Continental Divide-Creston Project Environmental Impact Statement

Air Quality Technical Support Document

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June 2014

TABLE OF CONTENTS

Page

APPENDICES

TABLES

FIGURES

Executive Summary

This Air Quality Technical Support Document reports the potential impacts on ambient air quality and Air Quality Related Values (AQRVs) from estimated air emissions due to the proposed development of the Continental Divide-Creston (CD-C) Natural Gas Development Project (CD-C Project) and from other documented regional emissions sources within a defined study area. Potential ambient air quality impacts are quantified and compared to applicable state and Federal standards, and potential AQRV impacts (on visibility, atmospheric deposition, and the acid neutralizing capacity of sensitive lakes) are quantified and compared to applicable thresholds as defined in the Federal Land Managers' (FLMs') Air Quality Related Values Work Group (FLAG) and Interagency Workgroup on Air Quality Modeling (IWAQM) guidance documents (FLAG, 2010 and IWAQM, 1998), and other state and Federal agency guidance.

ES1. CD-C PROJECT DESCRIPTION AND EMISSIONS

The Proposed Action Alternative for the CD-C Project includes the development of 8,950 new natural gas wells within the CD-C Project Area (Figure ES-1) in Southwest Wyoming. Drilling would take place for approximately 15 years with an approximate 30 to 40-year life of project (LOP). Up to 500 of the proposed wells could be coalbed natural gas (CBNG) wells. Under the No Action Alternative, development of the portion of the Proposed Action that involves fee and state gas leases, an estimated 485,819 acres (45.4 percent) of the Project Area, would take place, resulting in 4,063 new natural gas wells drilled (45.4% of the Proposed Action Alternative well count). As of the year 2008, there were 2,454 wells producing in the CD-C Project Area, these existing wells are separate from the new wells proposed under the CD-C Project Alternatives.

Emission inventories for CD-C Project Area development and production activities were compiled for all existing sources and proposed new sources within the CD-C Project Area. The inventoried pollutants are: total nitrogen oxides (NO_X), sulfur dioxide (SO_2), carbon monoxide (CO), particulate matter less than or equal to 10 microns in size (PM_{10}), particulate matter less than or equal to 2.5 microns in size ($PM_{2.5}$), volatile organic compounds (VOC), ethane, and hazardous air pollutants (HAPs) benzene, toluene, ethyl benzene, xylene, n-hexane and formaldehyde. Lead emissions are negligible and were not included in the inventory. The inventory accounts for emissions from new well development and production phase activities, as well as emissions from ancillary facilities planned as part of the CD-C Project. The inventory also includes emissions from existing wells and ancillary facilities in the CD-C Project Area that were already in production as of 2008, which is the year that was selected as the baseline year for the study. Although not considered a VOC by the EPA, ethane (C_2H_6) compounds can participate in ozone formation and were included in the inventory for use in the far-field modeling. In addition, methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) emissions are included in the CD-C Project emissions inventory for purposes of quantifying greenhouse gas (GHG) emissions. CO_2 equivalents for all three GHGs are reported over the LOP.

The CD-C Proposed Action Alternative and No Action Alternative emission inventories were developed using data from the CD-C Operators as the primary source of information.

