	28.0	0.0018	0.0450	1.177	1.51%	0.4219	<10%	yes	27.6
West Snowdon Lake	39.4	0.0007	0.0330	0.978	0.93%	0.3666	<10%	yes	39.0
White Dome Lake	2.1	0.0011	0.0348	1.128	16.43%	0.3385	<1(μeq/L)	yes	1.7
South Golden Lake	111.4	0.0031	0.0571	0.984	0.58%	0.6489	<10%	yes	110.8

* USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC

Table 5-37c. ANC calculations at sensitive lakes for new Federal oil and gas development and mining and new non-Federal oil and gas within the 14 Colorado and northern New Mexico BLM Planning Areas (Source Group T) and the 2021 Medium Development Scenario.

Lake	10th Percentile Lowest ANC Value (μeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%)*	Delta ANC (μeq/L)*	USFS LAC Threshold	Below Threshold?	2021 Med Predicted 10th Percentile Lowest ANC Value (μeq/L)
Brooklyn Lake	101.7	0.0071	0.1347	0.898	1.64%	1.6718	<10%	yes	100.0
Tabor Lake	112.4	0.0069	0.1372	0.860	1.58%	1.7763	<10%	yes	110.6
Booth Lake	86.8	0.0088	0.1928	0.844	2.92%	2.5307	<10%	yes	84.2
Upper Willow Lake	134.1	0.0070	0.1413	0.741	1.58%	2.1223	<10%	yes	132.0
Ned Wilson Lake	39.0	0.0217	0.2423	1.158	6.17%	2.4048	<10%	yes	36.6
Upper Ned Wilson Lake	12.9	0.0217	0.2423	1.158	18.67%	2.4048	<1(μeq/L)	no	10.5
Lower NWL Packtrail Pothole	29.7	0.0217	0.2423	1.158	8.11%	2.4048	<10%	yes	27.2
Upper NWL Packtrail Pothole	48.7	0.0217	0.2423	1.158	4.94%	2.4048	<10%	yes	46.3
Walk Up Lake	55.2	0.0003	0.0057	0.878	0.13%	0.0728	<10%	yes	55.2
Bluebell Lake	55.5	0.0001	0.0036	0.883	0.08%	0.0449	<10%	yes	55.5
Dean Lake	48.9	0.0001	0.0031	1.061	0.07%	0.0322	<10%	yes	48.8
No Name (Utah, Duchesne - 4D2-039)	67.0	0.0004	0.0070	0.844	0.14%	0.0924	<10%	yes	66.9
Upper Coffin Lake	64.9	0.0002	0.0041	0.960	0.07%	0.0469	<10%	yes	64.8
Fish Lake	105.8	0.0003	0.0055	0.869	0.07%	0.0708	<10%	yes	105.7
Blodgett Lake, Colorado	47.7	0.0094	0.1971	0.928	4.95%	2.3588	<10%	yes	45.3
Upper Turquoise Lake	104.0	0.0109	0.2084	0.809	2.76%	2.8736	<10%	yes	101.1
Upper West Tennessee Lake	114.2	0.0068	0.1588	0.904	1.70%	1.9433	<10%	yes	112.3
Blue Lake (Colorado; Boulder - 4E1-040)	19.3	0.0133	0.2273	1.128	11.73%	2.2589	<1(μeq/L)	no	17.0
Crater Lake	53.1	0.0137	0.1964	1.071	3.91%	2.0754	<10%	yes	51.1
King Lake (Colorado; Grand - 4E1-049)	52.3	0.0135	0.2170	0.959	4.87%	2.5434	<10%	yes	49.7
No Name Lake (Colorado; Boulder - 4E1-055)	25.6	0.0146	0.2490	1.126	9.67%	2.4781	<10%	yes	23.1
Upper Lake	69.0	0.0146	0.2069	1.139	2.98%	2.0569	<10%	yes	66.9
Small Lake Above U-Shaped Lake	59.9	0.0022	0.0636	0.927	1.26%	0.7533	<10%	yes	59.1
U-Shaped Lake	81.4	0.0022	0.0636	0.927	0.93%	0.7533	<10%	yes	80.6
Avalanche Lake	158.8	0.0135	0.2321	1.282	1.28%	2.0283	<10%	yes	156.8
Capitol Lake	154.4	0.0135	0.2281	1.110	1.49%	2.3031	<10%	yes	152.1
Moon Lake (Upper)	53.0	0.0135	0.2281	1.110	4.35%	2.3031	<10%	yes	50.7
Upper Middle Beartrack Lake	50.9	0.0068	0.1541	0.869	3.86%	1.9647	<10%	yes	48.9
Abyss Lake	81.1	0.0062	0.1432	0.896	2.18%	1.7692	<10%	yes	79.3
Frozen Lake	93.3	0.0062	0.1432	0.896	1.90%	1.7692	<10%	yes	91.5
North Lake	80.9	0.0062	0.1432	0.896	2.19%	1.7692	<10%	yes	79.2
South Lake	66.7	0.0062	0.1432	0.896	2.65%	1.7692	<10%	yes	65.0
Lake Elbert	56.6	0.0311	0.2264	1.726	2.77%	1.5664	<10%	yes	55.0
Seven Lakes (LG East)	36.2	0.0222	0.1859	1.546	3.91%	1.4167	<10%	yes	34.8
Summit Lake	48.0	0.0343	0.2262	1.449	3.93%	1.8847	<10%	yes	46.1
Deep Creek Lake	20.6	0.0109	0.1950	0.887	11.93%	2.4569	<1(μeq/L)	no	18.1
Island Lake	71.0	0.0153	0.1536	1.079	2.33%	1.6514	<10%	yes	69.4
Kelly Lake	179.9	0.0153	0.1536	1.079	0.92%	1.6514	<10%	yes	178.2
Rawah Lake #4	41.3	0.0149	0.1591	1.098	4.05%	1.6719	<10%	yes	39.6
Crater Lake (Sangre de Cristo)	162.9	0.0033	0.0837	0.959	0.59%	0.9634	<10%	yes	162.0
Lower Stout Lake	145.2	0.0037	0.0943	0.671	1.07%	1.5492	<10%	yes	143.7
Upper Little Sand Creek Lake	129.5	0.0034	0.0814	1.064	0.65%	0.8447	<10%	yes	128.7
Upper Stout Lake	76.3	0.0037	0.0943	0.671	2.03%	1.5492	<10%	yes	74.8
Glacier Lake (Colorado)	63.4	0.0021	0.0646	1.145	0.98%	0.6183	<10%	yes	62.8
Lake South of Blue Lakes	16.9	0.0023	0.0839	1.312	4.13%	0.6979	<1(μeq/L)	yes	16.2
Big Eldorado Lake	19.6	0.0020	0.0565	1.128	2.80%	0.5499	<1(μeq/L)	yes	19.1
Four Mile Pothole	123.4	0.0027	0.0802	1.173	0.61%	0.7502	<10%	yes	122.6
Lake Due South of Ute Lake	13.2	0.0019	0.0543	1.067	4.25%	0.5593	<1(μeq/L)	yes	12.6
Little Eldorado	-3.3	0.0020	0.0565	1.128	16.66%	0.5499	<1(μeq/L)	yes	-3.8
Little Granite Lake	80.7	0.0018	0.0639	0.830	1.04%	0.8408	<10%	yes	79.9
Lower Sunlight Lake	80.9	0.0026	0.0649	1.177	0.75%	0.6080	<10%	yes	80.3
Middle Ute Lake	42.8	0.0018	0.0519	1.052	1.27%	0.5419	<10%	yes	42.2
Small Pond Above Trout Lake	25.5	0.0020	0.0653	1.087	2.58%	0.6573	<10%	yes	24.8
Upper Grizzly Lake	29.9	0.0030	0.0675	1.177	2.13%	0.6352	<10%	yes	29.2
Upper Sunlight Lake	28.0	0.0030	0.0675	1.177	2.27%	0.6352	<10%	yes	27.4
West Snowdon Lake	39.4	0.0014	0.0548	0.978	1.55%	0.6107	<10%	yes	38.7
White Dome Lake	2.1	0.0020	0.0565	1.128	26.69%	0.5499	<1(μeq/L)	yes	1.5
South Golden Lake	111.4	0.0052	0.1515	0.984	1.52%	1.6909	<10%	yes	109.7

* USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC

5.6 2021 NAAQS Comparisons

In this section we compare the CAMx 2021 High. Low and Medium Development Scenario modeling results against the National Ambient Air Quality Standard (NAAQS). For the ozone NAAQS analysis, the results are analyzed using both the absolute CAMx 2021 modeling results as well as using the CAMx 2008 and 2021 modeling results in a relative fashion to scale the observed current year Design Values (DVC) to project future year 2021 Design Values (DVF) as recommended by EPA (2007) and described in Section 4.5.

5.6.1 Ozone NAAQS Analysis using Relative Modeling Results

EPA's Model Attainment Test Software (MATS) was used to make future year ozone Design Value (DV) projections using the CAMx 2008 Base Case and 2021 High and Low Development Scenario modeling results. MATS was also used to make future year 2021 ozone DV (DVF) projections for the 2021 High and Low Development Scenario removing the contributions of four of the combined Source Groups R, S, T and U. MATS was used to make 2021 ozone DVF projections at the monitoring sites as well as throughout the CARMMS modeling domain using the MATS Unmonitored Area Analysis (UAA) procedures.

5.6.1.1 Ozone Design Value Projections at Monitoring Sites

The results of the 2021 ozone DVF projections at the monitoring sites are given in Attachments F-1, F-2 and F-3 and shown in Table 5-39. The maximum current year DVC (DVC; based on 2006-2010 observations) is 82.0 ppb at the Rocky Flats North (CO_Jefferson_006) monitor that is projected to be reduced to 79.5, 78.1 and 79.5 ppb for the 2021 High, Low and Medium Development Scenarios, respectively. There are 8 monitoring sites in the CARMMS 4 km domain with current year DVCs above the ozone NAAQS that are reduced to two sites in the 2021 emission scenarios, Rocky Flats North and Fort Collins West (CO_Larimer_0011). Removing the contributions due to new O&G and mining on Federal lands within the 13 Colorado BLM Planning Areas (Source Group R) reduces the 2021 DVF at Rocky Flats North by 0.9 ppb to 78.6 ppb for the High, by 0.3 ppb to 77.8 ppb for the Low and by 0.8 ppb to 78.7 ppb for the Medium Development Scenarios, which are still above the ozone NAAQS (76.0 ppb or higher). However, when emissions from new non-Federal O&G within the 13 Colorado Planning Areas are also removed (Source Group S), the projected 2021 DVFs are 74.5, 75.8 and 74.5 ppb for the High, Low and Medium Development Scenarios. The maximum reduction in 2021 DVFs due to the removal of Source Group R at any monitor is 0.9 ppb at the Rocky Flats North and South Bolder Creek (CO_Boulder_0011) monitoring site for the High Development Scenario. Whereas maximum reduction from removing Source Group R for the Low and Medium Scenarios are 0.3 and 0.8 ppb at Rocky Flats North. The maximum reduction in 2021 DVF due to the removal of Source Group S, T and U in the High Development Scenario are, respectively, 7.2, 7.3 and 9.0 ppb at the Greely – Weld Tower (CO_Weld_009) monitoring site. Most of the O&G development in Weld County (Royal Gorge FO Area#1; Source Group I) is on non-Federal lands so the monitors in Weld County are less affected by the Federal O&G development (Source Group R).

Table 5-39a. Current year ozone Design Values (DVC) and projected 2021 future year ozone Design Values (DVF) for the 2021 High Development Scenario and without Source Group R, S, T and U.

CID	Name	Lat	Long	State	County	DVC	DVF					Contribution from			
							2021 Hi	2021 Hi w/o R	2021 Hi w/o S	2021 Hi w/o T	2021 Hi w/o U	Group R	Group S	Group T	Group U
080013001	CO_Adams_3001	39.8381	-104.9498	Colorado	Adams	71.5	70.5	69.7	67.2	67.2	65.6	0.8	3.3	3.3	4.9
080130011	CO_Boulder_0011	39.9572	-105.2385	Colorado	Boulder	77.3	74.4	73.5	69.0	69.0	66.8	0.9	5.4	5.4	7.6
080310014	CO_Denver_0014	39.7518	-105.0307	Colorado	Denver	70.3	69.0	68.3	66.2	66.2	64.8	0.7	2.8	2.8	4.2
080350004	CO_Douglas_0004	39.5345	-105.0704	Colorado	Douglas	78.3	75.7	74.9	72.3	72.3	70.7	0.8	3.4	3.4	5.0
080410013	CO_El Paso_0013	38.9583	-104.8172	Colorado	El Paso	68.0	66.0	65.4	64.5	64.5	63.3	0.6	1.5	1.5	2.7
080410016	CO_El Paso_0016	38.8531	-104.9013	Colorado	El Paso	70.3	68.8	68.4	67.7	67.6	66.4	0.4	1.1	1.2	2.4
080590002	CO_Jefferson_0002	39.8003	-105.1000	Colorado	Jefferson	75.0	73.5	72.6	70.0	70.0	68.4	0.9	3.5	3.5	5.1
080590005	CO_Jefferson_0005	39.6388	-105.1395	Colorado	Jefferson	74.3	72.4	71.8	70.0	70.0	68.8	0.6	2.4	2.4	3.6
080590006	CO_Jefferson_0006	39.9128	-105.1886	Colorado	Jefferson	82.0	79.5	78.6	74.5	74.5	72.4	0.9	5.0	5.0	7.1
080590011	CO_Jefferson_0011	39.7437	-105.1780	Colorado	Jefferson	76.3	74.0	73.3	71.0	71.0	69.7	0.7	3.0	3.0	4.3
080671004	CO_La Plata_1004	37.3039	-107.4842	Colorado	La Plata	70.0	69.8	69.5	69.3	69.3	68.9	0.3	0.5	0.5	0.9
080677001	CO_La Plata_7001	37.1368	-107.6286	Colorado	La Plata	66.0	65.9	65.5	65.1	64.8	61.6	0.4	0.8	1.1	4.3
080677003	CO_La Plata_7003	37.1026	-107.8702	Colorado	La Plata	67.0	66.8	66.4	66.0	65.8	62.9	0.4	0.8	1.0	3.9
080690007	CO_Larimer_0007	40.2772	-105.5450	Colorado	Larimer	74.3	72.7	72.4	70.1	70.1	68.9	0.3	2.6	2.6	3.8
080690011	CO_Larimer_0011	40.5925	-105.1411	Colorado	Larimer	78.0	78.9	78.6	73.5	73.5	72.1	0.3	5.4	5.4	6.8
080691004	CO_Larimer_1004	40.5775	-105.0789	Colorado	Larimer	67.3	67.4	67.2	62.9	62.9	61.7	0.2	4.5	4.5	5.7
080830101	CO_Montezuma_0101	37.1983	-108.4903	Colorado	Montezuma	69.3	68.9	68.6	68.3	68.3	66.5	0.3	0.6	0.6	2.4
081230009	CO_Weld_0009	40.3864	-104.7374	Colorado	Weld	72.7	72.1	71.5	64.9	64.8	63.1	0.6	7.2	7.3	9.0
350010023	NM_Bernalillo_0023	35.1343	-106.5852	New Mexico	Bernalillo	66.0	63.8	63.6	63.5	63.4	62.4	0.2	0.3	0.4	1.4
350010024	NM_Bernalillo_0024	35.0631	-106.5788	New Mexico	Bernalillo	67.3	64.8	64.7	64.5	64.5	63.5	0.1	0.3	0.3	1.3
350010027	NM_Bernalillo_0027	35.1539	-106.6972	New Mexico	Bernalillo	68.3	64.7	64.6	64.5	64.5	63.7	0.1	0.2	0.2	1.0
350010029	NM_Bernalillo_0029	35.0171	-106.6574	New Mexico	Bernalillo	67.0	64.8	64.6	64.5	64.5	63.5	0.2	0.3	0.3	1.3
350011012	NM_Bernalillo_1012	35.1852	-106.5082	New Mexico	Bernalillo	69.0	66.7	66.5	66.3	66.3	65.2	0.2	0.4	0.4	1.5
350011013	NM_Bernalillo_1013	35.1932	-106.6138	New Mexico	Bernalillo	68.7	66.0	65.9	65.7	65.7	64.6	0.1	0.3	0.3	1.4
350431001	NM_Sandoval_1001	35.2994	-106.5483	New Mexico	Sandoval	60.3	58.3	58.1	58.0	57.9	56.9	0.2	0.3	0.4	1.4
350431003	NM_Sandoval_1003	35.2381	-106.6494	New Mexico	Sandoval	70.0	67.2	67.1	66.9	66.9	65.8	0.1	0.3	0.3	1.4
350439004	NM_Sandoval_9004	35.6153	-106.7244	New Mexico	Sandoval	68.0	67.8	67.5	67.2	67.1	65.4	0.3	0.6	0.7	2.4
350450009	NM_San Juan_0009	36.7422	-107.9769	New Mexico	San Juan	62.0	61.0	60.8	60.5	60.3	55.6	0.2	0.5	0.7	5.4
350451005	NM_San Juan_1005	36.7967	-108.4725	New Mexico	San Juan	67.0	65.9	65.5	65.0	64.8	61.2	0.4	0.9	1.1	4.7
490110004	UT_Davis_0004	40.9030	-111.8845	Utah	Davis	77.0	74.5	74.5	74.4	74.4	74.2	0.0	0.1	0.1	0.3
490350003	UT_Salt Lake_0003	40.6467	-111.8497	Utah	Salt Lake	78.0	75.8	75.8	75.8	75.8	75.6	0.0	0.0	0.0	0.2
490352004	UT_Salt Lake_2004	40.7364	-112.2103	Utah	Salt Lake	75.7	73.3	73.3	73.3	73.3	73.1	0.0	0.0	0.0	0.2
490353006	UT_Salt Lake_3006	40.7364	-111.8722	Utah	Salt Lake	77.0	74.3	74.3	74.3	74.3	74.1	0.0	0.0	0.0	0.2
490370101	UT_San Juan_0101	38.4500	-109.8167	Utah	San Juan	70.0	69.2	69.1	69.0	69.0	68.5	0.1	0.2	0.2	0.7
490490002	UT_Utah_0002	40.2536	-111.6631	Utah	Utah	72.0	70.3	70.3	70.3	70.3	70.2	0.0	0.0	0.0	0.1
490495008	UT_Utah_5008	40.4303	-111.8039	Utah	Utah	72.3	70.4	70.4	70.4	70.4	70.3	0.0	0.0	0.0	0.1
490495010	UT_Utah_5010	40.1364	-111.6597	Utah	Utah	72.3	70.3	70.3	70.3	70.3	70.2	0.0	0.0	0.0	0.1

Table 5-39b. Current year ozone Design Values (DVC) and projected 2021 future year ozone Design Values (DVF) for the 2021 Low Development Scenario and without Source Group R, S, T and U.

CID	Name	Lat	Long	State	County	DVC	DVF					Contribution from			
							2021 Low	2021 Low w/o R	2021 Low w/o S	2021 Low w/o T	2021 Low w/o U	Group R	Group S	Group T	Group U
080013001	CO_Adams_3001	39.8381	-104.9498	Colorado	Adams	71.5	69.6	69.4	68.1	68.1	66.3	0.2	1.5	1.5	3.3
080130011	CO_Boulder_0011	39.9572	-105.2385	Colorado	Boulder	77.3	72.8	72.6	70.3	70.2	67.9	0.2	2.5	2.6	4.9
080310014	CO_Denver_0014	39.7518	-105.0307	Colorado	Denver	70.3	68.2	68.0	67.0	66.9	65.5	0.2	1.2	1.3	2.7
080350004	CO_Douglas_0004	39.5345	-105.0704	Colorado	Douglas	78.3	74.7	74.5	73.2	73.2	71.5	0.2	1.5	1.5	3.2
080410013	CO_El Paso_0013	38.9583	-104.8172	Colorado	El Paso	68.0	65.6	65.5	65.0	64.9	63.7	0.1	0.6	0.7	1.9
080410016	CO_El Paso_0016	38.8531	-104.9013	Colorado	El Paso	70.3	68.6	68.5	68.1	68.0	66.8	0.1	0.5	0.6	1.8
080590002	CO_Jefferson_0002	39.8003	-105.1000	Colorado	Jefferson	75.0	72.5	72.3	70.9	70.9	69.2	0.2	1.6	1.6	3.3
080590005	CO_Jefferson_0005	39.6388	-105.1395	Colorado	Jefferson	74.3	71.7	71.5	70.6	70.6	69.3	0.2	1.1	1.1	2.4
080590006	CO_Jefferson_0006	39.9128	-105.1886	Colorado	Jefferson	82.0	78.1	77.8	75.8	75.8	73.4	0.3	2.3	2.3	4.7
080590011	CO_Jefferson_0011	39.7437	-105.1780	Colorado	Jefferson	76.3	73.2	73.1	71.9	71.8	70.4	0.1	1.3	1.4	2.8
080671004	CO_La Plata_1004	37.3039	-107.4842	Colorado	La Plata	70.0	69.7	69.6	69.4	69.4	69.0	0.1	0.3	0.3	0.7
080677001	CO_La Plata_7001	37.1368	-107.6286	Colorado	La Plata	66.0	65.7	65.7	65.3	65.0	61.8	0.0	0.4	0.7	3.9
080677003	CO_La Plata_7003	37.1026	-107.8702	Colorado	La Plata	67.0	66.7	66.6	66.2	66.0	63.1	0.1	0.5	0.7	3.6
080690007	CO_Larimer_0007	40.2772	-105.5450	Colorado	Larimer	74.3	71.9	71.9	70.7	70.7	69.3	0.0	1.2	1.2	2.6
080690011	CO_Larimer_0011	40.5925	-105.1411	Colorado	Larimer	78.0	77.2	77.2	73.9	73.9	72.0	0.0	3.3	3.3	5.2
080691004	CO_Larimer_1004	40.5775	-105.0789	Colorado	Larimer	67.3	66.0	65.9	63.2	63.2	61.7	0.1	2.8	2.8	4.3
080830101	CO_Montezuma_0101	37.1983	-108.4903	Colorado	Montezuma	69.3	68.8	68.7	68.5	68.4	66.6	0.1	0.3	0.4	2.2
081230009	CO_Weld_0009	40.3864	-104.7374	Colorado	Weld	72.7	70.3	70.1	66.0	66.0	63.5	0.2	4.3	4.3	6.8
350010023	NM_Bernalillo_0023	35.1343	-106.5852	New Mexico	Bernalillo	66.0	63.7	63.7	63.6	63.5	62.5	0.0	0.1	0.2	1.2
350010024	NM_Bernalillo_0024	35.0631	-106.5788	New Mexico	Bernalillo	67.3	64.8	64.7	64.6	64.6	63.5	0.1	0.2	0.2	1.3
350010027	NM_Bernalillo_0027	35.1539	-106.6972	New Mexico	Bernalillo	68.3	64.7	64.7	64.6	64.5	63.7	0.0	0.1	0.2	1.0
350010029	NM_Bernalillo_0029	35.0171	-106.6574	New Mexico	Bernalillo	67.0	64.7	64.7	64.6	64.6	63.6	0.0	0.1	0.1	1.1
350011012	NM_Bernalillo_1012	35.1852	-106.5082	New Mexico	Bernalillo	69.0	66.6	66.6	66.4	66.4	65.3	0.0	0.2	0.2	1.3
350011013	NM_Bernalillo_1013	35.1932	-106.6138	New Mexico	Bernalillo	68.7	66.0	65.9	65.8	65.8	64.7	0.1	0.2	0.2	1.3
350431001	NM_Sandoval_1001	35.2994	-106.5483	New Mexico	Sandoval	60.3	58.2	58.2	58.1	58.0	56.9	0.0	0.1	0.2	1.3
350431003	NM_Sandoval_1003	35.2381	-106.6494	New Mexico	Sandoval	70.0	67.2	67.2	67.0	67.0	65.9	0.0	0.2	0.2	1.3
350439004	NM_Sandoval_9004	35.6153	-106.7244	New Mexico	Sandoval	68.0	67.7	67.6	67.4	67.3	65.5	0.1	0.3	0.4	2.2
350450009	NM_San Juan_0009	36.7422	-107.9769	New Mexico	San Juan	62.0	60.9	60.9	60.6	60.4	55.7	0.0	0.3	0.5	5.2
350451005	NM_San Juan_1005	36.7967	-108.4725	New Mexico	San Juan	67.0	65.7	65.6	65.2	65.1	61.4	0.1	0.5	0.6	4.3
490110004	UT_Davis_0004	40.9030	-111.8845	Utah	Davis	77.0	74.5	74.5	74.5	74.5	74.3	0.0	0.0	0.0	0.2
490350003	UT_Salt Lake_0003	40.6467	-111.8497	Utah	Salt Lake	78.0	75.8	75.8	75.8	75.8	75.6	0.0	0.0	0.0	0.2
490352004	UT_Salt Lake_2004	40.7364	-112.2103	Utah	Salt Lake	75.7	73.3	73.3	73.3	73.3	73.1	0.0	0.0	0.0	0.2
490353006	UT_Salt Lake_3006	40.7364	-111.8722	Utah	Salt Lake	77.0	74.3	74.3	74.3	74.3	74.1	0.0	0.0	0.0	0.2
490370101	UT_San Juan_0101	38.4500	-109.8167	Utah	San Juan	70.0	69.2	69.1	69.1	69.1	68.5	0.1	0.1	0.1	0.7
490490002	UT_Utah_0002	40.2536	-111.6631	Utah	Utah	72.0	70.3	70.3	70.3	70.3	70.2	0.0	0.0	0.0	0.1
490495008	UT_Utah_5008	40.4303	-111.8039	Utah	Utah	72.3	70.4	70.4	70.4	70.4	70.3	0.0	0.0	0.0	0.1
490495010	UT_Utah_5010	40.1364	-111.6597	Utah	Utah	72.3	70.3	70.3	70.3	70.3	70.2	0.0	0.0	0.0	0.1

Table 5-39c. Current year ozone Design Values (DVC) and projected 2021 future year ozone Design Values (DVF) for the 2021 Medium Development Scenario and without Source Group R, S, T and U.

CID	Name	Lat	Long	State	County	DVC	DVF					Contribution from			
							2021 Med	2021 Med w/o R	2021 Med w/o S	2021 Med w/o T	2021 Med w/o U	Group R	Group S	Group T	Group U
080013001	CO_Adams_3001	39.8381	-104.9498	Colorado	Adams	71.5	70.5	69.8	67.3	67.2	65.6	0.7	3.2	3.3	4.9
080130011	CO_Boulder_0011	39.9572	-105.2385	Colorado	Boulder	77.3	74.4	73.6	69.1	69.1	66.9	0.8	5.3	5.3	7.5
080310014	CO_Denver_0014	39.7518	-105.0307	Colorado	Denver	70.3	69.0	68.3	66.2	66.2	64.9	0.7	2.8	2.8	4.1
080350004	CO_Douglas_0004	39.5345	-105.0704	Colorado	Douglas	78.3	75.6	75.0	72.3	72.3	70.8	0.6	3.3	3.3	4.8
080410013	CO_El Paso_0013	38.9583	-104.8172	Colorado	El Paso	68.0	66.0	65.5	64.5	64.5	63.3	0.5	1.5	1.5	2.7
080410016	CO_El Paso_0016	38.8531	-104.9013	Colorado	El Paso	70.3	68.8	68.4	67.7	67.7	66.5	0.4	1.1	1.1	2.3
080590002	CO_Jefferson_0002	39.8003	-105.1000	Colorado	Jefferson	75.0	73.4	72.6	70.0	70.0	68.5	0.8	3.4	3.4	4.9
080590005	CO_Jefferson_0005	39.6388	-105.1395	Colorado	Jefferson	74.3	72.4	71.8	70.0	70.0	68.8	0.6	2.4	2.4	3.6
080590006	CO_Jefferson_0006	39.9128	-105.1886	Colorado	Jefferson	82.0	79.5	78.7	74.5	74.5	72.4	0.8	5.0	5.0	7.1
080590011	CO_Jefferson_0011	39.7437	-105.1780	Colorado	Jefferson	76.3	74.0	73.4	71.1	71.0	69.7	0.6	2.9	3.0	4.3
080671004	CO_La Plata_1004	37.3039	-107.4842	Colorado	La Plata	70.0	69.8	69.5	69.3	69.3	68.9	0.3	0.5	0.5	0.9
080677001	CO_La Plata_7001	37.1368	-107.6286	Colorado	La Plata	66.0	65.8	65.5	65.1	64.9	61.6	0.3	0.7	0.9	4.2
080677003	CO_La Plata_7003	37.1026	-107.8702	Colorado	La Plata	67.0	66.8	66.4	66.0	65.9	62.9	0.4	0.8	0.9	3.9
080690007	CO_Larimer_0007	40.2772	-105.5450	Colorado	Larimer	74.3	72.7	72.5	70.2	70.1	69.0	0.2	2.5	2.6	3.7
080690011	CO_Larimer_0011	40.5925	-105.1411	Colorado	Larimer	78.0	78.9	78.7	73.5	73.5	72.1	0.2	5.4	5.4	6.8
080691004	CO_Larimer_1004	40.5775	-105.0789	Colorado	Larimer	67.3	67.4	67.2	62.9	62.9	61.7	0.2	4.5	4.5	5.7
080830101	CO_Montezuma_0101	37.1983	-108.4903	Colorado	Montezuma	69.3	68.9	68.6	68.3	68.3	66.5	0.3	0.6	0.6	2.4
081230009	CO_Weld_0009	40.3864	-104.7374	Colorado	Weld	72.7	72.0	71.5	64.9	64.9	63.1	0.5	7.1	7.1	8.9
350010023	NM_Bernalillo_0023	35.1343	-106.5852	New Mexico	Bernalillo	66.0	63.8	63.6	63.5	63.5	62.4	0.2	0.3	0.3	1.4
350010024	NM_Bernalillo_0024	35.0631	-106.5788	New Mexico	Bernalillo	67.3	64.8	64.7	64.5	64.5	63.5	0.1	0.3	0.3	1.3
350010027	NM_Bernalillo_0027	35.1539	-106.6972	New Mexico	Bernalillo	68.3	64.7	64.6	64.5	64.5	63.7	0.1	0.2	0.2	1.0
350010029	NM_Bernalillo_0029	35.0171	-106.6574	New Mexico	Bernalillo	67.0	64.8	64.6	64.5	64.5	63.6	0.2	0.3	0.3	1.2
350011012	NM_Bernalillo_1012	35.1852	-106.5082	New Mexico	Bernalillo	69.0	66.7	66.5	66.3	66.3	65.2	0.2	0.4	0.4	1.5
350011013	NM_Bernalillo_1013	35.1932	-106.6138	New Mexico	Bernalillo	68.7	66.0	65.9	65.7	65.7	64.7	0.1	0.3	0.3	1.3
350431001	NM_Sandoval_1001	35.2994	-106.5483	New Mexico	Sandoval	60.3	58.3	58.1	58.0	58.0	56.9	0.2	0.3	0.3	1.4
350431003	NM_Sandoval_1003	35.2381	-106.6494	New Mexico	Sandoval	70.0	67.2	67.1	67.0	66.9	65.8	0.1	0.2	0.3	1.4
350439004	NM_Sandoval_9004	35.6153	-106.7244	New Mexico	Sandoval	68.0	67.8	67.5	67.2	67.1	65.4	0.3	0.6	0.7	2.4
350450009	NM_San Juan_0009	36.7422	-107.9769	New Mexico	San Juan	62.0	61.0	60.8	60.5	60.3	55.7	0.2	0.5	0.7	5.3
350451005	NM_San Juan_1005	36.7967	-108.4725	New Mexico	San Juan	67.0	65.8	65.5	65.0	64.9	61.2	0.3	0.8	0.9	4.6
490110004	UT_Davis_0004	40.9030	-111.8845	Utah	Davis	77.0	74.5	74.5	74.4	74.4	74.2	0.0	0.1	0.1	0.3
490350003	UT_Salt Lake_0003	40.6467	-111.8497	Utah	Salt Lake	78.0	75.8	75.8	75.8	75.8	75.6	0.0	0.0	0.0	0.2
490352004	UT_Salt Lake_2004	40.7364	-112.2103	Utah	Salt Lake	75.7	73.3	73.3	73.3	73.3	73.1	0.0	0.0	0.0	0.2
490353006	UT_Salt Lake_3006	40.7364	-111.8722	Utah	Salt Lake	77.0	74.3	74.3	74.3	74.3	74.1	0.0	0.0	0.0	0.2
490370101	UT_San Juan_0101	38.4500	-109.8167	Utah	San Juan	70.0	69.2	69.1	69.0	69.0	68.5	0.1	0.2	0.2	0.7
490490002	UT_Utah_0002	40.2536	-111.6631	Utah	Utah	72.0	70.3	70.3	70.3	70.3	70.2	0.0	0.0	0.0	0.1
490495008	UT_Utah_5008	40.4303	-111.8039	Utah	Utah	72.3	70.4	70.4	70.4	70.4	70.3	0.0	0.0	0.0	0.1
490495010	UT_Utah_5010	40.1364	-111.6597	Utah	Utah	72.3	70.3	70.3	70.3	70.3	70.2	0.0	0.0	0.0	0.1

5.6.1.2 Ozone Design Value Projection Unmonitored Area Analysis

MATS was used to perform an unmonitored area analysis (UAA) of the 2021 ozone DVF projections for the 2021 High, Low and Medium Development Scenarios and the 2021 results without the contributions from the combined Source Groups R, S, T and U. The MATS UAA interpolates the current year observed ozone DVCs across the CARMMS 4 km domain and then makes 2021 ozone DVF projections throughout the domain using the relative change in the CAMx 2008 and 2021 modeling results in each 4 km grid cell. Figure 5-1 displays the spatial distribution of the MATS UAA derived 2008 ozone DVCs and 2021 ozone DVFs and their differences for the three 2021 emission scenarios. The color scheme for the spatial plots has a cut-point at 76.0 ppb so tiles that are yellow or warmer indicate exceedances of the 0.075 ppm ozone NAAQS. The current year DVCs indicate areas of ozone exceedances in Denver and Salt Lake City with a maximum DVC of 81.5 ppb just northwest of Denver (Figure 5-1, top left). For the 2021 High, Low and Medium Development Scenarios the areas of 2021 ozone DVF exceedances is reduced and limited to smaller areas in the Denver and SLC area and just east of SLC with a peak DVF of 79.3, 77.5 and 79.2 ppb for the 2021 High, Low and Medium Development Scenarios, respectively, just northwest of Denver near Rocky Flats North (top right in Figures 5-1a, 5-1b and 5-1c). The 2021 DVF – 2008 DVC difference plots (Figure 5-1, bottom) shows mainly ozone reductions with the largest reduction in the Denver and SLC areas but ozone increases in the Piceance Basin (Garfield County) for the 2021 High Scenario (Figure 5-1a) that is not scene for the Low Scenario (Figure 5-1b), but is seen in the Medium Development Scenario (Figure 5-1c). Although the largest ozone increase in both 2021 scenarios occurs near downtown Denver and is due to less fresh NO_X emissions that suppress urban ozone concentrations.

The 2021 High Development Scenario UAA ozone DVF without Source Group R (Federal O&G and mining in 13 CO BLM Planning Areas) results in reduction in the DVFs with the highest reduction of 6.4 ppb in the Piceance Basin and the peak DVF being reduced from 79.3 to 78.4 ppb that occurs just northwest of Denver (Figure 5-2a, top panels). In contrast, the removal of Source Group R from the 2021 Low Development Scenario results in smaller ozone reductions mainly in the Piceance Basin with a maximum reduction of 2.8 ppb (Figure 5-3a, top panels). The removal of Source Group R from the 2021 Medium Development Scenario reduces the maximum 2021 DFV from 79.2 to 78.5 ppb with a maximum DFV reduction of 5.6 ppb that occurs in the Piceance Basin (Figure 5-4a). There are still areas in Denver and SLC with 2021 DVFs exceeding the NAAQS with Source Group R removed.

Removing both Federal O&G and mining and non-Federal O&G (Source Group S) results in more reductions in the 2021 DVFs, especially in Weld County in the greater Denver area (Figures 5-2a, 5-3a and 5-4a, bottom panels). There are large reductions in 2021 DVFs in the Piceance and D-J Basins (Weld County) with the largest reduction being 12.8 ppb (High Scenario), 8.5 ppb (Low Scenario) and 12.2 ppb (Medium Scenario) in the Piceance Basin. There are no longer any ozone exceedances in the greater Denver area without emissions from Source Group S. The peak 2021 DVF is now ~77 ppb in the SLC area.

Source Group T adds the new O&G within the Mancos Shale development area to Source Group S (Figures 5-2b, 5-3b and 5-4b, top panels) and results in nearly identical 2021 DVFs as Source Group S in Colorado only with more ozone reductions in northwestern New Mexico.

When all O&G emissions are removed from the 2021 High and Low Development Scenarios in Source Group U, there are widespread reductions in the 2021 ozone DVFs throughout Colorado and spreading into Utah and New Mexico. Large ozone reductions occur in the D-J Basin (Weld County), Piceance Basin, Uinta Basin and South San Juan Basin; the single grid cell with the highest ozone reduction in the High (-18.8 ppb), Low (-16.1 ppb) and Medium (-18.4 ppb) occurs in the Piceance Basin (Figures 5-2b, 5-3b and 5-3c, bottom panels).

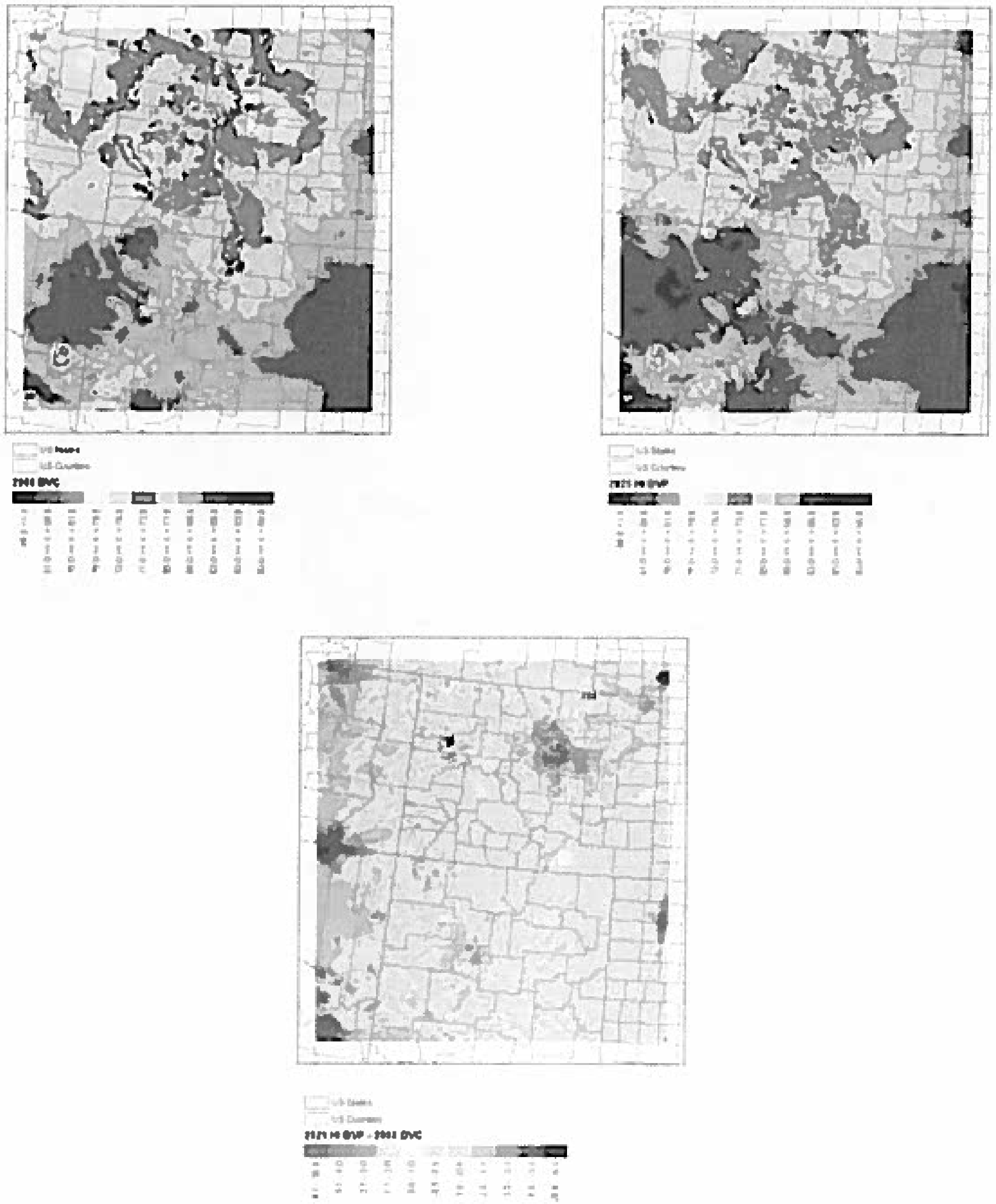

Figure 5-1a. 2008 ozone DVC (top left), 2021 High Development Scenario ozone DVF (top right) and their differences (2021 High – 2008) (bottom) calculated using MATS.

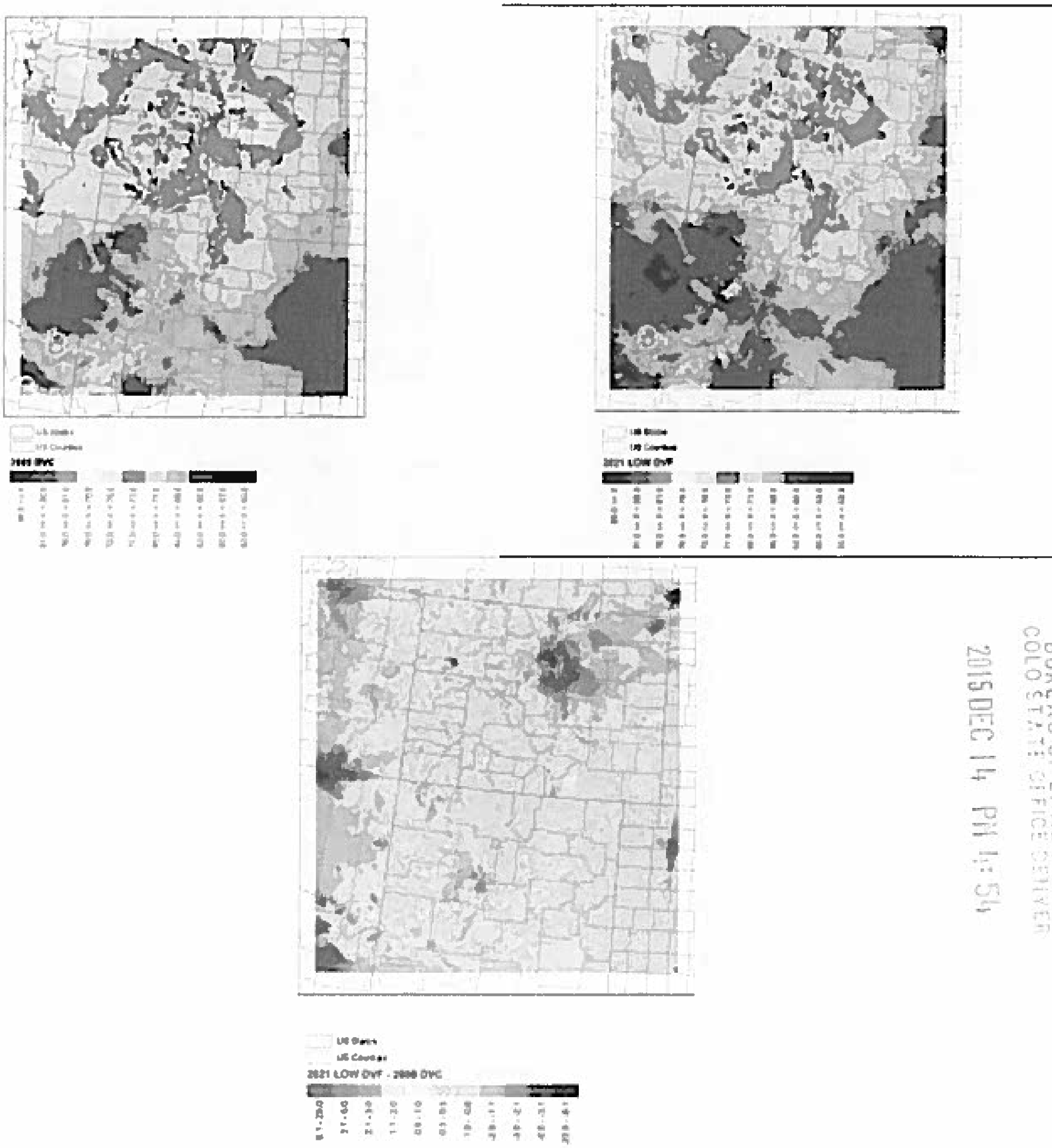

Figure 5-1b. 2008 ozone DVC (top left), 2021 Low Development Scenario ozone DVF (top right) and their differences (2021 Low – 2008) (bottom) calculated using MATS.

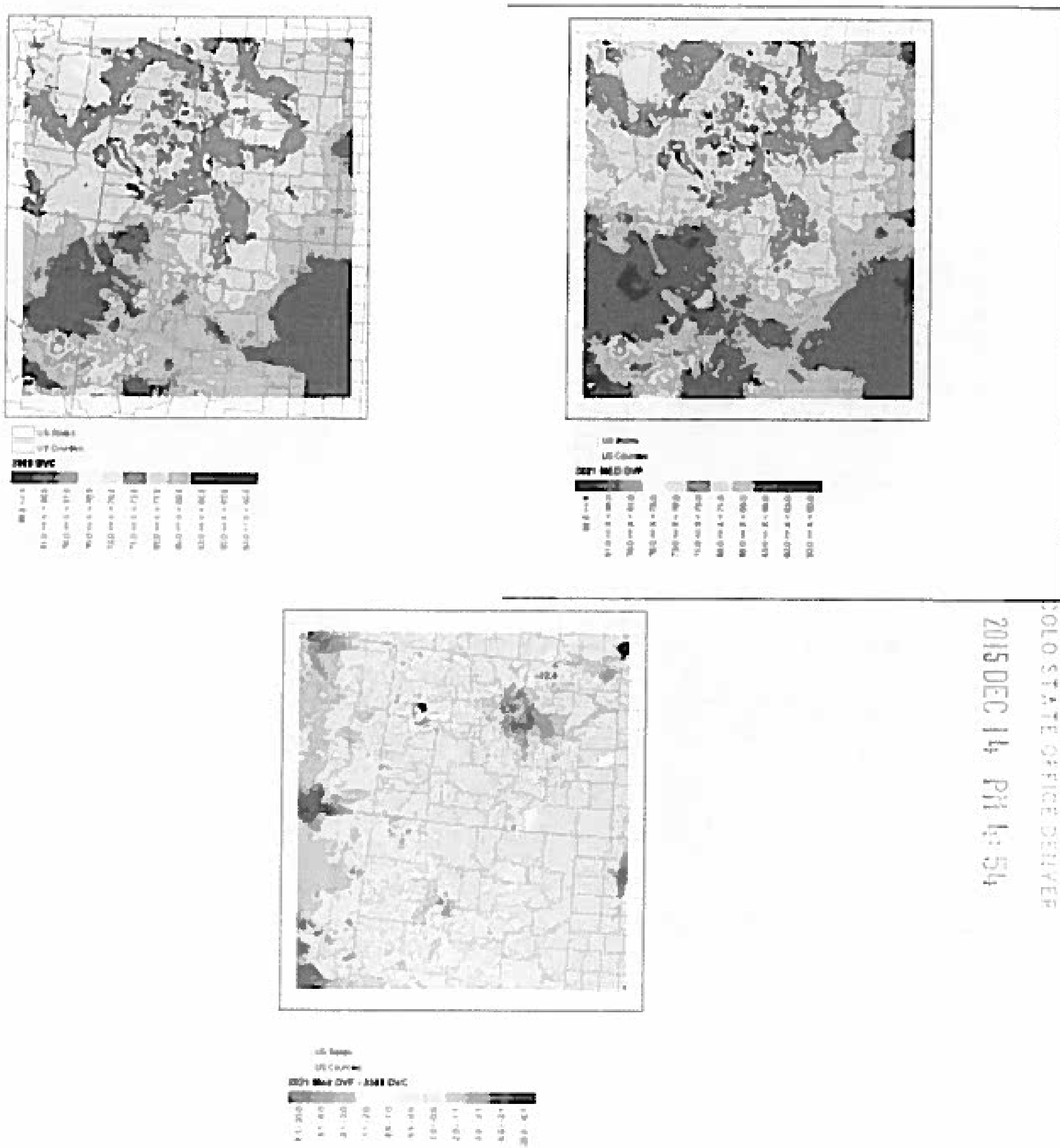

Figure 5-1c. 2008 ozone DVC (top left), 2021 Medium Development Scenario ozone DVF (top right) and their differences (2021 Medium – 2008) (bottom) calculated using MATS.

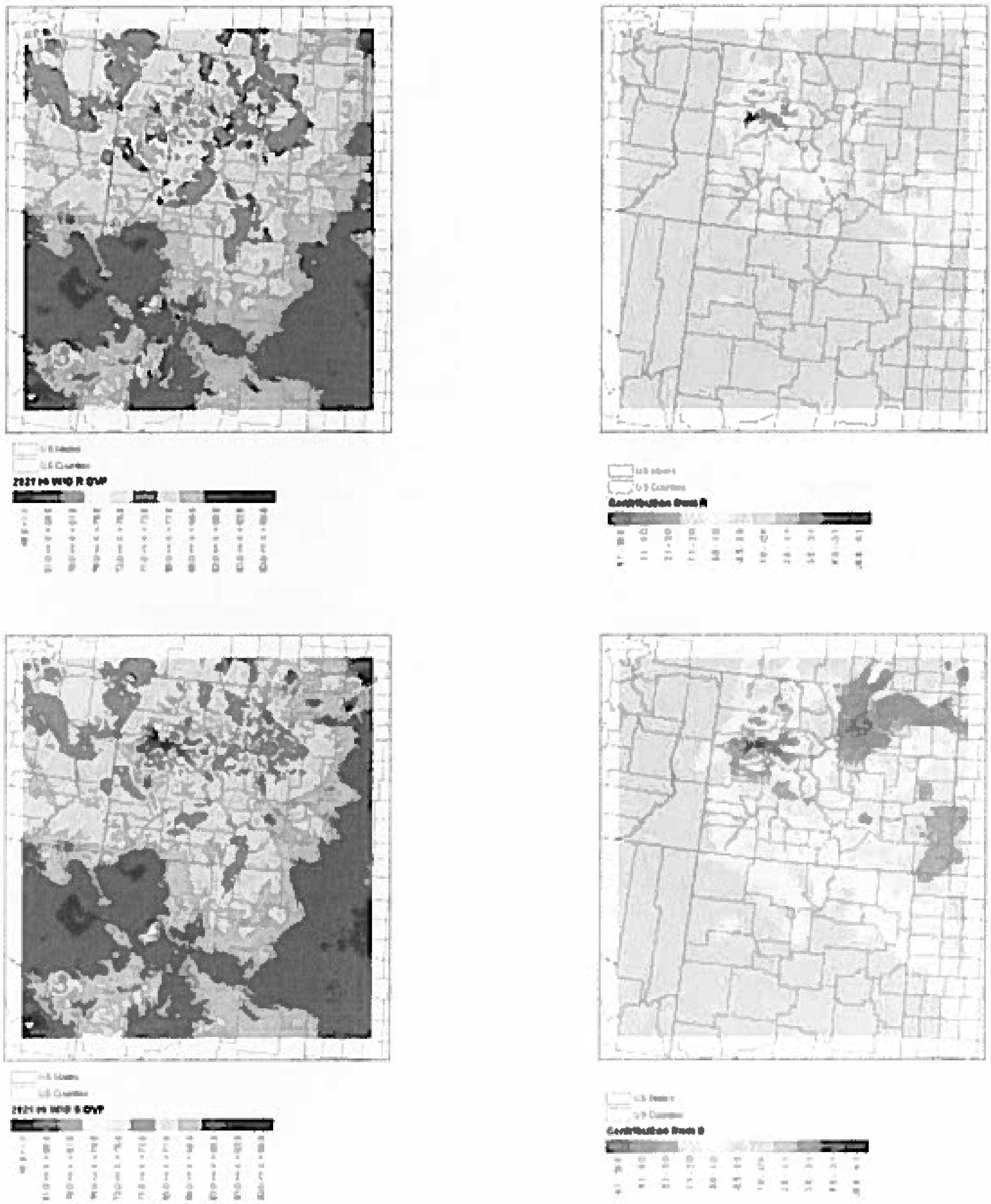

Figure 5-2a. 2021 projected ozone DVF 2021 Unmonitored Area Analysis for Source Group R (top) and S (bottom) showing 2021 DVF without each Source Group (left) and difference in DVFs with 2021 High Development Scenario (right).

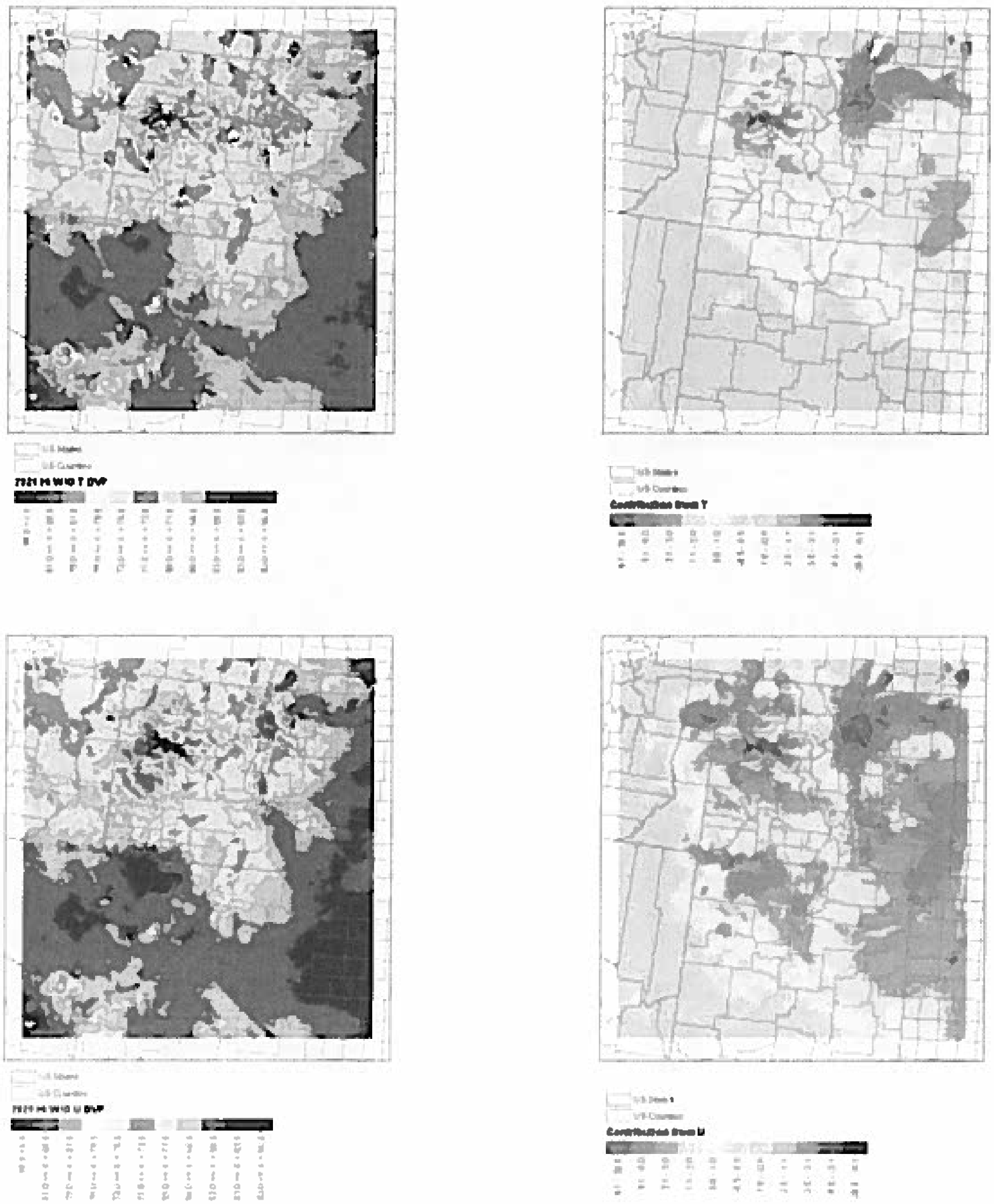

Figure 5-2b. 2021 projected ozone DVF 2021 Unmonitored Area Analysis for Source Group T (top) and U (bottom) showing 2021 DVF without each Source Group (left) and difference in DVFs with 2021 High Development Scenario (right).

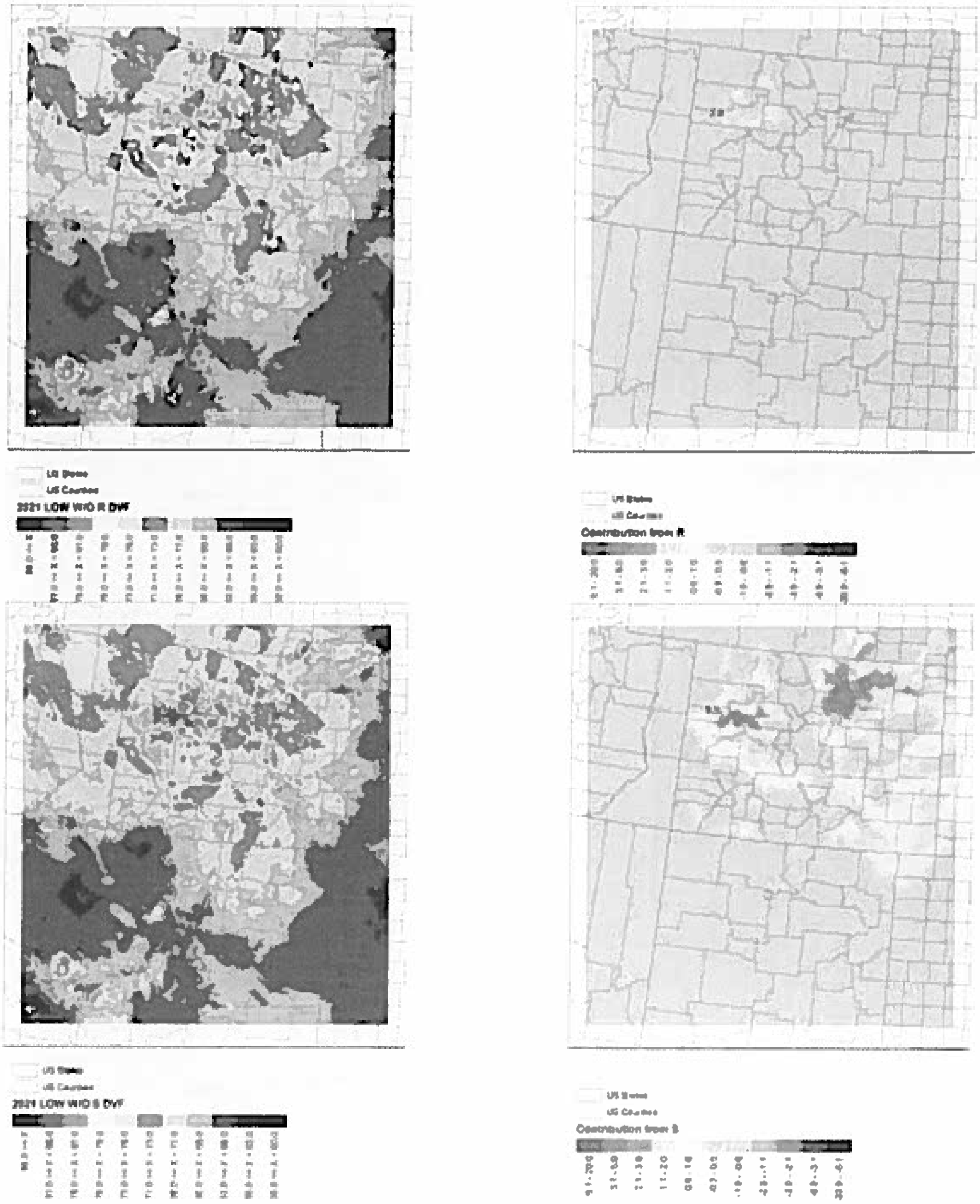

Figure 5-3a. 2021 projected ozone DVF 2021 Unmonitored Area Analysis for Source Group R (top) and S (bottom) showing 2021 DVF without each Source Group (left) and difference in DVFs with 2021 Low Development Scenario (right).

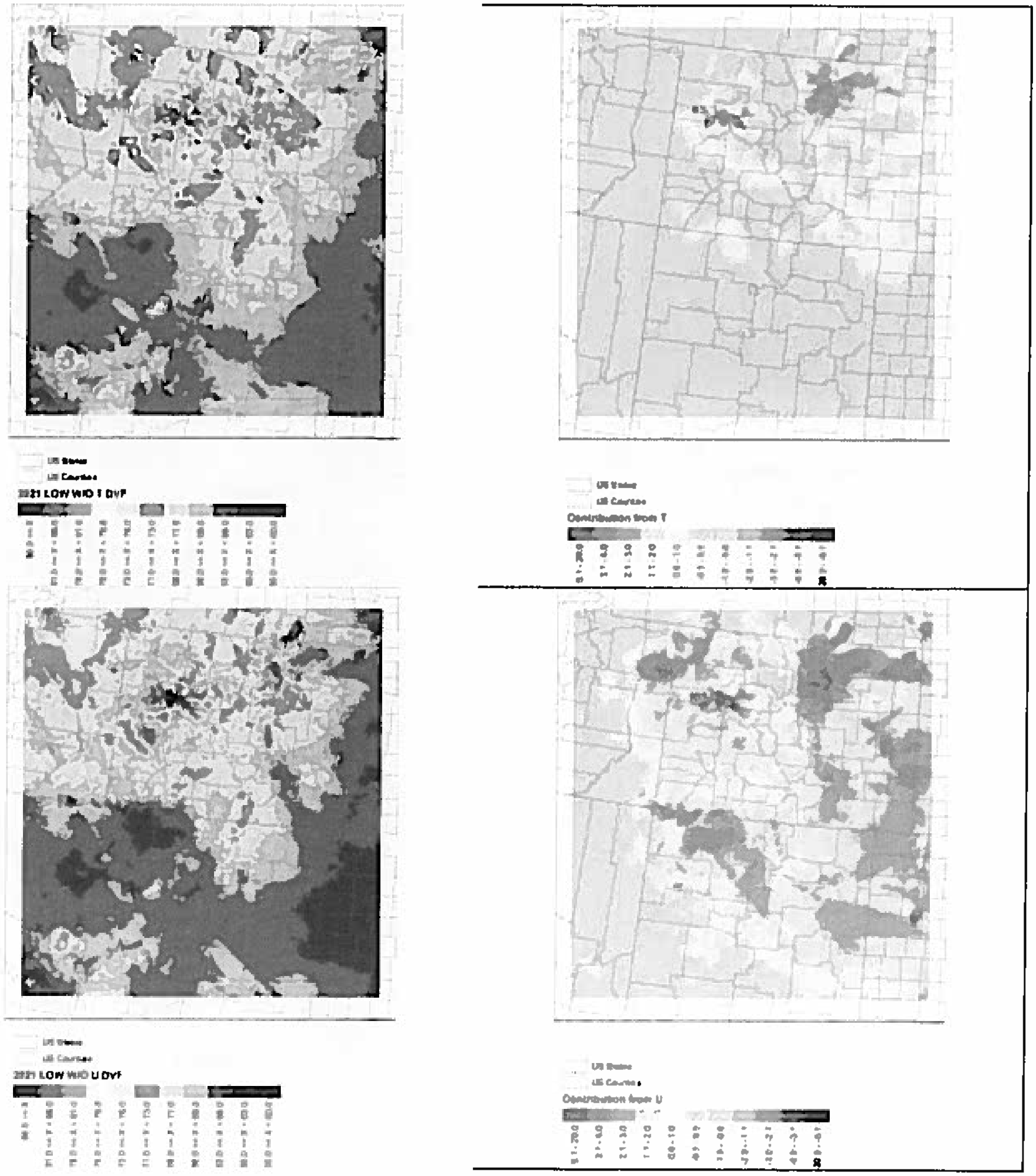

Figure 5-3b. 2021 projected ozone DVF 2021 Unmonitored Area Analysis for Source Group T (top) and U (bottom) showing 2021 DVF without each Source Group (left) and difference in DVFs with 2021 Low Development Scenario (right).

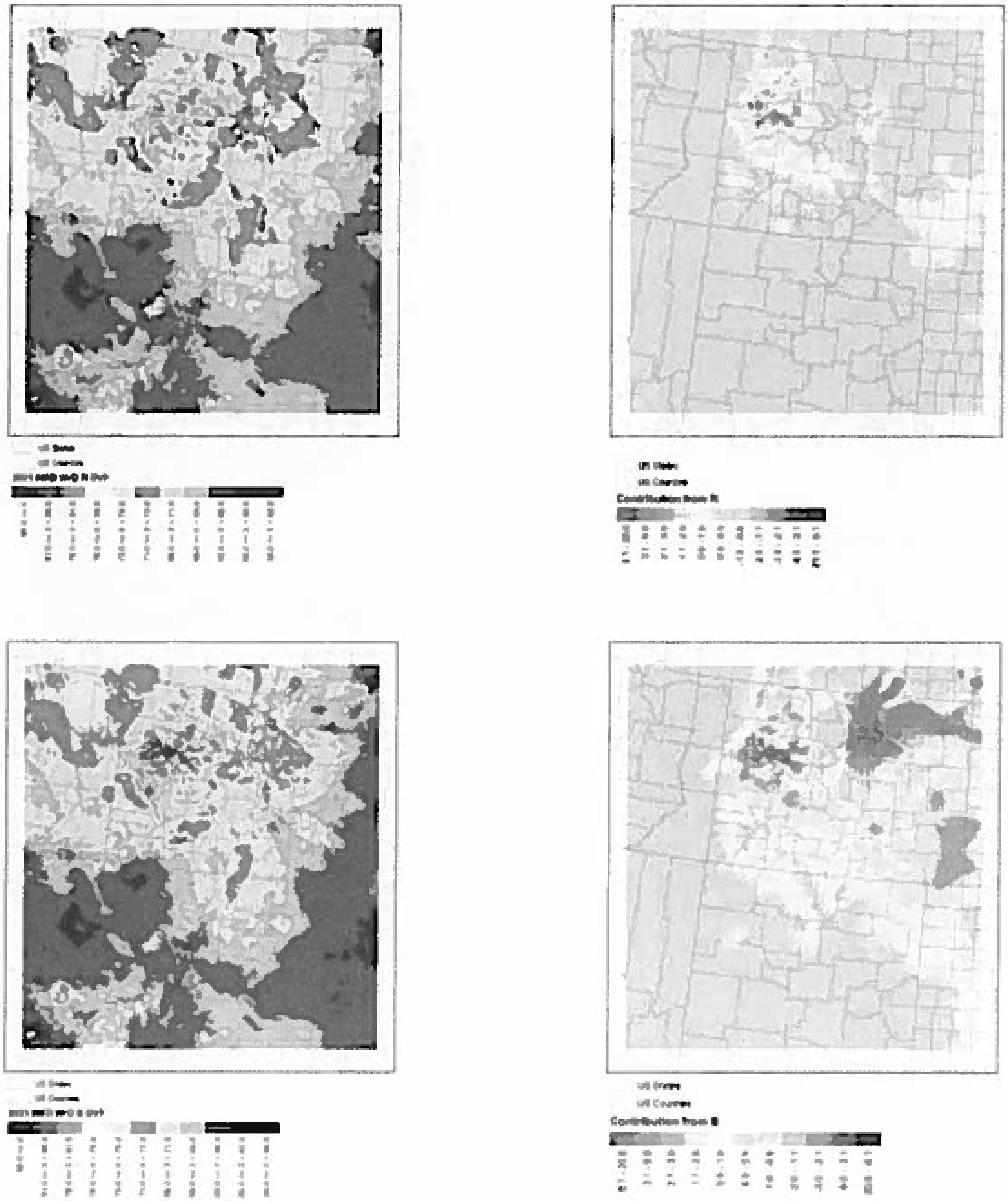

Figure 5-4a. 2021 projected ozone DVF 2021 Unmonitored Area Analysis for Source Group R (top) and S (bottom) showing 2021 DVF without each Source Group (left) and difference in DVFs with 2021 Medium Development Scenario (right).

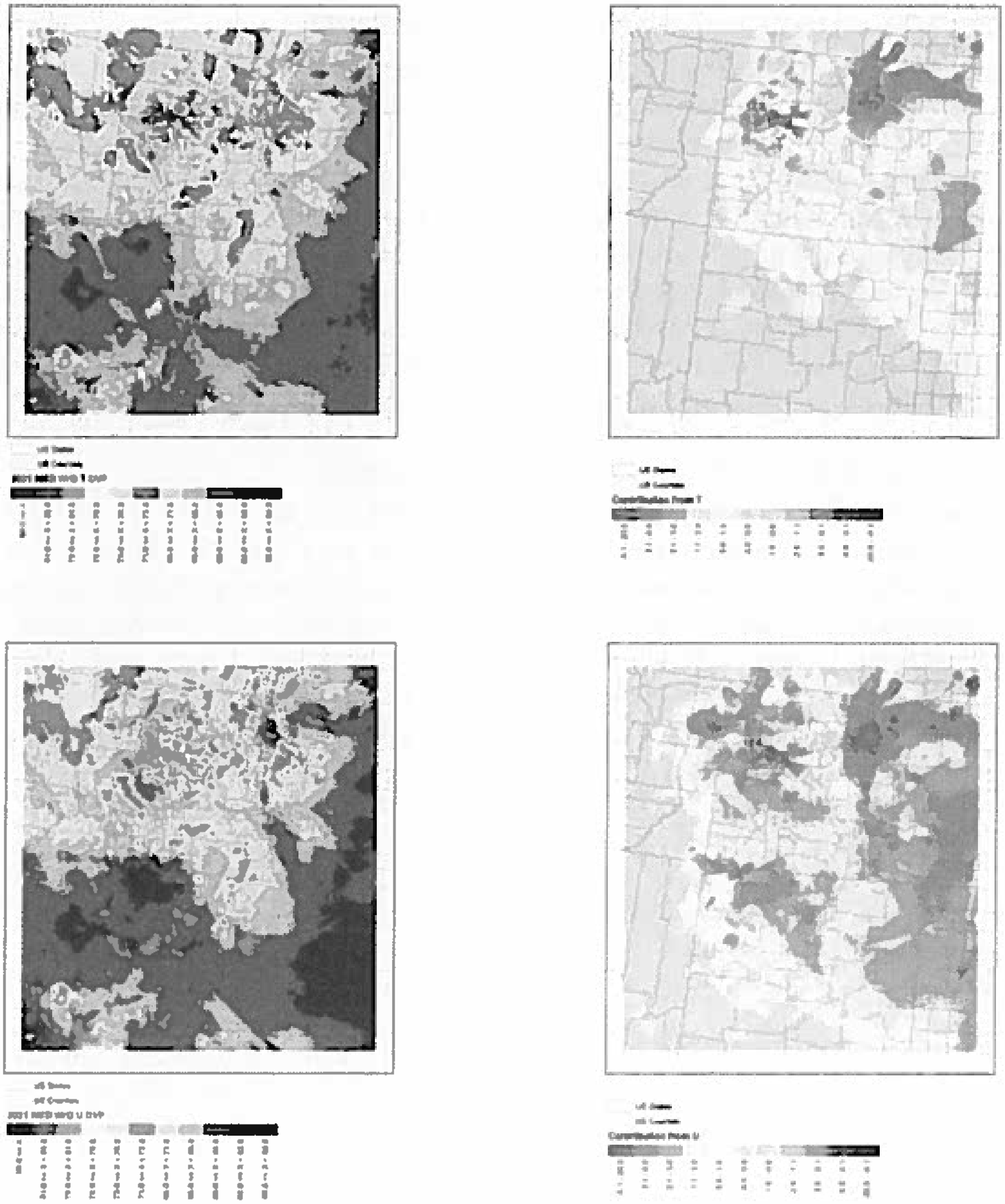

Figure 5-4b. 2021 projected ozone DVF 2021 Unmonitored Area Analysis for Source Group T (top) and U (bottom) showing 2021 DVF without each Source Group (left) and difference in DVFs with 2021 Medium Development Scenario (right).

5.6.2 Ozone NAAQS Analysis using the Absolute Modeling Results

The 2021 High and Low Development Scenario CAMx source apportionment absolute modeling results are analyzed and compared to the NAAQS in this section. The ozone NAAQS is defined as the three-year average of the 4th highest daily maximum 8-hour (DMAX8) ozone concentration. Since CARMMS only uses one year of modeling results (2008 meteorological year), the 2021 4th highest DMAX8 ozone concentration is used as a pseudo-NAAQS comparison metric. The contributions of each Source Group to ozone is examined as the difference between the 4th highest DMAX8 ozone concentration for the 2021 emissions scenario minus the 4th highest DMAX8 ozone for the 2021 scenario with the Source Group contributions removed. In addition, the contributions of each Source Group to modeled 2021 4th high DMAX8 ozone greater than the NAAQS (i.e., 76.0 ppb or greater) is also analyzed.

5.6.2.1 <u>Contributions of Source Groups to 4th High DMAX8 Ozone</u>

Figure 5-5 displays the 4th highest DMAX8 ozone for the 2008 Base Case and the 2021 High, Low and Medium Development Scenarios and their differences and the 4th highest DMAX8 ozone for the 2021 scenario with the ozone contributions from natural emissions removed (Source Group V). This last display was generated to determine whether exceedances of the NAAQS could have been primarily due to natural emissions. The color scale in Figure 5-5 has a sharp contrast from dark red to white when an exceedances of the ozone NAAQS occurs (i.e., 76.0 ppb or higher). For the 2008 Base Case, there are several regions where the modeled 2021 4th high DMAX8 ozone exceeds the NAAQS (Figure 5-5, top left):

- The Denver area;
- Uinta Basin and Salt Lake City (SLC), Utah;
- Northern New Mexico northeast of Santa Fe;
- Northern New Mexico northeast of Los Alamos;
- Northern New Mexico north of Taos; and
- On the UT/AZ border.

In the 2021 High, Low and Medium Development Scenarios, the area of ozone exceedances in Denver is reduced and the ozone exceedances in the SLC and UT/AZ border area are gone. However, the modeled ozone exceedance area in northern New Mexico remains the same and there is a new ozone exceedance area in the Uinta Basin in the three 2021 scenarios (Figure 5-5, top right). The 2021 – 2008 ozone differences (Figure 5-5, bottom left) show more decreases than increases and the areas of ozone increases tend to occur in O&G development areas, such as the D-J, Piceance and Uinta Basins. The contribution of natural emissions to the modeled 4th highest daily maximum 8-hour ozone concentrations (Figure 5-5, bottom right) show that the ozone exceedance areas in northern New Mexico are due to natural emissions, most likely wildfires.

Attachment I is a zipped file that contains spatial maps of concentrations including total concentrations and the contributions of each of the Source Groups to the 4th highest DMAX8 ozone and other pollutants from the 2021 High, Low and Medium Development Scenarios CAMx source apportionment modeling. Figure 5-6 displays example spatial maps of contributions to the 4th highest DMAX8 ozone concentrations for Source Groups E (GJFO), F (UFO), J (USFS-PG), R (Federal O&G/mining in CO) T (Cumulative Emissions Scenario) and U (all O&G in 4 km CARMMS domain) and the 2021 High, Low and Medium Development Scenarios that were extracted out of Attachment I. The maximum ozone contributions to the 4th highest DMAX8 ozone for each of the Source Groups are given in Table 5-40. Note that these maximum Source Group contributions to the 4th highest DMAX8 ozone occur when the total ozone is less than the ozone NAAQS. Section 5.6.2.2 discusses the Source Group contributions when the total 4th high DMAX8 ozone exceeds the ozone NAAQS. Ozone contributions due to Federal O&G development in the GJFO Planning Area are centered on the GJFO area where a maximum ozone contribution of 4.4 ppb occurs for the 2021 High Development Scenario (Table 5-40 and Figure 5-6a, top left). The mitigation in the 2021 Medium Development Scenario reduces this maximum GJFO ozone contribution by -18% to 3.6 ppb. There is much lower 4th high DMAX8 ozone contributions due to GJFO for the 2021 Low Development Scenario (Figure 5-6a, top right) with a maximum contribution of only 0.8 ppb (Table 5-40).

Lower 4th high DMAX8 ozone contributions are seen for UFO new Federal O&G with highest ozone contributions of 0.8, 0.2 and 0.6 ppb for the, respectively, 2021 High, Low and Medium Development Scenarios occurring in the northeast corner of the UFO Planning Area (Figure 5-6b). Even smaller ozone contributions still are seen due to new Federal O&G within the USFS-PG area with a maximum values of 0.5, 0.1 and 0.3 ppb for the 2021 High, Low and Medium Development Scenarios, respectively (Figure 5-6c).

The maximum ozone contribution due to Federal O&G and mining throughout the 13 CO Planning areas for the 2021 High, Low and Medium Development Scenarios are, respectively, 7.9, 2.8 and 6.1 ppb and occur in the Piceance Basin (Table 5-40 and Figure 5-6d). There are several areas with ozone contributions of 3 ppb or more for the 2021 High and Medium Development Scenarios and the Cumulative Emissions Source Group T (new Federal and non-Federal O&G and mining in the 14 BLM Planning Areas), including the Piceance and D-J Basins but also in southeastern Colorado (RGFO area No. 2) as shown in the top left and bottom panels of Figure 5-6e. Substantial ozone reductions are seen in the 2021 Low Development Scenario (Figure 5-6e, top right) with the highest ozone being reduced from 8.4 and 7.0 ppb in the High and Medium scenarios to 4.4 ppb in the Low Development Scenario.

Figure 5-6f displays the reduction in 4th highest DMAX8 ozone concentrations due to the elimination of all O&G in the 4 km CARMMS domain. All of the major O&G Basins exhibit reductions in ozone in excess of 3 ppb in the 2021 High and Medium Development Scenarios with the highest ozone reduction occurring in the Uinta Basin of 9.4 ppb for both the High and Medium Development scenarios and 9.2 ppb for the Low Development Scenario. Note that the same O&G emissions were used in the Uinta Basin for the three CARMMS 2021 Scenarios that came from the BLM UTSO ARMS study, which explains why there is little difference in the peak ozone contribution for the three scenarios.

Table 5-40. Maximum contribution to the 4th highest DMAX8 ozone (ppb) for each of the Source Groups and the 2021 High, Low and Medium Development Scenarios.

Source Group	High	Low	Medium
A. Little Snake FO	1.0	0.3	1.0
B. White River FO	3.9	1.2	3.6
C. Colorado River Valley FO (w/o Roan Plateau)	2.6	1.5	2.3
D. Roan Plateau	3.8	1.7	3.3
E. Grand Junction FO	4.4	0.8	3.6
F. Uncompahgre FO	0.8	0.2	0.6
G. Tres Rios FO	1.4	0.4	1.4
H. Kremmling FO	0.5	0.1	0.5
I. Royal Gorge FO No. 1 (North)	0.1	0.0	0.1
J. Pawnee Grasslands	0.5	0.1	0.3
K. Royal Gorge FO No. 2	0.9	0.1	0.7
L. Royal Gorge FO No. 3	0.2	0.1	0.2
M. Royal Gorge FO No. 4	0.1	0.0	0.1
N. New Mexico Farmington FO (Mancos)	1.1	0.8	0.8
O. Colorado River Valley FO (w/ Roan Plateau)	5.0	2.1	3.9
P. Royal Gorge FO (total)	0.9	0.1	0.7
Q. Federal Mining in Colorado	0.9	0.9	0.9
R. New Federal O&G and Mining In Colorado	7.9	2.8	6.1
S. New Federal/Non-Federal O&G/Mining in CO	8.4	4.4	7.0
T. New Federal/Non-Federal O&G/Mining in CO/NM	8.4	4.4	7.0
U. Existing and New Fed/Non-Fed O&G in 4 km Domain	9.4	9.2	9.4
V. Natural Emissions	5.6	5.7	5.6

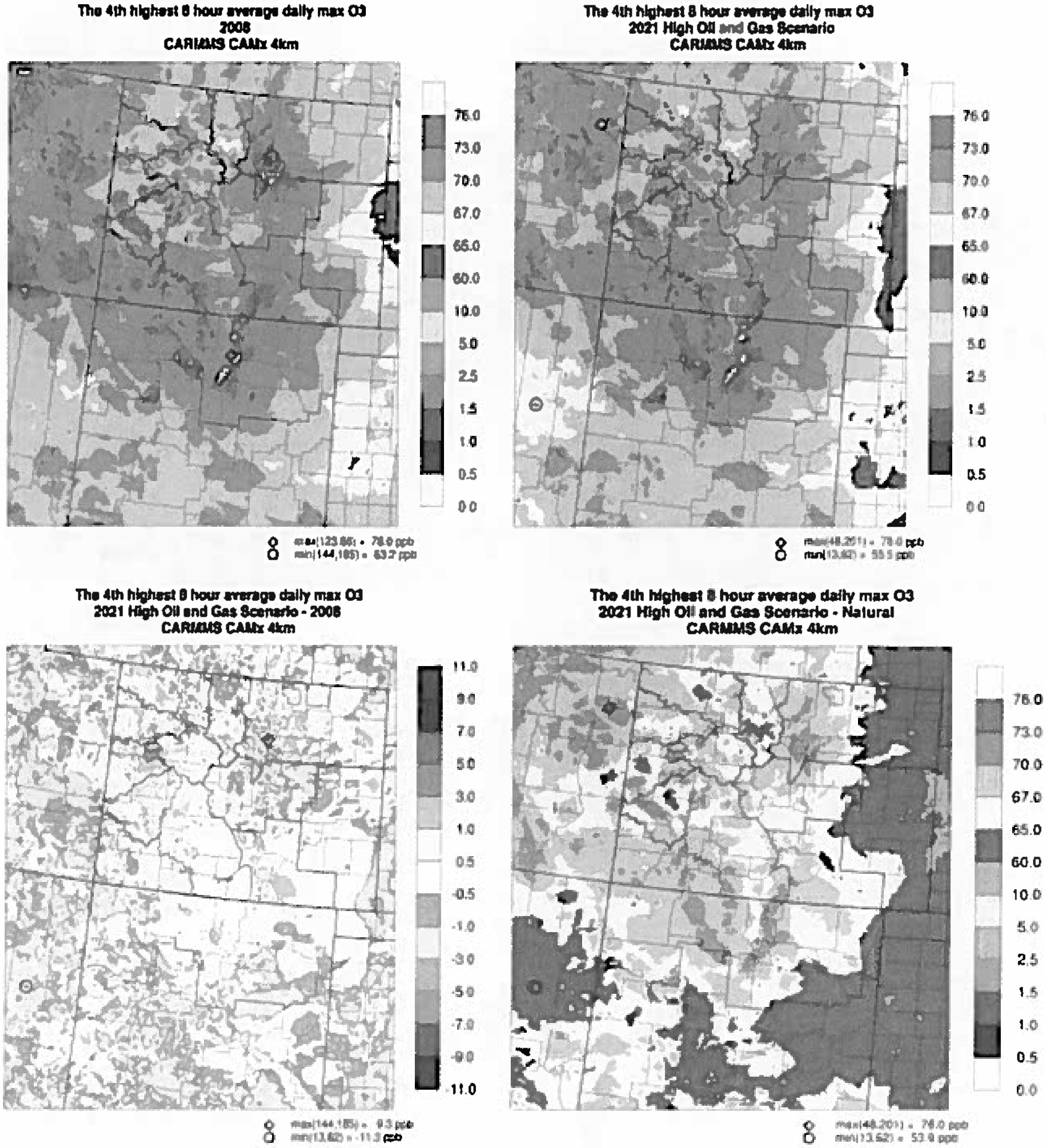

Figure 5-5a. Fourth highest daily maximum 8-hour ozone concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 High minus 2008 differences (bottom left) and Natural Emissions (bottom right).

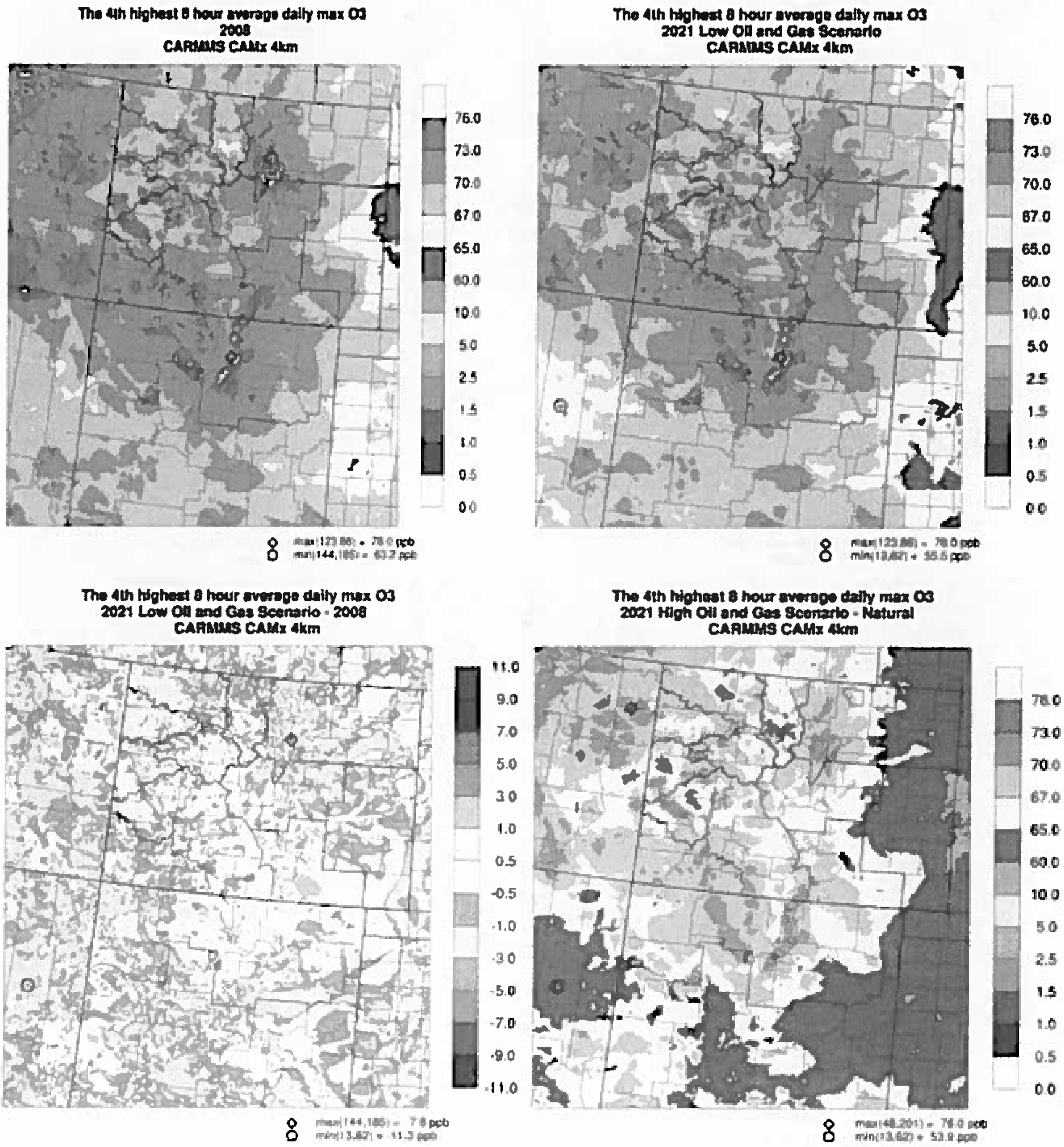

Figure 5-5b. Fourth highest daily maximum 8-hour ozone concentrations for the 2008 Base Case (top left), 2021 Low Development Scenario (top right), 2021 Low minus 2008 differences (bottom left) and Natural Emissions (bottom right).

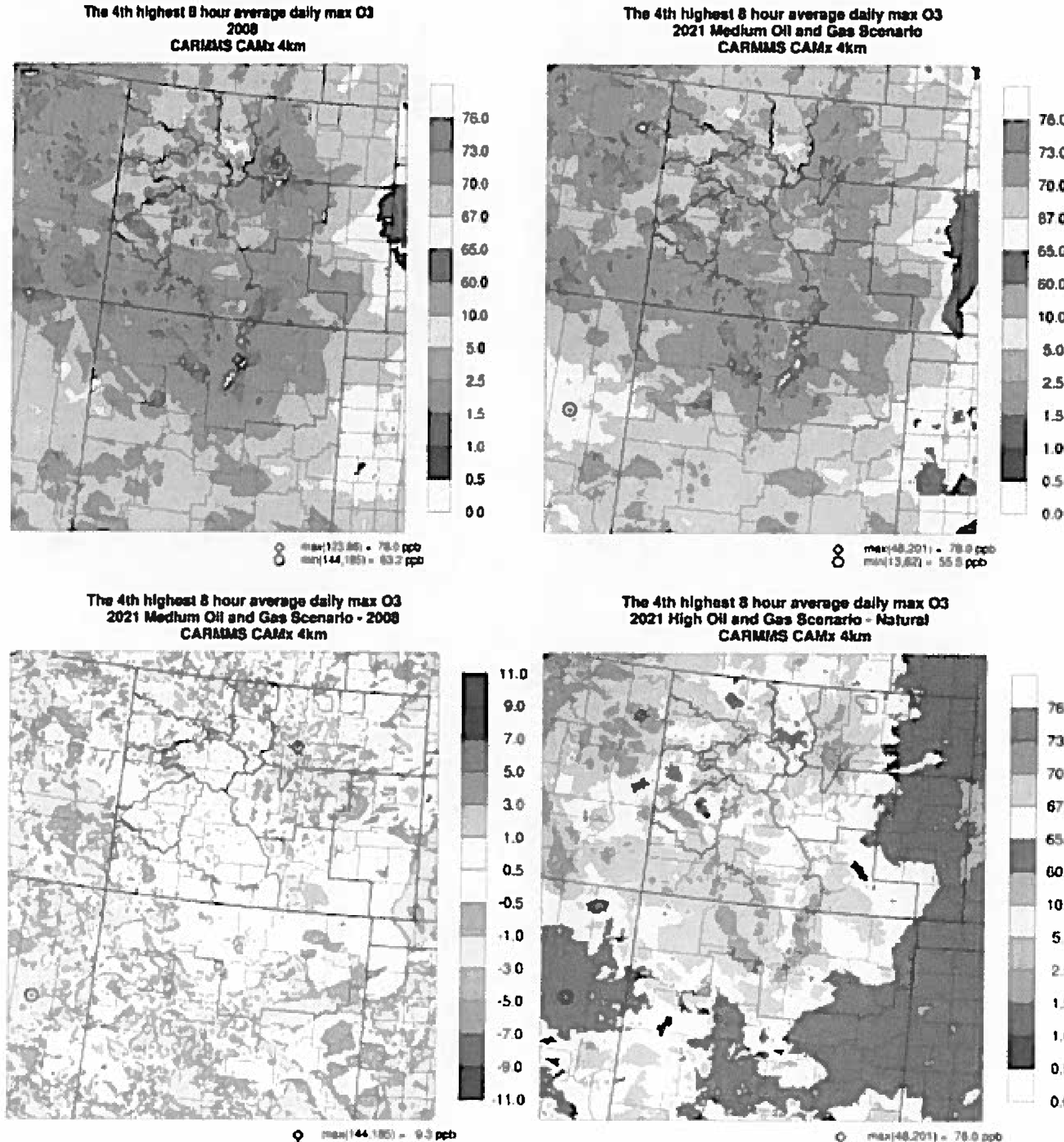

Figure 5-5c. Fourth highest daily maximum 8-hour ozone concentrations for the 2008 Base Case (top left), 2021 Medium Development Scenario (top right), 2021 Medium minus 2008 differences (bottom left) and Natural Emissions (bottom right).