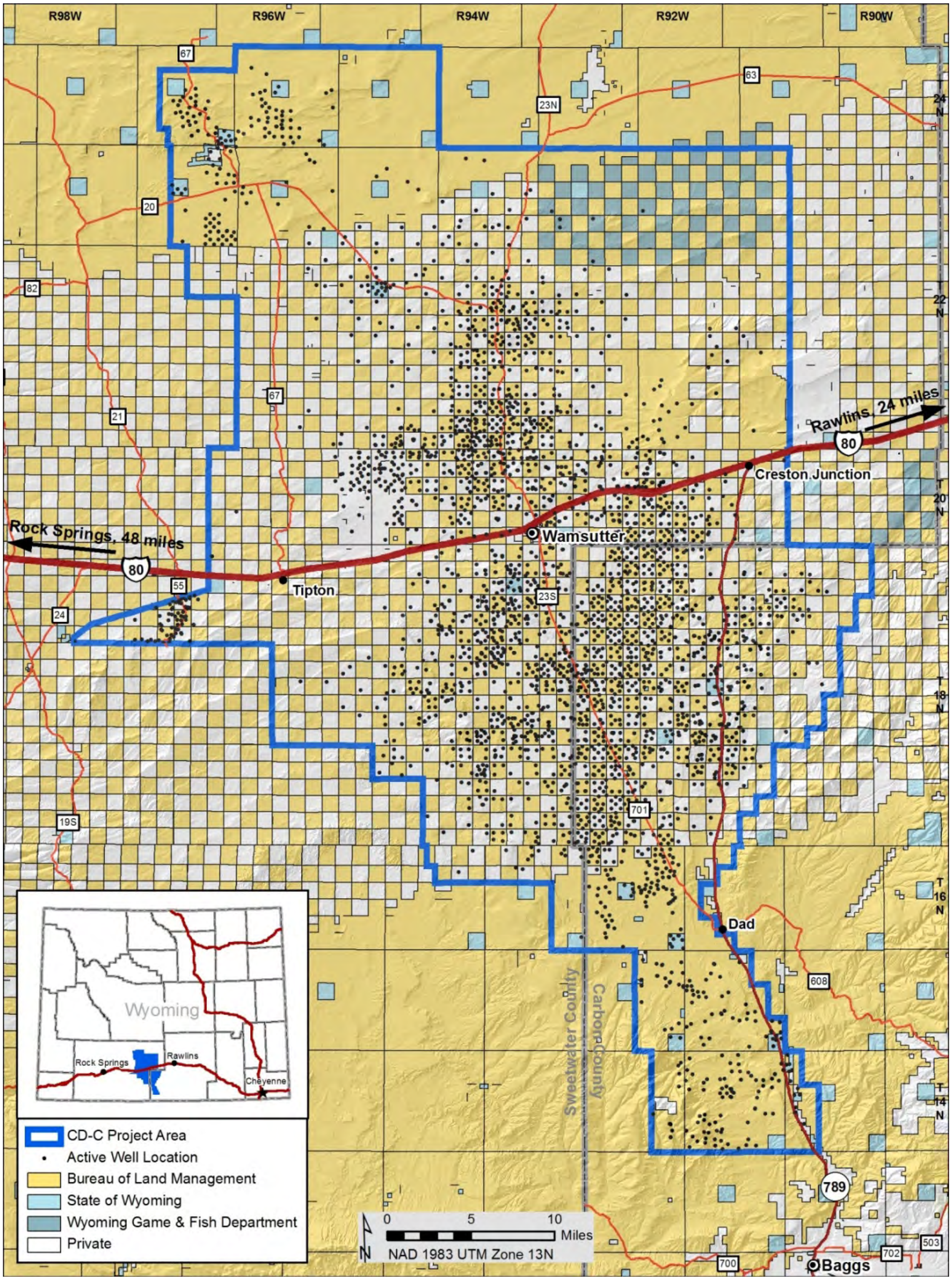

Figure ES-1. CD-C Project location in Southwest Wyoming.

The inventory accounts for all applicable emissions controls such as New Source Performance Standards (NSPS) and new Tier standards for non-road engines. The most important of these emissions controls are those specifically targeted at Wyoming oil and gas sources.

The Wyoming Department of Environmental Quality Air Quality Division (WDEQ-AQD) regulates emissions from oil and gas sources through their Oil and Gas Permitting Guidance (WDEQ-AQD, 2010). Different regulations apply in different regions of the State, with the most stringent level of controls applied to the areas with highest measured ambient ozone concentrations that occur in the Jonah-Pinedale Anticline Development (JPAD) area. The CD-C Project lies within a region of intensive oil and gas development known as the Concentrated Development Area (CDA; Figure ES-2). Under the WDEQ-AQD (2010) Guidance, emissions controls are required in the CDA for the following source categories:

- Tank Flashing
- Dehydration Units
- Pneumatic Pumps
- Pneumatic Controllers
- Produced Water Tanks
- Blow down / Venting

These control measures were taken into account in the development of the CD-C Project emission inventories. For some emissions categories, the WDEQ-AQD (2010) Guidance allows for removal of emissions controls if VOC emissions drop below a threshold that varies by source category. In the CD-C Project emission inventories, it was assumed that controls are left in place over the LOP. Table ES-1 shows the emissions control measures in each emissions source category that were modeled in this analysis.