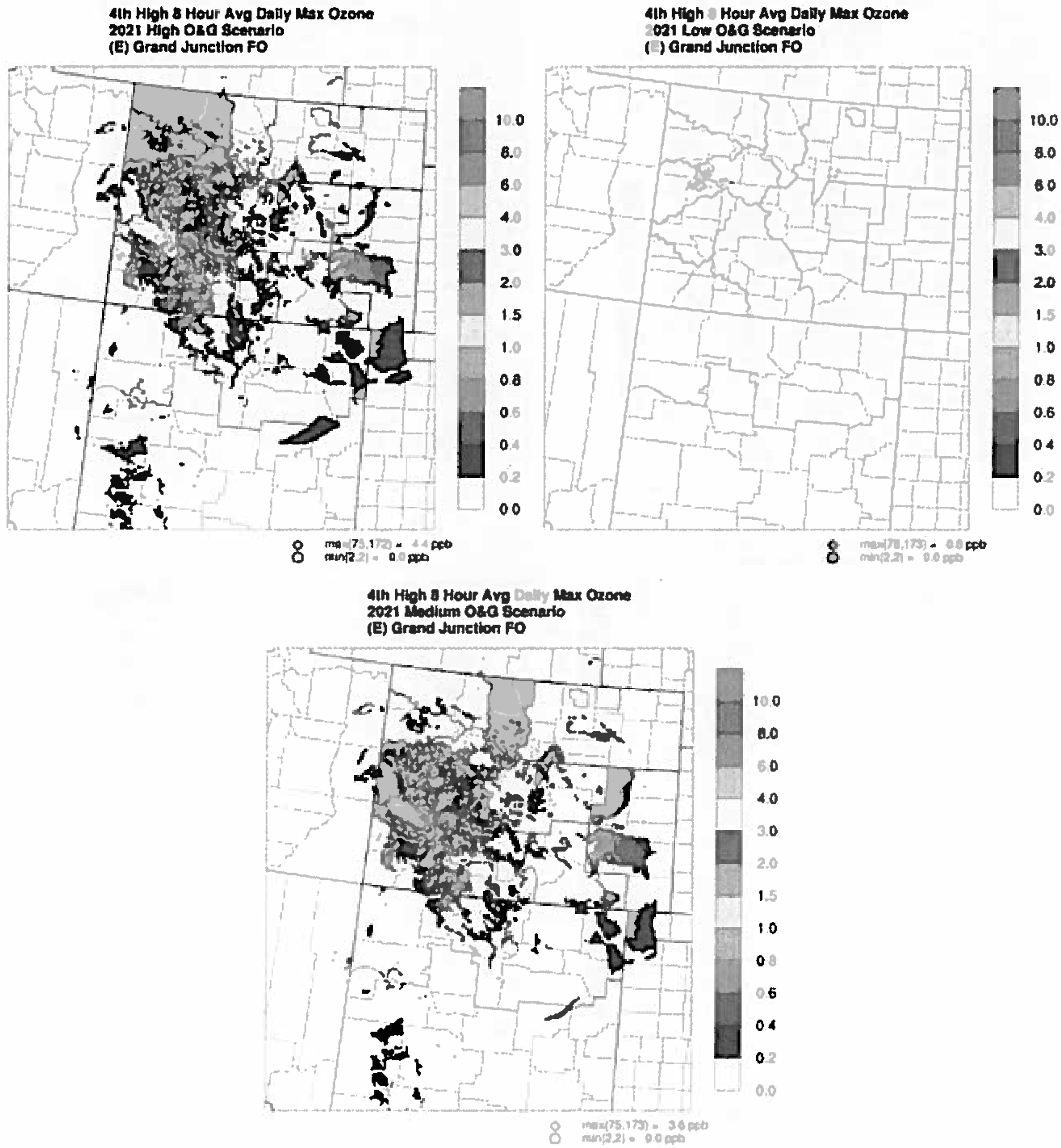

Figure 5-6a. Contributions to fourth highest daily maximum 8-hour ozone due to emissions from new Federal O&G within the GJFO (Source Group E) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

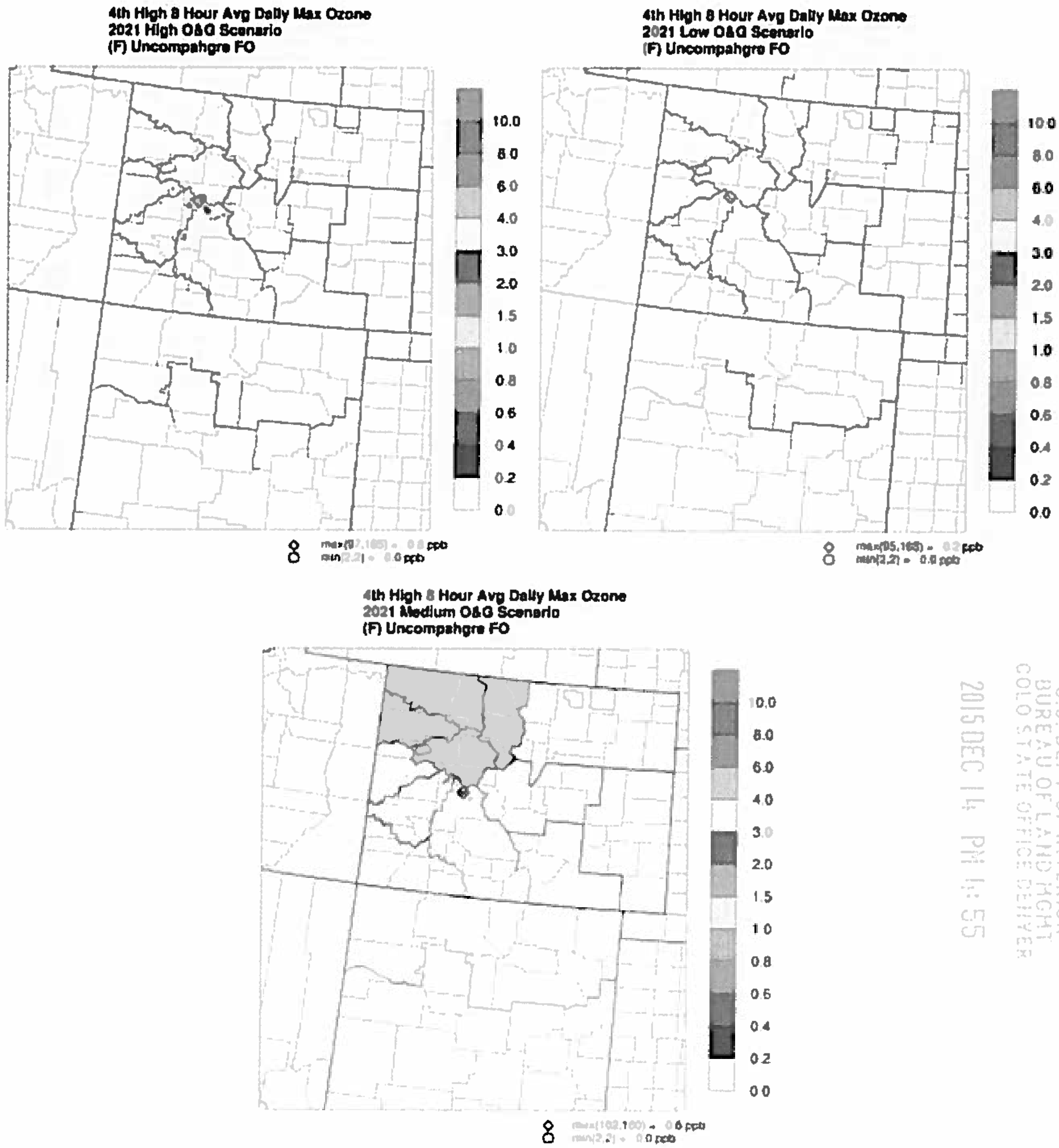

Figure 5-6b. Contributions to fourth highest daily maximum 8-hour ozone due to emissions from new Federal O&G within the UFO (Source Group F) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

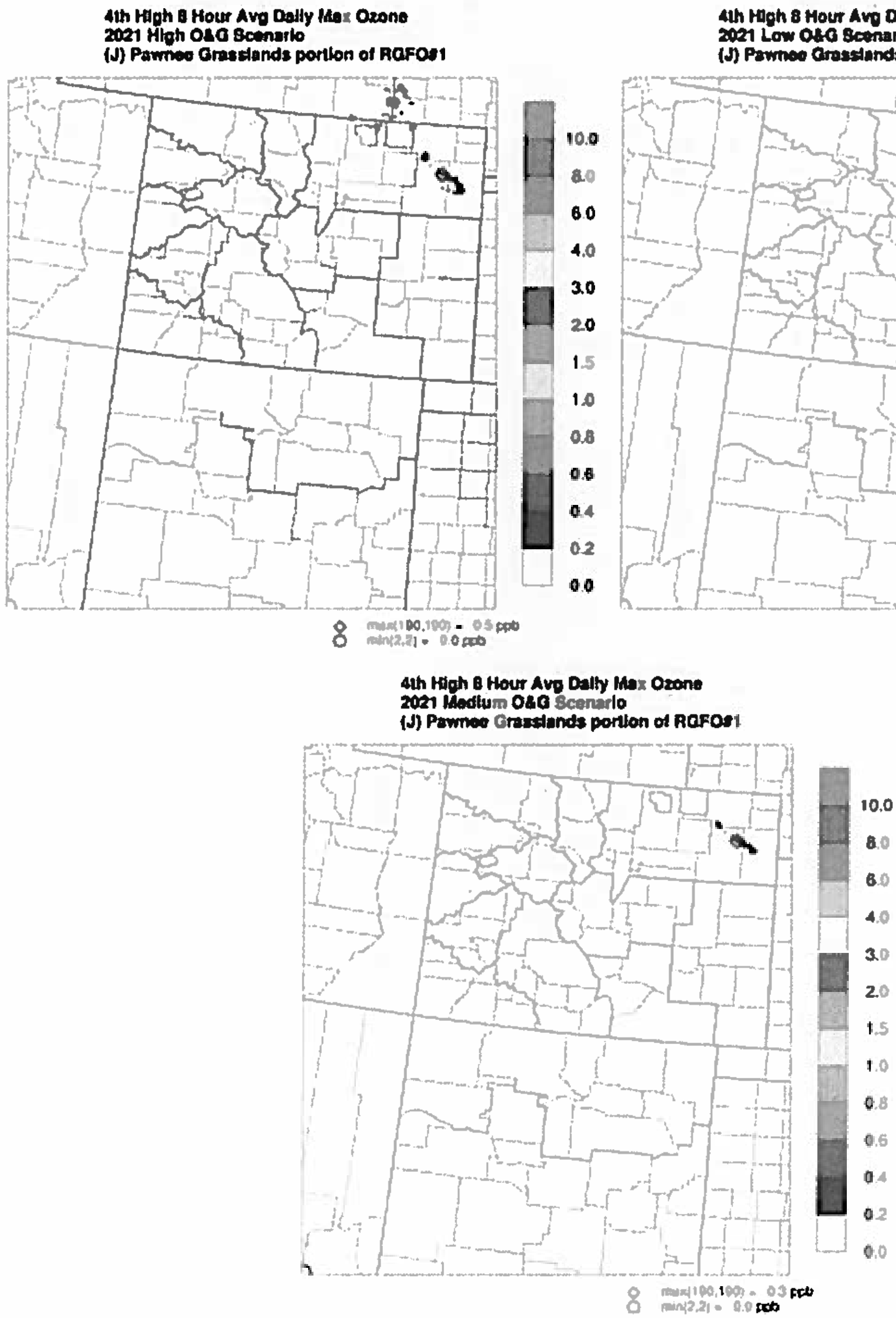

Figure 5-6c. Contributions to fourth highest daily maximum 8-hour ozone due to emissions from new Federal O&G within the USFS Pawnee Grasslands (Source Group J) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

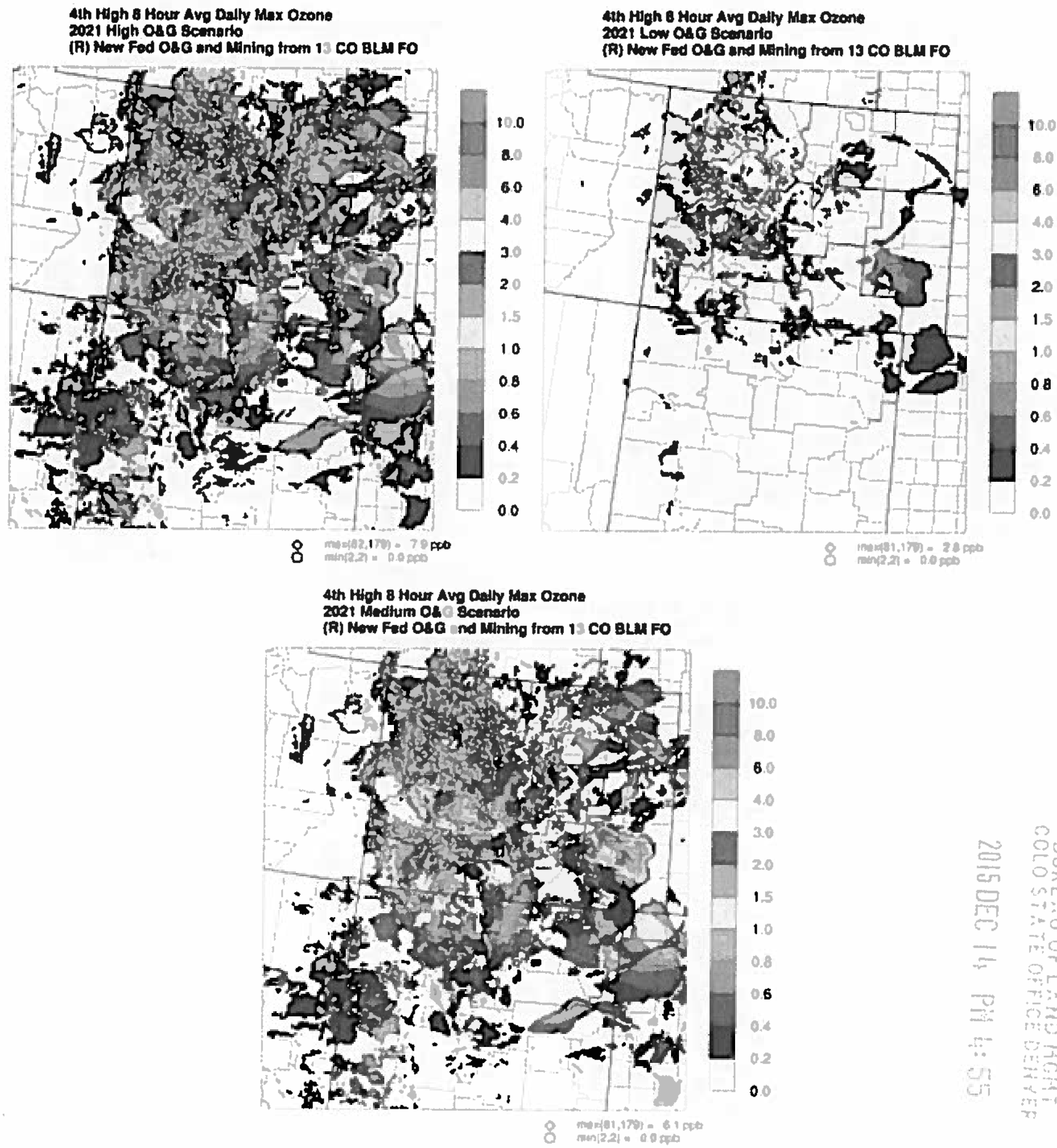

Figure 5-6d. Contributions to fourth highest daily maximum 8-hour ozone due to emissions from new Federal O&G and mining within the 13 Colorado BLM Planning Areas (Source Group R) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

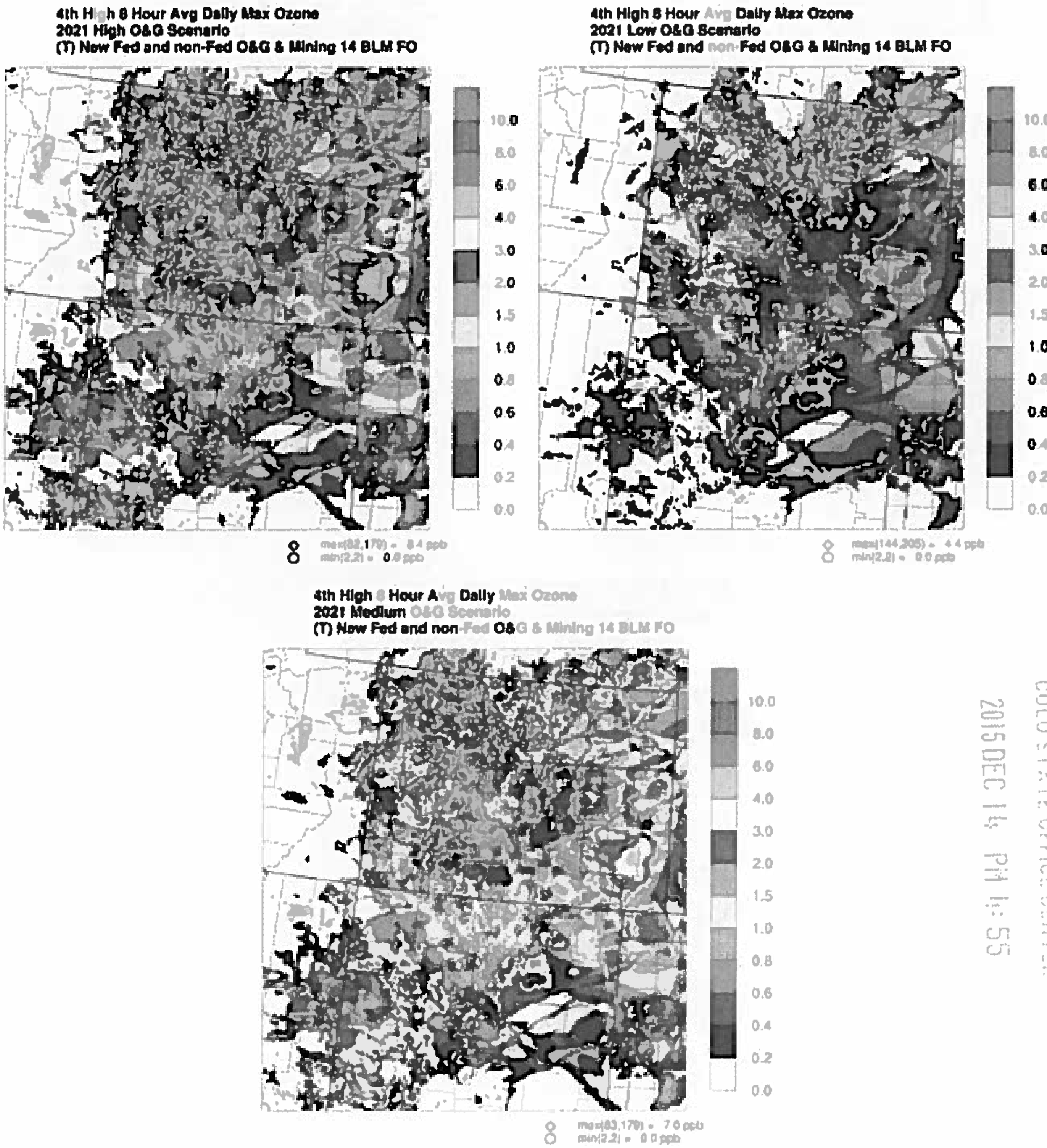

Figure 5-6e. Contributions to fourth highest daily maximum 8-hour ozone due to emissions from new Federal and non-Federal O&G and mining within the 14 CO/NM BLM Planning Areas (Source Group T) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

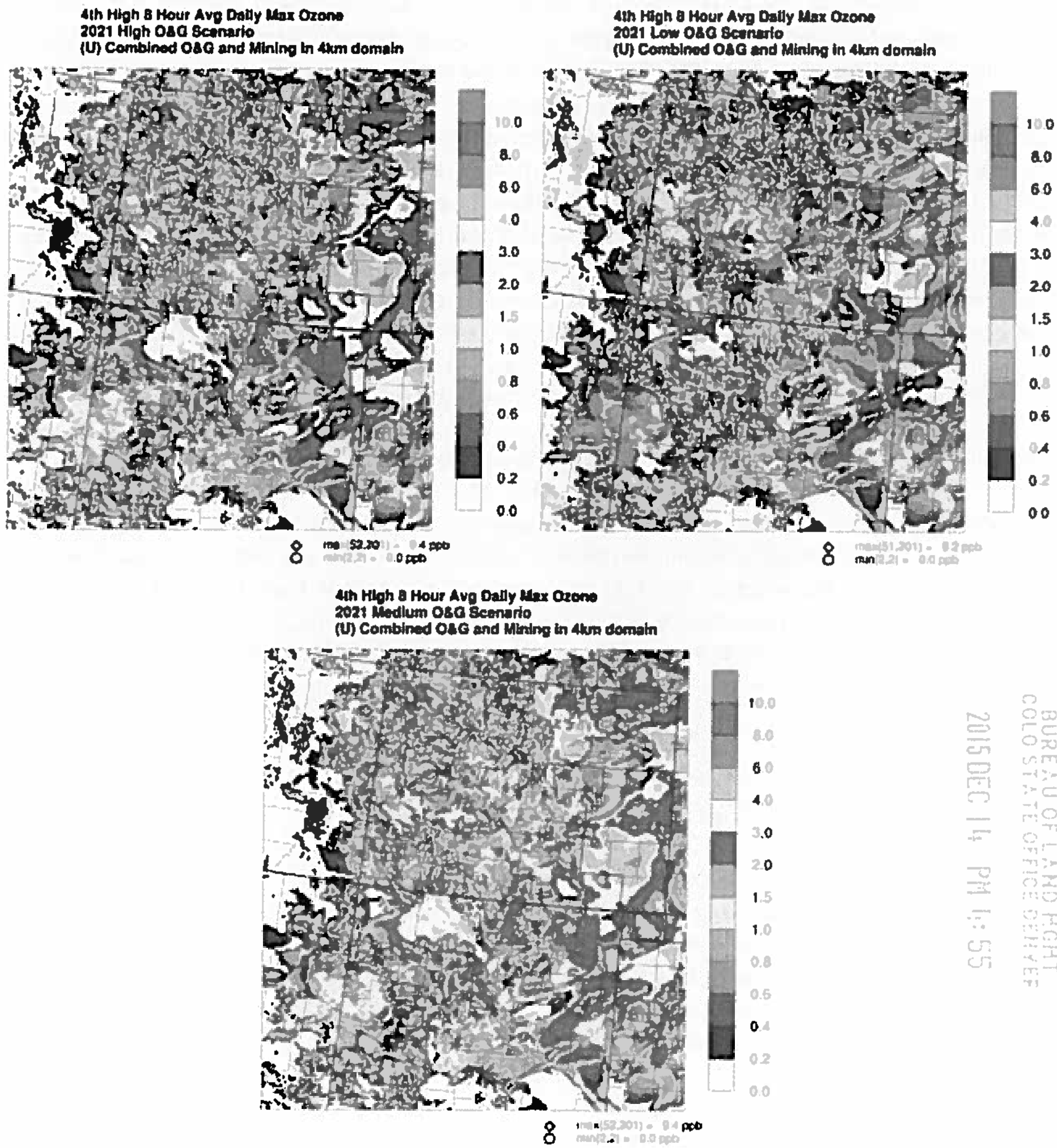

Figure 5-6f. Contributions to fourth highest daily maximum 8-hour ozone due to emissions from existing, new Federal and non-Federal O&G within the entire CARMMS 4 km domain and Federal mining in Colorado (Source Group U) for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

5.6.2.2 Source Group Absolute Contributions to Ozone Exceedances

The contributions of each Source Group to 4^{th} highest DMAX8 ozone above the current ozone NAAQS (76.0 ppb and higher) for the 2021 High, Low and Medium Development Scenarios are contained in Attachments G-1, G-2 and G-3, respectively. The Attachment G interactive Excel spreadsheet contains two sheets: "StatTable" that displays the maximum ozone contribution for each Source Group to modeled 2021 DMAX8 ozone greater than the NAAQS; and "Scatter_by_exceedance_region" that shows the ozone contribution of a Source Group, controlled by cell C1, to all grid cells with modeled 2021 4^{th} high DMAX8 ozone greater than the NAAQS by region. Table 5-41 from StatTable in Attachment G lists the maximum ozone contribution to any modeled 2021 4^{th} high DMAX8 ozone greater than the NAAQS. The WRFO is the individual BLM Planning Area with the largest contribution to 2021 modeled exceedances of the ozone NAAQS of 1.83 ppb for the High, 0.43 ppb for the Low and 1.66 ppb for the Medium Development Scenarios when the 2021 total ozone was 76.5, 77.0 and 76.3 ppb, respectively. All of the other individual BLM Planning Areas (Source Groups A through P) have maximum ozone contributions to modeled 2021 DMAX8 ozone in excess of the ozone NAAQS of less than 1 ppb for the 2021 High, Low and Medium Development Scenarios.

The highest contribution to 2021 DMAX8 ozone for all Federal O&G and mining within the 13 Colorado BLM Planning Areas (Source Group R) is 3.22, 0.86 and 2.84 ppb for the 2021 High, Low and Medium Development Scenarios, respectively. The contribution of new Federal and non-Federal O&G and Federal mining within the 14 BLM Planning Areas (Source Group T) to 2021 DMAX8 ozone exceedances are 5.32, 2.25 and 4.91 ppb for the High, Low and Medium Development Scenarios, respectively. The highest contribution of all O&G in the CARMMS domain to modeled 2021 DMAX8 ozone exceedances is 31.94, 30.73 and 31.79 ppb for the 2021 High, Low and Medium Development Scenarios that is primarily due to O&G emissions in the Uinta Basin.

Figure 5-7 displays the contribution of Federal O&G emissions from the GJFO BLM Planning Area to the 2021 4^{th} high DMAX8 ozone at all grid cells in the domain that came from the "Scatter_by_exceedance_region" sheet in Attachments G-1, G-2 and G-3. GJFO has the highest contribution to ozone exceedances in the Uinta Basin with contributions of ~0.70, ~0.06 and ~0.60 ppb for the 2021 High, Low and Medium Development Scenarios, respectively (Figure 5-7a, left). The contributions of new Federal O&G and mining within the 13 Colorado BLM Planning Areas (Source Group R) to exceedances of the ozone NAAQS is shown in the right panels in Figure 5-7a with the highest contributions of ~3.0, ~0.8 and 2.5 ppb for the High, Low and Medium Scenarios, respectively, occurring in the Uinta Basin. Source Group R also contributes ~1.5, ~0.1 and ~0.8 ppb to ozone exceedances in the Denver area for the High, Low and Medium Development Scenarios. Add in new non-Federal O&G that is contained in Source Group T greatly increases the O&G contribution to exceedances in the Denver area with contributions of ~4, ~1 and ~ 1 ppb for the High, Low and Medium Development Scenarios, respectively (Figure 5-7b, left). Add in the O&G emissions from the Uinta Basin (Source Group U) results in contributions of ~30 ppb to ozone exceedances in the Uinta Basin (Figure 5-7b, right).

Table 5-41a. Maximum ozone contribution by Source Group to total modeled 2021 4th high DMAX8 ozone greater than the NAAQS for the 2021 High Development Scenario.

Group	Name	Max		
		Max Contribution (ppb)	Corresponding 4th MDA8	% Max Contribution
A	Little Snake FO	0.2586	76.7	0.34%
B	White River FO	1.8306	76.5	2.39%
C	Colorado River Valley FO (CRVFO)	0.1765	76.5	0.23%
D	Roan Plateau Planning area portion of CRVFO	0.1608	76.5	0.21%
E	Grand Junction FO	0.7570	77.3	0.98%
F	Uncompahgre FO	0.0725	76.5	0.09%
G	Tres Rios FO	0.6715	76.7	0.88%
H	Kremmling FO	0.0678	76.8	0.09%
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0073	76.0	0.01%
J	Pawnee Grasslands portion of RGFO#1	0.0321	76.0	0.04%
K	RGFO#2 – West-Central/South	0.0015	76.0	0.00%
L	RGFO#3 – South	0.0030	76.0	0.00%
M	RGFO#4 – East-Central	0.0039	76.0	0.01%
N	New Mexico Farmington District	0.2340	78.0	0.30%
O	Total Colorado River Field Office	0.3374	76.5	0.44%
P	Total Royal Gorge Field Office	0.0477	76.0	0.06%
Q	Mining from 13 Colorado BLM Planning Areas	0.1104	76.7	0.14%
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	3.2125	76.5	4.20%
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	5.2711	76.5	6.89%
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	5.3221	76.5	6.96%
U	Combined O&G and Mining in 4 km domain	31.9435	76.4	41.80%
V	Natural Emissions	2.6494	76.5	3.46%

Table 5-41b. Maximum ozone contribution by Source Group to total modeled 2021 4th high DMAX8 ozone greater than the NAAQS for the 2021 Low Development Scenario.

Group (low O&G)	Name	Max		
		Max Contribution (ppb)	Corresponding 4th MDA8	% Max Contribution
A	Little Snake FO	0.0480	76.4	0.06%
B	White River FO	0.4321	77.0	0.56%
C	Colorado River Valley FO (CRVFO)	0.1406	77.0	0.18%
D	Roan Plateau Planning area portion of CRVFO	0.1043	77.0	0.14%
E	Grand Junction FO	0.0608	76.1	0.08%
F	Uncompahgre FO	0.0249	77.0	0.03%
G	Tres Rios FO	0.0926	76.0	0.12%
H	Kremmling FO	0.0021	76.3	0.00%
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0021	76.3	0.00%
J	Pawnee Grasslands portion of RGFO#1	0.0104	76.3	0.01%
K	RGFO#2 – West-Central/South	0.0000	76.9	0.00%
L	RGFO#3 – South	0.0002	77.0	0.00%
M	RGFO#4 – East-Central	0.0015	76.3	0.00%
N	New Mexico Farmington District	0.2342	78.0	0.30%
O	Total Colorado River Field Office	0.2449	77.0	0.32%
P	Total Royal Gorge Field Office	0.0140	76.3	0.02%
Q	Mining from 13 Colorado BLM Planning Areas	0.1164	76.4	0.15%
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	0.8622	77.0	1.12%
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	2.1963	77.0	2.85%
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	2.2502	77.0	2.92%
U	Combined O&G and Mining in 4 km domain	30.7272	77.0	39.93%
V	Natural Emissions	2.8167	77.0	3.66%

Table 5-41c. Maximum ozone contribution by Source Group to total modeled 2021 4th high DMAX8 ozone greater than the NAAQS for the 2021 Medium Development Scenario.

Group (medium O&G)	Name	Max		
		Max Contribution (ppb)	Corresponding 4th MDA8	% Max Contribution
A	Little Snake FO	0.2360	76.7	0.31%
B	White River FO	1.6579	76.3	2.17%
C	Colorado River Valley FO (CRVFO)	0.1461	76.3	0.19%
D	Roan Plateau Planning area portion of CRVFO	0.1353	78.0	0.17%
E	Grand Junction FO	0.6520	77.1	0.85%
F	Uncompahgre FO	0.0576	76.3	0.08%
G	Tres Rios FO	0.5825	76.7	0.76%
H	Kremmling FO	0.0594	76.8	0.08%
I	Royal Gorge FO Area#1 (RGFO#1) -- North	0.0003	77.1	0.00%
J	Pawnee Grasslands portion of RGFO#1	0.0019	77.1	0.00%
K	RGFO#2 – West-Central/South	0.0002	77.1	0.00%
L	RGFO#3 – South	0.0002	77.1	0.00%
M	RGFO#4 – East-Central	0.0019	76.3	0.00%
N	New Mexico Farmington District	0.1829	78.0	0.23%
O	Total Colorado River Field Office	0.2807	78.0	0.36%
P	Total Royal Gorge Field Office	0.0043	77.1	0.01%
Q	Mining from 13 Colorado BLM Planning Areas	0.1111	76.6	0.14%
R	Combined new Federal O&G and Mining from the 13 Colorado BLM Planning Areas	2.8433	76.3	3.73%
S	Combined new Federal and non-Federal O&G and Mining from 13 Colorado BLM Planning Areas	4.8718	76.3	6.39%
T	Cumulative Emissions Scenario – New Federal and non-Federal O&G from 14 BLM Planning Areas plus mining in the 14 BLM Planning Areas	4.9114	76.3	6.44%
U	Combined O&G and Mining in 4 km domain	31.7908	78.0	40.75%
V	Natural Emissions	2.6588	76.3	3.49%

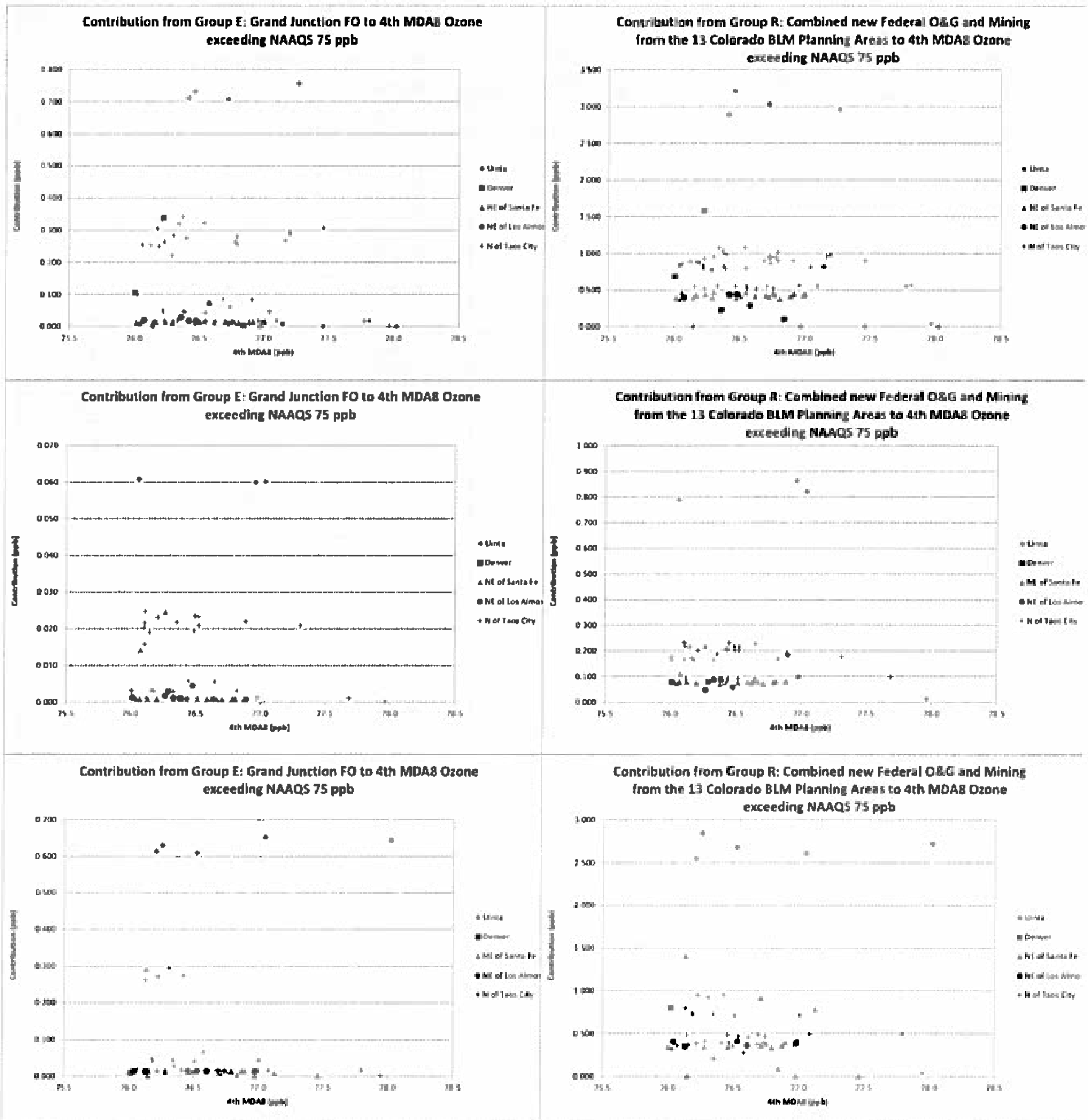

Figure 5-7a. Contributions of Federal O&G from the GJFO (Source Group E; left) and new Federal O&G and mining in the 13 Colorado Planning Areas (Source Group R; right) to modeled fourth highest daily maximum 8-hour ozone concentrations greater than the NAAQS for the 2021 High (top), Low (middle) and Medium (bottom) Development Scenarios.

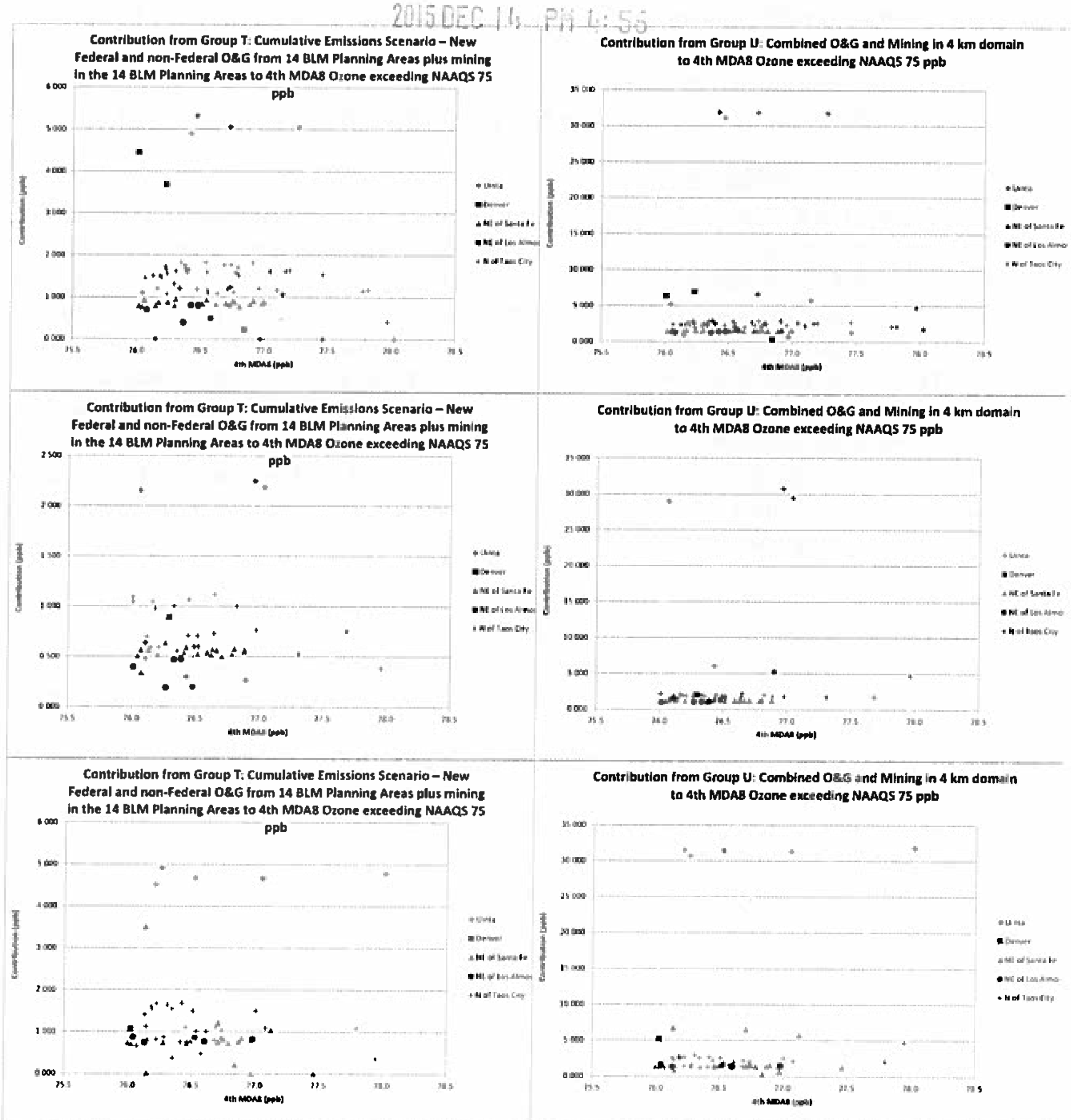

Figure 5-7b. Contributions of new Federal and non-Federal O&G and mining from the 14 BLM Planning Areas (Source Group T; left) and all O&G within the 4 km CARMMS domain plus Colorado Federal mining (Source Group U; right) to modeled fourth highest daily maximum 8-hour ozone concentrations greater than the NAAQS for the 2021 High (top), Low (middle) and Medium (bottom) Development Scenarios.

5.6.3 $PM_{2.5}$ NAAQS Analysis

There are two $PM_{2.5}$ NAAQS, one for a 24-hour averaging time that is expressed as a three-year average of the 98th percentile value in a year with a threshold of 35 µg/m³ and an annual average over three-years with a threshold of 12 µg/m³. With a complete year of modeling results, the 98th percentile corresponds to the 8th highest daily $PM_{2.5}$ concentration in a year.

5.6.3.1 24-Hour $PM_{2.5}$ NAAQS Analyses

Figure 5-8 displays the 8th highest 24-hour $PM_{2.5}$ concentrations for the 2008 Base Case and 2021 emission scenarios and their differences and the contributions of Natural Emissions to the 8th highest 24-hour $PM_{2.5}$ concentration. The maximum 8th high 24-hour $PM_{2.5}$ in 2008 (670 µg/m³) and 2021 High, Low and Medium Development Scenarios (671 µg/m³) far exceeds the 35 µg/m³ NAAQS (Figure 5-8, top panels). This high value occurs on the southern border of the CARMMS 4 km domain and is due to emissions from wildfires, as shown by its absence when Natural Emissions are removed (Figure 5-8, bottom right). Even without Natural Emissions, there are several areas where the model-estimated 8th highest 24-hour $PM_{2.5}$ concentration exceeds the NAAQS in the 2021 emissions scenarios as shown in Figure 5-9 for the 2021 High Development Scenario. These 24-hour $PM_{2.5}$ exceedance areas are identified in Figure 5-9 with numbered labels. In the analysis below we group several exceedance grid cells together: North NM (Areas 13-18); Arizona (Areas 7-9); and Central NM (Areas 11-12).

Attachments H-1, H-2 and H-3 display Source Group's contribution to 8th highest 24-hour $PM_{2.5}$ concentrations when the total concentration is above the NAAQS for the, respectively, 2021 High, Low and Medium Development Scenarios. Figure 5-10 from Attachment H-1 displays the contributions of Natural Emissions (Source Group V) and Federal mining in Colorado (Source Group Q) to the 8th highest 24-hour $PM_{2.5}$ concentration in the 2021 High Development Scenario when it exceeds the 24-hour $PM_{2.5}$ NAAQS. The exceedances in Ruidoso NM (Area 10) and North NM (Areas 13-18) appear to be due to wildfires (Natural Emissions) based on the top panel in Figure 5-10. Mining on Federal lands (Source Group Q) is causing the exceedance in South Moffat County (Area 3) based on the bottom panel in Figure 5-10.

The contributions to the 8th highest daily $PM_{2.5}$ concentrations that exceed the NAAQS from Source Groups R and S and the 2021 High Development Scenario are shown in Figure 5-11. For Source Group R, the scale has been set at a maximum of 0.25 µg/m³ (Figure 5-11, top) so the 45.8 µg/m³ contribution from mining in South Moffat County that was seen in Figure 5-10 (bottom) is not shown. This figure indicates that new Federal O&G within the 13 CO BLM Planning Areas contribute less than 0.25 µg/m³ when the modeled 2021 8th highest 24-hour $PM_{2.5}$ concentration exceeds the NAAQS (Figure 5-11, top). Adding in the non-Federal O&G emissions (Source Group S; Figure 5-11, bottom) we see contributions due to non-Federal O&G to modeled exceedances of the NAAQS as high as 15 µg/m³ that is due to non-Federal O&G emissions in the RGFO Planning Area north of Denver (Weld County).

Figure 5-12 displays the contributions of Federal O&G from the GRFO, UFO and USFS-PG Planning Areas and combined Source Group R (new Federal O&G and mining in 13 Colorado Planning Areas) to the 8th highest 24-hour $PM_{2.5}$ concentrations for the 2021 High Development Scenario. Results for the 2021 Low and Medium Development Scenario are lower and can be found in Attachment I. The maximum contribution to 8^{th} highest 24-hour $PM_{2.5}$ concentration due to emissions from new Federal O&G in these four Source Groups and the 2021 High, Low and Medium Development Scenarios are: 1.2, 0.1 and 0.8 $\mu g/m^3$ (GJFO), 0.3, 0.1 and 0.2 $\mu g/m^3$ (UFO), 0.6, 0.1 and0.2 (USFS-PG) and 39.8, 29.8 and 39.8 $\mu g/m^3$ (Source Group R) (Table 5-42). The maximum contribution due to new Federal O&G and mining from all of the Colorado BLM Planning areas is 39.8 $\mu g/m^3$ that is due to a coal mine in the LSFO Planning Area, which explains the maximum contribution of Source Group R.

Figure 5-13 shows the contributions of new Federal and non-Federal O&G and mining in the 14 BLM Planning Areas (Source Group T) and all O&G emissions in the 4 km CARMMS domain (Source Group U) for the 2021 High, Low and Medium Development Scenarios. The maximum 24-hour $PM_{2.5}$ contribution in all four panels in Figure 5-12 is essentially identical (40 $\mu g/m^3$) and is due to a coal mine in the LSFO Planning Area. 24-hour $PM_{2.5}$ contributions in excess of 3 $\mu g/m^3$ can be seen in the D-J and Piceance Basins and the Uinta Basin for Source Group U.

Table 5-42 summarizes the maximum contribution to the 8^{th} highest 24-hour $PM_{2.5}$ concentrations for all of the Source Groups and the 2021 High, Low and Medium Development Scenarios. For most BLM Planning Areas, the contribution of Federal O&G to the 8^{th} highest 24-hour $PM_{2.5}$ concentrations is small, less than 1 $\mu g/m^3$. The exception to this is new Federal O&G emissions from the WRFO (5.6, 0.6 and3.2 $\mu g/m^3$) and GJFO (1.2, 0.1 and 0.8 $\mu g/m^3$) Planning Areas. As noted previously, mining on Federal lands in the LSFO contributes a maximum of 39.8 $\mu g/m^3$ to the 8^{th} highest 24-hour $PM_{2.5}$ concentration; the mining contribution drives the maximum contribution for all of the combination Source Groups (Q through U).

The year 2021 minus year 2008 impacts difference plots (bottom left of Figures 5-8a, 5-8b and 5-8c) while comparing plots for Source Groups R and T indicates relatively large increases in 24-hour $PM_{2.5}$ concentrations primarily due to new non-Federal oil and gas in the RGFO. It should be noted that unpaved road traffic and construction fugitive dust emissions were calculated by the BLM COSO for all new RGFO Federal and non-Federal oil and gas development and the year 2008 emissions inventory did not account for total oil and gas related traffic / construction fugitive dust and therefore, the difference plots concentration changes (year 2021 minus year 2008) are overestimates.

Table 5-42a. Maximum contribution to the 8th high 24-hour $PM_{2.5}$ concentrations ($\mu g/m^3$) for each of the Source Groups and the 2021 High, Low and Medium Development Scenarios.

Source Group	24-Hour $PM_{2.5}$ ($\mu g/m^3$)		
	High	Low	Medium
A. Little Snake FO	0.8	0.2	0.6
B. White River FO	5.6	0.6	3.2
C. CRVFO (No Roan)	0.4	0.2	0.3
D. Roan Plateau	0.3	0.1	0.3
E. Grand Junction FO	1.2	0.1	0.8
F. Uncompahgre FO	0.3	0.1	0.2
G. Tres Rios FO	0.3	0.0	0.2
H. Kremmling FO	0.1	0.0	0.0
I. Royal Gorge FO No. 1	0.2	0.0	0.1
J. Pawnee Grasslands	0.6	0.1	0.2
K. Royal Gorge FO No. 2	0.1	0.0	0.0
L. Royal Gorge FO No. 3	0.0	0.0	0.0
M. Royal Gorge FO No. 4	0.1	0.0	0.0
N. NMFFO (Mancos)	0.5	0.6	0.4
O. CRVFO (w/ Roan)	0.7	0.3	0.5
P. Royal Gorge FO (total)	0.7	0.2	0.2
Q. Federal Mining in CO	39.8	39.8	39.8
R. New Federal O&G/Mining in CO	39.8	39.8	39.8
S. New O&G/Mining in CO	40.0	39.8	39.9
T. New O&G/Mining in CO/NM	40.0	39.8	39.9
U. All O&G in 4 km Domain	40.0	40.0	40.0
V. Natural Emissions	658.2	658.2	658.2

Table 5-42b. Maximum contribution to the annual $PM_{2.5}$ concentrations ($\mu g/m^3$) for each of the Source Groups and the 2021 High, Low and Medium Development Scenarios.

Source Group	Annual $PM_{2.5}$ ($\mu g/m^3$)		
	High	Low	Medium
A. Little Snake FO	0.7	0.1	0.5
B. White River FO	4.4	0.7	2.6
C. CRVFO (No Roan)	0.3	0.2	0.2
D. Roan Plateau	0.2	0.1	0.2
E. Grand Junction FO	1.0	0.1	0.6
F. Uncompahgre FO	0.2	0.1	0.1
G. Tres Rios FO	0.4	0.1	0.2
H. Kremmling FO	0.0	0.0	0.0
I. Royal Gorge FO No. 1	0.1	0.0	0.0
J. Pawnee Grasslands	0.2	0.0	0.1
K. Royal Gorge FO No. 2	0.0	0.0	0.0
L. Royal Gorge FO No. 3	0.0	0.0	0.0
M. Royal Gorge FO No. 4	0.1	0.0	0.0
N. NMFFO (Mancos)	0.3	0.3	0.2
O. CRVFO (w/ Roan)	0.5	0.3	0.3
P. Royal Gorge FO (total)	0.3	0.1	0.1
Q. Federal Mining in CO	20.7	20.7	20.7
R. New Federal O&G/Mining in CO	20.7	20.7	20.7
S. New O&G/Mining in CO	20.7	20.7	20.7
T. New O&G/Mining in CO/NM	20.7	20.7	20.7
U. All O&G in 4 km Domain	20.8	20.7	20.8
V. Natural Emissions	26.4	26.4	26.4

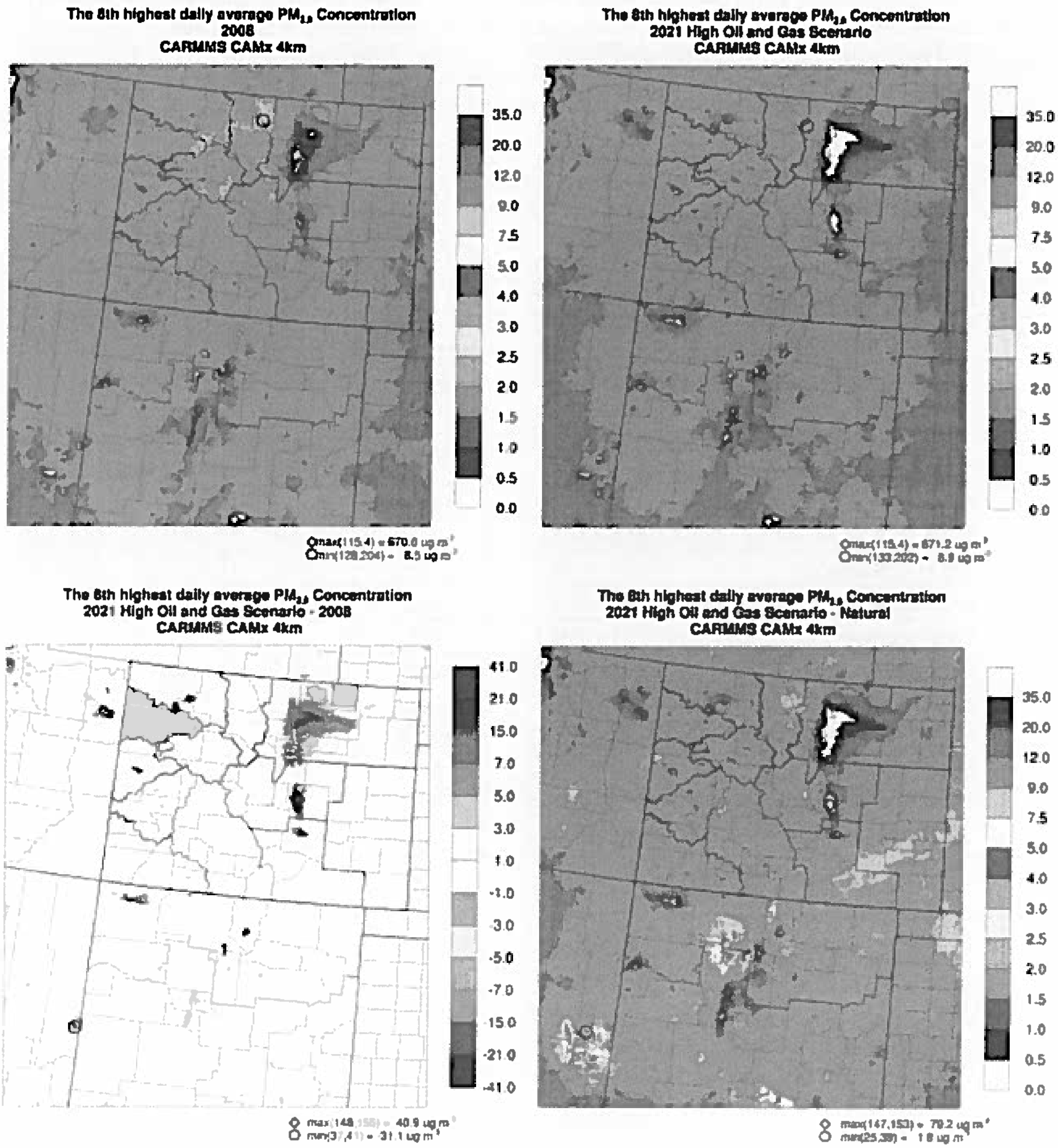

Figure 5-8a. Eighth highest 24-hour $PM_{2.5}$ concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 High minus 2008 differences (bottom left) and Natural Emissions (bottom right).

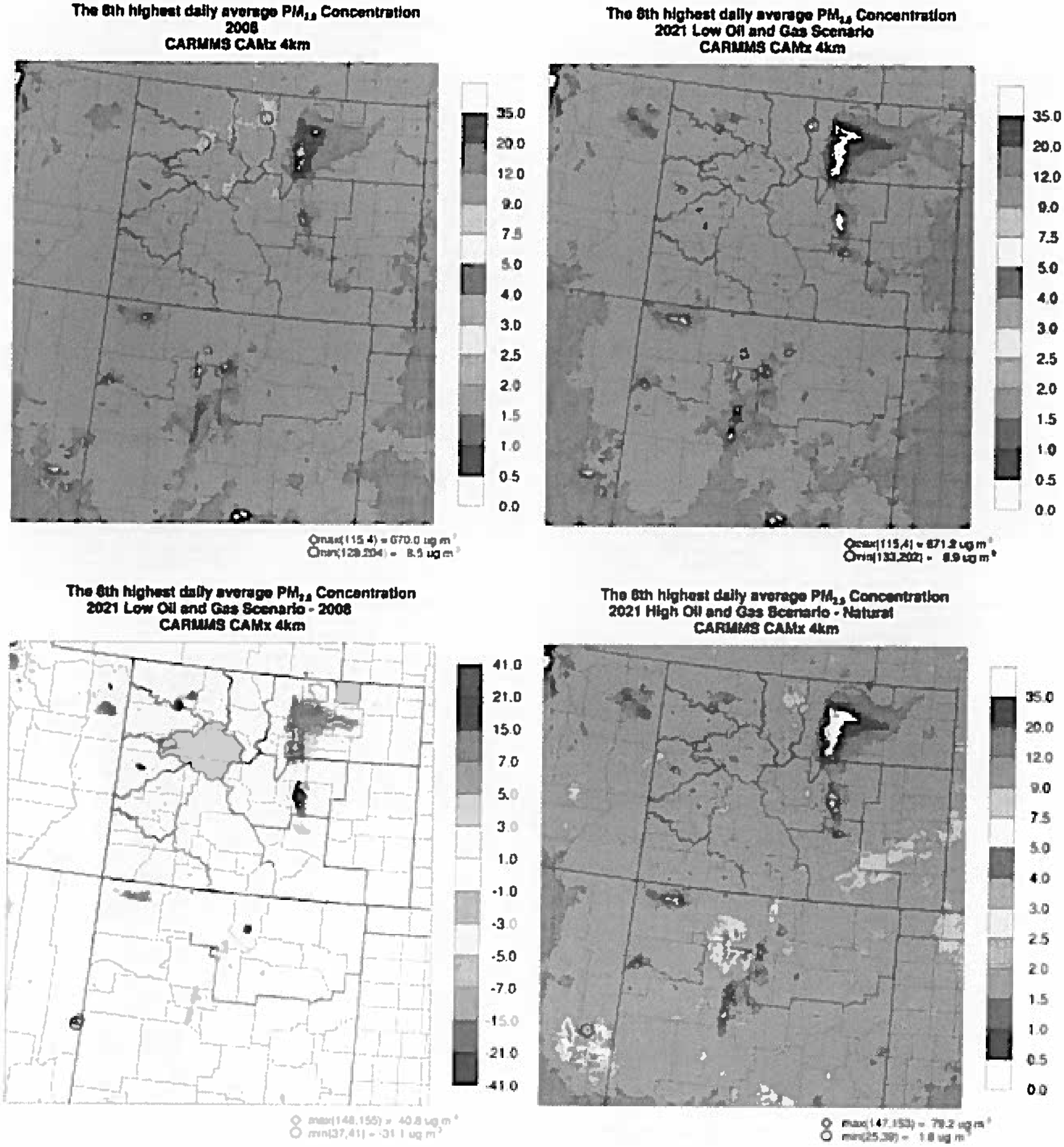

Figure 5-8b. Eighth highest 24-hour $PM_{2.5}$ concentrations for the 2008 Base Case (top left), 2021 Low Development Scenario (top right), 2021 Low minus 2008 differences (bottom left) and Natural Emissions (bottom right).

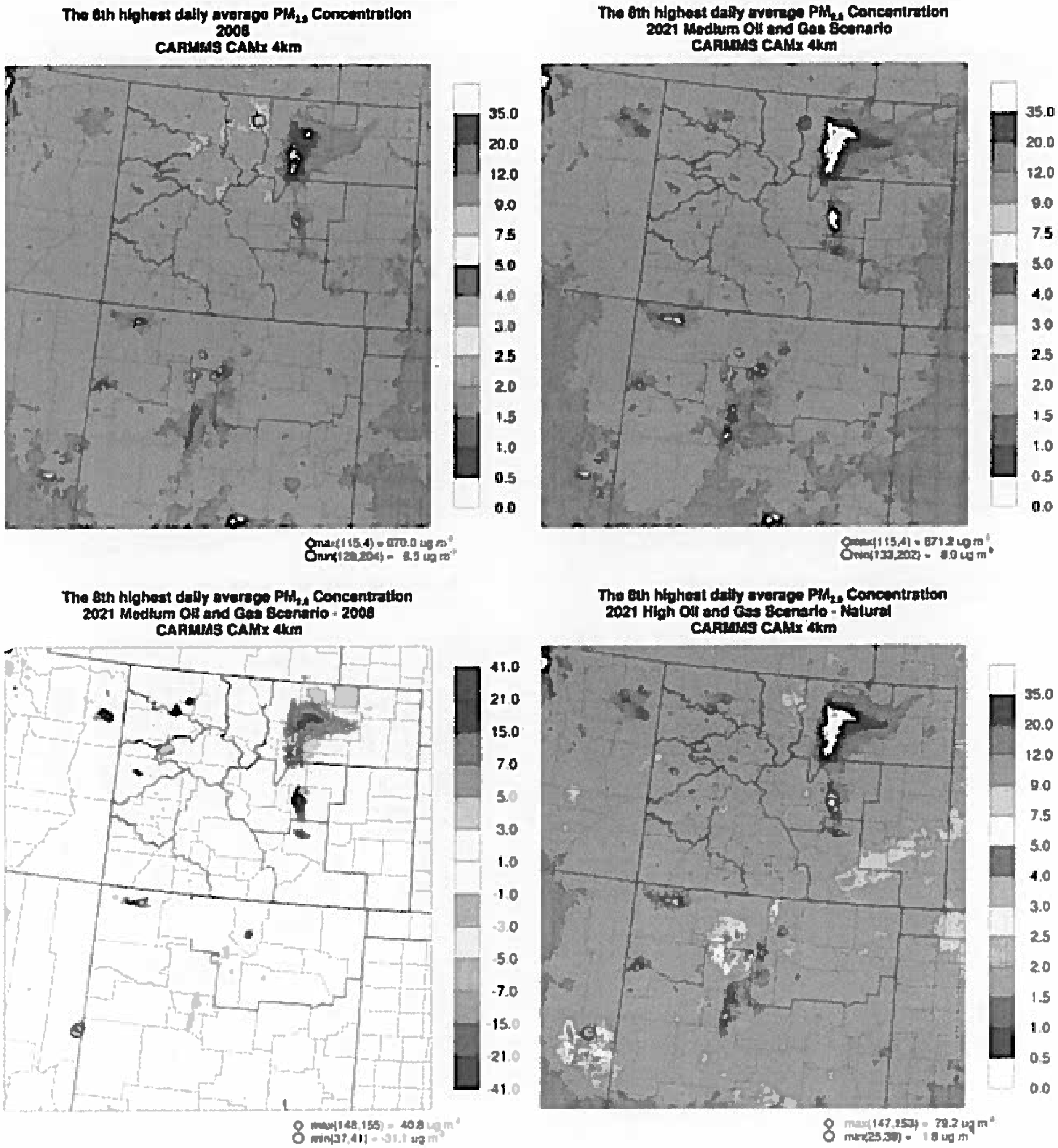

Figure 5-8c. Eighth highest 24-hour $PM_{2.5}$ concentrations for the 2008 Base Case (top left), 2021 Medium Development Scenario (top right), 2021 Medium minus 2008 differences (bottom left) and Natural Emissions (bottom right).

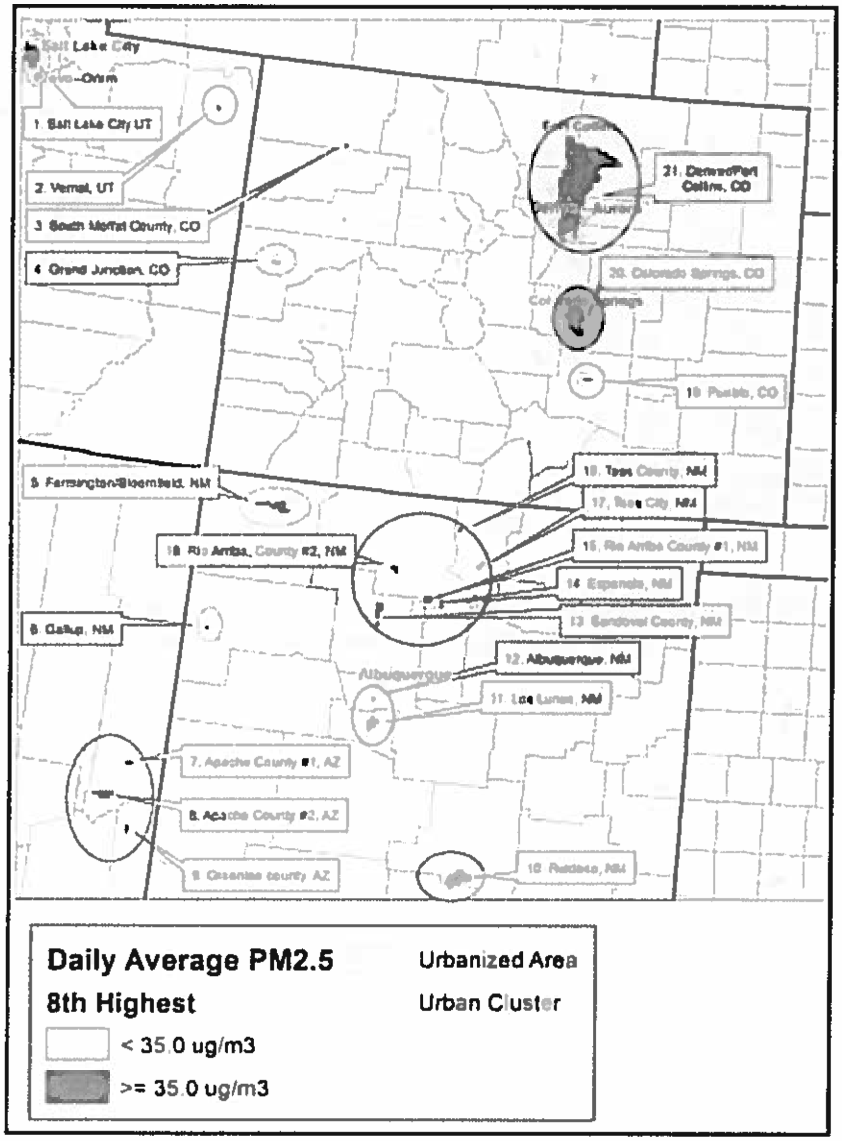

Figure 5-9. Locations of grid cells with modeled 2021 High Development Scenario 8th highest 24-hour $PM_{2.5}$ concentrations above the 35 $\mu g/m^3$ NAAQS.

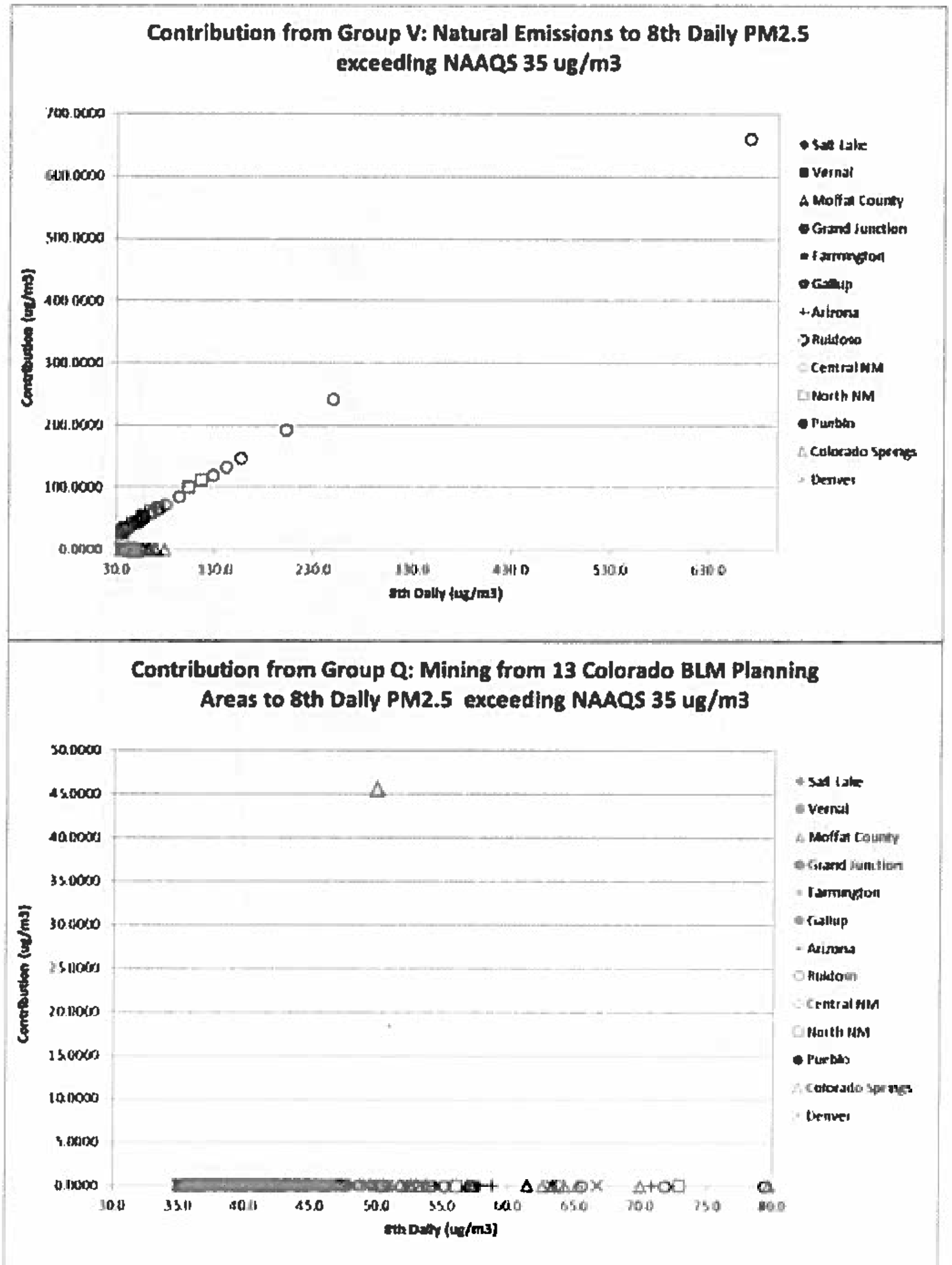

Figure 5-10. Natural Emissions (Source Group V, top) and Mining of Federal land in Colorado (Source Group Q, bottom) contributions to the modeled 8th highest 24-hour $PM_{2.5}$ concentration from the 2021 High Development Scenario.

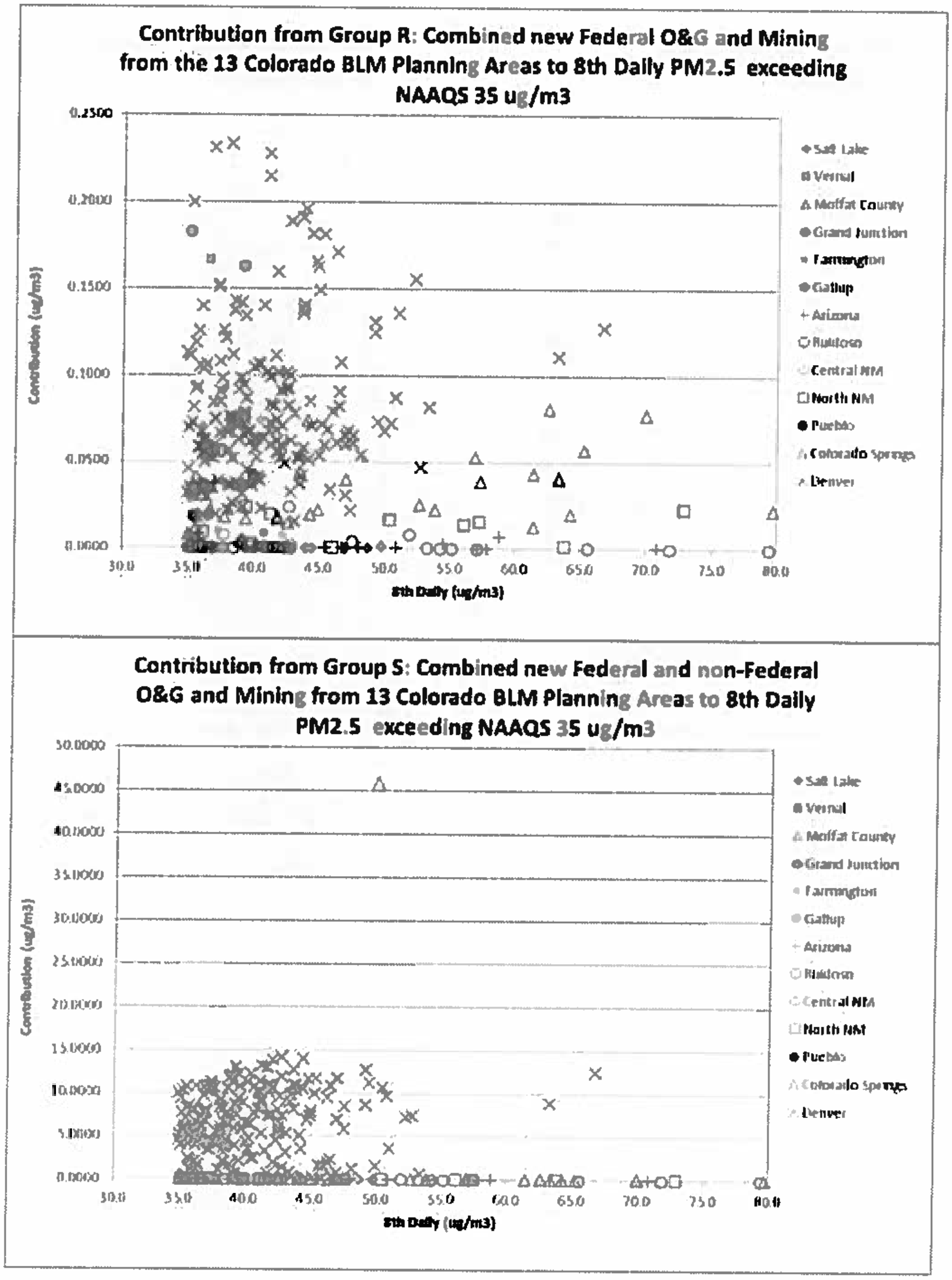

Figure 5-11. Natural Emissions (Source Group V, top) and Mining of Federal land in Colorado (Source Group Q, bottom) contributions to the modeled 8th highest 24-hour $PM_{2.5}$ concentration from the 2021 High Development Scenario.

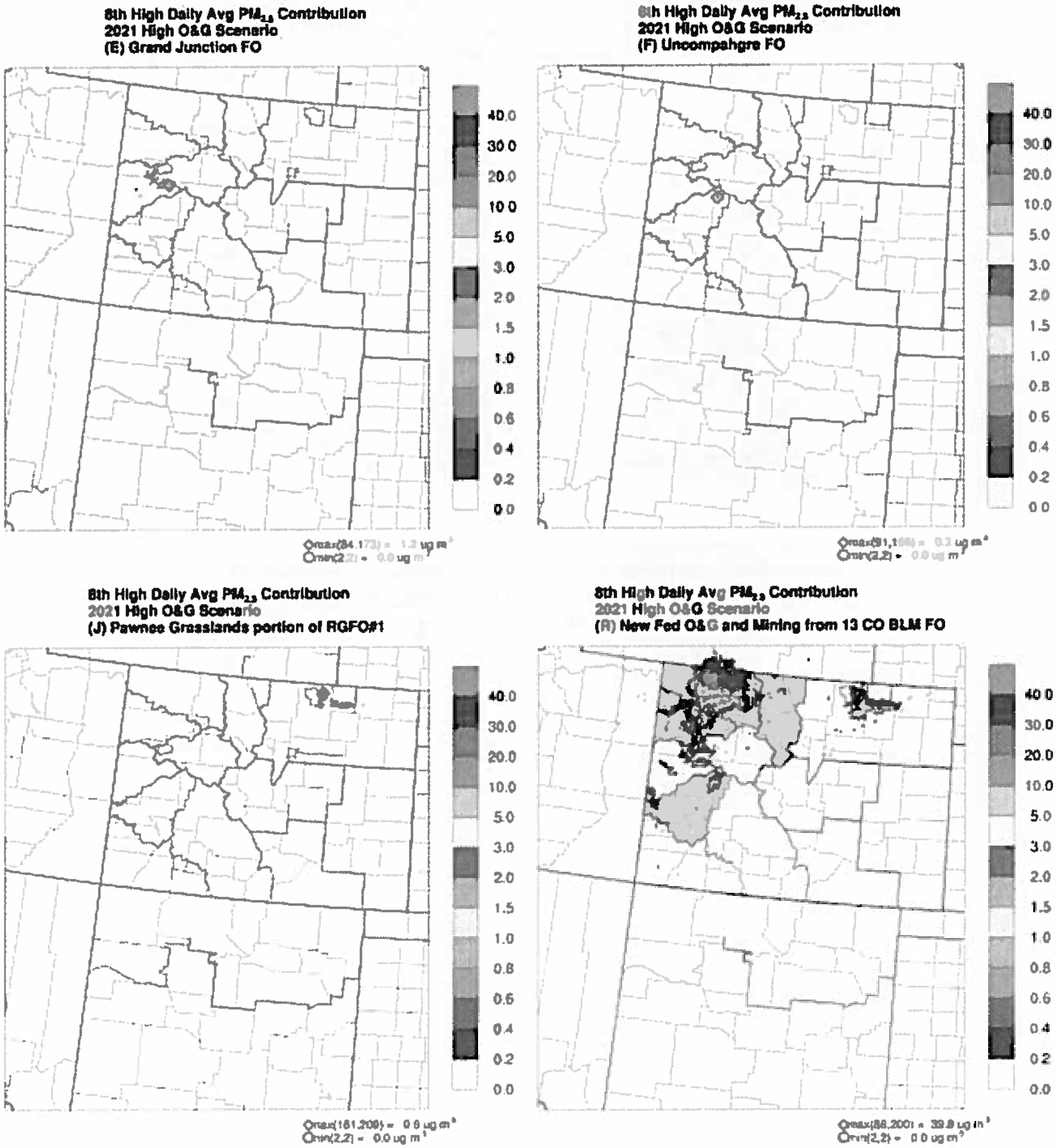

Figure 5-12. Contribution to 8th highest daily $PM_{2.5}$ concentrations due to emissions from new Federal O&G within the GJFO (top left), UFO (top right) and USFS-PG (bottom left) Planning Areas and new Federal O&G and mining within the 13 Colorado BLM Planning Areas (bottom right) for the 2021 High Development Scenario.

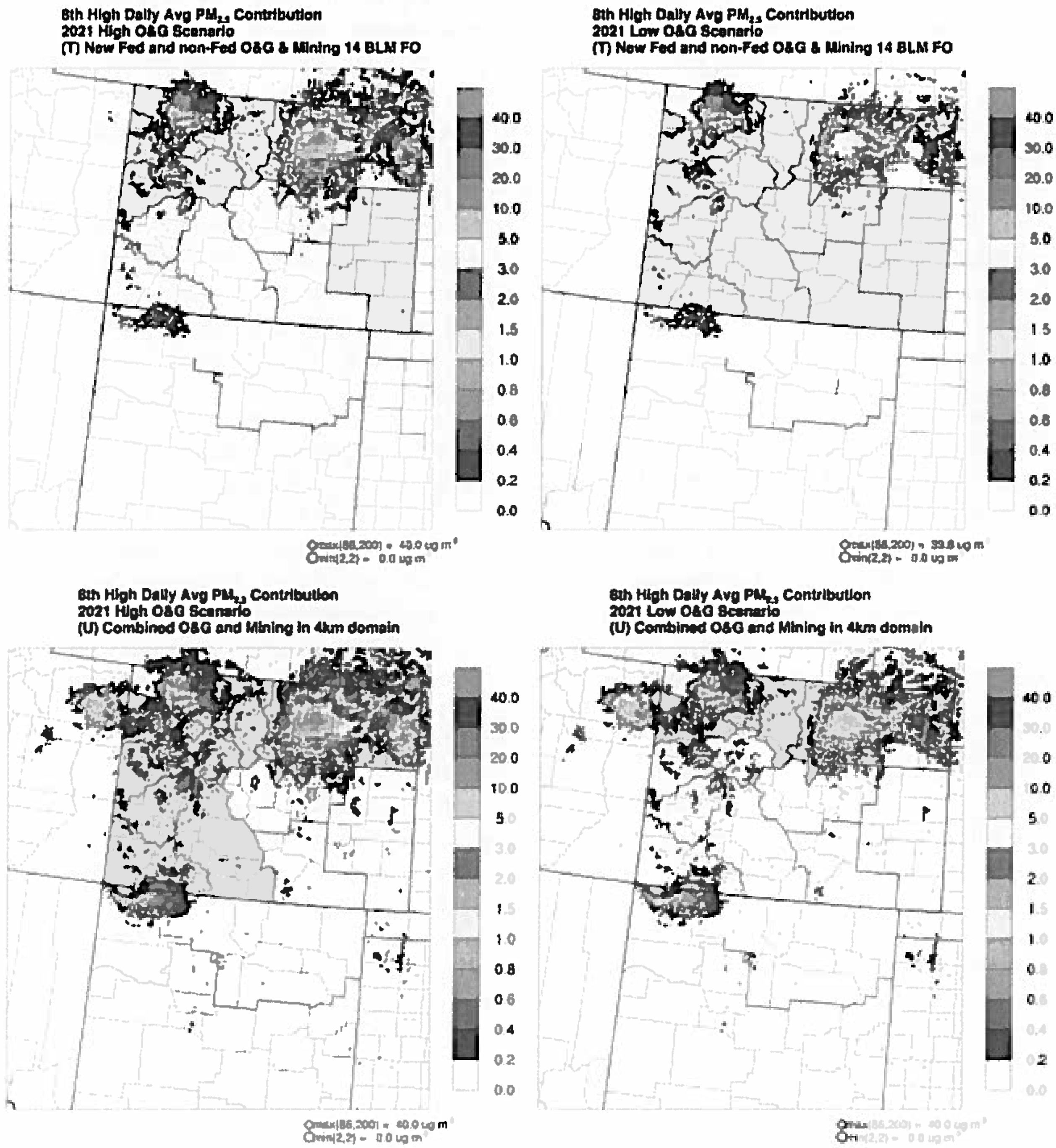

Figure 5-13. Contribution to 8th highest daily $PM_{2.5}$ concentrations due to emissions from new Federal and non-Federal O&G and mining within the 14 BLM Planning Areas (top) and all O&G emissions within the 4 km CARMMS domain (bottom) for the 2021 High (left) and Low (right) Development Scenarios.

5.6.3.2 Annual $PM_{2.5}$ NAAQS Analysis

Figure 5-14 displays the annual average $PM_{2.5}$ concentrations for the 2008 Base Case and 2021 emissions scenarios and their differences and the annual average $PM_{2.5}$ concentrations without Natural Emissions. The highest annual average $PM_{2.5}$ concentration is ~30 µg/m^3 in the 2008 and 2021 emission scenarios and occurs in the southern most portion of the CARMMS 4 km domain near Ruidoso, NM and is due to wildfires since it is gone when the natural emissions are removed. However, even without Natural Emissions there are several areas where the modeled annual $PM_{2.5}$ concentrations exceed the 12 µg/m^3 annual $PM_{2.5}$ NAAQS (red areas in Figure 5-14) in the 2008 Base case and 2021 High and Low Development Scenarios. There are noticeable increases in $PM_{2.5}$ concentrations in Moffat County in the BLM LSFO Planning Area for the 2021 emission scenarios compared to the 2008 base case that are due to higher emissions from mines (Figure 5-14, top two panels). For example, the Colowyo mine $PM_{2.5}$ emissions are 325 TPY in the 2008 base case and 3,400 TPY in the 2021 emission scenarios.

The maximum contribution of each Source Group to annual $PM_{2.5}$ concentrations for the 2021 High and Low Development Scenarios are shown in Table 5-42b. With two exceptions, new Federal O&G within each of the 14 BLM Planning Areas have contributions of less than 1 µg/m^3 to annual average $PM_{2.5}$ concentrations. The two exceptions are the WRFO (4.4, 0.7 and 2.6 µg/m^3) and GJFO (1.0, 0.1 and 0.6 µg/m^3) Planning Areas, and even for those two areas the contributions of the 2021 Low Development Scenario are below 1 µg/m^3. Mining on Federal lands in Colorado contributes a maximum of 20.7 µg/m^3 due to the coal mine in the LSFO Planning Area. The maximum annual $PM_{2.5}$ due to mining drives the maximum annual $PM_{2.5}$ contributions for all of the combined Source Groups Q through U. Natural emissions (wildfires) contribute a maximum annual $PM_{2.5}$ contribution of 26.4 µg/m^3.

Figure 5-15 displays the differences in annual average $PM_{2.5}$ concentrations between the 2021 High Development Scenario and 2021 with the contributions from Source Groups F (UFO), J (USFS-PG), R and T removed; results for the 2021 Low and Medium Development Scenarios are similar but lower and can be found in Attachment I. Very small contributions to annual $PM_{2.5}$ are seen for new Federal O&G from the UFO and USFS-PG Planning Areas (maximum of 0.2 µg/m^3). The high contribution of the LSFO coal mine (20.7 µg/m^3) is seen in the Source Group R plot (Figure 5-15, bottom left). Relatively high (> 3 µg/m^3) contributions to annual average $PM_{2.5}$ are seen in the Source Group T contributions in Weld County (Figure 5-15, bottom right). These higher Weld County $PM_{2.5}$ contributions in Source Group T compared to Source Group R are due to $PM_{2.5}$ emissions from new non-Federal O&G emissions, which is confirmed by the spatial emission plots in Figure 3-10. As noted for $PM_{2.5}$ 24-hour average impacts discussion, unpaved road traffic and construction fugitive dust emissions were calculated by the BLM COSO for all new RGFO Federal and non-Federal oil and gas development and the year 2008 emissions inventory did not account for total oil and gas related traffic / construction fugitive dust and therefore, the difference plots concentration changes (year 2021 minus year 2008) are overestimates.

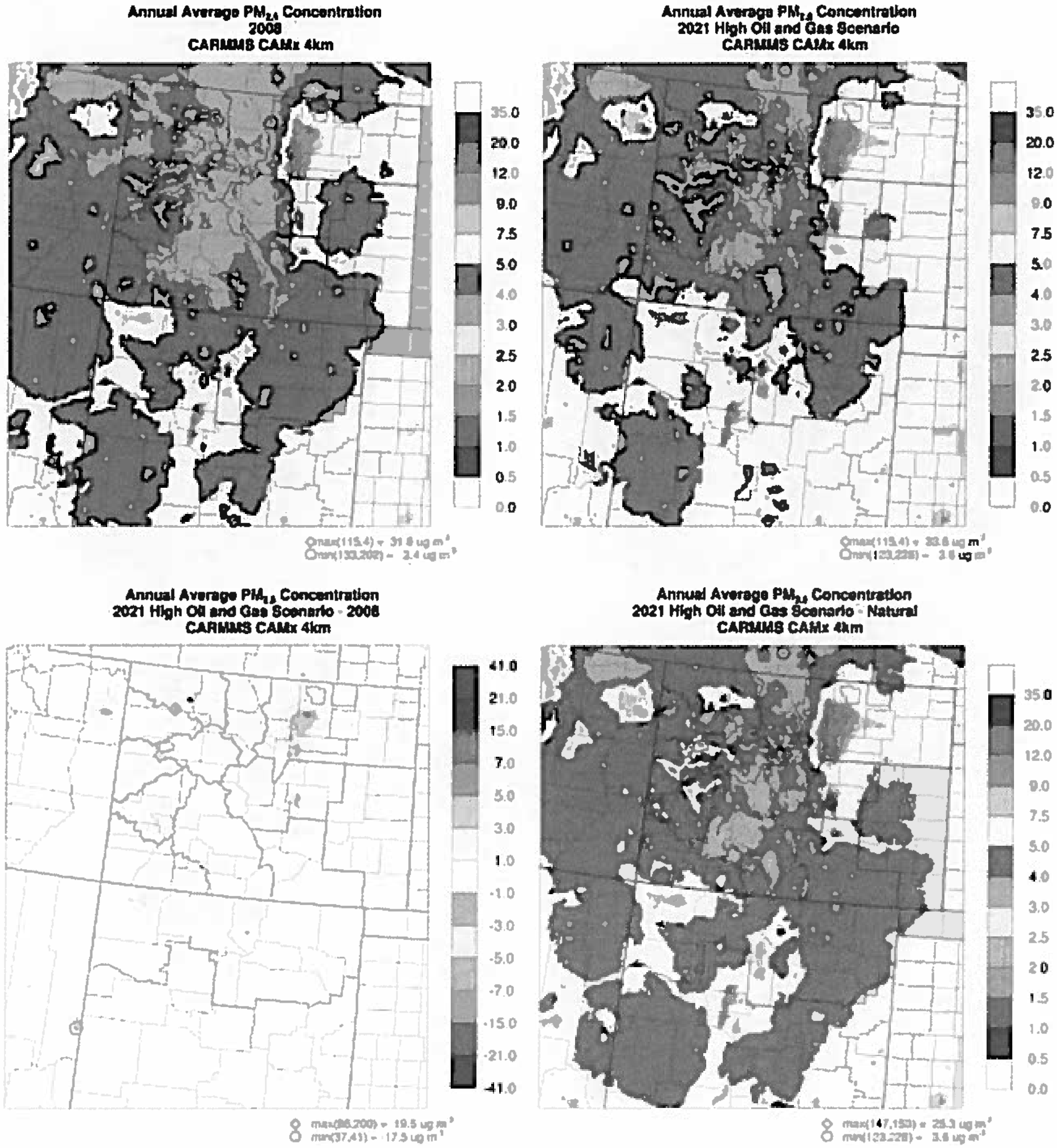

Figure 5-14a. Annual average $PM_{2.5}$ concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 High minus 2008 differences (bottom left) and Natural Emissions (bottom right).

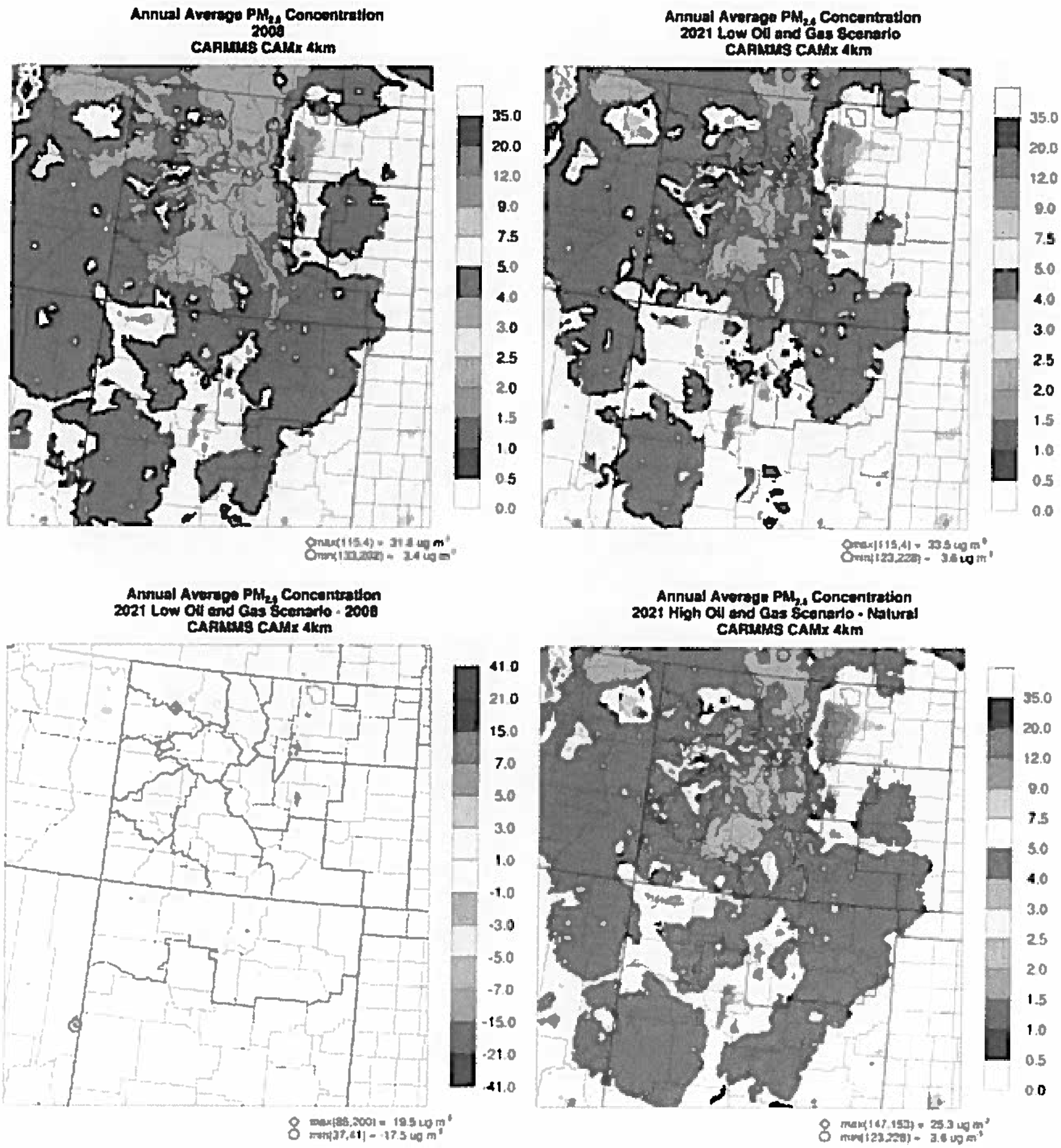

Figure 5-14b. Annual average $PM_{2.5}$ concentrations for the 2008 Base Case (top left), 2021 Low Development Scenario (top right), 2021 Low minus 2008 differences (bottom left) and Natural Emissions (bottom right).

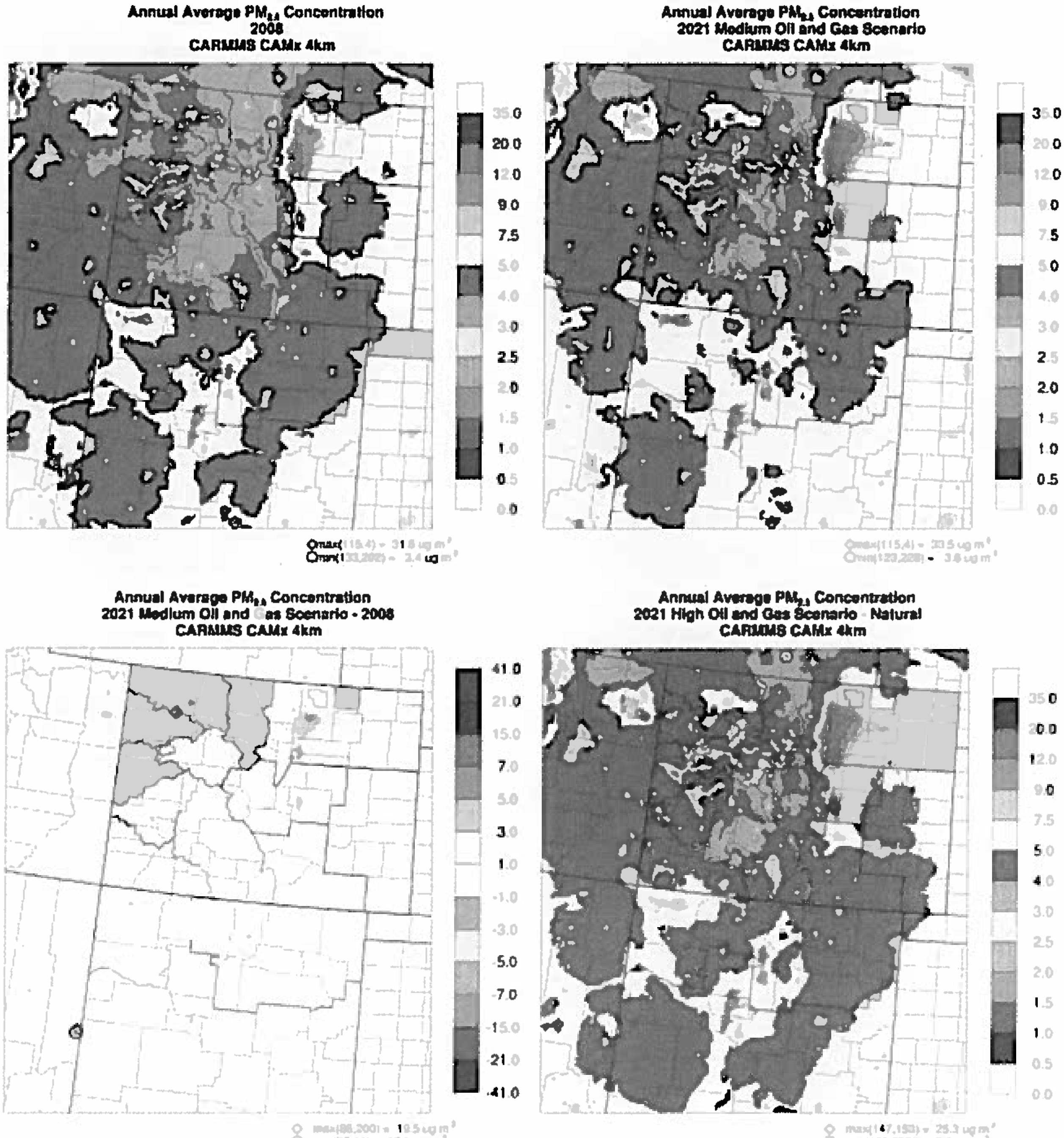

Figure 5-14c. Annual average $PM_{2.5}$ concentrations for the 2008 Base Case (top left), 2021 Medium Development Scenario (top right), 2021 Medium minus 2008 differences (bottom left) and Natural Emissions (bottom right).

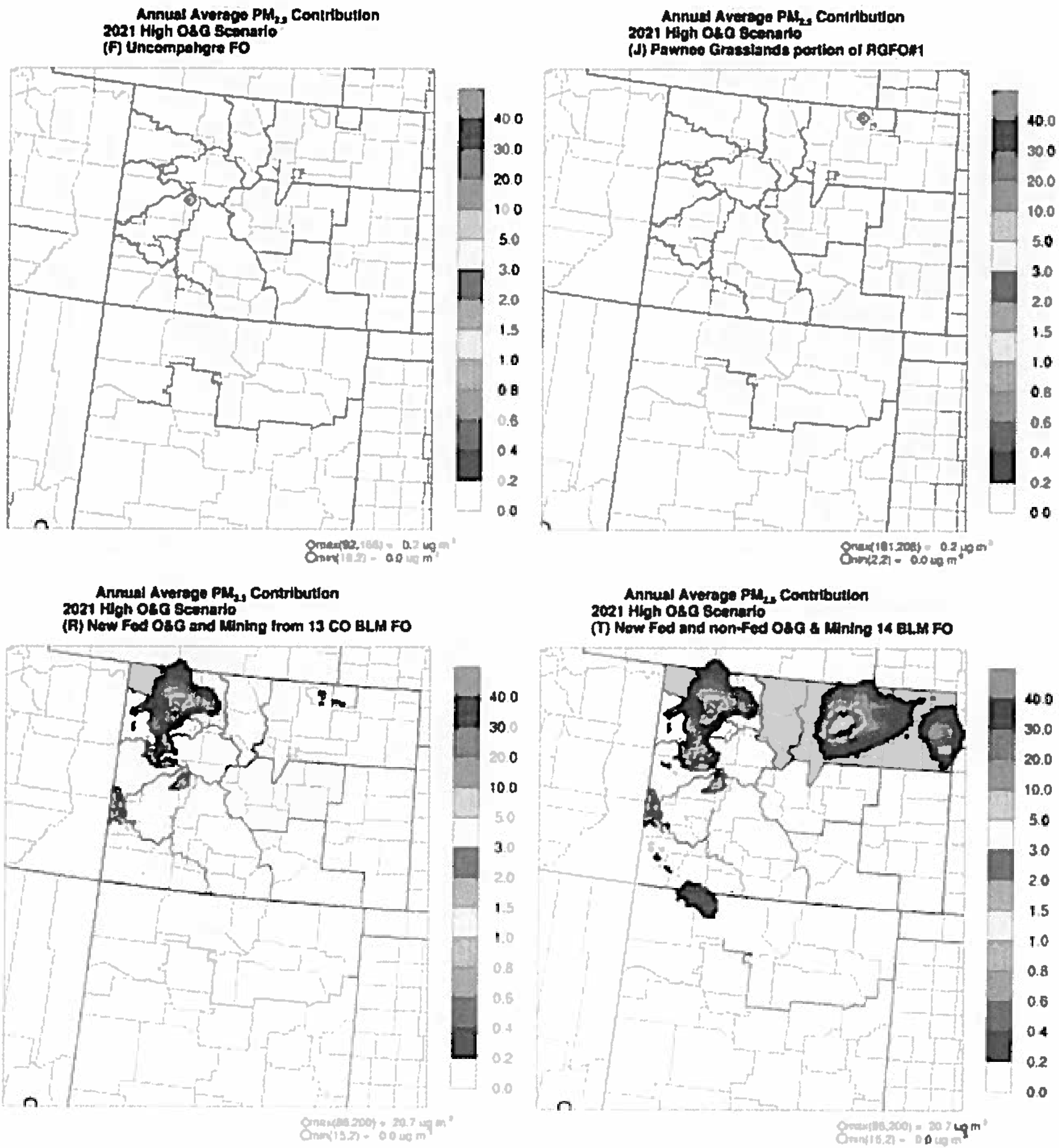

Figure 5-15. Contribution to annual average $PM_{2.5}$ concentrations due to emissions from new Federal O&G within the UFO (top left) and USGS-PG (top right) Planning Areas and new O&G and mining from the 13 Colorado BLM Planning Areas (bottom left) and new Federal O&G and mining and non-Federal O&G from the 14 CO/NM BLM Planning Areas for the 2021 High Development Scenario.

5.6.4 PM_{10} NAAQS Analysis

Figure 5-16 and 5-17 displays the 2021 High Development Scenario modeling results for 24-hour PM_{10} that can be compared to the 150 µg/m^3 24-hour PM_{10} NAAQS. Much of the discussion on 24-hour $PM_{2.5}$ also holds for 24-hour PM_{10}, although there are less exceedances of the 24-hour PM_{10} NAAQS since the threshold is higher. Extremely high highest second high PM_{10} concentrations occur in the 2008 and 2021 emissions scenarios that exceed 1,000 µg/m^3 (Figure 5-16, top panels). However, when natural emissions are removed the highest PM_{10} concentration drops to ~390 µg/m^3, which is much lower but still above the 24-hour PM_{10} NAAQS. With two exceptions, the maximum contribution of new Federal O&G emissions to the 2nd highest 24-hour PM_{10} concentrations from each of the BLM Planning Areas individually is less than 3 µg/m^3. The two exceptions and the maximum contributions due to the 2021 High, Low and Medium Development Scenarios are the WRFO (32.2, 3.1 and 11.5 µg/m^3) and GJFO (7.9, 0.2 and 3.5 µg/m^3) Planning Areas. Mining on Federal lands contributes a maximum of 47.8 µg/m^3 to the 2nd high 24-hour PM_{10} concentrations in all three of the 2021 emission scenarios. The contributions due to new Federal O&G to 2nd high 24-hour PM_{10} for the UFO and USFS-PG and the 2021 High Development Scenario are shown in the top two panels of Figure 5-17 with very small contributions seen. The bottom two panels in Figure 5-17 show the contributions of Source Groups R and T to the 2nd high 24-hour PM_{10} concentration for the 2021 High Development Scenario that display the mining contribution in South Moffat County and new non-Federal O&G contribution in Weld County. The contributions of all of the Source Groups and all three 2021 emission scenarios to 24-hour PM_{10} concentrations can be found in Attachment I.

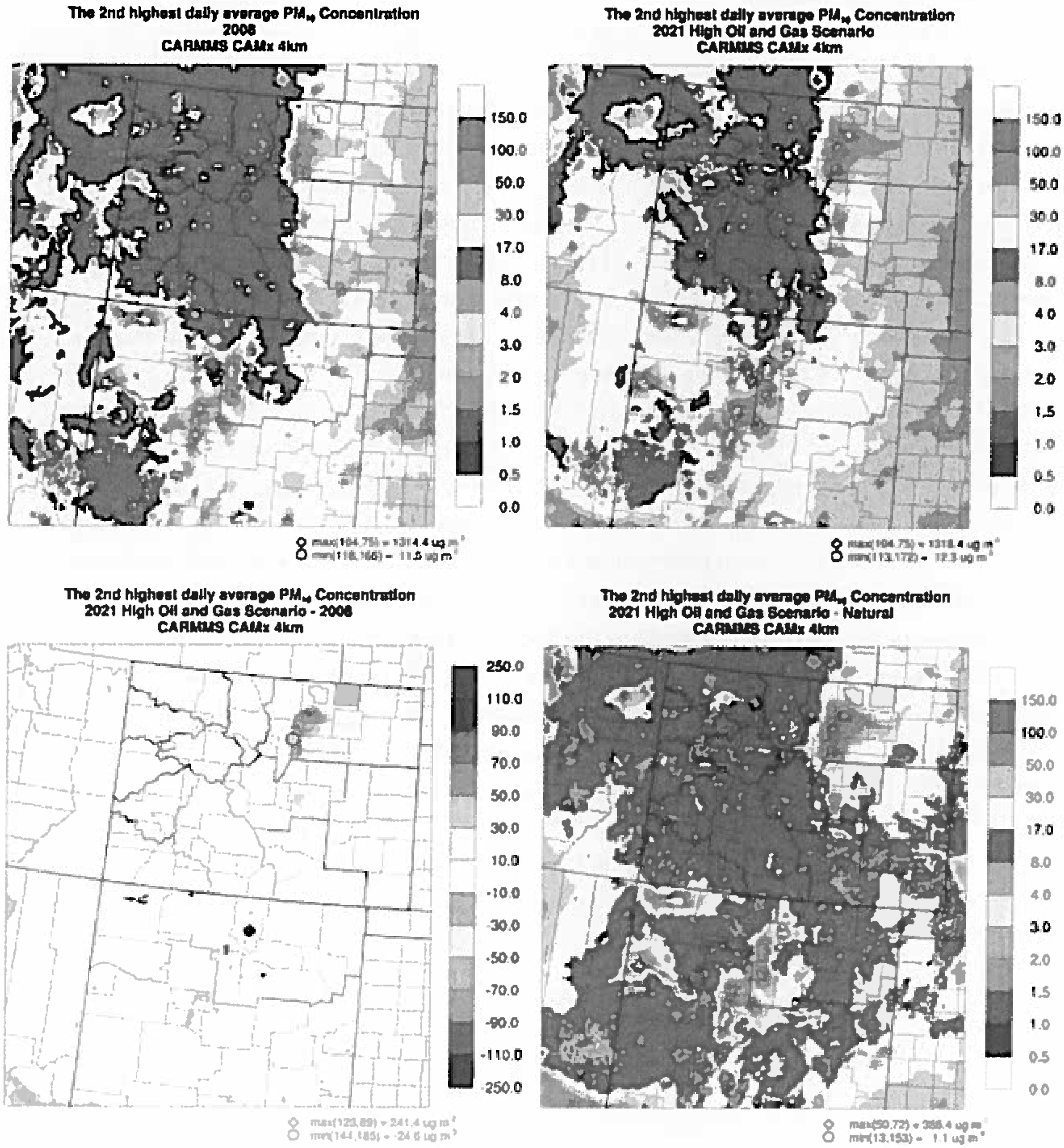

Figure 5-16. Second highest 24-hour average PM_{10} concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 minus 2008 differences (bottom left) and Natural Emissions (bottom right).

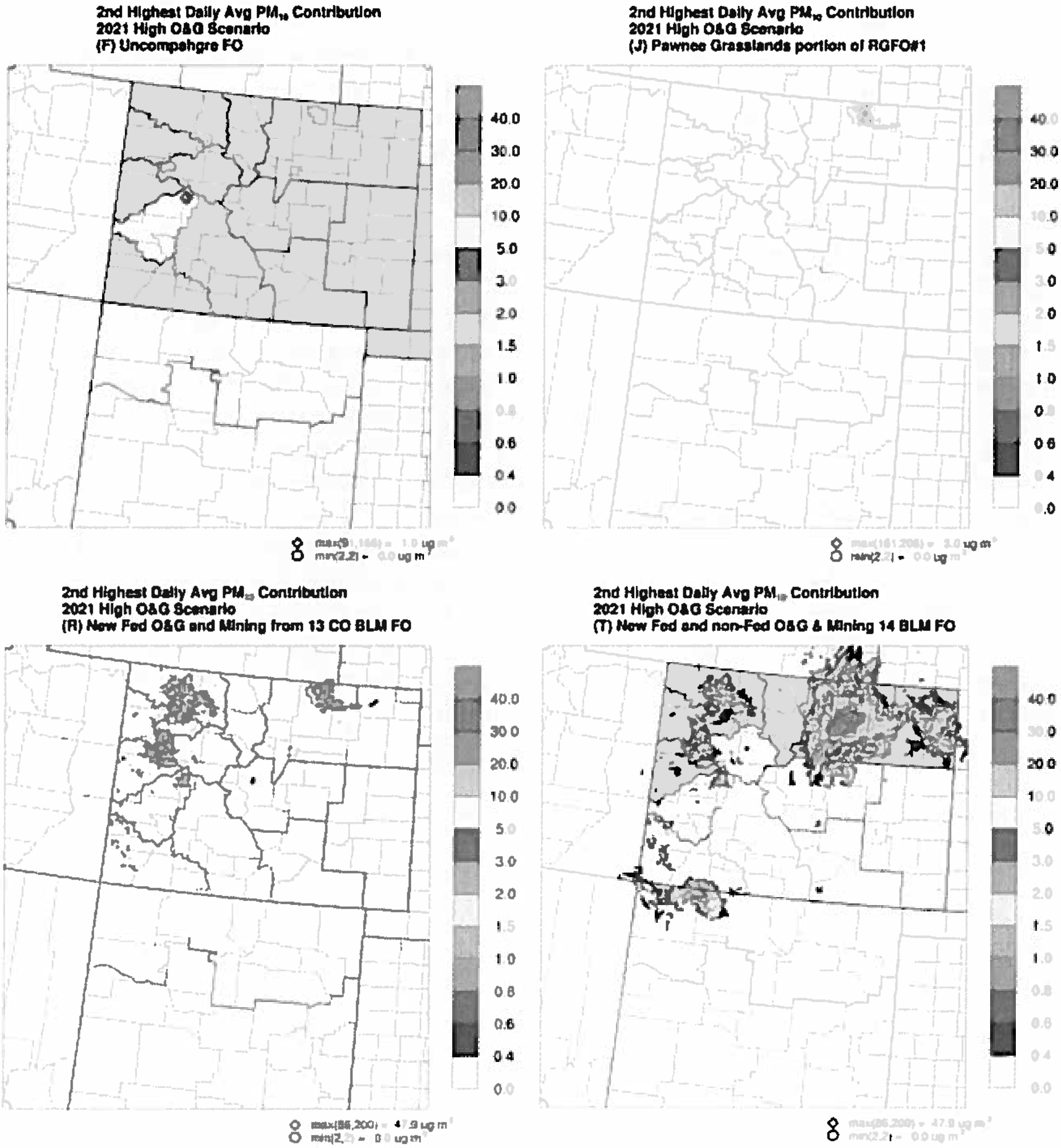

Figure 5-17. Contribution to second highest 24-hour average PM_{10} concentrations due to emissions from new Federal O&G within the UFO (top left) and USGS-PG (top right) Planning Areas and new O&G and mining from the 13 Colorado BLM Planning Areas (bottom left) and new Federal O&G and mining and non-Federal O&G from the 14 CO/NM BLM Planning Areas for the 2021 High Development Scenario.

5.6.5 SO_2 NAAQS Analysis

The 2008 Base Case and 2021 High Development Scenario, their differences and contributions of Natural Emissions to 1-hour, 3-hour and annual SO_2 concentrations are shown in, respectively, Figures 5-18 through 5-21. The 1-hour SO_2 NAAQS is 196 $\mu g/m^3$ and it is exceeded when the colors in Figure 5-17 are yellow or hotter. With one exception, the 4th highest daily maximum 1-hour SO_2 concentrations are below the NAAQS throughout the 4 km CARMMS domain for the 2021 High Development Scenario. The exception is an isolated point in northeast Arizona where a value of 212 $\mu g/m^3$ is seen that is not due to natural emissions (see Figure 5-18, bottom right) or O&G and mining emissions in Colorado or New Mexico that is the focus of CARMMS. With one exception, new Federal O&G emissions in the 14 BLM Planning Areas have very small contributions to 1-hour, 3-hour, 24-hour and annual SO_2 concentrations with contributions being less than 1 $\mu g/m^3$. The exception is for the WRFO Planning Area (Source Group B) that contributes 78.4, 75.0, 42.7 and 18.0 $\mu g/m^3$ to the 1-hour, 3-hour, 24-hour and annual average SO_2 concentrations for the 2021 High and Medium Development Scenarios and 12.9, 12.0, 7.0 and 3.0 $\mu g/m^3$ for the 2021 Low Development Scenario. As noted in Section 3.7, a majority of the SO_2 emissions in the WRFO Planning Area are due to the Meeker and Willow Creek gas plants whose emissions were based on the CDPHE 2008 APEN data grown to 2021 based on the change in gas production within the Piceance Basin between 2008 and 2021. For the 2021 High Development Scenario the 2021 growth factor from 2008 was a factor of 3.4. Example spatial maps showing the SO_2 contributions for Source Groups R and T and the 2021 High Development Scenario are given in Figure 5-22 with other Source Groups and 2021 emission scenarios given in Attachment I.

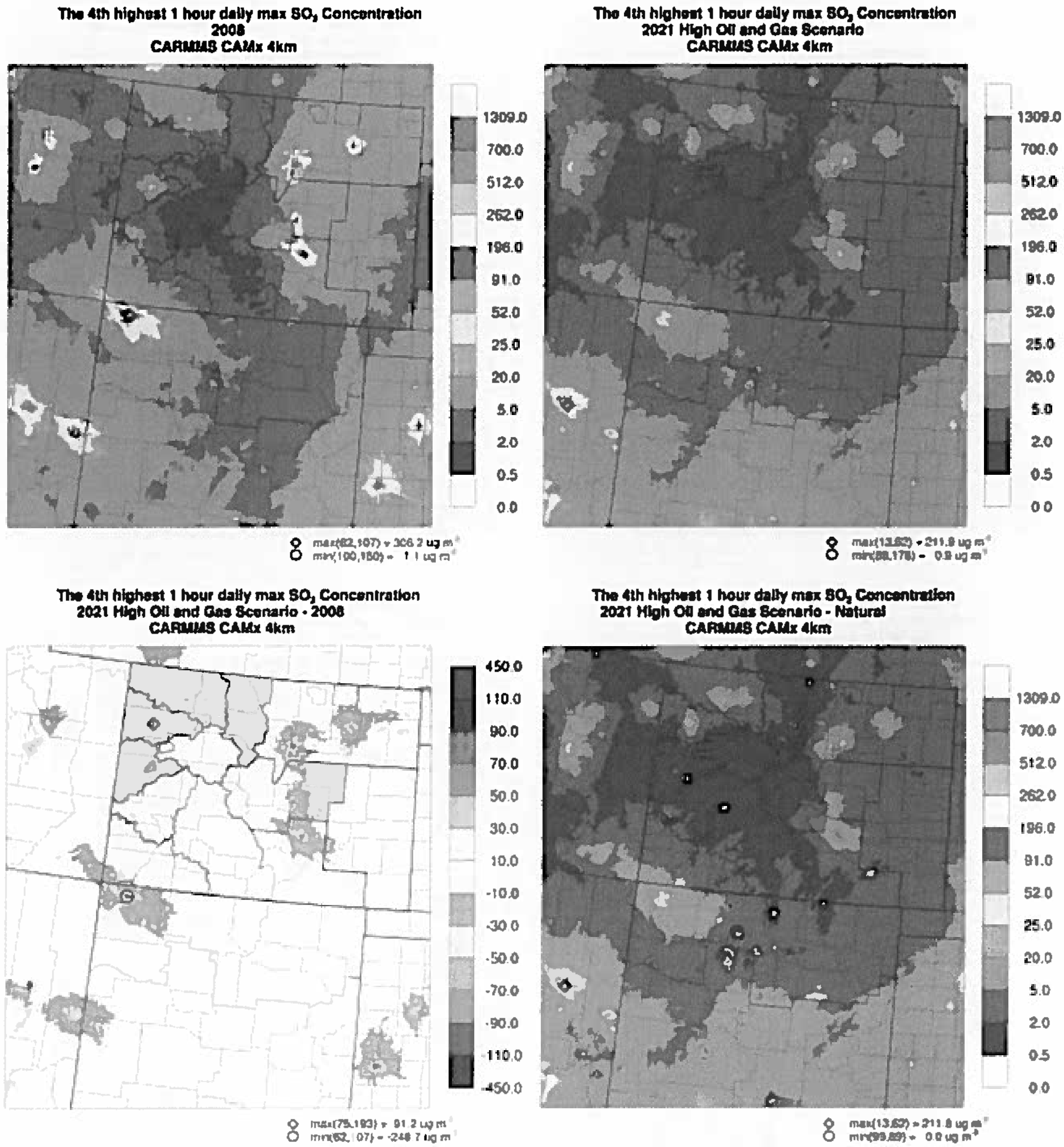

Figure 5-18. Fourth highest (99th percentile) daily maximum 1-hour average SO_2 concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 minus 2008 differences (bottom left) and Natural Emissions (bottom right).

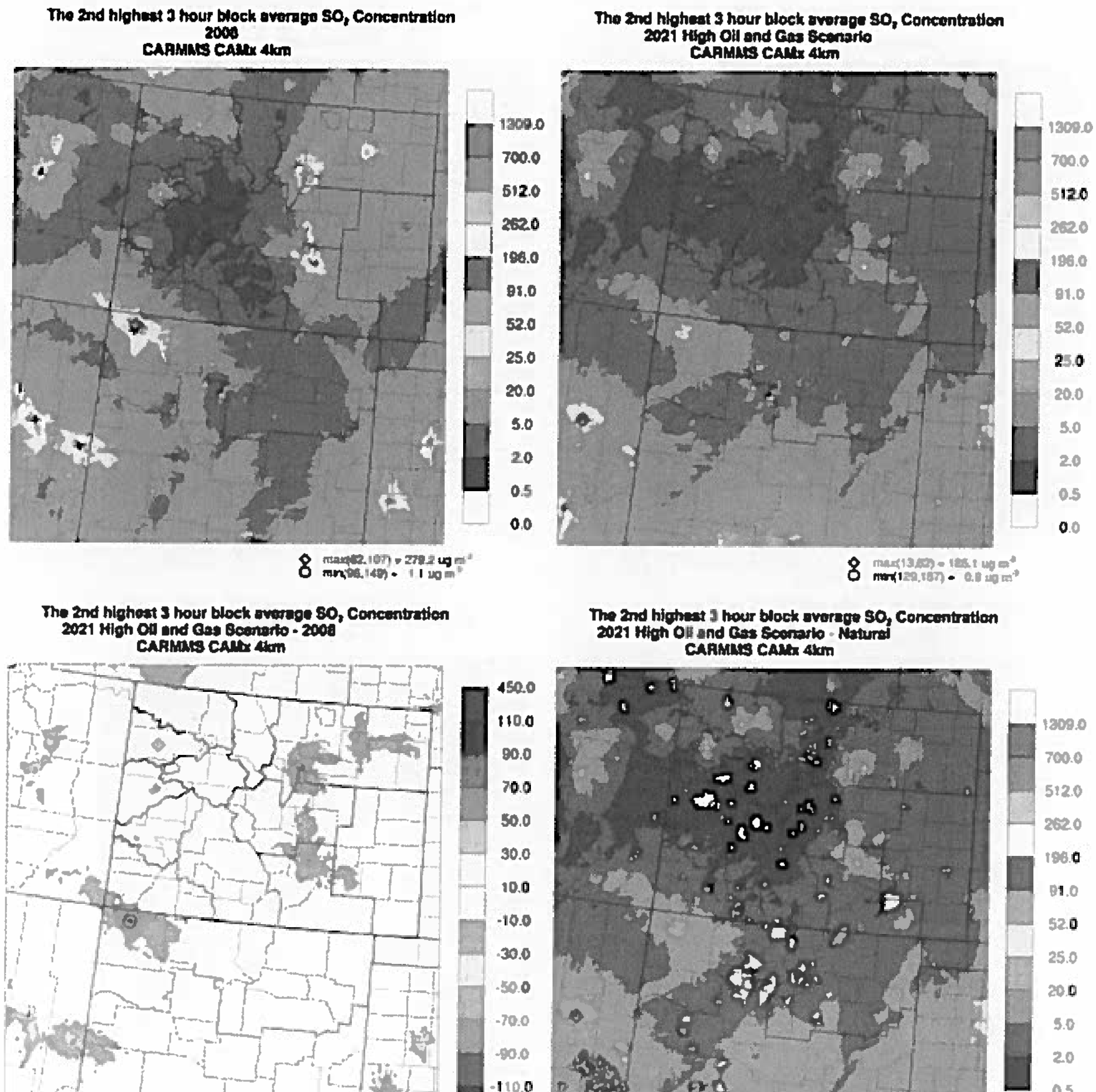

Figure 5-19. Second highest 3-hour average SO_2 concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 minus 2008 differences (bottom left) and Natural Emissions (bottom right).

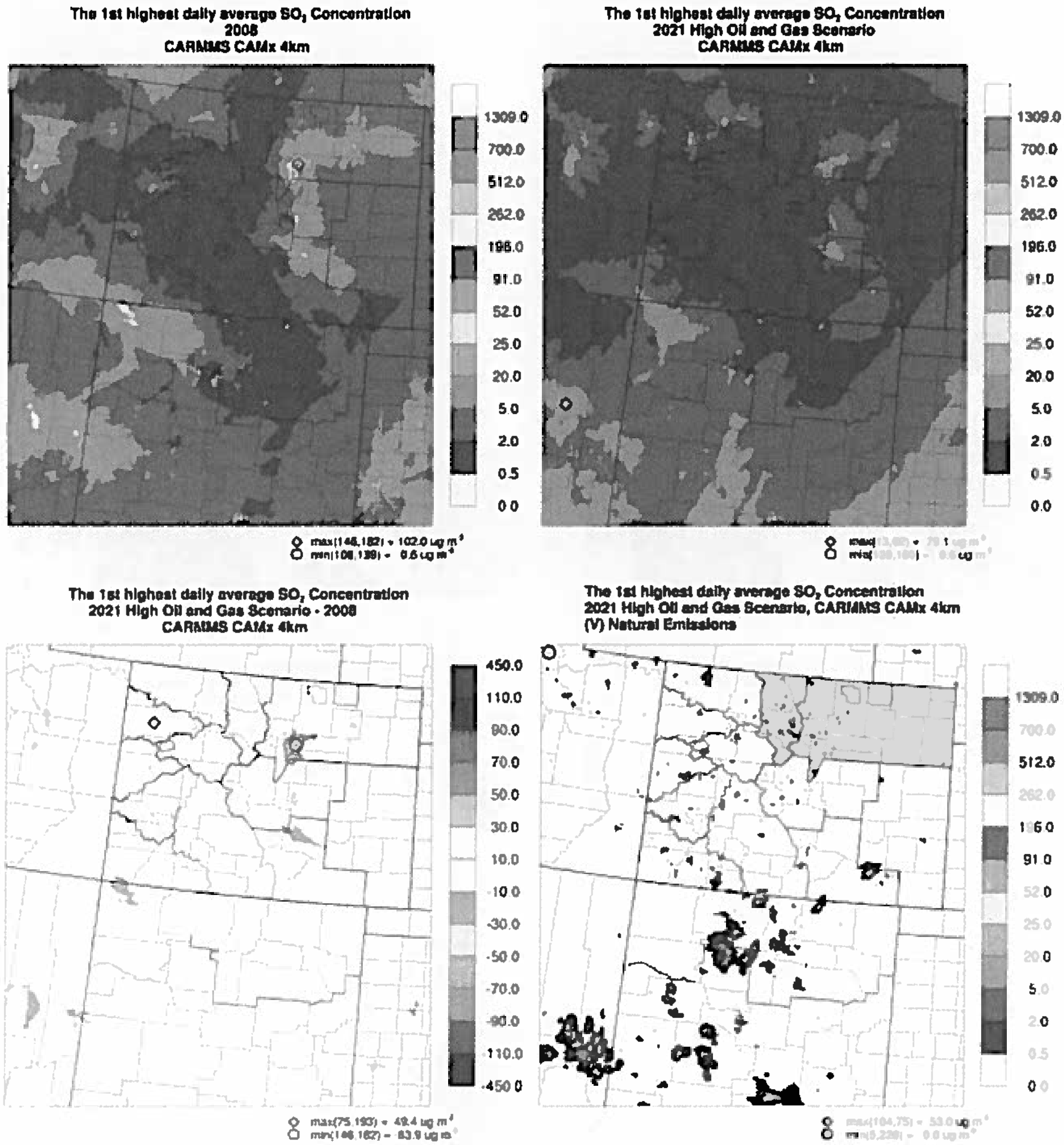

Figure 5-20. 24-hour average SO_2 concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 minus 2008 differences (bottom left) and Natural Emissions (bottom right).

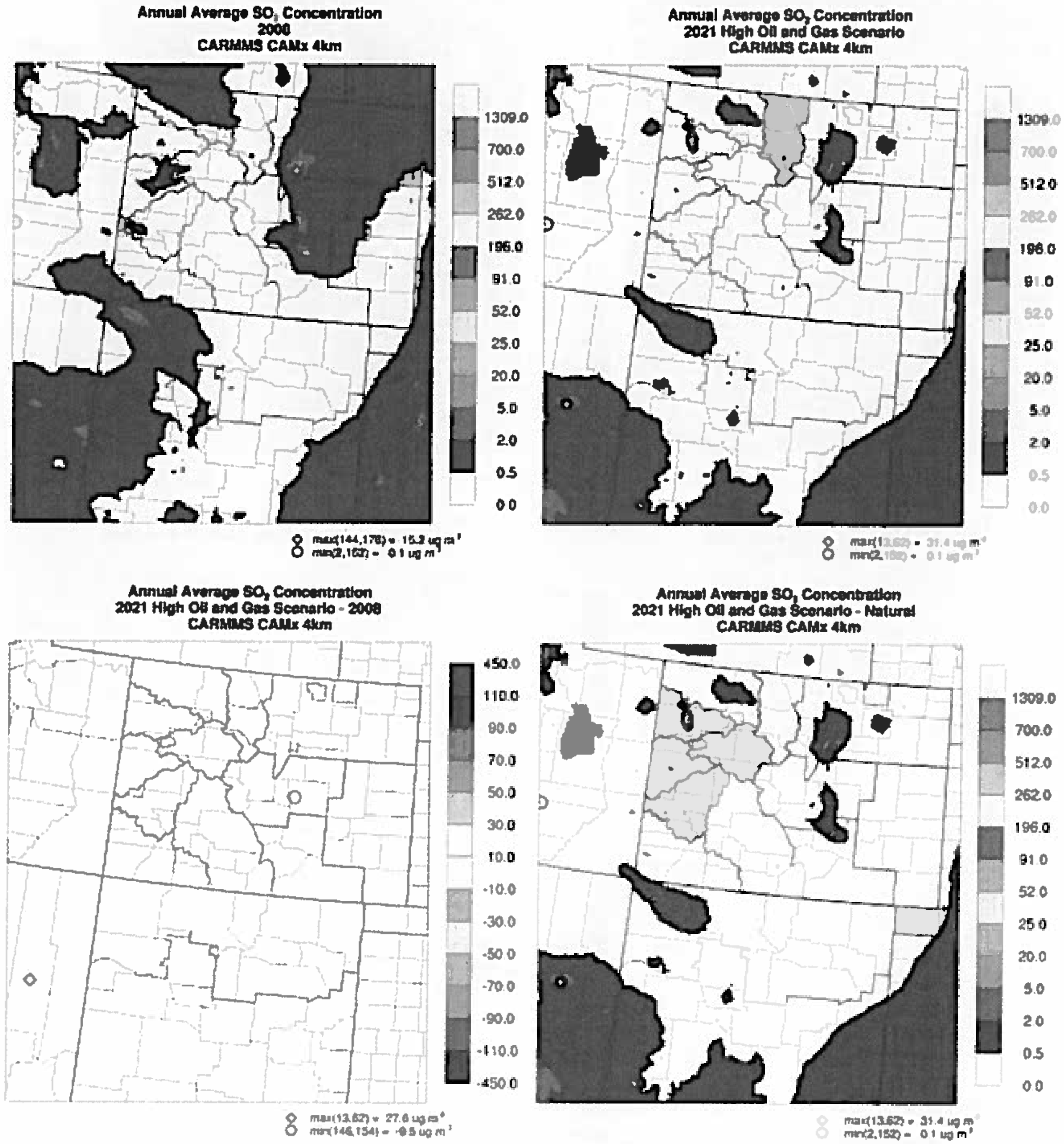

Figure 5-21. Annual average SO_2 concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 minus 2008 differences (bottom left) and Natural Emissions (bottom right).

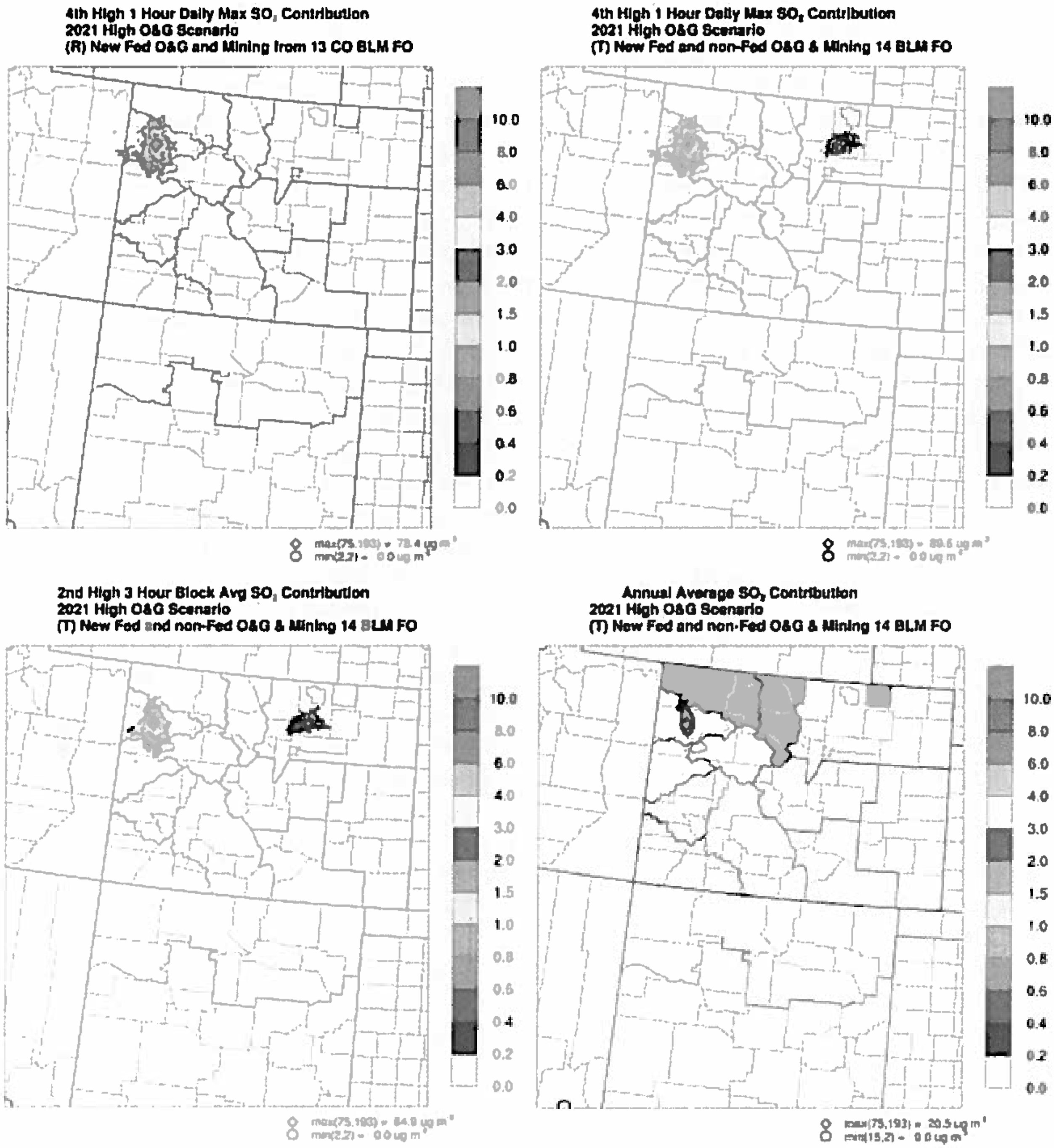

Figure 5-22. Contribution to fourth highest daily maximum hourly SO_2 concentrations due to emissions from new Federal O&G and mining within the 13 CO BLM Planning Areas (top left) and new Federal O&G and mining and non-Federal O&G within the 14 CO/NM BLM Planning Areas (top right). New Federal O&G and mining and new non-Federal O&G from 14 CO/NM BLM Planning Areas contributions to second highest 3-hour SO_2 (bottom left) and annual average SO_2 (bottom right) concentrations for the 2021 High Development Scenario.

5.6.6 NO_2 NAAQS Analysis

Figure 5-23a displays spatial maps of the 98th percentile daily maximum 1-hour NO_2 concentrations for the 2008 Base Case and 2021 High, Low and Medium Development Scenarios with the differences in NO_2 concentrations between the 2021 emissions scenarios and the 2008 Base Case shown in Figure 5-23b. The 1-hour NO_2 NAAQS is 188 $\mu g/m^3$ (100 ppb) and the tile plots in Figure 5-23a have a cut-point at 188 $\mu g/m^3$ from red to white. For example, an exceedance of the 1-hour NO_2 NAAQS can be seen in the Denver area in the 2008 Base Case that goes away in the 2021 emission scenarios. In all four scenarios, the highest 1-hour NO_2 concentration occurs on the southern border of the 4 km CARMMS domain that is above the NAAQS. This NO_2 exceedance is due to wildfires so is present in the 2008 Base Case and 2021 scenarios since wildfires were assumed to be unchanged. The fact that the peak 1-hour NO_2 value at this wildfire location is identical for all three 2021 emission scenarios indicates that the 2021 O&G emissions have minimal contributions to it. Outside of this isolated wildfire location in the most southern part of the 4 km CARMMS domain, the 8th highest daily maximum 1-hourNO_2 concentrations only exceeds the 1-hour NO_2 NAAQS at one other location in the 2021 emission scenarios that is the most northeastern corner of Weld County. Although there are Federal O&G emissions increases nearby to this location, they do not occur at this high NO_2 concentration location (Figure 3-10). The fact that there is little reduction in this 1-hour NO_2 peak between the 2021 High and Low Development Scenarios (Figure 5-23b) suggests that the high NO_2 concentration in Weld County is due to other new sources in the 2021 emission scenario and could be attributed to increases in non-Federal oil and gas emissions. As indicated from the plots shown in Section 3.2.1, RGFO area 1 (Weld County is located in RGFO area 1) non-Federal oil and gas emissions for the Low Scenario are actually higher than projected year 2021 non-Federal oil and gas emissions for the High / RFD Scenario.

The differences in 1-hour NO_2 concentrations between the 2008 and 2021 emission scenarios (Figure 5-23b) indicate reductions in the Denver area, slight increases in the O&G development areas (e.g., Uinta, Piceance and D-J Basins) and several isolated occurrences of large increases in northern, eastern and southern Colorado as well as eastern Arizona and New Mexico. As noted above, the cause of the large NO_2 concentration increase at the point in northeast corner of Weld County is not clear but doesn't appear to be due to new Federal O&G emissions. As shown in Figure 3-10, there are some increases in non-Federal oil and gas emissions projected to occur in the vicinity of the predicted Weld County concentrations and are likely contributing to the modeled impacts. The NO_2 increase in Cheyenne County in eastern Colorado does not appear to be due to new O&G emissions since there are no new O&G emissions at that location in the 2021 emission scenarios (Figure 3-10). Upon further review of the year 2011 oil and gas APENs database that was used to define existing O&G emissions inventory, there is a large (> 1,200 TPY) NO2 emissions source located in the vicinity of the predicted concentrations in Cheyenne County. The increase in 2021 NO_2 concentrations in the southwest corner of Las Anima County in southern Colorado is at the location of new O&G emissions (primarily non-Federal) for the Raton Basin and likely due to O&G emissions, but the resultant total NO_2 concentrations are below the NAAQS. The final two locations of NO_2 concentration increases in eastern Arizona and New Mexico are away from any O&G emissions (Figure 3-10). Since the same increases are seen for the 2021 High, Low and Medium Development Scenarios (Figure 5-23b) then they are not due to Colorado based O&G emissions. They are likely due to EPA's

2020 emission projections used for non-O&G anthropogenic emissions in the 2021 emission scenarios, possibly the deployment of new electrical generating units.

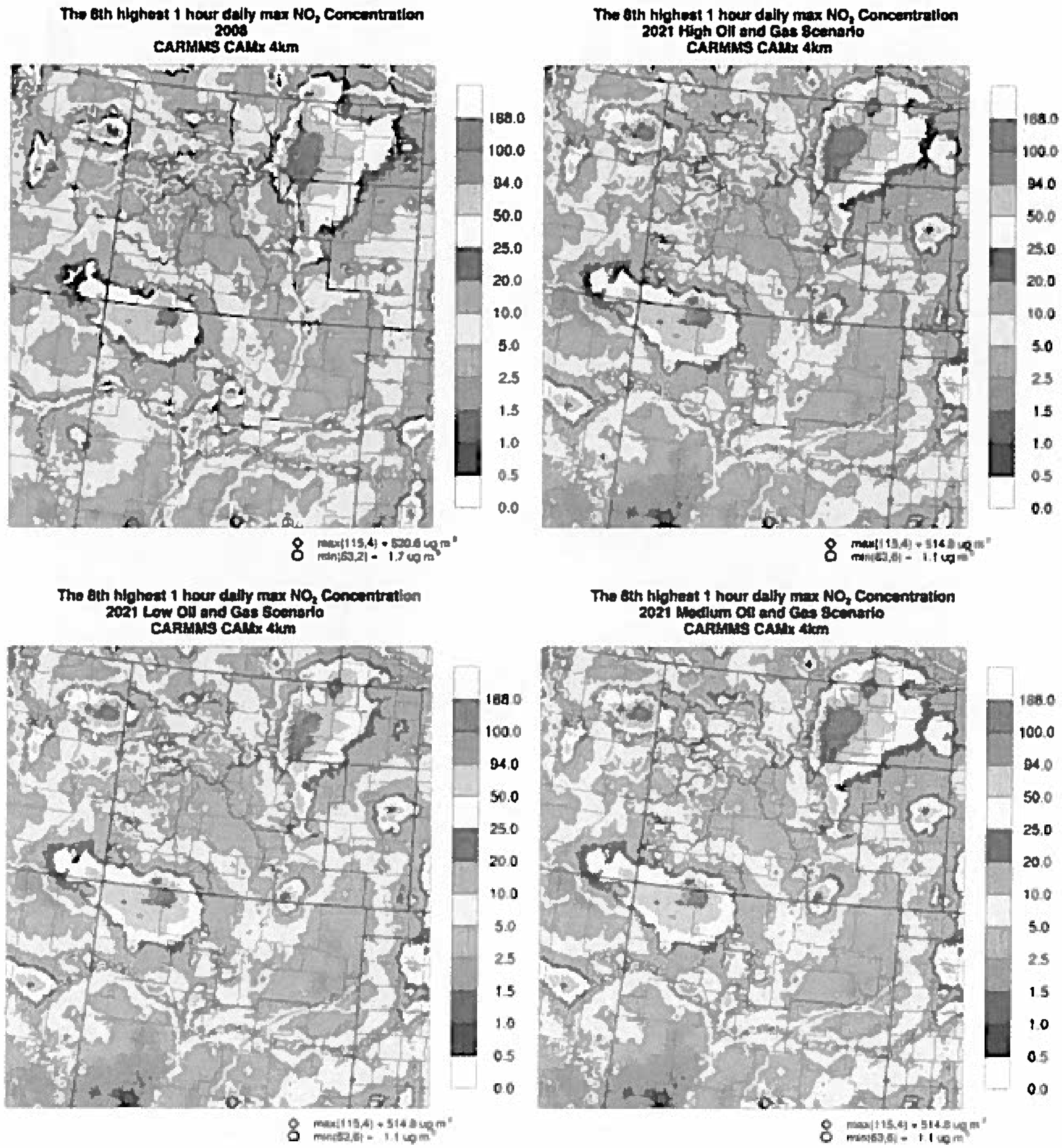

Figure 5-23a. Eighth highest (98th percentile) daily maximum 1-hour average NO_2 concentrations for the 2008 Base Case (top left), 2021 High Development Scenario (top right), 2021 Low Development Scenario (bottom left) and 2021 Medium Development Scenario (bottom right).

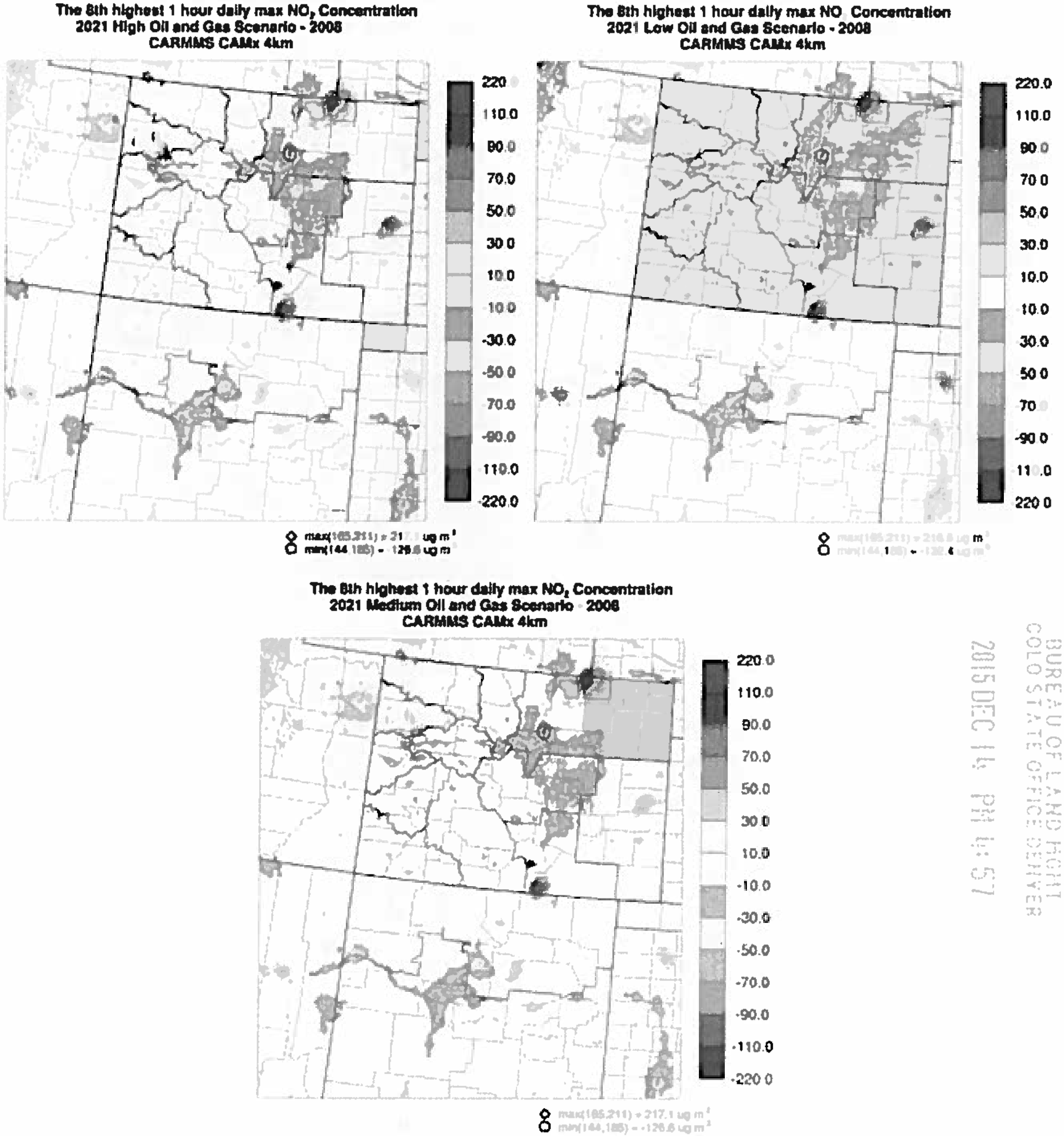

Figure 5-23b. Differences in eighth highest (98th percentile) daily maximum 1-hour average NO_2 concentrations between the 2021 emission scenarios and the 2008 Base Case for the 2021 High (top left), Low (top right) and Medium (bottom) Development Scenarios.

5.7 Source-Receptor Issues

Grid cells were assumed to represent receptors for Class I and sensitive Class I areas if there was any overlap between the grid cell and Class I/II area. Thus, there was the potential for emissions from oil and gas and other sources to be located in the same grid cell/receptor as a Class I/II area. However, in reality new oil and gas sources would not be located in a Class I area so such situations would likely overstate the oil and gas air quality impacts in a Class I area. This section identifies several instances when Class I/II areas are defined very close to new oil and gas emissions resulting air quality impacts that are likely higher than would actually occur.

New Federal O&G development on some of the BLM Planning Areas had relatively higher concentrations impacts at specific Class I areas. For example, new Federal O&G within the TRFO had Maximum annual NO_2 impacts at Mesa Verde Class I area of 1.97 $\mu g/m^3$ that was 79% of the annual NO_2 PSD Class I increment for the 2021 High Development Scenario. In addition, the visibility impacts at Mesa Verde due to new Federal O&G within TRFO Planning Area for the 2021 High Development Scenario had 35 days with $\Delta dv > 0.5$ and 4 days with $\Delta dv > 1.0$. Recall that grid cells used to represent receptors for Class I and sensitive Class II areas were defined if any portion of the Class I/II area intersected with the grid cell no matter how small the overlap is in order to be conservative (see Section 4.3.2). Figure 5-24 displays the grid cells used to represent the Mesa Verde Class I area along with new Federal O&G emissions from the TRFO Planning Area. The most northern Mesa Verde 4 km grid cell receptor is surrounded by emissions from the TRFO Planning Area with the Class I area covering approximately 20% of the 4 km grid cell so using this 4 km grid cell as a receptor for the Mesa Verde Class I area is probably appropriate. However, there have been other cases when the Class I/II area cover a very small portion of a grid cell that is used as a receptor for a Class I/II area. Perhaps a Class I/II area should be required to have a minimal overlap with a grid cell (e.g., 5%) in order for the grid cell to be considered as a receptor for the Class I/II area.

Another example of relatively larger impacts was seen for TRFO at the South San Juan Class II area (16 days with $\Delta dv > 0.5$). Figure 5-25 compares the grid cells used to represent the South San Juan Wilderness and compares them to new Federal O&G emissions from the TRFO Planning Area. In this case the emissions from the TRFO Planning Area occur in one of the grid cells being used to represent the South San Juan area and the grid cell contains a large portion of the Class II area. It might be beneficial to examine the TRFO O&G emissions to determine whether they are spatially located correctly.

A final example of relatively larger impacts is for new Federal O&G emissions from the NMFFO that had relatively large visibility impacts (210 days with $\Delta dv > 0.5$ and 50 days with $\Delta dv > 1.0$) at the Aztec Ruins Class II area. Aztec Ruins is a small area that is represented by two 4 km grid cells and sits in the middle of the NMFFO Mancos Shale development area. This is shown in Figure 5-26 with the two cells representing Aztec Ruins unlabeled but seen in the middle of the NMFFO O&G emissions.

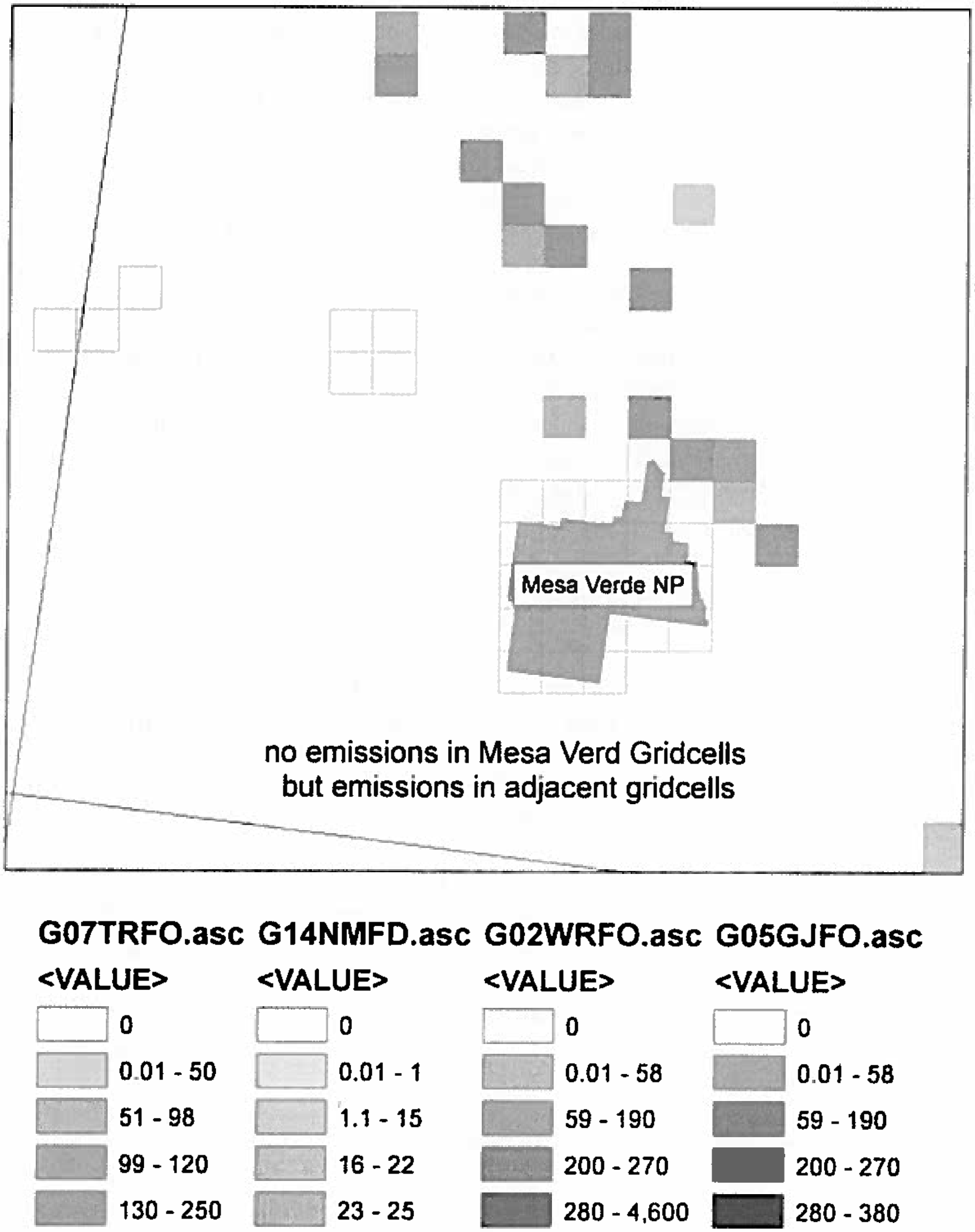

Figure 5-24. Grid cells used to represent the Mesa Verde Class I area with new Federal O&G emissions from the TRFO Planning Area.

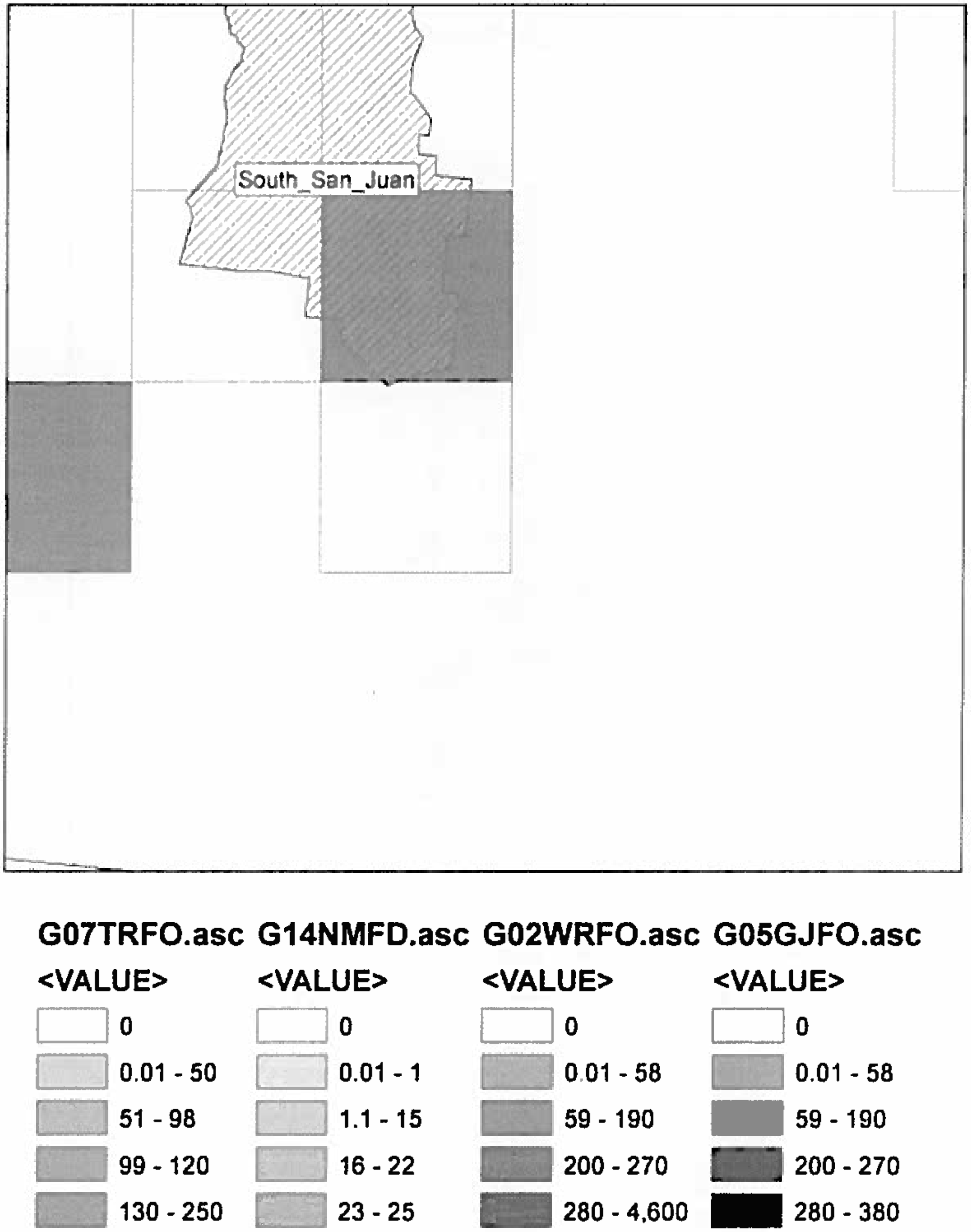

Figure 5-25. Grid cells used to represent the South San Juan Class II area with new Federal O&G emissions from the TRFO Planning Area.

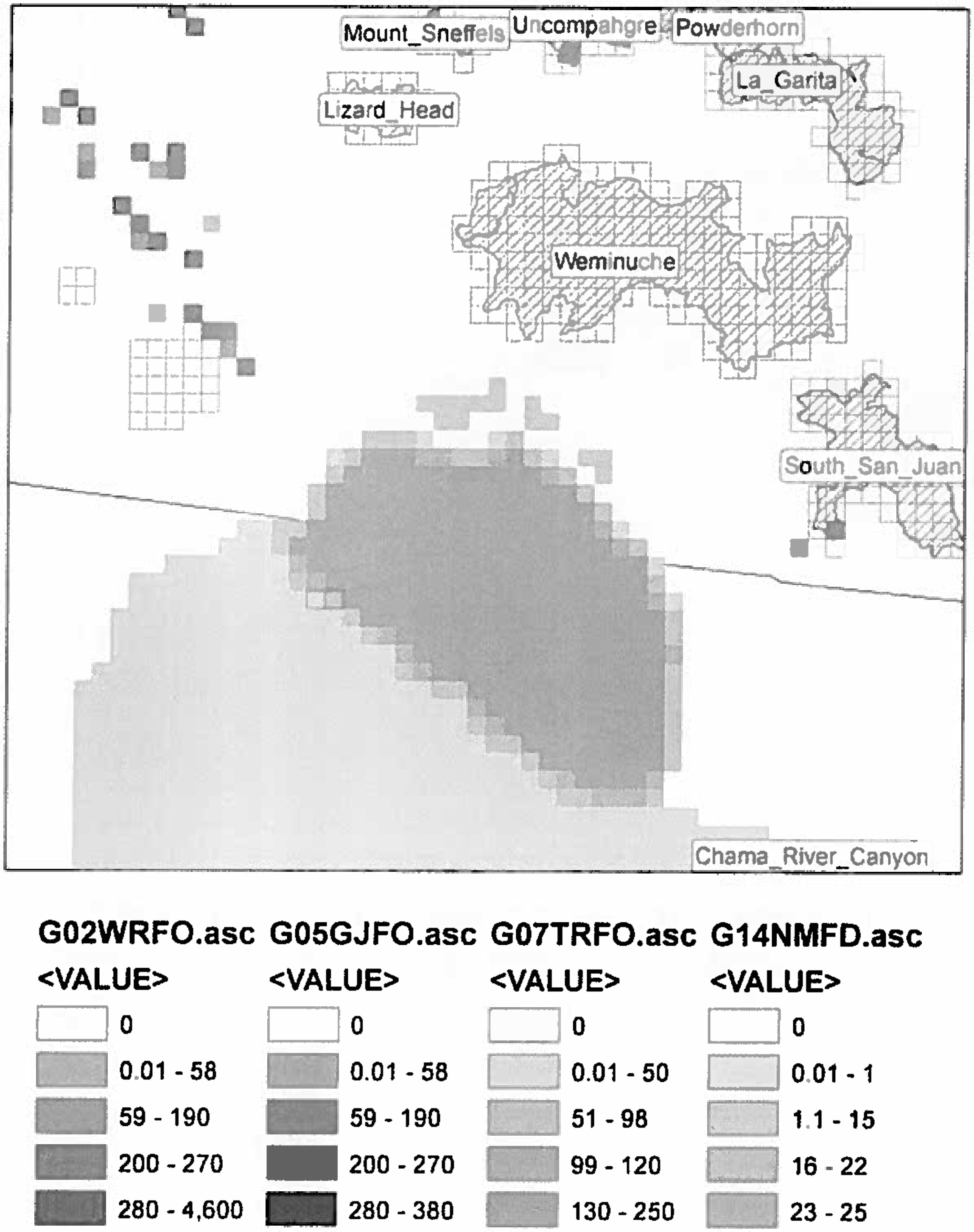

Figure 5-26. Grid cells used to represent the Class I and sensitive Class II areas with new Federal O&G emissions from the NMFFO (Mancos Shale) Planning Area.

6.0 ACRONYMS

ACHD	Allegheny County Health Department
AES	Applied Envirosolutions
AMET	Atmospheric Model Evaluation Tool
APCA	Anthropogenic Precursor Culpability Assessment
APU	Auxiliary Power Units
ARMS	Air Resource Management Study
AQ	Air Quality
AQRV	Air Quality Related Value
AQS	Air Quality System
BC	Boundary Condition
BLM	Bureau of Land Management
CAFOS	Concentrated Animal Feeding Operations
CAMD	Clean Air Markets Division
CAMx	Comprehensive Air-quality Model with extensions
CAPS	Criteria Air Pollutants
CARMMS	Colorado Air Resource Management Modeling Study
CASTNet	Clean Air Status and Trends Network
CAVR	Clean Air Visibility Rule
CB05	Carbon Bond mechanism version 5
CD-C	Continental Divide-Creston
CDPHE	Colorado Department of Health and Environment
CEM	Continuous Emissions Monitor
CENRAP	Central Regional Air Planning Association
CMAQ	Community Multiscale Air Quality modeling system
CMU	Carnegie Mellon University
ConCEPT	Consolidated Community Emissions Processing Tool
CONUS	Continental United States
COSO	BLM Colorado State Office
CRVFO	Colorado River Valley Field Office
CPC	Center for Prediction of Climate
CSAPR	Cross State Air Pollution Rule
CSN	Chemical Speciation Network
DDM	Decoupled Direct Method
DEASCO3	Deterministic and Empirical Assessment of Smoke's Contribution to Ozone
Dv	deciview
ECA	Emissions Control Area
EGU	Electrical Generating Units
EIS	Environmental Impact Statement
EM	Emissions Model
EMS	Emissions Modeling System
EPA	Environmental Protection Agency
EPS	Emissions Processing System
ERG	Eastern Research Group
ESRL	Earth Systems Research Laboratory
FB	Fractional Bias
FE	Fractional Error

FFO	New Mexico BLM Farmington Field Office
FINN	Fire Inventory from NCAR
FLM	Federal Land Manager
FRM	Federal Reference Method
FWS	Fish and Wildlife Service
GCM	Global Chemistry Model
GEOS-Chem	Goddard Earth Observing System (GEOS) global chemistry model
GJFO	Grand Junction Field Office
GSE	Ground Support Equipment
IAD	Impact Assessment Domain
IMPROVE	Interagency Monitoring of Protected Visual Environments
IMWD	Inter-Mountains West Processing Domain
IPAMS	Independent Petroleum Association of the Mountain States
JSFP	Joint Science Fire Program
FO	Kremmling Field Office
LCP	Lambert Conformal Projection
LTO	Landing and Takeoff Operations
LSFO	Little Snake Field Office
LSM	Land Surface Model
MADIS	Meteorological Assimilation Data Ingest System
MATS	Modeled Attainment Test Software
MEGAN	Model of Emissions of Gases and Aerosols in Nature
MM	Meteorological Model
MM5	Version 5 of the Mesoscale Model
MNGE	Mean Normalized Gross Error
MNB	Mean Normalized Bias
MOVES	Motor Vehicle Emissions Simulator
MOZART	Model for Ozone And Related chemical Tracers
NAAQS	National Ambient Air Quality Standard
NADP	National Acid Deposition Program
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NDBC	National Data Buoy Center
NEI	National Emissions Inventory
NEPA	National Environmental Policy Act
NMB	Normalized Mean Bias
NME	Normalized Mean Error
NMED	New Mexico Environmental Department
NMFFO	New Mexico Farmington Field Office
NMIM	National Mobile Inventory Model
NMSO	BLM New Mexico State Office
NOAA	National Oceanic and Atmospheric Administration
NPRI	National Pollutant Release Inventory
NPS	National Park Service
NSPS	New Source Performance Standard
NSR	New Source Review
O&G	Oil and Gas
OA	Organic Aerosol
OSAT	Ozone Source Apportionment Technology

PAVE	Package for Analysis and Visualization
PBL	Planetary Boundary Layer
PGM	Photochemical Grid Model
PiG	Plume-in-Grid
PM	Particulate Matter
PPM	Piecewise Parabolic Method
PSAT	Particulate Source Apportionment Technology
PSD	Prevention of Significant Deterioration
QA	Quality Assurance
QC	Quality Control
RAQC	Regional Air Quality Council
RGFO	Royal Gorge Field Office
RMC	Regional Modeling Center
RMNP	Rocky Mountain National Park
RMP	Resource Management Plan
ROMANS	Rocky Mountain Atmospheric Nitrogen and Sulfur Study
SCC	Source Classification Code
SIP	State Implementation Plan
SMOKE	Sparse Matrix Kernel Emissions modeling system
SOA	Secondary Organic Aerosol
TCEQ	Texas Commission on Environmental Quality
TRFO	Tres Rios Field Office
UAM	Urban Airshed Model
UCR	University of California at Riverside
UFO	Uncompahgre Field Office
UNC	University of North Carolina
UPA	Unpaired Peak Accuracy
USFS	United States Forest Service
USFS-PG	United State Forest Service Pawnee Grasslands
UTSO	BLM Utah State Office
VERDI	Visualization Environment for Rich Data Interpretation
VISTAS	Visibility Improvements for States and Tribal Associations in the Southeast
VMT	Vehicle Miles Traveled
WBD	Wind Blown Dust model
WEA	Western Energy Alliance
WESTUS	Western United States
WRAP	Western Regional Air Partnership
WRFO	White River Field Office
WGA	Western Governors' Association
WRF	Weather Research Forecasting model

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APPENDIX A

2008 WRF Meteorological Modeling for CARMMS

A.1 Introduction

The WRF model performance evaluation was conducted as part of WestJumpAQMS and is documented in a "WRF Application/Evaluation" report (ENVIRON and Alpine, 2012[1]). The WestJumpAQMS 2008 WRF model performance evaluation was based on a combination of qualitative and quantitative analyses. The qualitative approach was to compare the spatial distribution of the model estimated monthly total precipitation with the monthly Center for Prediction of Climate (CPC) precipitation analysis using graphical outputs. The quantitative approach was to examine tabulations and graphical displays of the model bias and error for surface wind speed, wind direction, temperature, and mixing ratio (humidity) and compare the performance statistics to benchmarks developed based on a history of meteorological modeling as well as past meteorological model performance evaluations. The statistics were calculated using the publicly available METSTAT evaluation tool, which calculates the statistical performance metrics and can produce time series of predicted and observed meteorological variable and performance statistics. The observed database for winds, temperature, and water mixing ratio that were used in this analysis is from the National Oceanic and Atmospheric Administration (NOAA), Earth System Research Laboratory (ESRL) Meteorological Assimilation Data Ingest System (MADIS). The locations of the MADIS monitoring sites within the 36 and 12 km WRF modeling domains are shown in Figures A-1 and A-2. The rain observations were taken from the NOAA CPC[2] retrospective rainfall archives.

The WestJumpAQMS 2008 WRF Application/Evaluation report evaluated the WRF surface meteorological parameters using METSTAT across the 36 km CONUS, 12 km WESTUS and 4 km IMWD modeling domains and compared them against meteorological model performance benchmarks. Provided with the WestJumpAQMS WRF Application/Evaluation report was the evaluation of the WRF model performance at each individual surface monitoring site in the inter-mountains western states. The results for all sites in Colorado are available on the WestJumpAQMS website[3] with a few examples of the WRF Colorado model performance given below.

[1] http://www.wrapair2.org/pdf/WestJumpAQMS_2008_Annual_WRF_Final_Report_February29_2012.pdf
[2] http://www.cpc.ncep.noaa.gov/products/precip/realtime/retro.shtml
[3] http://www.wrapair2.org/pdf/westjump.wrf.site.co.2012-04-04.pdf

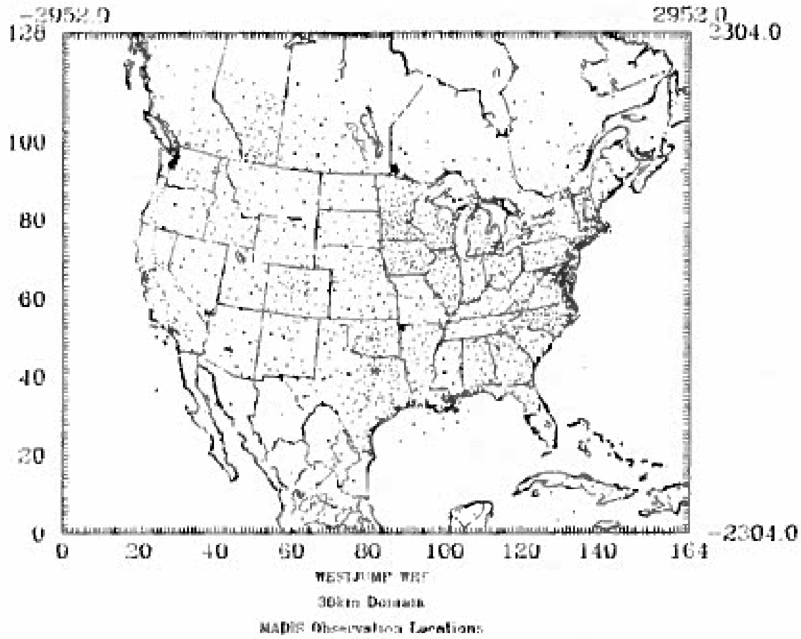

Figure A-1. Locations of MADIS surface meteorological modeling sites within the WestJumpAQMS WRF 36 km modeling domain.

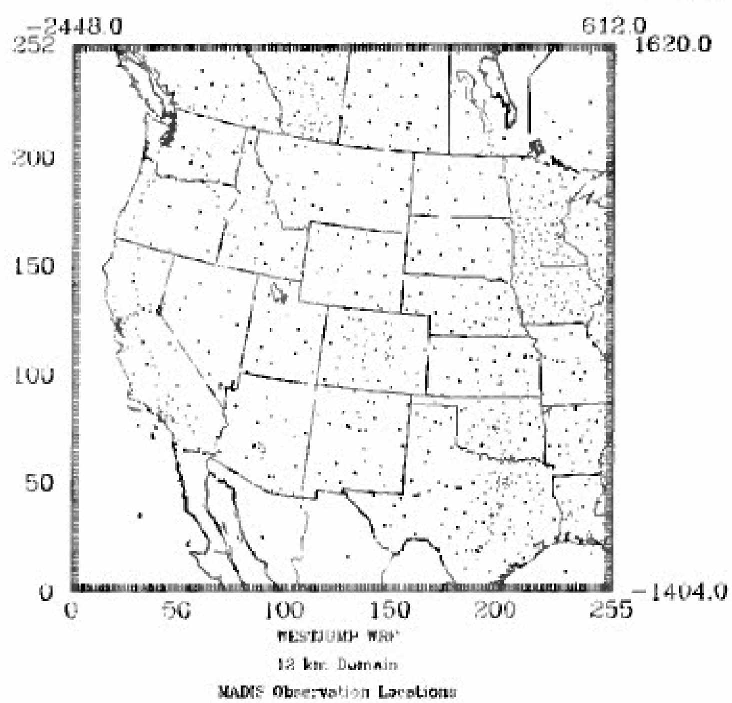

Figure A-2. Locations of MADIS surface meteorological modeling sites within the WestJumpAQMS WRF 12 km modeling domain.

A.2 Meteorological Model Performance Benchmarks

Meteorological model performance evaluation benchmarks have been developed after examining the model performance of ~30 meteorological model simulations that produced "good" air quality model performance, primarily to support ozone SIPs (Emery et al., 2001). The key to the benchmarks is to understand how good or poor the results are relative to other model applications run for the U.S. These meteorological model performance benchmarks include measures of bias and error in surface temperature, wind speed and direction and water vapor mixing ratio. Because the benchmarks were developed primarily for meteorological model simulations to support urban ozone planning they represent model performance under fairly "simple" conditions. That is, usually fairly flat terrain (although sometimes with coastal conditions) with simple meteorological conditions (e.g., stationary high pressure). Meteorological model performance within the complex terrain of the Inter-Mountain West would be expected to be not as good as in these simple conditions. Thus, for some of the meteorological model performance metrics (i.e., temperature) more "complex" performance benchmarks have been developed (Kemball-Cook et al., 2005; McNally, 2009).

The equations for bias, error and Root Mean Squared Error (RMSE) are given below. Table A-1 list the simple and complex meteorological model performance benchmarks that the WRF 2008 simulation model performance was compared against. It is important to emphasize that the benchmarks are not passing/failing grades, rather they are metrics that allow the intercomparison of meteorological model performance.

$$\text{Bias} = \frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)$$

$$\text{Error} = \frac{1}{N}\sum_{i=1}^{N}|P_i - O_i|$$

$$\text{RMSE} = \left[\frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)^2\right]^{1/2}$$

Table A-1. Simple and complex meteorological model performance benchmarks for surface meteorological model performance evaluation.

Meteorological Variable	Benchmark		
	Simple (Emery et al., 2001)	Complex (McNally, 2009)	Complex (Kemball-Cook et al., 2005)
Temperature Bias	≤±0.5°K	≤±1.0 K	≤±2.0 K
Temperature Error	≤2.0°K	≤3.0 K	≤3.5 K
Mixing Ratio Bias	≤±1.0 g/kg	--	NA
Mixing Ratio Error	≤2.0 g/kg	--	NA
Wind Speed Bias	≤±0.5 m/s	--	≤±1.5 m/s
Wind Speed RMSE	≤2.0 m/s	--	≤2.5 m/s
Wind Direction Bias	≤±10 degrees	--	NA
Wind Direction Error	≤30 degrees	--	≤±55 degrees

A.3 Summary of 2008 WRF Model Performance Evaluation for the CARMMS Region

The WestJumpAQMS WRF Application/Evaluation report evaluated WRF across several preliminary Impact Assessment Domains as shown in Figure A-3. The CO_UT 4 km IAD most closely resembles the CARMMS 4 km modeling domain so those results are discussed below. WestJumpAQMS also evaluated WRF's surface meteorological model performance separately for each site in Colorado that is discussed at the end of this section.

A.3.1 Surface Meteorological Model Performance

Figure A-4 display soccer plots of monthly humidity (mixing ratio) and temperature model performance within the CO_UT 4 km IAD domain (see Figure A-3) for the WestJumpAQMS 2008 4 km WRF simulation. Soccer plots plot a model's bias versus error and compares them with the model performance benchmark, where in these figures from the WestJumpAQMS WRF Application/Evaluation report (ENVIRON and Alpine, 2012) the Simple and McNally (2009) Complex benchmarks are used (see Table A-1). The WRF 36, 12 and 4 km humidity model performance achieves the Simple Performance Benchmark within the CO_UT 4 km IAD domain (Figure A-4, left). The monthly humidity performance for the WRF 4 km simulation is exhibiting near zero bias and very low error that achieves the Performance Benchmarks.

The WRF 36 km temperature performance has a bias that achieves the ≤±1.0 K McNally and ≤±2.0 K Kemball-Cook Complex Benchmarks (Figure A-4, right). However, the WRF 12 and 4 km simulation temperature exhibits a positive bias ranging from 0.0 to 1.3 K so that some months fall outside of the McNally but are within the Kemball-Cook Complex Benchmarks. The last four months of the year have a positive bias that is greater than 1.0 K. The WRF 12 and 4 km simulation temperature error falls between the Simple (2.0 K) and Complex 3.0/3.5 K) Benchmarks.

The WRF wind speed bias and error falls between the Simple and Complex benchmarks (Figure A-5, left). WRF exhibits a low wind speed bias across the CO-UT 4 km IAD domain with the negative bias greater for the warm than the cool months. The WRF 12 and 4 km wind direction has a near zero bias that is always within ±5 degrees that achieves the Simple Benchmark (≤±10 degrees). However, the wind direction error falls between the Simple (≤30 degrees) and Complex ≤55 degree benchmarks

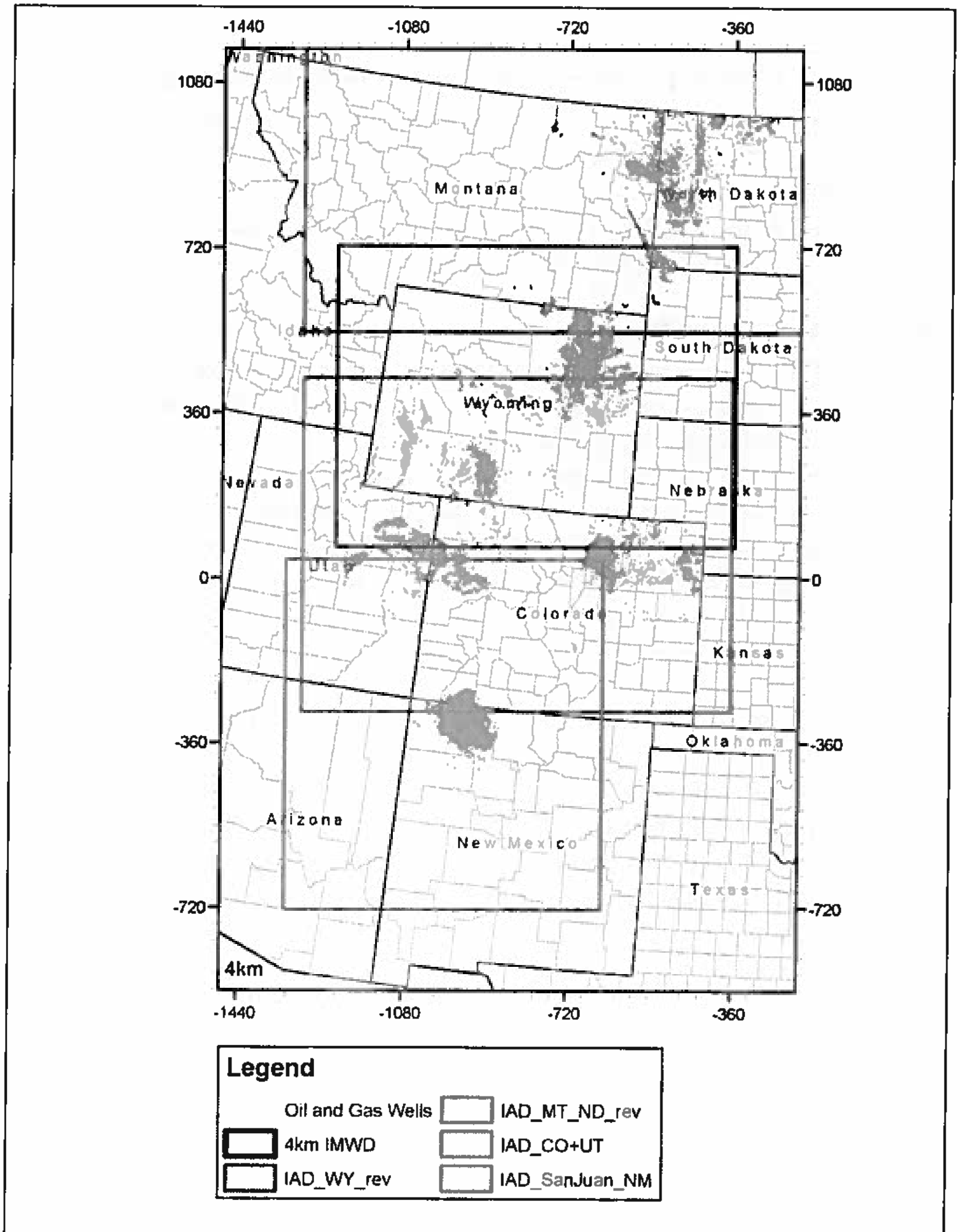

Figure A-3. Locations of the preliminary 4 km Impact Assessment Domains (IADs) used in the WestJumpAQMS 2008 WRF evaluation.

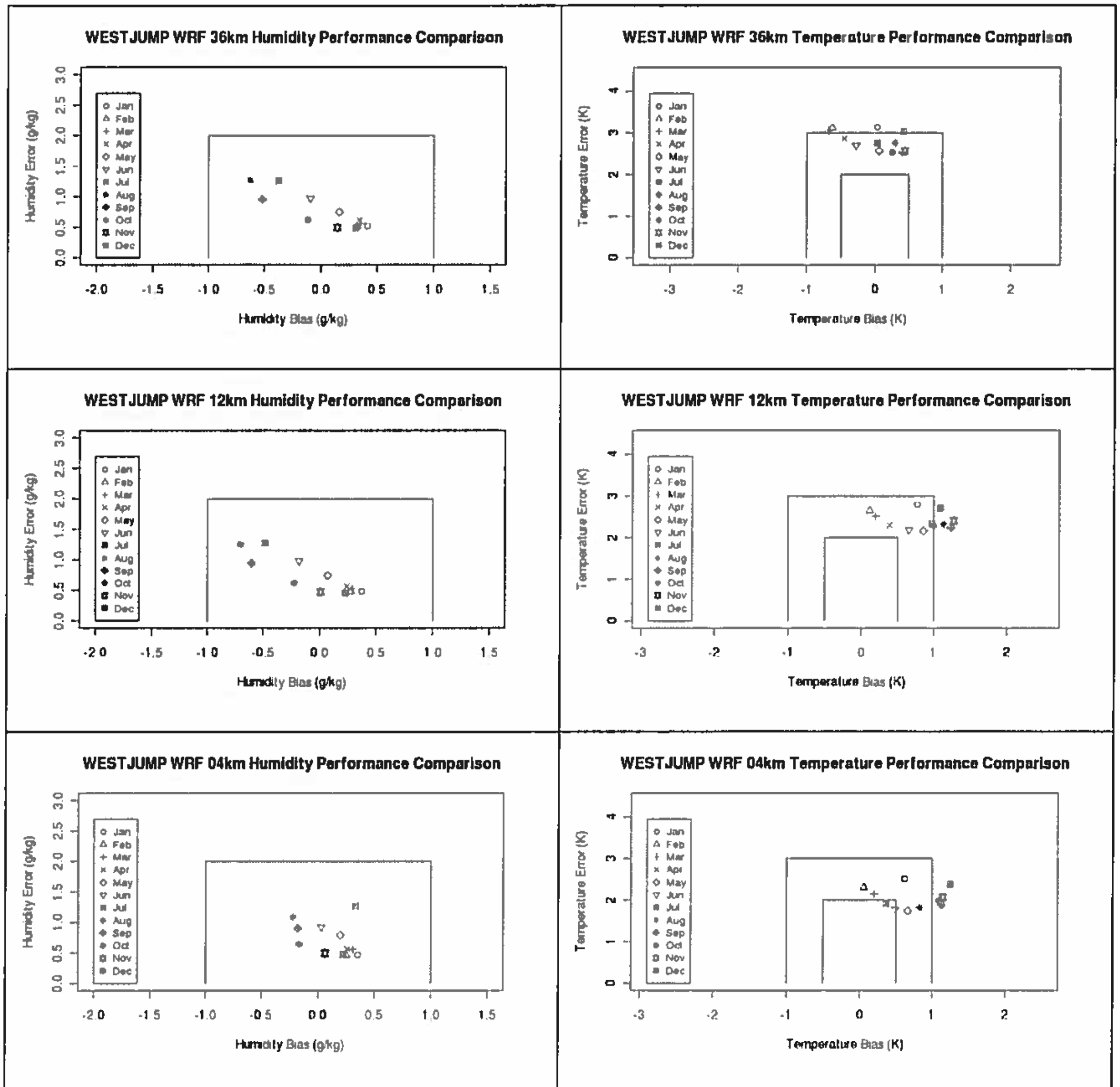

Figure A-4. Monthly Humidity (left) and Temperature (right) performance for all sites in the preliminary CO_UT 4 km Impact Assessment Domain for the 36 km (top), 12 km (middle) and 4 km (bottom) WestJumpAQMS WRF simulations.

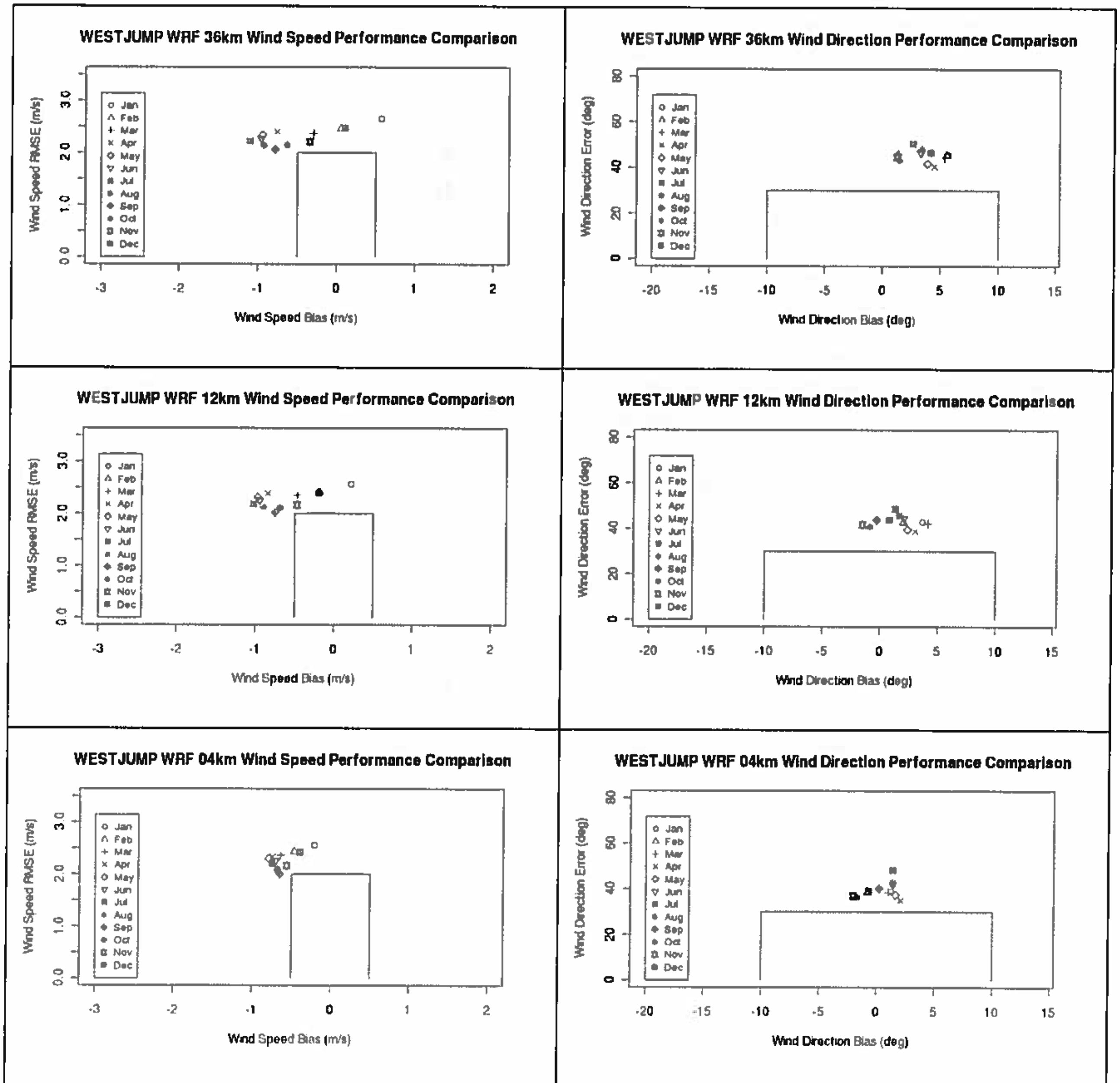

Figure A-5. Wind Speed (left) and Wind Direction (right) performance for all sites in the preliminary CO_UT 4 km Impact Assessment Domain for the 36 km (top), 12 km (middle) and 4 km (bottom) WestJumpAQMS WRF simulations.

A.3.2 Precipitation Evaluation

Figure A-6 compares monthly total precipitation across the 4 km IMWD for the CPC analysis fields based on observations, the WRF 4 km estimates and the four months of January, April, July and October (see WestJumpAQMS WRF report for remainder of months, ENVIRON and Alpine, 2012). The much higher resolution in the WRF 4 km precipitation fields is readily apparent compared to the coarser CPC fields and must be accounted for in the interpretation of precipitation model performance. In January 2008, the spatial distribution of the CPC and WRF monthly precipitation fields are very similar with most of it occurring in the western half of the domain and much dryer conditions east of the Front Range. The CPC and WRF estimate similar areas of higher precipitation intensity, although the WRF has smaller areas of higher intensity than the CPC analysis fields due to the higher resolution (Figure A-6a, top).

In April 2008, both the CPC analysis and WRF monthly precipitation exhibit a diagonal northwest to southeast orientation in the precipitation pattern with areas of higher intensity occurring over the Bitterroot Range on the ID-MT border, stretching down along the continental divide and in NB, KS and OK (Figure A-6a, bottom).

In July 2008, the desert southwest summer monsoon is clearly evident in the CPC and WRF precipitation fields with the highest intensity occurring in Arizona and New Mexico (Figure A-6b, top). Higher precipitation amounts are also seen in the high plains in the eastern part of the 4 km IMWD, with the Rocky Mountains in the western part of the 4 km IMWD being much dryer.

In October 2008, both the CPC and WRF have very similar spatial patterns of monthly precipitation with the highest intensity precipitation occurring in Kansas stretching down to OK and TX, with WRF estimating higher intensity in OK/TX than seen in the CPC fields (Figure A-6b, bottom).

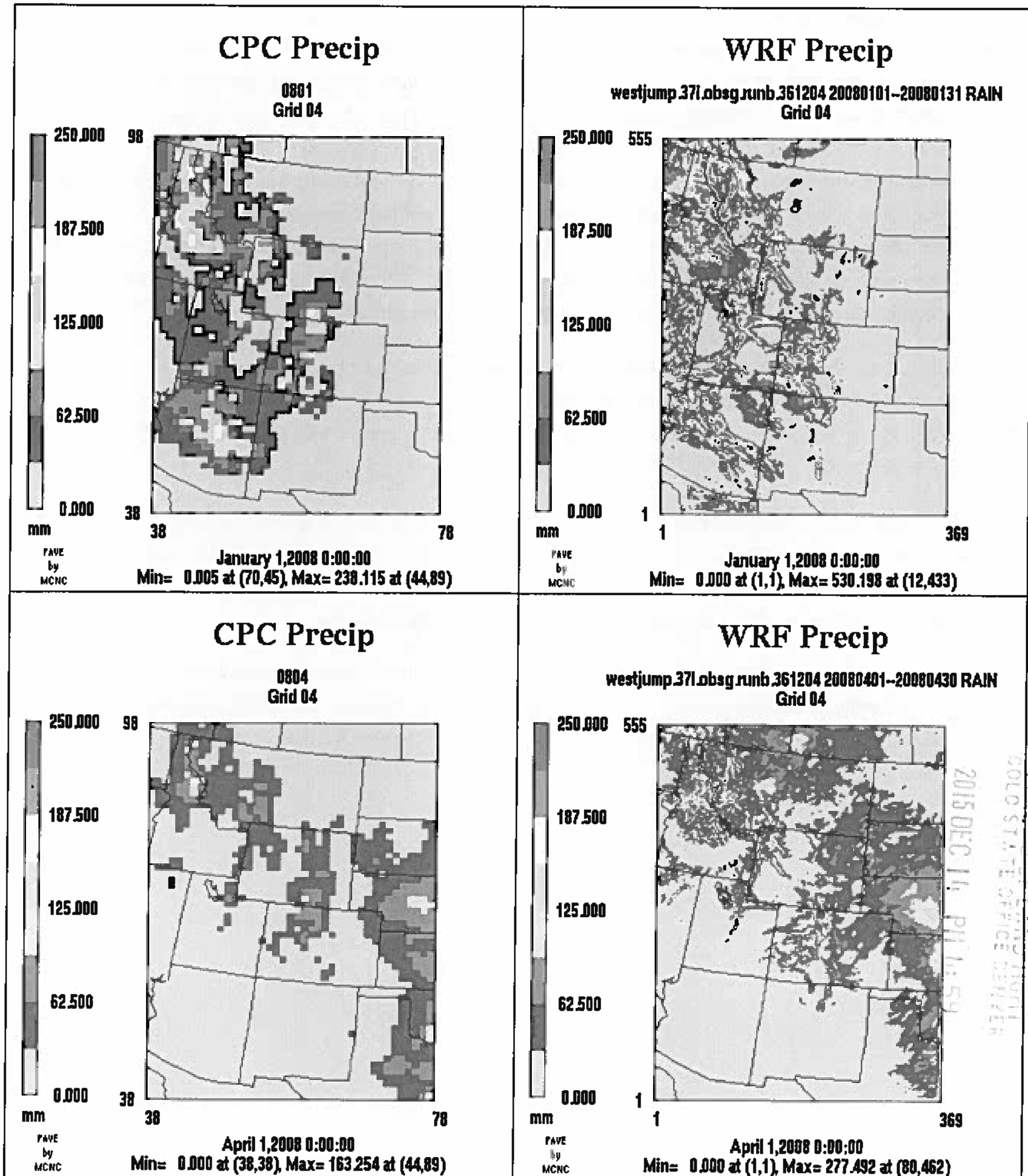

Figure A-6a. Comparison of January (top) and April (bottom) 2008 monthly precipitation amounts (mm) over the 4 km Inter-Mountain West Domain (IMWD) from the CPC analysis of observations (left) and estimated by the WestJumpAQMS 4 km WRF simulation.

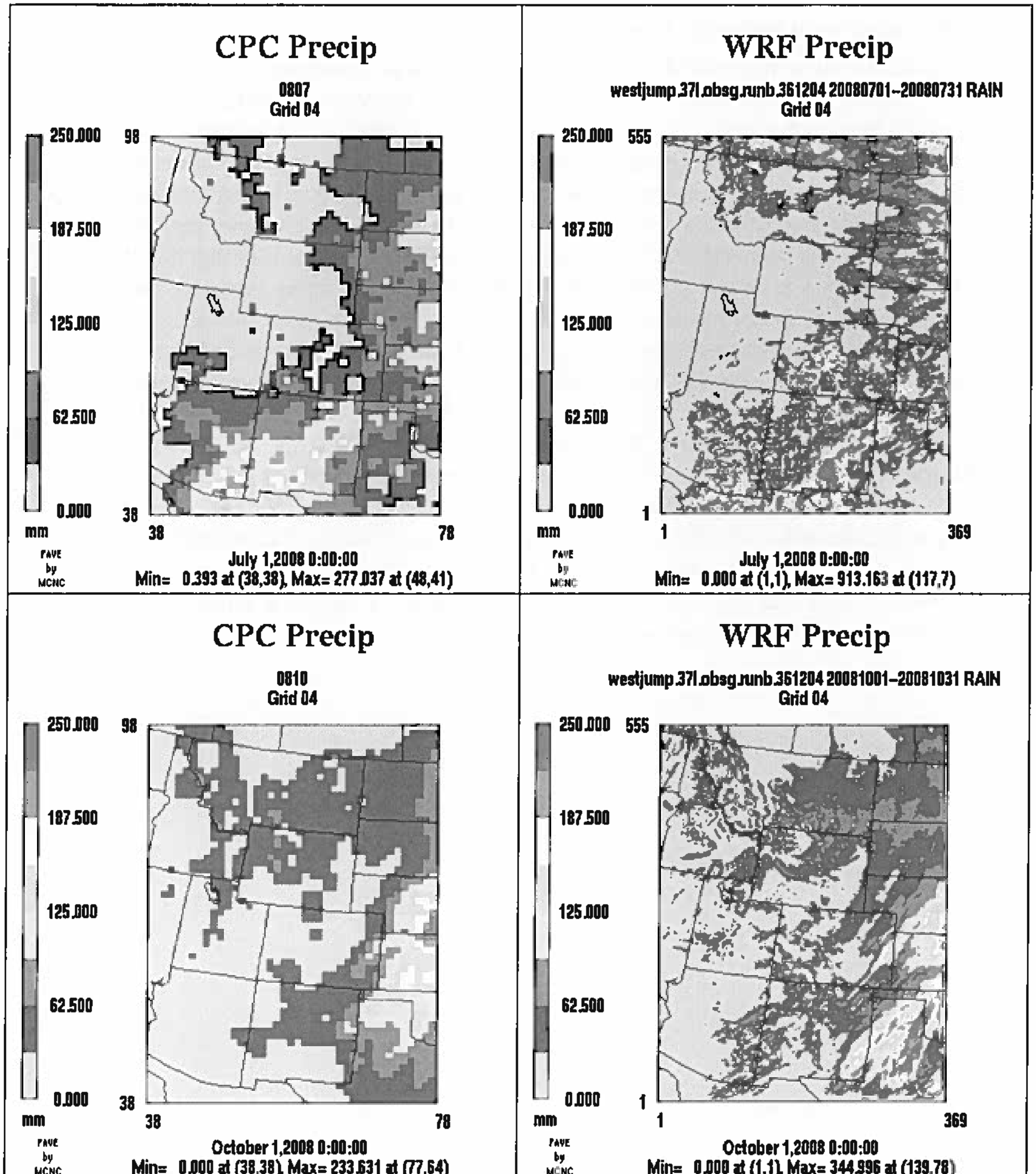

Figure A-6b. Comparison of July (top) and October (bottom) 2008 monthly precipitation amounts (mm) over the 4 km Inter-Mountain West Domain (IMWD) from the CPC analysis of observations (left) and estimated by the WestJumpAQMS 4 km WRF simulation.