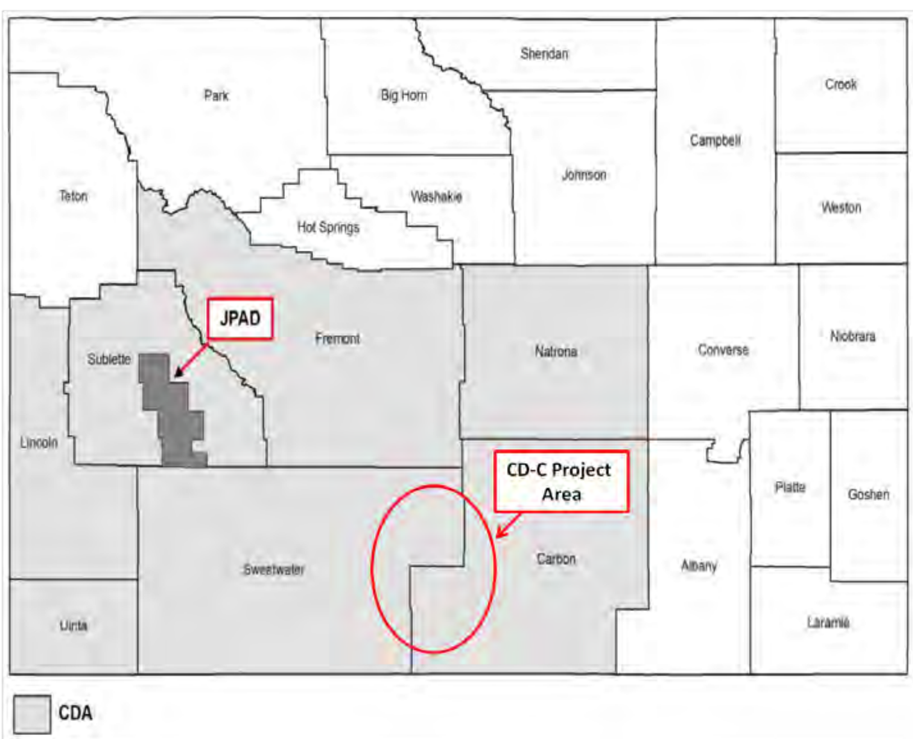

Figure ES-2. CD-C Project Area location within the Concentrated Development Area shown in light gray shading (from WDEQ-AQD, 2010).

Table ES-1. Table of modeled CD-C Project emissions control measures.

CD-C Project Emissions Source Category	Type of Control Applied
Well Pad Const Equip (diesel ICE)	Change in fuel sulfur content
Completion Equipment (diesel ICE)	Change in fuel sulfur content
Construction Traffic, Road and Well pad	Change in emissions due to fleet turnover
Construction Traffic, Road and Well pad- Fugitive Dust	Watering
Drilling Equipment (diesel ICE)	Change in fuel sulfur content and emissions reductions due to cleaner engine technology
Drilling Traffic	Change in emissions due to fleet turnover
Drilling Traffic- Fugitive Dust	Watering
Completion Traffic	Change in emissions due to fleet turnover
Completion Traffic- Fugitive Dust	Watering
Completion Venting	96% of Gas to Green Completions and 4% of Gas will be Flared
Completion Flaring	N/A
Well Pad and Access Road Construction- Fugitive Dust	Watering
Construction Wind Erosion- Fugitive Dust	None
Workover Equip (diesel ICE)	Change in fuel sulfur content
Workover Rig Traffic	Change in emissions due to fleet turnover
Workover Rig Traffic- Fugitive Dust	Watering
Heaters	None
Fugitives	None
Pneumatic Devices	No bleed devices
Pneumatic Pump	WYDEQ BACT
Dehydrator Venting	WYDEQ BACT
Tank Loadout (vapor losses)	None
Well Venting	None
Production Traffic	Change in emissions due to fleet turnover
Production Traffic- Fugitive Dust	Watering
Condensate Tank Flashing Losses	WYDEQ BACT
Condensate Tank Working Losses	WYDEQ BACT
Condensate Tank Breathing Losses	WYDEQ BACT
Production Flaring	-
Compressor Station	WYDEQ BACT was assumed to limit NOx and CO emissions for reciprocating engines
Gas Plant	WYDEQ BACT was assumed to limit NOx and CO emissions for reciprocating engines
Evaporation Ponds	None

Figure ES-3 shows drilling activity and total active well count within the CD-C Project Area during the LOP. In Figure ES-3, the differences in activity levels between the Proposed Action Alternative and the No Action Alternative are evident; in the No Action Alternative, new CD-C Project wells account for 45.4% of the Proposed Action Alternative new wells shown per year. The charts also include existing wells within the CD-C Project Area. These wells were drilled and may have been already producing in the CD-C Project Area as of 2008. The existing wells are not part of the Proposed Action Alternative or the No Action Alternative. Drilling of new CD-C Project wells under the Proposed Action Alternative and No Action Alternative begins in the year 2009. Information on the pace of drilling shown in Figure ES-3 was provided by the CD-C Operators.

The number of existing wells shown in the active well figure decreases continually over the LOP as wells reach the end of their productive life and are abandoned. The number of new CD-C Project wells increases while drilling is underway from 2009 to 2023. The total (existing + new) well count reaches its peak in 2023 and then declines for the remainder of the LOP as well abandonment occurs.

The field-wide CD-C Project Area gas and condensate production from existing and new CD-C Proposed Action Alternative and No Action Alternative wells over the LOP are shown in Figure ES-4. Production of gas and condensate from existing wells decreases throughout the LOP. This is because production from a single gas well peaks just after drilling is completed and declines as the reservoir is drained. Gas and condensate production from the new CD-C Project wells for both the Proposed Action Alternative and No Action Alternative rises while drilling is underway and then falls off after 2023 as drilling ceases and production from individual wells declines.