A.3.3 Performance at Individual Monitoring Sites

WestJumpAQMS performed WRF 4 km surface meteorological model performance at individual monitoring sites in Colorado that is posted to its website[4]. The WRF performance varies greatly by site, which may be due in part to each site having its own local influences that cannot be captured by the 4 km WRF average meteorological conditions. For example, Figures A-7 and A-8 displays the WRF 4 km model performance at the Grand Junction (KGJT) and Gunnison (KGUC) Colorado monitoring sites that lie within the BLM Grand Junction and Uncompahgre Field Offices planning areas, respectively. KGJT has a negative wind direction bias that mostly falls within the ±10 degree performance benchmark and error that falls between the 30 and 55 degree simple and complex benchmarks. KGUC, on the other hand, has much worse wind direction performance with a positive bias that ranges from 0 to 30 degrees and errors of 50 to 80 degrees that fall outside of the benchmark ranges. Similar wind speed performance is seen with mostly an underestimation bias right at the -0.5 m/s simple benchmark but always achieving the complex benchmarks. The humidity benchmarks are almost always achieved at both sites with only July at KGJT falling outside of the benchmark due to being too moist. Different temperature model performance characteristics are seen at the two sites with KGJT achieving the complex benchmark (≤±1.0 K) except for the cold winter months that are too warm by from 1.5 to 3.0 K. Whereas KGUC always achieves the complex benchmark with monthly temperature bias and error clustered around the -0.5 K and 2.0 K simple benchmark bias and error point, except for January that has an overestimation bias of ~0.75 K.

[4] http://www.wrapair2.org/pdf/westjump.wrf.site.co.2012-04-04.pdf

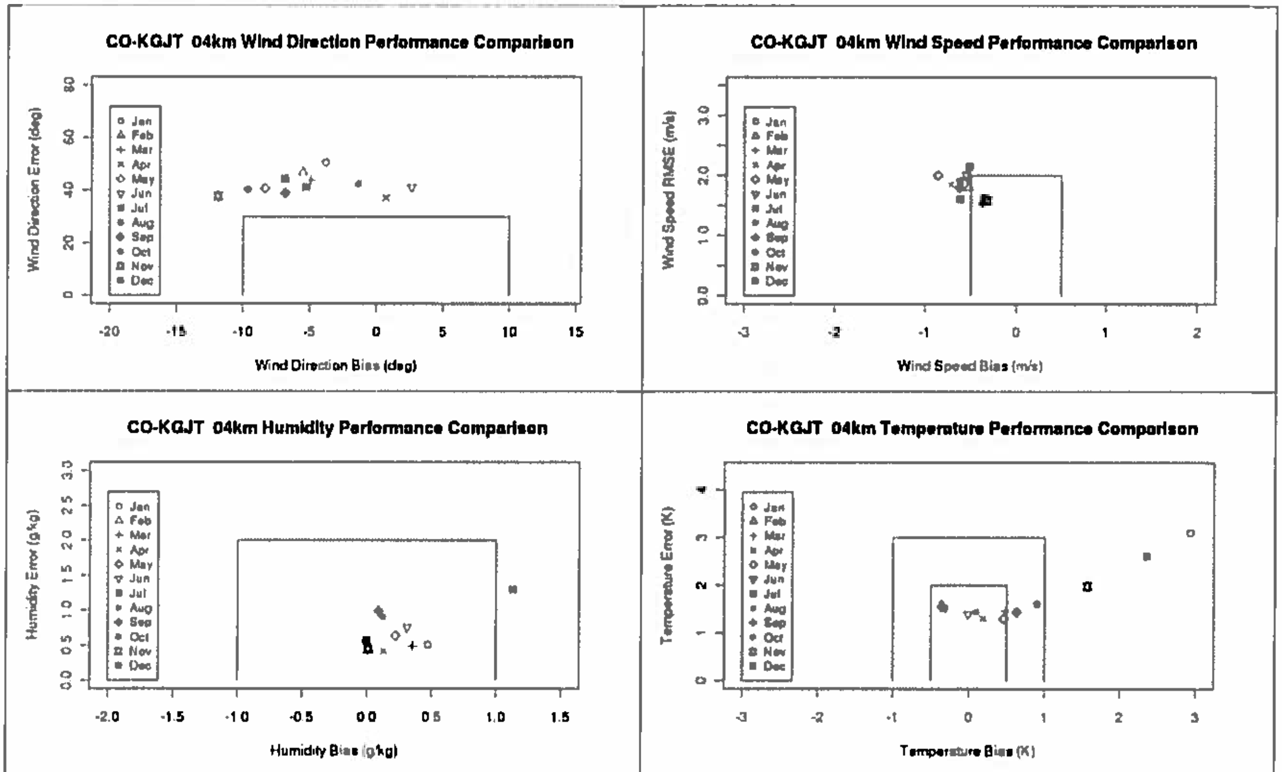

Figure A-7. Monthly WRF 4 km surface meteorological model performance at the Grand Junction (KGJT), Colorado monitoring site.

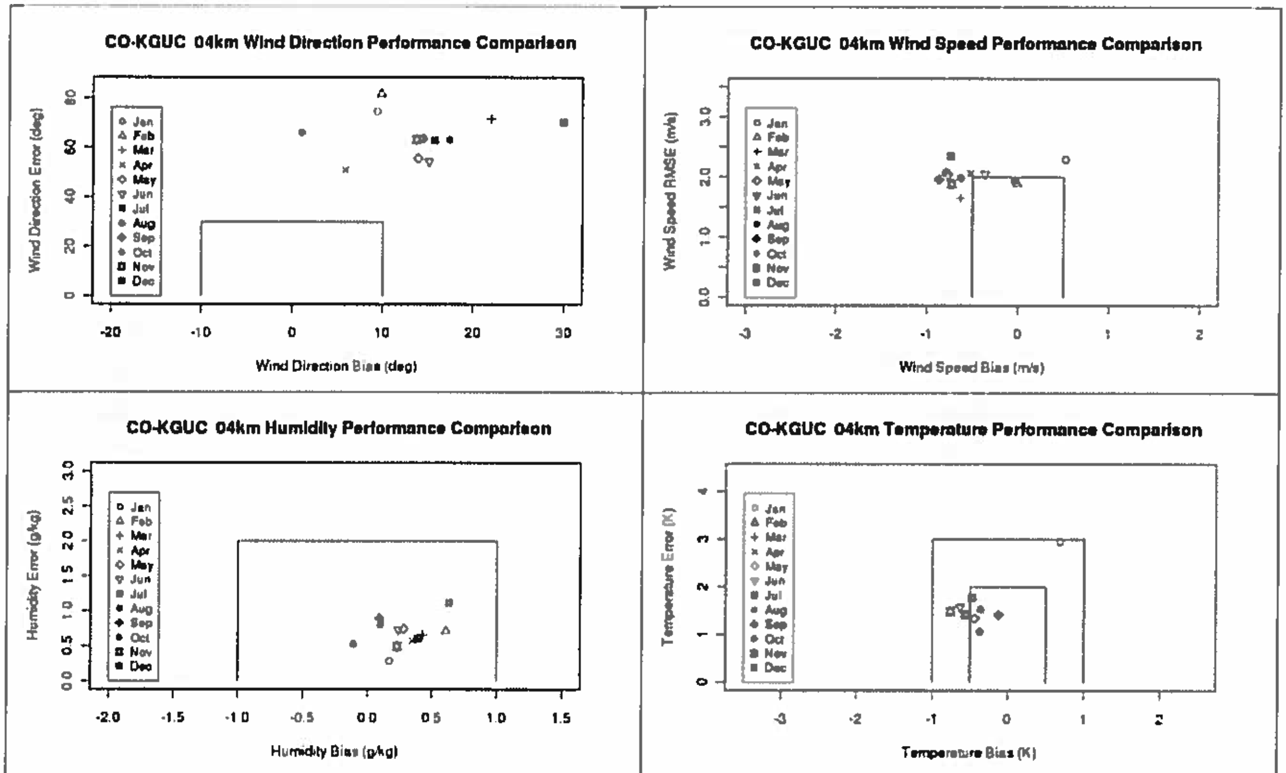

Figure A-8. Monthly WRF 4 km surface meteorological model performance at the Gunnison (KGUT), Colorado monitoring site.

APPENDIX B

2008 CAMX Base Case Model Performance Evaluation

B.1 Introduction

The CAMx PGM was selected for modeling air quality and AQRV impacts due to oil and gas and other activity within the Colorado and northern New Mexico BLM-planning areas. CAMx was selected over CMAQ due to the availability of the CAMx source apportionment tool and the need to obtain separate air quality and air quality related value (AQRV) contributions due to emissions of BLM authorized oil and gas sources in numerous Colorado and northern New Mexico BLM planning areas. CAMx Version 6.1 (V6.1, released April, 2014) was used in the CARMMS future year modeling analysis. However, CAMx V6.0 (September 2013 release) was used for the 2008 Base Case modeling. The CAMx V6.1 future year and CAMx V6.0 2008 Base Case models were configured to obtain identical results, although the CAMx V6.1 future year source apportionment took advantage of a new point source emissions "compact format" feature that greatly reduces the disk space requirements and consequently computational resources for the future year source apportionment modeling.

B.2 CAMx Model Configuration

The CAMx PGM 2008 Base Case modeling was configured as shown in Table B-1 and described below.

Advection and Diffusion Methods: The piecewise parabolic method (PPM) advection solver was used for horizontal transport (Colella and Woodward, 1984) along with the spatially varying (Smagorinsky) horizontal diffusion approach. CAMx will use K-theory for vertical diffusion using the CMAQ-like vertical diffusivities from WRFCAMx.

Chemical Mechanism: The CB05 gas-phase chemical mechanism was selected for the CAMx 2008 Base Case modeling to be consistent with WestJumpAQMS.

Spin-Up Initialization: A minimum of ten days of model spin up (i.e., using meteorological and emission conditions for December 21-31, 2007) was used to initialize the PGM.

Model Run Strategy: CAMx includes two approaches for using multiple central processing units (CPUs) for multi-processing: (1) Message Passing Interface (MPI) that performs modeling domain decomposition, passes the model solution for each subdomain to different CPUs at each time step, and then reassembles the solution across the whole domain at the end of the time step; and (2) Open Multiprocessing (OpenMP) that uses compiler directives to use multiple CPUs in the model simulation. An optimal configuration of MPI and OpenMP will be determined for the Linux Cluster being used to minimize the model throughput time. After benchmarking several different configurations, the CAMx CARMMS current and future year model simulations were run separately for four quarters using ~10 days of spin-up and using 24 CPUs for each quarter (i.e., using 96 CPUs at once) with 6 MPI domain decomposition and each MPI subdomain was run with 4 OpenMP multi-processing CPUs (24 = 6 x 4).

Boundary Conditions: Boundary conditions (BCs) for the 36 km CONUS domain CAMx simulation were based on output from the Model for OZone And Related chemical Tracers

(MOZART,[1]) global chemistry model. BCs for the CARMMS CAMx 2008 4 km based case simulation were based on the WestJumpAQMS CAMx 2008 36/12 km Base Case simulation.

Photolysis Rates: For photolysis rates, CAMx requires a lookup table of photolysis rates as well as gridded albedo/haze/ozone/snow as input. Day-specific ozone column data are based on the Total Ozone Mapping Spectrometer (TOMS) data measured using the satellite-based Ozone Monitoring Instrument (OMI[2]). Albedo is based on land use data, which includes enhanced albedo values when snow cover is present. For CAMx there is an ancillary snow cover input that is based on WRF output that overrides the land use based albedo input to use an enhanced snow cover albedo value. The Tropospheric Ultraviolet and Visible (TUV) Radiation Model[3] photolysis rate processor was used. CAMx is configured to use the in-line TUV to adjust for cloud cover and account for the effects aerosol loadings have on photolysis rates; this latter effect on photolysis may be especially important in adjusting the photolysis rates due to the occurrence of PM concentrations associated with emissions from fires. Note that the same photolysis rates are used in the 2008 Base Case and 2021 future year modeling.

Landuse: Landuse fields were generated based on U.S. Geological Survey (USGS) Geographic Information Retrieval and Analysis System (GIRAS) data[4]. The WRF estimate snow cover data is used to override the USGS land cover categories when snow cover is present.

Meteorological Inputs: The WestJumpAQMS 2008 WRF-derived meteorological fields were processed to generate CAMx meteorological inputs for the CARMMS 4 km domain and 2008 using the WRFCAMx processor.

Plume in Grid: The subgrid-scale Plum-in-Grid module was not used in the CARMMS modeling.

Other Model configuration options are detailed in Table B-1.

[1] http://www.acd.ucar.edu/wrf-chem/mozart.shtml

[2] http://ozoneaq.gsfc.nasa.gov/

[3] http://cprm.acd.ucar.edu/Models/TUV/

[4] http://pubs.usgs.gov/ds/2006/240/

Table B-1. CAMx model configurations for BLM CARMMS 2008 4 km Base Case simulation.

Science Options	Configuration	Details
Model Codes	CAMx V6.0 – May 2013 Release	CAMx V6.1 (April 2014) used in 2021 future year modeling
Horizontal Grid Mesh- Regional Run to generate Boundary Conditions (BC) for the 4 km impact assessment domain	36/12 km	36/12 km run to generate BC for CARMMS 4 km impact assessment domain. 36/12 km run with 2 way grid nesting
36 km grid	148 x 112 cells	36 km CONUS RPO domain
12 km grid	239 x 206 cells	12 km WESTUS domain from WestJumpAQMS domain
Horizontal Grid Mesh- CARMMS Impact Assessment Runs	4 km	216 x 234
Vertical Grid Mesh	25 vertical layers, defined by WRF	Layer 1 thickness ~24- m. Model top at ~19-km above MSL
Grid Interaction	36/12 km two way nesting provide one-way grid nesting to 4 km CARMMS domain	CARMMS 4 km stand-alone domain
Initial Conditions	10 day spin-up	
Boundary Conditions	36 km CONUS domain from MOZART global chemistry model	4 km domain BCs from 36/12 km regional run
Emissions		
Baseline Emissions Processing	SMOKE, MOVES and MEGAN	
Sub-grid-scale Plumes	No Plume-in-Grid for major NO_X sources	
Chemistry		
Gas Phase Chemistry	CB05	
Meteorological Processor	WRFCAMx	
Horizontal Diffusion	Spatially varying	Smagorinsky
Vertical Diffusion	CMAQ-like in WRFCAMx	
Diffusivity Lower Limit	Kz_min = 0.1 to 1.0 m^2/s or 2.0 m_2/s	
Deposition Schemes		
Dry Deposition	Zhang dry deposition scheme	Zhang et al., 2001; 2003
Wet Deposition	CAMx -specific formulation	rain/snow/graupel/virga
Numerics		
Gas Phase Chemistry Solver	Euler Backward Iterative (EBI) -- Fast Solver	
Vertical Advection Scheme	Implicit scheme w/ vertical velocity update (CAMx)	
Horizontal Advection Scheme	Piecewise Parabolic Method (PPM) scheme	Colella and Woodward, 1984
Integration Time Step	Wind speed dependent	~0.1-1 min for 4 km domain

B.3 2008 CAMx Base Case Modeling

WestJumpAQMS performed CAMx modeling using two-way grid nesting on the regional 36 km CONUS and 12 km WESTUS domains using the 2008 Base Case emission scenario to develop boundary conditions (BCs) for the smaller 4 km CARMMS domain. WestJumpAQMS then ran CAMx for the 4 km CARMMS impact assessment domain using 2008 Base Case emissions and BCs from the CAMx 2008 Base Case 36/12 km run.

B.4 Photochemical Model Performance Evaluation

The CAMx 2008 Base Case modeling and model performance evaluation was conducted under the WestJumpAQMS. Originally CARMMS was going to completely rely on the WestJumpAQMS model evaluation of the CARMMS 2008 Base Case simulation and CARMMS did not intend to perform any additional 2008 Base Case modeling or model performance evaluation. WestJumpAQMS conducted a comprehensive detailed model performance of the CAMx 2008 36/12 km Base Case simulation across the 36 km CONUS and 12 km WESTUS domains, and within each western State for ozone, total $PM_{2.5}$ mass, speciated $PM_{2.5}$, sulfur and nitrogen wet deposition and for several ozone and $PM_{2.5}$ precursor (e.g., SO_2 and NO_X) and related (e.g., HNO3) species. Section 4.5.3 of the WestJumpAQMS final report (ENVIRON, Alpine and UNC[5]) presented the evaluation the CARMMS 2008 4 km Base Case simulation across the CARMMS 4 km domain.

B.4.1 February 28, 2014 IAQRT Meeting

The WestJumpAQMS model evaluation results for the CARMMS CAMx 4 km Base Case simulation were presented to the Interagency Air Quality Review Team (IAQRT) on February 28, 2014 at the BLM Colorado State Office (COSO). EPA expressed several concerns regarding the adequacy of the model performance evaluation of the CARMMS 2008 4 km Base Case. In particular they believed that the ozone model performance evaluation should be performed using a 60 ppb observed ozone cut-off instead of the 40 ppb cut-off used by WestJumpAQMS. In addition, they expressed concerns about just calculating monthly model performance statistics across the entire 4 km CARMMS modeling domain.

The evaluation of the CAMx model for the CARMMS 2008 base case simulation produced many more evaluation products than provided in the WestJumpAQMS final report. However, it did not calculate ozone model performed statistics using a 60 ppb observed ozone cut-off threshold as desired by EPA. So we calculated additional ozone model performance statistics using the 60 ppb ozone cut-off threshold. The spreadsheet of monthly ozone bias and error model performance statistics and their comparison with the ozone bias (≤±15%) and error (≤35%) performance goals was updated as follows:

[5] http://www.wrapair2.org/pdf/WestJumpAQMS_FinRpt_Finalv2.pdf

Ozone Averaging Times

- Hourly
- Daily maximum 8-Hour Ozone Concentrations

Ozone Monitoring Networks

- AQS
- CASTNet

Bias and Error Statistical Metrics

- Fractional Bias and Error
- Normalized Mean Bias and Error
- Mean Normalized Bias and Error

As discussed below, with the exception of some winter months, the monthly ozone statistical performance metrics across the CARMMS 4 km domain still achieved EPA's performance goals even using the 60 ppb cut-off threshold for both averaging times and monitoring networks and three types of bias/error performance metrics.

Regarding more details on the CARMMS CAMx 4 km base case MPE, we packaged up the model performance products in a zipped file that includes many differences types of monthly model performance metrics and species for sites in the CARMMS 4 km modeling domain. Model performance displays include scatter plots and time series plots of predicted and observed concentrations, in addition to a full suite of model performance evaluation statistical metrics, and are provided for each month of 2008 as follows:

- All sites in the CARMMS 4 km domain and all hours/days in a month.
- At each individual site in the CARMMS 4 km domain and all hours/days in a month.
- For each day in 2008 across all sites in the CARMMS 4 km domain.

Model performance displays and statistics are provided for numerous gas-phase (e.g., ozone and NO_X) and particulate matter (PM) species (e.g., SO4, NO3, NH4, EC, OA). EPA specifically requested model performance for ammonia (NH3) and ammonium (NH4). However, there were no routine NH3 measurements available in 2008 and NH4 was just measured at the CSN network. Although we also evaluated CAMx against derived ammonium (NH4d) at IMPROVE sites that is obtained using the IMPROVE SO4 and NO3 measurements and assuming they are completely neutralized by NH4; note this will overstate actual NH4 values because SO4 is not always neutralized and both SO4 and NO3 can be neutralized by other cations besides NH4.

The detailed model performance displays and metrics for the CARMMS CAMx 2008 base case simulation is contained in the zipped file "CARMMS_2008_4km_MPE_Details.zip" that contains over 4,500 separate model performance displays and is larger than 70 Mb.

Below we present the WestJumpAQMS evaluation of the CARMMS 2008 Base Case simulation across the 4 km CARMMS domain with the addition of the ozone metrics using the 60 ppb cut-off concentrations discussed above. However, we do not present the evaluation down to the individual site as the amount of information is too overwhelming.

B.4.2 Observed Monitoring Networks

The following routine air quality measurement data networks were used in the CAMx model performance evaluation:

EPA AQS Surface Air Quality Data: Data files containing hourly-averaged concentration measurements at a wide variety of state and EPA monitoring networks are available in the Air Quality System (AQS[6]) database throughout the U.S. These data sets will be reformatted for use in the model evaluation software tools. There are several types of networks within the AQS that measure different species. The standard hourly AQS AIRS monitoring stations typically measure hourly ozone, NO_2, NO_X and CO concentration and there are thousands of sites across the U.S. The Federal Reference Method (FRM) network measures 24-hour total $PM_{2.5}$ mass concentrations using a 1:3 day sampling frequency, with some sites operating on an everyday frequency. The Chemical Speciation Network (CSN) measures speciated $PM_{2.5}$ concentrations including SO_4, NO_3, NH_4, EC, OC and elements at 24-hour averaging time period using a 1:3 or 1:6 day sampling frequency.

IMPROVE Monitoring Network: The Interagency Monitoring of Protected Visual Environments (IMPROVE[7]) network collects 24-hour average $PM_{2.5}$ and PM_{10} mass and speciated $PM_{2.5}$ concentrations (with the exception of ammonium) using a 1:3 day sampling frequency. IMPROVE monitoring sites are mainly located at more rural Class I area sites that correspond to specific National Parks and Wilderness Areas across the U.S., with most of the sites located in the western U.S. Although there are also some IMPROVE protocol sites that can be more urban-oriented.

CASTNet Monitoring Network: The Clean Air Status and Trends Network (CASTNet[8]) operates approximately 80 monitoring sites in mainly rural areas across the U.S. CASTNet sites typically collected hourly ozone, temperature, wind speed and direction, sigma theta, solar radiation, relative humidity, precipitation and surface wetness. CASTNet also collects weekly (Tuesday to Tuesday) samples of speciated $PM_{2.5}$ sulfate, nitrate, ammonium and other relevant ions and weekly gaseous SO_2 and nitric acid (HNO_3).

NADP Network: The National Acid Deposition Program (NADP[9]) collects weekly samples of SO_4, NO_3 and NH_4 in precipitation (wet deposition) in their National Trends Network (NTN) at over a 100 sites across the U.S. that are mainly located in rural areas away from big cities and major point sources. Seven NADP sites also collect daily wet deposition measurements (AIRMON) when precipitation occurs. Over 20 of the NADP sites also collect weekly mercury (MDN)

[6] http://www.epa.gov/ttn/airs/airsaqs/aqsweb/
[7] http://vista.cira.colostate.edu/IMPROVE/
[8] http://java.epa.gov/castnet/
[9] http://nadp.sws.uiuc.edu/NADP/

samples. Note that observed sulfate and nitrate dry deposition can be estimated at CASTNet sites using concentrations and a micro-meteorological model that produces a deposition velocity. But these are not true observations, but model estimates of dry deposition flux using observed atmospheric concentrations and meteorological variables and a micro-meteorological deposition model.

B.4.3 Model Performance Goals

Over two decades ago EPA developed PGM ozone model performance goals that are listed in Table B-2 (EPA, 1991). During the regional haze RPO process, additional model performance goals and criteria were developed for PM species (Boylan, 2004; Morris et al., 2009c,d) that are listed in Table B-3. Note that the EPA 1991 ozone model performance goals were applied to the mean normalized bias (MNB) and mean normalized gross error (MNGE) model performance statistics that are calculated for all predicted and observed hourly ozone pairs matched by time and location for which the observed hourly ozone is above a threshold, with a 60 ppb threshold recommended. However, the 60 ppb ozone cut-off was selected for urban ozone modeling of areas with high ozone concentrations addressing the 1-hour ozone NAAQS of 124 ppb. Ozone is much lower these days so an observed ozone cut-off threshold concentration of 40 ppb was used for calculating the MNB and MNGE ozone statistics in addition to the 60 ppb cut-off value. For PM performance statistics, the Fractional Bias (FB) and Fractional Error (FE) bias/error performance metrics are compared against goals and criteria developed during the Regional Planning Organizations (RPOs) modeling to support the Regional Haze Rule (Boylan, 2004; Morris et al., 2009c,d). Table B-4 lists the definitions of the model performance statistical metrics.

More recently, EPA compiled and interpreted the model performance from 69 PGM modeling studies in the peer-reviewed literature between 2006 and March 2012 and developed recommendations on what should be reported in a model performance evaluation (Simon, Baker and Phillips, 2012). Although these recommendations are not official EPA guidance, they are useful for consideration in the BLM CARMMS model performance evaluation:

- PGM MPE studies should at a minimum report the Mean Bias (MB) and Mean Error (ME or RMSE), and Normalized Mean Bias (NMB) and Normalized Mean Error (NME) and/or Fractional Bias (FB) and Fractional Error (FE). Both the MNB and FB are symmetric around zero with the FB bounded by -200% to +200%.
- Use of the Mean Normalized Bias (MNB) and Gross Error (MNGE) is not encouraged because they are skewed toward low observed concentrations and can be misinterpreted due to the lack of symmetry around zero.
- The model evaluation statistics should be calculated for the highest resolution temporal resolution available and for important regulatory averaging times (e.g., daily maximum 8-hour ozone).
- It is important to report processing steps in the model evaluation and how the predicted and observed data were paired and whether data are spatially/temporally averaged before the statistics are calculated.

- Predicted values should be taken from the grid cell that contains the monitoring site, although bilinear interpolation to the monitoring site point can be used for higher resolution modeling (< 12 km).
- $PM_{2.5}$ should also be evaluated separately for each major component species (e.g., SO_4, NO_3, NH_4, EC, OA and OPM2.5).
- Evaluation should be performed for subsets of the data including, high observed concentrations (e.g., ozone > 60 ppb[10]), by subregions and by season or month.
- Evaluation should include more than just ozone and $PM_{2.5}$, such as SO_2, NO_2 and CO.
- Spatial displays should be used in the model evaluation to evaluate model predictions away from the monitoring sites. Time series of predicted and observed concentrations at a monitoring site should also be used.
- It is necessary to understand measurement artifacts in order to make meaningful interpretation of the model performance evaluation.

Given these recommendations we will stress the FB and FE and NMB and NME measures of bias and error over the MNB and MNGE.

Table B-2. Hourly ozone model performance goals from EPA's 1991 PGM modeling guidance.

Goal	Metric	Definition	Comment
≤±20%	Unpaired Peak Accuracy (UPA)	$\frac{P-O_{peak}}{O_{peak}}$	Compare highest predicted and observed daily maximum hourly ozone concentrations unmatched by location and hour but matched by day.
≤±15%	Mean Normalized Bias (MNB)	$\frac{1}{N}\sum_{i=1}^{N}\frac{(P_i-O_i)}{O_i}$	Predicted and observed hourly ozone concentrations matched by time and location when observed ozone is 60 ppb or greater. Use a 40 ppb cut-off in CARMMS.
≤35%	Mean Normalized Gross Error (MNGE)	$\frac{1}{N}\sum_{i=1}^{N}\frac{\lvert P_i-O_i\rvert}{O_i}$	Predicted and observed hourly ozone concentrations matched by time and location when observed ozone is 60 ppb or greater. Use a 40 ppb cut-off in CARMMS.

Table B-3. Ozone and PM model performance goals and criteria for bias and error (Boylan, 2004; Morris et al., 2009c,d).

Bias	Error	Comment
≤±15%	≤35%	Ozone model performance Goal from the 1991 guidance that would be considered very good model performance for PM species (EPA, 1991).
≤±30%	≤50%	PM model performance Goal, considered good PM performance (Boylan, 2004).
≤±60%	≤75%	PM model performance Criteria, considered average PM performance. Exceeding this level of performance for PM species with significant mass may be cause for concern (Boylan, 2004).

[10] Note that because of the low ozone concentrations in the Montana/Dakotas the Simon, Baker and Phillips (2012) 60 ppb threshold recommendation should be lowered to 40 ppb.

Table B-4. Definition of model performance evaluation statistical measures used to evaluate PGMs in the past.

Statistical Measure	Mathematical Expression	Notes
Accuracy of paired peak (AP)	$\frac{P - O_{peak}}{O_{peak}}$	Comparison of the peak observed value (O_{peak}) with the predicted value at same time and location
Coefficient of determination (r2)	$\frac{\left[\sum_{i=1}^{N}(P_i - \overline{P})(O_i - \overline{O})\right]^2}{\sum_{i=1}^{N}(P_i - \overline{P})^2 \sum_{i=1}^{N}(O_i - \overline{O})^2}$	Pi = prediction at time and location i; Oi = observation at time and location i; $\overline{P}$ = arithmetic average of Pi, i=1,2,..., N; $\overline{O}$ = arithmetic average of Oi, i=1,2,...,N
Normalized Mean Error (NME)	$\frac{\sum_{i=1}^{N}\lvert P_i - O_i\rvert}{\sum_{i=1}^{N} O_i}$	Reported as %
Root Mean Squared Error (RMSE)	$\left[\frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)^2\right]^{1/2}$	Reported as %
Fractional Gross Error (FE)	$\frac{2}{N}\sum_{i=1}^{N}\left\lvert\frac{P_i - O_i}{P_i + O_i}\right\rvert$	Reported as % and bounded by 0% to 200%
Mean Absolute Gross Error (MAGE)	$\frac{1}{N}\sum_{i=1}^{N}\lvert P_i - O_i\rvert$	Reported as concentration (e.g., $\mu g/m^3$)
Mean Normalized Gross Error (MNGE)	$\frac{1}{N}\sum_{i=1}^{N}\frac{\lvert P_i - O_i\rvert}{O_i}$	Reported as %
Mean Bias (MB)	$\frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)$	Reported as concentration (e.g., $\mu g/m^3$)
Mean Normalized Bias (MNB)	$\frac{1}{N}\sum_{i=1}^{N}\frac{(P_i - O_i)}{O_i}$	Reported as %
Mean Fractionalized Bias (Fractional Bias, FB)	$\frac{2}{N}\sum_{i=1}^{N}\left(\frac{P_i - O_i}{P_i + O_i}\right)$	Reported as %, bounded by -200% to +200%
Normalized Mean Bias (NMB)	$\frac{\sum_{i=1}^{N}(P_i - O_i)}{\sum_{i=1}^{N} O_i}$	Reported as %
Bias Factor (BF)	$\frac{1}{N}\sum_{i=1}^{N}\left(\frac{P_i}{O_i}\right)$	Reported as BF:1 or 1: BF or in fractional notation (BF/1 or 1/BF).

B.4.4 Model Performance Evaluation Approach

The WestJumpAQMS CAMx 2008 base case model performance evaluation focused on evaluating the model for its primary intended purpose, estimating the air quality and AQRV impacts within the 4 km CARMMS modeling domain. Based on EPA modeling guidance (EPA, 1991; 2007), the recommendations of Simon, Baker and Philips (2012) and previous studies, the WestJumpAQMS CAMx model performance evaluation included the following:

- The PGM should be evaluated across all relevant species for which observations are available, including ozone, NO, NO_2, NO_X, HNO_3, SO_2, $PM_{2.5}$, PM_{10}, speciated $PM_{2.5}$ (SO_4, NO_3, NH_4, EC, OA and OPM2.5) and wet sulfur and nitrogen deposition.
- Numerous statistical performance measures should be calculated (Table B-4) and reported following the recommendations of Simon, Baker and Phillips (2012)
- The native sampling frequency of the observations will be used in the evaluation, along with important regulatory averaging times (e.g., daily maximum 8-hour ozone, annual $PM_{2.5}$ and annual wet deposition).
- The PGM evaluation should also include geographic, temporal and concentration stratifications.
- The PGM results should be more thoroughly evaluated for the 4 km CARMMS domain.
- Seasonal and monthly evaluation should be included.
- Evaluation for high observed concentrations should be made.
- Several graphical displays of model performance may be used, including, but not limited to:
    - Scatter Plots of predicted and observed concentrations/depositions.
    - Spatial Maps of performance, including spatial maps of model predictions with superimposed observations and interpolated spatial maps of bias and error.
    - Time Series Plots of predicted and observed concentrations using native observation averaging time.
    - Soccer Plots that compare model performance statistics with model performance goals (Table B-3).

Details on the CAMx 2008 model performance evaluation are provided in the WestJumpAQMS final report and supporting material. Below we summarized the CAMx model performance evaluation statistical metrics for just within the CARMMS 4 km modeling domain that is the subject of this study.

B.5 Model Evaluation within the 4 km CARMMS Domain

WestJumpAQMS developed a separate CAMx 4 km modeling database for the 2008 annual period and the 4 km CARMMS modeling domain (see Figure 2-1) that covers all of Colorado, the northern two-thirds of New Mexico as well as eastern Utah and northeastern Arizona. WestJumpAQMS conducted a separate model performance evaluation of the CAMx 2008 base case simulation for the CARMMS 4 km domain that is summarized from the WestJumpAQMS final report (ENVIRON, Alpine and UNC, 2013) in this section. Also presented below are some supplemental ozone evaluation results as suggested by the IAQRT in their February 28, 2014 meeting.

Figures B-1 through B-4 displays the monthly and annual daily maximum 8-hour (DMAX8) and hourly ozone model performance statistics across all CASTNet (top) and AQS (bottom) sites in the 4 km CARMMS domain using observed ozone cut-off concentrations of 40 and 60 ppb. The Fractional Bias and Error (FB and FE) and Normalized Mean Bias and Error (NMB and NME) performance statistics are used in these Figures. The Mean Normalized Bias and Error (MNB and MNE) statistics are not presented following the recommendations of Simon, Baker and Philips (2012). The CARMMS ozone model performance statistics are compared against EPA's 1991 bias (≤±15%) and error (≤35%) ozone model performance goals (Table B-2). The CAMx 4 km model pDMAX8 ozone performance evaluation across CASTNet and AQS monitors within the CARMMS 4 km domain using the FB 40 ppb cut-off are ≤±6% with an annual FB of less than 2%, which achieves the ozone bias ≤±15% performance goal by a wide margin (Figure B-1a). Similarly, the monthly DMAX8 ozone FE tends to be between 5% and 12%, so achieves the ozone performance goal of ≤35% by over a factor of 2 (Figure B-1a). Some of the underestimation of the DMAX8 ozone at the Colorado CASTNet sites (e.g., in May) may be due in part to the model's inability to fully simulate stratospheric ozone intrusion events (e.g., at Gothic). Figure B-1b presents similar DMAX8 ozone modeling results for the NMB and NME performance statistics using a 40 ppb cut-off that also exhibit very good model performance statistics that achieves the ozone model performance goals.

Figure B-2 presents similar DMAX8 ozone performance statistics as Figure B-1 only using a 60 ppb ozone cut-off value instead of 40 ppb. With a focus on higher observed ozone concentrations then it is not surprising that the model exhibits an underestimation bias. The maximum underestimation bias occurs in the late winter and spring when stratospheric ozone and winter ozone events occur that the model has difficulty in reproducing. The DMAX8 ozone with 60 ppb cut-off performance statistics still achieve the ozone error performance goal for all months and bias goal for all months except February 2008.

Figure B-3 and B-4 are like Figure B-1 and B-2 only for hourly ozone model performance instead of DMAX8 ozone. The hourly ozone model performance using a 40 ppb cut-off value achieves the ozone goals for all months of the year (Figure B-3); it is encouraging that much better ozone performance is seen during the summer ozone season. Using a 60 ppb ozone cut-off, the hourly ozone underestimation bias is so great during the winter months that it exceeds the ozone model performance goal (Figure B-4). However, during the summer when the observed and model ozone is higher and is the primary ozone period of concern, CAMx achieves the ozone model performance goals.

The CAMx 4 km total $PM_{2.5}$ mass performance across the FRM, IMPROVE and CSN sites in the 4 km CARMMS domain is shown in Figure B-5. The model tends to overestimate $PM_{2.5}$ in the winter falling to a near zero bias in the summer. However, the overestimation bias is usually within the PM Performance Criteria with only 5 of the 36 monthly FBs (14% of the time) failing to achieve the PM Performance Criteria. 14 months achieve the PM Performance goal (~40% of the time), which occur in the summer and months adjacent to the summer.

Figures B-6 and B-7 display the CAMx 4 km model performance related to sulfur species that includes SO4 at IMPROVE, CSN and CASTNet monitoring networks, SO2 at CASTNet and wet SO4 deposition at NADP. SO4 tends to be overestimated in the winter and underestimated in the spring, summer and early fall. SO2 is also overestimated in the winter and fall with near zero bias to underestimating in the spring and summer, which indicates that the summer SO4 underestimation is not due to insufficient oxidation of available SO2 concentrations. The wet SO4 deposition also is overestimated in the winter and underestimated in the summer suggesting that too rapid wet depositions is not the cause of the summer SO4 underestimation tendency. The summer underestimation of wet SO4 deposition also suggests that the overstated WRF convective precipitation is not overly washing out the atmospheric pollutants.

Figures B-8 and B-9 displays CAMx 4 km model performance statistics related to nitrogen species including NO3, HNO3 and combined NO3 plus HNO3. Monthly NO3 performance at the IMPROVE sites almost always achieves the PM Performance Goal, whereas it is generally underestimated across the CSN and CASTNet networks with the largest underestimation bias occurring in the summer. On the other hand, HNO3 tends to be overestimated by the CAMx 4 km CARMMS base case and the performance of total nitrate (HNO3+NO3) exhibits much better performance with near zero bias in the spring and summer that achieves the PM Performance Goals. These results suggest that some of the NO3 underestimation bias may be due to not enough conversion of the gaseous HNO3 to particulate NO3. This could be due to insufficient ammonia present to buffer the nitric acid or not fully accounting for other basic compounds that can neutralize nitric acid (e.g., Calcium, Sodium, etc.). Thermodynamic variables could also partly account for this if the temperatures were too hot or the atmosphere not moist enough.

NH4 model performance across he IMPROVE, CSN and NADP networks in the CARMMS 4 km domain is shown in Figure B-10. NH4 is underestimated, which is consistent with the SO4 and NO3 underestimation bias, with the performance being better across the CSN network that always achieves the PM Performance Criteria and sometimes achieves the PM Performance Goal. The underestimation bias is greater across the IMPROVE network due to the use of derived NH4d in the evaluation that overestimates actual ambient NH4 concentrations. The NH4 wet deposition exhibits near zero or an underestimation bias indicating that the NH4 underestimation tendency is not due to overstated wet scavenging.

The CAMx 4 km model performance for gaseous NO_X and NO_Y across AQS and nonmethane organic compounds (NMOC) across PAMS monitoring sites are shown in Figure B-11. NO_X is underestimated in the winter with near zero bias in the summer, whereas NO_Y is overestimated in the summer, underestimated in the winter and has near zero bias in the spring. Given that these measurements may have artifacts and picking up other reactive nitrogen species, it is hard to interpret the evaluation. NMOC is underestimated throughout the year, which may be due in part to the fact they tend to be sited in urban areas.

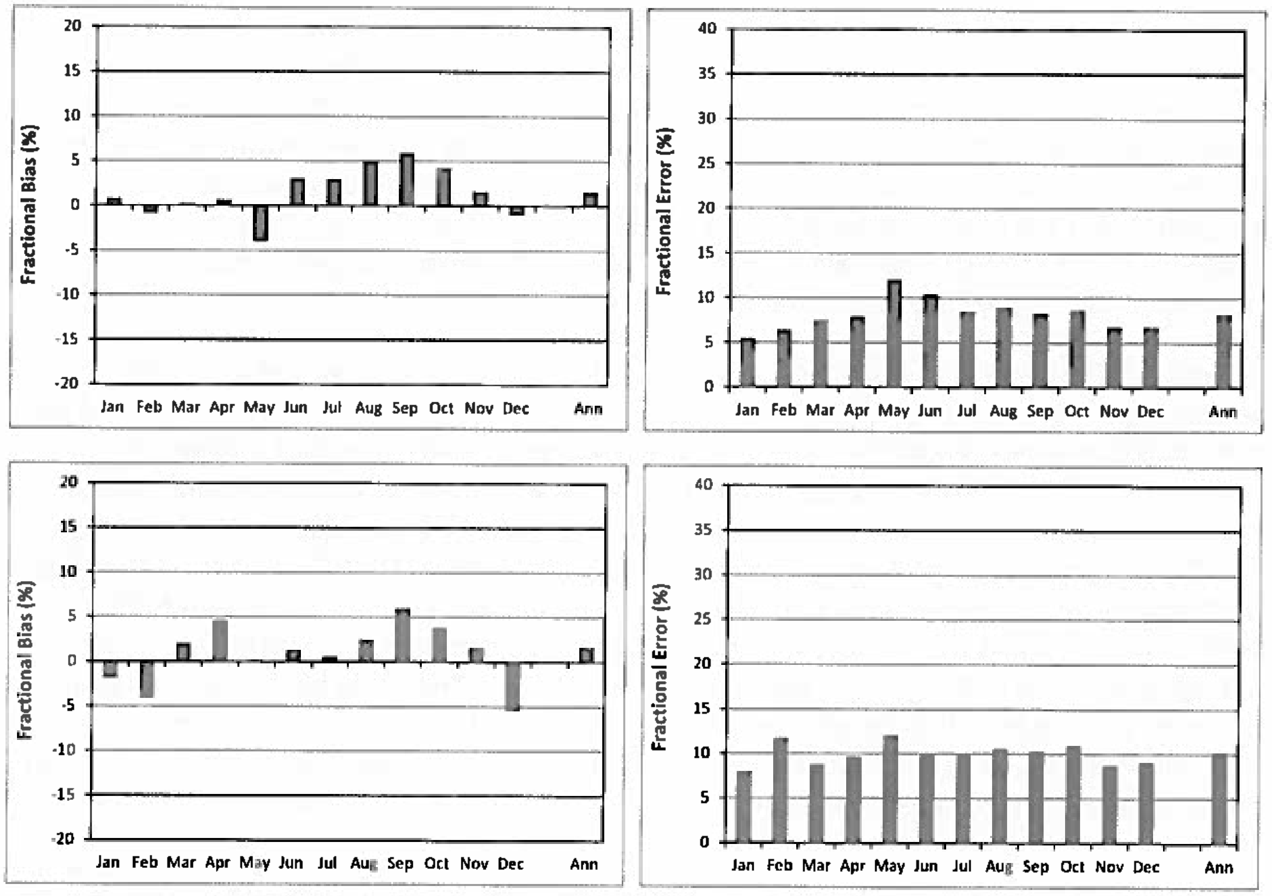

Figure B-1a. CAMx 4 km daily maximum 8-hour ozone model performance for Fractional Bias (left) and Fractional Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 40 ppb observed ozone cut-off value.

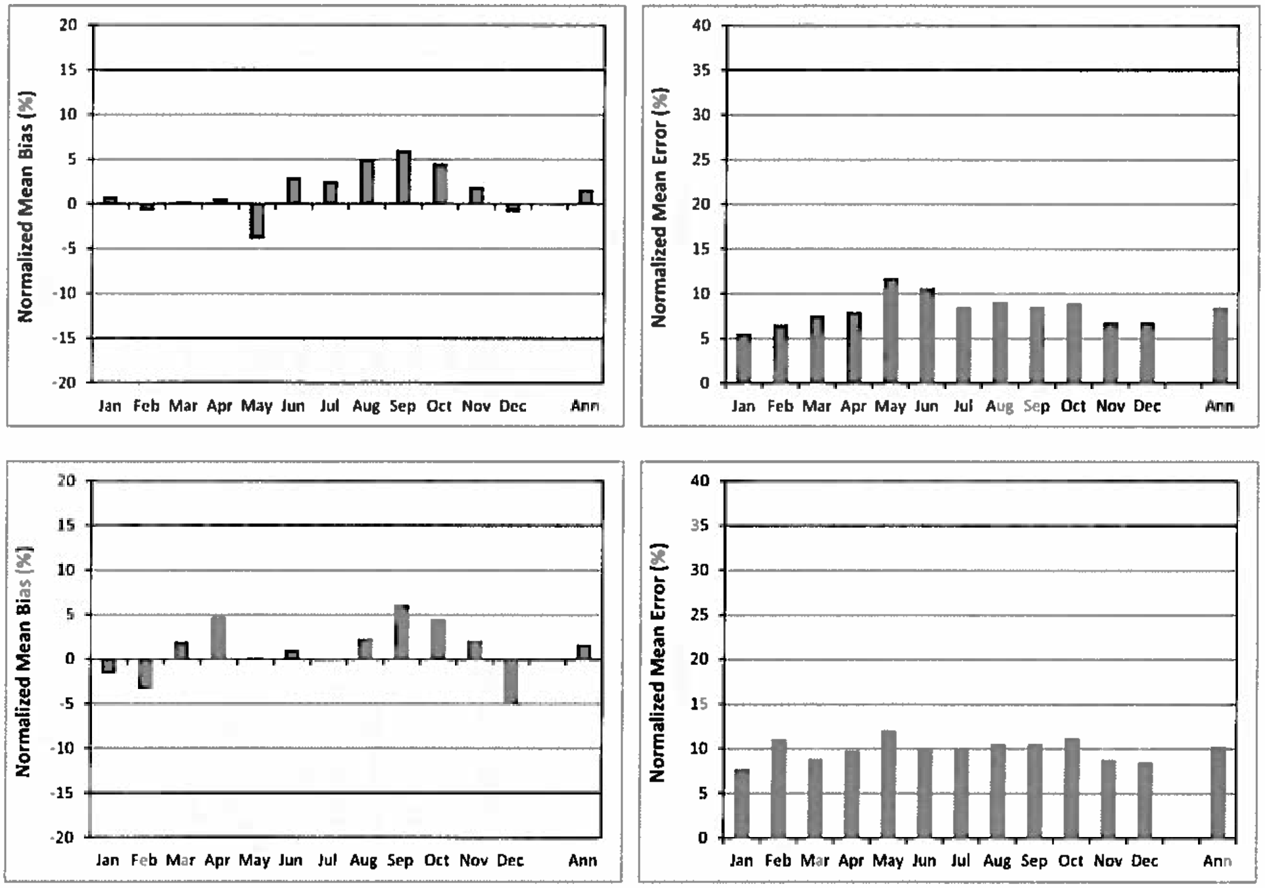

Figure B-1b. CAMx 4 km daily maximum 8-hour ozone model performance for Normalized Mean Bias (left) and Normalized Mean Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 40 ppb observed ozone cut-off value.

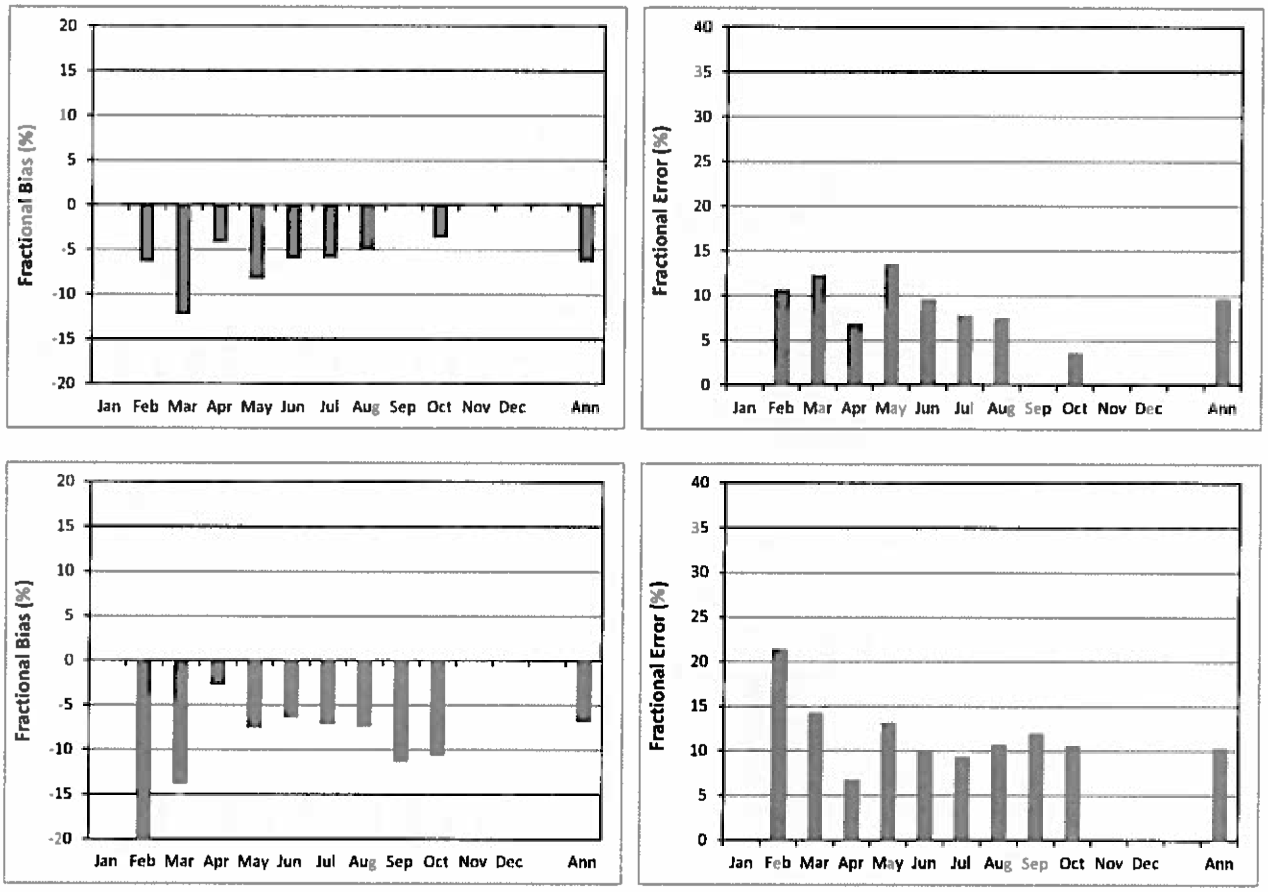

Figure B-2a. CAMx 4 km daily maximum 8-hour ozone model performance for Fractional Bias (left) and Fractional Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 60 ppb observed ozone cut-off value.

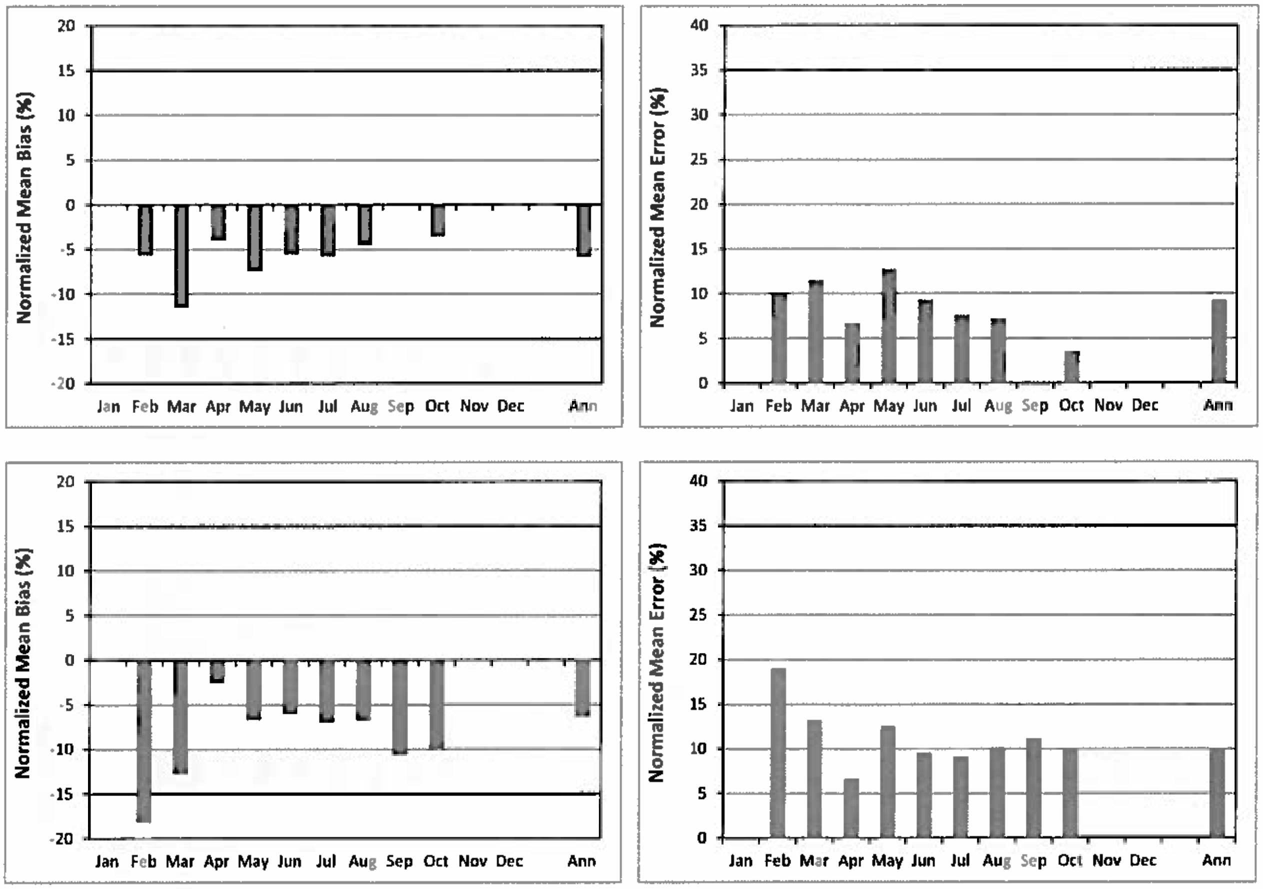

Figure B-2b. CAMx 4 km daily maximum 8-hour ozone model performance for Normalized Mean Bias (left) and Normalized Mean Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 60 ppb observed ozone cut-off value.

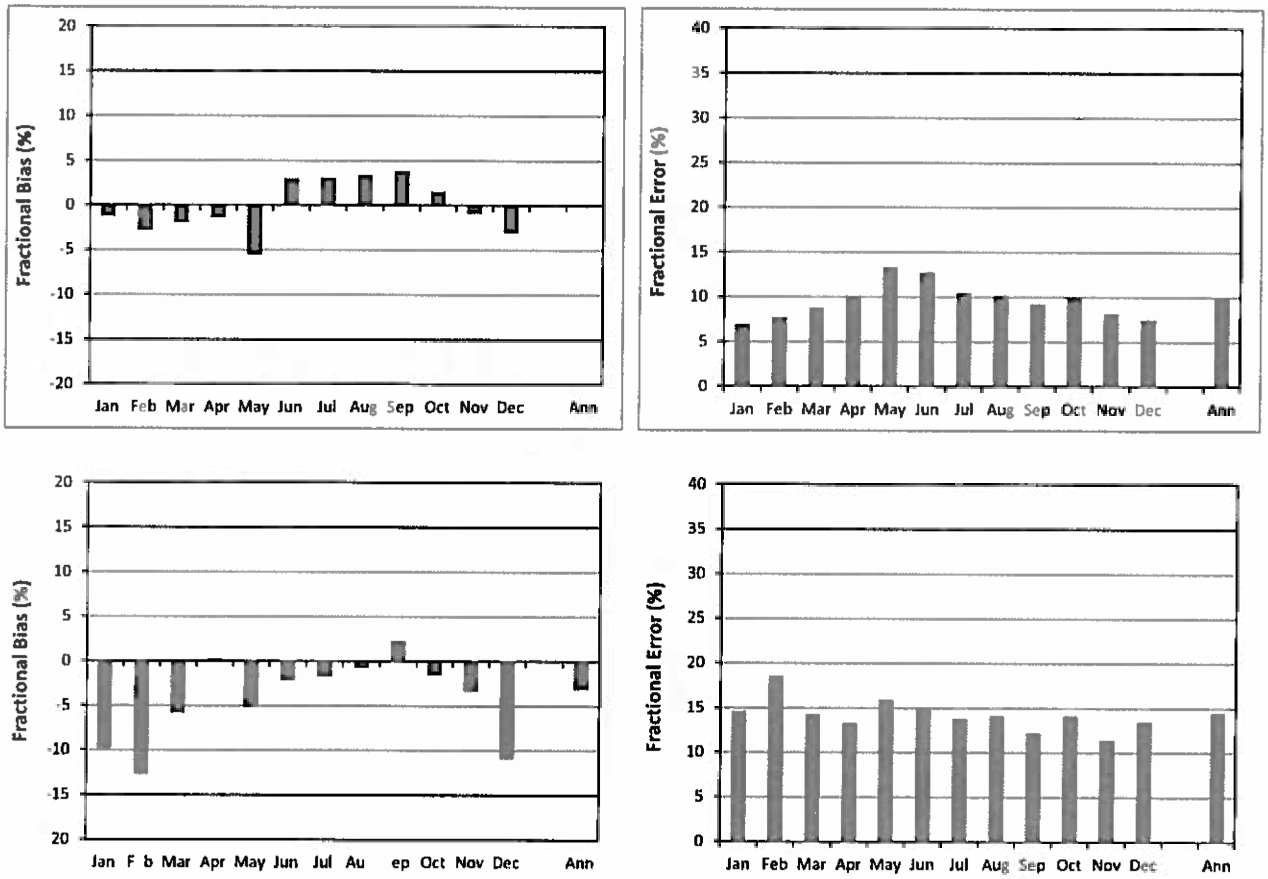

Figure B-3a. CAMx 4 km hourly ozone model performance for Fractional Bias (left) and Fractional Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 40 ppb observed ozone cut-off value.

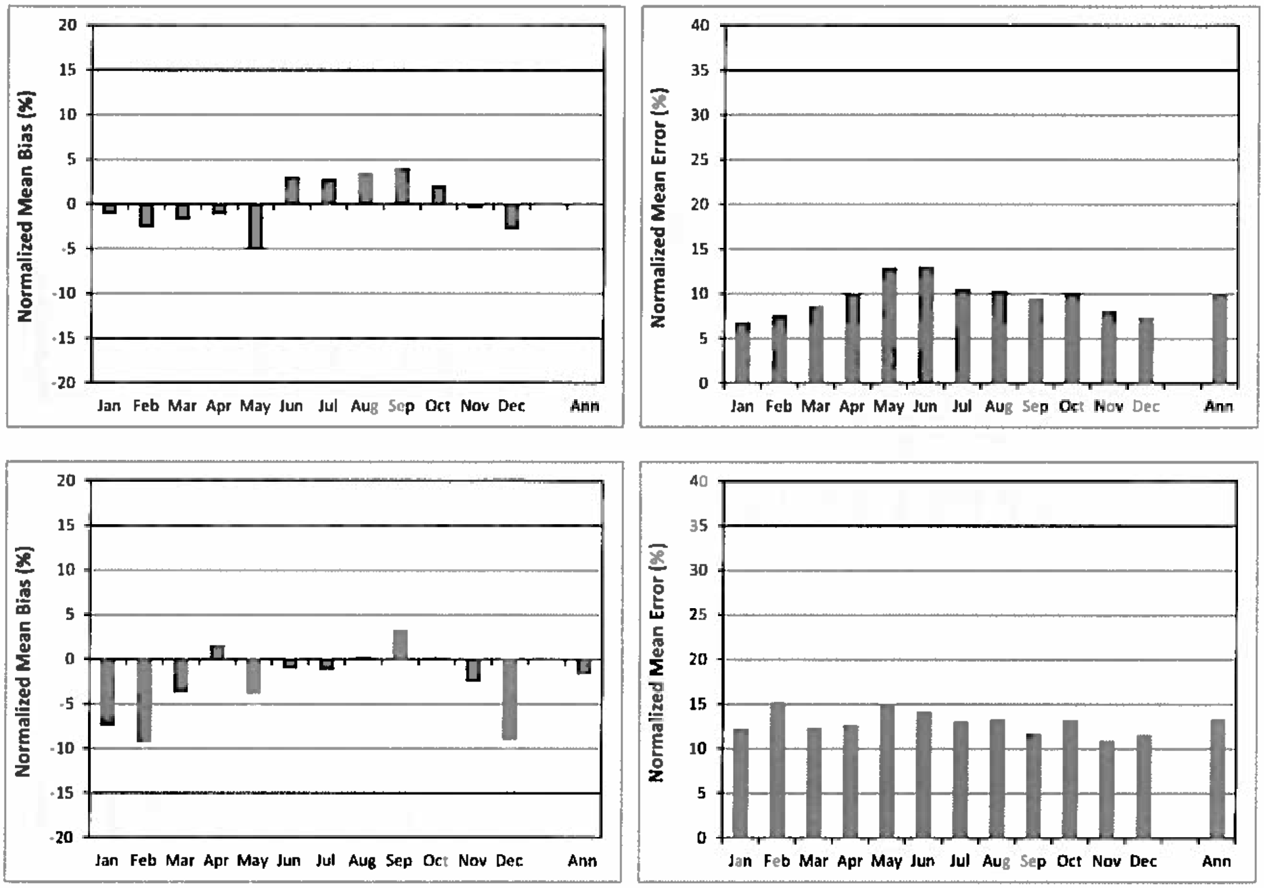

Figure B-3b. CAMx 4 km hourly ozone model performance for Normalized Mean Bias (left) and Normalized Mean Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 40 ppb observed ozone cut-off value.

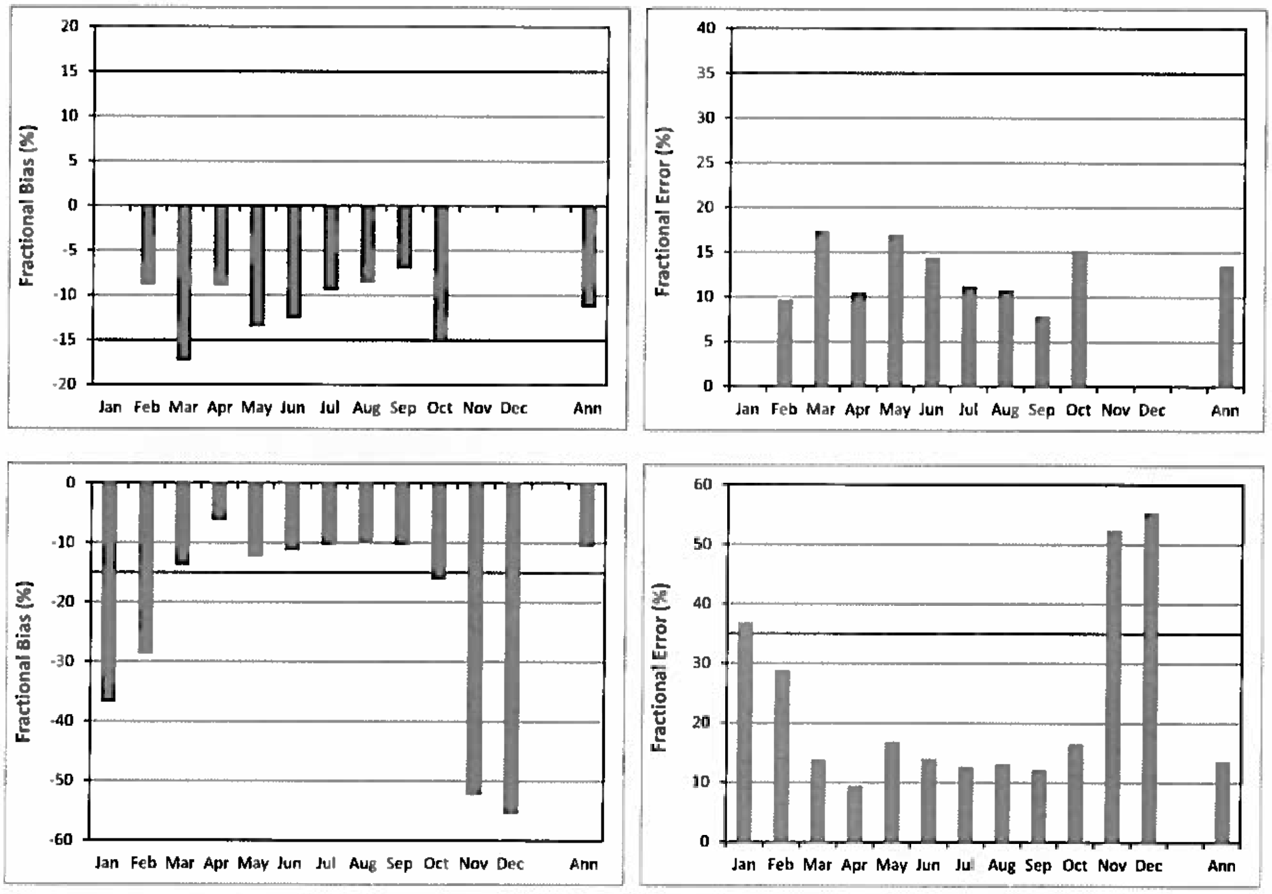

Figure B-4a. CAMx 4 km hourly ozone model performance for Fractional Bias (left) and Fractional Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 60 ppb observed ozone cut-off value.

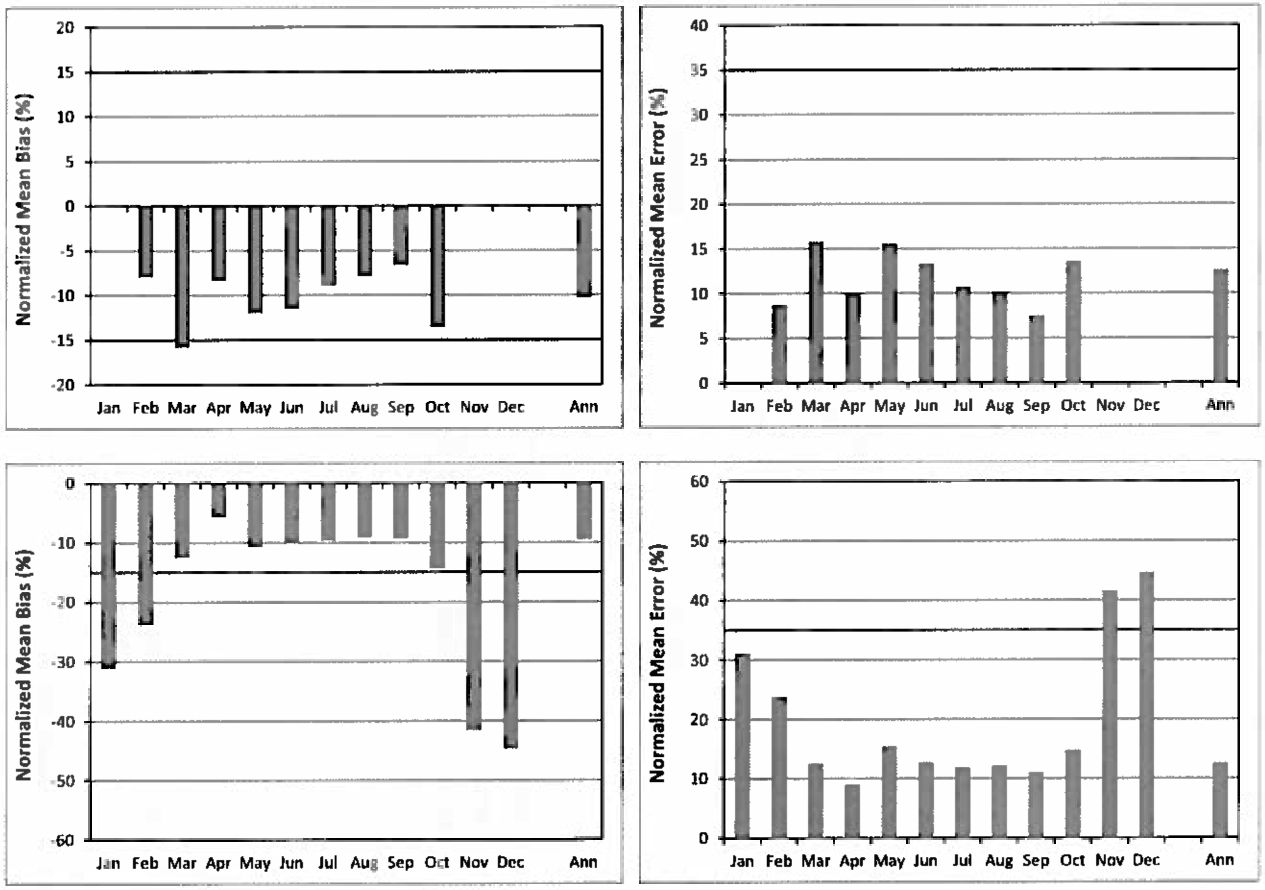

Figure B-4b. CAMx 4 km hourly ozone model performance for Normalized Mean Bias (left) and Normalized Mean Error (right) across CASTNet (top) and AQS (bottom) monitors within the CARMMS 4 km domain using a 60 ppb observed ozone cut-off value.

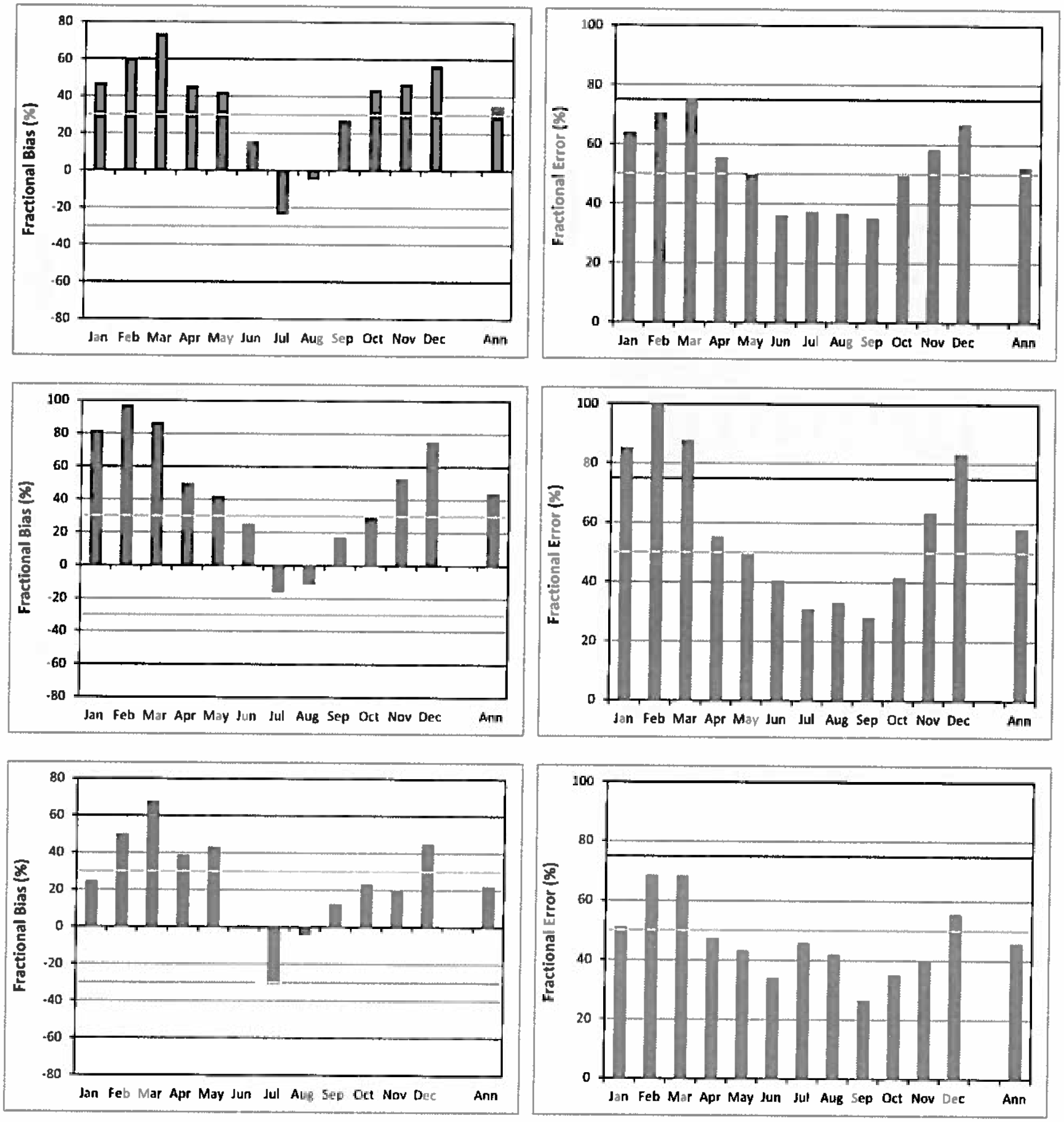

Figure B-5. CAMx 4 km $PM_{2.5}$ model performance for FB (left) and FE (right) across FRM (top), IMPROVE (middle) and CSN (bottom) monitors within the CARMMS 4 km Impact Assessment Domain (IAD).

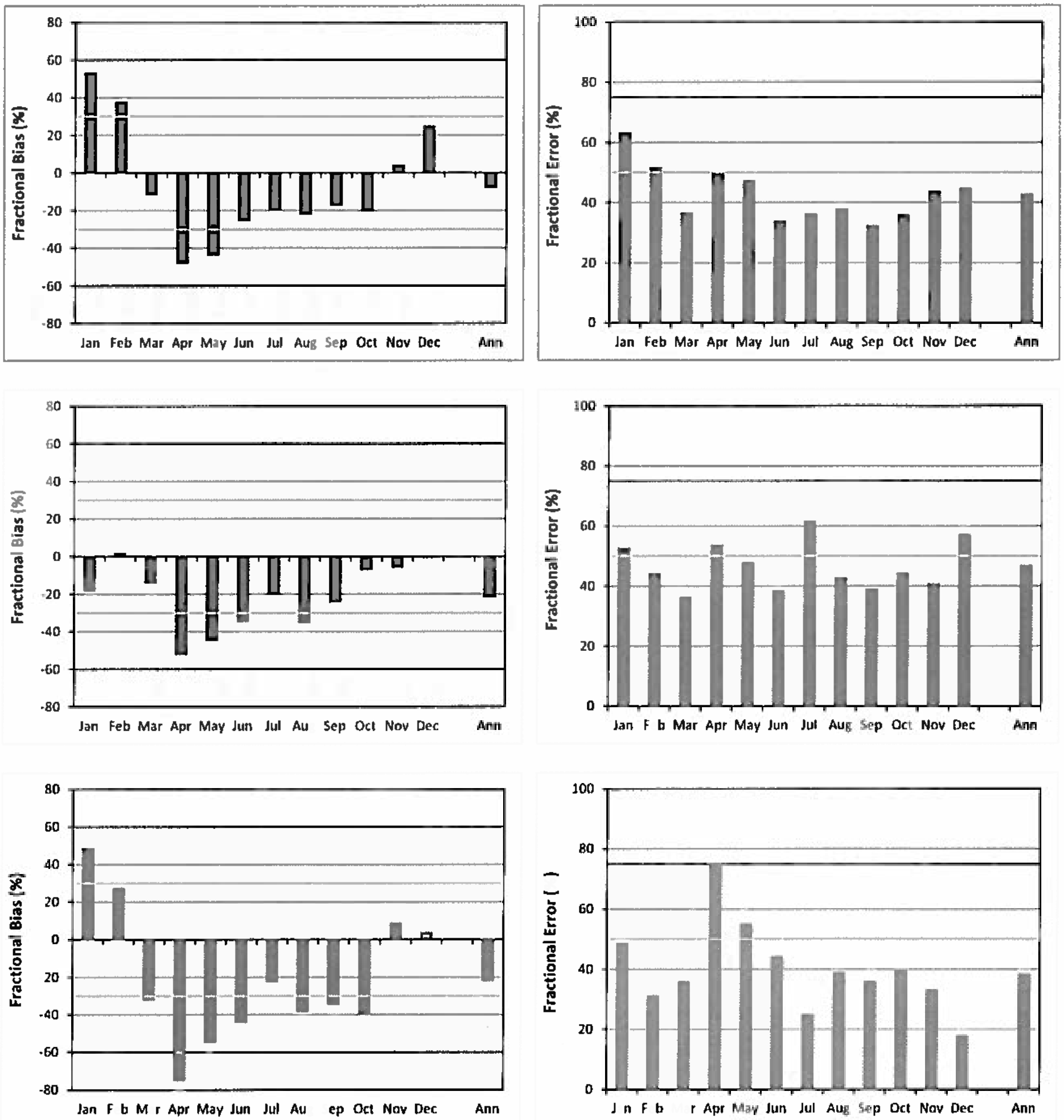

Figure B-6. CAMx 4 km Sulfate (SO4) model performance for FB (left) and FE (right) across IMPROVE (top), CSN (middle) and CASTNet (bottom) monitors within the CARMMS 4 km Impact Assessment Domain (IAD).

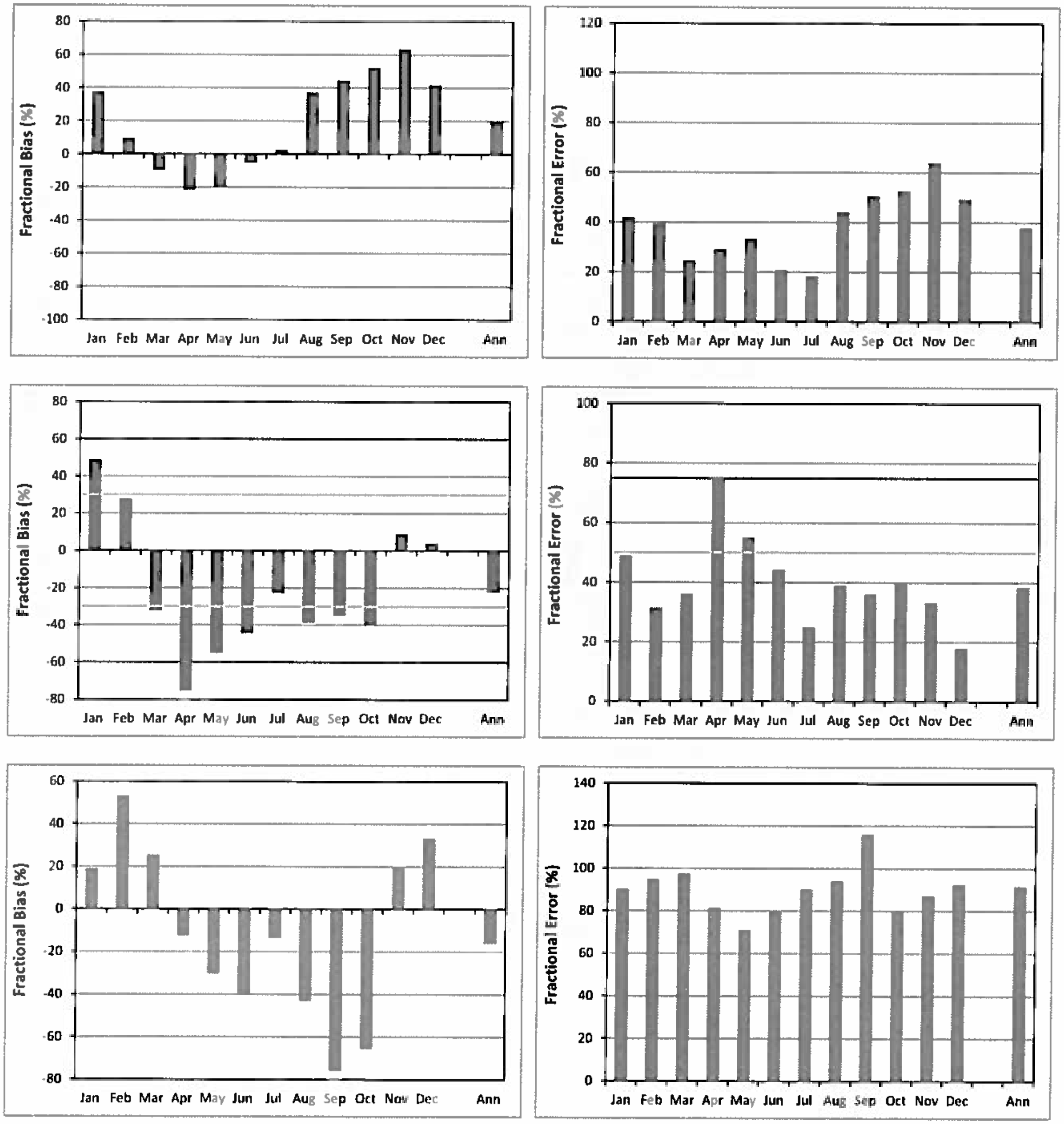

Figure B-7. CAMx 4 km SO2 (top) and SO4 (middle) at CASTNet and SO4 Wet Deposition (bottom) at NADP model performance for FB (left) and FE (right) monitors within the CARMMS 4 km Impact Assessment Domain (IAD).

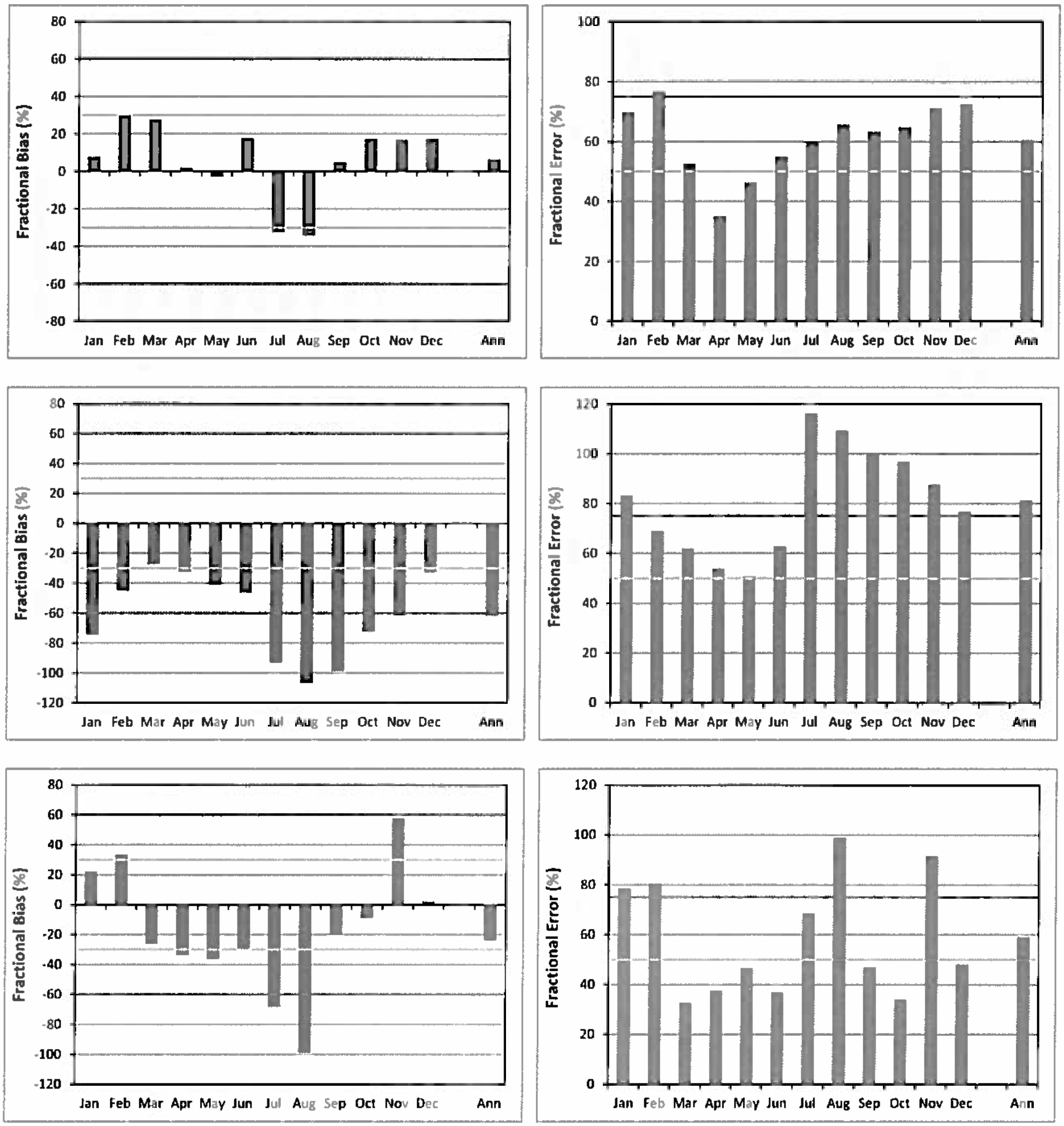

Figure B-8. CAMx 4 km NO3 model performance for FB (left) and FE (right) across IMPROVE (top), CSN (middle) and CASTNet (bottom) monitors within the CARMMS 4 km Impact Assessment Domain (IAD).

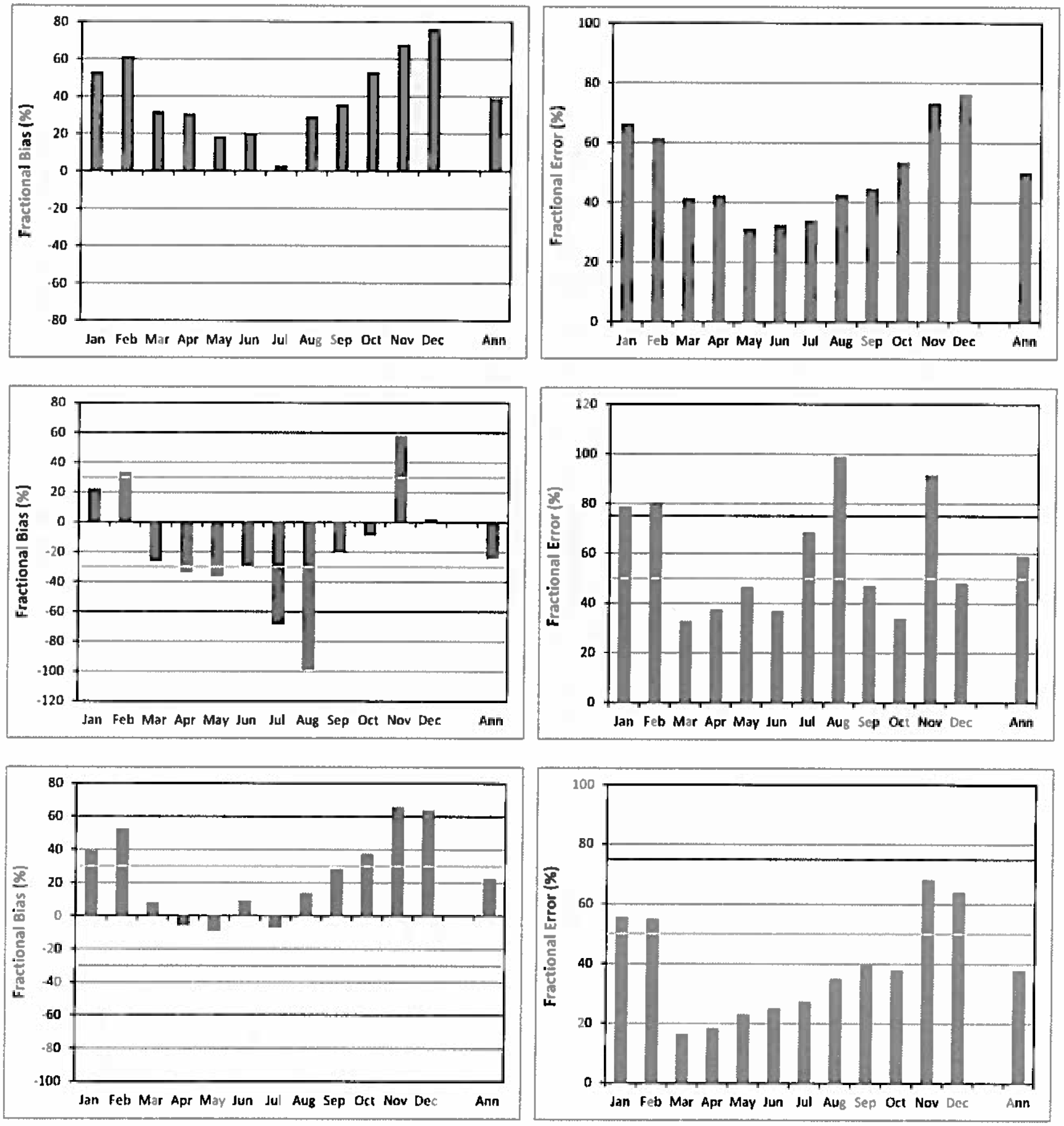

Figure B-9. CAMx 4 km HNO3 (top), NO3 (middle) and tHNO3+NO3 (bottom) model performance for FB (left) and FE (right) across CASTNet monitors within the CARMMS 4 km Impact Assessment Domain (IAD).

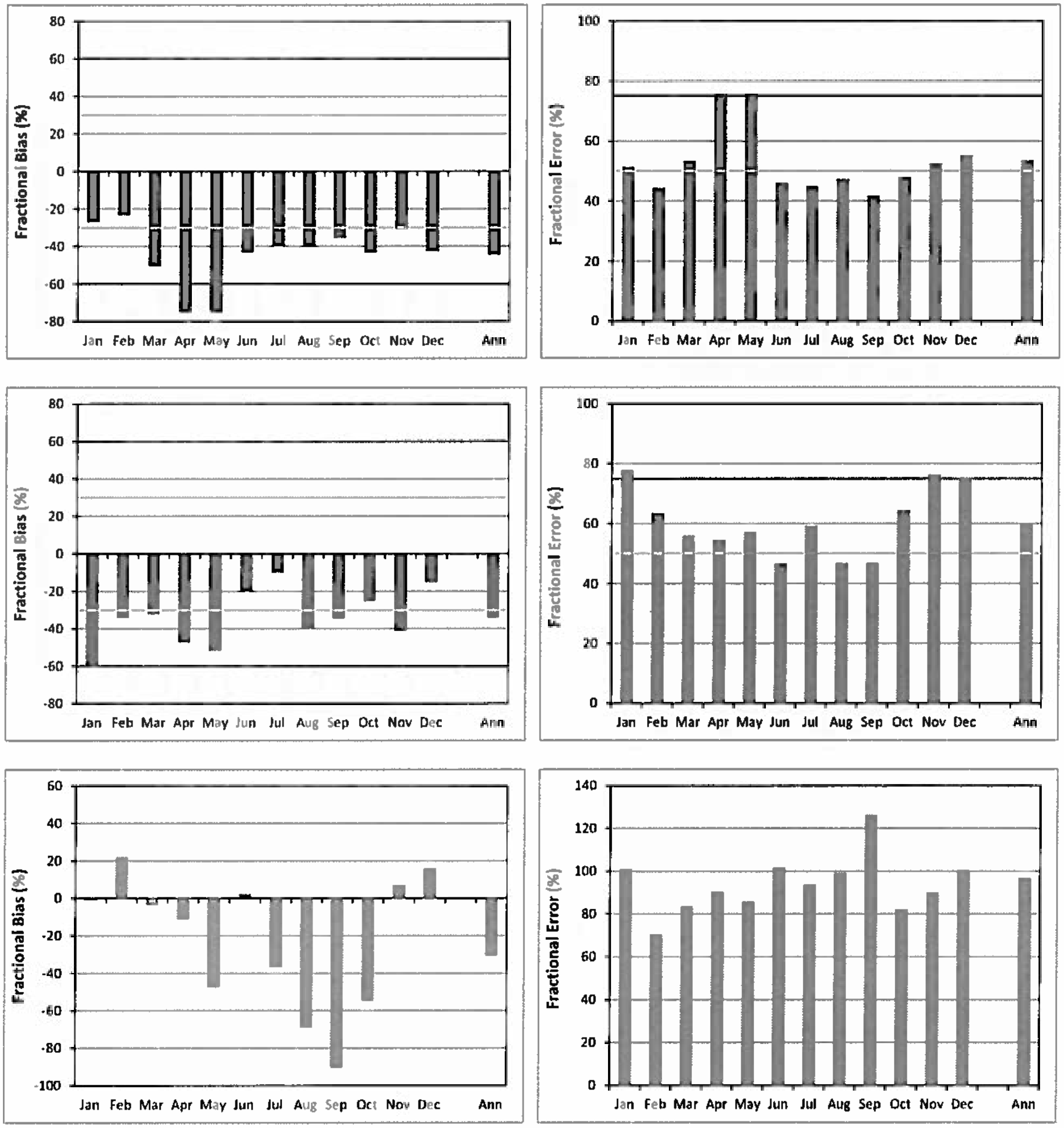

Figure B-10. CAMx 4 km NH4 concentration and wet deposition model performance for FB (left) and FE (right) across IMPROVE (top), CSN (middle) and NADP (bottom) monitors within the CARMMS 4 km Impact Assessment Domain (IAD).

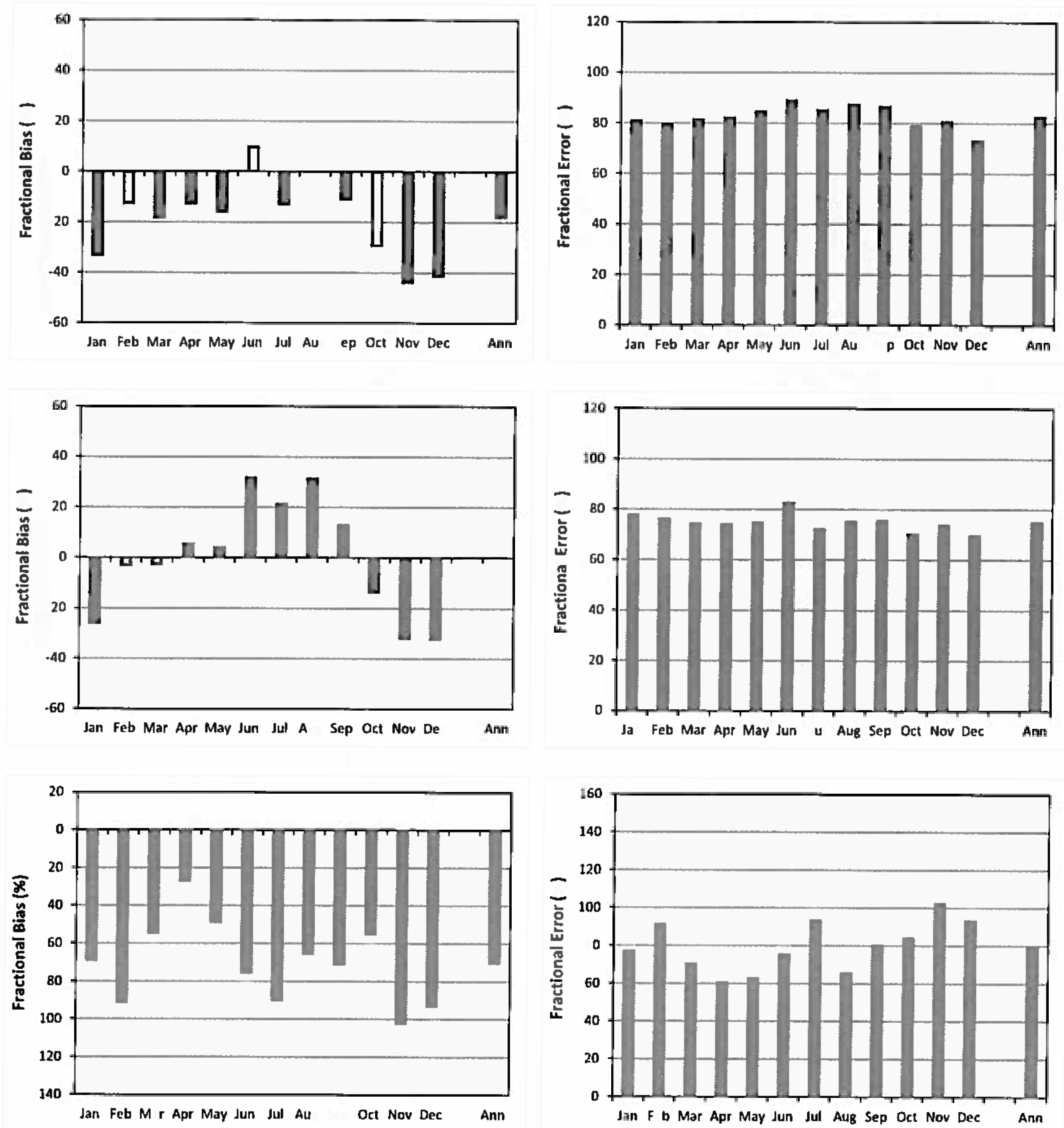

Figure B-11. CAMx 4 km NO_X (top), NO_Y (middle) and NMOC (bottom) model performance for FB (left) and FE (right) across AQS and PAMS) monitors within the CARMMS 4 km Impact Assessment Domain (IAD).

APPENDIX C

CARMMS Technical Memorandum
Draft Final CARMMS Oil and Gas Emission Calculator Documentation
August 15, 2013

August 15, 2013

MEMORANDUM

To: Chad Meister and Forrest Cook, BLM Colorado State Office
From: John Grant, Jim Zapert, and Ralph Morris
Subject: Draft Final CARMMS Oil and Gas Emission Calculator Documentation

1.0 INTRODUCTION

1.1 Scope and Goals

The purpose of this document is to explain the emissions calculation procedures used in the oil and gas emission calculators that have been developed for the Western Colorado Air Resource Management Modeling Study (West-CARMMS). We have improved existing emissions calculators and develop representative calculators for "typical" crude oil, conventional gas (with condensate), coal bed natural gas (CBNG), and shale gas within the region. New information has been incorporated for drilling times; engine configurations; condensate and produced water production; well pad versus offsite gas treatment and storage; well-head, infield, and pipeline compression; and gas/oil production. The ability to readily modify input assumptions such as production parameters, emission control assumptions, and wellhead equipment configurations has also been incorporated into the calculator.

The refined emission calculators will be used to develop the baseline and future-year emissions inventories under Task 2 for the Western Colorado Bureau of Land Management (BLM) planning areas (see Figure 1-1).

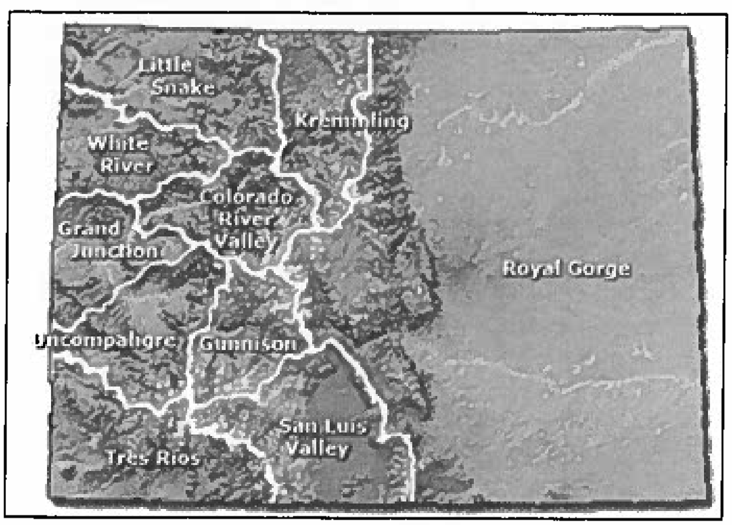

Figure 1-1. Colorado Field Office Planning Areas.

1.2 Overview of Calculators

Emission calculators have been developed for each of the following well types.

- Conventional gas
- Conventional oil
- Shale gas
- Coalbed natural gas (CBNG)

For each well type a separate, a self-contained emission calculator spreadsheet contains all of the inputs and calculations need to generate wellsite emissions.

Additionally, a calculator has been developed to estimate midstream emissions for each area. The midstream emission calculator draws upon Colorado Department of Public Health (CDPHE) Air Pollutant Emission Notice (APEN) emissions for base year emission estimates. Future year midstream emission projections are dependent on the change in oil and gas production in a given planning area which can be updated based on linkages to the by well type emission calculators.

1.2.1 Pollutants

The emission calculators include estimates of emissions of criteria air pollutants (CAPs), greenhouse gases (GHGs), and hazardous air pollutants (HAPs) as follows:

- Criteria Pollutants
  - Carbon monoxide (CO)
  - Nitrogen oxides (NO_X)
  - Particulate matter less than or equal to 10 microns in diameter (PM_{10})
  - Particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$)
  - Sulfur dioxide (SO_2)
  - Volatile Organic Compounds (VOCs)
- Greenhouse Gases
  - Carbon dioxide (CO_2)
  - Methane (CH_4)
  - Nitrous oxide (N_2O)
- Hazardous Air Pollutants (HAPs)

While lead (pb) is a criteria pollutant, emissions of lead in the BLM western Colorado planning areas are expected to be extremely low and are therefore not included in this analysis.

HAP emissions were estimated for each emissions source. For oil and gas emissions sources, HAP emissions from venting and combustion source categories were estimated for formaldehyde, n-hexane, benzene, toluene, ethylbenzene, and xylenes (BTEX).

Anthropogenic greenhouse gas emission inventories typically include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. Fluorinated gases are not expected to be emitted in appreciable quantities by any category considered in this emission inventory and were therefore not included in this analysis.

1.2.2 Temporal

The calculators estimate annual emissions associated with oil and gas exploration. Per the West-CARMMS scope of work, base year emissions are estimated for 2011 with annual emission forecasts to 2021.

2.0 CALCULATOR DEVELOPMENT

2.1 Calculator Inputs

The emission calculator for each well type allows for specification of the following inputs.

- Base year oil and gas activity (gas production, oil production, spud counts, active well counts)
- Well decline estimates
- Level of control by source category
- Gas composition
- Equipment configurations (e.g. drill rigs, fracing rigs)
- Gas venting activity (e.g. completions, blowdowns)

The inputs are implemented to estimate by source category emissions as described below. Appendices A, B, C, and D show the by source category inputs for each well type.

The midstream emission calculator includes estimates of base year 2011 gas plant and compressor station emissions taken from CDPHE APEN data. Base year midstream emissions are projected to future years based upon the gas production in each planning area. Appendix C5 shows base year 2011 midstream emissions by field office and facility as reported in APENS data.

2.2 Emission Calculations

Emission calculations for all emission-generating activities were developed based on typical emission inventory methodology. Methods used to estimate emissions from each source category are explained in Section 2.2.1. For each source category, emissions for the base year were estimated. Emissions were then forecasted to future years, accounting for activity growth and for applicable sources emissions controls.

The methodologies described here are used consistently in all four calculators by well type; however the input data of each calculator was selected to best reflect the operational characteristics of each well type (oil, gas, CBNG, and shale gas) and thus obtained from literature sources including the following Air Quality Technical Support Documents (AQTSD) from Colorado field office planning areas and BLM emission calculators listed below; shale gas calculator inputs were taken from a recent shale gas project (Bull Mountain, Zapert, 2013) in the Uncompahgre field office:

- White River AQTSD (URS, 2012a)
- Colorado River Valley AQTSD (URS, 2012b)
- Grand Junction AQTSD (ENVIRON, 2012a)
- Uncompahgre AQTSD (ENVIRON, 2012b)
- BLM Crude Oil Well Gas Emission Calculator (BLM, 2013a)
- BLM Coalbed Natural Gas Well Emission Calculator (BLM, 2013b)

Emissions are generated in three main phases of oil and gas systems:

- Emissions from Well Construction and Development
- Emissions from the Production Phase (occurring at-or-nearby the well pad)
- Emissions from Midstream Sources (Central Gas Compression and Processing)

The methodologies implemented to estimate base year and future year emissions from oil and gas sources are explained in this section.

2.2.1 Emissions from Well pad Construction and Development

Emissions from Well pad Construction and Development include those generated by equipment, vehicles and activities related to well pad construction, access roads construction, pipeline construction, wellbore drilling and well completions. Table 2-1 includes the emission sources identified for the well pad construction and development phase. Pollutant emissions are initially estimated on a per surrogate basis and later scaled with the projected surrogate estimate to obtain area-wide annual emissions from each source.

Table 2-1. Construction source categories and scaling surrogates.

Equipment Source Category	Emissions units per event	Scaling Surrogate
Well Pad, Access Road, and Pipeline Construction Equipment	tons/new pad	New pads per year
Well Pad, Access Road and Pipeline Construction Traffic	tons/new pad	New pads per year
Drilling Equipment and Completion Equipment	tons/spud	Spuds per year
Fracing Equipment	tons/spud	Spuds per year
Refracing Equipment	tons/well	Active wells per year
Drilling and Well Completion Traffic	tons/spud	Spuds per year
Rig Hauling and Rig Moving Traffic	tons/pad	New pads per year
Well Pad, Access Road and Pipeline Construction Wind Erosion	tons/new pad	New pads per year
Well Completion Venting	tons/spud	Spuds per year

2.2.1.1 <u>Well Pad, Access Road, and Pipeline Construction Equipment</u>

This category refers to emissions associated with off-road engines used during construction of well pads, access roads and pipelines and is also inclusive of well pad reclamation activity. Detailed data for each engine type such as horsepower rating, hours of operation, fuel type, engine technology and load factors were derived from the literature. The EPA NONROAD2008a model (USEPA, 2009b) was used to compile emission factors for each equipment type. The N_2O emissions factor was obtained from the 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17 (API, 2009). Engines were classified in three types as activity data and emissions factors vary by utility: well pad construction equipment, access road construction equipment and pipeline construction equipment.

Emissions on a per event (new well pads) basis for an engine type for which data was provided were estimated according to Equation 1:

$$E_{engine\ k,i} = \frac{EF_i \times HP \times LF \times t_{event} \times n}{907{,}185} \qquad \text{Equation (1)}$$

where:

E_{engine} are emissions of pollutant *i* from an engine type k [ton/pad]
EF_i is the emissions factor of pollutant *i* [g/hp-hr]
HP is the horsepower of the engine k [hp]
LF is the load factor of the engine k
t_{event} is the number of hours the engine is used [hr/pad]
907,185 is the mass unit conversion [g/ton]
n is the number of type-k engines

2.2.1.1.1 *Area-Wide Annual Emissions from Source Category*

Annual emissions from well pad construction equipment by pollutant were estimated from the sum of engine emissions from each of the construction engine types ($E_{engineTOTAL,i} = \sum E_{engine\ k,i}$) according to Equation 2:

$$E_{well\ pad\ equip,\ i} = E_{engineTOTAL,i} \times S_{well\ pad} \qquad \text{Equation (2)}$$

where:

$E_{well\ pad\ equip}$ are annual emissions of pollutant i from well pad construction and development equipment [ton/yr]
$E_{engineTOTAL,i}$ is sum of all engine emissions per event [ton/pad]
$S_{well\ pad}$ is the scaling surrogate for well pad construction [new pads/yr]

2.2.1.2 Well Pad, Access Road and Pipeline Construction Traffic

This category refers to the exhaust emissions from light-duty and heavy-duty vehicle traffic during well pad, access road and pipeline construction. Emission factors were developed using the MOVES2010a model (USEPA, 2010). For each field office, by project year representative county emissions factors were developed. The emission factors were prepared for two vehicle classes, heavy duty trucks (source type combination short-haul truck) and pick-up trucks (source type light commercial truck). MOVES2010a emissions factors were modeled to include exhaust running, idle and start, brake wear, tire wear, and evaporative processes. The N_2O emission factor was obtained from 2012 Climate Registry Default Emission Factors (TCR, 2012).

The representative county for each field office and annual average per mile emission factors by county, year and vehicle type are summarized in Appendix C-6.

Emissions from two distinct fleet types were estimated in this source category dependent on the vehicle destination/use: (1) well pad and access road construction vehicles and (2) pipeline construction vehicles. Annual vehicle miles traveled (VMT) to well site were available for each vehicle class (light duty and heavy duty) within each fleet type (well pad and access road, and pipeline construction), thus exhaust emissions for each of four vehicle groups were calculated using the MOVES2010a emission factors on a grams per mile basis, as shown in Equation 3.

$$E_{traffic,\ i} = \frac{EF_i \times N_{trips} \times D}{907185} \qquad \text{Equation (3)}$$

where:

$E_{traffic,\ i}$ is traffic exhaust emissions for pollutant i per well pad [ton/pad]
EF_i is the average emission factor of pollutant i [g/mile]
N_{trips} is the annual number of round trips per activity [trips/pad]
D is the round trip distance [miles/trip]
907185 is the mass conversion [g/ton]

2.2.1.2.1 *Area-Wide Annual Emissions from Source Category*

Annual emissions for well pad, pipeline and access road construction traffic by pollutant were propagated with the appropriate scaling surrogate according to Equation 4:

$$E_{well\ pad\ traffic,\ i} = E_{traffic,\ i} \times S_{well\ pad} \qquad \text{Equation (4)}$$

where:

$E_{well\ pad\ traffic,\ i}$ is the annual exhaust emissions of pollutant i from well pad, pipeline and access road construction traffic [ton/yr]
$E_{traffic,\ i}$ are the emissions of pollutant i per new well pad [ton/wellpad]
$S_{well\ pad}$ is the scaling surrogate for well pad and access road construction traffic [new pads/yr]

2.2.1.3 Drilling, Completion and Hydraulic Fracturing Equipment

This section refers to emissions associated with off-road engines used during drilling and completion activities. Detailed data for each engine type per source category such as horsepower rating, hours of operation, fuel type, engine technology and load factors was derived from the literature. Emissions for four distinct engine groups were estimated: (1) drilling equipment, (2) completion equipment, (3) fracing equipment, and (4) refracing equipment. Emissions were estimated separately by engine type as inputs and surrogates (see Table 2-1) varied by type; however the same methodology delineated by Equations 5 and 6 was used in all calculations.

For drilling, completion and hydraulic fracturing equipment, the EPA Tier 2 Federal Diesel Engine Standard emission rates were applied for NO_X, VOC, CO, PM_{10} and $PM_{2.5}$ emissions. The

N_2O emissions factor was obtained from the 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17 (API, 2009). Emissions on a per event (spuds or active wells) basis for an engine type were estimated according to Equation 5:

$$E_{engine\ k,i} = \frac{EF_i \times HP \times LF \times t_{event} \times n}{907{,}185} \qquad \text{Equation (5)}$$

where:

E_{engine} are exhaust emissions of pollutant *i* from an engine type k [ton/event]
EF_i is the emissions factor of pollutant *i* [g/hp-hr]
HP is the horsepower of the engine k [hp]
LF is the load factor of the engine k
t_{event} is the number of hours engine k is used [hr/event]
907,185 is the mass unit conversion [g/ton]
n is the number of type-k engines

2.2.1.3.1 *Area-Wide Annual Emissions from Source Category*

Annual equipment emissions by pollutant were estimated separately for each of the four engine groups and scaled with the appropriate scaling surrogate according to Equation 6:

$$E_{D\&C\ equipment,\ i} = E_{engineTOTAL,i} \times S_{event} \qquad \text{Equation (6)}$$

where:

$E_{D\&C\ equipment,i}$ is annual emissions of pollutant i from completion/drilling equipment [ton/yr]
$E_{engineTOTAL,i}$ is sum of all engine emissions per event [ton/event]
S_{event} is the scaling surrogate for completion/drilling operations [event/yr] according to Table 2-1.

2.2.1.4 Drilling and Well Completion Traffic

This section refers to on-road emissions from light-duty and heavy-duty vehicle traffic during drilling and completion operations. Methodology to estimate traffic emissions from these source categories was similar to that of source category *Well Pad, Access Road and Pipeline Construction Traffic*. However, emissions for *Drilling Traffic* and *Completion Traffic* were calculated separately since activity inputs and surrogates varied by source category. Input data to estimate the annual vehicle miles traveled (VMT) per activity was derived from the literature for each vehicle class (light duty and heavy duty) within each fleet. Fleets were defined by the vehicle destination or utility, which vary by the type of oil and gas development (conventional and CBNG versus shale). These are shown in Table 2-2 below. Annual average emission factors from EPA's MOVES2010a model as described in Section 2.2.1.2 were applied.

Table 2-2. Vehicle fleets used during drilling and completion.

Vehicle Use/Destination	Vehicle Class		Fleet group ID
	Type	Class	
Drilling Traffic	Semi Trucks	Heavy Duty Truck	1
	Pickup Trucks	Light Duty Truck	2
Rig Move Drilling Traffic	Semi Trucks	Heavy Duty Truck	3
Rig Hauling	Semi Trucks	Heavy Duty Truck	4
Well Completion & Testing	Semi Trucks	Heavy Duty Truck	5
	Pickup Trucks	Light Duty Truck	6

Exhaust emissions for each of the fleet groups were calculated using the appropriate MOVES2010a emission factors on a grams per mile basis, as shown in Equation 7:

$$E_{traffic,\ i} = \frac{EF_i \times N_{trips} \times D}{907185} \qquad \text{Equation (7)}$$

where:

- $E_{traffic,\ i}$ is the traffic emissions for pollutant i per spud [tons/spud]
- EF_i is the average emission factor of pollutant i [g/mile]
- N_{trips} is the annual number of round trips per activity [trips/spud]
- *D* is the round trip distance [miles/trip]
- *907185* is the mass unit conversion [g/ton]

Given that emissions from the vehicle fleets are based on the same surrogate (spuds), total emissions from drilling and completion traffic will be the sum of emissions per spud from each fleet (calculated with Equation 7), as shown in Equation 8:

$$E_{traffic,D\&C,\ i} = \sum_{fleet=1}^{7} \left(E_{traffic,\ i}\right)_{fleet} \qquad \text{Equation (8)}$$

where

- $E_{traffic,D\&C,\ i}$ is the total drilling and completions emissions of pollutant i per spud [ton/spud]
- $E_{traffic,\ i}$ is the traffic emissions for pollutant i per spud for a vehicle fleet [tons/spud]

2.2.1.4.1 Area-Wide Annual Emissions from Source Category

Annual emissions for drilling/completion traffic by pollutant were propagated with the appropriate scaling surrogate (spuds per year) according to Equation 9:

$$E_{traffic,\ i} = E_{traffic,D\&C,\ i} \times S_{spud} \qquad \text{Equation (9)}$$

where:

- $E_{category\ traffic,\ i}$ are annual emissions of pollutant i from drilling/completion traffic [ton/yr]
- $E_{traffic,D\&C,\ i}$ is the total drilling and completions emissions of pollutant i per spud [ton/spud]

S_{spud} is the scaling surrogate for drilling/completion traffic [spuds/yr]

2.2.1.5 Construction Equipment Fugitive Dust

Fugitive dust emissions from disturbed land by well pad construction and reclamation equipment were estimated based on AP-42 Chapter 13 Section 13.2.3 guidance for estimating emissions from Heavy Construction Operations (USEPA, 1995). A construction fugitive dust emission factor for total suspended particles (TSP) is available in the AP-42 guidance (1.2 tons-TSP/acre/month of activity).

Total suspended particle emissions from wellpad construction equipment on a per wellpad basis are estimated based on Equation 10:

$$E_{equip.dust,TSP} = EF \times A \times t \times \frac{(1-C)}{30} \qquad \text{Equation (10)}$$

where:

$E_{equip,dust,TSP}$ is the TSP emissions from construction equipment fugitive dust [tons/wellpad]
A is the average number of acres disturbed per wellpad [acres/wellpad]
t is the number of construction days per wellpad [days]
C is the control efficiency
30 is the conversion factor for days/month

Conversion factors for TSP to particulate matter PM_{10} (EPA, 2006b) and from PM_{10} to $PM_{2.5}$ (Midwest Research Institute, 2006) were used to estimate other fugitive dust pollutant emissions (PM_{10} and $PM_{2.5}$). A control efficiency of 50% was assumed for well pad construction watering control.

2.2.1.5.1 Area-Wide Annual Emissions from Source Category

Annual emissions for construction equipment fugitive dust, by pollutant i, were propagated with the appropriate scaling surrogate (wellpads per year) according to Equation 11:

$$E_{equip.dust,i_{TOTAL}} = E_{equip.dust,i} \times S_{new\ pads} \qquad \text{Equation (11)}$$

where:

$E_{equip,dust,i_{TOTAL}}$ is the annual dust emissions of pollutant i from construction equipment [ton/yr]
$E_{equip.dust,i}$ is the fugitive dust emissions of pollutant i from construction equipment per pad [tons/wellpad]
$S_{new\ pads}$ is the scaling surrogate for construction equipment fugitive dust [new pads/yr]

2.2.1.6 Fugitive Dust Emissions from Construction, Drilling and Completion Support Vehicles

Fugitive dust emissions from vehicle travel on unpaved roads were estimated based on the AP-42 technical guidance in Section 13.2.2.1 Unpaved Roads (USEPA, 2006a). Road dust emission factors for vehicles traveling on unpaved surfaces at industrial sites can be estimated with Equation 12.

$$EF_i = k\left(\frac{s}{12}\right)^a\left(\frac{W}{3}\right)^b \qquad \text{Equation (12)}$$

where:

EF is the size-specific particulate emissions factor for pollutant i (lb/mile)
s is the surface material silt content (%)
W is the mean vehicle weight (tons)
k, a, b are empirical constants according to Table 2-3.

Table 2-3. Empirical constants by pollutant to estimate road dust emissions factor.

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

Because the emissions factor is a function of vehicle weight, individual emissions factor for heavy duty vehicles and light duty vehicles were derived with Equation 12. To account for natural mitigation of road dust emissions due to annual precipitation and from watering control, Equation 13 was applied:

$$EF_{mitigated} = EF_i \times \frac{365-P}{365} \times \frac{100-CE}{100} \qquad \text{Equation (13)}$$

where:

$EF_{mitigated}$ is the annual average emission factor for uncontrolled conditions including natural mitigation [lb/mile]
EF_i is the size-specific emission factor [lb/mile]
P is number of precipitation days (>0.01" rainfall) at the site
CE is the control efficiency for watering in unpaved roads; CE =50%

Emissions were estimated for all types of vehicles involved in construction, drilling and completion activities. The vehicle groups were classified according to their vehicle class and utility, and literature data was collected to estimate annual vehicle miles traveled per activity (or event), which varied by vehicle groups and by the type of oil and gas development (conventional oil, conventional gas, CBNG, and shale). The vehicle fleets used in each type of development are shown in Table 2-4.

Table 2-4. Vehicles groups related to fugitive road dust emissions in well construction and development.

Vehicle group ID	Utility/destination	Vehicle Class	Event (surrogate)
1	Well Pad Access Road Construction	Heavy Duty Truck	New pads
2		Light Duty Truck	
3	Pipeline Construction	Heavy Duty Truck	
4		Light Duty Truck	

Vehicle group ID	Utility/destination	Vehicle Class	Event (surrogate)
5	Drilling Traffic	Heavy Duty Truck	Spuds
6		Light Duty Truck	
7	Rig Move Drilling Traffic	Heavy Duty Truck	New pads
8		Light Duty Truck	
9	Rig Hauling	Heavy Duty Truck	
10	Well Completion & Testing	Heavy Duty Truck	Spuds
11		Light Duty Truck	
12	Fuel Haul Truck	Heavy Duty Truck	Spuds

Fugitive dust road emissions were calculated using the mitigated emissions factor ($EF_{mitigated}$) from Equation 13, along with the vehicle miles traveled for each vehicle group as shown in Equation 14.

$$E_{traffic,\ i} = \frac{EF_{mitigated} \times N_{trips} \times D}{2000} \qquad \text{Equation (14)}$$

where:

$E_{traffic,\ i}$ is the traffic fugitive dust emissions for pollutant i per event [ton/event]

$EF_{mitigated}$ is the average emission factor of pollutant i for fugitive dust emissions [lb/mile]

N_{trips} is the annual number of round trips per activity [trips/event]
D is the round trip distance [miles/trip]
2000 is the mass conversion [lb/ton]

2.2.1.6.1 Area-Wide Annual Emissions from Source Category

Annual emissions for road fugitive dust from construction/drilling/completion traffic were propagated with the appropriate scaling surrogate according to Equation 15:

$$E_{dust,traffic,\ i} = E_{traffic,\ i} \times S_{event} \qquad \text{Equation (15)}$$

where:

$E_{dust,traffic,\ i}$ are annual emissions of pollutant i for road fugitive dust from construction/drilling/completion traffic [ton/yr]
$E_{traffic,\ i}$ are the emissions of pollutant i per event (spuds or new pads) [ton/event]
S_{event} is the scaling surrogate for the vehicle group [event/yr]

2.2.1.7 Construction Wind Erosion

Wind erosion dust emissions associated with well pad construction, and road, pipeline construction operations, and well pad reclamation activity were estimated based on AP-42 guidance for the estimation of emissions from industrial wind erosion (USEPA, 2006b). Wind erosion emissions per well pad were estimated based on Equation 16:

$$E_{dust,i} = \frac{P \times A \times r}{907{,}185}$$ Equation (16)

where:

$E_{dust,i}$ are dust emissions for pollutant i from construction wind erosion [ton/pad]
P is the erosion potential [g/m^2]
A is the well pad construction area [m^2/pad]
r is the particle size multiplier for PM_{10} or $PM_{2.5}$
907,185 is a mass unit conversion [g/ton]

The erosions potential is a function of the wind friction velocity, as shown in equation 17 and 18:

$$P = 58 \times (u^* - u_t)^2 + 25(u^* - u_t)$$ Equation (17)

where:

u^* is the friction velocity (m/s)
u_t is the threshold friction velocity (m/s)

$$P = 0 \qquad for \qquad (u^* \leq u_t)$$ Equation (18)

Friction velocity estimates (u*) were made by multiplying the average annual fastest wind speed by 0.053 per AP-42 guidance (USEPA, 2006b). Particle size multipliers of 0.5 and 0.075 were assumed for PM_{10} and $PM_{2.5}$ respectively per AP-42 guidance.

2.2.1.7.1 Area-Wide Annual Emissions from Source Category

The annual construction dust wind erosion emissions were scaled by multiplying per well pad emissions by the scaling surrogate (new pads) according to Equation 19:

$$E_{wind\ erosion\ total,\ i} = E_{dust,\ i} \times S_{well\ pad}$$ Equation (19)

where:

$E_{.dust\ erosion\ total,i}$ are the annual emissions of pollutant *i* from construction dust wind erosion [ton/yr]
$E_{dust,i}$ are the dust emissions of pollutant i per well pad [ton/pad]
$S_{well\ pad}$ is the scaling surrogate for construction dust wind erosion [pad/yr]

2.2.1.8 Well Completion Venting

This section describes emissions from well completion venting. The calculation methodology for estimating venting emissions from a single completion event is shown below in Equation 20:

$$E_{completion,i} = \left[\frac{P \times Q_{completion}}{\frac{R}{MW_{gas}} \times T \times 3.5 \times 10^{-5}}\right] \times \frac{f_i}{907185} \times (1 - 0.95F_{flare} - F_{green})$$ Equation (20)

where:

$E_{completion,i}$ is the uncontrolled emissions of pollutant i from a single completion event [ton/event]
P is atmospheric pressure [1 atm]
$Q_{completion}$ is the volume of gas generated per completion [MCF/event]
R is the universal gas constant [0.082 L-atm/mol-K]
MW_{gas} is the molecular weight of the gas [g/mol]
T is the atmospheric temperature [298 K]
f_i is the mass fraction of pollutant i in the completion venting gas
F_{green} is the fraction of completions that were controlled by green completion techniques
F_{flare} is the fraction of completions controlled by flare
0.95 is the control efficiency of the flare

2.2.1.8.1 *Extrapolation to Area-Wide Annual Emissions*

Annual emissions are obtained by scaling-up emissions per event by the number of spuds for a particular year. The total emissions from completion venting are estimated following Equation 21:

$$E_{completion,TOTAL,i} = E_{completion,i} \times S_{spuds} \qquad \text{Equation (21)}$$

where:

$E_{completion,TOTAL}$ are the annual emissions for pollutant i from completion venting [tons/year]
$E_{completion,i}$ are the completion emissions from a single completion event [tons/event], event=spuds
S_{spuds} is the scaling surrogate for completion venting in a particular year [spuds/year]

2.2.1.9 Well Completion Flaring

This section describes the methodology for estimating flaring emissions from completion venting as described in Equation 22. It was assumed the efficiency of the flare was 95 percent.

$$E_{flare,completion} = \left(\frac{EF_i \times Q_{completion} \times F_{flared} \times HV}{1000} \right) \Big/ 2000 \qquad \text{Equation (22)}$$

where:

$E_{flare,completion}$ is the area-wide flaring emissions of pollutant i for well completions [ton/event]
EF_i is the flaring emissions factor for pollutant i [lb/MMBtu]
$Q_{completion}$ is the volume of gas generated per completion [MCF/event]
HV is the local heating value of the gas [BTU/SCF]
F_{flared} is the fraction of well completions with flares

2.2.1.9.1 *Extrapolation to Area-Wide Annual Emissions*

Annual area-wide flaring emissions for well completions are scaled-up using the total number of spuds per year as shown in Equation 23:

$$E_{heater,TOTAL,i} = E_{heater,i} \times S_{TOTAL}$$ Equation (23)

where:

$E_{heater,TOTAL}$ is the annual emissions from well completion flaring for pollutant i [[ton/yr]
E_{heater} is the emissions from well completion flaring for pollutant i per event [ton/event]
S_{TOTAL} is the total number of spuds for a particular year [spuds]. The number of well completions is assumed equal to the spuds count for the year.

2.2.2 Emissions from the Production Phase

Emissions from the Production phase include those generated by equipment, vehicles and activities related to oil and gas production at well sites after a well has been completed. Pollutant emissions are initially estimated on a per event basis and later scaled with the projected number of events per year (scaling surrogate) to obtain Area-wide annual emissions from each source.

2.2.2.1 Well Workovers Equipment

This category refers to emissions associated with off-road engines used during well workovers. Detailed data for a typical workover engine such as horsepower rating, hours of operation, fuel type, engine technology and load factor was derived from the literature. The EPA NONROAD2008a model (EPA, 2009b) was used to compile emission factors for 'other oil field equipment' representative of workover engines. The N_2O emissions factor was obtained from the 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17 (API, 2009).

Emissions on a per well basis for a workover engine were estimated according to Equation 24:

$$E_{engine,\ i} = f \times \frac{EF_i \times HP \times LF \times t \times n}{907{,}185}$$ Equation (24)

where:

E_{engine} are emissions of pollutant *i* from a workover engine [ton/well]
EF_i is the emissions factor of pollutant *i* [g/hp-hr]
HP is the horsepower of the engine [hp]
LF is the load factor of the engine
t is the number of hours of use per day [hr/day]
907,185 is the mass unit conversion [g/ton]
n is the number of operating days per well [days/well]
f is the well workover frequency per year

2.2.2.1.1 Area-Wide Annual Emissions from Source Category

Annual emissions from well workover equipment by pollutant were estimated according to Equation 25:

$$E_{WO-equip,\ i} = E_{engine\ i} \times S_{wells}$$ Equation (25)

where:

$E_{WO\text{-}equip,\,i}$ are annual emissions of pollutant i from workover equipment [ton/yr]
$E_{engine,\ i}$ is emissions of pollutant i from workover equipment per well [ton/well]
$S_{well\ pad}$ is the scaling surrogate for workovers [active wells/yr]

2.2.2.2 Production Traffic (Well workovers, Road Maintenance, Well Pad Reclamation and Production)

This section describes the estimation of exhaust emissions from light-duty and heavy-duty vehicle traffic used for Well Workovers, Maintenance, Well Pad Reclamation and Production. This excludes traffic from tank loading and compressor stations maintenance. Vehicle classes within the four source categories are shown in Table 2-5. Emissions from these vehicle fleets were first estimated on a per well basis and later on scaled to annual Area-wide emissions with the scaling surrogate, active wells per year.

Table 2-5. Vehicle fleets comprising production traffic.

Vehicle fleets ID	Utility (source category)	Vehicle Class	Event (surrogate)
1	Well Workover Commuting Vehicles	Light Duty Truck	Active Wells
2		Heavy Duty Truck	
3	Road Maintenance	Light Duty Truck	
4	Road and Well Pad Reclamation	Light Duty Truck	

Emission factors were developed using the MOVES2010a model as described in Section 2.2.1.2 above.

Exhaust emissions for the five vehicle groups were estimated as shown in Equation 26.

$$E_{fleet,traffic,\ i} = \frac{EF_i \times N_{trips} \times D}{907185} \qquad \text{Equation (26)}$$

where:

$E_{fleet,traffic,\ i}$ is the fleet's traffic emissions for pollutant i per well [tons/well]
EF_i is the average emission factor of pollutant i [g/mile]
N_{trips} is the annual number of round trips per activity [trips/well]
D is the round trip distance [miles/trip]
907185 is the mass unit conversion [g/ton]

2.2.2.2.1 Area-Wide Annual Emissions from Source Category

Annual emissions for each category (fleet) of production traffic were propagated with the appropriate scaling surrogate (active wells per year) according to Equation 27:

$$E_{fleet,TOTAL,i} = E_{fleet,traffic,,\ i} \times S_{wells} \qquad \text{Equation (27)}$$

where:

$E_{fleet,TOTAL,\,i}$ are annual emissions of pollutant i from a production fleet [ton/yr]
$E_{fleet,traffic,\,i}$ is the emissions of pollutant i per well for a production traffic fleet [ton/well]
S_{wells} is the scaling surrogate for the source category [active wells/yr]

2.2.2.3 Fugitive Dust Emissions from Production Traffic (Well Workovers, Road Maintenance, Well Pad Reclamation and Other Production)

Fugitive dust emissions from vehicle travel on unpaved roads were estimated based on the AP-42 technical guidance Section 13.2.2.1 Unpaved Roads (EPA, 2006a). Road dust emission factors for vehicles traveling on unpaved surfaces at industrial sites can be estimated with Equation 28.

$$EF_i = k\left(\frac{s}{12}\right)^a \left(\frac{W}{3}\right)^b \qquad \text{Equation (28)}$$

Where:

EF is the size-specific particulate emissions factor for pollutant i (lb/mile)
s is the surface material silt content (%)
W is the mean vehicle weight (tons)
k, a, b are empirical constants according to Table 2-6.

Table 2-6. Empirical constants by pollutant to estimate road dust emissions factor.

Parameter	PM_{10}	$PM_{2.5}$
k	1.5	0.15
a	0.9	0.9
b	0.45	0.45

Because the emissions factor is a function of vehicle weight, individual emissions factor for heavy duty vehicles and light duty vehicles were calculated with Equation 28. To account for natural mitigation of road dust emissions due to annual precipitation and from watering control, Equation 29 was applied:

$$EF_{mitigated} = EF_i \times \frac{365-P}{365} \times \frac{100-CE}{100} \qquad \text{Equation (29)}$$

Where:

$EF_{mitigated}$ is the annual average emission factor for uncontrolled conditions including natural mitigation [lb/mile]
EF_i is the size-specific emission factor [lb/mile]
P is number of precipitation days (>0.01" rainfall) at the site
CE is the control efficiency for watering in unpaved roads

Vehicle fleets comprising production traffic are shown in Table 2-5. Fugitive dust emissions from these vehicle fleets were first estimated on a per well basis and later scaled to annual Area-wide emissions with the scaling surrogate, active wells per year.

Fugitive dust road emissions per well were calculated using the mitigated emissions factor ($EF_{mitigated}$) from Equation 29, along with the vehicle miles traveled for each vehicle group. This is shown in Equation 30

$$E_{fleet,traffic,\ i} = \frac{EF_{mitigated} \times N_{trips} \times D}{2000} \qquad \text{Equation (30)}$$

where:

$E_{fleet,traffic,\ i}$ is the traffic fugitive dust emissions for pollutant i per well [ton/well]
$EF_{mitigated}$ is the average emission factor of pollutant i for fugitive dust emissions [lb/mile]
N_{trips} is the annual number of round trips per activity [trips/well]
D is the round trip distance [miles/trip]
2000 is the mass conversion [lb/ton]

2.2.2.3.1 *Area-Wide Annual Emissions from Source Category*

Annual fugitive dust emissions for each category (fleet) of Production traffic were propagated with the appropriate scaling surrogate (active wells per year) according to Equation 31:

$$E_{fleet,TOTAL,i} = E_{fleet,traffic,,\ i} \times S_{wells} \qquad \text{Equation (31)}$$

where:

$E_{fleet,TOTAL,\ i}$ are annual fugitive dust emissions of pollutant i from a production fleet [ton/yr]
$E_{fleet,traffic,\ i}$ is the fugitive dust emissions of pollutant i per well for a production traffic fleet [ton/well]
S_{wells} is the scaling surrogate for the source category [active wells/yr]

2.2.2.4 Blowdown venting

This section refers to the estimation of emissions from venting during well blowdowns. The calculation methodology for estimating emissions from a single blowdown event is shown below in Equation 32:

$$E_{blowdown,i} = \left(\frac{P \times (V_{vented})}{\left(R/MW_{gas} \right) \times T \times 3.5 \times 10^{-5}} \right) \times \frac{f_i}{907185}$$

Equation (32)

where:

$E_{blowdown,i}$ is the emissions of pollutant *i* from a single blowdown event [ton/event]
P is atmospheric pressure [1 atm]

V_{vented} is the volume of vented gas per blowdown (uncontrolled) [MCF/event]
R is the universal gas constant [0.082 L-atm/mol-K]
MW_{gas} is the molecular weight of the gas [g/mol]
T is the atmospheric temperature [298 K]
f_i is the mass fraction of pollutant i in the vented gas

2.2.2.4.1 Area-Wide Annual Emissions from Source Category

The total emissions from all annual blowdowns events occurring are estimated with Equation 33:

$$E_{blowdown,TOTAL} = E_{blowdown,i} \times N_{blowdown} \times S_{wells} \qquad \text{Equation (33)}$$

where:

$E_{blowdown,TOTAL}$ are the total annual emissions from blowdowns [tons/yr]
$E_{blowdown,i}$ are the blowdown emissions from a single blowdown event [tons/event]
$N_{blowdown}$ is the frequency of blowdowns per well per year [events/yr-well]
S_{wells} is the total number of active wells for a particular year [wells]

2.2.2.5 <u>Well Recompletion Venting</u>

This section describes emissions from well recompletion venting. The calculation methodology for estimating venting emissions from a single recompletion event is shown below in Equation 34:

$$E_{recompletion,i} = \left[\frac{P \times Q_{recompletion}}{\frac{R}{MW_{gas}} \times T \times 3.5 \times 10^{-5}}\right] \times \frac{f_i}{907185} \qquad \text{Equation (34)}$$

where:

$E_{recompletion,i}$ is the uncontrolled emissions of pollutant i from a single recompletion event [ton/event]
P is atmospheric pressure [1 atm]
$Q_{recompletion}$ is the volume of gas generated per recompletion [MCF/event]
R is the universal gas constant [0.082 L-atm/mol-K]
MW_{gas} is the molecular weight of the gas [g/mol]
T is the atmospheric temperature [298 K]
f_i is the mass fraction of pollutant i in the recompletion venting gas

2.2.2.5.1 Extrapolation to Annual Area-Wide Emissions

Annual emissions are obtained by scaling-up emissions per event with the total number of recompletion events in a particular year. The total emissions from recompletion venting are estimated following Equation 35:

$$E_{recompletion,TOTAL,i} = E_{recompletion,i} \times f \times S_{well\ count} \qquad \text{Equation (35)}$$

where:

$E_{completion,TOTAL}$ are the annual emissions for pollutant i from recompletion venting [tons/year]

$E_{completion,i}$ are the venting emissions from a single recompletion event [tons/event]

f is the frequency of recompletion events per well per year [events/yr-well]

$S_{well\ count}$ is the scaling surrogate for recompletion venting in a particular year [active wells]

2.2.2.6 Wellhead Fugitives

This source category refers to fugitive emissions or *leaks* from well equipment such as pump seals, valves, connectors, flanges, etc. Fugitive emissions were estimated for three main streams identified: gas service stream, liquids service stream and high oil stream. VOC, CO_2 and CH_4 emissions per stream were estimated using device-specific TOC emission factors for oil and gas production (USEPA, 1995b) and equipment counts. Input data was obtained from the literature on total device counts per well by type of equipment and by the type of service to which the equipment applies – gas, liquids and high oil.

Fugitive VOC emissions for an individual device in a given stream (gas, liquids, and high oil) were estimated according to Equation 36:

$$E_{fugitiveVOC,k} = EF_{TOC} \times N \times t_{annual} \times Y \qquad \text{Equation (36)}$$

where:

$E_{fugitive\ VOC,k}$ is the fugitive VOC emissions for a given device k [ton/yr-well]

EF_{TOC} is the emission factor of TOC [kg/hr/device]

N is the total number of devices type-k for a given stream per well [devices/well]

Y is the ratio of VOC to TOC in the vented gas

Total VOC fugitive emissions for a given stream are equal to the sum of all fugitive emissions from devices in that stream per Equation 37:

$$E_{fugitiveVOC,stream} = \sum E_{fugitiveVOC,\ k} \qquad \text{Equation (37)}$$

where:

$E_{fugitive\ VOC,stream}$ is the total fugitive VOC emissions in a given stream per well [ton/yr-well]

CO_2 and CH_4 fugitive emissions per stream were estimated according to Equations 38 and 39:

$$E_{fugitiveCH4,stream} = E_{fugitiveVOC,stream} \times \frac{weight\ fraction_{CH4}}{weight\ fraction_{VOC}} \qquad \text{Equation (38)}$$

$$E_{fugitiveCO2,stream} = E_{fugitiveVOC,stream} \times \frac{weight\ fraction_{CO2}}{weight\ fraction_{VOC}} \qquad \text{Equation (39)}$$

where:

$E_{fugitive\ CO2,stream}$ is the total fugitive CO_2 emissions in a given stream per well [ton/yr-well]

$E_{fugitive\ CH4,stream}$ is the total fugitive CH_4 emissions in a given stream per well [ton/yr-well]
Weight fractions per pollutant were based on gas compositions. For gas and well streams, sales gas composition was used. For condensate stream, fugitive-post flash compositions were used.

2.2.2.6.1 Area-Wide Annual Emissions from Source Category

Fugitive emissions were propagated annually according to Equation 40 using the scaling surrogate, active well counts:

$$E_{fugitive,\ i} = E_{fugitive\ i,stream} \times S_{well\ count} \qquad \text{Equation (40)}$$

where:

$E_{fugitive,\ i}$ are the annual fugitive emissions for pollutant i in a given stream [ton/yr]
$E_{fugitive\ I,\ stream}$ are fugitive emissions of pollutant i in a stream per well [ton/yr-well]
$S_{well\ count}$ is the number of active wells for a particular year [active wells]

2.2.2.7 Pneumatic Devices

Emissions for pneumatic devices will vary by the bleed rate of the device. The methodology for estimating the emissions from a mix of pneumatic devices i (liquid level controllers, pressure controllers, etc.) for a single typical well is shown in Equation 41:

$$E_{pneumatic,j} = \frac{f_j}{907185}\left(\sum_i \dot{V}_i \times N_i \times t_{annual}\right) \times \frac{P}{\left(\left(R/MW_{gas}\right) \times T \times 3.5 \times 10^{-5}\right)} \qquad \text{Equation (41)}$$

where:

$E_{pneumatic,j}$ is the total emissions of pollutant *j* from all pneumatic devices for a typical well [ton/year/well]
$\dot{V}_i$ is the volumetric bleed rate from device *i* [MCF/hr/device]
N_i is the average number of devices *i* found in a well [devices/well]
t_{annual} is the number of hours per year that devices were operating [8760 hr/yr]
P is the atmospheric pressure [1 atm]
R is the universal gas constant [0.082 L-atm/mol-K]
MW_{gas} is the molecular weight of the gas [g/mol]
T is the atmospheric temperature [298 K]
f_j is the mass fraction of pollutant *j* in the vented gas

2.2.2.7.1 Extrapolation to Area-Wide Annual Emissions

Annual emissions from pneumatic devices were estimated according to Equation 42:

$$E_{pneumatic,TOTAL,j} = E_{pneumatic,j} \times N_{well} \qquad \text{Equation (42)}$$

where:

$E_{pneumatic,TOTAL,j}$ is the total annual emissions of pollutant j from pneumatic devices [ton/yr]
$E_{pneumatic,j}$ is the pneumatic device emissions of pollutant j for a single typical well [ton/yr/well]
N_{well} is the total number of active wells in the basin [wells]

2.2.2.8 Pneumatic Pumps

To estimate emissions from pneumatic pumps, literature data indicating the average rate of gas consumption per gallon of chemical injected and the annual chemical throughput for a single pump was applied. Emissions per well from pneumatic pumps were estimated as shown in Equation 43:

$$E_{pump,i} = \frac{N_{CIP} \times V_{vented,gas} \times t_{pump} \times MW_i \times R \times Y_i}{2000} \qquad \text{Equation (43)}$$

where:

$E_{pump,\,i}$ is the pneumatic pump emissions for pollutant i per well [ton/yr-well]
$V_{vented,TOTAL}$ is the average gas venting rate per pump [SCF/pump/hr]
N_{CIP} is the number of gas-actuated pneumatic pumps per well [pump/well]
t_{pump} is the annual hours of operation of a pump [hrs/yr]
MW_i is the molecular weight of pollutant i [lb/lb-mol]
R is the universal gas constant [lb-mol/391.9scf]
Y_i is the molar fraction of pollutant i in pneumatic pump vented gas
2000 is the mass unit conversion [lb/ton]

2.2.2.8.1 *Area-Wide Annual Emissions from Source Category*

To estimate area-wide annual emissions from pneumatic pumps the scaling surrogate, active wells, was used according to Equation 44

$$E_{pneumaticpumps,\ i} = E_{pump,\ i} \times S_{well\ count} \qquad \text{Equation (44)}$$

where:

$E_{pneumaticpumps,\,i}$ are the annual emissions for pollutant i from pneumatic pumps [ton/yr]
$E_{pump,\,i}$ is the emissions from all pneumatic pumps per well [ton/yr-well]
$S_{well\ count}$ is the number of active wells for a particular year [wells]

2.2.2.9 Water Injection Pumps

This category refers to exhaust emissions associated with diesel combustion in water injection pump engines. Detailed data for each engine type such as horsepower rating, hours of operation, fuel type, engine technology and load factors was derived from the literature. The EPA NONROAD2008a model (USEPA, 2009b) was used to compile emission factors. The N_2O emissions factor was obtained from the 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17 (API, 2009).

Emissions on a per well basis for a water injection pump were estimated according to Equation 45:

$$E_{engine,i} = \frac{EF_i \times HP \times LF \times t_{event} \times n}{907{,}185} \qquad \text{Equation (45)}$$

where:

E_{engine} are per-well emissions of pollutant *i* from water injection pumps [ton/well]
EF_i is the emissions factor of pollutant *i* [g/hp-hr]
HP is the horsepower of the pump [hp]
LF is the load factor of the pump
t_{event} is the number of hours the engine is used annually [hrs/unit]
907,185 is the mass unit conversion [g/ton]
n is the number of water injection pumps per well [units/well]

2.2.2.9.1 *Area-Wide Annual Emissions from Source Category*

Annual emissions from water injection pumps for pollutant i were estimated according to Equation 46:

$$E_{water\ pumps,\ i} = E_{engine,\ i} \times S_{well} \qquad \text{Equation (46)}$$

where:

$E_{well\ pad\ equip}$ are annual emissions of pollutant i from water injection pumps [ton/yr]
$E_{engine,\ i}$ is engine emissions per well [ton/well]
S_{well} is the scaling surrogate for water injection pumps [active wells/yr]

2.2.2.10 Miscellaneous Engines

This category refers to exhaust emissions associated with miscellaneous engines at well sites. Detailed data for miscellaneous engines such as horsepower rating, hours of operation, fuel type, engine technology and load factors was derived from the literature. The EPA NONROAD2008a model (USEPA, 2009b) was used to compile emission factors. The N_2O emissions factor was obtained from the 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17 (API, 2009).

Emissions on a per well basis for miscellaneous engines were estimated according to Equation 47:

$$E_{engine,i} = \frac{EF_i \times HP \times LF \times t_{event} \times n}{907{,}185} \times f \qquad \text{Equation (47)}$$

where:

E_{engine} are per-well emissions of pollutant *i* from miscellaneous engines [ton/well]
EF_i is the emissions factor of pollutant *i* [g/hp-hr]
HP is the horsepower of the pump [hp]
LF is the load factor of the pump
t_{event} is the number of hours the engine is used [hrs/unit]

f is the fraction of wells served by a miscellaneous engine
907,185 is the mass unit conversion [g/ton]
n is the number of engines per well [units/well]

2.2.2.10.1 Area-Wide Annual Emissions from Source Category

Annual emissions from miscellaneous engines for pollutant i were estimated according to Equation 48:

$$E_{water\ pumps,\ i} = E_{engine,\ i} \times S_{well} \qquad \text{Equation (48)}$$

where:

$E_{well\ pad\ equip}$ are annual emissions of pollutant i from miscellaneous engines [ton/yr]
$E_{engine,\ i}$ is engine emissions per well [ton/well]
S_{well} is the scaling surrogate for miscellaneous engines [active wells/yr]

2.2.2.11 Compressor Station Maintenance Traffic Exhaust

This section describes the estimation of exhaust emissions from light-duty vehicles (pickup trucks) used for compressor maintenance at compressor stations. Emission factors were developed using the MOVES2010a model (USEPA, 2010) as described in Section 2.2.1.2. The total vehicle miles travelled annually from maintenance visits to a single compressor station were obtained from the literature.

Exhaust emissions for this fleet were estimated as shown in Equation 49.

$$E_{fleet,traffic,\ i} = \frac{EF_i \times VMT_{CS}}{907185} \qquad \text{Equation (49)}$$

where:

$E_{fleet,traffic,\ i}$ is the fleet's traffic emissions for pollutant i per well [tons/station]
EF_i is the average emission factor for light duty vehicles of pollutant i [g/mile]
VMT_{CS} is the annual miles travelled for maintenance compressor station [miles/station]
907185 is the mass unit conversion [g/ton]

2.2.2.11.1 Area-Wide Annual Emissions from Source Category

Annual emissions for the compressor maintenance fleet were propagated with the scaling surrogate "total count of active compressor stations" according to Equation 50:

$$E_{fleet,TOTAL,i} = E_{fleet,traffic,,\ i} \times S_{CS} \qquad \text{Equation (50)}$$

where:

$E_{fleet,TOTAL,\ i}$ are annual emissions of pollutant i from compressor station maintenance traffic [ton/yr]
$E_{fleet,traffic,\ i}$ is the emissions of pollutant i per station for the fleet [ton/station]
S_{CS} is the scaling surrogate for the source category [number of active compressor stations per year]

2.2.2.12 Fugitive Dust Emissions from Compressor Station Maintenance Traffic

Road dust emission factors for light duty vehicles traveling on unpaved surfaces to and from compressor stations were estimated with the same methodology as in Section 2.2.1.2.6 using Equations 28 and 29. Fugitive dust road emissions per station (visited) were calculated using the mitigated emissions factor ($EF_{mitigated}$) from Equation 29, along with the annual vehicle miles traveled per compressor station. This is shown in Equation 51.

$$E_{fleet,traffic,\ i} = \frac{EF_{mitigated} \times VMT}{2000} \qquad \text{Equation (51)}$$

where:

$E_{fleet,traffic,\ i}$ is the traffic fugitive dust emissions for pollutant i per station [ton/station]
$EF_{mitigated}$ is the average emission factor of pollutant i for fugitive dust emissions [lb/mile]
VMT is the annual miles travelled for maintenance compressor station [miles/station]
2000 is the mass conversion [lb/ton]

2.2.2.12.1 Area-Wide Annual Emissions from Source Category

Annual fugitive dust emissions for compressor station maintenance traffic were propagated with the "total number of compressor stations" according to Equation 52:

$$E_{fleet,TOTAL,i} = E_{fleet,traffic,,\ i} \times S_{CS} \qquad \text{Equation (52)}$$

where:

$E_{fleet,TOTAL,\ i}$ are annual fugitive dust emissions of pollutant i from compressor station maintenance traffic [ton/yr]
$E_{fleet,traffic,\ i}$ is the emissions of pollutant i per station for the fleet [ton/station]
S_{CS} is the scaling surrogate for the source category [number of active compressor stations per year]

2.2.2.13 Condensate Tanks Flashing

Condensate tank emissions were calculated differently for conventional oil and gas developments and for shale gas developments.

An uncontrolled VOC emissions factor applicable to Garfield, Mesa, Rio Blanco, and Moffat Counties (CDPHE, 2011) was used to estimate emissions for condensate tanks in conventional gas, shale gas and coalbed natural gas developments on a per barrel basis. The published emissions factor was 10 lbs VOC/bbl [0.005 tons/bbl]; for planning areas outside of those counties the emission factor of 11.3 lbs VOC/bbl [0.008 tons/bbl] can be used (CDPHE, 2011). For conventional oil developments, the emissions factor of 1.6 lbs VOC/bbl was used based on BLM (2013). The VOC emissions factor was multiplied by the annual condensate production from each type of well to propagate VOC emissions to the Planning Area level for each year.

Similar to the methodology for conventional oil and gas sources, CO_2 and CH_4 total emissions were then calculated using the weight fraction ratios from local flash gas composition analyses using Equations 53 and 54.

$$E_{tanks,CH4} = E_{tanks,VOC} \times \frac{weight\ fraction_{CH4}}{weight\ fraction_{VOC}}$$ Equation (53)

$$E_{tanks,CO2} = E_{tanks,VOC} \times \frac{weight\ fraction_{CO2}}{weight\ fraction_{VOC}}$$ Equation (54)

where:

$E_{tanks,VOC}$ is the total annual condensate tanks emissions from APENS database [tons/yr]
$E_{tanks,CO2}$ is the total condensate tank CO_2 emissions [tons/yr]
$E_{tanks,CH4}$ is the total condensate CH_4 emissions [tons/yr]
Weight fractions of each pollutant in flash gas

2.2.2.14 Loading Emissions from Condensate or Oil Tanks

This section describes emissions from truck loading of condensate or crude oil from tanks. The loading loss rate is estimated following Equation 55:

$$L = 12.46 \times \left(\frac{S \times V \times M}{T} \right)$$ Equation (55)

where:

L is the loading loss rate [lb/1000gal]
S is the saturation factor taken from AP-42 default values based on operating mode. The operating mode for loading assumed was submerged loading: dedicated normal service.
V is the true vapor pressure of the liquid loaded [psia]
M is the molecular weight of the vapor [lb/lb-mole]
T is the temperature of the bulk liquid [^{o}R], T=540 R

VOC tank loading emissions are then estimated by Equation 56:

$$E_{loading,\ VOC} = L \times Y_{voc} \times \frac{42}{2000}$$ Equation (56)

where:

$E_{loading}$ are the VOC tank loading emissions [ton/bbl]
L is the loading loss rate [lb/1000gal]
Y_{VOC} is the weight fraction of VOC in the vapor in the liquid loaded
42 is a unit conversion [gal/bbl]
2000 is a unit conversion [lbs/ton]

CO_2 and CH_4 emissions are calculated based on Equations 57-58:

$$E_{loading,CH4} = E_{loading,VOC} \times \frac{weight\ fraction_{CH4}}{weight\ fraction_{VOC}}$$ Equation (57)

$$E_{loading,CO2} = E_{loading,VOC} \times \frac{weight\ fraction_{CO2}}{weight\ fraction_{VOC}}$$ Equation (58)

where:

$E_{loading,CO2}$ is the total loading CO_2 emissions per barrel of liquid [ton/bbl]
$E_{loadingCH4}$ is the total loading CH_4 emissions per barrel of liquid [ton/bbl]
Weight fractions of each pollutant in the vapor losses from the liquid loaded

2.2.2.14.1 Area-Wide Annual Emissions from Source Category

Annual emissions per pollutant i from condensate loading were scaled by annual condensate production per Equation 59:

$$E_{tank\ loadout,\ i} = E_{loading,\ i} \times S_{bbl\ condensate}$$ Equation (59)

where:

$E_{tank\ loadout,\ i}$ is the total condensate loading emissions for pollutant i from tank load-out [ton/yr]
$E_{loading,\ i}$ is the condensate loading emissions for pollutant i from per barrel [ton/bbl]
$S_{bbl\ condensate}$ is the total annual of barrels condensate [bbl/yr]

2.2.2.15 Condensate, Crude Oil and Produced Water Hauling Traffic Exhaust

This section describes the estimation of exhaust emissions from heavy-duty vehicles (haul trucks) used for produced condensate hauling from the well site. Emission factors were developed using the MOVES2010a model (EPA, 2010) as described in Section 2.2.1.2. The total round trip distance for each hauling trip was derived from the literature. A hauling volume of per truck of 200 barrels of condensate or crude oil, hence the number of round trips per barrel was estimated (1/200).

Exhaust emissions for condensate and crude oil hauling fleet were estimated as shown in Equation 60a.

$$E_{fleet,traffic,\ i} = \frac{EF_i \times N_{trips} \times D}{907185}$$ Equation (60a)

where:

$E_{fleet,traffic,\ i}$ is the hauling traffic exhaust emissions for pollutant i per barrel [ton/bbl]
EF_i is the average emission factor of pollutant i for heavy duty vehicles [g/mile]
N_{trips} is the annual number of round trips per barrel [trips/bbl]. N=1/200
D is the round trip distance [miles/trip]
907185 is the mass conversion [g/ton]

2.2.2.15.1 Area-Wide Annual Emissions from Condensate or Crude Oil Hauling

Annual emissions for the condensate and crude oil hauling fleet were propagated with the annual condensate or crude oil production according to Equation 61a:

$$E_{fleet,TOTAL,i} = E_{fleet,traffic,,\ i} \times S_{bbl,condensate} \quad \text{Equation (61a)}$$

where:

$E_{fleet,TOTAL,\ i}$ are annual emissions of pollutant i from condensate hauling traffic [ton/yr]
$E_{fleet,traffic,\ i}$ is the emissions of pollutant i per barrel for the hauling fleet [ton/bbl]
$S_{bbl,condensate}$ is the scaling surrogate for the source category [barrels of condensate produced per year]

2.2.2.15.2 Produced water hauling exhaust emissions

Produced water refers to the water produced with the gas once the well has been completed and is under operation. This water is typically hauled from the well site storage tanks with water trucks or sent via pipeline to injection wells. Annual produced water rates will vary by the type of well. It was assumed that the annual rate of water production for conventional oil, conventional gas and shale gas wells was 18,250 bbl/well (URS, 2012a); this value can be updated for a given area based on Colorado Oil and Gas Conservation Commission water production data. It was assumed that produced water truck capacity is 130 bbl and that 50 percent of the water is hauled out.

The annual water production per CBNG well was assumed to be 97,900 bbl/well (BLM, 2012); this value can be updated for a given area based on Colorado Oil and Gas Conservation Commission water production data.

Exhaust emissions for produced water hauling fleet were estimated as shown in Equation 60b:

$$E_{fleet,traffic,\ i} = \frac{EF_i \times N_{trips} \times D}{907185} \quad \text{Equation (60b)}$$

where:

$E_{fleet,traffic,\ i}$ is the produced water hauling exhaust emissions for pollutant i per well [ton/well]
EF_i is the average emission factor of pollutant i for heavy duty vehicles [g/mile]
N_{trips} is the annual number of round trips per well [trips/well]
D is the round trip distance [miles/trip]
907185 is the mass conversion [g/ton]

2.2.2.15.2.1 Area-Wide Annual Emissions from Produced Water Hauling

Annual emissions for the produced water hauling fleet were propagated to the planning area according to Equation 61b:

$$E_{fleet,TOTAL,i} = E_{fleet,traffic,,\ i} \times S_{active\ wells} \quad \text{Equation (61b)}$$

where:

$E_{fleet,TOTAL,\ i}$ are annual emissions of pollutant i from produced water hauling traffic [ton/yr]
$E_{fleet,traffic,\ i}$ is the emissions of pollutant i per well for the hauling fleet [ton/well]
$S_{active\ wells}$ is the scaling surrogate for the source category, active wells per year [wells/yr]

2.2.2.15.3 Fugitive Dust Emissions from Condensate and Produced Water Hauling Traffic

Road dust emission factors for heavy duty vehicles traveling on unpaved surfaces for condensate hauling and produced water hauling were estimated with the same methodology as in Section 2.2.1.2.6 using Equations 28 and 29. Because the number of trips for both of these activities is based on different surrogates - per barrel for condensate hauling and per well for produced water hauling - as shown in Section 2.2.1.2.15, fugitive dust road emissions of each fleet were calculated using the mitigated emissions factor ($EF_{mitigated}$) from Equation 29. This is shown in Equation 62.

$$E_{fleet,traffic,\ i} = \frac{EF_{mitigated} \times D \times N_{trips}}{2000} \qquad \text{Equation (62)}$$

where:

- $E_{fleet,traffic,\ i}$ is the traffic fugitive dust emissions for pollutant i per (1) barrel of condensate [ton/bbl] for condensate hauling or (2) well [ton/well] for produced water hauling
- $EF_{mitigated}$ is the average emission factor of pollutant i for fugitive dust emissions [lb/mile]
- N_{trips} is the annual number of round trips per (1) barrel of condensate hauled [trips/bbl] for condensate hauling or (2) well [trips/well] for produced water hauling
- *D* is the round trip distance per hauling trip [miles/trip]
- *2000* is the mass conversion [lb/ton]

2.2.2.15.3.1 Area-Wide Annual Emissions from Condensate and Produced Water Hauling Traffic

Annual fugitive dust emissions for condensate hauling were propagated with the annual condensate production according to Equation 63:

$$E_{fleet,TOTAL,i} = E_{fleet,traffic,,\ i} \times S_{bbl,condensate\ or\ active\ wells} \qquad \text{Equation (63)}$$

where:

- $E_{fleet,TOTAL,\ i}$ are annual fugitive dust emissions of pollutant i from condensate hauling traffic [ton/yr]
- $E_{fleet,traffic,\ i}$ is the dust emissions of pollutant i per barrel for the hauling fleet [ton/surrogate]
- $S_{bbl,condensate\ or\ active\ wells}$ is the scaling surrogate for the source category: (1) [barrels of condensate produced per year] for condensate hauling or (2) [active wells per year] for produced water hauling

2.2.2.16 <u>Heaters</u>

This section describes the methodology for estimating emissions from heaters and reboilers. Heater emissions are a function of the properties of the local produced gas used as a fuel. Emissions factors for external combustion of natural gas were obtained from AP-42 Section 1.4 Natural Gas Combustion (USEPA, 1995a). Emissions per well from heaters and reboilers can be estimated individually using Equation 64.

$$E_{heater,i} = N_{heaters} \times \frac{EF_i \times Q_{heater} \times t_{annual}}{(HV_{local} \times 2000)}$$ Equation (64)

where:

$E_{heater,i}$ is the per well emissions for pollutant from a given heater [ton/well-yr]
EF_i is the heater emission factor for a given pollutant i [lb/MM SCF]
Q_{heater} is the heater MMBTU/hr rating [$MMBTU_{rated}$/hr]
HV_{local} is the local natural gas heating value [BTU_{local}/SCF]
t_{annual} is the annual hours of operation [hr/yr]
$N_{heaters}$ is the number of heaters per well

2.2.2.16.1 Area-Wide Annual Emissions from heaters

Annual emissions for heaters and reboilers are estimated with Equation 65 using the scaling surrogate active wells.

$$E_{heater,TOTAL,i} = E_{heater,i} \times W_{TOTAL}$$ Equation (65)

where:

$E_{heater,TOTAL}$ is the total emissions of pollutant i for a given heater type in the Project [ton/yr]
E_{heater} is the per well annual emissions from a given heater type for pollutant i [ton/well-yr]
W_{TOTAL} is the total number of wells for a particular year [wells]

2.2.2.17 Dehydrator Emissions

This section describes the methodology to estimate emissions from dehydrator still vents. Uncontrolled emission factors per unit of gas production for emissions of VOC, CH_4 and CO_2 were derived from the literature for the various well types. Total emissions were propagated using the gas production by well type, assuming 100 percent of the gas undergoes well site dehydration. This was done applying Equation 66.

$$E_{dehyTOTAL,i,j} = EF_{dehy,i} \times S_{gas\ production,j}$$ Equation (66)

where:

$E_{dehy,TOTAL,,i,j}$ are the total area-wide emissions from dehydrators still vents for pollutant i in year j [tons/yr]
$EF_{dehy,i}$ is the dehydrator still vent emissions rate [tons/MCF]
$S_{gas\ production}$ is the annual gas production in year j [MCF/yr]

2.2.3 Midstream sources

Midstream sources include gathering and treating emissions associated with facilities such as compressor stations and gas plants. Midstream emissions are taken from the 2011 APEN (Air Pollutant Emission Notice) emissions database provided by CDPHE (CDPHE, 2013). CDPHE provided APEN emissions for all oil and gas related emission sources covered by the following SCC and SIC codes:

- All of the SCCs 202002*, 310*, 404003* (where * indicates all sub-SCCs for the SCC)
- And only those with the following SICs: 13*, 492*, 4612

BLM field office planning area designation was assigned according to the latitude and longitude of each source. The APEN oil and gas emissions database includes both well site and midstream sources. Midstream sources were identified for inclusion in the calculator based on the facility name and the suite of equipment included at a given facility. Appendix C-2 includes a table of emissions by facility for each field office area.

Emissions were available in the APEN emissions database for the pollutants VOCs, CO, NO_X, PM_{10} and SO_2 in tons per year. Emissions for CH_4 and CO_2 were calculated using the vented gas speciation according to Equations 67 and 68 for the following sources.

- Glycol Dehydrator
- Natural Gas Processing Facilities, Gas Sweeting: Amine Process
- Condensate Tanks
- Natural Gas Processing Facilities, Flanges and Connections

$$E_{source,CH4} = E_{tanks,VOC} \times \frac{weight\ fraction_{CH4}}{weight\ fraction_{VOC}} \qquad \text{Equation (67)}$$

$$E_{sourceCO2} = E_{tanks,VOC} \times \frac{weight\ fraction_{CO2}}{weight\ fraction_{VOC}} \qquad \text{Equation (68)}$$

where:

$E_{source,VOC}$ is the total annual emissions from APENS database *a source* [tons/yr]
$E_{source,CO2}$ is the total CO_2 emissions from *a source* [tons/yr]
$E_{source,CH4}$ is the total CH_4 emissions from *a source* [tons/yr]
Weight fractions of each pollutant in the vented gas

For combustion sources such as compressor engines, process heaters and flares, emissions for CH_4, N_2O and CO_2 were estimated using the ratios of each greenhouse gas to NOx of emissions factors from AP-42.

Emissions in future years were estimated by multiplying 2011 emissions by the ratio of gas production in a given future year to gas production in 2011.

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APPENDIX C-1

Conventional Gas Well
Calculator Inputs by Source Category

Note: Yellow highlights indicate that inputs were obtained from the Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012. All inputs taken from other sources are noted.

Gas Analysis & Venting	Speciated Sales Gas Analysis
Gas Component	Mole Fraction (%)
Methane C1	81.012
Ethane C2	4.334
Nitrogen	6.718
Water	0.000
Carbon Dioxide	5.380
Nitrous Oxide	0.000
Hydrogen Sulfide	0.000
Propane C3	1.437
i-Butane i-C4	0.288
n-Butane n-C4	0.329
i-Pentane iC5	0.154
n-Pentane nC5	0.104
Hexanes C6	0.111
Heptanes C7	0.037
Octanes+	0.017
Benzene	0.004
Ethylbenzene	0.000
n-Hexane n-C6	0.068
Toluene	0.003
2,2,4-Trimethylpentane	0.001
Xylenes	0.002

Cn_HEq_Exh Construction/Drilling/Completion Equipment

Construction Equipment

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well Pad	Equipment Category	HP Range
Well Pad	Construction Equipment	250	4	42	10	13	Other Construction Equipment	300
Well Pad Access Road	Construction Equipment	250	4	42	10	10	Other Construction Equipment	300
Pipeline	Construction Equipment	250	2	42	10	2	Other Construction Equipment	300

Construction Site	Equipment Type	2011 Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Well Pad	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Well Pad Access Road	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Pipeline	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Drilling

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range for Efs
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	2469	2	40	24	17	2270010010	Tier 2	>1200

Construction Site	Equipment Type	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Source: EPA Federal Tier Standards

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Completion/Fracing

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range
Completion Equipment	1230	1	40	7	1	2270010010	Tier 2	>1200
Fracing Equipment	12000	1	85	24	1	2270010010	Tier 2	>1200
Refracing Equipment	1500	4	97	1	3	2270010010	Tier 2	>1200

Grand Junction Field Office Air Quality Technical Support Document, ENVIRON, 2012
Data updated from White River Air Quality Technical Support Document, URS, 2012 (Fracing Equipment), and from Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012 (Completion)

Equipment Type	Capacity (hp)	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Completion Equipment	1230	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Fracing Equipment	12000	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Refracing Equipment	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002

Source: EPA Federal Tier Standards
[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Fracing frequency per spud	1
Refracing Frequency per Year per Well	0.05

Cn_CV_Exh Construction Traffic Exhaust

Well Pad and Access Road Construction Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well Pad/ Year
	Type	Class		
Well Pad and Access Road Construction Traffic	Semi Trucks	HDDV	4	80
	Pickup Trucks	LDDT	4	30
Pipeline Construction	Semi Trucks	HDDV	5	16
	Pickup Trucks	LDDT	5	18

Drilling/Completion/Fracing Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/activity/ Year
	Type	Class		
Drilling Traffic	Semi Trucks	HDDV	4	136
	Pickup Trucks	LDDT	5	136
Rig Hauling	Semi Trucks	HDDV	5	1
Rig Move Drilling Traffic	Semi Trucks	HDDV	5	90
	Pickup Trucks	LDDT	5	42
Well Completion & Testing	Semi Trucks	HDDV	5	84
	Pickup Trucks	LDDT	5	74

Ops_Well WO Workovers

Construction Equipment

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	Load Factor	Well Workover Frequency per Year	NONROAD SCC
Well Workover	Workover Equipment	638	9	6	43	0.08	2270010010

Tier Level	HP Range for Efs	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Tier 2	600-750	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year
	Type	Class		
Well Workover	WO Rig	HDDV	4	4
	Haul Truck	HDDV	4	12
	Pickup Truck	LDDT	4	20

blowdown

Blowdown Venting

Type	Control Efficiency (%)	Volume of gas vented per blowdown Uncontrolled (MCF)	Frequency of Blowdown per well per year
Blowdown	0%	0.75	3.0

Data updated from White River Air Quality Technical Support Document, URS, 2012

well completion

Completion Venting

Type	Total volume of gas during completion (mcf)
All completions	1,000

Data updated from White River Air Quality Technical Support Document, URS, 2012

Recompletion

Recompletion Venting

Type	Control Efficiency (%)	Volume of gas vented per well per recompletion Uncontrolled (MCF)	No. of recompletion per well per year
Recompletion	0%	1000	1%

Data updated from White River Air Quality Technical Support Document, URS, 2012

Compressor_Venting — Compressor Venting

Type	Control Efficiency (%)	Volume of gas vented per start-up or shutdown Uncontrolled (MCF)	Frequency of Start-up per well per year	Frequency of Shutdown per well per year
Compressor Shutdown	0%	10	1	1

Wellhead Fugitives — Wellhead Fugitive Devices, Pneumatic Devices, and Pneumatic Pumps

Fugitive Devices

component	Ave. # in Gas Service	Ave. # in Liquid service	Ave. # in High Oil service	Ave. # in Water/Oil Service
valves	49	14	0	3
pump seals	2	1	0	0
others	46	0	0	0
connectors	0	0	0	0
flanges	13	8	0	1
open-ended lines	6	2	0	0

Pneumatic Pumps

Type	Gallons/yr/pump	SCF/Gallon	Number of Pump
Pneumatic Pumps	91	118	1

Pneumatic Devices

Device	Number of Devices / well	Lo-Bleed Rate (cfh)
Liquid level controller	2	6
Pressure controller	1	6
Valve controllers	2.0	6
Liquid level controller	0.1	6

Data updated from Colorado River Valley Air Quality Technical Support Document, URS, 2012

WaterInjection_ Pumps_Exh	Water Injection Pumps													
Type	Capacity (hp)	# of Units per well	Avg. Load Factor (%)	# of Operating Hours	Equipment Category	2011 Emission Factors (g/hp-hr)								
						VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O^a
Water Injection Pumps	347	0.06	47	2920	Pumps	0.13	0.59	2.14	0.10	0.10	0.00	227.95	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Misc_Engines_Exh	Miscellaneous Engines					
Construction Site	Capacity (hp)	# of Units per Well	Fraction of wells to be served by Miscellaneous engine	Avg. Load Factor (%)	# of Operating Hours/Well	Equipment Category
Misc. Engines	118	1	1	50	4380	Misc. Engines

HP Range	2011 Emission Factors (g/hp-hr)								
	VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O^a
175	0.12	0.41	1.59	0.10	0.10	0.00	227.98	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Condensate Tanks & Traffic	Condensate Tanks
Type	***Base Year Assumptions***
Condensate	1. All Condensate Throughput Sent Tanks
	2. Average Condensate Truck Haulout of 200 bbl/load
Produced Water	3. All Water Throughput Sent Tanks
	4. Average Water Truck Haulout of 100 bbl/load
	5. Based on COGCC data from 2008 to 2011, assumed that about 16 times as much produced water from active wells relative to condensate

Uncontrolled VOC Emission Factors for Condensate Tanks

Applicable to Garfield, Mesa, Rio Blanco, Moffat Counties*	10	lb/bbl

**The uncontrolled VOC emissions factor from Oil and Gas Exploration and Regulation Requirement Fact Sheet, Colorado Department of Public Health and Environment, Air Pollution Control Division, January, 2009.*
http://www.cdphe.state.co.us/ap/sbap/SBAPoilgastankguidance.pdf

Flash Gas Weight Fractions

CO2 Fraction in Flash Gas	%wt	2
CH4 Fraction in Flash Gas	%wt	9
VOC Fraction in Flash Gas	%wt	58
VOC Molecular weight in Flash gas	lb/lb-mol	36

Condensate Truck Load-out

True vapor pressure of liquid loaded, pounds per square inch absolute (psia)	5.2
Mode of Operation	submerged loading: dedicated normal service

Produced Water and Condensate Truck Traffic

Construction Site Destination	Vehicle		Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/BBL OR Round Trips/Year/well
	Type	Class			
Produced Condensate Hauling	Haul Truck (200 bbl)	HDDV	15	4	0.005
Water Hauling	Haul Truck (130 bbl)	HDDV	35	20	70.19

Based on 50% of the water production being hauled. BLM Coalbed Methane Emissions Calculator. Received from BLM March 2012

Ops_RoadMaint Maintenance Traffic

Activity	Vehicle		Total Miles Traveled Per Well	Avg. Vehicle Speed (mph)
	Type	Class		
Road Maintenance	Pickup Truck	LDDV	18	15

Compressor_Engines Compressor Engines

Type of Compressors / Pumps	Rate (Hp)	# Units per Well	Annual Compression (Hp)	Operating Hours/Year
Wellhead Compressor Engines	45	0.1	4	6,778
Lateral Compressor Engines	212	0.02	5	8,760

comp_main_Traffic Compressor Station Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Compressor Station
Compressor Maintenance	Pickup Truck	13	855

Reclaim-RdsWells Well Pad Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Well
Road and Well Pad Reclamation	Pickup Truck	13	1,110

Others Traffic Other Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Year/well
Fuel Hauling	HDDV	15	7	0.6

Heaters and Flaring Heaters

Wellsite Heaters	Heater Rating (MMBtu/hr)	Fraction of the year heating	hr/yr	No.of Units per Well
Heaters	0.83	0.57	4964	1
Reboilers	0.67	0.53	4599	1

Ops Dehy Dehydrators

Uncontrolled VOC Emissions (tons/mscf)	Uncontrolled CH4 Emissions (tons/mscf)	Uncontrolled CO2 Emissions (tons/mscf)
2.51E-06	4.03E-06	3.15E-07

Data updated from White River Air Quality Technical Support Document, URS, 2012

APPENDIX C-2

Shale Gas Well
Calculator Inputs by Source Category

Note: Yellow highlights indicate that inputs were obtained from the Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012. All inputs except those from the Bull Mountain Emission Inventory are noted.
Green highlights indicate that inputs were obtained from the data from Bull Mountain Emission Inventory Aug, 2013

Gas Analysis & Venting	Speciated Sales Gas Analysis
Gas Component	Mole Fraction (%)
Methane C1	90.150
Ethane C2	1.960
Nitrogen	0.160
Water	0.000
Carbon Dioxide	6.660
Nitrous Oxide	0.000
Hydrogen Sulfide	0.000
Propane C3	0.520
i-Butane i-C4	0.120
n-Butane n-C4	0.100
i-Pentane iC5	0.060
n-Pentane nC5	0.030
Hexanes+ C6+	0.128
Heptanes C7	0.000
Octanes+	0.000
Benzene	0.036
Ethylbenzene	0.002
n-Hexane n-C6	0.000
Toluene	0.047
2,2,4-Trimethylpentane	0.000
Xylenes	0.017
Helium	0.010
O2	0.000

*The full gas composition did not include BTEX and n-hexane components. These were included by adding separately provided BTEX and n-hexane mole fractions to the composition above and subtracting the corresponding mole fractions from the hexanes+ component.

Cn_HEq_Exh Construction/Drilling/Completion Equipment
Construction Equipment

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well Pad**	HP Range
Well Pad	Haul Truck	250	3	40	8	13	300
	Trackhoe	250	1	40	8	13	300
	Dozer	250	2	40	8	13	300
	Grader	250	1	40	8	13	300
	Compactor	250	1	40	8	13	300
	Water Truck	250	1	40	8	13	300
Well Pad Access Road	Dozer	250	2	40	8	10	300
	Grader	250	1	40	8	10	300
	Trackhoe	250	1	40	8	10	300
	Haul Truck	250	3	40	8	10	300
Pipeline	Dozer	250	1	40	10	10	300
	Grader	250	1	40	10	10	300
	Trackhoe	250	1	40	10	10	300
	Bending Mach	250	1	40	10	10	300
	Sideboom	250	1	40	10	10	300
	Utility Tractor	250	1	40	10	10	300

**Includes pad reclamation associated activity

Construction Site	Equipment Type	2011 Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Well Pad	For all Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Well Pad Access Road	For all Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Pipeline	For all Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00

Source: EPA NONROADS 2008a
[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Drilling

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range for Efs
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	1200	1	40	24	35	2270010010	Tier 2	>1200

Construction Site	Equipment Type	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Source: EPA Federal Tier Standards
[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

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Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range
Completion Equipment	1230	1	40	7	1	2270010010	Tier 2	>1200
Fracing Equipment	12000	1	85	24	1	2270010010	Tier 2	>1200
Refracing Equipment	1500	4	97	1	3	2270010010	Tier 2	>1200

Grand Junction Field Office Air Quality Technical Support Document, ENVIRON, 2012
Data updated from White River Air Quality Technical Support Document, URS, 2012 (Fracing Equipment), and from Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012 (Completion)

Equipment Type	Capacity (hp)	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Completion Equipment	1230	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Fracing Equipment	12000	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Refracing Equipment	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002

Source: EPA Federal Tier Standards
[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Fracing frequency per spud	1
Refracing Frequency per Year per Well	0.25

Cn_CV_Exh Construction Traffic Exhaust

Well Pad and Access Road Construction Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well Pad/ Year
	Type	Class		
Well Pad and Access Road Construction Traffic	Semi Trucks	HDDV	16	164
	Pickup Trucks	LDDT	16	40
Pipeline Construction	Semi Trucks	HDDV	16	35
	Pickup Trucks	LDDT	16	48

ENVIRON

Drilling/Completion/Fracing Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/activity/ Year
	Type	Class		
Drilling Traffic	Semi Trucks	HDDV	16	917
	Pickup Trucks	LDDT	16	274
Rig Hauling	Semi Trucks	HDDV	16	1
Rig Move Drilling Traffic	Semi Trucks	HDDV	16	90
	Pickup Trucks	LDDT	16	42
Well Completion & Testing	Semi Trucks	HDDV	16	84
	Pickup Trucks	LDDT	16	74

Cn_HEq_FDust Construction Traffic Dust

Area Disturbed for Oil Wells	Avg. Disturbed Acres per wellpad	Construction Days
Well Pad	3.75	15
Well Pad Access Road and Pipeline Construction	1.8	8

Road and Pipeline Construction, (Pipeline Percentage of Acreage)	6%

Ops_Well WO Workovers

Construction Equipment

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	Load Factor	Well Workover Frequency per Year	NONROAD SCC
Well Workover	Workover Equipment	500	10	7	43	0.5	2270010010

Tier Level	HP Range for Efs	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Tier 2	600-750	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year
	Type	Class		
Well Workover	WO Rig	HDDV	4.1	0.6
	Haul Truck	HDDV	4.1	1.3
	Pickup Truck	LDDT	4.1	6.4

blowdown	Blowdown Venting		
Type	Control Efficiency (%)	Volume of gas vented per blowdown Uncontrolled (MCF)	Frequency of Blowdown per well per year
Blowdown	0%	0.81	3.4

Data updated from White River Air Quality Technical Support Document, URS, 2012

well completion	Completion Venting
Type	Total volume of gas during completion (mcf)
All completions	1,000

Recompletion	Recompletion Venting		
Type	Control Efficiency (%)	Volume of gas vented per well per recompletion Uncontrolled (MCF)	No. of recompletion per well per year
Recompletion	0%	30	50%

Compressor_Venting — Compressor Venting

Type	Control Efficiency (%)	Volume of gas vented per start-up or shutdown Uncontrolled (MCF)	Frequency of Start-up per well per year	Frequency of Shutdown per well per year
Compressor Shutdown	0%	10	1	1

Wellhead Fugitives — Wellhead Fugitive Devices, Pneumatic Devices, and Pneumatic Pumps

Fugitive Devices

component	Ave. # in Gas Service	Ave. # in Liquid service	Ave. # in High Oil service	Ave. # in Water/Oil Service
valves	49	14	0	3
pump seals	2	1	0	0
others	46	0	0	0
connectors	0	0	0	0
flanges	13	8	0	1
open-ended lines	6	2	0	0

Pneumatic Pumps

Type	Gallons/yr/pump	SCF/Gallon	Number of Pump
Pneumatic Pumps	91	118	1

Pneumatic Devices

Device	Number of Devices / well	Lo-Bleed Rate (cfh)
Liquid level controller	2	6
Pressure controller	1	6
Valve controllers	2.0	6
Liquid level controller	0.1	6

Data updated from Colorado River Valley Air Quality Technical Support Document, URS, 2012

WaterInjection_Pumps_Exh | Water Injection Pumps

Type	Capacity (hp)	# of Units per well	Avg. Load Factor (%)	# of Operating Hours	Equipment Category	2011 Emission Factors (g/hp-hr)								
						VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Water Injection Pumps	347	0.09	47	2920	Pumps	0.13	0.59	2.14	0.10	0.10	0.00	227.95	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Misc_Engines_Exh | Miscellaneous Engines

Construction Site	Capacity (hp)	# of Units per Well	Fraction of wells to be served by Miscellaneous engine	Avg. Load Factor (%)	# of Operating Hours/Well	Equipment Category
Misc. Engines (wellsite water pumps)	19	1	1	47%	8760	Misc. Engines

HP Range	2011 Emission Factors (g/hp-hr)								
	VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
25	0.27	1.68	8.16	0.04	0.04	0.00	557.28	0.01	0.00

Source: Emission factors for NOx and VOC from EPA Nonroad Spark-Ignition Engines 19 kW and Below - Exhaust Emission Standards, Phase 2, Class II Engine. Emission factors for CO, PM10 and PM2.5 and HAPs from AP-42, Volume I, Fifth Edition, Table 3.2-1.

Emission factors for CO2, CH4, and N2O from Tables C-1 and C-2 of 40 CFR Part 98, Mandatory Reporting of Greenhouse Gases; Final Rule.

Condensate Tanks & Traffic	Condensate Tanks
Type	***Base Year Assumptions***
Condensate	1. All Condensate Throughput Sent Tanks
	2. Average Condensate Truck Haulout of 200 bbl/load
Produced Water	3. All Water Throughput Sent Tanks
	4. Average Water Truck Haulout of 100 bbl/load
	5. Based on COGCC data from 2008 to 2011, assumed that about 16 times as much produced water from active wells relative to condensate

Uncontrolled VOC Emission Factors for Condensate Tanks

Applicable to Garfield, Mesa, Rio Blanco, Moffat Counties*	10	lb/bbl

**The uncontrolled VOC emissions factor from Oil and Gas Exploration and Regulation Requirement Fact Sheet, Colorado Department of Public Health and Environment, Air Pollution Control Division, January, 2009.*
http://www.cdphe.state.co.us/ap/sbap/SBAPoilgastankguidance.pdf

Flash Gas Weight Fractions

CO2 Fraction in Flash Gas	%wt	2
CH4 Fraction in Flash Gas	%wt	9
VOC Fraction in Flash Gas	%wt	58
VOC Molecular weight in Flash gas	lb/lb-mol	36

Condensate Truck Load-out

True vapor pressure of liquid loaded, pounds per square inch absolute (psia)	5.2
Mode of Operation	submerged loading: dedicated normal service

Produced Water and Condensate Truck Traffic

Construction Site Destination	Vehicle		Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/BBL OR Round Trips/Year/well
	Type	Class			
Produced Condensate Hauling	Haul Truck (200 bbl)	HDDV	15	4	0.005
Water Hauling	Haul Truck (130 bbl)	HDDV	15	4	70.19

Based on 50% of the water production being hauled. BLM Coalbed Methane Emissions Calculator. Received from BLM March 2012

Ops_RoadMaint Maintenance Traffic

Activity	Vehicle		Total Miles Traveled Per Well	Avg. Vehicle Speed (mph)
	Type	Class		
Road Maintenance	Pickup Truck	LDDV	18	15

Compressor_Engines Compressor Engines

Type of Compressors / Pumps	Rate (Hp)	# Units per Well	Annual Compression (Hp)	Operating Hours/Year
Wellhead Compressor Engines	45	0.1	4	6,778
Lateral Compressor Engines	212	0.02	5	8,760

comp_main_Traffic Compressor Station Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Compressor Station
Compressor Maintenance	Pickup Truck	13	107

Reclaim-RdsWells Well Pad Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Well
Road and Well Pad Reclamation	Pickup Truck	15	416

Others Traffic Other Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Year/well
Fuel Hauling	HDDV	15	7	7

Heaters and Flaring Heaters

Wellsite Heaters	Heater Rating (MMBtu/hr)	Fraction of the year heating	hr/yr	No.of Units per Well
Heaters	0.23	0.17	1460	3
Reboilers	0.25	0.50	4380	1

The Bull Mountain Emission Inventory estimated emissions from one separator heater with 0.125 mmbtu/hr heater rating,4380 hours /year and 4 tank heaters with 0.25 mmbtu/hr heater rating and 730 hours/year. For this project, weighted average of separator heater and tank heaters data were used to estimate heater emissions.

Ops Dehy Dehydrators

Uncontrolled VOC Emissions (tons/mscf)	Uncontrolled CH_4 Emissions (tons/mscf)	Uncontrolled CO_2 Emissions (tons/mscf)
1.72E-06	2.24E-06	2.91E-06

APPENDIX C-3

Coalbed Natural Gas Well Calculator Inputs by Source Category

Note: Yellow highlights indicate that inputs were obtained from theBLM Coalbed Methane Emissions Calculator. Received from BLM March 2012. All inputs taken from other sources are noted.

Gas Analysis & Venting	Speciated Sales Gas Analysis
Gas Component	Mole Fraction (%)
Methane C1	97.913
Ethane C2	0.000
Nitrogen	1.173
Water	0.000
Carbon Dioxide	0.851
Nitrous Oxide	0.000
Hydrogen Sulfide	0.000
Propane C3	0.063
i-Butane i-C4	0.000
n-Butane n-C4	0.000
i-Pentane iC5	0.000
n-Pentane nC5	0.000
Hexanes C6	0.000
Heptanes C7	0.000
Octanes+	0.000
Benzene	0.000
Ethylbenzene	0.000
n-Hexane n-C6	0.000
Toluene	0.000
2,2,4-Trimethylpentane	0.000
Xylenes	0.000

Cn_HEq_Exh Construction/Drilling/Completion Equipment

Construction Equipment

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well Pad	Equipment Category	HP Range
Well Pad	Construction Equipment	200	2	80	12	3	Other Construction Equipment	300
Well Pad Access Road	Construction Equipment	200	1	80	4	1	Other Construction Equipment	300
Pipeline	Construction Equipment	200	2	80	10	2	Other Construction Equipment	300

Construction Site	Equipment Type	2011 Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Well Pad	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Well Pad Access Road	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Pipeline	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Drilling

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range for Efs
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	400	3	77	24	3	2270010010	Tier 2	300-600

Construction Site	Equipment Type	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Source: EPA Federal Tier Standards

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Completion/Fracing

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range
Completion Equipment	400	1	50	10	5	2270010010	Tier 2	300-600
Fracing Equipment	-	-	-	-	-	-	-	-
Refracing Equipment	-	-	-	-	-	-	-	-

Equipment Type	Capacity (hp)	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Completion Equipment	400	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Fracing Equipment	-	-	-	-	-	-	-	-	-	-
Refracing Equipment	-	-	-	-	-	-	-	-	-	-

Source: EPA Federal Tier Standards
[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Fracing frequency per spud	-
Refracing Frequency per Year per Well	-

Cn_CV_Exh Construction Traffic Exhaust

Well Pad and Access Road Construction Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well Pad/ Year
	Type	Class		
Well Pad and Access Road Construction Traffic	Semi Trucks	HDDV	20	3
	Pickup Trucks	LDDT	20	3
Pipeline Construction	Semi Trucks	HDDV	20	8
	Pickup Trucks	LDDT	20	8

Drilling/Completion/Fracing Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/activity/ Year
	Type	Class		
Drilling Traffic	Semi Trucks	HDDV	20	2
	Pickup Trucks	LDDT	20	20
Rig Hauling	Semi Trucks	HDDV	20	12
Rig Move Drilling Traffic	Semi Trucks	HDDV	20	1
	Pickup Trucks	LDDT	20	16
Well Completion & Testing	Semi Trucks	HDDV	20	36
	Pickup Trucks	LDDT	20	12

Cn_HEq_FDust Construction Traffic Dust

Area Disturbed for Oil Wells	Avg. Disturbed Acres per wellpad	Construction Days
Well Pad	6.00	2.50
Well Pad Access Road and Pipeline Construction	4.9	2.17

Road and Pipeline Construction, (Pipeline Percentage of Acreage)	6%

Data from Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012

Ops_Well WO Workovers

Construction Equipment

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	Load Factor	Well Workover Frequency per Year	NONROAD SCC
Well Workover	Workover Equipment	400	10	2	43	0.08	2270010010

Data from Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012

Tier Level	HP Range for Efs	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Tier 2	600-750	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year
	Type	Class		
Well Workover	WO Rig	HDDV	20	1
	Haul Truck	HDDV	20	1
	Pickup Truck	LDDT	20	2

blowdown Blowdown Venting

Type	Control Efficiency (%)	Volume of gas vented per blowdown Uncontrolled (MCF)	Frequency of Blowdown per well per year
Blowdown	0%	200	2.0

Data updated from White River Air Quality Technical Support Document, URS, 2012

well completion Completion Venting

Type	Total volume of gas during completion (mcf)
All completions	1,000

Data updated from White River Air Quality Technical Support Document, URS, 2012

Recompletion | Recompletion Venting

Type	Control Efficiency (%)	Volume of gas vented per well per recompletion Uncontrolled (MCF)	No. of recompletion per well per year
Recompletion	0%	1000	1%

Data updated from White River Air Quality Technical Support Document, URS, 2012

Compressor_Venting | Compressor Venting

Type	Control Efficiency (%)	Volume of gas vented per start-up or shutdown Uncontrolled (MCF)	Frequency of Start-up per well per year	Frequency of Shutdown per well per year
Compressor Shutdown	0%	10	1	1

Data from Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012

Wellhead Fugitives | Wellhead Fugitive Devices, Pneumatic Devices, and Pneumatic Pumps

Fugitive Devices

component	Ave. # in Gas Service	Ave. # in Liquid service	Ave. # in High Oil service	Ave. # in Water/Oil Service
valves	49	14	0	3
pump seals	2	1	0	0
others	46	0	0	0
connectors	0	0	0	0
flanges	13	8	0	1
open-ended lines	6	2	0	0

Pneumatic Pumps

Type	Gallons/yr/pump	SCF/Gallon	Number of Pump
Pneumatic Pumps	-	-	-

Pneumatic Devices

Device	Number of Devices / well	Lo-Bleed Rate (cfh)
Liquid level controller	5	6
Transducer	5	6

WaterInjection_Pumps_Exh Water Injection Pumps

Type	Capacity (hp)	# of Units per well	Avg. Load Factor (%)	# of Operating Hours	Equipment Category	2011 Emission Factors (g/hp-hr)								
						NOxa	PM10b	SO2b	COa	VOCa	PM2.5b	CO2c	CH4c	N2Oc
Water injection Pumps	34	1	47	8760	Pumps	2.14	0.10	0.0045	0.59	0.13	0.10	227.95	0.002	0.002

a Source: assume compressors will comply with NSPS 40 CFR part 60 subpart JJJJ (same rates as Colorado Regulation 7)
b Source: EPA, AP-42 Section 3.2 Natural Gas Fired Reciprocating Engines
c EPA Mandatory GHG Reporting, Part 98, Subpart C, Tables C-1 and C-2.

Condensate Tanks & Traffic	Condensate Tanks
Type	***Base Year Assumptions***
Condensate	1. All Condensate Throughput Sent Tanks
	2. Average Condensate Truck Haulout of 200 bbl/load
Produced Water	3. All Water Throughput Sent Tanks
	4. Average Water Truck Haulout of 100 bbl/load
	5. Based on COGCC data from 2008 to 2011, assumed that about 16 times as much produced water from active wells relative to condensate

Uncontrolled VOC Emission Factors for Condensate Tanks

Applicable to Garfield, Mesa, Rio Blanco, Moffat Counties*	10	lb/bbl

***The uncontrolled VOC emissions factor from Oil and Gas Exploration and Regulation Requirement Fact Sheet, Colorado Department of Public Health and Environment, Air Pollution Control Division, January, 2009.**
http://www.cdphe.state.co.us/ap/sbap/SBAPoilgastankguidance.pdf

Flash Gas Weight Fractions

CO2 Fraction in Flash Gas	%wt	2
CH4 Fraction in Flash Gas	%wt	9
VOC Fraction in Flash Gas	%wt	58
VOC Molecular weight in Flash gas	lb/lb-mol	36

Condensate Truck Load-out

True vapor pressure of liquid loaded, pounds per square inch absolute (psia)	5.2
Mode of Operation	submerged loading: dedicated normal service

Produced Water and Condensate Truck Traffic

Construction Site Destination	Vehicle		Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/BBL OR Round Trips/Year/well
	Type	Class			
Produced Condensate Hauling	Haul Truck (200 bbl)	HDDV	30	20	0.0
Water Hauling	Haul Truck (130 bbl)	HDDV	35	20	70

Assumed 50% of the water production is hauled.

Ops_RoadMaint Maintenance Traffic

Activity	Vehicle		Total Miles Traveled Per Well	Avg. Vehicle Speed (mph)
	Type	Class		
Road Maintenance	Pickup Truck	LDDV	1	15

comp_main_Traffic Compressor Station Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Compressor Station
Compressor Maintenance	Pickup Truck	35	2,920

Reclaim-RdsWells Well Pad Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Well
Road and Well Pad Reclamation	Pickup Truck	30	28

Others Traffic Other Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Year/well
Fuel Hauling	HDDV	15	14	1.0

Heaters and Flaring Heaters

Wellsite Heaters	Heater Rating (MMBtu/hr)	Fraction of the year heating	hr/yr	No.of Units per Well
Heaters	0.50	0.30	8760	1
Reboilers	3.00	0.30	8760	0.002

Data from Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012

Ops Dehy Dehydrators

Uncontrolled VOC Emissions (tons/mscf)	Uncontrolled CH4 Emissions (tons/mscf)	Uncontrolled CO2 Emissions (tons/mscf)
1.26E-07	1.60E-05	0.00E+00

APPENDIX C-4

Conventional Oil Well
Calculator Inputs by Source Category

Note: Yellow highlights indicate that inputs were obtained from the Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012. All inputs taken from other sources are noted.

Gas Analysis & Venting	Speciated Sales Gas Analysis
Gas Component	Mole Fraction (%)
Methane C1	81.012
Ethane C2	4.334
Nitrogen	6.718
Water	0.000
Carbon Dioxide	5.380
Nitrous Oxide	0.000
Hydrogen Sulfide	0.000
Propane C3	1.437
i-Butane i-C4	0.288
n-Butane n-C4	0.329
i-Pentane iC5	0.154
n-Pentane nC5	0.104
Hexanes C6	0.111
Heptanes C7	0.037
Octanes+	0.017
Benzene	0.004
Ethylbenzene	0.000
n-Hexane n-C6	0.068
Toluene	0.003
2,2,4-Trimethylpentane	0.001
Xylenes	0.002

Cn_HEq_Exh Construction/Drilling/Completion Equipment

Construction Equipment

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/Well Pad	Equipment Category	HP Range
Well Pad	Construction Equipment	250	4	42	10	13	Other Construction Equipment	300
Well Pad Access Road	Construction Equipment	250	4	42	10	10	Other Construction Equipment	300
Pipeline	Construction Equipment	250	2	42	10	2	Other Construction Equipment	300

Construction Site	Equipment Type	2011 Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Well Pad	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Well Pad Access Road	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00
Pipeline	Construction Equipment	0.18	0.78	2.32	0.15	0.15	0.01	316.19	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Drilling

Construction Site	Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range for Efs
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	2469	2	40	24	17	2270010010	Tier 2	>1200

Construction Site	Equipment Type	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Rig-up, Drilling, and Rig-down	Drilling Equipment - Avg	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Source: EPA Federal Tier Standards

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Completion/Fracing

Equipment Type	Capacity (hp)	# of Units	Avg. Load Factor (%)	# of Operating Hours/Day	# of Operating Days/activity	NONROAD SCC	Tier Level	HP Range
Completion Equipment	1230	1	40	7	1	2270010010	Tier 2	>1200
Fracing Equipment	12000	1	85	24	1	2270010010	Tier 2	>1200
Refracing Equipment	1500	4	97	1	3	2270010010	Tier 2	>1200

Grand Junction Field Office Air Quality Technical Support Document, ENVIRON, 2012

Data updated from White River Air Quality Technical Support Document, URS, 2012 (Fracing Equipment), and from Uncompahgre Field Office Air Quality Technical Support Document, ENVIRON, 2012 (Completion)

Equipment Type	Capacity (hp)	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Completion Equipment	1230	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Fracing Equipment	12000	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002
Refracing Equipment	1500	0.26	2.61	4.53	0.15	0.15	0.11	523	0.004	0.002

Source: EPA Federal Tier Standards

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Fracing frequency per spud	1
Refracing Frequency per Year per Well	0.05

Cn_CV_Exh Construction Traffic Exhaust

Well Pad and Access Road Construction Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well Pad/ Year
	Type	Class		
Well Pad and Access Road Construction Traffic	Semi Trucks	HDDV	4	80
	Pickup Trucks	LDDT	4	30
Pipeline Construction	Semi Trucks	HDDV	5	16
	Pickup Trucks	LDDT	5	18

Drilling/Completion/Fracing Traffic

Construction Site Destination	Vehicle		Round Trip Distance (miles)	# of Round Trips/activity/ Year
	Type	Class		
Drilling Traffic	Semi Trucks	HDDV	4	136
	Pickup Trucks	LDDT	5	136
Rig Hauling	Semi Trucks	HDDV	5	1
Rig Move Drilling Traffic	Semi Trucks	HDDV	5	90
	Pickup Trucks	LDDT	5	42
Well Completion & Testing	Semi Trucks	HDDV	5	84
	Pickup Trucks	LDDT	5	74

Cn_HEq_FDust Construction Traffic Dust

Area Disturbed for Oil Wells	Avg. Disturbed Acres per wellpad	Construction Days
Well Pad	4.88	13
Well Pad Access Road and Pipeline Construction	9	10

Road and Pipeline Construction, (Pipeline Percentage of Acreage)	6%

Ops_Well WO Workovers

Construction Equipment

Activity	Equipment Type	Capacity (hp)	# of Operating Hours/Day	# of Operating Days/Well	Load Factor	Well Workover Frequency per Year	NONROAD SCC
Well Workover	Workover Equipment	638	9	6	43	0.08	2270010010

Tier Level	HP Range for Efs	Tier Emission Factors (g/hp-hr)								
		VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N2O[a]
Tier 2	600-750	0.26	2.61	4.53	0.15	0.15	0.11	530	0.004	0.002

Traffic

Activity	Vehicle		Round Trip Distance (miles)	# of Round Trips/Well/ Year
	Type	Class		
Well Workover	WO Rig	HDDV	4	4
	Haul Truck	HDDV	4	12
	Pickup Truck	LDDT	4	20

blowdown Blowdown Venting

Type	Control Efficiency (%)	Volume of gas vented per blowdown Uncontrolled (MCF)	Frequency of Blowdown per well per year
Blowdown	0%	0.75	3.0

Data updated from White River Air Quality Technical Support Document, URS, 2012

well completion Completion Venting

Type	Total volume of gas during completion (mcf)
All completions	1,000

Data updated from White River Air Quality Technical Support Document, URS, 2012

Recompletion — Recompletion Venting

Type	Control Efficiency (%)	Volume of gas vented per well per recompletion Uncontrolled (MCF)	No. of recompletion per well per year
Recompletion	0%	1000	1%

Data updated from White River Air Quality Technical Support Document, URS, 2012

Compressor_Venting — Compressor Venting

Type	Control Efficiency (%)	Volume of gas vented per start-up or shutdown Uncontrolled (MCF)	Frequency of Start-up per well per year	Frequency of Shutdown per well per year
Compressor Shutdown	0%	10	1	1

Wellhead Fugitives — Wellhead Fugitive Devices, Pneumatic Devices, and Pneumatic Pumps

Fugitive Devices

component	Ave. # in Gas Service	Ave. # in Liquid service	Ave. # in High Oil service	Ave. # in Water/Oil Service
valves	49	14	0	3
pump seals	2	1	0	0
others	46	0	0	0
connectors	0	0	0	0
flanges	13	8	0	1
open-ended lines	6	2	0	0

Pneumatic Pumps

Type	Gallons/yr/pump	SCF/Gallon	Number of Pump
Pneumatic Pumps	91	118	1

Pneumatic Devices

Device	Number of Devices / well	Lo-Bleed Rate (cfh)
Liquid level controller	2	6
Pressure controller	1	6

Valve controllers	2.0	6
Liquid level controller	0.1	6
	Data updated from Colorado River Valley Air Quality Technical Support Document, URS, 2012	

WaterInjection_Pumps_Exh Water Injection Pumps

Type	Capacity (hp)	# of Units per well	Avg. Load Factor (%)	# of Operating Hours	Equipment Category	2011 Emission Factors (g/hp-hr)								
						VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
Water Injection Pumps	347	0.06	47	2920	Pumps	0.13	0.59	2.14	0.10	0.10	0.00	227.95	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Misc_Engines_Exh Miscellaneous Engines

Construction Site	Capacity (hp)	# of Units per Well	Fraction of wells to be served by Miscellaneous engine	Avg. Load Factor (%)	# of Operating Hours/Well	Equipment Category
Misc. Engines	118	1	1	50	4380	Misc. Engines

HP Range	2011 Emission Factors (g/hp-hr)								
	VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O[a]
175	0.12	0.41	1.59	0.10	0.10	0.00	227.98	0.00	0.00

Source: EPA NONROADS 2008a

[a]N2O factor source: 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17. 130,500 Btu/gallon, 2545 Btu/hp-hr.

Condensate Tanks & Traffic	Condensate Tanks
Type	***Base Year Assumptions***
Condensate	1. All Condensate Throughput Sent Tanks
	2. Average Condensate Truck Haulout of 200 bbl/load
Produced Water	3. All Water Throughput Sent Tanks
	4. Average Water Truck Haulout of 100 bbl/load
	5. Based on COGCC data from 2008 to 2011, assumed that about 16 times as much produced water from active wells relative to condensate

Uncontrolled VOC Emission Factors for Condensate Tanks

Applicable to Garfield, Mesa, Rio Blanco, Moffat Counties*	1.6	lb/bbl

**The uncontrolled VOC emissions factor from the BLM crude oil emission calculator*

Flash Gas Weight Fractions

CO_2 Fraction in Flash Gas	%wt	2
CH_4 Fraction in Flash Gas	%wt	9
VOC Fraction in Flash Gas	%wt	58
VOC Molecular weight in Flash gas	lb/lb-mol	36

Condensate Truck Load-out

True vapor pressure of liquid loaded, pounds per square inch absolute (psia)	5.2
Mode of Operation	submerged loading: dedicated normal service

Produced Water and Condensate Truck Traffic

Construction Site Destination	Vehicle		Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/BBL OR Round Trips/Year/well
	Type	Class			

ENVIRON

Produced Condensate Hauling	Haul Truck (200 bbl)	HDDV	15	4	0.005
Water Hauling	Haul Truck (130 bbl)	HDDV	35	20	70.19

Based on 50% of the water production being hauled. BLM Coalbed Methane Emissions Calculator. Received from BLM March 2012

Ops_RoadMaint Maintenance Traffic

Activity	Vehicle		Total Miles Traveled Per Well	Avg. Vehicle Speed (mph)
	Type	Class		
Road Maintenance	Pickup Truck	LDDV	18	15

Compressor_Engines Compressor Engines

Type of Compressors / Pumps	Rate (Hp)	# Units per Well	Annual Compression (Hp)	Operating Hours/Year
Wellhead Compressor Engines	45	0.1	4	6,778
Lateral Compressor Engines	212	0.02	5	8,760

comp_main_Traffic Compressor Station Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Compressor Station
Compressor Maintenance	Pickup Truck	13	855

Reclaim-RdsWells — Well Pad Reclamation

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Total Miles Traveled per Well
Road and Well Pad Reclamation	Pickup Truck	13	1,110

Others Traffic — Other Traffic

Activity	Vehicle Type	Avg. Vehicle Speed (mph)	Round Trip Distance (miles)	# of Round Trips/Year/well
Fuel Hauling	HDDV	15	7	0.6

Heaters and Flaring — Heaters

Wellsite Heaters	Heater Rating (MMBtu/hr)	Fraction of the year heating	hr/yr	No.of Units per Well
Heaters	0.83	0.57	4964	1
Reboilers	0.67	0.53	4599	1

Ops Dehy — Dehydrators

Uncontrolled VOC Emissions (tons/mscf)	Uncontrolled CH4 Emissions (tons/mscf)	Uncontrolled CO2 Emissions (tons/mscf)
2.51E-06	4.03E-06	3.15E-07

Data updated from White River Air Quality Technical Support Document, URS, 2012

APPENDIX C-5

Midstream Emissions by Field Office and Facility

Field Office	County	Facility Name	2011 Emissions (tons/year)					
			NOx	VOC	CO	PM10	PM2.5	SO2
Grand Junction	Garfield	BARGATH LLC - CRAWFORD TRAIL	208.02	71.50	80.14	6.262	6.262	0.430
Grand Junction	Garfield	CHEVRON USA INC - PICEANCE BASIN CENTRAL	91.80	58.22	52.00	1.938	1.938	0.174
Grand Junction	Garfield	ENCANA (WEST) - HAY CANYON	0.00	23.74	0.00	0.000	0.000	0.000
Grand Junction	Garfield	NATIONAL FUEL CORP. - BAXTER FACILITY	18.50	2.90	4.40	0.081	0.081	0.005
Grand Junction	Garfield	OXY USA WTP LP - CONN CREEK GAS	132.80	35.28	19.13	0.010	0.010	1.760
Grand Junction	Garfield	PUBLIC SERVICE CO BAXTER STATION	58.04	7.56	67.23	0.230	0.230	0.028
Grand Junction	Garfield	SOURCEGAS DBA ROCKY MTN -DEBEQUE C S	28.48	7.97	65.49	0.591	0.591	0.013
Grand Junction	Garfield	TRANSCOLORADO GAS - CONN CREEK	2.10	0.32	0.28	0.040	0.040	0.000
Grand Junction	Garfield	WPX ENERGY RKY MTN, LLC - TRAIL RIDGE CS	31.70	8.00	5.85	0.073	0.073	0.004
Grand Junction	Mesa	ASPEN OPERATING, LLC - SINK CREEK C.S.	49.15	2.81	2.72	0.052	0.000	0.003
Grand Junction	Mesa	AXIA ENERGY - TAYLOR COMPRESSOR STATION	32.75	54.32	72.48	0.000	0.000	0.000
Grand Junction	Mesa	BADGER MIDSTREAM SERVICES - BADGER WGP	50.02	31.39	54.43	1.074	1.074	0.075
Grand Junction	Mesa	BLACK HILLS MIDSTREAM - HORSESHOE CANYON	35.30	66.14	26.50	0.570	0.570	0.035
Grand Junction	Mesa	COLLBRAN VALLEY GAS - ANDERSON GULCH	127.63	68.11	60.97	4.369	4.366	0.120
Grand Junction	Mesa	COLLBRAN VALLEY GAS GATHERING- CVG #2	192.66	112.89	49.33	0.000	0.000	0.000
Grand Junction	Mesa	COLORADO FUEL MANUFACTURERS, INC.	33.20	87.51	21.75	0.975	0.975	1.077
Grand Junction	Mesa	DELTA PETROLEUM CORP - MVS CS AND HCPWRF	4.70	61.90	22.10	0.000	0.000	0.000
Grand Junction	Mesa	ENCANA - PLATEAU CREEK	19.74	11.24	12.78	0.800	0.800	0.008
Grand Junction	Mesa	ETC CANYON PIPELINE - BAR X C.S.	12.20	20.48	14.20	0.376	0.376	0.023
Grand Junction	Mesa	ETC CANYON PIPELINE - PREMIER BAR X	73.32	7.82	5.09	1.340	1.340	0.020
Grand Junction	Mesa	ETC CANYON PIPELINE -PREMIER DEBEQUE	76.04	43.37	55.85	0.998	0.998	0.060
Grand Junction	Mesa	FRAM OPERATING - REEDER MESA CS	74.46	48.70	100.70	0.011	0.011	0.081
Grand Junction	Mesa	NATL FUEL CORP	22.07	7.55	8.85	0.307	0.307	0.015
Grand Junction	Mesa	OXY USA - BRUSH CREEK COMPRESSOR	86.20	61.31	57.57	0.443	0.443	0.027

Field Office	County	Facility Name	2011 Emissions (tons/year)					
			NOx	VOC	CO	PM10	PM2.5	SO2
		STATION						
Grand Junction	Mesa	OXY USA INC. - East Plateau CS	77.67	32.42	48.93	1.772	1.772	0.106
Grand Junction	Mesa	PICEANCE ENERGY - BRUTON C.S.	12.13	11.03	17.19	0.640	0.640	0.000
Grand Junction	Mesa	PICEANCE ENERGY LLC - HAWXHURST RANCH	8.64	23.32	17.26	0.000	0.000	0.000
Grand Junction	Mesa	PUBLIC SERVICE CO ASBURY STATION	26.78	10.67	43.32	0.110	0.110	0.007
Grand Junction	Mesa	PUBLIC SERVICE CO HUNTER CANYON STA	16.37	0.62	1.99	0.200	0.200	0.003
Grand Junction	Mesa	SOURCEGAS DBA ROCKY MTN NG - COLLBRAN	22.82	12.50	19.72	0.460	0.260	0.010
Grand Junction	Mesa	TRANSCOLORADO GAS TR CO - WHITEWATER CS	12.37	5.73	4.65	0.360	0.360	0.020
Kremmling	Grand	PUBLIC SERVICE CO WILLIAMS FORK STATION	12.40	0.40	0.75	0.006	0.006	0.001
Little Snake	Moffat	AGAVE ENERGY - BIL HOL GULCH TREATING	8.58	32.79	17.16	0.040	0.040	0.000
Little Snake	Moffat	ARGALI EXPLORATION COMPANY	45.59	0.98	3.27	0.080	0.080	0.005
Little Snake	Moffat	CUSTOM ENERGY CONSTRUCTION INC BUCK PEAK	4.73	3.47	1.92	0.008	0.008	0.001
Little Snake	Moffat	J W OPERATING CO - GREAT DIVIDE C.S.	10.80	7.79	4.84	0.000	0.000	0.000
Little Snake	Moffat	J-W OPERATING COMPANY -SAND HILLS	28.40	13.25	2.10	0.000	0.000	0.000
Little Snake	Moffat	MERIT ENERGY - SANDWASH C.S.	19.34	7.96	12.90	0.000	0.000	0.000
Little Snake	Moffat	MERRION OIL & GAS - BLUE GRAVEL	34.41	0.11	35.37	0.070	0.070	0.000
Little Snake	Moffat	OVERLAND PASS - MIDPOINT STATION	0.00	8.60	0.00	0.000	0.000	0.000
Little Snake	Moffat	QEP FIELD SERVICES - EAST HIAWATHA CS	58.72	31.42	51.98	0.602	0.592	0.036
Little Snake	Moffat	QEP FIELD SERVICES - LION C.S.	14.30	7.63	14.30	0.475	0.475	0.029
Little Snake	Moffat	QEP FIELD SERVICES - W HIAWATHA C. S.	32.76	31.87	15.09	0.380	0.380	0.000
Little Snake	Moffat	QUESTAR - SKULL CREEK DEW POINT PLANT	56.46	87.10	41.61	0.364	0.359	0.022
Little Snake	Moffat	QUESTAR PIPELINE CO STATE LINE COMP STA	13.41	0.10	1.69	0.320	0.320	0.012
Little Snake	Moffat	QUESTAR PIPELINE PWFC SOUTHSIDE 2/MUSSER	38.54	2.15	1.91	0.070	0.070	0.004
Little Snake	Moffat	ROCKIES EXPRESS PIPELINE - BIG HOLE CS	12.60	4.01	9.96	0.690	0.690	1.290
Little Snake	Moffat	SAMSON RESOURCES - SHELL CREEK GAS COND	31.29	1.03	12.70	0.227	0.170	0.003

Field Office	County	Facility Name	2011 Emissions (tons/year)					
			NOx	VOC	CO	PM10	PM2.5	SO2
Little Snake	Moffat	WYOMING INTERSTATE - SNAKE RIVER C.S.	64.97	7.58	77.43	4.489	4.489	2.177
Little Snake	Rio Blanco	CHEVRON USA - WILSON CREEK GAS PLT	4.94	90.10	10.32	0.008	0.007	1.000
Tres Rios	Archuleta	PUBLIC SERVICE CO - PAGOSA SPRINGS STA	0.10	0.03	0.10	0.000	0.000	0.000
Tres Rios	Dolores	MID-AMERICA PIPELINE CO DOVE CR STA	28.22	2.46	34.37	0.460	0.460	0.010
Tres Rios	Dolores	QEP ENERGY CO - SPARGO NO 2	36.60	0.30	32.70	0.049	0.049	0.003
Tres Rios	Dolores	TRANSCOLORADO GAS TRANS - DOLORES C.S.	17.49	17.58	10.71	0.580	0.580	0.030
Tres Rios	Dolores	WILLIAMS FIELD SERV- JOHNSON AC #1 FACIL	21.20	30.90	13.48	0.413	0.413	0.025
Tres Rios	La Plata	BP AMERICA - PINON COMPRESSOR FACILITY	85.00	24.40	79.60	1.460	1.460	0.088
Tres Rios	Montezuma	KINDER MORGAN CO2 CO. -YELLOW JACKET H10	9.00	2.13	1.96	0.422	0.162	17.000
Tres Rios	Montezuma	MID-AMERICA PIPELINE CO DOLORES STA	25.27	2.20	30.77	0.460	0.460	0.010
Tres Rios	Montezuma	NORTHWEST PIPELINE CORP PLEASANT VIEW	94.73	0.51	7.52	1.142	1.142	1.535
Tres Rios	Montezuma	TRANSCOLORADO GAS TRANS - MANCOS CS	5.97	1.50	2.88	0.150	0.150	0.000
Tres Rios	Montezuma	WILLIAMS FIELD SERVICES- KOSKIE-BRUMLEY	19.41	21.95	6.47	0.443	0.443	0.027
Tres Rios	San Miguel	PATARA MIDSTREAM - ANDY'S MESA	117.46	68.20	43.64	1.963	1.963	0.118
Tres Rios	San Miguel	PATARA MIDSTREAM - HAMILTON CREEK CS	50.86	24.21	27.75	0.426	0.415	0.036
Tres Rios	San Miguel	PATARA OIL & GAS - DOUBLE EAGLE PLANT	57.03	10.35	18.44	0.081	0.081	0.005
Uncompahgre	Gunnison	GUNNISON ENERGY-RAGGED MOUNTAIN C.S.	64.44	55.32	135.60	0.689	0.687	0.053
Uncompahgre	Montrose	TRANSCOLORADO GAS - OLATHE C.S.	12.37	0.51	12.37	0.320	0.320	0.150
Uncompahgre	Montrose	TRANSCOLORADO GAS TRANS - REDVALE CS	17.23	9.42	5.78	0.680	0.680	0.030
Uncompahgre	San Miguel	ROCKY MOUNTAIN NATURAL GAS - NORWOOD C.S	12.20	7.30	25.20	0.213	0.213	0.013
CRV (in Roan Plt.)	Garfield	BARGATH - RABBIT BRUSH C.S.	177.82	64.32	35.31	5.53	5.53	0.30
CRV (in Roan Plt.)	Garfield	BARGATH LLC - ANVIL POINTS CS	131.00	52.60	40.00	2.77	2.77	0.17
CRV (in Roan Plt.)	Garfield	BARGATH LLC - CLOUGH CS	100.80	82.90	40.80	1.98	1.98	0.12
CRV (in Roan Plt.)	Garfield	BARGATH LLC - COTTONWOOD POINT CS	132.60	86.40	132.60	2.27	2.27	0.14
CRV (in Roan Plt.)	Garfield	BARGATH LLC - HAYBARN	54.80	20.30	33.92	2.12	2.12	0.09
CRV (in Roan Plt.)	Garfield	BARGATH LLC - HAYES GULCH	115.80	58.05	34.20	2.35	2.35	0.14

Field Office	County	Facility Name	2011 Emissions (tons/year)					
			NOx	VOC	CO	PM10	PM2.5	SO2
CRV (in Roan Plt.)	Garfield	BARGATH LLC - HEATH CS	220.13	83.88	64.88	4.51	4.51	0.28
CRV (in Roan Plt.)	Garfield	BARGATH LLC - PARACHUTE	299.21	146.32	161.67	9.68	9.68	0.39
CRV (in Roan Plt.)	Garfield	BARGATH LLC - RIFLE STATION	2.80	33.90	2.40	0.00	0.00	0.00
CRV (in Roan Plt.)	Garfield	BARGATH LLC - RILEY CS	115.80	62.40	34.05	2.35	2.35	0.14
CRV (in Roan Plt.)	Garfield	BARGATH LLC - ROAN CLIFFS GAS PLANT	94.60	47.60	66.70	1.80	1.80	0.10
CRV (in Roan Plt.)	Garfield	BARGATH LLC - RULISON CS	116.72	63.71	34.91	0.00	0.00	0.00
CRV (in Roan Plt.)	Garfield	BARGATH LLC - SHARRARD CS	131.84	60.94	64.95	2.98	2.98	0.16
CRV (in Roan Plt.)	Garfield	BARGATH LLC - WEBSTER HILL	172.95	82.59	61.67	5.29	5.29	0.29
CRV (in Roan Plt.)	Garfield	BARGATH LLC - WHEELER GULCH CS	96.50	49.20	28.50	1.90	1.90	0.07
CRV (in Roan Plt.)	Garfield	BARGATH, LLC - WASATCH COMPRESSOR YARD	86.00	82.19	35.60	1.56	1.56	0.09
CRV (in Roan Plt.)	Garfield	ENCANA - RIFLE BOOSTER STATION	43.52	41.73	48.75	1.33	1.32	0.00
CRV (in Roan Plt.)	Garfield	ENCANA (WEST) - MIDDLE FORK C.S.	0.00	422.07	20.10	0.00	0.00	0.00
CRV (in Roan Plt.)	Garfield	ETC CANYON PIPELINE - RIFLE C.S.	238.88	92.78	137.93	4.73	4.73	0.26
CRV (in Roan Plt.)	Garfield	HALLIBURTON ENERGY SVCS	2.66	0.21	0.57	0.18	0.18	0.18
CRV (in Roan Plt.)	Garfield	PUBLIC SERVICE CO - RIFLE GAS PLANT	16.99	18.29	3.33	0.55	0.55	0.01
CRV (in Roan Plt.)	Garfield	WILLIAMS PRODUCTION RMT CO - WEBSTER CS	10.46	2.10	10.46	0.00	0.00	0.00
CRV (in Roan Plt.)	Garfield	WILLIAMS RMT CO - DOE COMPRESSOR STATION	33.10	12.90	3.70	0.09	0.09	0.01
CRV (not in Roan Plt.)	Garfield	ANTERO RES - CASTLE SPRINGS CENTRAL	18.30	6.11	18.30	0.25	0.25	0.02
CRV (not in Roan Plt.)	Garfield	ANTERO RESOURCES - HUNTER MESA COMP STAT	26.14	38.03	31.97	0.00	0.00	0.00
CRV (not in Roan Plt.)	Garfield	BARGATH LLC - CALLAHAN C.S.	102.00	64.45	34.20	2.35	2.35	0.14
CRV (not in Roan Plt.)	Garfield	BARGATH LLC - GRAND VALLEY	94.61	68.70	92.70	1.48	1.41	0.56
CRV (not in Roan Plt.)	Garfield	BARGATH LLC - HOOVER EXPRESS	132.00	71.69	39.00	2.70	2.28	0.18
CRV (not in Roan Plt.)	Garfield	BARGATH LLC - JANGLES	68.00	43.55	22.80	1.55	1.55	0.09
CRV (not in Roan Plt.)	Garfield	BARGATH LLC - STARKEY GULCH CS	132.00	50.95	39.00	2.69	2.69	0.16
CRV (not in Roan Plt.)	Garfield	BARGATH LLC - UNA COMPRESSOR STATION	155.05	65.53	51.83	3.60	3.18	0.45

ENVIRON

Field Office	County	Facility Name	2011 Emissions (tons/year)					
			NOx	VOC	CO	PM10	PM2.5	SO2
CRV (not in Roan Plt.)	Garfield	BARGATH, LLC - HYRUP PROD FACILITY	237.62	124.37	82.05	5.77	5.69	0.92
CRV (not in Roan Plt.)	Garfield	BILL BARRETT - BAILEY COMPRESSOR STATION	166.37	193.20	69.30	7.77	7.77	0.44
CRV (not in Roan Plt.)	Garfield	BILL BARRETT CORP - MAMM CREEK CS	292.06	78.37	227.95	15.53	4.44	0.71
CRV (not in Roan Plt.)	Garfield	ENCANA OIL & GAS - HIGH MESA COMP STATIO	99.45	262.57	16.69	1.99	1.99	0.12
CRV (not in Roan Plt.)	Garfield	ENTERPRISE PRODUCTS OP- JACKRABBIT CS	194.08	141.91	134.34	0.01	0.01	0.00
CRV (not in Roan Plt.)	Garfield	ETC CANYON PIPELINE - HOLMES MESA CS	123.73	101.83	82.67	0.00	0.00	0.00
CRV (not in Roan Plt.)	Garfield	ETC CANYON PIPELINE - WALLACE CREEK CS	0.00	18.00	0.00	0.00	0.00	0.00
CRV (not in Roan Plt.)	Garfield	GRAND RIVER GATH - EAST MAMM CREEK CS	138.21	162.64	80.27	3.86	3.86	0.23
CRV (not in Roan Plt.)	Garfield	GRAND RIVER GATHERING - HUNTER MESA CS	148.32	181.24	87.43	0.00	0.00	0.00
CRV (not in Roan Plt.)	Garfield	GRAND RIVER GATHERING - ORCHARD CS	63.20	34.61	20.90	1.07	1.07	0.06
CRV (not in Roan Plt.)	Garfield	GRAND RIVER GATHERING - PUMBA CS	98.35	122.76	140.49	3.56	3.56	0.21
CRV (not in Roan Plt.)	Garfield	NOBLE ENERGY - RULISON STATION	38.84	4.01	14.68	0.84	0.84	0.05
CRV (not in Roan Plt.)	Garfield	PETROLEUM DEVELOPMENT - GARDEN GULCH	26.20	42.03	39.14	1.49	1.49	0.09
CRV (not in Roan Plt.)	Mesa	OXY USA - ALKALI CREEK C.S.	71.56	64.13	56.49	0.04	0.04	0.00
CRV (not in Roan Plt.)	Mesa	SG INTERESTS I - DIVIDE CREEK TREATMENT	39.91	24.14	33.43	1.48	1.48	0.11
White River Valley	Garfield	HUNTER RIDGE - CDP K22 496	29.57	31.78	56.86	0.00	0.00	0.00
White River Valley	Garfield	HUNTER RIDGE ENERGY - STORY GULCH C.S.	155.07	236.41	96.81	0.00	0.00	0.01
White River Valley	Rio Blanco	BARGATH LLC - BLACK SULPHUR CREEK	31.90	0.35	52.20	0.13	0.13	0.01
White River Valley	Rio Blanco	BARGATH LLC - GREASEWOOD CS	96.28	45.82	28.38	1.96	1.96	0.12
White River Valley	Rio Blanco	BARGATH LLC - RYAN GULCH GAS	192.00	127.15	27.30	5.64	5.64	0.34
White River Valley	Rio Blanco	BARGATH LLC - SAGEBRUSH GAS PROCESSING	157.28	44.81	117.04	3.46	3.04	0.20
White River Valley	Rio Blanco	CCES PICEANCE - BUCKSKIN MESA CFS-2	84.70	30.80	21.80	2.70	2.40	0.00
White River Valley	Rio Blanco	ENCANA OIL - EAST DRAGON TRAIL CS	34.66	22.93	41.55	0.53	0.53	0.03
White River Valley	Rio Blanco	ENCANA OIL & GAS - DRAGON TRAIL	431.04	99.33	174.57	13.91	13.89	0.23
White River Valley	Rio Blanco	ENCANA OIL & GAS - PARK CANYON WEST	48.83	40.99	31.73	0.43	0.43	0.03
White River Valley	Rio Blanco	ENCANA OIL & GAS (USA) INC - BULL FORK	39.53	56.80	12.12	0.00	0.00	0.00
White River Valley	Rio Blanco	ENCANA OIL & GAS (USA), INC. - CR 109 CS	2.81	1.03	2.53	0.04	0.04	0.00

ENVIRON

Field Office	County	Facility Name	2011 Emissions (tons/year)					
			NOx	VOC	CO	PM10	PM2.5	SO2
White River Valley	Rio Blanco	ENCANA OIL & GAS (USA), INC. - HORSE DRA	10.23	5.93	5.73	0.22	0.22	0.01
White River Valley	Rio Blanco	ENCANA OIL & GAS (USA), INC.- W DRAGON T	60.19	37.96	48.30	0.54	0.54	0.03
White River Valley	Rio Blanco	ENCANA OIL & GAS (USA), INC-W DOUGLAS CR	32.20	97.11	32.20	3.34	3.34	0.07
White River Valley	Rio Blanco	ENTERPRISE GAS PROC - MEEKER GAS PLANT	138.73	317.66	254.06	26.40	26.40	205.27
White River Valley	Rio Blanco	ENTERPRISE GAS-PICEANCE DEV. PROJECT	93.18	208.64	112.70	4.54	4.54	21.83
White River Valley	Rio Blanco	ETC CANYON PIPELINE - N. DOUGLAS CREEK	72.17	54.12	83.19	1.82	0.45	0.10
White River Valley	Rio Blanco	ETC CANYON PIPELINE- CATHEDRAL C.S.	10.77	0.63	1.04	0.02	0.02	0.00
White River Valley	Rio Blanco	ETC CANYON PIPELINE-FOUNDATION CREEK	73.05	69.47	49.87	0.58	0.58	0.03
White River Valley	Rio Blanco	KINDER MORGAN TREATING - MEEKER PLANT	44.96	26.30	43.77	1.56	1.40	0.13
White River Valley	Rio Blanco	NORTHWEST PIPELINE CORP RANGELY STA	382.05	11.61	53.51	2.67	2.67	0.04
White River Valley	Rio Blanco	PICEANCE BASIN GAS GATH - FLETCHER PLANT	45.56	60.67	75.59	1.15	1.15	0.07
White River Valley	Rio Blanco	PUBLIC SERVICE CO GREASEWOOD STATION	24.41	0.17	21.51	0.05	0.05	0.00
White River Valley	Rio Blanco	QUESTAR PIPELINE CO - GREASEWOOD GULCH	51.56	22.50	9.20	2.32	2.32	0.13
White River Valley	Rio Blanco	ROCKY MOUNTAIN NAT GAS - PICEANCE	28.29	31.86	36.01	0.92	0.29	0.02
White River Valley	Rio Blanco	SOUTH-TEX - BASS YELLOW CREEK	14.59	54.91	12.26	0.00	0.00	0.00
White River Valley	Rio Blanco	WEST TEXAS - PICEANCE CREEK GP	61.67	52.39	52.63	1.04	1.03	0.06
White River Valley	Rio Blanco	WHITING OIL & GAS CORP-BOIES RANCH	32.04	37.48	23.06	1.47	1.47	0.09
White River Valley	Rio Blanco	WHITING OIL & GAS -JIMMY GULCH STATION	23.28	19.25	10.03	0.52	0.52	0.03
White River Valley	Rio Blanco	WILLIAMS FIELD - WILLOW CREEK GAS PLANT	199.84	109.89	218.90	37.61	36.90	71.75
White River Valley	Rio Blanco	XTO ENERGY, INC. - PICEANCE CREEK	89.96	91.71	90.02	7.12	6.79	7.85
White River Valley	Mesa	PIONEER NATURAL RES - CSP-3	24.40	5.50	23.09	0.42	0.42	0.02
Canyon Of The Ancients Nm	Montezuma	KINDER MORGAN CO2 CO. -HOVENWEEP CENTRAL	8.60	2.13	1.96	0.422	0.325	16.844

APPENDIX C-6

EPA MOVES Emissions Factor by Field Office, County, and Year

Table F1. Field Office to Representative County On-road Emission Factor Cross-reference.

Field Office	County
Colorado River Valley	Garfield County
Kremmling Field Office	Grand County
Tres Rios Field Office	La Plata County
Grand Junction Field Office	Mesa County
Little Snake Field Office	Moffat County
Uncompahgre Field Office	Montrose County
White River Field Offices	Rio Blanco County

Table F2. On-road Light Duty and Heavy Duty Truck Emisison Factors by Representative County and by Project Year.

County	Year	Vehicle Type	Emission Rates (grams/mile)								
			VOC	CO	NOx	PM10	PM2.5	SO2	CO2	CH4	N2O
Garfield County	2011	Light Duty	1.02	12.80	1.49	0.05	0.03	0.01	491	0.05	0.03
Garfield County	2011	Heavy Duty	0.71	3.94	14.41	1.09	0.93	0.02	2403	0.03	0.00
Grand County	2011	Light Duty	1.04	13.58	1.50	0.06	0.04	0.01	495	0.06	0.03
Grand County	2011	Heavy Duty	0.73	4.04	14.69	1.09	0.93	0.02	2404	0.04	0.00
La Plata County	2011	Light Duty	0.99	12.58	1.48	0.05	0.03	0.01	490	0.05	0.03
La Plata County	2011	Heavy Duty	0.72	4.07	14.57	1.09	0.93	0.02	2404	0.04	0.00
Mesa County	2011	Light Duty	0.98	11.99	1.45	0.05	0.02	0.01	488	0.05	0.03
Mesa County	2011	Heavy Duty	0.71	3.99	14.28	1.09	0.93	0.02	2403	0.03	0.00
Moffat County	2011	Light Duty	1.00	12.78	1.47	0.05	0.03	0.01	492	0.05	0.03
Moffat County	2011	Heavy Duty	0.73	4.06	14.54	1.09	0.93	0.02	2404	0.04	0.00
Montrose County	2011	Light Duty	0.97	12.22	1.46	0.05	0.03	0.01	489	0.05	0.03
Montrose County	2011	Heavy Duty	0.72	4.07	14.44	1.09	0.93	0.02	2404	0.04	0.00
Rio Blanco County	2011	Light Duty	1.00	12.68	1.47	0.05	0.03	0.01	491	0.05	0.03
Rio Blanco County	2011	Heavy Duty	0.72	4.03	14.51	1.09	0.93	0.02	2404	0.04	0.00
Garfield County	2012	Light Duty	0.95	12.06	1.39	0.05	0.03	0.01	485	0.05	0.03
Garfield County	2012	Heavy Duty	0.64	3.54	12.74	0.98	0.83	0.02	2402	0.04	0.00
Grand County	2012	Light Duty	0.97	12.83	1.40	0.06	0.03	0.01	489	0.06	0.03
Grand County	2012	Heavy Duty	0.65	3.63	13.00	0.98	0.83	0.02	2404	0.04	0.00
La Plata County	2012	Light Duty	0.92	11.86	1.38	0.05	0.03	0.01	484	0.05	0.03
La Plata County	2012	Heavy Duty	0.65	3.65	12.89	0.98	0.83	0.02	2404	0.04	0.00
Mesa County	2012	Light Duty	0.91	11.28	1.35	0.05	0.02	0.01	481	0.04	0.03
Mesa County	2012	Heavy Duty	0.64	3.58	12.63	0.98	0.83	0.02	2403	0.04	0.00
Moffat County	2012	Light Duty	0.93	12.05	1.37	0.05	0.03	0.01	485	0.05	0.034

County	Year	Vehicle Type	Emission Rates (grams/mile)								
			VOC	CO	NOx	PM10	PM2.5	SO2	CO2	CH4	N2O
Moffat County	2012	Heavy Duty	0.65	3.65	12.86	0.98	0.83	0.02	2404	0.04	0.003
Montrose County	2012	Light Duty	0.91	11.51	1.36	0.05	0.03	0.01	482	0.05	0.033
Montrose County	2012	Heavy Duty	0.65	3.66	12.77	0.98	0.83	0.02	2404	0.04	0.003
Rio Blanco County	2012	Light Duty	0.93	11.95	1.37	0.05	0.03	0.01	484	0.05	0.033
Rio Blanco County	2012	Heavy Duty	0.64	3.62	12.84	0.98	0.83	0.02	2404	0.04	0.004
Garfield County	2013	Light Duty	0.89	11.40	1.29	0.05	0.03	0.01	477	0.05	0.033
Garfield County	2013	Heavy Duty	0.56	3.15	11.19	0.87	0.72	0.02	2402	0.05	0.003
Grand County	2013	Light Duty	0.91	12.18	1.30	0.06	0.03	0.01	481	0.05	0.032
Grand County	2013	Heavy Duty	0.57	3.24	11.41	0.87	0.72	0.02	2404	0.05	0.004
La Plata County	2013	Light Duty	0.86	11.22	1.28	0.05	0.03	0.01	476	0.05	0.033
La Plata County	2013	Heavy Duty	0.57	3.26	11.32	0.87	0.72	0.02	2404	0.05	0.004
Mesa County	2013	Light Duty	0.85	10.66	1.26	0.05	0.02	0.01	473	0.04	0.033
Mesa County	2013	Heavy Duty	0.56	3.19	11.09	0.87	0.72	0.02	2403	0.05	0.003
Moffat County	2013	Light Duty	0.87	11.41	1.27	0.05	0.03	0.01	477	0.05	0.032
Moffat County	2013	Heavy Duty	0.57	3.25	11.30	0.87	0.72	0.02	2404	0.05	0.003
Montrose County	2013	Light Duty	0.84	10.88	1.26	0.05	0.03	0.01	474	0.04	0.030
Montrose County	2013	Heavy Duty	0.57	3.27	11.22	0.87	0.72	0.02	2404	0.05	0.003
Rio Blanco County	2013	Light Duty	0.87	11.31	1.27	0.05	0.03	0.01	477	0.05	0.030
Rio Blanco County	2013	Heavy Duty	0.57	3.23	11.27	0.87	0.72	0.02	2404	0.05	0.004
Garfield County	2014	Light Duty	0.83	10.78	1.19	0.05	0.03	0.01	468	0.05	0.031
Garfield County	2014	Heavy Duty	0.49	2.78	9.83	0.78	0.63	0.02	2402	0.05	0.003
Grand County	2014	Light Duty	0.85	11.55	1.20	0.06	0.03	0.01	472	0.05	0.030
Grand County	2014	Heavy Duty	0.50	2.86	10.03	0.78	0.63	0.02	2404	0.06	0.004
La Plata County	2014	Light Duty	0.80	10.61	1.18	0.05	0.03	0.01	468	0.04	0.030
La Plata County	2014	Heavy Duty	0.50	2.89	9.95	0.78	0.63	0.02	2404	0.06	0.004
Mesa County	2014	Light Duty	0.79	10.06	1.16	0.05	0.02	0.01	465	0.04	0.030
Mesa County	2014	Heavy Duty	0.49	2.82	9.75	0.78	0.63	0.02	2403	0.05	0.003
Moffat County	2014	Light Duty	0.81	10.80	1.18	0.05	0.03	0.01	469	0.05	0.029
Moffat County	2014	Heavy Duty	0.50	2.88	9.93	0.78	0.63	0.02	2404	0.06	0.003
Montrose County	2014	Light Duty	0.79	10.28	1.17	0.05	0.02	0.01	466	0.04	0.028
Montrose County	2014	Heavy Duty	0.50	2.89	9.86	0.78	0.63	0.02	2404	0.05	0.003
Rio Blanco County	2014	Light Duty	0.81	10.70	1.18	0.05	0.03	0.01	468	0.05	0.028
Rio Blanco County	2014	Heavy Duty	0.50	2.86	9.91	0.78	0.63	0.02	2404	0.05	0.004
Garfield County	2015	Light Duty	0.77	10.17	1.10	0.05	0.03	0.01	460	0.04	0.028
Garfield County	2015	Heavy Duty	0.43	2.44	8.61	0.69	0.55	0.02	2402	0.06	0.003
Grand County	2015	Light Duty	0.79	10.95	1.11	0.06	0.03	0.01	463	0.05	0.027
Grand County	2015	Heavy Duty	0.44	2.53	8.79	0.69	0.55	0.02	2404	0.06	0.004
La Plata County	2015	Light Duty	0.75	10.02	1.09	0.05	0.03	0.01	459	0.04	0.027

County	Year	Vehicle Type	Emission Rates (grams/mile)								
			VOC	CO	NOx	PM10	PM2.5	SO2	CO2	CH4	N2O
La Plata County	2015	Heavy Duty	0.44	2.55	8.72	0.69	0.55	0.02	2404	0.06	0.004
Mesa County	2015	Light Duty	0.74	9.49	1.07	0.05	0.02	0.01	456	0.04	0.027
Mesa County	2015	Heavy Duty	0.43	2.48	8.54	0.69	0.55	0.02	2403	0.06	0.003
Moffat County	2015	Light Duty	0.76	10.21	1.09	0.05	0.03	0.01	460	0.04	0.026
Moffat County	2015	Heavy Duty	0.44	2.54	8.70	0.69	0.55	0.02	2404	0.06	0.003
Montrose County	2015	Light Duty	0.74	9.70	1.07	0.05	0.02	0.01	457	0.04	0.025
Montrose County	2015	Heavy Duty	0.44	2.55	8.64	0.69	0.55	0.02	2404	0.06	0.003
Rio Blanco County	2015	Light Duty	0.76	10.11	1.08	0.05	0.03	0.01	459	0.04	0.025
Rio Blanco County	2015	Heavy Duty	0.44	2.52	8.68	0.69	0.55	0.02	2404	0.06	0.004
Garfield County	2016	Light Duty	0.71	9.52	1.01	0.05	0.02	0.01	450	0.04	0.026
Garfield County	2016	Heavy Duty	0.37	2.14	7.54	0.62	0.47	0.02	2402	0.06	0.003
Grand County	2016	Light Duty	0.73	10.29	1.02	0.06	0.03	0.01	453	0.05	0.025
Grand County	2016	Heavy Duty	0.38	2.22	7.70	0.62	0.47	0.02	2404	0.06	0.003
La Plata County	2016	Light Duty	0.69	9.38	1.00	0.05	0.03	0.01	449	0.04	0.025
La Plata County	2016	Heavy Duty	0.38	2.24	7.63	0.62	0.47	0.02	2404	0.06	0.004
Mesa County	2016	Light Duty	0.68	8.86	0.98	0.05	0.02	0.01	446	0.04	0.025
Mesa County	2016	Heavy Duty	0.37	2.18	7.47	0.62	0.47	0.02	2403	0.06	0.003
Moffat County	2016	Light Duty	0.70	9.57	1.00	0.05	0.03	0.01	450	0.04	0.024
Moffat County	2016	Heavy Duty	0.38	2.24	7.62	0.62	0.47	0.02	2404	0.06	0.003
Montrose County	2016	Light Duty	0.68	9.08	0.99	0.05	0.02	0.01	448	0.04	0.023
Montrose County	2016	Heavy Duty	0.38	2.25	7.56	0.62	0.47	0.02	2404	0.06	0.003
Rio Blanco County	2016	Light Duty	0.70	9.47	1.00	0.05	0.03	0.01	450	0.04	0.023
Rio Blanco County	2016	Heavy Duty	0.38	2.21	7.60	0.62	0.47	0.02	2404	0.06	0.004
Garfield County	2017	Light Duty	0.67	9.10	0.93	0.05	0.02	0.01	441	0.04	0.024
Garfield County	2017	Heavy Duty	0.32	1.87	6.58	0.55	0.41	0.02	2402	0.06	0.003
Grand County	2017	Light Duty	0.68	9.87	0.94	0.06	0.03	0.01	444	0.04	0.023
Grand County	2017	Heavy Duty	0.33	1.96	6.72	0.55	0.41	0.02	2404	0.06	0.003
La Plata County	2017	Light Duty	0.64	8.97	0.92	0.05	0.03	0.01	440	0.04	0.023
La Plata County	2017	Heavy Duty	0.33	1.98	6.67	0.55	0.41	0.02	2404	0.06	0.004
Mesa County	2017	Light Duty	0.64	8.46	0.90	0.04	0.02	0.01	437	0.04	0.023
Mesa County	2017	Heavy Duty	0.32	1.92	6.52	0.55	0.41	0.02	2403	0.06	0.003
Moffat County	2017	Light Duty	0.65	9.16	0.92	0.05	0.03	0.01	441	0.04	0.022
Moffat County	2017	Heavy Duty	0.33	1.97	6.65	0.55	0.41	0.02	2404	0.06	0.003
Montrose County	2017	Light Duty	0.63	8.67	0.91	0.05	0.02	0.01	438	0.04	0.021
Montrose County	2017	Heavy Duty	0.33	1.98	6.60	0.55	0.41	0.02	2404	0.06	0.003
Rio Blanco County	2017	Light Duty	0.65	9.06	0.92	0.05	0.03	0.01	440	0.04	0.021
Rio Blanco County	2017	Heavy Duty	0.33	1.95	6.64	0.55	0.41	0.02	2403	0.06	0.003
Garfield County	2018	Light Duty	0.62	8.72	0.86	0.05	0.02	0.01	432	0.04	0.022

County	Year	Vehicle Type	Emission Rates (grams/mile)								
			VOC	CO	NOx	PM10	PM2.5	SO2	CO2	CH4	N2O
Garfield County	2018	Heavy Duty	0.28	1.64	5.75	0.49	0.35	0.02	2402	0.06	0.003
Grand County	2018	Light Duty	0.64	9.49	0.87	0.05	0.03	0.01	436	0.04	0.021
Grand County	2018	Heavy Duty	0.28	1.72	5.88	0.49	0.35	0.02	2404	0.07	0.003
La Plata County	2018	Light Duty	0.60	8.60	0.85	0.05	0.02	0.01	431	0.04	0.021
La Plata County	2018	Heavy Duty	0.28	1.74	5.83	0.49	0.35	0.02	2404	0.07	0.004
Mesa County	2018	Light Duty	0.60	8.09	0.83	0.04	0.02	0.01	429	0.04	0.021
Mesa County	2018	Heavy Duty	0.28	1.68	5.70	0.49	0.35	0.02	2403	0.06	0.003
Moffat County	2018	Light Duty	0.61	8.79	0.85	0.05	0.03	0.01	432	0.04	0.021
Moffat County	2018	Heavy Duty	0.28	1.73	5.82	0.49	0.35	0.02	2404	0.07	0.003
Montrose County	2018	Light Duty	0.59	8.30	0.84	0.05	0.02	0.01	430	0.04	0.020
Montrose County	2018	Heavy Duty	0.28	1.74	5.77	0.49	0.35	0.02	2404	0.07	0.003
Rio Blanco County	2018	Light Duty	0.61	8.69	0.85	0.05	0.03	0.01	432	0.04	0.020
Rio Blanco County	2018	Heavy Duty	0.28	1.71	5.80	0.49	0.35	0.02	2403	0.07	0.003
Garfield County	2019	Light Duty	0.58	8.37	0.79	0.05	0.02	0.01	424	0.04	0.020
Garfield County	2019	Heavy Duty	0.24	1.43	5.04	0.44	0.30	0.02	2402	0.06	0.003
Grand County	2019	Light Duty	0.59	9.14	0.80	0.05	0.03	0.01	427	0.04	0.019
Grand County	2019	Heavy Duty	0.24	1.51	5.15	0.44	0.30	0.02	2404	0.07	0.003
La Plata County	2019	Light Duty	0.56	8.26	0.78	0.05	0.02	0.01	423	0.04	0.020
La Plata County	2019	Heavy Duty	0.24	1.53	5.11	0.44	0.30	0.02	2404	0.07	0.004
Mesa County	2019	Light Duty	0.56	7.76	0.77	0.04	0.02	0.01	421	0.03	0.020
Mesa County	2019	Heavy Duty	0.24	1.47	5.00	0.44	0.30	0.02	2403	0.07	0.003
Moffat County	2019	Light Duty	0.57	8.45	0.78	0.05	0.03	0.01	424	0.04	0.019
Moffat County	2019	Heavy Duty	0.24	1.52	5.10	0.44	0.30	0.02	2404	0.07	0.003
Montrose County	2019	Light Duty	0.56	7.97	0.77	0.05	0.02	0.01	422	0.03	0.018
Montrose County	2019	Heavy Duty	0.24	1.53	5.06	0.44	0.30	0.02	2404	0.07	0.003
Rio Blanco County	2019	Light Duty	0.57	8.35	0.78	0.05	0.03	0.01	424	0.04	0.018
Rio Blanco County	2019	Heavy Duty	0.24	1.50	5.09	0.44	0.30	0.02	2403	0.07	0.003
Garfield County	2020	Light Duty	0.55	8.06	0.73	0.05	0.02	0.01	416	0.04	0.018
Garfield County	2020	Heavy Duty	0.20	1.26	4.43	0.40	0.26	0.02	2402	0.07	0.003
Grand County	2020	Light Duty	0.56	8.84	0.74	0.05	0.03	0.01	420	0.04	0.018
Grand County	2020	Heavy Duty	0.21	1.34	4.54	0.40	0.26	0.02	2403	0.07	0.003
La Plata County	2020	Light Duty	0.53	7.96	0.73	0.05	0.02	0.01	416	0.04	0.018
La Plata County	2020	Heavy Duty	0.21	1.36	4.50	0.40	0.26	0.02	2404	0.07	0.003
Mesa County	2020	Light Duty	0.53	7.47	0.71	0.04	0.02	0.01	413	0.03	0.018
Mesa County	2020	Heavy Duty	0.20	1.30	4.40	0.40	0.26	0.02	2403	0.07	0.003
Moffat County	2020	Light Duty	0.54	8.15	0.73	0.05	0.03	0.01	417	0.04	0.018
Moffat County	2020	Heavy Duty	0.21	1.35	4.49	0.40	0.26	0.02	2404	0.07	0.003
Montrose County	2020	Light Duty	0.52	7.67	0.72	0.05	0.02	0.01	414	0.03	0.017

County	Year	Vehicle Type	Emission Rates (grams/mile)								
			VOC	CO	NOx	PM10	PM2.5	SO2	CO2	CH4	N2O
Montrose County	2020	Heavy Duty	0.21	1.36	4.46	0.40	0.26	0.02	2404	0.07	0.003
Rio Blanco County	2020	Light Duty	0.54	8.05	0.72	0.05	0.03	0.01	416	0.04	0.017
Rio Blanco County	2020	Heavy Duty	0.21	1.33	4.48	0.40	0.26	0.02	2403	0.07	0.003
Garfield County	2021	Light Duty	0.52	7.80	0.68	0.05	0.02	0.01	409	0.04	0.017
Garfield County	2021	Heavy Duty	0.17	1.12	3.94	0.36	0.23	0.02	2402	0.07	0.003
Grand County	2021	Light Duty	0.53	8.57	0.69	0.05	0.03	0.01	413	0.04	0.017
Grand County	2021	Heavy Duty	0.18	1.19	4.04	0.36	0.23	0.02	2403	0.07	0.003
La Plata County	2021	Light Duty	0.50	7.70	0.67	0.05	0.02	0.01	409	0.03	0.017
La Plata County	2021	Heavy Duty	0.18	1.21	4.00	0.36	0.23	0.02	2404	0.07	0.003
Mesa County	2021	Light Duty	0.50	7.22	0.66	0.04	0.02	0.01	406	0.03	0.017
Mesa County	2021	Heavy Duty	0.18	1.16	3.91	0.36	0.23	0.02	2403	0.07	0.003
Moffat County	2021	Light Duty	0.51	7.89	0.67	0.05	0.03	0.01	410	0.03	0.016
Moffat County	2021	Heavy Duty	0.18	1.21	3.99	0.36	0.23	0.02	2404	0.07	0.003
Montrose County	2021	Light Duty	0.49	7.42	0.66	0.05	0.02	0.01	407	0.03	0.016
Montrose County	2021	Heavy Duty	0.18	1.21	3.96	0.36	0.23	0.02	2404	0.07	0.003
Rio Blanco County	2021	Light Duty	0.51	7.79	0.67	0.05	0.02	0.01	409	0.03	0.016
Rio Blanco County	2021	Heavy Duty	0.18	1.19	3.98	0.36	0.23	0.02	2403	0.07	0.003

APPENDIX D

CARMMS Technical Memorandum
Draft CARMMS Coal and Uranium/Vanadium Mining Emissions
June 21, 2013

December 2014

June 21, 2013

MEMORANDUM

To:	Chad Meister and Forrest Cook, BLM Colorado State Office
From:	John Grant ENVIRON, Jim Zapert Carter Lake Consulting, Ralph Morris ENVIRON
Subject:	Draft CARMMS Coal and Uranium/Vanadium Mining Emissions

INTRODUCTION

The purpose of this document is to explain the sources of emissions and methodology used to compile Western Colorado coal and uranium/vanadium mining emissions. Emissions from coal and uranium/vanadium mines under federal jurisdiction have been developed for the Western Colorado Air Resource Management Modeling Study (West-CARMMS). The primary sources used to compile these emissions are Environmental Assessments and Environmental Impact Statements developed for individual mines as well as 2011 reported emissions from Colorado Department of Public Health (CDPHE) Air Pollutant Emission Notices (APENs).

These mining emissions will be used in baseline and future-year emissions inventories as estimates of coal and uranium mining emissions under Task 2 for the Western Colorado Bureau of Land Management (BLM) planning areas (see Figure 1-1).

Emissions were not estimated for mines not under federal jurisdiction; emissions from these mines in the West-CARMMS will be taken from existing inventory estimates. To avoid double counting in air quality modeling, emissions were not estimated for on-road or off-road mobile sources.

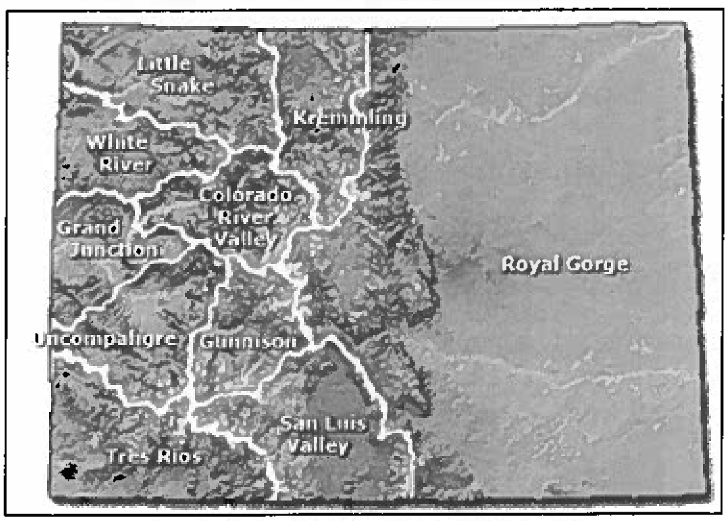

Figure 1-1. Colorado Field Office Planning Areas.

Pollutants

The emissions include estimates of criteria air pollutants (CAPs), greenhouse gases (GHGs), and hazardous air pollutants (HAPs) as follows:

- Criteria Pollutants
  - Carbon monoxide (CO)
  - Nitrogen oxides (NO_X)
  - Particulate matter less than or equal to 10 microns in diameter (PM_{10})
  - Particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$)
  - Sulfur dioxide (SO_2)
  - Volatile Organic Compounds (VOCs)
- Greenhouse Gases
  - Carbon dioxide (CO_2)
  - Methane (CH_4)
  - Nitrous oxide (N_2O)
- Hazardous Air Pollutants (HAPs)

While lead (pb) is a criteria pollutant, emissions of lead in the BLM western Colorado planning areas are expected to be extremely low and are therefore not included in this analysis.

HAP emissions were estimated for each emissions source.

Anthropogenic greenhouse gas emission inventories typically include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. Fluorinated gases are not expected to be emitted in appreciable quantities by any category considered in this emission inventory and were therefore not included in this analysis.

Temporal

The calculators estimate annual emissions associated coal and uranium/vanadium mining. Per the West-CARMMS scope of work, base year emissions are estimated for 2011 with annual emission forecasts to 2021.

EMISSIONS ESTIMATION

Coal Mining

Annual base year emissions from coal mining were estimated for the coal mines in Western Colorado under federal jurisdiction. As mentioned above, the mining emission estimates are not inclusive of mobile sources to avoid double counting with the mobile sources emissions in the air quality modeling inventory. Additionally, lacking any data upon which to base emission estimates, we have not accounted for potential growth in Kremmling Field Office surface coal mining in Jackson County where the U.S..Geological Survey (USGS) has defined the McCallum area as a known recoverable coal resource area. Table 1 provides a listing of the Western Colorado mines under BLM jurisdiction and the sources upon which emissions were estimated for those mines. Appendix D-1 provides emission estimates by year and mine.

Table 1. Coal mine emissions estimation methodology.

Mine Name (Field Office)	Emission Estimation Methodology
Book Cliffs Area (Grand Junction)	**Base Year 2011:** Non-operational, zero emissions. **Future Years 2012-2021:** Per the Grand Junction Field Office Draft Regional Management Plant Air Quality Technical Support document (ENVIRON, 2012a), the Book Cliffs area is assumed to have three additional new mines with estimated annual production of 2,000,000 tons/year in the future. Mines are assumed to come online in 2017, 2019, and 2021. Emissions for each mine are assumed to be similar to the Red Cliff Mine Environmental Impact Statement estimates (BLM, 2009) with a scalar of 25% to account for smaller production.
McClane (Grand Junction)	**Base Year 2011:** Non-operational, zero emissions. **Future Years 2012-2021:** Per the Grand Junction Field Office Draft Regional Management Plant Air Quality Technical Support document (ENVIRON, 2012a), the McClane mine is assumed operational from 2015 to 2021. Emissions are assumed to be at pre-December 2010 levels (BLM, 2012a).
Oak Mesa Area (Uncompahgre)	**Base Year 2011:** CDPHE APEN emissions (CDPHE, 2013). **Future Years 2012-2021:** Assume emissions are at levels estimated in the following Environmental Assessment documents: Bowie #2 (BLM, 2012c), West Elk (BLM, 2012d), and Elk Creek (BLM, 2012f) and that emissions remain constant in the 2012-2021 period. The Uncompahgre Coal Resource and Development Potential Report (BLM, 2010), indicated that Somerset Coal Field production is likely to remain stable at recent levels into the future (ENVIRON, 2012b).
King (Tres Rios)	**Base Year 2011:** CDPHE APEN emissions (CDPHE, 2013). **Future Years 2012-2021:** Assume emissions at permitted levels in future years (CDPHE, 2011).
Foidel (Kremmling)	**Base Year 2011, Future Year 2012:** CDPHE APEN emissions (CDPHE, 2013). **Future Years 2013-2021:** Assume emissions are at levels estimated in the draft Environment Assessment (BLM 2013a).
Deserado (White River)	**Base Year 2011:** CDPHE APEN emissions (CDPHE, 2013). **Future Years 2012-2021:** Assume emissions are at levels estimated in the draft Environment Assessment (BLM 2013b).
Trapper (Little Snake)	**Base Year 2011:** CDPHE APEN emissions (CDPHE, 2013). **Future Years 2012-2021:** Assume emissions remain constant at CDPHE 2011 APEN levels.
Colowyo (Little Snake)	**Base Year 2011:** CDPHE APEN emissions (CDPHE, 2013). **Future Years 2012-2021:** Assume emissions remain constant at CDPHE 2011 APEN levels.
Sage Creek (Little Snake)	**Base Year 2011:** Non-operational, zero emissions. **Future Years 2012-2021:** Assume mining begins in 2013 with constant emissions to 2021 at levels estimated in the draft Environment Assessment (BLM 2013c).

Uranium/Vanadium Mining

Annual emissions from uranium/vanadium mining were estimated according to the number of mines constructed and producing in a given year combined with estimates of emissions per mine from discrete emission producing activities: wind erosion, fugitive dust, and stationary engines. Activity inputs such as the equipment operation, tons of material processed, and disturbed area were taken primarily from the Whirlwind Mine EA (BLM, 2008). The estimated number of future uranium mines in operation in the Grand Junction Field Office and Uncompahgre Field Office were taken from ENVIRON (2012a) and ENVIRON (2012b) and are shown in Table 2. Emissions results are presented in Appendix D-2.

Table 2. Schedule of uranium/vanadium mines in production.

Year	Uranium Mining Facilities, GJFO (source: ENVIRON, 2012a)	Uranium Mining Facilities, UFO (source: ENVIRON, 2012b)
2011-2012	0	0
2013	1	1
2014	3	3
2015	5	5
2016	7	7
2017	9	9
2018	10	10
2019	11	11
2020	12	12
2021	13	13
2022	14	14
2023	15	15
2024	16	16
2025	17	17
2026	18	18
2027	19	19
2028	20	20
2029	20	20
2030	20	20

Wind Erosion

Wind erosion dust emissions were estimated based on AP-42 guidance for the estimation of emissions from industrial wind erosion (USEPA, 2006b) based on Equation 1:

$$E_{dust,i} = \frac{k \times P \times M \times N}{907{,}185} \qquad \text{Equation (1)}$$

where:

$E_{dust,i}$ are dust emissions for pollutant i from construction wind erosion [ton/mine]
k is the particle size multiplies [0.5 for PM_{10} and 0.075 from $PM_{2.5}$]
P is the erosion potential [g/m^2]
M is the number of disturbed acres [m^2/pad]
N is the number of disturbances
907,185 is a mass unit conversion [g/ton]

The erosions potential is a function of the wind friction velocity, as shown in Equation 2 and 3:

$$P = 58 \times (u^* - u_t)^2 + 25(u^* - u_t) \qquad \text{Equation (2)}$$

where:

u^* is the friction velocity (m/s)

u_t is the threshold friction velocity (m/s)

$$P = 0 \quad for \quad (u^* \leq u_t) \qquad \text{Equation (3)}$$

Friction velocity estimates (u*) were made by multiplying the average annual fastest wind speed from Uncompahgre, Colorado from 1947 to 1979 by 0.053 per AP-42 guidance (USEPA, 2006b).

Fugitive Dust

Fugitive dust emissions from ventilation and surface facilities were taken from Whirlwind Mine Environmental Assessment (BLM, 2008) permit not-to-exceed values.

Stationary Engines

This category refers to emissions associated with stationary internal combustion engines used in uranium mining. Emission estimates for NOx were taken from the Whirlwind Mine Environmental Assessment permit not-to-exceed values (BLM, 2008). Emission estimates were not available in the Whirlwind Mine Environmental Assessment (BLM, 2008) for other pollutants. Emissions of other pollutants were estimated based on the EPA NONROAD2008a model (USEPA, 2009b) except for N_2O which was estimated based on the 2009 API O&G GHG Methodologies Compendium, Tables 4-13 and 4-17 (API, 2009).

Emissions on per piece of equipment were estimated according to Equation 74:

$$E_{engine,i} = \frac{EF_i \times HP \times LF \times t_{event} \times n}{907{,}185} \qquad \text{Equation (4)}$$

where:

E_{engine} are emissions of pollutant *i* [ton/equipment]

EF_i is the emissions factor of pollutant *i* [g/hp-hr]

HP is the horsepower [hp]

LF is the load factor

t_{event} is the number of hours the engine is used [hr/pad]

907,185 is the mass unit conversion [g/ton]

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APPENDIX D-1

Coal Mining Emissions

Table A1. 2011 to 2021 Coal Mine Emissions for mines in Western Colorado under federal jurisdiction (tons/year).

Year	VOC (short tons/year)	CO (short tons/year)	NOx (short tons/year)	PM10 (short tons/year)	PM2.5 (short tons/year)	SO2 (short tons/year)	CO2 (short tons/year)	CH4 (short tons/year)	N2O (short tons/year)	HAPs (short tons/year)	CO2eq (short tons/year)	CO2eq (metric tonnes/year)
Book Cliffs (Grand Junction Field Office)												
2011	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0
2017	1	3	20	6	2	0	2,616	21,278	0	0	449,496	407,891
2018	1	3	20	6	2	0	2,616	21,278	0	0	449,496	407,891
2019	2	5	40	12	4	0	5,231	42,556	0	0	898,992	815,783
2020	2	5	40	12	4	0	5,231	42,556	0	0	898,992	815,783
2021	3	8	60	18	5	0	7,847	63,833	0	0	1,348,489	1,223,674
McClane (Grand Junction Field Office)												
2011	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	13	0.3	0	0	3,818	0	0	80,178	72,757
2016	0	0	0	13	0.3	0	0	3,818	0	0	80,178	72,757
2017	0	0	0	13	0.3	0	0	3,818	0	0	80,178	72,757
2018	0	0	0	13	0.3	0	0	3,818	0	0	80,178	72,757
2019	0	0	0	13	0.3	0	0	3,818	0	0	80,178	72,757
2020	0	0	0	13	0.3	0	0	3,818	0	0	80,178	72,757
2021	0	0	0	13	0.3	0	0	3,818	0	0	80,178	72,757

Year	VOC (short tons/year)	CO (short tons/year)	NOx (short tons/year)	PM10 (short tons/year)	PM2.5 (short tons/year)	SO2 (short tons/year)	CO2 (short tons/year)	CH4 (short tons/year)	N2O (short tons/year)	HAPs (short tons/year)	CO2eq (short tons/year)	CO2eq (metric tonnes/year)
Oak Mesa Area (Uncompahgre Field Office)												
2011	2	15	14	291	81	0.2	44,671	80,619	0.8	0.2	1,737,918	1,577,058
2012	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2013	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2014	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2015	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2016	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2017	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2018	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2019	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2020	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
2021	13	41	55	513	190	0.8	53,176	140,290	0.9	1.3	2,999,549	2,721,914
King (Tres Rios Field Office)												
2011	0	0	0	15	14	0	0	0	0	0	0	0
2012	0	0	0	25	24	0	0	0	0	0	0	0
2013	0	0	0	25	24	0	0	0	0	0	0	0
2014	0	0	0	25	24	0	0	0	0	0	0	0
2015	0	0	0	25	24	0	0	0	0	0	0	0
2016	0	0	0	25	24	0	0	0	0	0	0	0
2017	0	0	0	25	24	0	0	0	0	0	0	0
2018	0	0	0	25	24	0	0	0	0	0	0	0
2019	0	0	0	25	24	0	0	0	0	0	0	0
2020	0	0	0	25	24	0	0	0	0	0	0	0
2021	0	0	0	25	24	0	0	0	0	0	0	0

Year	VOC (short tons/year)	CO (short tons/year)	NOx (short tons/year)	PM10 (short tons/year)	PM2.5 (short tons/year)	SO2 (short tons/year)	CO2 (short tons/year)	CH4 (short tons/year)	N2O (short tons/year)	HAPs (short tons/year)	CO2eq (short tons/year)	CO2eq (metric tonnes/year)
Foidel (Kremmling Field Office)												
2011	0	1	4	259	54	0	*	*	*	0	*	*
2012	0	1	4	259	54	0	*	*	*	0	*	*
2013	5	6	11	161	33	0	36,878	1,257	0	0	63,298	57,439
2014	5	6	11	161	33	0	36,878	1,257	0	0	63,298	57,439
2015	5	6	11	161	33	0	36,878	1,257	0	0	63,298	57,439
2016	5	6	11	161	33	0	36,878	1,257	0	0	63,298	57,439
2017	5	6	11	161	33	0	36,878	1,257	0	0	63,298	57,439
2018	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0	0	0	0	0	0
Deserado (White River Field Office)												
2011	0	0	0	119	13	0	*	*	*	0	*	*
2012	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2013	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2014	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2015	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2016	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2017	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2018	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2019	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2020	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383
2021	5	6	11	126	15	0	29,498	923	0	0	48,910	44,383

Year	VOC (short tons/year)	CO (short tons/year)	NOx (short tons/year)	PM10 (short tons/year)	PM2.5 (short tons/year)	SO2 (short tons/year)	CO2 (short tons/year)	CH4 (short tons/year)	N2O (short tons/year)	HAPs (short tons/year)	CO2eq (short tons/year)	CO2eq (metric tonnes/year)
Trapper (Little Snake Field Office)												
2011	0	452	115	852	251	0	*	*	*	0	*	*
2012	0	452	115	852	251	0	*	*	*	0	*	*
2013	0	452	115	852	251	0	*	*	*	0	*	*
2014	0	452	115	852	251	0	*	*	*	0	*	*
2015	0	452	115	852	251	0	*	*	*	0	*	*
2016	0	452	115	852	251	0	*	*	*	0	*	*
2017	0	452	115	852	251	0	*	*	*	0	*	*
2018	0	452	115	852	251	0	*	*	*	0	*	*
2019	0	452	115	852	251	0	*	*	*	0	*	*
2020	0	452	115	852	251	0	*	*	*	0	*	*
2021	0	452	115	852	251	0	*	*	*	0	*	*
Colowyo (Little Snake Field Office)												
2011	0	0	0	1,700	252	0	*	*	*	0	*	*
2012	0	0	0	1,700	252	0	*	*	*	0	*	*
2013	0	0	0	1,700	252	0	*	*	*	0	*	*
2014	0	0	0	1,700	252	0	*	*	*	0	*	*
2015	0	0	0	1,700	252	0	*	*	*	0	*	*
2016	0	0	0	1,700	252	0	*	*	*	0	*	*
2017	0	0	0	1,700	252	0	*	*	*	0	*	*
2018	0	0	0	1,700	252	0	*	*	*	0	*	*
2019	0	0	0	1,700	252	0	*	*	*	0	*	*
2020	0	0	0	1,700	252	0	*	*	*	0	*	*
2021	0	0	0	1,700	252	0	*	*	*	0	*	*

Year	VOC (short tons/year)	CO (short tons/year)	NOx (short tons/year)	PM10 (short tons/year)	PM2.5 (short tons/year)	SO2 (short tons/year)	CO2 (short tons/year)	CH4 (short tons/year)	N2O (short tons/year)	HAPs (short tons/year)	CO2eq (short tons/year)	CO2eq (metric tonnes/year)
Sage Creek (Little Snake Field Office)												
2011	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0
2013	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2014	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2015	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2016	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2017	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2018	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2019	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2020	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480
2021	4	3	4	112	15	0	4,178	298	0	0	10,447	9,480

* Greenhouse gas emissions not available for all years for the Trapper and Colowyo mines, in 2011 for the Deserado mine, and in 2011 and 2012 for the Foidel mine.

APPENDIX D-2

Uranium/Vanadium Mining Emissions

Table B1. Grand Junction Field Office Uranium/Vanadium Mine Emissions (tons/year).

Year	Mines	VOC (short tons/year)	CO (short tons/year)	NOx (short tons/year)	PM10 (short tons/year)	PM2.5 (short tons/year)	SO2 (short tons/year)	CO2 (short tons/year)	CH4 (short tons/year)	N2O (short tons/year)	HAPs (short tons/year)	CO2eq (short tons/year)	CO2eq (metric tonnes/ year)
2011	0	0	0	0	0	0	0.0	0	0.0	0.0	0.0	0	0
2012	0	0	0	0	0	0	0.0	0	0.0	0.0	0.0	0	0
2013	1	1	4	12	14	13	0.2	1,077	0.0	0.0	0.1	1,080	980
2014	3	3	13	37	42	39	0.7	3,231	0.0	0.0	0.3	3,240	2,940
2015	5	5	22	62	69	66	1.2	5,386	0.1	0.0	0.5	5,401	4,901
2016	7	7	31	86	97	92	1.6	7,540	0.1	0.1	0.7	7,561	6,861
2017	9	9	40	111	125	118	2.1	9,694	0.1	0.1	0.9	9,721	8,821
2018	10	10	44	123	139	131	2.3	10,771	0.2	0.1	1.0	10,801	9,801
2019	11	11	49	135	153	145	2.6	11,848	0.2	0.1	1.1	11,881	10,782
2020	12	12	53	148	167	158	2.8	12,925	0.2	0.1	1.2	12,961	11,762
2021	13	13	57	160	181	171	3.0	14,003	0.2	0.1	1.3	14,041	12,742
2022	14	14	62	172	194	184	3.3	15,080	0.2	0.1	1.4	15,122	13,722
2023	15	15	66	185	208	197	3.5	16,157	0.2	0.1	1.5	16,202	14,702
2024	16	16	71	197	222	210	3.7	17,234	0.2	0.1	1.6	17,282	15,682
2025	17	17	75	209	236	223	4.0	18,311	0.3	0.1	1.7	18,362	16,662
2026	18	18	79	221	250	236	4.2	19,388	0.3	0.2	1.8	19,442	17,642
2027	19	19	84	234	264	250	4.5	20,465	0.3	0.2	1.9	20,522	18,623
2028	20	20	88	246	278	263	4.7	21,542	0.3	0.2	2.0	21,602	19,603
2029	20	20	88	246	278	263	4.7	21,542	0.3	0.2	2.0	21,602	19,603
2030	20	20	88	246	278	263	4.7	21,542	0.3	0.2	2.0	21,602	19,603

Table B2. Uncompahgre Field Office Uranium/Vanadium Mine Emissions (tons/year).

Year	Mines	VOC (short tons/year)	CO (short tons/year)	NOx (short tons/year)	PM10 (short tons/year)	PM2.5 (short tons/year)	SO2 (short tons/year)	CO2 (short tons/year)	CH4 (short tons/year)	N2O (short tons/year)	HAPs (short tons/year)	CO2eq (short tons/year)	CO2eq (metric tonnes/ year)
2011	0	0	0	0	0	0	0.0	0	0.0	0.0	0.0	0	0
2012	0	0	0	0	0	0	0.0	0	0.0	0.0	0.0	0	0
2013	1	1	4	12	14	13	0.2	1,077	0.0	0.0	0.1	1,080	980
2014	3	3	13	37	42	39	0.7	3,231	0.0	0.0	0.3	3,240	2,940
2015	5	5	22	62	69	66	1.2	5,386	0.1	0.0	0.5	5,401	4,901
2016	7	7	31	86	97	92	1.6	7,540	0.1	0.1	0.7	7,561	6,861
2017	9	9	40	111	125	118	2.1	9,694	0.1	0.1	0.9	9,721	8,821
2018	10	10	44	123	139	131	2.3	10,771	0.2	0.1	1.0	10,801	9,801
2019	11	11	49	135	153	145	2.6	11,848	0.2	0.1	1.1	11,881	10,782
2020	12	12	53	148	167	158	2.8	12,925	0.2	0.1	1.2	12,961	11,762
2021	13	13	57	160	181	171	3.0	14,003	0.2	0.1	1.3	14,041	12,742
2022	14	14	62	172	194	184	3.3	15,080	0.2	0.1	1.4	15,122	13,722
2023	15	15	66	185	208	197	3.5	16,157	0.2	0.1	1.5	16,202	14,702
2024	16	16	71	197	222	210	3.7	17,234	0.2	0.1	1.6	17,282	15,682
2025	17	17	75	209	236	223	4.0	18,311	0.3	0.1	1.7	18,362	16,662
2026	18	18	79	221	250	236	4.2	19,388	0.3	0.2	1.8	19,442	17,642
2027	19	19	84	234	264	250	4.5	20,465	0.3	0.2	1.9	20,522	18,623
2028	20	20	88	246	278	263	4.7	21,542	0.3	0.2	2.0	21,602	19,603
2029	20	20	88	246	278	263	4.7	21,542	0.3	0.2	2.0	21,602	19,603
2030	20	20	88	246	278	263	4.7	21,542	0.3	0.2	2.0	21,602	19,603

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BLM

United States Department of the Interior
Bureau of Land Management

Environmental Assessment
DOI-BLM-CO-S010-2012-0036-EA

July 2013

D.J. Simmons, Inc.
Two Pinto Wells Project
Pinto 1-7 and Pinto 3-17 Oil Wells
Dolores County, Colorado

Location: The two-well project area is located in the Papoose Canyon Oil Field about 15.5 kilometers (9.6 miles) south-southwest of Dove Creek, Colorado in the vicinity of the intersection of Dolores County Roads 4 and T, and on County Road 4 on the point of land between Squaw and Cross Canyons.

Pinto 1-7: Lot 11 (SE NW) Sec 7, T39N, R19W
Pinto 3-17: SE NW Sec 17, T39N, R19W

Applicant/Address: D.J. Simmons, Inc.
1009 Ridgeway Place, Suite 200
Farmington, NM 87401

Tres Rios Field Office
29211
Dolores, CO 81323
970-882-7296
970-882-6841

Two Pinto-Wells Project - Pinto 1-7 and Pinto 3-17
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CHAPTER 1
INTRODUCTION AND NEED FOR THE PROPOSED ACTION

INTRODUCTION

D.J. Simmons, Inc. (D.J. Simmons) is proposing to vertically drill the Pinto 1-7 and Pinto 3-17 oil wells and to construct associated access roads and pipelines. The proposed project would be located on privately-owned surface with the subsurface minerals owned by the federal government and administered by the Bureau of Land Management (BLM) Tres Rios Field Office (TRFO). D.J. Simmons has submitted Colorado Oil and Gas Conservation Commission (COGCC) applications and Applications for Permits to Drill (APDs) the two oil wells and associated well tie pipelines. The proposed wells would be located in Dolores County, Colorado as shown on Figure 1. Legal coordinates of the proposed wells and lease information are given in Table 1. The southwest corner of the proposed Pinto 1-7 well pad would be located approximately 50 feet outside the boundary of the Canyon of the Ancients National Monument (CANM) (Figure 2). The proposed pipeline for Pinto 3-17 terminates at the existing Santa Fe Canyon 42-18 well site that is located on private land about 130-feet east of the CANM boundary (Figure 3).

Table 1. Lease Summaries and Legal Descriptions for Proposed Well Pad Locations.

Well Name	Mineral Lease	Surface Location (Ownership)	Bottom Hole Location (Mineral Ownership)	Proposed Vertical Depth (Feet)
Pinto 1-7	COC 38420	2,832 feet from the south line (FSL) and 2,841 feet from the east line (FEL); Lot 11, Section 7, Township 39 North, Range 19 West (Fee)	2,832 feet FSL and 2,841 feet FEL; SE NW, Section 7, Township 39 North, Range 19 West (BLM)	6,325
Pinto 3-17	COC 36140	2,498 feet from the north line (FNL) and 2,523 feet from the west line (FWL); SE NW Section 17, Township 39 North, Range 19 West (Fee)	2,498 feet FNL and 2,523 feet FWL; SE NW Section 17, Township 39 North, Range 19 West (BLM)	6,350

This Environmental Assessment (EA) has been prepared to assess the site-specific environmental effects of the proposed development of two oil wells, and associated access roads and pipelines as proposed by D.J. Simmons. The EA would be used to assist the BLM TRFO in project planning and ensuring compliance with the National Environmental Policy Act (NEPA) of 1969, as amended (Public Law [Pub. L.] 91-90, 42 United States Code [USC] 4321 et seq.).

PURPOSE AND NEED FOR THE PROPOSED ACTION

The purpose of the proposed action is to allow the applicant to exercise valid existing fluid-mineral rights by developing the mineral estate from Federal Leases COC 38420 and COC 36140. The need for the action is established by the BLM's responsibility under the Mineral Leasing Act, the Mining and Minerals Policy Act of 1970 (30 USC 21 et seq.), the Federal Land Policy and Management Act, the National Materials and Minerals Policy, Research, and Development Act of 1980 (30 USC 1601 et seq.), and the Federal Onshore Oil and Gas Leasing Reform Act of 1987 (30 USC 181 et seq.; 43 Code of Federal Regulations [CFR] 3160) to consider the proposal submitted by DJ Simmons. The BLM will decide whether or not to approve the APDs, and if so, under what terms and conditions.

CONFORMANCE WITH BLM LAND USE PLAN(S)

Pursuant to 40 CFR 1508.20 and 1502.28, this EA tiers to the analysis contained in the Record of Decision for San Juan/San Miguel Resource Management Plan and Final Environmental Impact Statement (EIS) (USDI/BLM 1985) and the Colorado Oil and Gas Leasing and Development Final EIS amendment to the Resource Management Plan (USDI/BLM 1991).

The proposed action is subject to and has been reviewed for conformance with the following land use plan (43 CFR 1610.5, BLM 1617.3):

- San Juan/San Miguel Planning Area Resource Management Plan and the Record of Decision approved September 1985 (USDI/BLM 1985).
- Colorado Oil and Gas Leasing and Development Final Environmental Impact Statement Record of Decision, approved October 1991 (USDI/BLM 1991b).

BLM actively encourages and facilitates the development by private industry of public land mineral resources so that national and local needs are satisfied and economically and environmentally sound exploration, extraction, and reclamation practices are provided (USDI/BLM 1985; page 17).

RELATIONSHIPS TO STATUTES, REGULATIONS AND OTHER PLANS

The Proposed Action is consistent with the terms, conditions of other Federal Laws, statutes, regulations, and other plans including:

- The Endangered Species Act of 1973 (USC 4321 et seq.)
- The Migratory Bird Treaty Act of 1918, as amended (16 USC 703-712)
- The Bald and Golden Eagle Protection Act of 1940, as amended (16 USC 668-668d)
- The Federal Water Pollution Control Act of 1948, as amended (33 USC 26)
- The Clean Air Act of 1963, as amended (42 USC 7401 et seq.)
- Clean Water Act of 1972, amended 1977 (33 USC 1251 et seq.)
- The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 USC 103)
- The Antiquities Act of 1906, as amended (16 USC 431–433)

- The National Historic Preservation Act of 1966, as amended (16 USC 470 et seq.)
- The Archaeological and Historic Preservation Act of 1974 (16 USC 469-469c)
- The Archaeological Resources Protection Act of 1979, as amended (16 USC 470aa-mm)
- The American Indian Religious Freedom Act of 1978, as amended (42 USC 1996)
- The Native American Graves Protection and Repatriation Act of 1990 (25 USC 3001 et seq.)
- Executive Order 12898 of 1994 "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations"
- Code of Federal Regulations, Title 43, part 3101 section1-2, Surface Use Rights.

This EA considers the requirements of these laws and implementing regulations, as applicable, as part of the proposed action. The proposed action, including associated applicant-committed mitigation measures, complies with the laws and implementing regulations indicated above.

SCOPING AND PUBLIC INVOLVEMENT AND ISSUES

An on-site inspection was conducted on June 4, 2012 at each of the proposed well sites. Present were the landowners, representatives from D.J. Simmons, the BLM project manager, a BLM archaeologist, wildlife biologists from Colorado Parks and Wildlife, consultants from Ecosphere Environmental Services (Ecosphere) and Woods Canyon Archaeological Consultants (Woods Canyon); and surveyors from Basin Surveying. A follow-up on-site inspection was conducted by the BLM project manager and a BLM wildlife biologist on June 5, 2013. A second follow-up on-site inspection was conducted on July 19, 2012, by the BLM project manage and a COGCC representative. The on-site discussions were used as the initial scoping for the project, to develop the design features for the project, and to shape the content of the APD.

In addition, two public hearings were held in Dove Creek about the project. A Dolores County Planning Commission public hearing was held on March 13, 2013 and a Dolores County Board of County Commissioners public hearing was held on May 6, 2013. Public notice was published in the Dove Creek Press for two consecutive weeks prior to both of these hearings and certified letters were sent to all adjacent land owners notifying them of the project and the up-coming hearings. A third certified project notification letter was sent to all adjacent landowners to meet COGCC requirements.

The environmental resources were examined by an interdisciplinary team (ID-Team) of BLM specialists to determine which resources were present at the project area and which of those had a potential to be impacted by the proposed project. Those resources that were determined to be present with the potential for relevant impacts were evaluated by the ID-team and are documented in the Interdisciplinary Team Checklist (Appendix A) and in this EA. Concerns were expressed that the proposed action may affect the following the resources:

- Air Quality.
- Cultural Resources

- Fish and Wildlife
- Threatened or Endangered Species
- Lands and Access
- Soils
- Water Resources and Water Quality
- Visual Resources

Resources that were considered but not analyzed in the EA are listed in the ID-Team Checklist (Appendix A) with brief explanations for why these resources were not analyzed further.

CHAPTER 2
DESCRIPTION OF ALTERNATIVES

INTRODUCTION

D.J. Simmons has filed APDs for the proposed wells, which would be located on split-estate lands, where the surface is privately owned and the federal government owns the subsurface minerals. The proposed action would allow for development of the mineral resources present in the area, while minimizing environmental effects to surface resources.

Potential sites were evaluated for archaeological, biological, and hydrologic resource concerns and landowners were consulted. Based upon this screening, the proposed project locations were chosen as those that would least impact resources, while allowing for efficient and economical development of the mineral resources and consideration of landowner needs. In choosing the well pad and access road/pipeline locations, a number of factors were considered including the potential for the occurrence of cultural resources on the site, impacts to wildlife, consideration of topography and the presence of drainage channels, and the proximity to existing access routes.

The proposed action is described in detail below. The no action alternative is considered and analyzed to provide a baseline for comparison of the impacts of the proposed action. The site locations represent the result of a screening process that accounted for landowner needs and environmental concerns. Based on this screening process, other potential locations were excluded from consideration.

PROPOSED ACTION ALTERNATIVE

D.J. Simmons filed APDs with the BLM TRFO and the COGCC to vertically drill and develop the proposed Pinto 1-7 and the Pinto 3-17 oil wells on private land in Dolores County, Colorado (Table 1 and Figure 1). The wells would be drilled to the Upper Ismay/Desert Creek zone of the Paradox Formation. The proposed action would extract oil (liquid hydrocarbons) and natural gas from the formation. The APDs were submitted in November 2012.

The two wells are proposed to be drilled in July through fall of 2013. Drilling, testing, and well completion would take approximately 45 days at each well - for a total of about 3 months to drill and complete both wells. Well pad construction would take approximately an additional 2 weeks. Gas pipelines, as described below and in Table 2, would be constructed after testing and completion of the wells and upon determination that the pipeline is necessary to transport produced natural gas. Construction of the pipeline at Pinto 3-17 would take about 1 week. The pipeline at Pinto 1-7 is much shorter and could be completed in about 2 days. If the wells are successful, the production period could last up to about 30 years. Given successful wells, interim reclamation of the well pads would begin immediately after well and pipeline completion as described below and in Appendix B.

A summary of the proposed surface disturbance is provided in Table 2 and details of construction and reclamation of the sites are described below.

Construction activities associated with the proposed action include drilling the two proposed wells, building a new access road and pipeline right-of-way (ROW) to Pinto 1-7 (Figure 2), improving the existing access road to Pinto 3-17, constructing a new buried pipeline from Pinto 3-17 to the tie-in at the Santa Fe Canyon 42-18 well site (Figure 3), and installing surface equipment necessary for production. All construction, drilling, access roads, and pipelines would be located on private lands.

Surface disturbance for the proposed Pinto 1-7 well pad would include a 300-foot by 225-foot well pad with a 50-foot wide construction buffer zone around the perimeter, plus a 105-foot long access road and pipeline ROW, for a total maximum disturbance of 2.98 acres (Table 2). The 50-ft. construction buffer is available for construction activities such as top-soil storage and equipment movement. Therefore, the minimum disturbance would consist of the working well pad and the access-pipeline ROW, a total of 1.65 acres and the maximum disturbance will be 2.98 acres. The proposed Pinto 1-7 well project is shown on Figure 2.

The proposed Pinto 3-17 well pad would include a 225-foot by 300-foot area, with a construction buffer zone of 50 feet wide on the north and west sides, 25 feet wide on the south side, and 9.4 feet wide on the east side for a maximum total well-pad disturbance of 2.48 acres (Table 2). The access road would be an improved farm two-track that would be 2,645-feet long and 40-feet wide - a total of 2.43 acres. The pipeline corridor, if needed, would be completely separate from the access road and would be 2,484-feet long and 40-feet wide - a total of 3.29 acres. Therefore the total maximum disturbance for Pinto 3-17 would be 8.2 acres (2.48 + 2.43 + 3.29). The proposed Pinto 3-17 well project is shown on Figure 3.

The well pad locations would be leveled and graded to provide a work area for the drilling activities. Stripped topsoil would be segregated outside of the well pad work area, but within the construction buffer zone that defines the construction boundary limit. The stripped topsoil would be utilized for interim reclamation activities and excavated materials from cuts would be used on the fill portion of the location to level the pad. The drill rigs would be assembled on each well pad. Associated drilling facilities and equipment may include a drill rig, generators, diesel engines, water tanks, mud tanks, safety stations, equipment and material storage units, blowout preventer, an accumulator station, and gas buster. Produced water and cuttings on each well pad would be contained in a lined 70-foot by 110-foot temporary pit.

Each well location would require construction of a new or improved access road. The proposed roads would spur from county roads (Figures 1, 2, and 3) and would be constructed according to specifications outlined in the Surface Use Plan. Roads would be constructed within a 40-foot wide corridor, which would be reclaimed back to a 25-foot width. Refer to Table 2 for the amount of disturbance associated with proposed access roads.

Table 2. Summary of Proposed Surface Disturbance, in acres.

Well Name	Access Road Length/Disturbance[1]	Pipeline Length/Disturbance	Well Pad Area (Acres)	Total Affected Surface Area (Acres)
Pinto 1-7	105 feet/0.10 acre	105 feet/0.10 acre [2]	2.98	3.08
Pinto 3-17	2,645 feet/2.43 acre	2,484 feet/3.29 acres	2.48	8.2
			Total	**11.28**

[1] Access road construction width would be 40 feet wide and reclaimed to 25 feet wide.

[2] No additional disturbance associated with pipeline; constructed within the access road corridor.

Following well completion and successful production, two or three storage tanks with 400- to 500-barrel capacities would be located on each well pad. Produced liquids would be stored on site in the tanks and trucked out as needed. One to two truck trips per week are anticipated.

Subsurface natural gas pipelines may or may not be needed as part of the proposed action because it is unknown how much gas, if any, would be produced from the wells. The pipeline associated with the Pinto 1-7 well would be constructed completely within the access road corridor, resulting in no additional surface disturbance. The Pinto 3-17 pipeline would result in additional disturbance of 3.29 acres of disturbance along its 2,484 foot length. Typically, pipeline construction consists of clearing the corridor, trenching a ditch 5 to 6 feet deep, stringing and welding pipe, placing pipe in the trench, backfilling the trench, and reclaiming disturbed areas of the corridor. Reclamation of the Pinto 3-17 pipeline corridor should result in 100-percent of the disturbed area reclaimed to its pre-construction land use.

Interim reclamation of the unused areas of the well pad, the reserve pit, and pipeline route would be implemented after construction, drilling, and well completion activities are completed. Interim and final reclamation activities would be completed as described in Appendix B - Surface Use Design Features, Conditions of Approval (COAs), and Proposed Mitigation Measures. In summary, disturbed areas would be re-contoured to original topography, re-seeded with a seed mix as specified by the landowner, and weeds would be controlled at least to the specifications outlined in the Dolores County Development and Land Use Regulations.

Additional details regarding construction activities and interim and final reclamation are provided in the Design Features section of this EA, below, and in Appendix B.

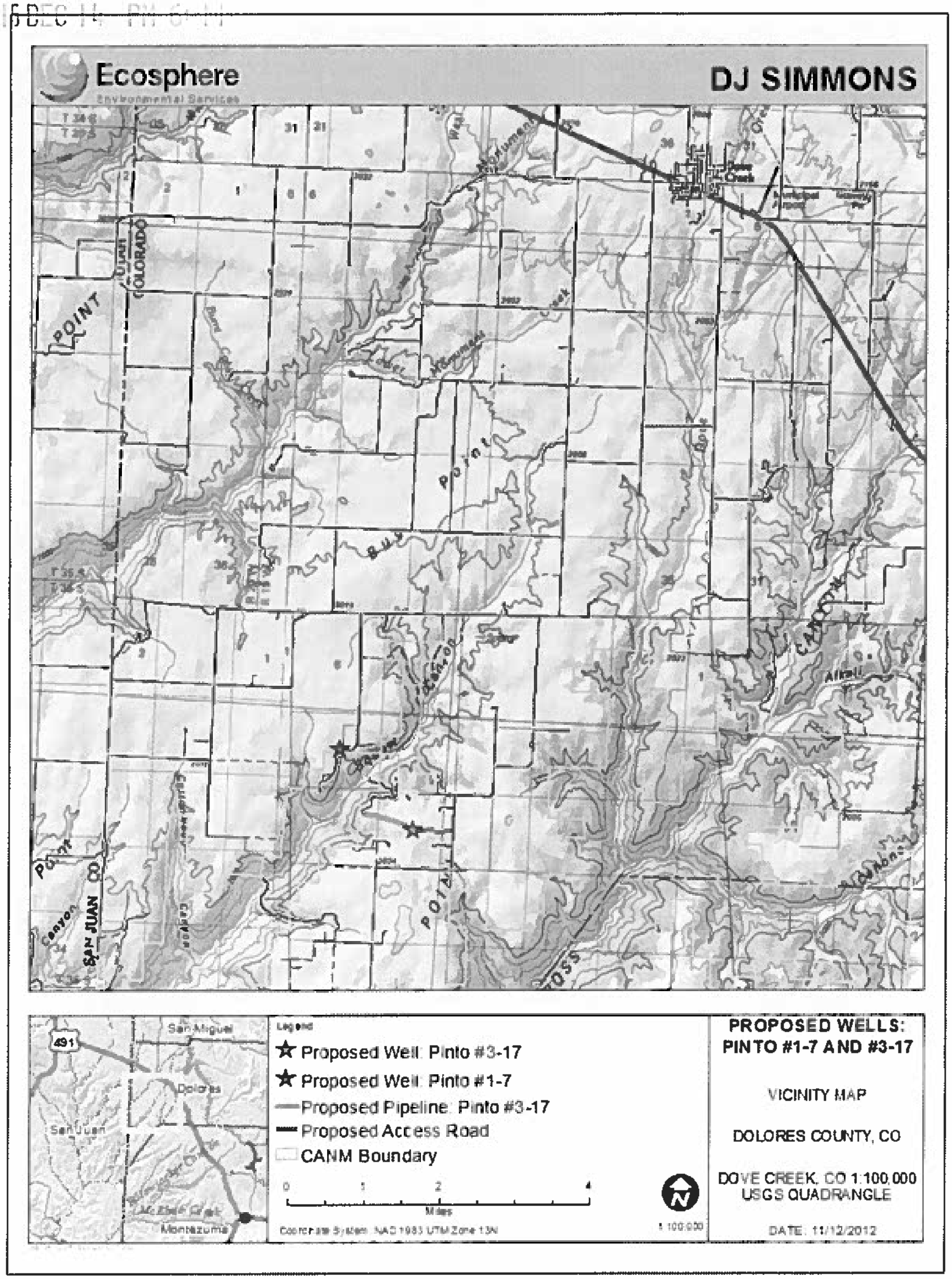

Figure 1: Vicinity of the proposed Pinto 1-7 and Pinto 3-17

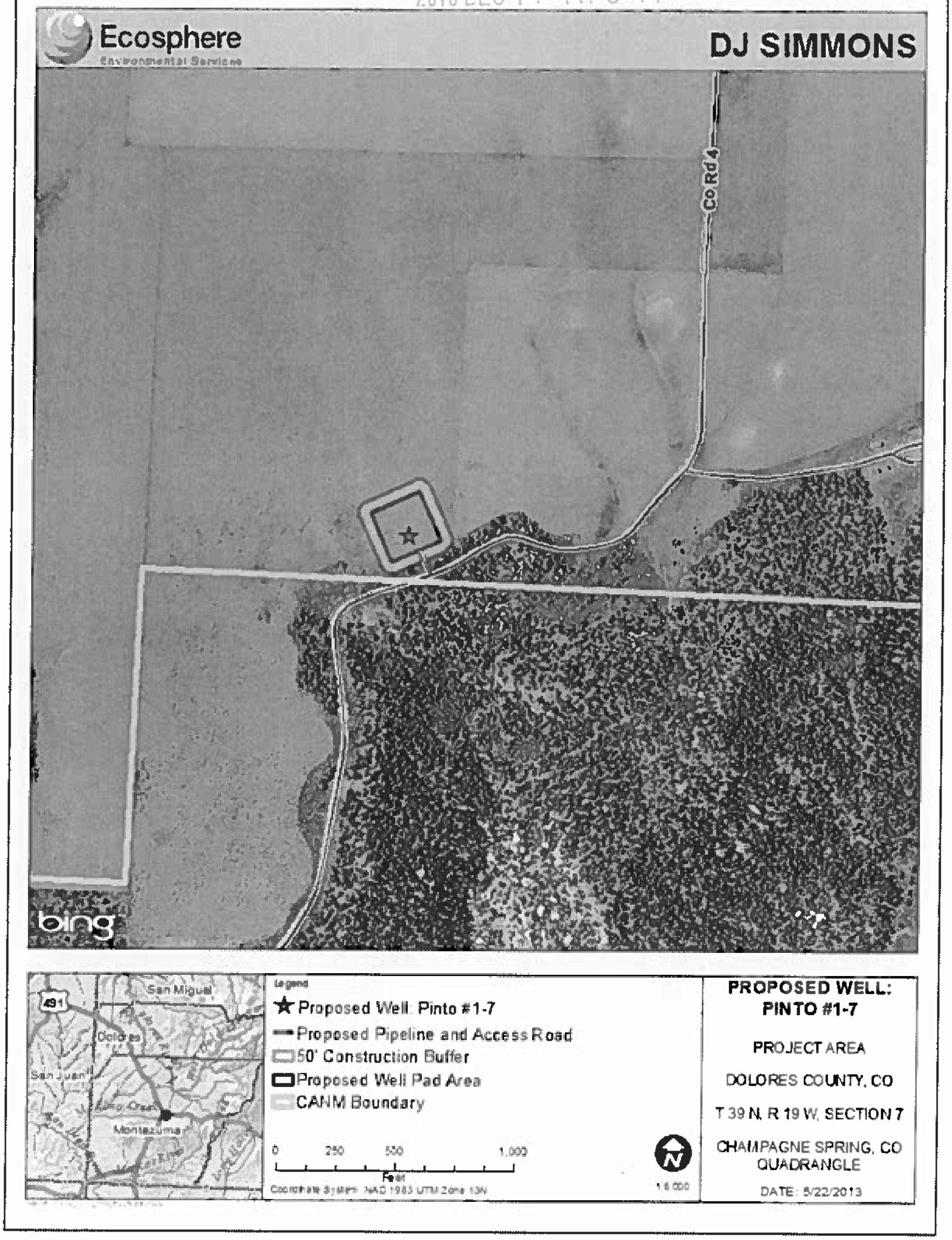

Figure 2: Proposed Pinto #1-7 Project Area

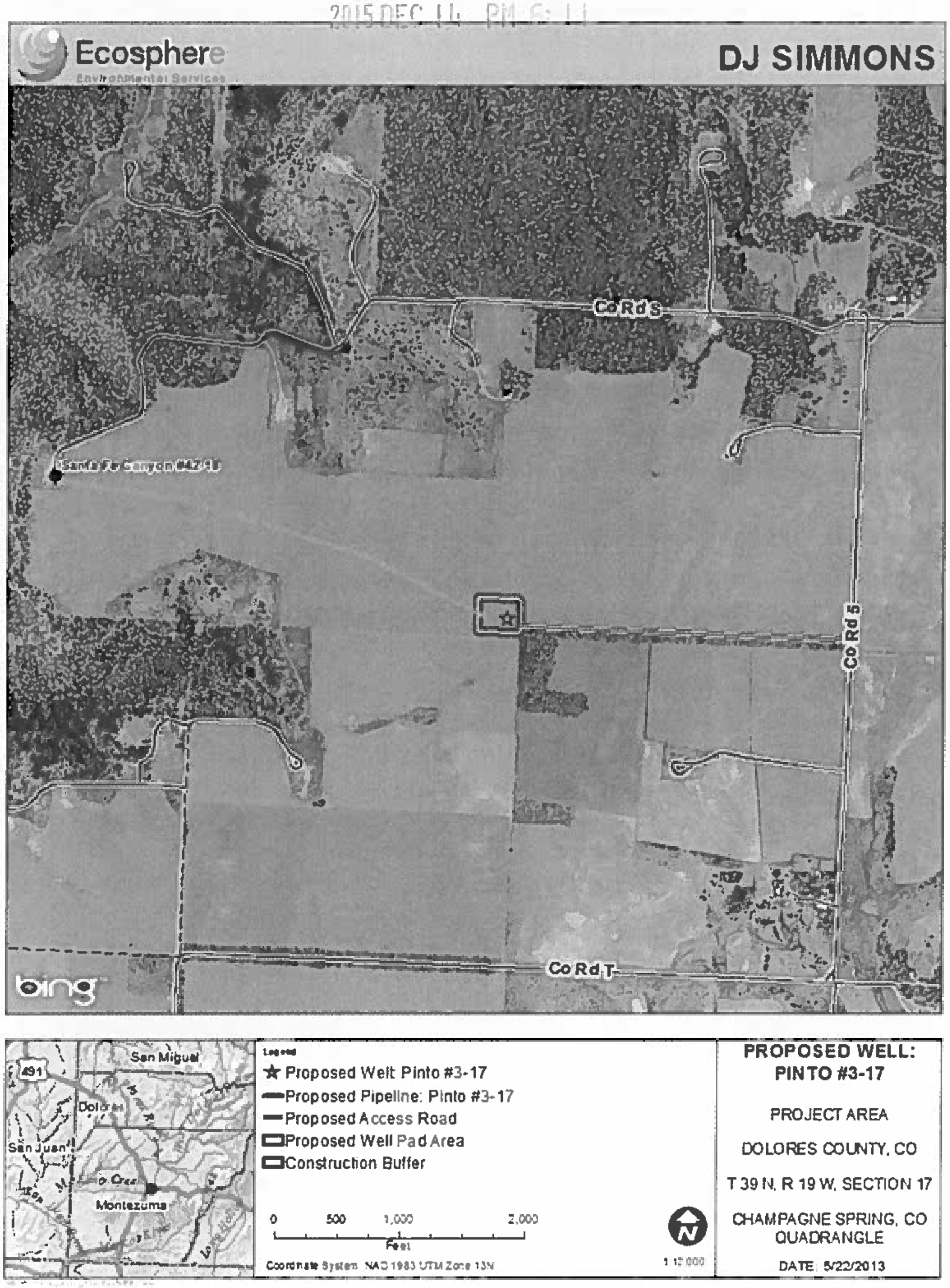

Figure 3: Proposed Pinto 3-17 Project Area

Design Features

Design features that include use of best management practices, adherence to lease stipulations, and standard operating procedures are an integral part of the proposed action. These design features were proposed in the surface use plan of operations in the APD package and would be implemented to minimize or eliminate potential impacts to resources.

- Stripped topsoil would be segregated outside of the well pad work area, but within the construction boundary limit. 100-percent of the stripped topsoil would be utilized for interim reclamation activities (see Appendix B, #1).
- Water for drilling and completion would be hauled by truck from a permitted water source. The drill cuttings, fluids, and completion fluids would be placed in a reserve pit, which would be lined according to COGCC Rule 904 (see Appendix B, #2).
- Drilling mud will consist of fresh water and will not be salt-saturated or oil-based. The drill cuttings, fluids, and completion fluids will be placed in the reserve pit. Reserve pits will be lined according to Colorado Oil and Gas Conservation Commission Rule 904 and all will be constructed to prevent leakage from occurring and will not be located on a natural drainage. Upon completion of drilling, testing, and completion of the well, the reserve pit will be allowed to dry, and materials remaining in the reserve pit buried. The reserve pit will be backfilled, leveled, and contoured so as to prevent any materials being carried into the watershed (Appendix B, #3).
- All garbage and trash material would be contained on location in an industry-approved trash container and would be removed from the site for proper disposal (see Appendix B, #4 for more details).
- Industry approved chemical toilets will be provided and maintained during drilling, testing, and completion operations (Appendix B, #5.
- Following drilling and completion, interim reclamation, as per the surface use plan submitted with the APD, would reduce the amount of surface disturbance to approximately 1 acre per each well pad (see Appendix B, #6 for more details).
- The reserve pit closure and reclamation would be conducted as per COGCC Rule 1003.d. The reserve pit would be backfilled, leveled, and contoured as part of the interim reclamation (Appendix B, #7).
- Weed control measures would be implemented in compliance with Colorado Noxious Weed Act, C.R.S. §35-5.5-115 and, at a minimum, to the Dolores County Development and Land Use Regulations, (Amended Nov. 2012), Article IV - Performance Standards, Section 2, Paragraph C - Noxious Weeds, page 14 (see Appendix B, #8 for more details).
- During final reclamation, following abandonment of the wells, the locations and access roads would be reclaimed and restored as close to the original topographic contours as possible and reseeded. The access road at Pinto 3-17 would be reclaimed at the

discretion and direction of the land owner who may want the road left, in some form, for access to fields (see Appendix B, #9 for more details).

NO ACTION ALTERNATIVE

The No Action Alternative would be to deny the APDs. This alternative would not approve the APDs for the proposed Pinto 1-7 and Pinto 3-17 wells, as well as the associated access roads and pipelines. The BLM's authority to implement the no action alternative may be limited because oil and gas leases allow drilling in the lease area subject to the stipulations of the specific lease agreement, 40 CFR 3160, and conditions that may result as part of an environmental analysis.

ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS

No other alternatives are needed to address any unresolved resource conflicts.

CHAPTER 3
AFFECTED ENVIRONMENT

INTRODUCTION AND GENERAL SETTING

Chapter 3 describes the environment that would be affected by implementation of the proposed action described in Chapter 2 and is organized by environmental resource. Descriptive information was obtained from a range of sources, including the BLM and other federal and state agencies.

The affected environment was considered and analyzed by an interdisciplinary team as documented in the Interdisciplinary Team Checklist (Appendix A). The checklist indicates which resources of concern are either not present in the project area or would not be impacted to a degree that requires detailed analysis. Environmental resources that would not be affected or that are not present in the project area include the following: Forests and Rangeland health, Migratory birds, Native American Religious Concerns, Wastes (Hazardous or Solid), Wild and Scenic Rivers, Wilderness, Environmental Justice, Floodplains, Wetlands-Riparian Zones, Farmlands (Prime or Unique), and Lands with Wilderness Characteristics. Resources that could be affected to a level requiring further analysis are described in Chapter 3, below, and effects on these resources are analyzed in Chapter 4.

The project area is located in southwestern Dolores County, Colorado approximately 9.6 miles south-southwest of the town of Dove Creek. This area is a high-desert plateau of mesas covered by eolian (wind -deposited) soil, and incised by deep, sandstone-walled canyons. The proposed action would be located on two mesas known as Bug Point and Squaw Point on the northwest and southeast sides of Squaw Canyon, respectively. The Abajo Mountains are visible to the west and the La Plata Mountains and San Juan Mountains are visible to the east and northeast, respectively. The eolian soils are underlain by the Dakota Sandstone and Burro Canyon Formation that generally comprise the cliff-forming cap rock at the top of the canyon walls in the area.

The eolian soils are deep and fertile so agriculture is a primary land use of most of the mesa tops in the area.

Pinto 1-7

The proposed Pinto 1-7 well pad would be located within 100 feet of the Canyons of the Ancients National Monument boundary (Figure 2). The elevation at the site is approximately 6,325 feet, with slopes ranging from zero to 5 degrees. The proposed Pinto 1-7 well pad lies northwest of the upper end of Squaw Canyon and would be located on previously cultivated land that has been enrolled in the Conservation Resource Program (CRP). Lands are enrolled in the CRP at the request of the land owner and may be taken out of CRP when needed by the landowner.

The existing vegetation at the proposed Pinto 1-7 well pad consists of a mixed shrub/grass community. Shrubs in the area include big sagebrush (*Artemesia tridentata*), broom snakeweed (*Guterrezia sarothrae*) Russian thistle (*Salsola tragus*), and the subshrub hairy false goldenaster (*Heterotheca villosa*). Grasses include crested wheatgrass (*Agropyron cristatum*), western wheatgrass (*Pascopyrum smithii*), smooth brome (*Bromus inermus*), purple three-awn (*Aristida* *purpurea*), and alfalfa (*Medicago sativa*). Adjacent land to the east consists of open-canopy, piñon-juniper woodland that occupies the steep, southeast-facing slopes of an unnamed tributary to Squaw Canyon.

Pinto 3-17

The proposed Pinto 3-17 access road would follow an existing two-track farm road west from County Road 5, along the north side of a fence line (Figure 3). The access would enter the well pad from the southeast and the pad would be located on tilled, dry-land farm land. The proposed Pinto 3-17 project lies on Squaw Point between Squaw canyon to the northwest and Cross Canyon to the southeast. The elevation at the well pad is approximately 6,500 feet, with slopes ranging from zero to 5 degrees. The proposed pipeline would exit the western side of the well pad and cross a tilled field before tying into a pipeline at the existing Santa Fe Canyon 42-18 well site. This well pad is located about 130-feet east of the CANM boundary. No natural vegetation occurs within the proposed area of disturbance as it is actively farmed.

AIR QUALITY

The project study area lies within the Southwestern Colorado Air Quality Control Region, as defined by the Colorado Air Quality Control Commission Report to the Public 2010-2011, (CDPHE 2011). On-going state air quality monitoring and sources of air quality impairment in the area are summarized in the annual air quality report. Currently, air quality concerns in the Southwestern region are from impacts from energy development including direct emissions, support services, and associated growth. Coal-fired Power plants in New Mexico, motor vehicles, and wildfires are also emission sources in this region (CDPHE 2011).

The Air Quality Division of the Colorado Department of Public Health and Environment (CDPHE) regulates air quality impacts from oil and gas activities and develops mitigation measures on a case-by-case basis. Impacts are evaluated to see if they are allowable or unacceptable. Air quality permits are required for emission sources on well pads if established emission thresholds for designated pollutants are exceeded. Currently, the area is in attainment for all criteria pollutants as defined under the Clean Air Act.

CULTURAL RESOURCES

Generally, the project area is known to be culturally rich with numerous surface and subsurface cultural resources, as evidenced by the close proximity to the Canyons of the Ancients National Monument. Woods Canyon Archaeological Consultants conducted a Class III cultural resource inventory on a total of approximately 22 acres consisting of two, 10-acre areas around the proposed well pads and along approximately 5,234 feet of proposed access roads and pipeline corridors—all within private lands (Fetterman 2012). The cultural surveys located one archaeological site along the Pinto 3-17 pipeline corridor. Composed of eight artifacts, this site is recommended as "not eligible" to the National Register of Historic Places. However, the proposed pipeline corridor for Pinto 3-17 was re-designed/re-routed to avoid the site.

FISH AND WILDLIFE

The region surrounding the proposed projects is composed of a patchwork of agricultural lands, native and re-vegetated mixed grasses and shrub habitat, and piñon-juniper woodland habitat.

These combine to provide cover and forage for a wide range of terrestrial wildlife. Several common mammalian species are likely to be found throughout the project area including the cougar (*Puma concolor*), coyote (*Canis latrans*), black bear (Ursus americanus), fox (*Vulpes* sp.), skunk (*Mephitis* sp.), and porcupine (*Erethizon dorsatum*). Mule deer (*Odocoileus hemionus*) and elk (*Cervus canadensis*) are year-round residents on public and private land. Both big-game species tend to migrate between forested lands at higher elevations in the spring and summer, to agricultural lands and woodlands at lower elevations in the fall and winter. Migration between winter and summer ranges may exceed 50 miles in this region (USDI/BLM 1991).

Sage-grouse (*Centrocercus urophasianus*), chukar partridge (*Alectoris chukar*), quail (*Callipepla gambelii*), wild turkey (*Meleagris gallopavo*), and pheasant (*Phasianus colchicus*) are present in small numbers and scattered throughout the San Juan/San Miguel Resource Area. Pheasants are mainly dependent on agricultural land, while the other species are associated with native rangeland and forest-type habitats (USDI/BLM 1991). Raptors potentially occurring in the area include golden eagle (*Aquila chrysaetos*), red-tailed hawk (*Buteo jamaicensis*), great horned owl (*Bubo virginianus*), sharp-shinned hawk *(Accipiter striatus)*, Cooper's hawk *(Accipiter cooperii)*, and American kestrel *(Falco sparverius)*.

THREATENED OR ENDANGERED SPECIES

Gunnison sage-grouse *(Centrocercus minimus)*: Critical habitat for Gunnison sage-grouse has been proposed by the U.S. Fish and Wildlife Service (USFWS) for a large area of Dolores County, including much of the agricultural lands on which the proposed Pinto Wells are located. This proposed critical habitat is mapped by the USFWS as unoccupied in the project area. Habitat around each of the proposed well pads does not meet the constituent elements listed in the proposed rule for critical habitat for Gunnison sage-grouse. Well locations were buffered by 1.5 km and sagebrush in unoccupied critical habitat was less than 25% for each of the proposed well locations. In the proposed rule, only areas that meet primary constituent element 1 are considered as critical habitat.

Table 3 – Constituent Element Analysis for Proposed Critical Habitat

Well Name	Acres of unoccupied critical habitat w/in 1.5 km	Acres of sagebrush	% sagebrush
Pinto 1-7	995	20	2.0%
Pinto 3-17	1196	50	4.2%

LANDS/ACCESS

All well pads, access roads, and pipelines are located on private lands. Surface Access Agreements typically describe how construction, drilling, production and maintenance of the oil wells and the associated pads and facilities will be conducted. In addition, the agreements include information about construction and/or improvement of access roads and their maintenance over the life of the wells, and interim and final reclamation of the well pads, access roads, and pipeline corridors.

SOILS

Soils in the proposed Pinto 1-7 well pad and approximately 20 feet of the proposed access road/pipeline corridor are Wetherill loam, 3 to 6 percent slopes. This soil is considered prime farmland, if irrigated, but it is not irrigated in the project area. The Wetherill loam is very deep, well drained, and has high available water capacity. The soil is comprised of eolian (wind-blown) deposits derived from sandstone. Major uses of this soil type include cropland and livestock grazing. The remainder of the proposed access road/pipeline corridor would cross the Gladel-Pulpit complex, 3 to 9 percent slopes. This soil is comprised of eolian deposits over residuum weathered from sandstone. This soil complex is shallow to moderately deep, well drained, has moderate to very low available water capacity, and is not considered prime farmland (USDA/NRCS 2013). Major uses of this soil unit are livestock grazing and wildlife habitat.

Soils in the proposed Pinto 3-17 well pad site, pipeline, and approximately 1,000 feet of the proposed access road/pipeline corridor are Wetherill loam, 3 to 6 percent slopes. A small portion of the proposed Pinto 3-17 pipeline (approximately 200 feet) runs through the Sharps-Cahona complex, 6 to 12 percent slopes. This soil is well drained and is not considered prime farmland. The eastern portion of the proposed Pinto 3-17 access road (approximately 1,650 feet) is within the Cahona-Sharps-Wetherill complex, 2 to 6 percent slopes. This soil is deep, well drained, has a high available water capacity and is not considered prime farmland (USDA/NRCS 2013).

WATER RESOURCES/WATER QUALITY

Surface drainage in the vicinity of both proposed well pads flows to Squaw Canyon creek via intermittent and/or ephemeral streams in steep, tributary canyon drainages. Squaw Canyon creek flows south to Cross Canyon creek which, in turn, is a tributary to Montezuma Creek with the confluence near the northeastern corner of the Navajo Indian Reservation. Montezuma Creek flows south-southwest across the Navajo Indian Reservation to the San Juan River at Montezuma Creek, Utah.

No perennial waters, wetlands, or riparian habitats are located within a ½-mile radius of the proposed well pads or access/pipeline route locations. The hydrologic regime in the vicinity of the project area is such that surface water flows only on an intermittent basis in conjunction with sizable precipitation events. Thunderstorms are the primary source of flow in these ephemeral drainages, which are also fed by snowmelt. Key factors that influence the surface-water quality in the project area include agricultural practices, sparse vegetative cover, highly erosive soils, rapid runoff, existing roads, oil and gas well pads and facilities, and livestock grazing.

An ephemeral stock pond is located to the southeast of the proposed Pinto 1-7 well pad. This pond is approximately 0.4 acre in size and was dry during the on-site and the biological survey. One water well is located within a one-mile radius of the proposed well site. This domestic/stock well (permit # 83355) is located about 2,000 feet west of the proposed well site and, according to Colorado Division of Water Resources (DWR), the well is 18-feet deep and has a yield of 3 gallons per minute (gpm). Another water well (permit # 93488) is located about

6,300-feet southwest of the proposed well location. According to DWR, the well is 185-feet deep, has a yield of 0.8 gallons per minute and is used for domestic water supply and stock watering.

One un-named spring is located about 2,000 feet southwest of the proposed Pinto 3-17 well location at the head of an un-named tributary canyon to Squaw Canyon creek. The proposed well pad is upstream about 2,300 feet and immediately adjacent to the same drainage that contains this spring. Seven water wells are located within one mile of the proposed Pinto 3-17 well location (Water Well Table, below).

Table 4 - Water Wells Within One-Mile of Proposed Pinto 3-17 Location

Permit No.	Approximate Distance/Direction From Proposed Well Pad	Depth (ft.)	Yield (gpm)	Water Level below surface (ft.)	Use
93488	1,600 ft./NW	185	0.8	NA	Domestic/Stock
239006	3.300 ft./SE	100	10	48	Domestic/Stock
269710	3,600 ft./NE	142	NA	NA	Domestic
125479	3,600 ft./SE	45	15	NA	Domestic/Stock
17082	3,900 ft./SE	28	1	7	Stock
273136	4,600 ft./SE	15	15	NA	Domestic
120272A	4,900 ft./SE	100	NA	60	Domestic

Source: Colorado Division of Water Resources (DWR)

The ground-water resources in the project area are derived mostly from the Dakota -Glen Canyon aquifer system that underlies most of the Colorado Plateau in western Colorado, northwestern New Mexico, northeast Arizona, and eastern Utah. The Dakota-Glen Canyon aquifer system is composed of a series of aquifers and confining units that are interconnected enough to be considered a thick, connected aquifer system. The Dakota aquifer is the uppermost aquifer in the system and is composed of the Dakota Sandstone and the Burro Canyon Formation (Robson and Banta 1995). This is the primary ground-water-supply unit for the project area since the Dakota Sandstone is the cap rock at the top of most of the local canyon walls and is the bedrock unit that immediately underlies the agricultural soils in the area. The Brushy Basin Member of the Morrison Formation underlies the Dakota aquifer and is a local confining unit which is a poor water producer. The Salt Wash Member of the Morrison Formation is also known as the Morrison aquifer and can supply potable water to wells in the project area. However, the drilling depth to the Morrison aquifer is great enough that the cost is beginning to get prohibitive for the typical home/landowner. The Entrada and Navajo Sandstone units are two aquifers of the Dakota-Glen Canyon aquifer system lying below the Morrison aquifer. The

Entrada Sandstone, the uppermost of these two aquifers, is the unit in the Sand Canyon area and in Canyon of the Ancients National Monument that contains numerous natural alcoves where ancient Puebloan cliff dwellings were built. The Navajo Sandstone is only exposed at the surface at the Sand Canyon parking lot and vicinity in McElmo Canyon. Both of these aquifers can be good sources of ground water, but the drilling depth to reach these sandstone aquifers in the project area is prohibitive. The Glen Canyon aquifer is lowermost aquifer of the Dakota-Glen Canyon aquifer system and is composed of the Kayenta Formation and Wingate Sandstone (Robson and Banta 1995).

More localized and shallow ground-water resources are encountered within alluvial deposits that are associated with the surface water drainages within the project area. These aquifers consist of Quaternary period deposits of alluvial gravel, sand, silt, and clay or Quaternary deposits of eolian sand and silt (Robson and Banta 1995). These aquifers tend to be localized near surface water and of limited aerial extent. There are a few of these shallow wells in the project area such as the 18-ft. deep well west of the Pinto 1-7 location and the 15 -ft. and 28-ft. deep wells southeast of the Pinto 3-17 location.

VISUAL RESOURCES

Visual Resources of the area consist of dry-land, agriculture scenery in the sparsely populated section of southwestern Dolores County, Colorado.

The Pinto 1-7 well would be located about 100 feet north of the CANM boundary along Dolores County Road 4. The area surrounding the proposed well site is piñon-juniper forest, in CANM, immediately to the south and rolling hills of formerly cultivated lands that of the well pad

The proposed project area contains broad, level mesa tablelands intersected by deep canyons and numerous smaller draws. Viewsheds within the Project Area are dominated in the foreground (0 to 0.5 mile) and middle-ground (0.5 to 3 to 5 miles) by active, dry-land agricultural fields on the mesa tops. The individual fields are typically separated by windrows of deciduous trees, mature piñon-juniper (P-J) woodlands (in the canyons), and/or desert scrub shrublands. The rolling topography periodically provides background views (3 to 5 miles to 15 miles and beyond) south to Sleeping Ute Mountain, northwest to the Abajo Mountains in Utah, and east to the La Plata Mountains. Overall, existing conditions in the Project Area are moderately natural.

Visual disturbances currently exist in foreground and middle-ground views along public travel corridors and in the agricultural lands. These disturbances include: paved and gravel roadways; oil and gas well pads with storage tanks and facilities; overhead, rural-supply power lines along roadways and to residences; rural residences; and agricultural development including cultivated fields, crops, barns, hay and equipment sheds, and farm equipment stored or abandoned in fields.

Previous visual resource management (VRM) efforts at the oil and gas well pads in the area have yielded mixed results. Best management practices (BMPs) for visual resources have been implemented on all wells pads on federal lands in the area and, as such, blend into the surrounding colors and forms fairly well and do not tend to dominate the view for the casual observer. Comparatively, similar BMPs have not been utilized at some well facilities on private lands where BLM does not have jurisdiction, and the resultant VRM impacts (typified by white, rusting storage tanks and other facilities) become visual focal points within the near and mid-distance backgrounds.

Pinto 1-7 Proposed Location:

The Pinto 1-7 location is in a good location from a VRM perspective. It is in a relatively low location that is not visible from any middle- or back-ground viewpoints. Foreground viewpoints would be from local fields and from two points on County Road 4 (on the approach to the well site and as the road passes the south side of the well site). The view of the site from the south, southeast and east is screened by P-J forest and from the northeast, north, northwest, west and southwest by topography and/or P-J forest. The well pad is located less than 100 feet north of the Canyons of the Ancients National Monument (the Monument) boundary but, in spite of that, the well site would be visible from only a small, very local portion of the Monument - from the road immediately adjacent to the well pad and from an open field southwest of the well location in a corner of the Monument. There are no residences in direct line of site with this well location.

Pinto 3-17 Proposed Location:

The proposed Pinto 3-17 well pad is located on a gentle southeast-facing slope in a cultivated, dry-land agricultural field. The location is slightly higher than most of the surrounding foreground lands and would be visible intermittently from numerous viewpoints on surrounding private lands. The well site would be visible from various points along County Road S, County Road 5 and County Road T - all approximately 1/2 -mile from the well site. Various visibility screens such as wind-block rows of trees, stands of P-J forests, and topography would make the views of this site intermittent, depending on perspective. Degree of visibility would vary by season because the color used to paint the facilities on site would blend in better during the summer months when crops are on the fields, as opposed to snow-covered fields in the winter and brown, tilled fields in the spring.

Visibility from the Monument would be limited because nearby Monument lands tend to drop off quickly into local canyons and the view of this well location would immediately be screened by topography and P-J forest as one moved into the Monument proper. One local residence would have a direct view of the well pad to the south. The resident here is the owner of the land on which the well would be located. This location would also be visible from three or four other oil & gas well pad locations in the vicinity.

CHAPTER 4
ENVIRONMENTAL IMPACTS

DIRECT AND INDIRECT IMPACTS

This EA tiers to the information and analysis contained in the San Juan/San Miguel Resource Management Plan and EIS (USDI/BLM 1985) and the Colorado Oil and Gas Leasing and Development Final EIS amendment to the Resource Management Plan (USDI/BLM 1991). The 1991 Resource Management Plan Amendment projected that oil and gas exploration over the life of the plan would result in approximately 1,430 acres of disturbance within the planning area. Approximately 410 acres of this disturbance would be long term (USDI/BLM 1991, page 4-31). The analysis determined that the cumulative impacts of oil and gas leasing and development would not be significant (USDI/BLM 1991, page 4-27).

PROPOSED ACTION

This section analyzes the impacts of the proposed action to those potentially impacted resources described in the affected environment Chapter 3, above.

Air Quality

Air emissions associated with oil and gas development and production activities primarily occur during well pad construction and drilling phases. Air emissions during construction activities include hydrocarbons, carbon monoxide, and nitrogen oxides associated with production equipment; gas-fired drilling equipment; and vehicle exhaust. Other air quality effects associated with the construction, drilling, and operation of the proposed wells and associated access roads and pipeline routes would occur from several sources:

- Suspended particulates (dust) generated during site clearing and from vehicular traffic on unpaved roads.
- Suspended particulates (dust) from wind erosion on cleared construction areas.
- Hydrocarbon emissions from the drill rig, service/support vehicles, and operation of gasoline and diesel engines (e.g., generators).

A temporary increase in emissions and fugitive dust is anticipated due to an increase in vehicle and equipment use in the area. However, the degree to which this increase would affect the air quality is difficult to predict due to variables such as vehicle speed, distance traveled, road conditions, duration of engine idling, and the effectiveness of smog control devices on vehicles.

Air quality effects from construction and drilling operations, primarily from vehicle/equipment exhaust and increased fugitive dust, would likely be localized to the proposed project area (1/2 mile radius) and short term. Drilling and construction activities would occur over an estimated 45 day period for each well. Therefore, air quality impacts and greenhouse gas emissions should be of short duration and are not considered significant.

Indirect effects to air quality during the production phase would occur from vehicle travel on area roads during ongoing facility and well operation inspections. The operation of the wells and pipelines are not a source of emissions of monitored parameters. No compressors or other equipment with internal combustion engines are planned for the production facilities at these sites. No permits or authorizations are required from Colorado Air Quality Control Commission for project-related activities.

Proposed Air Quality Mitigation Measures

The entire Two Pinto Well Project is located on private lands. The surface-mitigation measures here are not intended to dictate the surface management on private lands. However, the following air-quality mitigation measures are recommended, by BLM, as best management practices (BMPs) that, if implemented, would reduce effects to the natural and human environment in the vicinity of the wells.

1. Construction activities that disturb a surface area greater than 1 acre and are of a duration greater than 5 days should use effective dust-suppression materials and techniques to prevent dust from visibly transporting from the area of disturbance (e.g., well pad, access road, or pipeline ROW) or drift more than 50 feet from the road prism.

   Effective dust abatement would be used to control air-born dust. Water or other dust suppressants would be used to the extent necessary to control dust during windy conditions or when traffic/construction activities create dusty conditions. This would reduce the amount of dust in the air and maintain good construction-site visibility and air quality for worker safety.

   This recommended BMP would prevent fugitive dust from leaving the construction zones of this project and, as a result, would prevent dust accumulation at local residences, reduce or eliminate dust pollution that is often associated with construction projects, and would reduce or eliminate the visual effects of blowing dust.

2. All activities should handle, transport, and store construction materials, such as excess pit spoils and topsoil storage piles, in such a way to prevent particulate matter (dust) from visibly transporting from the storage area or area of disturbance.

   This BMP, if implemented, would serve the same purpose as stated above - to maintain the air and visual quality of the agricultural community surrounding the project area.

3. No oil, solvents, or other unacceptable contaminates will be used in dust-abatement fluids.

   This mitigation measure would protect surface- and ground-water quality as well as soil quality and health. Additionally, the use of oil or other toxic materials to control dust would fall under the same category as a spill of toxic materials and would require cleanup.

Cultural Resources

The construction of the proposed well pads and access roads/pipelines would avoid all known cultural resource sites. No effects to significant cultural resources are expected to occur. However, there is a potential to encounter buried cultural deposits despite the lack of archaeological material on the present ground surface.

As per Conditions of Approval (Appendix B, numbers 11, 12, and 13), all construction personnel would be informed that disturbance, collecting, or removal of cultural resources is a violation of federal law and that disclosure or release of information regarding the nature and location of archaeological, historic, or sacred sites without written approval of the BLM is prohibited under provisions of the Archaeological Resources Protection Act.

Fish and Wildlife

A wildlife clearance report was completed on 4/09/2013. Impacts to: Threatened, Endangered, Proposed, and Candidate species listed under the Endangered Species Act, BLM Special Status Species, Birds of Conservation Concern, and migratory birds were addressed in the report. Only BLM special status species, birds of conservation concern, or migratory birds that may be impacted as identified in the report are addressed in the EA. Species not potentially affected are not addressed in the EA.

The proposed Pinto 1-7 well pad would remove approximately 3 acres of previously cultivated land that was enrolled in the Conservation Reserve Program. Vegetation removal would result in temporary habitat modification and loss. Approximately 2.4 acres would be reclaimed following drilling and completion. There would be a long term loss of approximately 1 acre due the decrease in habitat effectiveness and avoidance by wildlife.

During construction and drilling activities at the Pinto 1-7 location, there would be short-term effects to area wildlife as a result of human and vehicular activity, increased noise, and night-lighting. Wildlife would be temporarily displaced and would avoid the project area. However, wildlife could return to the area after construction is completed. During the production period, there would be an increase of one to two tanker-truck and/or pick-up truck trips per week to the proposed well to remove stored liquids from the site and for routine maintenance. This increased traffic would not measurably impact wildlife species within the proposed project area. The current access is on existing county roads.

Construction activities could directly disturb birds, including raptor species occupying canyon habitat adjacent to the Pinto #1-7 due to increased noise, night-lighting, and human activity. Potential disturbance could cause birds to change their normal breeding, foraging, and nesting behavior. Disturbance would be highest during construction and drilling, then decreasing to intermittent disturbance during long-term operation and maintenance of the wells. The duration of construction activities for the proposed wells would be for approximately a period of four weeks, thereby limiting the severity of potential impacts to a short time period for any specific area.

Bat roosting habitat in the project area is comprised of rock crevices and piñon and juniper trees.

No snags or rock crevices are proposed to be disturbed during construction; however the disturbance may preclude the use of the area during construction for any tree roosting species. Bats may be drawn to the area during drilling operations due to increased insects attracted to the rig lights. Long term impacts may result in the 'take' of individuals depending upon the equipment and design at the well location. Meter runs, treaters, vent pipes and other oil and gas facilities present potential roost habitat for various bat species. Exhaust stacks on oil and gas equipment have been known to trap and kill birds and bats. Exhaust stacks and vent pipes covered with screen can exclude birds and bats from nesting and roosting in potentially hazardous production equipment.

To access the proposed Pinto #3-17 well pad, an existing two-track would be upgraded. The proposed Pinto #3-17 well pad and pipeline would be located within tilled cropland. There would be no native vegetation removed. Short-term impacts to wildlife from development of the proposed Pinto #3-17 would be limited to avoidance during construction and drilling. During the production period, there would be an increase of one to two tanker-truck and/or pick-up truck trips per week to the proposed well to remove stored liquids from the site and for routine maintenance. This traffic increase is not expected to measurably impact wildlife species within the proposed project area.

Proposed Wildlife Mitigation Measures

As previously stated, the entire Two Pinto well project is located on private lands. The surface-mitigation measures listed here are not intended to dictate the surface management on private lands. However, the following wildlife mitigation measures are recommended, by BLM, as best management practices (BMPs) that, if implemented, would reduce or avoid effects to wildlife populations and the important natural human/wildlife interactions in the vicinity of the wells.

1. Drilling, Completion, Production, Emergency, or NPDES pits must be maintained to exclude wildlife at all times. The operator shall install fencing and/or other deterrents necessary to preclude access to pits by wildlife. Other deterrents to preclude pit access may include screening and/or netting. Flagging is not considered an effective deterrent and is not allowed (USFWS 2011). If netting is used to exclude wildlife it needs to be maintained so it does not become a trap for wildlife. This mitigation measure is required to meet the intent of the Migratory Bird Treaty Act, 16 U.S.C. 703.

2. BLM recommends that equipment used for production be maintained and/or modified to minimize noise impacts to wildlife. If this recommendation were implemented, it would benefit local wildlife populations by reducing noise disturbance during important phases of their reproduction cycles and would reduce noise for local human residents as well.

3. Production equipment with vent pipes, exhaust stacks, or other areas that may provide access for migratory birds and bats must be screened to exclude wildlife. Mesh screening must be no larger than ¼ inch. This mitigation measure is required to meet the intent of the Migratory Bird Treaty Act, 16 U.S.C. 703.

4. BLM recommends that when brush hogging or mowing, operators ensure that no active migratory bird nests are destroyed. Destruction of an active nest may result in a violation of the Migratory Bird Treaty Act. To ensure compliance, no activity should take place between May 15 and June 15 annually to protect nesting migratory birds. If activities must take place during this time period, pre-construction surveys should be conducted for any activities after May 15, to clear for nesting migratory birds.

5. If power lines are needed for production facilities, BLM recommends that they be buried whenever possible in the project area to protect bald eagles and other important wildlife. When it is not possible to bury them, overhead power lines should be constructed to standards identified by the Avian Power Line Interaction Committee (most recent version) to minimize raptor electrocution potential.

6. As agreed at the on-site meeting For Pinto 1-7, held on June 4, 2012, , no surface disturbing activity would be allowed within ½ mile of documented active raptor nests from February 1 through July 31, annually. The presence of an active raptor nest would be based on a raptor nest occupancy survey for the current breeding season. This timing limitation date will be adjusted for species-specific guidance. The timing limitation applies to construction, drilling, completions operations, placing of production equipment, and associated infrastructure to include roads, pipelines, power lines, etc.

7. If the proposed action is not completed by March 15, 2014, then the raptor survey requirements of #6, above would be carried through to 2014 operations prior to any activities taking place.

Threatened or Endangered Species

Table 5 - Federally listed species for the BLM Tres Rios Field Office based on July 14th, 2010 list from the USFWS and the quarterly updates received at the Tres Rios Field Office.

Species	Status	Presence	Project Effects	Rationale
Canada lynx	Threatened	NP	NE	No habitat in project area
New Mexico jumping mouse	Candidate	NP	NE	No habitat in project area
Gunnison sage-grouse	Proposed	NP	NE	No grouse in project area
Gunnison sage-grouse critical habitat	Proposed	K	NE	Project area does not meet constituent elements.
Mexican spotted owl	Threatened	NP	NE	No habitat in project area
Southwestern willow flycatcher	Endangered	NP	NE	No habitat in project area
Yellow-billed cuckoo	Candidate	NP	NE	No habitat in project area
Bonytail	Endangered	NP	LAA	Water depletions
Colorado pikeminnow	Endangered	NP	LAA	Water depletions
Greenback cutthroat trout	Threatened	NP	NE	No habitat in project area, outside watershed
Humpback chub	Endangered	NP	LAA	Water depletions
Razorback sucker	Endangered	NP	LAA	Water depletions
Uncompahgre fritillary butterfly	Endangered	NP	NE	No habitat in project area

**Project effect determinations are: no effect (NE); may affect (MA); not likely to adversely affect (NLAA); likely to adversely affect (LAA). Presence determinations are: habitat not present (NP); habitat present species not expected to occur (NS); suspected occurrence (S); known occurrence (K)*

Site-specific evaluation of the proposed critical Gunnison sage-grouse habitat resulted in a determination that the habitat in the project area for the two wells is not suitable in its present state and does not provide habitat necessary to meet the primary constituent element in the proposed rule for critical habitat. Therefore, the impacts from the project activities will have no effect on proposed critical habitat and the Proposed Action will have no effect on Gunnison sage-grouse. No other threatened or endangered plants or animals are known to occur in the area.

Given that the proposed action would result in the depletion of approximately 1.29 acre-feet of water from within the Colorado River basin, this project falls under BLM Colorado's Programmatic Biological Assessment (PBA) for water depleting activities associated with BLM's fluid minerals program in the Colorado River basin in Colorado (BLM 2008).

In response to BLM's PBA, the U. S. Fish and Wildlife Service (USFWS) issued a Programmatic Biological Opinion (PBO) (ES/GJ-6-CO-08-F-0006) on December 19, 2008, which concurred with BLM's determination that water depletions are "Likely to Adversely Affect" the Colorado pikeminnow, humpback chub, bonytail, and razorback sucker. Likewise, the project is also likely to adversely affect designated critical habitats for these endangered fish along the Green, Yampa, White, Colorado, and Gunnison rivers. However, the USFWS also determined that BLM water depletions from the Colorado River Basin are not likely to jeopardize the continued existence of the Colorado pikeminnow, humpback chub, bonytail, or razorback sucker, and that BLM water depletions are not likely to destroy or adversely modify designated critical habitat.

A Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin was initiated in January 1988. The Recovery Program serves as the reasonable and prudent alternative to avoid jeopardy and aid in recovery efforts for these endangered fishes resulting from water depletions from the Colorado River Basin. The PBO addresses water depletions associated with fluid minerals development on BLM lands, including water used for well drilling, hydrostatic testing of pipelines, and dust abatement on roads. The PBO includes reasonable and prudent alternatives developed by the USFWS which allow BLM to authorize oil and gas wells that result in water depletion while avoiding the likelihood of jeopardy to the endangered fishes and avoiding destruction or adverse modification of their critical habitat. As a reasonable and prudent alternative in the PBO, USFWS authorized BLM to solicit a one-time monetary contribution to the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin (Recovery Program) in the amount equal to the average annual acre-feet depleted by fluid minerals activities on BLM lands.

This project has been entered into the Tres Rios Field Office fluid minerals water depletion log which will be submitted to the Colorado State Office at the end of the Fiscal Year.

Lands/Access

Drilling operations would increase traffic, including heavy truck traffic, on local county roads for a period of about 45 days per each well or, roughly, a total of 3 months. If the wells are economically productive, production operations may continue for up to about 30 years. During that production period, there would be an increase of one to two tanker-truck and/or pick-up truck trips per week to recover liquid resources gathered at the site and for routine maintenance. Based on the anticipated increase in vehicle traffic during construction, drilling, and production, the proposed action would measurably increase traffic impacts on area roads. Impacts would include, but are not necessarily limited to: increased noise, safety concerns attendant with increased traffic, increase in large truck traffic, potential for spills from trucks, increased wear and tear on paved county roads, and increased need for county road maintenance and repairs.

Soils

The proposed action would result in temporary displacement, compaction, and mixing of approximately 11.28 acres soils in the project area. Accidental spills or releases of hazardous substances could result in soil contamination requiring remediation. Temporary reduced capacity for plant growth due to removal and/or disturbance of the soil would be an additional direct effect. Due to the susceptibility of the project area soils to wind and water erosion, construction activities may cause loss of some upper soil layers.

The proposed action would result in the scraping and temporary removal of the topsoil as the roads and pipelines are constructed and the well pads are leveled. Topsoil will be excavated, separated, and stored inside the construction buffer. All stockpiled soils would be protected from degradation due to contamination, compaction, and erosion by wind and water during drilling and completion operations.

Interim reclamation would replace all stockpiled topsoil to its original relative position and contoured and seeded as practicable to achieve erosion control and long-term stability and soil health.

Best management practices would be implemented to prevent noxious weed establishment (Appendix B, #23). Interim reclamation best management practices would be implemented, as per Appendix B, numbers, 33-37, to stabilize and protect soils in the project areas.

Water Resources/Water Quality

The proposed action would temporarily disturb an estimated 11.28 acres of soil that, if not mitigated, could serve as a sediment source to adjacent drainages. Disturbance of soils, particularly near washes and on slopes, would lead to a potential increase in the amount of sediment transport from the project area, particularly during and following storm events. Slight alterations in the project area drainage patterns may also lead to an increase in sediment transport. However, the storm-water-control plan for these wells contains mitigation measures designed to reduce or eliminate sediment moving off-site or into area drainage ways. In addition, the planned interim reclamation and reestablishment of healthy vegetation cover will facilitate stabilization of the disturbed areas and, once accomplished, would eliminate the potential for sediment transport from areas disturbed by project activities.

As in any drilling operation, there is a potential for contamination of aquifers through co-mingling in the wellbore. However, placing sealed surface casing in the wellbore to protect ground-water resources is a required standard procedure. The surface casing is set to a depth well below the potential ground-water aquifer system and the casing is sealed with concrete along the entire length to prevent water movement along the well bore hole.

The operator's proposed drilling plans were reviewed by a BLM geologist and a BLM petroleum engineer as part of the BLM's APD approval process. It was determined that D.J. Simmons's drilling plan included procedures adequate to protect ground water aquifers. Design features and conditions of approval related to lining pits and immediate spill clean-up (Appendix B, numbers 3, 7, 17, and 21) are designed to protect surface-water and shallow ground-water resources and other resources.

Additional requirements were agreed upon at the on-site inspection, requiring drainage protection for any water that may leave the site during storm events. D.J. Simmons would provide adequate storm-water protection as required by Colorado law.

Visual Resources

Both proposed well pads would be constructed on private lands. Drill rigs, trailer and equipment storage, and vehicle use would occur at the well pad locations during drilling activities. The 132-foot high drill rig derricks and nighttime lighting on the derricks would be visible above surrounding vegetation for three to four weeks at each well site during well drilling activities.

The completed well pads and their associated storage tanks would be visible from various local points along county roads and from local agricultural fields. However, interim reclamation to reduce the size of the well pad to a small, tear-drop shape, re-vegetation of reclaimed areas, and painting the facilities with a flat, earth-tone color as recommended in Appendix B, # 38, would make the well pad facilities blend into the surrounding colors and forms fairly well. As such, the facilities would not tend to dominate the view for the casual observer.

The proposed Pinto 1-7 well pad would be located on previously cultivated land adjacent to County Road 4 that has been enrolled in the Conservation Resource Program. Drilling and production activities on Pinto 1-7 would be readily visible from the approach on County Road 4 and where the road passes the proposed well site. Changes to existing landform, vegetation, and structures from project activities would result in a weak to moderate degree of contrast in form, line, texture, and color.

The proposed Pinto 3-17 well pad would be located on active, tilled, dry-land farm land. Drilling and production activities on Pinto 3-17 would be visible from various points along County Road S, County Road 5 and County Road T - all approximately 1/2 -mile from the well site - and from various points in the surrounding agricultural fields. Various visibility screens such as wind-block rows of trees, stands of P-J forests, and topography would make the views of this site intermittent, depending on perspective. Degree of visibility would vary by season because the color used to paint the facilities on site would blend in better during the summer months when crops are on the fields, as opposed to snow-covered fields in the winter and brown, tilled fields in the spring. Changes to existing landform, vegetation, and structures from project activities would result in a weak to moderate degree of contrast in form, line, texture, and color.

NO ACTION ALTERNATIVE

The no-action alternative would not meet the purpose and need for the proposed action. Under the no action alternative, the proposed natural gas well pads, access roads, and well-tie pipelines would not be constructed nor the wells drilled. The no-action alternative would result in the continuation of the current land and resource uses in the project area. There would be no environmental impacts from the no-action alternative as described above to Air Quality; Cultural Resources, Fish and Wildlife species, Threatened or Endangered Species, Lands and Access, Soils, Water Resources and Water Quality, and Visual Resources. Therefore, the environment would remain as described in Chapter 3.

CUMULATIVE IMPACTS

This section analyzes the environmental consequences of the proposed action to those potentially impacted resources described in the Chapter 3: Affected Environment.

The proposed action would result in approximately 11.28 acres of short-term disturbance. Following interim reclamation, the proposed action would contribute approximately 2.4 acres of long-term disturbance for operation and access in the planning area.

The proposed action is not expected to cumulatively impact cultural resources, land ownership, or access as these resources are not expected to be directly or indirectly affected. The proposed action would result in cumulative impacts to air quality, wildlife habitat, soils, and water resources.

Air Quality

The cumulative impacts analysis area for air quality is the San Juan airshed. Past, present and reasonably foreseeable development that has and would affect air quality include: coal-fired power plants operated in the Four Corners area; windblown dust from exposed soils, dirt and gravel roads, and soil erosion; vehicle emissions; agricultural practices such as burning irrigation ditches and tilling soils; emissions from oil and gas and mineral development construction and operation activities including vehicle operations. Farming and livestock herding activities have and would continue to impact local air quality primarily from fugitive dust and vehicle emissions. The proposed action would contribute a small incremental increase in overall hydrocarbon emissions, including greenhouse gases (GHGs), NO_X, and volatile Organic Compounds (VOCs). When combined with impacts from past, present, and reasonably foreseeable development, the proposed action would result in synergistic and long-term additive impacts to air quality in the San Juan airshed.

Fish and Wildlife

The cumulative impacts analysis area for general wildlife is the San Juan/San Miguel planning area. The 1991 Resource Management Plan Amendment projected that oil and gas exploration over the life of the plan would result in approximately 1,430 acres of disturbance within the planning area. Approximately 410 acres of this disturbance would be long term (USDI/BLM 1991, page 4-31). In the analysis area, impacts to wildlife and habitat have resulted from residential, commercial, and community development; agricultural and grazing land use; industrial development including oil and gas development; and land management activities such as prescribed burning. The proposed action would contribute approximately 2.4 acres of long-term disturbance to wildlife habitat within the analysis area. The cumulative impact of the proposed action on wildlife—when considered with past, present and reasonably foreseeable activities in the analysis area—is expected to be additive and long term.

Soils

The cumulative impacts analysis area for soils and water resources is the San Juan/San Miguel planning area. Past, present, and future developments are expected to result in a range of short- and long-term impacts to soils including disturbance, temporarily increasing erosion prior to reclamation, and reducing soil loss to erosion where reclamation and re-vegetation occurs. A maximum of 11.28 acres of soil would be disturbed by the proposed action and all but about 2.4 of that area would be interim-reclaimed to its original land use. Also, the soil types affected by this project are abundant in the San Juan River Watershed. Therefore, any impact from the proposed action is not expected to contribute appreciably to cumulative impacts to soils when added to past, present, and reasonably foreseeable actions. Cumulative impacts on approximately 2.4 acres of soils affected by the proposed action would be long term (approximately 30 years) and additive.

Water Resources

Past activities that have contributed to water quality impacts in the analysis area include sedimentation resulting from surface disturbance associated with residential, commercial, agricultural, and industrial development as well as land management activities (e.g., prescribed fires). Given the minimal amount of surface disturbance (coupled with design features and conditions of approval), the cumulative impacts of the proposed action on surface and groundwater resources are expected to be short to long term, and additive when added to past, present and reasonably foreseeable development.

CHAPTER 5
PERSONS, GROUPS, AND AGENCIES CONSULTED

Table 6. List of Persons, Agencies and Organizations Consulted

Name	Purpose and Authorities for Consultation or Coordination	Findings Conclusions
Brian Magee, Colorado Parks and Wildlife	Information on special status species.	The proposed action requires mitigation measures for protection of raptors.
Chris Lopez and Craig Starkey, D.J. Simmons	Information regarding the proposed action.	
Cindy Crist, Soil Conservationist, USDA/ NRCS	Information regarding Soils and Prime Farmlands	

Table 7. List of Preparers

Name	Title	Responsible for the Following Section(s) of this Document
Robert Garrigues	BLM Natural Resource Specialist	Project Manager, technical coordination and quality control, impact analyses for water resources/water quality, and soils.
Nate West	BLM Wildlife Biologist	Impact analyses for wildlife and TES
Julie Bell	BLM Archaeologist	Impact analysis for cultural resources
Kelly Palmer	San Juan Nat'l Forest Hydrologist	Impact analyses for air quality, water resources/water quality, and soils.
Jeff Christenson	BLM Outdoor Recreation Planner	Impact analysis for Visual Resources
Gina Jones	BLM NEPA coordinator	Review
Tracy Perfors	BLM Natural Resource Specialist	Review

Table 8. List of Non-BLM Preparers

Name	Title	Responsible for the Following Section(s) of this Document
Elizabeth Burak	Project Manager, Ecosphere	Chapters 1 and 2, technical review
Lucas Phipps	GIS Analyst/Biologist, Ecosphere	Chapters 1-5, biological resources and impacts analysis.
Joey Herring	Senior Project Manager, Ecosphere	Chapters 1-5, quality control and

		coordination.
Jerry Fetterman	Woods Canyon Archaeological Consultants	Archaeological surveys and report

CHAPTER 6
REFERENCES

Colorado Department of Public Health and Environment (CDPHE), Colorado Air Quality Control Commission. 2011. Report to the Public 2010 to 2011. Available online at: http://www.cdphe.state.co.us/ap/down/RTTP10-11Web.pdf. Accessed September 2012.

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USFWS, U.S. Fish and Wildlife Service. 2011. The Ineffectiveness of Flagging to Deter Migratory Birds from Oilfield Production Skim Pits and Reserve Pits. Available on-line at: http://www.fws.gov/mountain-prairie/contaminants/documents/Flagging_oil_pits.pdf

APPENDICES

APPENDIX A
INTERDISCIPLINARY TEAM CHECKLIST

Project Title: Two Pinto Wells Project

NEPA Log Number: **DOI-BLM-CO-S010-2012-0035-E**

Project Leader: Robert Garrigues

DETERMINATION OF STAFF: ***(Choose one of the following abbreviated options for the left column)***

NP = not present in the area impacted by the proposed or alternative actions
NI = present, but not affected to a degree that detailed analysis is required
PI = present with potential for relevant impact that need to be analyzed in detail in the EA
NC = (DNAs only) actions and impacts not changed from those disclosed in the existing NEPA documents cited in Section D of the DNA form. The Rationale column may include NI and NP discussions.

Determination	Resource	Rationale for Determination*	Signature	Date
RESOURCES AND ISSUES CONSIDERED (INCLUDES SUPPLEMENTAL AUTHORITIES APPENDIX 1 H-1790-1)				
PI	**Air Quality**	**Local air quality would be directly impacted by the proposed action.**		
NP	Areas of Critical Environmental Concern	No ACECs in or in close proximity to the proposed project areas	R.S. Garrigues	7/7/13
NP	BLM Natural Areas	No BLM Natural Areas in or in close proximity to the proposed project areas.	R.S. Garrigues	7/7/13
PI	**Cultural Resources**	**Cultural resources occur within the Class III archeological survey area.**	[illegible]	5/22/13
NI	Greenhouse Gas Emissions	The proposed action will not result in substantial greenhouse gas emissions		
NI	Environmental Justice	No adverse effects to low-income or minority populations would occur.	R. Garrigues	7/7/13
NI	Farmlands (Prime or Unique)	The project areas are located within Prime Farmlands if irrigated. However; current land use does not employ irrigation.	R. Garrigues	7/7/13
PI	**Fish and Wildlife Excluding USFW Designated Species**	**The proposed actions could affect general wildlife.**	[illegible]	5/22/2013
NP	Floodplains	No floodplains located within the proposed project areas.		
NP	Fuels/Fire Management	Proposed actions are located on private lands.	R. Garrigues	7/7/13
NI	Geology / Mineral Resources/Energy Production	The proposed actions would affect mineral resources and energy production. These impacts are not expected to be significant.	R. Garrigues	7/7/13
NI	Invasive Species/Noxious Weeds	No invasive species or noxious weeds were found within the proposed project areas.	R. Garrigues	7/7/13
PI	**Lands/Access**	**The proposed actions would construct/improve two roads on private property to access the sites. Traffic increases would occur on local county roads.**	R. Garrigues	7/7/13
NP	Livestock Grazing	The proposed actions are located on private lands that are not used for livestock grazing.	R. Garrigues	7/7/13
NI	Migratory Birds.	The proposed actions would impact migratory bird habitats; however, these impacts would not be significant.	[illegible]	5/22/2013
NP	Native American Religious Concerns	No known Native American religious concerns (traditional cultural properties) within the proposed project areas.	[illegible]	5/22/13

Determination	Resource	Rationale for Determination*	Signature	Date
NP	Paleontology	There are no known paleontology resources within the proposed project areas.	R. Garrigues	7/7/13
NP	Rangeland Health Standards	The proposed actions would be located on private lands and there are no effects on rangelands	R. Garrigues	7/7/13
NP	Recreation	The proposed actions would be located on private lands and would not affect recreation resources	[illegible]	5/22/13
NI	Socio-Economics	No negative effects to socioeconomic conditions anticipated. Positive economic effects to county.	R. Garrigues	7/7/13
PI	**Soils**	**The proposed actions would impacts soils.**		
NP	Threatened, Endangered or Candidate Plant Species	No suitable habitat for any federally listed threatened, endangered, or candidate plant species.	R. Garrigues (as per personal comm. 7/8/13)	7/8/13
PI	**Threatened, Endangered or Candidate Animal Species**	**The project is likely to adversely affect fish species associated with the Colorado River System.**	[illegible]	5/22/2013
NI	Wastes (hazardous or solid)	No chemicals subject to the Superfund Amendments and Reauthorization Act Title III in amounts greater than 10,000 pounds will be used during project activities. No extremely hazardous substances as defined in 40 CFR 355 in threshold planning quantities will be used.	R. Garrigues	7/7/13
PI	**Water Resources/Water Quality**	**The proposed actions could impact surface and ground-water resources primarily from increased sedimentation or accidental spills.**		
NP	Wetlands/Riparian Zones	No wetlands or riparian zones are within the proposed project areas.		
NP	Wild and Scenic Rivers	No Wild and Scenic Rivers are within the proposed project areas.	R. S. Garrigues	7/7/13
NP	Wilderness/WSA	No Wilderness or Wilderness Study Areas are located within the proposed project areas.	[illegible]	5/22/13
NP	Woodland / Forestry	No saleable forestry products are within the proposed project areas. The proposed actions would be located on private lands.	[illegible]	
NI	Vegetation Excluding USFW Designated Species	Vegetation and cropland would be impacted by the proposed actions. These impacts would not be significant and would occur on private lands.	R. S. Garrigues	7/7/13
PI	**Visual Resources**	**Visual impacts would occur during construction and drilling. There would be long-term impacts from aboveground facilities. Visual resource BMPs will be implemented to mitigate visual impacts.**	[illegible]	5/22/13
NP	Wild Horses and Burros	No wild horses or burros are within the proposed project areas.	R. S. Garrigues	7/7/13
NP	Areas with Wilderness Characteristics**	No areas with Wilderness characteristics fall within the proposed project areas.	[illegible]	5/21/13

FINAL REVIEW:

Environmental Coordinator	Gina Jones	5/21/13	Gina Jones
Authorized Officer			

APPENDIX A
INTERDISCIPLINARY TEAM C HECKLIST

Project Title: Tw › Pinto Wells Project

NEPA Log Numb er: DOI-BLM-CO-S010-2012-0035-E

Project Leader: Robert Garrigues

DETERMINATION OF STAFF: ***(Choose one of the following abbreviated ptions for the left column)***

NP = not present n the area impacted by the proposed or alternative actio
NI = present, but iot affected to a degree that detailed analysis is requirec
PI = present with potential for relevant impact that need to be analyzed in etail in the EA
NC = (DNAs onl:) actions and impacts not changed from those disclosed i the existing NEPA documents cited in Section D of :he DNA form. The Rationale column may include NI a NP discussions.

Determination	Resource	Rationale for Determination*	Signature	Date
RESOURCES AND ISSUES CONSIDERED (INCLUDES SUPPLEMENTAL UTHORITIES APPENDIX 1 H-1790-1)				
PI	Ai: Quality	Local air quality would be directly impacte ›y the proposed action.	Kerry Pa[illegible]	6/21/13
NP	Area : of Critical Enviror: nental Concern	No ACECs in or in close proximity to the pro; sed project areas		
NP	BLM Natural Areas	No BLM Natural Areas in or in close proximi to the proposed project areas.		
PI	Cultu: al Resources	Cultural resources occur within the Class I archeological survey area.	[illegible] Reed	5/22/13
NI	Gree nhouse Gas E nissions	The proposed action will not result in substan l greenhouse gas emissions	Kerry Pa[illegible]	6/21/13
NI	Envirc mental Justice	No adverse effects to low-income or minority pulations would occur.		
NI	Farmla nds (Prime or Jnique)	The project areas are located within Prime Fa lands if irrigated. However, current land use does not mploy irrigation.		
PI	Fish nd Wildlife Excl: ding USFW Desig iated Species	The proposed actions could affect general dlife.	[illegible]	5/22/2013
NP	F oodplains	No floodplains located within the proposed p ect areas.	Kerry Pa[illegible]	6/21/13
NP	Fuels/F re Management	Proposed actions are located on private lands		
NI	Geol gy / Mineral Rese urces/Energy F roduction	The proposed actions would affect mineral re urces and energy production. These impacts are not exp ted to be significant.		
NI	Invasive Species Noxious Weeds	No invasive species or noxious weeds were f nd within the proposed project areas.		
PI	La nds/Access	The proposed actions would construct/imp ve two roads on private property to access the sit Traffic increases would occur on local county roa		
NP	Live tock Grazing	The proposed actions are located on private l ds that are not used for livestock grazing.		
NI	Mi; ratory Birds.	The proposed actions would impact migrato bird habitats, however, these impacts would not l significant.	[illegible]	5/22/2013
NP	Nat ve American Reli; ious Concerns	No known Native American religious conce (traditional cultural properties) within the proposed proj areas.	[illegible] Reed	5/22/13

Determination	Resource	Rationale for Determination*	Signature	Date
NP	Pa eontology	There are no known paleontology resources v iin the proposed project areas.		
NP	Ranı eland Health Standards	The proposed actions would be located on pri te lands and there are no effects on rangelands		
NP	R creation	The proposed actions would be located on pri te lands and would not affect recreation resources		5/22/13
NI	Soci -Economics	No negative effects to socioeconomic conditi s anticipated. Positive economic effects to cou .		
PI	Soils	The proposed actions would impacts soils.	Kay Pa	6/21/13
NP	Threatei ed, Endangered or Ca ıdidate Plant Species	No suitable habitat for any federally listed thr ıtened, endangered, or candidate plant species.		
PI	Tl reatened, Enr angered or Cand date Animal Species	The project is likely to adversely affect fish ecies associated with the Colorado River System		5/22/2013
NI	Wastes (haza dous or solid)	No chemicals subject to the Superfund Amen ents and Reauthorization Act Title III in amounts grea than 10,000 pounds will be used during project act ties. No extremely hazardous substances as defined in CFR 355 in threshold planning quantities will be used.		
PI	Water Reso irces/Water Quality	The proposed actions could impact surface id ground-water resources primarily from increased sedimentation or accidental spills.	Kay Pa	6/21/13
NP	Wetl nds/Riparian Zones	No wetlands or riparian zones are within the posed project areas.	Kay Pa	6/21/13
NP	Wild ar l Scenic Rivers	No Wild and Scenic Rivers are within the pro sed project areas.		
NP	Wilc erness/WSA	No Wilderness or Wilderness Study Areas ar ocated within the proposed project areas.		5/22/13
NP	Wood and / Forestry	No saleable forestry products are within the p posed project areas. The proposed actions would be cated on private lands.		
NI	Veget .ion Excluding USF V Designated Species	Vegetation and cropland would be impacted l the proposed actions. These impacts would not b ignificant and would occur on private lands.		
PI	Visu l Resources	Visual impacts would occur during constru ion and drilling. There would be long-term impact om aboveground facilities. Visual resource BM will be implemented to mitigate visual impacts.		5/22/13
NP	Wild H rses and Burros	No wild horses or burros are within the propo d project areas.		
NP	Areas vith Wilderness Cha acteristics**	No areas with Wilderness characteristics fall thin the proposed project areas.		5/22/13

FINAL REVIEW:

Environmental Co rdinator	Gina Jones	/21/13	Gina Jones
Authorized Of icer			

Appendix B
Surface Use Design Features, Conditions of Approval, and Proposed Mitigation Measures

D.J. Simmons, Inc.

Pinto 1-7 and Pinto 3-17 Well Pads, Access Roads,

and Pipelines

Dolores County, Colorado

The following is a compilation of all Design Features, proposed Mitigation Measures and proposed Conditions of Approval (collectively referred to as COAs) identified during the EA analyses. If approved in the Decision Record, these COAs will take precedence over any or all terms and conditions set forth in the Applications for Permits to Drill (APD). D.J. Simmons, Inc. (D.J. Simmons) and its contractors should refer to these COAs and the APD package for specific information associated with construction, drilling, production, and reclamation.

Exceptions or waivers from these COAs are only granted with written permission from the BLM Authorized Officer.

The following Design Features and COAs are required on BLM and private lands. However, some COAs may be waived by the private landowner if their written request for a waiver is approved by the BLM and the COGCC.

Design Features

The following design features were proposed by the project proponent and were included in the project proposal as best management practices designed to minimize or eliminate potential impacts to the environment.

1. Stripped topsoil would be segregated outside of the well pad work area, but within the construction boundary limit. 100-percent of the stripped topsoil would be utilized for interim reclamation activities.

2. Water for drilling and completion would be hauled by truck from a permitted water source. The drill cuttings, fluids, and completion fluids would be placed in a reserve pit, which would be lined according to COGCC Rule 904.

3. Drilling mud will consist of fresh water and will not be salt saturated or oil-based. The drill cuttings, fluids, and completion fluids will be placed in the reserve pit. Reserve pits will be lined according to Colorado Oil and Gas Conservation Commission Rule 904 and all will be constructed to prevent leakage from occurring and will not be located on a natural drainage. Upon completion of drilling, testing, and completion of the well, the reserve pit will be allowed to dry, and materials remaining in the reserve pit buried. The reserve pit will be backfilled, leveled, and contoured so as to prevent any materials being carried into the watershed.

4. All garbage and trash material would be contained on location in an industry-approved trash container and would be removed from the site for proper disposal (see #14, below for additional COAs related to this design feature).

5. Industry approved chemical toilets will be provided and maintained during drilling, testing, and completion operations.

6. Following drilling and completion, interim reclamation, as per the surface use plan submitted with the APD, would reduce the amount of surface disturbance to approximately 1 acre per each well pad (see numbers 33 - 35, below for additional COAs related to this design feature).

7. The reserve pit closure and reclamation would be conducted as per COGCC Rule 1003.d. The reserve pit would be backfilled, leveled, and contoured as part of the interim reclamation.
8. Weed control measures would be implemented in compliance with Colorado Noxious Weed Act, C.R.S. §35-5.5-115 and, at a minimum, to the Dolores County Development and Land Use Regulations, (Amended Nov. 2012), Article IV - Performance Standards, Section 2, Paragraph C - Noxious Weeds, page 14 (see #23, below for additional COAs related to this design feature).
9. During final reclamation, following abandonment of the wells, the locations and access roads would be reclaimed and restored as close to the original topographic contours as possible and reseeded. The access road at Pinto 3-17 would be reclaimed at the discretion and direction of the land owner who may want the road left, in some form, for access to fields (see numbers 36 and 37 below for additional COAs related to this design feature).

Proposed Required Conditions of Approval (COAs)

The following COAs are required by the BLM to protect various environmental resources.

10. The operator or operator's contractor will contact the BLM Authorized Officer (Robert Garrigues at 970-882-6845) at least seven (7) days before beginning any surface-disturbing activities and at least seven (7) days before beginning any reclamation.

11. Before beginning any work, it is the responsibility of the operator to inform all employees, contractors, and subcontractors of applicable cultural resource laws and regulations as well as the project-specific measures for protecting cultural resources. Disturbance to, defacement of, or collection or removal of archaeological, historical, or

sacred material is prohibited by law. Disclosure or release of information regarding the nature and location of archaeological, historic, or sacred sites, without written approval by the Bureau of Land Management (BLM) is prohibited by law

12. Disclosure or release of information regarding the nature and location of archaeological, historic, or sacred sites, without written approval by the BLM, is prohibited under provisions of the Archaeological Resources Protection Act. Cultural resource consultants and other permitees of the BLM are allowed to use this information during the course of the project for site protection purposes only. Unauthorized use or distribution of this information (which includes site location information present in cultural resource reports) is a violation of Federal statute.

13. If cultural resources or human remains, funerary items, sacred objects, or objects of cultural patrimony are discovered during construction, activity in the vicinity of the resource will cease, the resource will be protected, and Julie Bell, BLM Archaeologist at 970-882-6832, and/or Robert Garrigues, BLM Project Manager at 970-882-8645, will be notified immediately and the following procedures will be carried out. The operator shall take any measures requested by the BLM to protect the resources until they can be evaluated and treated. The discovered resources will be documented and evaluated by a permitted archaeologist. The permitted archaeologist, in consultation with the BLM archaeologist, will make a determination of the nature and significance of the discovery, and will determine the appropriate method of treatment for it. Avoidance is the preferable treatment. However, if the resources cannot be avoided, the appropriate treatment method will be determined, and the permitted archaeologist will prepare any and all necessary treatment plans. These plans will be reviewed and approved by the BLM. Treatment activities will be conducted after all necessary consultations have been completed as required by Section 106 of the National Historic Preservation Act, the Native American Graves Protection and Repatriation Act, and the Archaeological Resources Protection Act. The BLM will be responsible for conducting all necessary consultations. Construction within the area of the discovery will be allowed to proceed after the appropriate treatment has been completed.

14. Throughout the lifetime of the project, trash and debris will be collected from the location and the surrounding area and removed to an approved sanitary landfill. During construction and drilling, the operator will collect trash and debris on a regular schedule of at least once per week from the project area. This trash can be stored in an appropriate on-site trash bin that will prevent loss due to wind and which will be periodically hauled to a permitted land fill or disposal site.

15. Storm-water controls will be implemented, inspected, and maintained for the well pads, roads, pipelines, if applicable, for the life of the project. They should be sized for a 25-year storm. Any unsatisfactory storm-water controls (by evidence of wind or water erosion or cutting, or sedimentation transported off the project area) will be replaced or upgraded as needed. All storm-water controls needed during the construction phase of this project must be installed before ground disturbance begins.

16. Storm-water control measures will be designed by a specialist with proof of training in storm-water management, design, and implementation of best management practices (BMPs) for storm-water control. The specialist must be qualified to design the storm-water control systems, supervise the installation/construction of storm-water control features and, to ensure adequate storm-water management. Training certified by the Colorado Dept. of Transportation (CDOT) or Colorado Dept. of Public Health and Environment (CDPHE) or similar entities from other states would qualify as adequate training. If the operator does not have a trained storm-water specialist on staff, a storm-water specialist should be hired to do the designs and supervise the installation.

17. Spills and leaks will be cleaned up immediately, and contaminated soils will be removed to a permitted disposal site. BLM spill reporting procedures will be followed.

18. A copy of Appendix B and the operator's Surface Use Plan of Operations must be located at the well pad during construction, drilling, and completion activities.

19. For any well pad locations with any slope across the pad area, an "eyebrow ditch" shall be installed above the locations on the uphill side. The intent of the eyebrow ditch is to intercept surface water flows and disperse the water to either side of the location. The ends of the ditch or "daylight" ends should be placed in native soils, within undisturbed areas. Any natural moisture will be diverted off of the pads and away from the location. The well pads would be designed in such a manner as not to allow runoff water to enter the pads.

20. The top six-inches of topsoil will be stripped and stockpiled within the authorized area of disturbance for use in reclamation. To preserve topsoil health and viability, the topsoil stockpile should, preferably, be distributed in low berms around the sides of the well pad. These berms can be used to form the storm-water-controlling eye-brow ditches required in COA, 12, above. Topsoil storage piles shall not be more than 3-feet high (deep). If the topsoil stockpile is not used within 6 months, it will be seeded to ensure topsoil integrity and prevent erosion.

21. Degreasing of machinery or equipment is not allowed on location.

22. Water withdrawals from surface waters require notification to the State of Colorado by the company and the water rights holder if using a private water right that is not decreed for industrial use. The Colorado Division of Water Resources (WRD) requests notification 2 weeks prior to the beginning of surface waters withdrawals to determine if there is a call on or below the withdrawal point. Regardless of when or how fresh water is used, the WRD will be notified and allowed to respond before water is withdrawn from any surface waters in Colorado. The contact office for Southwestern Colorado is the Division of Water Resources in Durango, Colorado (970-247-1845), and for the Water Commissioner for the Dolores River is 970-565-0694. After the drilling operations are completed, a final estimate of the volume of water used for all activities should be submitted in writing to the State of Colorado. If required by WRD, the operator must apply and obtain water rights prior to water withdrawals. The operator will comply with all state and local water laws and regulations.

23. The Permit Holder (Holder) shall be responsible for control of all State listed noxious weed species on all disturbed areas. The Holder is responsible for consultation with the Authorized Officer and local authorities for acceptable weed control methods and shall comply with the following:

    a. Weed control measures would be implemented in compliance with Colorado Noxious Weed Act, C.R.S. §35-5.5-115 and, at a minimum, to the Dolores County Development and Land Use Regulations, (Amended Nov. 2012), Article IV - Performance Standards, Section 2, Paragraph C - Noxious Weeds, page 14.

    b. Use of pesticides shall comply with all applicable Federal and State laws. Pesticides shall be used only in accordance with their registered uses within limitations imposed by the Secretary of the Interior. Prior to the use of pesticides, the Holder shall obtain approval from the Authorized Officer of a Pesticide Use Proposal showing the type and quantity of material to be used, pests to be controlled, method of application, locations of storage and disposal of containers, and any other information deemed necessary by the Authorized Officer.

    c. All pesticide applicators must hold a valid Colorado Qualified Supervisor license or Certified Operator license, and the license must be valid for the applicable pesticide application category. For all areas treated, Pesticide Application Records (BLM Form 3-3-94) must be submitted to the BLM Tres Rios Field Office by November 1 of each year. Pesticide Application Records must be completed no later than 14 days following the pesticide application and must be maintained for 10 years.

24. Excavated materials from cuts would be used on the fill portion of the location to level the pad. Any excess materials (non-topsoil) would be stored within the construction boundary limit (inside the 50-ft. buffer zone) and used for interim and/or final reclamation of the pits and well pad.

25. Access roads at both locations will be maintained to keep the travel surface in good working order, free of ruts, and to keep storm-water control measures operating properly.

Proposed Required Conditions of Approval Specific to Wildlife Issues

26. Observations of any threatened, endangered, proposed, or candidate species within the project area shall be reported to the BLM Tres Rios Field Office (970-882-6845 or 882-6856).

27. If any dead or injured sensitive species is located during construction or operation, the BLM Tres Rios Field Office shall be notified at (970-882-6845 or 882-6856) within 24 hours.

28. If any dead or injured threatened, endangered, proposed, or candidate species is located during construction or operation, the U.S. Fish and Wildlife Service's Colorado Ecological Services Field Office (970-243-2778) and law enforcement office (970-882-

6849) and BLM Tres Rios Field Office (970-882-6845 or 882-6856) shall be notified within 24 hours.

29. BLM shall be notified at 970-882-6845 or 882-6856 if wildlife (other than insects and other invertebrates), or livestock are discovered in a pit.

Proposed Recommended Conditions of Approval

30. The following COAs are recommended by BLM as best management practices that, if implemented, would serve to protect various environmental resources, and reduce the environmental and aesthetic impacts of the proposed project. Since the proposed wells and associated disturbance would be located on private lands, the landowners have jurisdiction over the activities that impact the land surface - so long as those activities do not violate national, state, or local laws or regulations. So, for example, the landowner cannot overrule COAs designed to protect cultural resources, threatened or endangered species, or to protect water quality but the landowner does have jurisdiction over such things as: how the site is reclaimed; what type of seed mix is used; the color of the facilities; and noise levels allowed from the facilities.

31. All work, staging, and parking of equipment will be confined to the well pads, roads and pipeline ROW. No pullouts or off-road parking will be allowed unless specifically authorized. "Keep vehicles on the road surface" signs must be installed by the operator to assist with compliance, as needed. No shortcutting by any motor vehicles operated by employees or contractors is permitted on roads not identified as access routes in the APD. Vehicular access to the pads will be strictly limited to authorized vehicles only; these vehicles are restricted to use on the drill pad only; no off-pad or off-road parking.

32. Heavy equipment will be pressure-washed to remove all dirt and vegetative materials at an offsite location prior to entering either of the two well locations in this project. This is a preventive measure for reducing noxious weed infestation at the drilling sites. If equipment is removed from the project area, used elsewhere, then brought back to the project area, pressure washing is required before the equipment can be used in the project area. Likewise, the heavy equipment should be pressure washed before moving to the other well location in this project. This COA pertains to heavy equipment such as dozers, trackhoes, backhoes, bobcats, and other earth-moving equipment. Pickup trucks, passenger vehicles, water trucks, and gravel trucks do not require pressure washing prior to entering these sites.

33. During interim reclamation, those portions of the road/pipeline ROW deemed unnecessary for production shall be shaped to conform to the natural terrain. 100-percent of the topsoil stockpiled during construction should be spread back over the re-contoured, interim reclamation areas, and the area reseeded. The brush, limbs, crushed stumps and other woody material stockpiled during construction, if any, should be spread back over reclaimed areas and associated pipelines after seeding. This reclamation shall begin within 6 months of completion of the pipeline construction.

34. During interim reclamation, those portions of the well pads deemed unnecessary for production shall be shaped to conform to the natural terrain, using 100-percent of the stockpiled topsoil, and should be reseeded, leaving only a small teardrop for access to the wellhead during operations, and the area reseeded. The brush, limbs, crushed stumps and other woody material stockpiled during construction, if any, should be spread back over reclaimed areas after seeding. Interim reclamation shall begin within 6 months of testing and completion of the wells, regardless of the timing of putting the well into production. Notify Surface Managing Agency representative (Robert Garrigues at 970 882 6845) seven (7) days prior to seeding so that they may be present to witness reseeding activities. The seed mixture shown in Table B-1 shall be used for reseeding at the Pinto 1-7 well pad during reclamation, unless another seed mixture is specified in a landowner Surface Use Agreement. The Pinto 3-17 site is an actively cultivated field and it is assumed that the land owner will specify a crop seed mix for the reclamation of this site. The woody materials stockpiled during construction, if any, are to be spread evenly back over the reclaimed and seeded areas.

Table B-1 - Sage Flats Mix

Common Name	***Species Name***	***Variety***(2)	***PLS***(1) ***lbs/ac****
Sand Dropseed	*Sporobolus cryptandrus*	VNS	0.05
Galleta	*Hilaria jamesii*	Viva, florets	1.6
Big Sagebrush	*Artemisia tridentata*	VNS	0.1
Winterfat	*Krasheninnikovia lanata*	VNS	0.25
Four-wing Saltbrush	*Atriplex canescens*	VNS	0.25
Indian Ricegrass	*Achnatherum hymenoides*	Paloma	2.5
Blue Grama	*Chondrosum gracile*	Alma	0.3
Squirreltail	*Elymus elymoides*	Tusas	1.4
Muttongrass	*Poa fendleriana*	CO Source ID	0.1
		Total	6.6

*This reflects the drilled seeding rate of 40 PLS /ft², it needs to be doubled if broadcast.

(1) PLS stands for Pure Live Seed. It is a number that takes into account that the germination rate of any seed lot will inevitably be less than 100% and that there is inert material in the seedlot that is not viable seed. So PLS pounds/acre = bulk pounds/acre * % germination rate - inert material.
(2) VNS=Variety Not Specified, get most local variety available.

If the seed is broadcast, application rates will be twice the drilled rate, and some means such as a rake or harrow will be used to incorporate the seed into the soil. Certified weed-free mulch may be required on locations with an inadequate supply of removed vegetation.

35. The seed mixture used must be ***certified*** weed free. There shall be NO primary or secondary noxious weeds in the seed mixture. Seed labels from each bag shall be available for inspection while seeding is being accomplished. The seeding contractor shall keep a record of the dates seeding was accomplished for each site and shall send that information along with the seed labels from each bag to the Authorized Officer.

36. Upon final reclamation, all compacted areas and areas devoid of vegetation on location shall be ripped, along the contour, to a minimum of 6 inches in depth before the re-spread of topsoil and subsequent reseeding according to the seed mix in Table B-1, or as per land-owner specified seed mix, for the Pinto 1-7 location. All access roads will be shaped to conform to the natural terrain and left as rough as possible to deter vehicle travel. Access will be ripped, along the contour when possible, to a minimum depth of 6 inches, water barred, and reseeded according to the seed mix in Table B-1 (Pinto 1-7). All erosion problems created by the development must be corrected prior to acceptance of release.

37. Reclamation (whether interim or final) will be considered successful when the desired vegetative species are established at 70% cover or higher, as compared to reference sites with undisturbed vegetation. In addition, erosion must be controlled, weeds considered a minimal threat, there must be evidence of vegetation reproduction, either spreading by rhizomatous species or seed production, and it is deemed likely that ground cover will return to a desirable condition. The operator will be required to continue re-vegetation efforts, at the direction of BLM, until these standards are met.

38. All surface production equipment constructed or installed at the two well sites (onsite for 6 months or longer), should be painted with the flat, non-reflective earth-tone color Shale Green (Munsell 5Y 4/2) from the BLM's Standard Environmental Color Chart CC-001 (June 2008) to minimize contrast with the existing environment unless the land owner specifically demands a different color, in writing.

Proposed Air Quality Mitigation Measures

39. Construction activities that disturb a surface area greater than 1 acre and are of a duration greater than 5 days should use effective dust-suppression materials and techniques to prevent dust from visibly transporting from the area of disturbance (e.g., well pad, access road, or pipeline ROW) or drift more than 50 feet from the road prism.

40. All activities should handle, transport, and store material in such a way to prevent particulate matter (dust) from visibly transporting from the storage area or area of disturbance.

41. No oil, solvents, or other unacceptable contaminates will be used in dust-abatement fluids.

Proposed Wildlife Mitigation Measures

42. Drilling, Completion, Production, Emergency, or NPDES pits must be maintained to exclude wildlife at all times. The operator shall install fencing and/or other deterrents necessary to preclude access to pits by wildlife. Other deterrents to preclude pit access may include screening and/or netting. Flagging is not considered an effective deterrent and is not allowed (USFWS 2011). If netting is used to exclude wildlife it needs to be maintained so it does not become a trap for wildlife. This mitigation measure is required to meet the intent of the Migratory Bird Treaty Act, 16 U.S.C. 703.

43. BLM recommends that equipment used for production be maintained and/or modified to minimize noise impacts to wildlife. If this recommendation were implemented, it would benefit local wildlife populations by reducing noise disturbance during important phases of their reproduction cycles and would reduce noise for local human residents as well.

44. Production equipment with vent pipes, exhaust stacks, or other areas that may provide access for migratory birds and bats must be screened to exclude wildlife. Mesh screening must be no larger than ¼ inch. This mitigation measure is required to meet the intent of the Migratory Bird Treaty Act, 16 U.S.C. 703.

45. BLM recommends that when brush hogging or mowing, operators ensure that no active migratory bird nests are destroyed. Destruction of an active nest may result in a violation of the Migratory Bird Treaty Act. To ensure compliance, no activity should take place between May 15 and June 15 annually to protect nesting migratory birds. If activities must take place during this time period, pre-construction surveys should be conducted for any activities after May 15, to clear for nesting migratory birds.

46. If power lines are needed for production facilities, BLM recommends that they be buried whenever possible in the project area to protect bald eagles and other important wildlife. When it is not possible to bury them, overhead power lines should be constructed to standards identified by the Avian Power Line Interaction Committee (most recent version) to minimize raptor electrocution potential.

47. As agreed at the on-site meeting For Pinto 1-7, held on June 4, 2012, , no surface disturbing activity would be allowed within ½ mile of documented active raptor nests from February 1 through July 31, annually. The presence of an active raptor nest would be based on a raptor nest occupancy survey for the current breeding season. This timing limitation date will be adjusted for species-specific guidance. The timing limitation applies to construction, drilling, completions operations, placing of production equipment, and associated infrastructure to include roads, pipelines, power lines, etc.

48. If the proposed action is not completed by March 15, 2014, then the raptor survey requirements of #47, above would be carried through to 2014 operations prior to any activities taking place.

U.S. DEPT OF INTERIOR
BUREAU OF LAND MGMT

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Ex. 6

Technical Support Document: -
Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis -
Under Executive Order 12866 -

Interagency Working Group on Social Cost of Carbon, United States Government

With participation by

Council of Economic Advisers
Council on Environmental Quality
Department of Agriculture
Department of Commerce
Department of Energy
Department of Transportation
Environmental Protection Agency
National Economic Council
Office of Management and Budget
Office of Science and Technology Policy
Department of the Treasury

May 2013

Revised July 2015
See Appendix B for Details on Revision

Executive Summary

Under Executive Order 12866, agencies are required, to the extent permitted by law, "to assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." The purpose of the "social cost of carbon" (SCC) estimates presented here is to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO_2) emissions into cost-benefit analyses of regulatory actions that impact cumulative global emissions. The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change.

The interagency process that developed the original U.S. government's SCC estimates is described in the 2010 interagency technical support document (TSD) (Interagency Working Group on Social Cost of Carbon 2010). Through that process the interagency group selected four SCC values for use in regulatory analyses. Three values are based on the average SCC from three integrated assessment models (IAMs), at discount rates of 2.5, 3, and 5 percent. The fourth value, which represents the 95th percentile SCC estimate across all three models at a 3 percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution.

While acknowledging the continued limitations of the approach taken by the interagency group in 2010, this document provides an update of the SCC estimates based on new versions of each IAM (DICE, PAGE, and FUND). It does not revisit other interagency modeling decisions (e.g., with regard to the discount rate, reference case socioeconomic and emission scenarios, or equilibrium climate sensitivity). Improvements in the way damages are modeled are confined to those that have been incorporated into the latest versions of the models by the developers themselves in the peer-reviewed literature.

The SCC estimates using the updated versions of the models are higher than those reported in the 2010 TSD. By way of comparison, the four 2020 SCC estimates reported in the 2010 TSD were $7, $26, $42 and $81 (2007$). The corresponding four updated SCC estimates for 2020 are $12, $43, $64, and $128 (2007$). The model updates that are relevant to the SCC estimates include: an explicit representation of sea level rise damages in the DICE and PAGE models; updated adaptation assumptions, revisions to ensure damages are constrained by GDP, updated regional scaling of damages, and a revised treatment of potentially abrupt shifts in climate damages in the PAGE model; an updated carbon cycle in the DICE model; and updated damage functions for sea level rise impacts, the agricultural sector, and reduced space heating requirements, as well as changes to the transient response of temperature to the buildup of GHG concentrations and the inclusion of indirect effects of methane emissions in the FUND model. The SCC estimates vary by year, and the following table summarizes the revised SCC estimates from 2010 through 2050.

Revised Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

I. Purpose

The purpose of this document is to update the schedule of social cost of carbon (SCC) estimates from the 2010 interagency technical support document (TSD) (Interagency Working Group on Social Cost of Carbon 2010).[1] E.O. 13563 commits the Administration to regulatory decision making "based on the best available science."[2] Additionally, the interagency group recommended in 2010 that the SCC estimates be revisited on a regular basis or as model updates that reflect the growing body of scientific and economic knowledge become available.[3] New versions of the three integrated assessment models used by the U.S. government to estimate the SCC (DICE, FUND, and PAGE), are now available and have been published in the peer reviewed literature. While acknowledging the continued limitations of the approach taken by the interagency group in 2010 (documented in the original 2010 TSD), this document provides an update of the SCC estimates based on the latest peer-reviewed version of the models, replacing model versions that were developed up to ten years ago in a rapidly evolving field. It does not revisit other assumptions with regard to the discount rate, reference case socioeconomic and emission scenarios, or equilibrium climate sensitivity. Improvements in the way damages are modeled are confined to those that have been incorporated into the latest versions of the models by the developers themselves in the peer-reviewed literature. The agencies participating in the interagency working group continue to investigate potential improvements to the way in which economic damages associated with changes in CO_2 emissions are quantified.

Section II summarizes the major updates relevant to SCC estimation that are contained in the new versions of the integrated assessment models released since the 2010 interagency report. Section III presents the updated schedule of SCC estimates for 2010 – 2050 based on these versions of the models. Section IV provides a discussion of other model limitations and research gaps.

II. Summary of Model Updates

This section briefly summarizes changes to the most recent versions of the three integrated assessment models (IAMs) used by the interagency group in 2010. We focus on describing those model updates that are relevant to estimating the social cost of carbon, as summarized in Table 1. For example, both the DICE and PAGE models now include an explicit representation of sea level rise damages. Other revisions to PAGE include: updated adaptation assumptions, revisions to ensure damages are constrained by GDP, updated regional scaling of damages, and a revised treatment of potentially abrupt shifts in climate damages. The DICE model's simple carbon cycle has been updated to be more consistent with a more complex climate model. The FUND model includes updated damage functions for sea level rise impacts, the agricultural sector, and reduced space heating requirements, as well as changes to the transient response of temperature to the buildup of GHG concentrations and the inclusion of indirect effects of

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[1] In this document, we present all values of the SCC as the cost per metric ton of CO_2 emissions. Alternatively, one could report the SCC as the cost per metric ton of carbon emissions. The multiplier for translating between mass of CO_2 and the mass of carbon is 3.67 (the molecular weight of CO_2 divided by the molecular weight of carbon = 44/12 = 3.67).
[2] http://www.whitehouse.gov/sites/default/files/omb/inforeg/eo12866/eo13563_01182011.pdf
[3] See p. 1, 3, 4, 29, and 33 (Interagency Working Group on Social Cost of Carbon 2010).

methane emissions. Changes made to parts of the models that are superseded by the interagency working group's modeling assumptions – regarding equilibrium climate sensitivity, discounting, and socioeconomic variables – are not discussed here but can be found in the references provided in each section below.

Table 1: Summary of Key Model Revisions Relevant to the Interagency SCC

IAM	Version used in 2010 Interagency Analysis	New Version	Key changes relevant to interagency SCC
DICE	2007	2010	Updated calibration of the carbon cycle model and explicit representation of sea level rise (SLR) and associated damages.
FUND	3.5 (2009)	3.8 (2012)	Updated damage functions for space heating, SLR, agricultural impacts, changes to transient response of temperature to buildup of GHG concentrations, and inclusion of indirect climate effects of methane.
PAGE	2002	2009	Explicit representation of SLR damages, revisions to damage function to ensure damages do not exceed 100% of GDP, change in regional scaling of damages, revised treatment of potential abrupt damages, and updated adaptation assumptions.

A. DICE

DICE 2010 includes a number of changes over the previous 2007 version used in the 2010 interagency report. The model changes that are relevant for the SCC estimates developed by the interagency working group include: 1) updated parameter values for the carbon cycle model, 2) an explicit representation of sea level dynamics, and 3) a re-calibrated damage function that includes an explicit representation of economic damages from sea level rise. Changes were also made to other parts of the DICE model—including the equilibrium climate sensitivity parameter, the rate of change of total factor productivity, and the elasticity of the marginal utility of consumption—but these components of DICE are superseded by the interagency working group's assumptions and so will not be discussed here. More details on DICE2007 can be found in Nordhaus (2008) and on DICE2010 in Nordhaus (2010). The DICE2010 model and documentation is also available for download from the homepage of William Nordhaus.

Carbon Cycle Parameters

DICE uses a three-box model of carbon stocks and flows to represent the accumulation and transfer of carbon among the atmosphere, the shallow ocean and terrestrial biosphere, and the deep ocean. These parameters are "calibrated to match the carbon cycle in the Model for the Assessment of Greenhouse Gas Induced Climate Change (MAGICC)" (Nordhaus 2008 p 44).[4] Carbon cycle transfer coefficient values

[4] MAGICC is a simple climate model initially developed by the U.S. National Center for Atmospheric Research that has been used heavily by the Intergovernmental Panel on Climate Change (IPCC) to emulate projections from more sophisticated state of the art earth system simulation models (Randall et al. 2007).

in DICE2010 are based on re-calibration of the model to match the newer 2009 version of MAGICC (Nordhaus 2010 p 2). For example, in DICE2010, in each decade, 12 percent of the carbon in the atmosphere is transferred to the shallow ocean, 4.7 percent of the carbon in the shallow ocean is transferred to the atmosphere, 94.8 percent remains in the shallow ocean, and 0.5 percent is transferred to the deep ocean. For comparison, in DICE 2007, 18.9 percent of the carbon in the atmosphere is transferred to the shallow ocean each decade, 9.7 percent of the carbon in the shallow ocean is transferred to the atmosphere, 85.3 percent remains in the shallow ocean, and 5 percent is transferred to the deep ocean.

The implication of these changes for DICE2010 is in general a weakening of the ocean as a carbon sink and therefore a higher concentration of carbon in the atmosphere than in DICE2007, for a given path of emissions. All else equal, these changes will generally increase the level of warming and therefore the SCC estimates in DICE2010 relative to those from DICE2007.

Sea Level Dynamics

A new feature of DICE2010 is an explicit representation of the dynamics of the global average sea level anomaly to be used in the updated damage function (discussed below). This section contains a brief description of the sea level rise (SLR) module; a more detailed description can be found on the model developer's website.[5] The average global sea level anomaly is modeled as the sum of four terms that represent contributions from: 1) thermal expansion of the oceans, 2) melting of glaciers and small ice caps, 3) melting of the Greenland ice sheet, and 4) melting of the Antarctic ice sheet.

The parameters of the four components of the SLR module are calibrated to match consensus results from the IPCC's Fourth Assessment Report (AR4).[6] The rise in sea level from thermal expansion in each time period (decade) is 2 percent of the difference between the sea level in the previous period and the long run equilibrium sea level, which is 0.5 meters per degree Celsius (°C) above the average global temperature in 1900. The rise in sea level from the melting of glaciers and small ice caps occurs at a rate of 0.008 meters per decade per °C above the average global temperature in 1900.

The contribution to sea level rise from melting of the Greenland ice sheet is more complex. The equilibrium contribution to SLR is 0 meters for temperature anomalies less than 1 °C and increases linearly from 0 meters to a maximum of 7.3 meters for temperature anomalies between 1 °C and 3.5 °C. The contribution to SLR in each period is proportional to the difference between the previous period's sea level anomaly and the equilibrium sea level anomaly, where the constant of proportionality increases with the temperature anomaly in the current period.

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[5] Documentation on the new sea level rise module of DICE is available on William Nordhaus' website at: http://nordhaus.econ.yale.edu/documents/SLR_021910.pdf.

[6] For a review of post-IPCC AR4 research on sea level rise, see Nicholls et al. (2011) and NAS (2011).

The contribution to SLR from the melting of the Antarctic ice sheet is -0.001 meters per decade when the temperature anomaly is below 3 °C and increases linearly between 3 °C and 6 °C to a maximum rate of 0.025 meters per decade at a temperature anomaly of 6 °C.

Re-calibrated Damage Function

Economic damages from climate change in the DICE model are represented by a fractional loss of gross economic output in each period. A portion of the remaining economic output in each period (net of climate change damages) is consumed and the remainder is invested in the physical capital stock to support future economic production, so each period's climate damages will reduce consumption in that period and in all future periods due to the lost investment. The fraction of output in each period that is lost due to climate change impacts is represented as one minus a fraction, which is one divided by a quadratic function of the temperature anomaly, producing a sigmoid ("S"-shaped) function.[7] The loss function in DICE2010 has been expanded by adding a quadratic function of SLR to the quadratic function of temperature. In DICE2010 the temperature anomaly coefficients have been recalibrated to avoid double-counting damages from sea level rise that were implicitly included in these parameters in DICE2007.

The aggregate damages in DICE2010 are illustrated by Nordhaus (2010 p 3), who notes that "...damages in the uncontrolled (baseline) [i.e., reference] case ... in 2095 are $12 trillion, or 2.8 percent of global output, for a global temperature increase of 3.4 °C above 1900 levels." This compares to a loss of 3.2 percent of global output at 3.4 °C in DICE2007. However, in DICE2010, annual damages are lower in most of the early periods of the modeling horizon but higher in later periods than would be calculated using the DICE2007 damage function. Specifically, the percent difference between damages in the base run of DICE2010 and those that would be calculated using the DICE2007 damage function starts at +7 percent in 2005, decreases to a low of -14 percent in 2065, then continuously increases to +20 percent by 2300 (the end of the interagency analysis time horizon), and to +160 percent by the end of the model time horizon in 2595. The large increases in the far future years of the time horizon are due to the permanence associated with damages from sea level rise, along with the assumption that the sea level is projected to continue to rise long after the global average temperature begins to decrease. The changes to the loss function generally decrease the interagency working group SCC estimates slightly given that relative increases in damages in later periods are discounted more heavily, all else equal.

B. FUND

FUND version 3.8 includes a number of changes over the previous version 3.5 (Narita et al. 2010) used in the 2010 interagency report. Documentation supporting FUND and the model's source code for all versions of the model is available from the model authors.[8] Notable changes, due to their impact on the

[7] The model and documentation, including formulas, are available on the author's webpage at http://www.econ.yale.edu/~nordhaus/homepage/RICEmodels.htm.

[8] http://www.fund-model.org/. This report uses version 3.8 of the FUND model, which represents a modest update to the most recent version of the model to appear in the literature (version 3.7) (Anthoff and Tol, 2013). For the purpose of computing the SCC, the relevant changes (between 3.7 to 3.8) are associated with improving

SCC estimates, are adjustments to the space heating, agriculture, and sea level rise damage functions in addition to changes to the temperature response function and the inclusion of indirect effects from methane emissions.[9] We discuss each of these in turn.

Space Heating

In FUND, the damages associated with the change in energy needs for space heating are based on the estimated impact due to one degree of warming. These baseline damages are scaled based on the forecasted temperature anomaly's deviation from the one degree benchmark and adjusted for changes in vulnerability due to economic and energy efficiency growth. In FUND 3.5, the function that scales the base year damages adjusted for vulnerability allows for the possibility that in some simulations the benefits associated with reduced heating needs may be an unbounded convex function of the temperature anomaly. In FUND 3.8, the form of the scaling has been modified to ensure that the function is everywhere concave and that there will exist an upper bound on the benefits a region may receive from reduced space heating needs. The new formulation approaches a value of two in the limit of large temperature anomalies, or in other words, assuming no decrease in vulnerability, the reduced expenditures on space heating at any level of warming will not exceed two times the reductions experienced at one degree of warming. Since the reduced need for space heating represents a benefit of climate change in the model, or a negative damage, this change will increase the estimated SCC. This update accounts for a significant portion of the difference in the expected SCC estimates reported by the two versions of the model when run probabilistically.

Sea Level Rise and Land Loss

The FUND model explicitly includes damages associated with the inundation of dry land due to sea level rise. The amount of land lost within a region is dependent upon the proportion of the coastline being protected by adequate sea walls and the amount of sea level rise. In FUND 3.5 the function defining the potential land lost in a given year due to sea level rise is linear in the rate of sea level rise for that year. This assumption implicitly assumes that all regions are well represented by a homogeneous coastline in length and a constant uniform slope moving inland. In FUND 3.8 the function defining the potential land lost has been changed to be a convex function of sea level rise, thereby assuming that the slope of the shore line increases moving inland. The effect of this change is to typically reduce the vulnerability of some regions to sea level rise based land loss, thereby lowering the expected SCC estimate. [10]

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consistency with IPCC AR4 by adjusting the atmospheric lifetimes of CH4 and N2O and incorporating the indirect forcing effects of CH4, along with making minor stability improvements in the sea wall construction algorithm.

[9] The other damage sectors (water resources, space cooling, land loss, migration, ecosystems, human health, and extreme weather) were not significantly updated.

[10] For stability purposes this report also uses an update to the model which assumes that regional coastal protection measures will be built to protect the most valuable land first, such that the marginal benefits of coastal protection is decreasing in the level of protection following Fankhauser (1995).

Agriculture

In FUND, the damages associated with the agricultural sector are measured as proportional to the sector's value. The fraction is bounded from above by one and is made up of three additive components that represent the effects from carbon fertilization, the rate of temperature change, and the level of the temperature anomaly. In both FUND 3.5 and FUND 3.8, the fraction of the sector's value lost due to the level of the temperature anomaly is modeled as a quadratic function with an intercept of zero. In FUND 3.5, the coefficients of this loss function are modeled as the ratio of two random normal variables. This specification had the potential for unintended extreme behavior as draws from the parameter in the denominator approached zero or went negative. In FUND 3.8, the coefficients are drawn directly from truncated normal distributions so that they remain in the range $[0,\infty)$ and $(-\infty,0]$, respectively, ensuring the correct sign and eliminating the potential for divide by zero errors. The means for the new distributions are set equal to the ratio of the means from the normal distributions used in the previous version. In general the impact of this change has been to decrease the range of the distribution while spreading out the distributions' mass over the remaining range relative to the previous version. The net effect of this change on the SCC estimates is difficult to predict.

Transient Temperature Response

The temperature response model translates changes in global levels of radiative forcing into the current expected temperature anomaly. In FUND, a given year's increase in the temperature anomaly is based on a mean reverting function where the mean equals the equilibrium temperature anomaly that would eventually be reached if that year's level of radiative forcing were sustained. The rate of mean reversion defines the rate at which the transient temperature approaches the equilibrium. In FUND 3.5, the rate of temperature response is defined as a decreasing linear function of equilibrium climate sensitivity to capture the fact that the progressive heat uptake of the deep ocean causes the rate to slow at higher values of the equilibrium climate sensitivity. In FUND 3.8, the rate of temperature response has been updated to a quadratic function of the equilibrium climate sensitivity. This change reduces the sensitivity of the rate of temperature response to the level of the equilibrium climate sensitivity, a relationship first noted by Hansen et al. (1985) based on the heat uptake of the deep ocean. Therefore in FUND 3.8, the temperature response will typically be faster than in the previous version. The overall effect of this change is likely to increase estimates of the SCC as higher temperatures are reached during the timeframe analyzed and as the same damages experienced in the previous version of the model are now experienced earlier and therefore discounted less.

Methane

The IPCC AR4 notes a series of indirect effects of methane emissions, and has developed methods for proxying such effects when computing the global warming potential of methane (Forster et al. 2007). FUND 3.8 now includes the same methods for incorporating the indirect effects of methane emissions. Specifically, the average atmospheric lifetime of methane has been set to 12 years to account for the feedback of methane emissions on its own lifetime. The radiative forcing associated with atmospheric methane has also been increased by 40% to account for its net impact on ozone production and stratospheric water vapor. All else equal, the effect of this increased radiative forcing will be to increase the estimated SCC values, due to greater projected temperature anomaly.

C. PAGE

PAGE09 (Hope 2013) includes a number of changes from PAGE2002, the version used in the 2010 SCC interagency report. The changes that most directly affect the SCC estimates include: explicitly modeling the impacts from sea level rise, revisions to the damage function to ensure damages are constrained by GDP, a change in the regional scaling of damages, a revised treatment for the probability of a discontinuity within the damage function, and revised assumptions on adaptation. The model also includes revisions to the carbon cycle feedback and the calculation of regional temperatures.[11] More details on PAGE09 can be found in Hope (2011a, 2011b, 2011c). A description of PAGE2002 can be found in Hope (2006).

Sea Level Rise

While PAGE2002 aggregates all damages into two categories – economic and non-economic impacts -, PAGE09 adds a third explicit category: damages from sea level rise. In the previous version of the model, damages from sea level rise were subsumed by the other damage categories. In PAGE09 sea level damages increase less than linearly with sea level under the assumption that land, people, and GDP are more concentrated in low-lying shoreline areas. Damages from the economic and non-economic sector were adjusted to account for the introduction of this new category.

Revised Damage Function to Account for Saturation

In PAGE09, small initial economic and non-economic benefits (negative damages) are modeled for small temperature increases, but all regions eventually experience economic damages from climate change, where damages are the sum of additively separable polynomial functions of temperature and sea level rise. Damages transition from this polynomial function to a logistic path once they exceed a certain proportion of remaining Gross Domestic Product (GDP) to ensure that damages do not exceed 100 percent of GDP. This differs from PAGE2002, which allowed Eastern Europe to potentially experience large benefits from temperature increases, and which also did not bound the possible damages that could be experienced.

Regional Scaling Factors

As in the previous version of PAGE, the PAGE09 model calculates the damages for the European Union (EU) and then, assumes that damages for other regions are proportional based on a given scaling factor. The scaling factor in PAGE09 is based on the length of a region's coastline relative to the EU (Hope 2011b). Because of the long coastline in the EU, other regions are, on average, less vulnerable than the EU for the same sea level and temperature increase, but all regions have a positive scaling factor. PAGE2002 based its scaling factors on four studies reported in the IPCC's third assessment report, and allowed for benefits

[11] Because several changes in the PAGE model are structural (e.g., the addition of sea level rise and treatment of discontinuity), it is not possible to assess the direct impact of each change on the SCC in isolation as done for the other two models above.

from temperature increase in Eastern Europe, smaller impacts in developed countries, and higher damages in developing countries.

Probability of a Discontinuity

In PAGE2002, the damages associated with a "discontinuity" (nonlinear extreme event) were modeled as an expected value. Specifically, a stochastic probability of a discontinuity was multiplied by the damages associated with a discontinuity to obtain an expected value, and this was added to the economic and non-economic impacts. That is, additional damages from an extreme event, such as extreme melting of the Greenland ice sheet, were multiplied by the probability of the event occurring and added to the damage estimate. In PAGE09, the probability of discontinuity is treated as a discrete event for each year in the model. The damages for each model run are estimated either with or without a discontinuity occurring, rather than as an expected value. A large-scale discontinuity becomes possible when the temperature rises beyond some threshold value between 2 and 4°C. The probability that a discontinuity will occur beyond this threshold then increases by between 10 and 30 percent for every 1°C rise in temperature beyond the threshold. If a discontinuity occurs, the EU loses an additional 5 to 25 percent of its GDP (drawn from a triangular distribution with a mean of 15 percent) in addition to other damages, and other regions lose an amount determined by the regional scaling factor. The threshold value for a possible discontinuity is lower than in PAGE2002, while the rate at which the probability of a discontinuity increases with the temperature anomaly and the damages that result from a discontinuity are both higher than in PAGE2002. The model assumes that only one discontinuity can occur and that the impact is phased in over a period of time, but once it occurs, its effect is permanent.

Adaptation

As in PAGE2002, adaptation is available to help mitigate any climate change impacts that occur. In PAGE this adaptation is the same regardless of the temperature change or sea level rise and is therefore akin to what is more commonly considered a reduction in vulnerability. It is modeled by reducing the damages by some percentage. PAGE09 assumes a smaller decrease in vulnerability than the previous version of the model and assumes that it will take longer for this change in vulnerability to be realized. In the aggregated economic sector, at the time of full implementation, this adaptation will mitigate all damages up to a temperature increase of 1°C, and for temperature anomalies between 1°C and 2°C, it will reduce damages by 15-30 percent (depending on the region). However, it takes 20 years to fully implement this adaptation. In PAGE2002, adaptation was assumed to reduce economic sector damages up to 2°C by 50-90 percent after 20 years. Beyond 2°C, no adaptation is assumed to be available to mitigate the impacts of climate change. For the non-economic sector, in PAGE09 adaptation is available to reduce 15 percent of the damages due to a temperature increase between 0°C and 2°C and is assumed to take 40 years to fully implement, instead of 25 percent of the damages over 20 years assumed in PAGE2002. Similarly, adaptation is assumed to alleviate 25-50 percent of the damages from the first 0.20 to 0.25 meters of sea level rise but is assumed to be ineffective thereafter. Hope (2011c) estimates that the less optimistic assumptions regarding the ability to offset impacts of temperature and sea level rise via adaptation increase the SCC by approximately 30 percent.

Other Noteworthy Changes

Two other changes in the model are worth noting. There is a change in the way the model accounts for decreased CO_2 absorption on land and in the ocean as temperature rises. PAGE09 introduces a linear feedback from global mean temperature to the percentage gain in the excess concentration of CO_2, capped at a maximum level. In PAGE2002, an additional amount was added to the CO_2 emissions each period to account for a decrease in ocean absorption and a loss of soil carbon. Also updated is the method by which the average global and annual temperature anomaly is downscaled to determine annual average regional temperature anomalies to be used in the regional damage functions. In PAGE2002, the scaling was determined solely based on regional difference in emissions of sulfate aerosols. In PAGE09, this regional temperature anomaly is further adjusted using an additive factor that is based on the average absolute latitude of a region relative to the area weighted average absolute latitude of the Earth's landmass, to capture relatively greater changes in temperature forecast to be experienced at higher latitudes.

III. Revised SCC Estimates

The updated versions of the three integrated assessment models were run using the same methodology detailed in the 2010 TSD (Interagency Working Group on Social Cost of Carbon 2010). The approach along with the inputs for the socioeconomic emissions scenarios, equilibrium climate sensitivity distribution, and discount rate remains the same. This includes the five reference scenarios based on the EMF-22 modeling exercise, the Roe and Baker equilibrium climate sensitivity distribution calibrated to the IPCC AR4, and three constant discount rates of 2.5, 3, and 5 percent.

As was previously the case, the use of three models, three discount rates, and five scenarios produces 45 separate distributions for the global SCC. The approach laid out in the 2010 TSD applied equal weight to each model and socioeconomic scenario in order to reduce the dimensionality down to three separate distributions representative of the three discount rates. The interagency group selected four values from these distributions for use in regulatory analysis. Three values are based on the average SCC across models and socio-economic-emissions scenarios at the 2.5, 3, and 5 percent discount rates, respectively. The fourth value was chosen to represent the higher-than-expected economic impacts from climate change further out in the tails of the SCC distribution. For this purpose, the 95th percentile of the SCC estimates at a 3 percent discount rate was chosen. (A detailed set of percentiles by model and scenario combination and additional summary statistics for the 2020 values is available in the Appendix.) As noted in the 2010 TSD, "the 3 percent discount rate is the central value, and so the central value that emerges is the average SCC across models at the 3 percent discount rate" (Interagency Working Group on Social Cost of Carbon 2010, p. 25). However, for purposes of capturing the uncertainties involved in regulatory impact analysis, the interagency group emphasizes the importance and value of including all four SCC values.

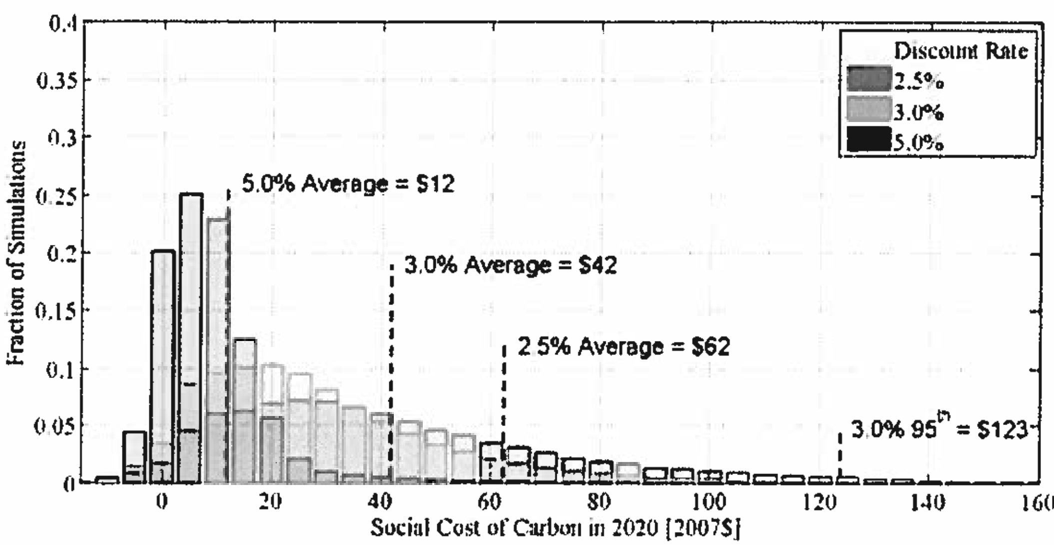
Table 2 shows the four selected SCC estimates in five year increments from 2010 to 2050. Values for 2010, 2020, 2030, 2040, and 2050 are calculated by first combining all outputs (10,000 estimates per model run) from all scenarios and models for a given discount rate. Values for the years in between are calculated using linear interpolation. The full set of revised annual SCC estimates between 2010 and 2050 is reported in the Appendix.

Table 2: Revised Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

The SCC estimates using the updated versions of the models are higher than those reported in the 2010 TSD due to the changes to the models outlined in the previous section. By way of comparison, the 2020 SCC estimates reported in the original TSD were \$7, \$26, \$42 and \$81 (2007\$) (Interagency Working Group on Social Cost of Carbon 2010). Figure 1 illustrates where the four SCC values for 2020 fall within the full distribution for each discount rate based on the combined set of runs for each model and scenario (150,000 estimates in total for each discount rate). In general, the distributions are skewed to the right and have long tails. The Figure also shows that the lower the discount rate, the longer the right tail of the distribution.

Figure 1: Distribution of SCC Estimates for 2020 (in 2007\$ per metric ton CO_2)



As was the case in the 2010 TSD, the SCC increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change. The approach taken by the interagency group is to compute the cost of a marginal ton emitted in the future by running the models for a set of perturbation years out to 2050. Table 3 illustrates how the growth rate for these four SCC estimates varies over time.

Table 3: Average Annual Growth Rates of SCC Estimates between 2010 and 2050

Average Annual Growth Rate (%)	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010-2020	1.2%	3.2%	2.4%	4.4%
2020-2030	3.4%	2.1%	1.7%	2.3%
2030-2040	3.0%	1.9%	1.5%	2.0%
2040-2050	2.6%	1.6%	1.3%	1.6%

The future monetized value of emission reductions in each year (the SCC in year *t* multiplied by the change in emissions in year *t*) must be discounted to the present to determine its total net present value for use in regulatory analysis. As previously discussed in the 2010 TSD, damages from future emissions should be discounted at the same rate as that used to calculate the SCC estimates themselves to ensure internal consistency – i.e., future damages from climate change, whether they result from emissions today or emissions in a later year, should be discounted using the same rate.

Under current OMB guidance contained in Circular A-4, analysis of economically significant proposed and final regulations from the domestic perspective is required, while analysis from the international perspective is optional. However, the climate change problem is highly unusual in at least two respects. First, it involves a global externality: emissions of most greenhouse gases contribute to damages around the world even when they are emitted in the United States. Consequently, to address the global nature of the problem, the SCC must incorporate the full (global) damages caused by GHG emissions. Second, climate change presents a problem that the United States alone cannot solve. Even if the United States were to reduce its greenhouse gas emissions to zero, that step would be far from enough to avoid substantial climate change. Other countries would also need to take action to reduce emissions if significant changes in the global climate are to be avoided. Emphasizing the need for a global solution to a global problem, the United States has been actively involved in seeking international agreements to reduce emissions and in encouraging other nations, including emerging major economies, to take significant steps to reduce emissions. When these considerations are taken as a whole, the interagency group concluded that a global measure of the benefits from reducing U.S. emissions is preferable. For additional discussion, see the 2010 TSD.

IV. Other Model Limitations and Research Gaps

The 2010 interagency SCC TSD discusses a number of important limitations for which additional research is needed. In particular, the document highlights the need to improve the quantification of both non-catastrophic and catastrophic damages, the treatment of adaptation and technological change, and the way in which inter-regional and inter-sectoral linkages are modeled. While the new version of the models discussed above offer some improvements in these areas, further work remains warranted. The 2010 TSD also discusses the need to more carefully assess the implications of risk aversion for SCC estimation as well as the inability to perfectly substitute between climate and non-climate goods at higher temperature increases, both of which have implications for the discount rate used. EPA, DOE, and other agencies continue to engage in research on modeling and valuation of climate impacts that can potentially improve SCC estimation in the future.

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Appendix A

Table A1: Annual SCC Values: 2010-2050 (2007$/metric ton CO_2)

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	10	31	50	86
2011	11	32	51	90
2012	11	33	53	93
2013	11	34	54	97
2014	11	35	55	101
2015	11	36	56	105
2016	11	38	57	108
2017	11	39	59	112
2018	12	40	60	116
2019	12	41	61	120
2020	12	42	62	123
2021	12	42	63	126
2022	13	43	64	129
2023	13	44	65	132
2024	13	45	66	135
2025	14	46	68	138
2026	14	47	69	141
2027	15	48	70	143
2028	15	49	71	146
2029	15	49	72	149
2030	16	50	73	152
2031	16	51	74	155
2032	17	52	75	158
2033	17	53	76	161
2034	18	54	77	164
2035	18	55	78	168
2036	19	56	79	171
2037	19	57	81	174
2038	20	58	82	177
2039	20	59	83	180
2040	21	60	84	183
2041	21	61	85	186
2042	22	61	86	189
2043	22	62	87	192
2044	23	63	88	194
2045	23	64	89	197
2046	24	65	90	200
2047	24	66	92	203
2048	25	67	93	206
2049	25	68	94	209
2050	26	69	95	212

Table A2: 2020 Global SCC Estimates at 2.5 Percent Discount Rate (2007$/metric ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario[12]	PAGE									
IMAGE	6	10	15	26	55	123	133	313	493	949
MERGE Optimistic	4	6	8	15	32	75	79	188	304	621
MESSAGE	4	7	10	19	41	104	103	266	463	879
MiniCAM Base	5	8	12	21	45	102	108	255	412	835
5th Scenario	2	4	6	11	24	81	66	192	371	915
Scenario	DICE									
IMAGE	25	31	37	47	64	72	92	123	139	161
MERGE Optimistic	14	18	20	26	36	40	50	65	74	85
MESSAGE	20	24	28	37	51	58	71	95	109	221
MiniCAM Base	20	25	29	38	53	61	76	102	117	135
5th Scenario	17	22	25	33	45	52	65	91	106	126
Scenario	FUND									
IMAGE	-14	-2	4	15	31	39	55	86	107	157
MERGE Optimistic	-6	1	6	14	27	35	46	70	87	141
MESSAGE	-16	-5	1	11	24	31	43	67	83	126
MiniCAM Base	-7	2	7	16	32	39	55	83	103	158
5th Scenario	-29	-13	-6	4	16	21	32	53	69	103

Table A3: 2020 Global SCC Estimates at 3 Percent Discount Rate (2007$/metric ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario	PAGE									
IMAGE	4	7	9	17	36	87	91	228	369	696
MERGE Optimistic	2	4	6	10	22	54	55	136	222	461
MESSAGE	3	5	7	13	28	72	71	188	316	614
MiniCAM Base	3	5	7	13	29	70	72	177	288	597
5th Scenario	1	3	4	7	16	55	46	130	252	632
Scenario	DICE									
IMAGE	16	21	24	32	43	48	60	79	90	102
MERGE Optimistic	10	13	15	19	25	28	35	44	50	58
MESSAGE	14	18	20	26	35	40	49	64	73	83
MiniCAM Base	13	17	20	26	35	39	49	65	73	85
5th Scenario	12	15	17	22	30	34	43	58	67	79
Scenario	FUND									
IMAGE	-13	-4	0	8	18	23	33	51	65	99
MERGE Optimistic	-7	-1	2	8	17	21	29	45	57	95
MESSAGE	-14	-6	-2	5	14	18	26	41	52	82
MiniCAM Base	-7	-1	3	9	19	23	33	50	63	101
5th Scenario	-22	-11	-6	1	8	11	18	31	40	62

[12] See 2010 TSD for a description of these scenarios.

Table A4: 2020 Global SCC Estimates at 5 Percent Discount Rate (2007$/metric ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario					PAGE					
IMAGE	1	2	2	4	10	27	26	68	118	234
MERGE Optimistic	1	1	2	3	6	17	17	43	72	146
MESSAGE	1	1	2	4	8	23	22	58	102	207
MiniCAM Base	1	1	2	3	8	20	20	52	90	182
5th Scenario	0	1	1	2	5	17	14	39	75	199
Scenario					DICE					
IMAGE	6	8	9	11	14	15	18	22	25	27
MERGE Optimistic	4	5	6	7	9	10	12	15	16	18
MESSAGE	6	7	8	10	12	13	16	20	22	25
MiniCAM Base	5	6	7	8	11	12	14	18	20	22
5th Scenario	5	6	6	8	10	11	14	17	19	21
Scenario					FUND					
IMAGE	-9	-5	-4	-1	2	3	6	10	14	24
MERGE Optimistic	-6	-4	-2	0	3	4	6	11	15	26
MESSAGE	-10	-6	-4	-1	1	2	5	9	12	21
MiniCAM Base	-7	-4	-2	0	3	4	6	11	14	25
5th Scenario	-11	-7	-5	-3	0	0	3	5	7	13

Table A5: Additional Summary Statistics of 2020 Global SCC Estimates

Discount rate:	5.0%				3.0%				2.5%			
Statistic:	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis
DICE	12	26	2	15	38	409	3	24	57	1097	3	30
PAGE	21	1481	5	32	68	13712	4	22	97	26878	4	23
FUND	3	41	5	179	19	1452	-42	8727	33	6154	-73	14931

Appendix B

The November 2013 revision of this technical support document is based on two corrections to the runs based on the FUND model. First, the potential dry land loss in the algorithm that estimates regional coastal protections was misspecified in the model's computer code. This correction is covered in an erratum to Anthoff and Tol (2013) published in the same journal (Climatic Change) in October 2013 (Anthoff and Tol (2013b)). Second, the equilibrium climate sensitivity distribution was inadvertently specified as a truncated Gamma distribution (the default in FUND) as opposed to the truncated Roe and Baker distribution as was intended. The truncated Gamma distribution used in the FUND runs had approximately the same mean and upper truncation point, but lower variance and faster decay of the upper tail, as compared to the intended specification based on the Roe and Baker distribution. The difference between the original estimates reported in the May 2013 version of this technical support document and this revision are generally one dollar or less.

The July 2015 revision of this technical support document is based on two corrections. First, the DICE model had been run up to 2300 rather than through 2300, as was intended, thereby leaving out the marginal damages in the last year of the time horizon. Second, due to an indexing error, the results from the PAGE model were in 2008 U.S. dollars rather than 2007 U.S. dollars, as was intended. In the current revision, all models have been run through 2300, and all estimates are in 2007 U.S. dollars. On average the revised SCC estimates are one dollar less than the mean SCC estimates reported in the November 2013 version of this technical support document. The difference between the 95th percentile estimates with a 3% discount rate is slightly larger, as those estimates are heavily influenced by results from the PAGE model.

Ex.7

THE COST OF DELAYING ACTION TO STEM CLIMATE CHANGE

July 2014

EXECUTIVE OFFICE OF THE PRESIDENT OF THE UNITED STATES
COUNCIL OF ECONOMIC ADVISERS

Executive Summary

The signs of climate change are all around us. The average temperature in the United States during the past decade was 0.8° Celsius (1.5° Fahrenheit) warmer than the 1901-1960 average, and the last decade was the warmest on record both in the United States and globally. Global sea levels are currently rising at approximately 1.25 inches per decade, and the rate of increase appears to be accelerating. Climate change is having different impacts across regions within the United States. In the West, heat waves have become more frequent and more intense, while heavy downpours are increasing throughout the lower 48 States and Alaska, especially in the Midwest and Northeast.[1] The scientific consensus is that these changes, and many others, are largely consequences of anthropogenic emissions of greenhouse gases.[2]

The emission of greenhouse gases such as carbon dioxide (CO_2) harms others in a way that is not reflected in the price of carbon-based energy, that is, CO_2 emissions create a negative externality. Because the price of carbon-based energy does not reflect the full costs, or economic damages, of CO_2 emissions, market forces result in a level of CO_2 emissions that is too high. Because of this market failure, public policies are needed to reduce CO_2 emissions and thereby to limit the damage to economies and the natural world from further climate change.

There is a vigorous public debate over whether to act now to stem climate change or instead to delay implementing mitigation policies until a future date. This report examines the economic consequences of delaying implementing such policies and reaches two main conclusions, both of which point to the benefits of implementing mitigation policies now and to the net costs of delaying taking such actions.

First, although delaying action can reduce costs in the short run, on net, delaying action to limit the effects of climate change is costly. Because CO_2 accumulates in the atmosphere, delaying action increases CO_2 concentrations. Thus, if a policy delay leads to higher ultimate CO_2 concentrations, that delay produces persistent economic damages that arise from higher temperatures and higher CO_2 concentrations. Alternatively, if a delayed policy still aims to hit a given climate target, such as limiting CO_2 concentration to given level, then that delay means that the policy, when implemented, must be more stringent and thus more costly in subsequent years. In either case, delay is costly.

These costs will take the form of either greater damages from climate change or higher costs associated with implementing more rapid reductions in greenhouse gas emissions. In practice, delay could result in both types of costs. These costs can be large:

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[1] For a fuller treatment of the current and projected consequences of climate change for U.S. regions and sectors, see the Third National Climate Assessment (United States Global Change Research Program (USGCRP) 2014).

[2] See for example the Summary for Policymakers in Working Group I contribution to the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC WG I AR5 2013).

- Based on a leading aggregate damage estimate in the climate economics literature, a delay that results in warming of 3° Celsius above preindustrial levels, instead of 2°, could increase economic damages by approximately 0.9 percent of global output. To put this percentage in perspective, 0.9 percent of estimated 2014 U.S. Gross Domestic Product (GDP) is approximately $150 billion. The incremental cost of an additional degree of warming beyond 3° Celsius would be even greater. Moreover, these costs are not one-time, but are rather incurred year after year because of the permanent damage caused by increased climate change resulting from the delay.

- An analysis of research on the cost of delay for hitting a specified climate target (typically, a given concentration of greenhouse gases) suggests that net mitigation costs increase, on average, by approximately 40 percent for each decade of delay. These costs are higher for more aggressive climate goals: each year of delay means more CO_2 emissions, so it becomes increasingly difficult, or even infeasible, to hit a climate target that is likely to yield only moderate temperature increases.

Second, climate policy can be thought of as "climate insurance" taken out against the most severe and irreversible potential consequences of climate change. Events such as the rapid melting of ice sheets and the consequent increase of global sea levels, or temperature increases on the higher end of the range of scientific uncertainty, could pose such severe economic consequences as reasonably to be thought of as climate catastrophes. Confronting the possibility of climate catastrophes means taking prudent steps now to reduce the future chances of the most severe consequences of climate change. The longer that action is postponed, the greater will be the concentration of CO_2 in the atmosphere and the greater is the risk. Just as businesses and individuals guard against severe financial risks by purchasing various forms of insurance, policymakers can take actions now that reduce the chances of triggering the most severe climate events. And, unlike conventional insurance policies, climate policy that serves as climate insurance is an investment that also leads to cleaner air, energy security, and benefits that are difficult to monetize like biological diversity.

I. Introduction

The changing climate and increasing atmospheric greenhouse gas (GHG) concentrations are projected to accelerate multiple threats, including more severe storms, droughts, and heat waves, further sea level rise, more frequent and severe storm surge damage, and acidification of the oceans (USGCRP 2014). Beyond the sorts of gradual changes we have already experienced, global warming raises additional threats of large-scale changes, either changes to the global climate system, such as the disappearance of late-summer Arctic sea ice and the melting of large glacial ice sheets, or ecosystem impacts of climate change, such as critical endangerment or extinction of a large number of species.

Emissions of GHGs such as carbon dioxide (CO_2) generate a cost that is borne by present and future generations, that is, by people other than those generating the emissions. These costs, or economic damages, include costs to health, costs from sea level rise, and damage from increasingly severe storms, droughts, and wildfires. These costs are not reflected in the price of those emissions. In economists' jargon, emitting CO_2 generates a negative externality and thus a market failure. Because the price of CO_2 emissions does not reflect its true costs, market forces alone are not able to solve the problem of climate change. As a result, without policy action, there will be more emissions and less investment in emissions-reducing technology than there would be if the price of emissions reflected their true costs.

This report examines the cost of delaying policy actions to stem climate change, and reaches two main conclusions. First, delaying action is costly. If a policy delay leads to higher ultimate CO_2 concentrations, then that delay produces persistent additional economic damages caused by higher temperatures, more acidic oceans, and other consequences of higher CO_2 concentrations. Moreover, if delay means that the policy, when implemented, must be more stringent to meet a given target, then it will be more costly.

Second, uncertainty about the most severe, irreversible consequences of climate change adds urgency to implementing climate policies *now* that reduce GHG emissions. In fact, climate policy can be seen as climate insurance taken out against the most damaging potential consequences of climate change—consequences so severe that these events are sometimes referred to as climate catastrophes. The possibility of climate catastrophes leads to taking prudent steps now to sharply reduce the chances that they occur.

The costs of inaction underscore the importance of taking meaningful steps today towards reducing carbon emissions. An example of such a step is the Environmental Protection Agency's (EPA) proposed rule (2014) to regulate carbon pollution from existing power plants. By adopting economically efficient mechanisms to reduce emissions over the coming years, this proposed rule would generate large positive net benefits, which EPA estimates to be in the range of $27 - 50 billion annually in 2020 and $49 - 84 billion in 2030. These benefits include benefits to health from reducing particulate emissions as well as benefits from reducing CO_2 emissions.

Delaying Climate Policies Increases Costs

Delaying climate policies avoids or reduces expenditures on new pollution control technologies in the near term. But this short-term advantage must be set against the disadvantages, which are the costs of delay. The costs of delay are driven by fundamental elements of climate science and economics. Because the lifetime of CO_2 in the atmosphere is very long, if a mitigation policy is delayed, it must take as its starting point a higher atmospheric concentration of CO_2. As a result, delayed mitigation can result in two types of cost, which we would experience in different proportions depending on subsequent policy choices.

First, if delay means an increase in the ultimate end-point concentration of CO_2, then delay will result in additional warming and additional economic damages resulting from climate change. As is discussed in Section II, economists who have studied the costs of climate change find that temperature increases of 2° Celsius above preindustrial levels or less are likely to result in aggregate economic damages that are a small fraction of GDP. This small net effect masks important differences in which some regions could benefit somewhat from this warming while other regions could experience net costs. But global temperatures have *already* risen nearly 1° above preindustrial levels, and it will require concerted effort to hold temperature increases to within the narrow range consistent with small costs.[3] For temperature increases of 3° Celsius or more above preindustrial levels, the aggregate economic damages from climate change are expected to increase sharply.

Delay that causes a climate target to be missed creates large estimated economic damages. For example, a calculation in Section II of this report, based on a leading climate model (the DICE model as reported in Nordhaus 2013), shows that if a delay causes the mean global temperature increase to stabilize at 3° Celsius above preindustrial levels, instead of 2°, that delay will induce annual additional damages of approximately 0.9 percent of global output, as shown in Figure 1.[4] To put this percentage in perspective, 0.9 percent of estimated 2014 U.S. GDP is approximately $150 billion.[5] The next degree increase, from 3° to 4°, would incur greater *additional* annual costs of approximately 1.2 percent of global output. These costs are not one-time: they are incurred year after year because of the permanent damage caused by additional climate change resulting from the delay.

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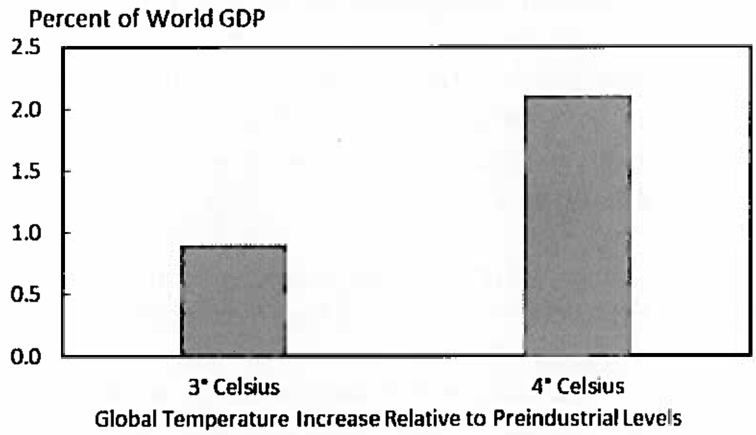
[3] The Working Group III contribution to the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC WG III AR5 2014) does not analyze scenarios producing temperatures in 2100 less than 1.5 Celsius above preindustrial, because this is considered so difficult to achieve.

[4] Nordhaus (2013) stresses that these estimates "are subject to large uncertainties...because of the difficulty of estimating impacts in areas such as the value of lost species and damage to ecosystems." (pp. 139-140).

[5] These percentages apply to gross world output and the application of them to U.S. GDP is illustrative.

Figure 1: Economic Damage from Temperature Increase Beyond 2° Celsius



Source: Nordhaus (2013) and CEA calculations

The second type of cost of delay is the increased cost of reducing emissions more sharply if, instead, the delayed policy is to achieve the same climate target as the non-delayed policy. Taking meaningful steps now sends a signal to the market that reduces long-run costs of meeting the target. Part of this signal is that new carbon-intensive polluting facilities will be seen as bad investments; this reduces the amount of locked-in high-carbon infrastructure that is expensive to replace. Second, taking steps now to reduce CO_2 emissions signals the value of developing new low- and zero-emissions technologies, so additional steps towards a zero-carbon future can be taken as policy action incentivizes the development of new technologies. For both reasons, the least-cost mitigation path to achieve a given concentration target typically starts with a relatively low price of carbon to send these signals to the market, and subsequently increases as new low-carbon technology becomes available.[6]

The research discussed in Section II of this report shows that any short run gains from delay tend to be outweighed by the additional costs arising from the need to adopt a more abrupt and stringent policy later.[7] An analysis of the collective results from that research, described in more detail in Section II, suggests that the cost of hitting a specific climate target increases, on average, by approximately 40 percent for each decade of delay. These costs are higher for more aggressive climate goals: the longer the delay, the more difficult it becomes to hit a climate target. Furthermore, the research also finds that delay substantially decreases the chances that even concerted efforts in the future will hit the most aggressive climate targets.

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[6] The 2010 National Research Council, *Limiting the Magnitude of Future Climate Change*, also stressed the importance of acting now to implement mitigation policies as a way to reduce costs. The NRC emphasized the importance of technology development in holding down costs, including by providing clear signals to the private sector through predictable policies that support development of and investment in low-carbon technologies.

[7] The IPCC WG III AR5 (2014) includes an extensive discussion of mitigation, including sectoral detail, potential for technological progress, and the timing of mitigation policies.

Although global action is essential to meet climate targets, unilateral steps both encourage broader action and benefit the United States. Climate change is a global problem, and it will require strong international leadership to secure cooperation among both developed and developing countries to solve it. America must help forge a truly global solution to this global challenge by galvanizing international action to significantly reduce emissions. By taking credible steps toward mitigation, the United States will also reap the benefits of early action, such as investing in low-carbon infrastructure now that will reduce the costs of reaching climate targets in the future.

Climate Policy as Climate Insurance

Individuals and businesses routinely purchase insurance to guard against various forms of risk such as fire, theft, or other loss. This logic of self-protection also applies to climate change. Much is known about the basic science of climate change: there is a scientific consensus that, because of anthropogenic emissions of CO_2 and other GHGs, global temperatures are increasing, sea levels are rising, and the world's oceans are becoming more acidic. These and other climate changes are expected to be harmful, on balance, to the world's natural and economic systems. Nevertheless, uncertainty remains about the magnitude and timing of these and other aspects of climate change, even if we assume that future climate policies are known in advance. For example, the Working Group I contribution to the IPCC's Fifth Assessment Report (IPCC WG I AR5 2013) provides a likely range of 1.5° to 4.5° Celsius for the equilibrium climate sensitivity, which is the long-run increase in global mean surface temperature that is caused by a sustained doubling of atmospheric CO_2 concentrations. The upper end of that range would imply severe climate impacts under current emissions trajectories, and current scientific knowledge indicates that values in excess of this range are also possible.[8]

An additional, related source of climate uncertainty is the possibility of irreversible, large-scale changes that have wide-ranging and severe consequences. These are sometimes called abrupt changes because they could occur extremely rapidly as measured in geologic time, and are also sometimes called climate catastrophes. We are already witnessing one of these events—the rapid trend towards disappearance of late-summer Arctic sea ice. A recent study from the National Research Council (NRC 2013) found that this strong trend toward decreasing sea-ice cover could have large effects on a variety of components of the Arctic ecosystem and could potentially alter large-scale atmospheric circulation and its variability. The NRC also found that another large-scale change has been occurring, which is the critical endangerment or loss of a significant percentage of marine and terrestrial species. Other events judged by the NRC to be likely in the more distant future (after 2100) include, for example, the possible rapid melting of the Western Antarctic ice and Greenland ice sheets and the potential thawing of Arctic permafrost and the consequent release of the potent GHG methane, which would accelerate global warming. These and other potential large-scale changes are irreversible on relevant time

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[8] It is important to note that, as a global average, the equilibrium climate sensitivity masks the expectation that temperature change will be higher over land than the oceans, and that there will be substantial regional variations in temperature increases. The equilibrium climate sensitivity describes a long-term effect and is only one component of determining near term warming due to the buildup of GHGs in the atmosphere.

scales—if an ice sheet melts, it cannot be reconstituted—and they could potentially have massive global consequences and costs. For many of these events, there is thought to be a "tipping point," for example a temperature threshold, beyond which the transition to the new state becomes inevitable, but the values or locations of these tipping points are typically unknown.

Section III of this report examines the implications of these possible climate-related catastrophes for climate policy. Research on the economic and policy implications of such threats is relatively recent. As detailed in Section III, a conclusion that clearly emerges from this young but active literature is that the threat of a climate catastrophe, potentially triggered by crossing an unknown tipping point, implies erring on the side of prudence today. Accordingly, in a phrase used by Weitzman (2009, 2012), Pindyck (2011), and others, climate policy can be thought of as "climate insurance." The logic here is that of risk management, in which one acts now to reduce the chances of worst-case outcomes in the future. Here, too, there is a cost to delay: the longer emission reductions are postponed, the greater are atmospheric concentrations of GHGs, and the greater is the risk arising from delay.

Other Costs of Delay and Benefits of Acting Now

An additional benefit of adopting meaningful mitigation policies now is that doing so sends a strong signal to the market to spur the investments that will reduce mitigation costs in the future. An argument sometimes made is that mitigation policies should be postponed until new low-carbon technologies become available. Indeed, ongoing technological progress has dramatically improved productivity and welfare in the United States because of vast inventions and process improvements in the private sector (see for example CEA 2014, Chapter 6). The private sector invests in research and development, and especially in process improvements, because those technological advances reap private rewards. But low-carbon technologies, and environmental technologies more generally, face a unique barrier: their benefits – the reduction in global impacts of climate change – accrue to everyone and not just to the developer or adopter of such technologies.[9] Thus private sector investment in low-carbon technologies requires confidence that those investments, if successful, will pay off, that is, the private sector needs to have confidence that there will be a market for low-carbon technologies now and in the future. Public policies that set out a clear and ongoing mitigation path provide that confidence. Simply waiting for a technological solution, but not providing any reason for the private sector to create that solution, is not an effective policy. Although public financing of basic research is warranted because many of the benefits of basic research cannot be privately appropriated, many of the productivity improvements and cost reductions seen in new technologies come from incremental advances and process improvements that only arise through private-sector experience producing the product and learning-by-doing. These advances are protected through the patent system and as trade secrets, but those advances will only transpire if it is clear that they will have current and

[9] Popp, Newell, and Jaffe (2010) provide a thorough review of the literature regarding technological change and the environment.

future value. In other words, policy action induces technological change.[10] Although a full treatment of the literature on technological change is beyond the scope of this report, providing the private sector with the certainty needed to invest in low-carbon technologies and produce such technological change is a benefit of adopting meaningful mitigation policies now.

Finally, because this report examines the economic costs of delay, it focuses on actions or consequences that have a market price. But the total costs of climate change include much that does not trade in the market and to which it is difficult to assign a monetary value, such as the loss of habitat preservation, decreased value of ecosystem goods and services, and mass extinctions. Although some studies have attempted to quantify these costs, including all relevant climate impacts is infeasible. Accordingly, the monetized economic costs of delay analyzed in this report understate the true total cost of delaying action to mitigate climate change.

[10] For example, Popp (2003) provides empirical evidence that Title IV of the 1990 Clean Air Act Amendments (CAAA) led to innovations that reduced the cost of the environmental technologies that reduced SO_2 emissions from coal-fired power plants. Other literature shows evidence linking environmental regulation more broadly to innovation (e.g., Popp 2006, Jaffe and Palmer 1997, Lanjouw and Mody 1996).

II. Costs from Delaying Policy Action

Delaying action on climate change can increase economic costs in two ways. First, if the delayed policy is no more stringent, it will miss the climate target of the original, non-delayed policy, resulting in atmospheric GHG concentrations that are permanently higher, thereby increasing the economic damages from climate change. Second, suppose a delayed policy alternatively strove to achieve the original climate target; if so, it would require a more stringent path to achieve that target. But this delayed, more stringent policy typically will result in additional mitigation costs by requiring more rapid adjustment later. In reality, delay might result in a mix of these two types of costs. The estimates of the costs of delay in this section draw on large bodies of research on these two types of costs. We first examine the economic damages from higher temperatures, then turn to the increased mitigation costs arising from delay.

Our focus here is on targets that limit GHG concentrations, both because this is what most of the "delay" literature considers and because concentration limits have been the focus of other assessments. These concentration targets are typically expressed as concentrations of CO_2-equivalent (CO_2e) GHGs, so they incorporate not just CO_2 concentrations but also methane and other GHGs. The CO_2e targets translate roughly into ranges of temperature changes as estimated by climate models and into the cumulative GHG emissions budgets discussed in some other climate literature. More stringent concentration targets decrease the odds that global average temperature exceeds 2°C above preindustrial levels by 2100. According to the IPCC WG III AR5 (2014), meeting a concentration target of 450 parts per million (ppm) CO_2e makes it "likely" (probability between 66 and 100 percent) that the temperature increase will be at most 2°C, relative to preindustrial levels, whereas stabilizing at a concentration level of 550 ppm CO_2e makes it "more unlikely than likely" (less than a 50 percent probability) that the temperature increase by 2100 will be limited to 2°C (IPCC WG III AR5 2014).[11]

Increasing Damages if Delay Means Missing Climate Targets

If delay means that a climate target slips, then the ultimate GHG concentrations, temperatures, and other changes in global climate would be greater than without the delay.[12]

A growing body of work examines the costs that climate change imposes on specific aspects of economic activity. The IPCC WG II AR5 (2014) surveys this growing literature and summarizes the impacts of projected climate change by sector. Impacts include decreased agricultural production; coastal flooding, erosion, and submergence; increases in heat-related illness and other stresses due to extreme weather events; reduction in water availability and quality;

[11] IPCC WG III AR5 (2014, ch. 6) provides a further refinement of these probabilities, associating a concentration target of 450 ppm of CO_2e with an approximate 70-85 percent probability of maintaining temperature change below 2°C, and a concentration level of 550 CO_2e with an approximate 30-45 percent probability of maintaining temperature change below 2°C.

[12] For information on the impacts of climate change at various levels of warming see *Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia* (NRC 2011).

displacement of people and increased risk of violent conflict; and species extinction and biodiversity loss. Although these impacts vary by region, and some impacts are not well-understood, evidence of these impacts has grown in recent years.[13]

A new class of empirical studies draw similar conclusions. Dell, Jones, and Olken (2013) review academic research that draws on historical variation in weather patterns to infer the effects of climate change on productivity, health, crime, political instability, and other social and economic outcomes. This approach complements physical science research by estimating the economic impacts of historical weather events that can be used to extrapolate to those expected in the future climate. The research finds evidence of economically meaningful impacts of climate change on a variety of outcomes. For example, when the temperature is greater than 100° Fahrenheit in the United States, labor supply in outdoor industries declines up to one hour per day relative to temperatures in the 76°-80° Fahrenheit range (Graff Zivin and Neidell 2014). Also in the United States, each additional day of extreme heat (exceeding 90° Fahrenheit) relative to a moderate day (50° to 59° Fahrenheit) increases the annual age-adjusted mortality rate by roughly 0.11 percent (Deschênes and Greenstone 2011).

These studies provide insights into the response of specific sectors or aspects of the economy to climate change. But because they focus on specific aspects of climate change, use different data sources, and use a variety of outcome measures, they do not provide direct estimates of the aggregate, or total, cost of climate change. Because estimating the total cost of climate change requires specifying future baseline economic and population trajectories, efforts to estimate the total cost of climate change typically rely on integrated assessment models (IAMs). IAMs are a class of economic and climate models that incorporate both climate and economic dynamics so that the climate responds to anthropogenic emissions and economic activity responds to the climate. In addition to projecting future climate variables and other economic variables, the IAMs estimate the total economic damages (and, in some cases, benefits) of climate change which includes impacts on agriculture, health, ecosystems services, productivity, heating and cooling demand, sea level rise, and adaptation.

Overall costs of climate change are substantial, according to IAMs. Nordhaus (2013) estimates global costs that increase with the rise in global average temperature, and Tol (2009, 2014) surveys various estimates. Two themes are common among these damage estimates. First, damage estimates remain uncertain, especially for large temperature increases. Second, the costs of climate change increase nonlinearly with the temperature change. Based on Nordhaus's (2013, Figure 22) net damage estimates, a 3° Celsius temperature increase above preindustrial levels, instead of 2°, results in additional damages of 0.9 percent of global output.[14] To put this

[13] The EPA's Climate Change Impacts and Risk Analysis project collects new research that estimates the potential damages of inaction and the benefits of GHG mitigation at national and regional scales for many important sectors, including human health, infrastructure, water resources, electricity demand and supply, ecosystems, agriculture, and forestry (Waldhoff et al. 2014).

[14] Some studies estimate that small temperature increases have a net economic *benefit*, for instance due to increased agricultural production in regions with colder climates. However, projected temperature increases even

percentage in perspective, 0.9 percent of estimated 2014 U.S. GDP is approximately $150 billion. The next degree increase, from 3° to 4°, would incur additional costs of 1.2 percent of global output. Moreover, these costs are not one-time, rather they recur year after year because of the permanent damage caused by increased climate change resulting from the delay. It should be stressed that these illustrative estimates are based on a single (albeit leading) model, and there is uncertainty associated with the aggregate monetized damage estimates from climate change; see for example the discussion in IPCC WG II AR5 (2014).

Increased Mitigation Costs from Delay

The second type of cost of delay arises if policy is delayed but still hits the climate target, for example stabilizing CO_2e concentrations at 550 ppm. Because a delay results in additional near-term accumulation of GHGs in the atmosphere, delay means that the policy, when implemented, must be more stringent to achieve the given long-term climate target. This additional stringency increases mitigation costs, relative to those that would be incurred under the least-cost path starting today.

This section reviews the recent literature on the additional mitigation costs of delay, under the assumption that both the original and delayed policy achieve a given climate target. We review 16 studies that compare 106 pairs of policy simulations based on integrated climate mitigation models (the studies are listed and briefly described in the Appendix). The simulations comprising each pair implement similar policies that lead to the same climate target (typically a concentration target but in some cases a temperature target) but differ in the timing of the policy implementation, nuanced in some cases by variation in when different countries adopt the policy. Because the climate target is the same for each scenario in the pair, the environmental and economic damages from climate change are approximately the same for each scenario. The additional cost of delaying implementation thus equals the difference in the mitigation costs in the two scenarios in each paired comparison. The studies reflect a broad array of climate targets, delayed timing scenarios, and modeling assumptions as discussed below. We focus on studies published in 2007 or later, including recent unpublished manuscripts.

In each case, a model computes the path of cost-effective mitigation policies, mitigation costs, and climate outcomes over time, constraining the emissions path so that the climate target is hit. Each path weighs technological progress in mitigation technology and other factors that encourage starting out slowly against the costs that arise if mitigation, delayed too long, must be undertaken rapidly. Because the models typically compute the policy in terms of a carbon price, the carbon price path computed by the model starts out relatively low and increases over the course of the policy. Thus a policy started today typically has a steadily increasing carbon price, whereas a delayed policy typically has a carbon price of zero until the start date, at which point it jumps to a higher initial level then increases more rapidly than the optimal immediate policy.

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under immediate action fall in a range with a strong consensus that the costs of climate change exceed such benefits. The cost estimates presented here are net of any benefits expected to accrue.

The higher carbon prices after a delay typically lead to higher total costs than a policy that would impose the carbon price today.[15]

The IPCC WG III AR5 (2014) includes an overview of the literature on the cost of delayed action on climate change. They cite simulation studies showing that delay is costly, both when all countries delay action and when there is partial delay, with some countries delaying acting alone until there is a more coordinated international effort. The present report expands on that overview by further analyzing the findings of the studies considered by the IPCC report as well as additional studies. Like the IPCC report, we find broad agreement across the scenario pairs examined that delayed policy action is more costly compared to immediate action conditional on a particular climate target. This finding is consistent across a range of climate targets, policy participants, and modeling assumptions. The vast majority of studies estimate that delayed action incurs greater mitigation costs compared to immediate action. Furthermore, some models used in the research predict that the most stringent climate targets are feasible only if immediate action is taken under full participation. One implication is that considering only comparisons with numerical cost estimates may understate the true costs of delay, as failing to reach a climate target means incurring the costs from the associated climate change.

The costs of delay in these studies depend on a number of factors, including the length of delay, the climate target, modeling assumptions, future baseline emissions, future mitigation technology, delay scenarios, the participants implementing the policy, and geographic location. More aggressive targets are more costly to achieve, and meeting them is predicted to be particularly costly, if not infeasible, if action is delayed. Similarly, international coordination in policy action reduces mitigation costs, and the cost of delay depends on which countries participate in the policy, as well as the length of delay.

[15] Some models explicitly identify the carbon price path that minimizes total social costs. These optimization models always find equal or greater costs for scenarios with a delay constraint. Other models forecast carbon prices that result in the climate target but do not demand that the path results in minimal cost. These latter models can predict that delay reduces costs, and a small number of comparisons we review report negative delay costs.

The Role of Technological Progress in Cost Estimates

Assumptions about energy technology play an important role in estimating mitigation costs. For example, many models assume that carbon capture and storage (CCS) will enable point sources of emission to capture the bulk of carbon emissions and store them with minimal leakage into the atmosphere over a long period. Some comparisons also assume that CCS will combine with large-scale bio-energy ("bio-CCS"), effectively generating "negative emissions" since biological fuels extract atmospheric carbon during growth. Such technology could facilitate reaching a long-term atmospheric concentration target despite relatively modest near-term mitigation efforts. However, the IPCC warns that "There is only limited evidence on the potential for large-scale deployment of [bio-CCS], large-scale afforestation, and other [CO_2 removal] technologies and methods" (IPCC WG III AR5 2014). In addition, models must also specify the cost and timing of availability of such technology, potentially creating further variation in mitigation cost estimates.

The potential importance of technology, especially bio-CCS, is manifested in differences across models. Clarke et al. (2009) present delay cost estimates for 10 models simulating a 550 ppm CO_2 equivalent target by 2100 allowing for overshoot. The three models that assume bio-CCS availability estimate global present values of the cost of delay ranging from $1.4 trillion to $4.7 trillion. Among the seven models without bio-CCS, four predict higher delay costs, one predicts that the concentration target was infeasible under a delay, and two predict lower delay costs. The importance of bio-CCS is even clearer with a more stringent target. For example, two of the three models with bio-CCS find that a 450 ppm CO_2 equivalent target is feasible under a delay scenario, while none of the seven models without bio-CCS find the stringent target to be feasible.

The Department of Energy sponsors ongoing research on CCS for coal-fired power plants. As part of its nearly $6 billion commitment to clean coal technology, the Administration, partnered with industry, has already invested in four commercial-scale and 24 industrial-scale CCS projects that together will store more than 15 million metric tons of CO_2 per year.

An important determinant of costs is the role of technological progress and the availability of mitigation technologies (see the box). The models typically assume technological progress in mitigation technology, which means that the cost of reducing emissions declines over time as energy technologies improve. As a result, it is cost-effective to start with a relatively less stringent policy, then increase stringency over time, and the models typically build in this cost-effective tradeoff. However, most models still find that immediate initiation of a less stringent policy followed by increasing stringency incurs lower costs than delaying policy entirely and then increasing stringency more rapidly.

We begin by characterizing the primary findings in the literature broadly, discussing the estimates of delay costs and how the costs vary based on key parameters of the policy scenarios; additional details can be found in the Appendix. We then turn to a statistical analysis of all the available delay cost estimates that we could gather in a standardized form, that is, we conduct a meta-analysis of the literature on delay cost estimates.

Effect on Costs of Climate Targets, Length of Delay, and International Coordination

Climate Targets

Researchers estimate a range of climate and economic impacts from a given concentration of GHGs and find that delaying action is much costlier for more stringent targets. Two recent major modeling simulation projects conducted by the Energy Modeling Forum (Clarke et al. 2009) and by AMPERE (Riahi et al. 2014) consider the economic costs of delaying policies to reach a range of CO_2e concentration targets from 450 to 650 ppm in 2100. In the Energy Modeling Forum simulations in Clarke et al. (2009), the median additional cost (global present value) for a 20-year delay is estimated to be $0.7 trillion for 650 ppm CO_2e but a substantially greater $4.7 trillion for 550 ppm CO_2e. Many of the models in these studies suggest that delay causes a target of 450 ppm CO_2e to be much more costly to achieve, or possibly even infeasible.

Length of Delay

The longer the delay, the greater the cumulative emissions before action begins and the shorter the available time to meet a given target. Several recent studies examine the cost implications of delayed climate action and find that even a short delay can add substantial costs to meeting a stringent concentration target, or even make the target impossible to meet. For example, Luderer et al. (2012) find that delay from 2010 to 2020 to stabilize CO_2 concentration levels at 450 ppm by 2100 raises mitigation cost by 50 to 700 percent.[16] Furthermore, Luderer et al. find that delay until 2030 renders the 450 ppm target infeasible. Edmonds et al. (2008) find that additional mitigation costs of delay by newly developed and developing countries are substantial. In fact, they find that stabilizing CO_2 concentrations at 450 ppm even for a relatively short delay from 2012 to 2020 increases costs by 28 percent over the idealized case, and a delay to 2035 increased costs by more than 250 percent.

International Coordination

Meeting stringent climate targets with action from only one country or a small group of countries is difficult or impossible, making international coordination of policies essential. Recent research shows, however, that even if a delay in international mitigation efforts occurs, unilateral or fragmented action reduces the costs of delay: although immediate coordinated international action is the least costly approach, unilateral action is less costly than doing nothing.[17] More specifically, Jakob et al. (2012) consider a 10-year delay of mitigation efforts to reach a 450 ppm CO_2 target by 2100 and find that global mitigation costs increase by 43 to 700 percent if all countries begin mitigation efforts in 2020 rather than 2010. However, early action in 2010 by more developed countries reduces this increase to 29 to 300 percent. In a similar scenario,

[16] We present a range of cost estimates which comes from the three IAMs – ReMIND-R, WITCH and IMACLIM-R – used by Luderer et al. (2012). These scenarios also allow temporary overshoot of the target.

[17] Waldhoff and Fawcett (2011) find that early mitigation action by industrialized economies significantly reduces the likelihood of large temperature changes in 2100 while also increasing the likelihood of lower temperature changes, relative to a no policy scenario.

Luderer et al. (2012) find that costs increase by 50 to 700 percent with global delay from 2010 to 2020, however if the industrialized countries begin mitigation efforts unilaterally in 2010 (and are joined by all countries in 2020), the estimated cost increases range from zero to about 200 percent. Luderer et al. (2013) and Riahi et al. (2014) find that costs of delay are smaller when fewer countries delay mitigation efforts, or when short-term actions during the delay are more aggressive.

Jakob et al. (2012) find it is in the best interest of the European Union to begin climate action in 2010 rather than delaying action with all other countries until 2020. They also estimate that the cost increase to the United States from delaying climate action with all other countries until 2020 is from 28 to 225 percent, relative to acting early along with other industrialized economies.[18] McKibbin, Morris, and Wilcoxen (2014) consider the impact that a delay in imposing a unilateral price of carbon would have on economic outcomes in the United States including GDP, investment, consumption and employment. They find that although unilateral mitigation efforts do incur costs, delay is costlier.

Summary: Quantifying Patterns across the Studies

We now turn to a quantitative summary and assessment, or meta-analysis, of the studies discussed above.[19] The data set for this analysis consists of the results on all available numerical estimates of the average or total cost of delayed action from our literature search. Each estimate is a paired comparison of a delay scenario and its companion scenario without delay. To make results comparable across studies, we convert the delay cost estimates (presented in the original studies variously as present values of dollars, percent of consumption, or percent of GDP) to percent change in costs as a result of delay.[20] We capture variation across study and experimental designs using variables that encode the length of the delay in years; the target CO_2e concentration; whether only the relatively more-developed countries act immediately (partial delay); the discount rate used to calculate costs; and the model used for the simulation.[21] All comparisons consider policies and outcomes measured approximately through the end of the century. To reduce the effect of outliers, the primary regression analysis only uses results with less than a 400 percent increase in costs (alternative methods of handling the outliers are

[18] Note that the IMACLIM model finds that U.S. mitigation declines to the point in which they are slightly negative (i.e. net gains compared to business-as-usual).

[19] A study of the results of other studies is referred to as a meta-analysis, and there is a rich body of statistical tools for meta-analysis, see for example Borenstein et al. (2009).

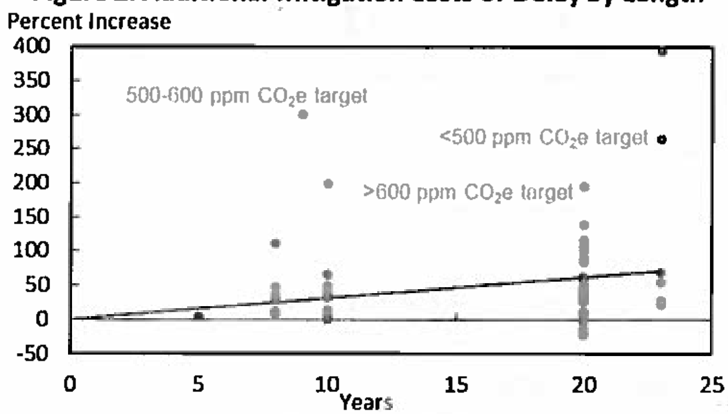
[20] For example, if in some paired comparison delay increased mitigation costs from 0.20 percent of GDP to 0.30 percent of GDP, the cost increase would be 50 percent. Comparisons for which the studies provided insufficient information to calculate the percentage increase in costs (including all comparisons from Riahi et al. 2014) are excluded. Also excluded are comparisons that report only the market price of carbon emissions at the end of the simulation, which is not necessarily proportional to total mitigation costs.

[21] When measuring delay length for policies with multiple stages of implementation, we count the delay as ending at the start of any new participation in mitigation by any party after the start of the simulation. We also exclude scenarios with delays exceeding 30 years. When other climate targets were provided (e.g., CO_2 concentration or global average temperature increase), the corresponding CO_2e concentration levels are estimated using conversions from IPCC WG III AR5 (2014).

discussed below as sensitivity checks), and only includes paired comparisons for which both the primary and delayed policies are feasible (i.e. the model was able to solve for both cases).[22] The dataset contains a total of 106 observations (paired comparisons), with 58 included in the primary analysis. All observations in the data set are weighted equally.

Analysis of these data suggests two main conclusions, both consistent with findings from specific papers in the underlying literature. The first is that, looking across studies, costs increase with the length of the delay. Figure 2 shows the delay costs as a function of the delay time. Although there is considerable variability in costs for a given delay length because of variations across models and experiments, there is an overall pattern of costs increasing with delay.

Figure 2: Additional Mitigation Costs of Delay by Length



Notes: Data points are percentage increase in mitigation costs from delay and the associated length of delay for a given paired simulation. The scatterplot presents a total of 58 paired delay simulations. The solid line is the regression fit to these data, restricted to pass through the origin.
Source: CEA calculations.

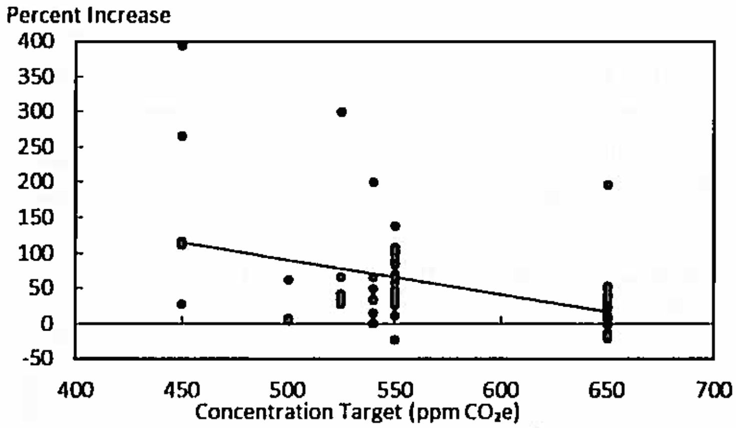
For example, of the 14 paired simulations with 10 years of delay (these are represented by the points in Figure 2 with 10 years of delay), the average delay cost is 39 percent. The regression line shown in Figure 2 estimates an average cost of delay per year using all 58 paired experiments under the assumption of a constant increasing delay cost per year (and, by definition, no cost if there is no delay), and this estimate is 37 percent per decade. This analysis ignores possible confounding factors, such as longer delays being associated with less stringent targets, and the multiple regression analysis presented below controls for such confounding factors.

The second conclusion is that the more ambitious the climate target, the greater are the costs of delay. This can be seen in Figure 3, in which the lowest (most stringent) concentration targets tend to have the highest cost estimates. In fact, close inspection of Figure 2 reveals a related pattern: the relationship between delay length and additional costs is steeper for the points representing CO_2e targets of 500 ppm or less than for those in the other two ranges. That is, costs

[22] In the event that a model estimates a cost for a first-best scenario but determines the corresponding delay scenario to be infeasible, the comparison is coded as having costs exceeding 400 percent. In addition, one comparison from Clarke et al. (2009) is excluded because a negative baseline cost precludes the calculation of a percent increase.

of delay are particularly high for scenarios with the most stringent target and the longest delay lengths.

Figure 3: Additional Mitigation Costs by CO_2 Concentration



Notes: Data points are percentage increase in mitigation costs from delay and the associated CO_2 concetration target for a given paired simulation. The scatterplot presents a total of 58 paired delay simulations. The solid line is the regression line fit to these data.

Table 1 presents the results of multiple regression analysis that summarizes how various factors affect predictions from the included studies, holding constant the other variables included in the regression. The dependent variable is the cost of delay, measured as the percentage increase relative to the comparable no-delay scenario, and the length of delay is measured in decades. Specifications (1) and (2) correspond to Figures 2 and 3, respectively. Each subsequent specification includes the length of the delay in years, an indicator variable for a partial delay scenario, and the target CO_2e concentration. In addition to the coefficients shown, specification (4) includes model fixed effects, which control for systematic differences across models, and each specification other than column (1) includes an intercept.

The results in Table 1 quantify the two main findings mentioned above. The coefficients in column (3) indicate that, looking across these studies, a one decade increase in delay length is on average associated with a 41 percent increase in mitigation cost relative to the no-delay scenario. This regression does not control for possible differences in baseline costs across the different models, however, so column (4) reports a variant that includes an additional set of binary variables indicating the model used ("model fixed effects"). Including model fixed effects increases the delay cost to 56 percent per decade. When the cost of a delay is estimated separately for different concentration target bins (column (5)), delay is more costly the more ambitious is the concentration target. But even for the least ambitious target – a CO_2e concentration exceeding 600 ppm – delay is estimated to increase costs by approximately 24 percent per decade. Because of the relatively small number of cases (58 paired comparisons), which are further reduced when delay is estimated within target bins, the standard errors are large, especially for the least ambitious scenarios, so for an overall estimate of the delay cost we do not differentiate between the different targets. While the regression in column (4) desirably controls for differences across models, other (unreported) specifications that handle the outliers in different ways and include other control variables give per-decade delay estimates both larger and smaller than the regression in column (3).[23] We therefore adopt the estimate in regression (3) of 41 percent per decade as the overall annual estimate of delay costs.

One caveat concerning this analysis is that it only considers cases in which model solutions exist. The omitted, infeasible cases tend to be ones with ambitious targets that cannot be met when there is long delay, given the model's technology assumptions. For this reason, omitting these cases arguably understates the costs of delay reported in Table 1.[24] Additionally, we note that estimates of the effect of a partial delay (when some developed nations act now and other nations delay action) are imprecisely estimated, perhaps reflecting the heterogeneity of partial delay scenarios examined in the studies.

[23] The results in Table 1 are generally robust to using a variety of other specifications and regression methods, including: using the percent decrease from the delay case, instead of the percent increase from the no-delay case, as the dependent variable as an alternative way to handle outliers; using median regression, also as an alternative way to handle outliers; and including the discount factor as additional explanation of variation in the cost of delay, but this coefficient is never statistically significant. These regressions use linear compounding, not exponential, because the focus is on the per-decade delay cost not the annual delay cost. An alternative approach is to specify the dependent variable in logarithms (although this eliminates the negative estimates), and doing so yields generally similar results after compounding to those in Table 1.

[24] An alternative approach to omitting the infeasible-solution observations is to treat their values as censored at some level. Accordingly, the regressions in Table 1 were re-estimated using tobit regression, for which values exceeding 400 percent (including the non-solution cases) are treated as censored. As expected, the estimated costs of delay per year estimated by tobit regression exceed the ordinary least squares estimates. A linear probability model (not shown) indicates that scenarios with longer delay and more stringent targets are more likely to have delay cost increases exceeding 400 percent (including non-solution cases). The assumption of bio-CCS technology has no statistically significant correlation with delay cost increase in a censored regression but is associated with a significantly lower probability of delay cost increases exceeding 400 percent.

Table 1: Increased Mitigation Costs Resulting from a Delay, Given a Specified Climate Target: Regression Results

	(1)	(2)	(3)	(4)	(5)
Delay (decades)	37.3***		41.1**	56.3***	
	(5.9)		(17.0)	(18.2)	
Delay (decades) x ppm $CO_2e \leq 500$					66.7**
					(27.1)
Delay (decades) x $500 < \text{ppm } CO_2e \leq 600$					24.9
					(18.5)
Delay (decades) x ppm $CO_2e > 600$					24.1
					(33.9)
Partial delay			8.3	-20.0	14.8
			(26.0)	(27.8)	(25.7)
Target CO_2e concentration		-0.49***	-0.61***	-0.61***	-0.30
		(0.16)	(0.16)	(0.15)	(0.49)
Model fixed effects?	No	No	No	Yes	No
Observations	58	58	58	58	58
R-squared	0.41	0.15	0.24	0.53	0.30

Notes: The table presents ordinary least squares regression coefficients, with each column representing a different regression. For each, the dependent variable is the percent increase in cost from a scenario involving no delay to a scenario involving a delay. Each observation is a comparison of a pair of scenarios with the same climate target, for a total of 58 observations. The regressors represent some of the variables that characterize each paired comparison: the simulated delay, the delay interacted with the concentration target (binned), whether only some countries delayed (partial delay), and the target concentration. The appendix lists all studies from which the data were drawn. The specification in column (1) does not include a constant.

Significant at the: *10% **5% ***1% significance level.

Source: CEA calculations on results from studies listed in appendix.

III. Climate Policy as Climate Insurance

As discussed in the 2013 NRC report, *Abrupt Impacts of Climate Change: Anticipating Surprises*, the Earth's climate history suggests the existence of "tipping points," that is, thresholds beyond which major changes occur that may be self-reinforcing and are likely to be irreversible over relevant time scales. Some of these changes, such as the rapid decline in late-summer Arctic sea ice, are already under way. Others represent potential events for which a tipping point likely exists, but cannot at the present be located. For example, there is new evidence that we might already have crossed a previously unrecognized tipping point concerning the destabilization of the West Antarctic Ice Sheet (Joughin, Smith, and Medley 2014 and Rignot et. al. 2014). A tipping point that is unknown, but thought unlikely to be reached in this century, is the release of methane from thawing Arctic permafrost, which could reinforce the greenhouse effect and spur additional warming and exacerbate climate change. Tipping points can also be crossed by slower climate changes that exceed a threshold at which there is a large-scale change in a biological system, such as the rapid extinction of species. Such impacts could pose such severe consequences for societies and economies that they are sometimes called potential climate catastrophes.

This section examines the implications of these potentially severe outcomes for climate policy, a topic that has been the focus of considerable recent research in the economics literature. The main conclusion emerging from this growing body of work is that the potential of these events to have large-scale impacts has important implications for climate policy. Because the probability of a climate catastrophe increases as GHG emissions rise, missing climate targets because of postponed policies increases risks. Uncertainty about the likelihood and consequences of potential climate catastrophes adds further urgency to implementing policies now to reduce GHG emissions.

Tail Risk Uncertainty and Possible Large-Scale Changes

Were some of these large-scale events to occur, they would have severe consequences and would effectively be irreversible. Because these events are thought to be relatively unlikely, at least in the near term – that is, they occur in the "tail" of the distribution – but would have severe consequences, they are sometimes referred to as "tail risk" events. Because these tail risk events are outside the range of modern human experience, uncertainty surrounds both the science of their dynamics and the economics of their consequences.

Because many of these events are triggered by warming, their likelihood depends in part on the equilibrium climate sensitivity. The IPCC WG I AR5 (2013) provides a likely range of 1.5° to 4.5° Celsius for the equilibrium climate sensitivity. However, considerably larger values cannot be ruled out and are more likely than lower values (i.e. the probability distribution is skewed towards higher values). Combinations of high climate sensitivity and high GHG emissions can result in extremely large end-of-century temperature changes. For example, the IPCC WG III AR5 (2014) cites a high-end projected warming of 7.8° Celsius by 2100, relative to 1900-1950.

A second way to express this risk is to focus on specific large-scale changes in Earth or biological systems that could be triggered and locked in by GHG concentrations rising beyond a certain point. At higher climate sensitivities, the larger temperature response to atmospheric GHG concentrations would make it even more likely that we would cross temperature-related tipping points in the climate system. The potential for additional releases of methane, a potent GHG, from thawing permafrost, thus creating a positive feedback to further increase temperatures, is an example of such a tail risk event. Higher carbon dioxide concentrations in the atmosphere, by increasing the acidity of the oceans, could also trigger and lock in permanent changes to ocean ecosystems, such as diminished coral reef-building, which decreases biodiversity supported on reefs and decreases the breakwater effects that protect shorelines. The probability of significant negative effects from ocean acidification can be increased by other stressors such as higher temperatures and overfishing.

The box summarizes some of these potential large-scale events, which are sometimes also referred to as "abrupt" because they occur in a very brief period of geological time. These events are sufficiently large-scale they have the potential for severely disrupting ecosystems and human societies, and thus are sometimes referred to as catastrophic outcomes.

Abrupt Impacts of Climate Change: Anticipating Surprises

The National Research Council's 2013 report, *Abrupt Impacts of Climate Change: Anticipating Surprises*, discusses a number of abrupt climate changes with potentially severe consequences. These events include:

- **Late-summer Arctic sea ice disappearance:** Strong trends of accelerating late-summer sea ice loss have been observed in the Arctic. The melting of Arctic sea ice comprises a positive feedback loop, as less ice means more sunlight will be absorbed into the dark ocean, causing further warming.
- **Sea level rise (SLR) from destabilization of West Antarctic ice sheets (WAIS):** The WAIS represents a potential SLR of 3-4 meters as well as coastal inundation and stronger storm surges. Much remains unknown of the physical processes at the ice-ocean frontier. However, two recent studies (Joughin, Smith, and Medley 2014, Rignot et. al. 2014) report evidence that irreversible WAIS destabilization has already started.
- **Sea level rise from other ice sheets melting:** Losing all other ice sheets, including Greenland, may cause SLR of up to 60 meters as well as coastal inundation and stronger storm surges. Melting of the Greenland ice sheet alone may induce SLR of 7m, but it is not expected to destabilize rapidly within this century.
- **Disruption to Atlantic Meridional Overturning Circulation (AMOC):** Potential disruptions to the AMOC may disrupt local marine ecosystems and shift tropical rain belts southward. Although current models do not indicate that an abrupt shift in the AMOC is likely within the century, the deep ocean remains understudied with respect to measures necessary for AMOC calculations.
- **Decrease in ocean oxygen:** As the solubility of gases decrease with rising temperature, a warming of the ocean will decrease the oxygen content in the surface ocean and expand existing Oxygen Minimum Zones. This will pose a threat to aerobic marine life as well as release nitrous oxide—a potent GHG—as a byproduct of microbial processes. The NRC study assesses a moderate likelihood of an abrupt increase in oxygen minimum zones in this century.
- **Increasing release of carbon stores in soils and permafrost:** Northern permafrost contains enough carbon to trigger a positive feedback response to warming temperatures. With an estimated stock of 1700-1800 Gt, the permafrost carbon stock could amplify considerably human-induced climate change. Small trends in soil carbon releases have been already observed.
- **Increasing release of methane from ocean methane hydrates:** This is a particularly potent long-term risk due to hydrate deposits through changes in ocean water temperature; the likely timescale for the physical processes involved spans centuries, however, and there is low risk this century.

- **Rapid state changes in ecosystems, species range shifts, and species boundary changes:** Research shows that climate change is an important component of abrupt ecosystem state-changes, with a prominent example being the Sahel region of Africa. Such state-changes from forests to savanna, from savanna to grassland, et cetera, will cause extensive habitat loss to animal species and threaten food and water supplies. The NRC study assesses moderate risk during this century and high risk afterwards.
- **Increases in extinctions of marine and terrestrial species:** Abrupt climate impacts include extensive extinctions of marine and terrestrial species; examples such as the destruction of coral reef ecosystems are already underway. Numerous land mammal, bird, and amphibian species are expected to become extinct with a high probability within the next one or two centuries.

Implications of Tail Risk

An implication of the theory of decision-making under uncertainty is that the risks posed by irreversible catastrophic events can be substantial enough to influence or even dominate decisions.

Weitzman's Dismal Theorem

Over the past few years, economists have examined the implications of decision-making under uncertainty for climate change policy. In a particularly influential treatment, Weitzman (2009) proposes his so-called "Dismal Theorem," which provides a set of assumptions under which the current generation would be willing to bear very large (in fact, arbitrarily large) costs to avoid a future event with widespread, large-scale costs. The intuition behind Weitzman's mathematical result rests with the basic insight that because individuals are risk-averse, they prefer to buy health, home, and auto insurance than to take their chances of a major financial loss. Similarly, if major climate events have the potential to reduce aggregate consumption by a large amount, society will be better off if it can take out "climate insurance" by paying mitigation costs now that will reduce the odds of a large-scale—in Weitzman's (2009) word, catastrophic—drop in consumption later.[25]

[25] This logic has its basis in expected utility theory. Because individuals are risk averse, each additional dollar of consumption provides less value, or utility, to individuals than the previous dollar. To avoid this major loss, an individual will buy home insurance. That insurance is provided by the market because an insurance company can offer home insurance to many homeowners in different regions of the country, and through diversification the company will on average have many homeowners paying premiums and a few collecting insurance, so diversification allows the company to run a relatively low-risk business. But risks from severe climate change are not diversifiable because their enormous costs would impact the global economy. Consequently, as long as there is a non-negligible probability of a large drop in consumption, and therefore a very large drop in utility, arising from a large-scale loss in consumption, society today should be willing to pay a substantial amount if doing so would avoid that loss.

Weitzman's (2009) dismal theorem has spurred a substantial amount of research on the economics of what this literature often refers to as climate catastrophes. A number of authors (e.g. Newbold and Daigneault 2009, Ackerman et al. 2010, Pindyck 2011, 2013, Nordhaus 2011, 2012, Litterman 2013, Millner 2013), including Weitzman (2011, 2014), stress that although the strong version of Weitzman's (2009) result—that society would be willing to pay an arbitrarily large amount to avoid future large-scale economic losses—depends on specific mathematical assumptions, the general principle of taking action to prevent such events does not. The basic insight is that, just as the sufficiently high threat of a fire justifies purchasing homeowners insurance, the threat of large-scale losses from climate change justifies purchasing "climate insurance" in the form of mitigation policies now (Pindyck 2011), and that taking actions today could help to avoid worst-case outcomes (Hwang, Tol, and Hofkes 2013). According to this line of thinking, the difficulty of assessing the probabilities of such large-scale losses or the location of tipping points does not change the basic conclusion that, because their potential costs are so overwhelming, the threat of very large losses due to climate change warrants implementing mitigation policies now.

Several recent studies have started down the road of quantifying the implications of the precautionary motive for climate policy. One approach is to build the effects of large-scale changes into IAMs, either by modeling the different risks explicitly or by simulation using heavy-tailed distributions for key parameters such as the equilibrium climate sensitivity or parameters of the economic damage function. Research along these lines includes Ackerman, Stanton, and Bueno (2013), Pycroft et al. (2011), Dietz (2011), Ceronsky et al. (2011), and Link and Tol (2011). Another approach is to focus on valuation of the extreme risks themselves outside an IAM, for example as examined by Pindyck (2012) and van der Ploeg and de Zeeuw (2013). Kopits, Marten, and Wolverton (2013) review some of the tail risk literature and literature on large-scale Earth system changes, and suggest steps forward for incorporating such events in IAMs, identifying ways in which the modeling could be improved even within current IAM frameworks and where additional work is needed. One of the challenges in assessing these large-scale events is that some of the most extreme events could occur in the distant future, and valuing consumption losses beyond this century raises additional uncertainty about intervening economic growth rates and questions about how to discount the distant future.[26] The literature is robust in showing that the potential for such events could have important climate policy implications, however, the scientific community has yet to derive robust quantitative policy recommendations based on a detailed analyses of the link between possible large-scale Earth system changes and their economic consequences.

Implications of Uncertainty about Tipping Points

Although research that embeds tipping points into climate models is young, one qualitative conclusion is that the prospect of a potential tipping point with unknown location enhances the precautionary motive for climate policy (Baranzini, Chesney, and Morisset 2003, Brozovic and Schlenker 2011, Cai, Judd, and Lontzek 2013, Lemoine and Traeger 2012, Barro 2013, van der

[26] For various perspectives on the challenges of evaluating long-term climate risks, see Dasgupta (2008), Barro (2013), Ackerman, Stanton, and Bueno (2013), Roe and Bauman (2013), and Weitzman (2013).

Ploeg 2014). To develop the intuition, first suppose that the tipping point is a known temperature increase, say 3° Celsius above preindustrial levels, and that the economic consequences of crossing the tipping point are severe, and temporarily put aside other reasons for reducing carbon emissions. Under these assumptions climate policy would allow temperature to rise, stopping just short of the 3° increase. In contrast, now suppose that the tipping point is unknown and that its estimated mean is 3°, but that it could be less or more with equal probability. In this case, the policy that stops just short of 3° warming runs a large risk of crossing the true tipping point. Because that mistake would be very costly, the uncertainty about the tipping point generally leads to a policy that is more stringent today than it would be absent uncertainty. To the extent that delayed implementation means higher long-run CO_2 concentrations, then the risks of hitting a tipping point increase with delay.

As a simplification, the above description assumes away other costs of climate change that increase smoothly with temperature, as well as the reality that important tipping points in biological systems could be crossed by small gradual changes in temperatures, so as to focus on the consequences of uncertainty about large-scale temperature changes. When the two sets of costs are combined, the presence of potential large-scale changes increases the benefits of mitigation policies, and the presence of uncertainty about tipping points that would produce abrupt changes increases those benefits further.[27] Cai, Judd, and Lontzek (2013) use a dynamic stochastic general equilibrium version of DICE model that is modified to include multiple tipping points with unknown (random) locations. To avoid the Weitzman "infinities" problem, they focus on tipping events with economic consequences that are large (5 or 10 percent of global GDP) but fall short of global economic collapses. They conclude that the possibility of future tipping points increases the optimal carbon price today: in their benchmark case, the optimal pre-tipping carbon price more than doubles, relative to having no tipping point dynamics. Similarly, Lemoine and Traeger (2012) embed unknown tipping points in the DICE model and estimate that the optimal carbon price increases by 45 percent as a result. In complementary work, Barro (2013) considers a simplified model in which the only benefits of reducing carbon emissions come from reducing the probability of potential climate catastrophes, and finds that this channel alone can justify investment in reducing GHG pollution of one percent of GDP or more, beyond what would normally occur in the market absent climate policy.

[27] Cai, Judd, and Lontzek (2013) provide a stark example of this dynamic. Their analysis, which is undertaken using a modified version of Nordhaus's (2008) DICE-2007 model, includes both the usual reasons for emissions mitigation (damages that increase smoothly with temperature) and the possibility of a tipping point at an uncertain future temperature which results in a jump in damages.

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Appendix: Literature on Delay Costs

This appendix lists the studies reviewed Section II and used in the meta-analysis, and briefly describes the scenarios they analyzed.

The EMF22 project engaged ten leading integrated assessment models to analyze the climate and economic consequences of delay scenarios. The EMF22 studies consist of Loulou, Labriet, and Kanudia (2009), Tol (2009), Gurney, Ahammad, and Ford (2009), van Vliet, den Elzen, and van Vuuren (2009), Blanford, Richels, and Rutherford (2009), Krey and Riahi (2009), Calvin et al. (2009a, 2009b), Russ and van Ierland (2009), and Bosetti, Carraro, and Tavoni (2009), with Clarke et al. (2009) providing an overview of the project.[28] Among other objectives, each study estimates the mitigation costs associated with five climate targets under both an immediate action scenario and a harmonized delay scenario. The targets are 450, 550, and 650 ppm CO_2e in 2100, and the models consider the first two targets alternatively allowing or prohibiting an overshoot before 2100.[29] In the delay scenario, only more developed countries (minus Russia) begin mitigation immediately in 2012 in a coordinated fashion (i.e., with the same carbon pricing), with some countries delaying action until 2030, and remaining countries delay action until 2050. These scenarios enable calculating the additional mitigation costs associated with delay for each concentration target.

The AMPERE project engaged nine modeling teams to analyze the climate and economic consequences of global emissions following the proposed policy stringency of the national pledges from the Copenhagen Accord and Cancún Agreements to 2030. (The AMPERE scenarios were not included in the meta-analysis in Section II because Riahi et al. (2014) did not provide sufficient information to calculate the percent increase in mitigation costs for each delay scenario.) One of the questions addressed by this project is the economic costs of delaying policies to reach CO2e concentration targets of 450 and 550 ppm in 2100 (Riahi et al. 2014). Eight models simulate pairs of policy scenarios reaching each target. One simulation in each pair assumes that all countries act immediately in a coordinated fashion (i.e., with the same carbon pricing), while the other simulation assumes that all countries follow the less stringent emissions commitments made during the Copenhagen Accord and Cancun Agreements until 2030, when coordinated international action begins.

The meta-analysis includes the following studies not associated with either AMPERE or EMF22: Jakob et al. (2012); Luderer et al. (2012, 2013); Edmonds et al. (2008); Richels et al. (2007), and Bosetti et al. (2009). Jakob et al. (2012) consider a 10-year delay of mitigation efforts to reach a 450 ppm CO_2 target by 2100, including variations where more developed countries implement mitigation immediately. Luderer et al. (2012) consider a similar 10-year delay and the same 450 ppm CO_2 target by 2100, with a scenario where Europe and all other industrialized countries

[28] Russ and van Ierland (2009) did not present estimates of total delay costs, so this paper is not included in the meta-analysis in Section II.

[29] We included three additional scenarios in van Vliet, den Elzen, and van Vuuren (2009) with alternate targets and models that were not reported in Clarke et al. (2009).

begin mitigation efforts in 2010. Luderer et al. (2013) analyze a scenario where countries implement fragmented policies before coordinating efforts in 2015, 2020, or 2030 to meet a target of 2°C above preindustrial levels by 2100, allowing for overshooting. Edmonds et al. (2008) consider targets of 450, 550, and 660 ppm CO_2, with newly developed and developing countries delaying climate action from a start date of 2012 to 2020, 2035 and 2050. Richels et al. (2007) estimate the additional cost of delay by newly developing countries until 2050 for a 450 and 550 ppm CO_2 target. Finally, Bosetti et al. (2009) estimate the additional cost when all countries delay climate action for 20 years with a goal of reaching a 550 ppm and 650 ppm CO_2e target by 2100.

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CLIMATE CHANGE

There's a Formula for Deciding When to Extract Fossil Fuels

"Drill, Baby, Drill" became a popular campaign mantra back in the 2008 election cycle. But now we're hearing the opposite call: "Leave It in the Ground."

These calls come from environmentalists who see the end of drilling and mining as the way to avoid disruptive climate change. They direct these calls toward the federal government because it is estimated that about half of the carbon in technologically recoverable fossil fuels in the United States is on public lands.

Is there a middle ground that can supply the energy we need without causing significant climate damages? Yes. And it doesn't involve exploiting all available resources, nor banning their use.

What if we continued to lease the rights to access fossil fuels on federal land but required the leases and royalty payments to reflect the full climate damages from these fuels? Doing so would put the market to work by unlocking fossil fuels that have the highest value in relation to their impact on the climate. The bonus: It provides money to pay for some of the damage of climate change.

We've seen the benefits of using our domestic resources over the last decade as the amount of our energy coming from domestic oil and gas resources increased 54 percent. Chiefly, we have lower fuel prices. We now pay 74 percent less for natural gas and 25 percent less for petroleum, compared with 2005. Further, net imports will account for just 23 percent of American liquid fuel supplies this year — down from 60 percent in 2005 — with important energy security benefits. Our carbon emissions are also below 2005 levels, with cheap natural gas having taken significant market share from coal, which is more carbon intensive.

At the same time, the combustion of fossil fuels causes climate change that is projected to impose myriad costs around the world. But in this regard, not all fossil fuels are created equal. The value per unit of energy, measured by the market price, is greater for some (like petroleum) than others (like coal). Further, some contain more carbon or result in the release of more emissions because of other factors like the extraction and transportation process, and inflict greater climate damages. Knowing the monetary value of climate damages associated with a ton of carbon emissions is therefore the key to this whole problem.

Luckily, there is a way to determine this. It is called the Social Cost of Carbon (S.C.C.), and the federal government sets it at $40 per metric ton of CO_2 emissions. The S.C.C. is used to inform a wide variety of regulations that limit the use of fossil fuels, including emissions standards for vehicles, appliances and power plants. But the S.C.C. has not been used to guide extraction policies. (I was co-leader of an interagency group that set the S.C.C. when I worked in the Obama administration from 2009 to 2010.)

If the S.C.C. were applied as a part of leasing and royalty rates on federal lands, we would unlock resources with the greatest net benefits. To illustrate the consequences of such a shift, I did some calculations based on the spot prices for coal, petroleum and natural gas and their respective energy and carbon contents. The addition of a charge based on the S.C.C. is unlikely to have a substantial effect on domestic production of petroleum: The spot price per million British thermal units (B.T.U.s) this year has been $8.81, and the associated climate damages are $2.98. If the federal government collected a charge of $2.98 for each million B.T.U.s of petroleum extracted on federal lands, the revenue could be refunded directly to taxpayers or used to help the nation adapt to climate damages. The story is similar for natural gas; its value today exceeds the expected climate damages.

The case of coal is different, especially coal from the federal land in the Powder River Basin in Wyoming and Montana. The climate damages from coal mined from this region are five to six times greater than its market value ($0.66 at market value versus $3.89 of climate damages). Thus, a climate charge linked to the S.C.C. would probably make at least some of the coal mining in this region unprofitable. There is currently an opportunity for policy overhaul: The Department of the Interior is considering how to restructure lease terms for fossil fuels on federal lands. Further, a federal judge ruled last year that the government should take into account climate impacts when making decisions about mining on federal lands.

The application of an S.C.C.-related fee would meet many goals. Environmentalists would naturally like it, and so should fiscal conservatives who recognize that the federal government will be increasingly on the hook for climate damages (recall the more than $50 billion of federal tax dollars appropriated in response to Hurricane Sandy). At the same time, this fee would not stop the development of economically attractive fossil fuels.

Such a change in policy would have challenges. There would inevitably be some shifting of fossil fuel production to private lands in the United States, as well as to other countries; but it would also reduce the long-run global supply of fossil fuels. Further, there would be a strong case for harmonizing S.C.C. charges with existing domestic climate regulations to ensure that the carbon policies operate as efficiently as possible. There is also a strong case for providing support to communities that experience meaningful declines in economic activity because of an extraction fee linked to the S.C.C.

An efficient climate policy would price carbon throughout the global economy so that users of all fossil fuels recognized their climate costs. It does not appear likely that the current Paris climate negotiations will produce such a system. In the absence of such a policy, the solution doesn't need to be to use all fossil fuels, or to ban their usage. Common sense suggests that we use the ones that provide more value than harm and that we leave the others in the ground.

For a detailed analysis of the calculations, the technical document is available here.

Michael Greenstone, the Milton Friedman professor of economics at the University of Chicago, runs the Energy Policy Institute there. He was the chief economist of President Obama's Council of Economic Advisers from 2009 to 2010.

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