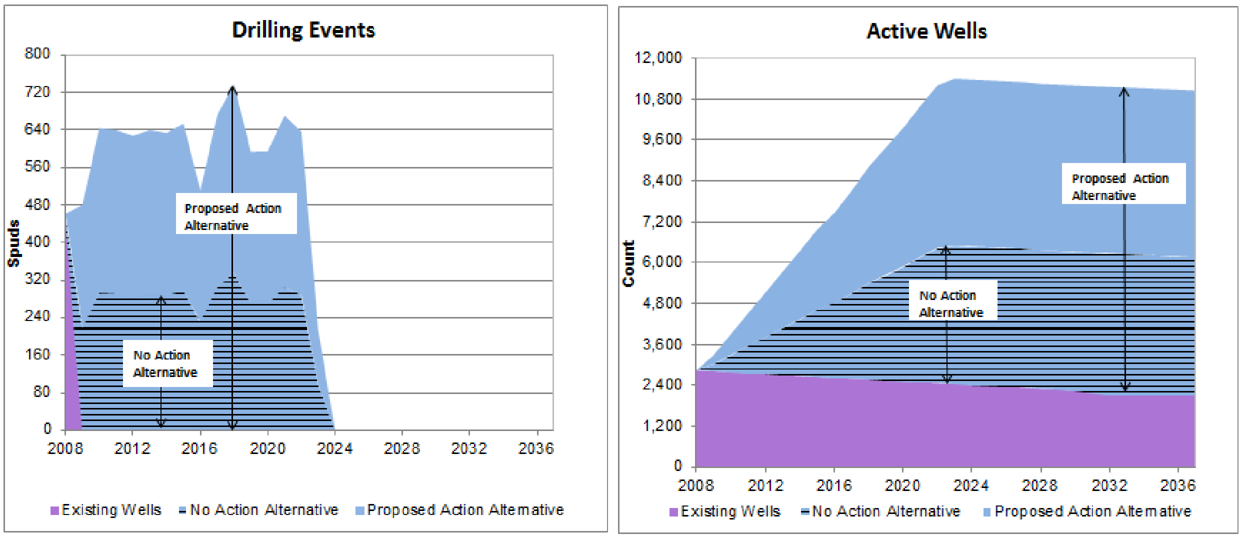

Figure ES-3. Number of CD-C Project Area wells drilled (spuds) in each year over the LOP (left panel) and number of active wells in each year over the LOP (right panel).

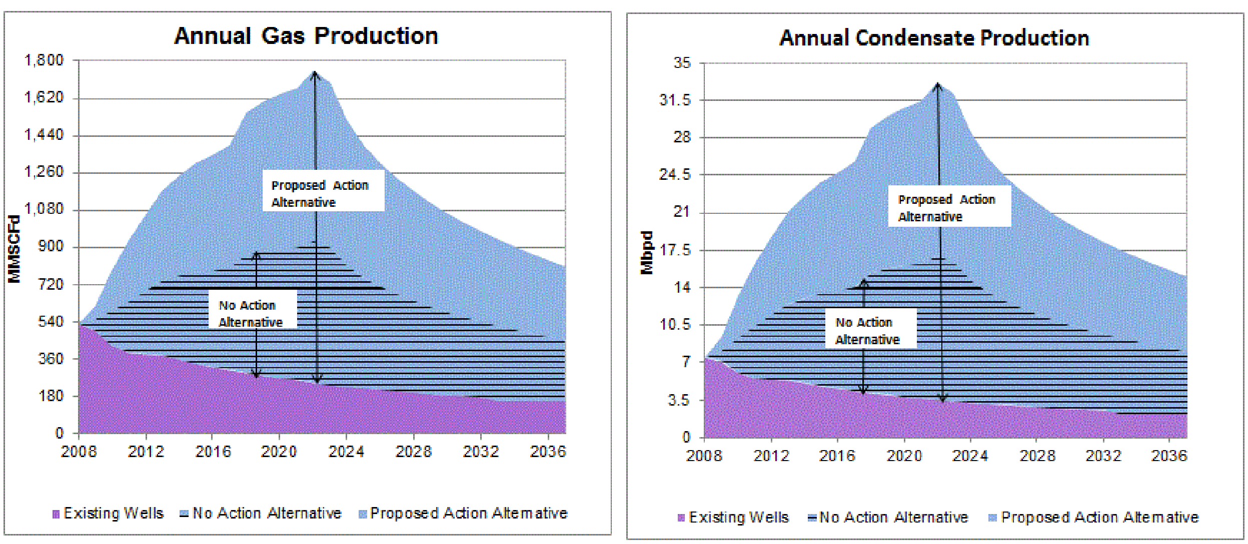

Figure ES-4. Yearly gas (left panel) and condensate (right panel) production of CD-C Project Area wells over the LOP.

Field-wide CD-C Project Area emissions are determined by drilling and production activity. Field-wide total annual NO_X and VOC emissions for new and existing CD-C Project Area sources are shown in Figure ES-5. NO_X emissions show the impact of drilling/completion activities, with peak emissions coinciding with the years when new CD-C Project wells are being drilled. NO_X emissions drop off sharply in 2024 following the end of drilling. NO_X emissions thereafter are controlled by production sources such as compressor engines and well-site heaters. NO_X emissions from CD-C Proposed Action Alternative sources are larger than NO_X emissions from existing sources because of the well construction/drilling activities and because there are many more Proposed Action Alternative wells than existing wells (Figure ES-3).

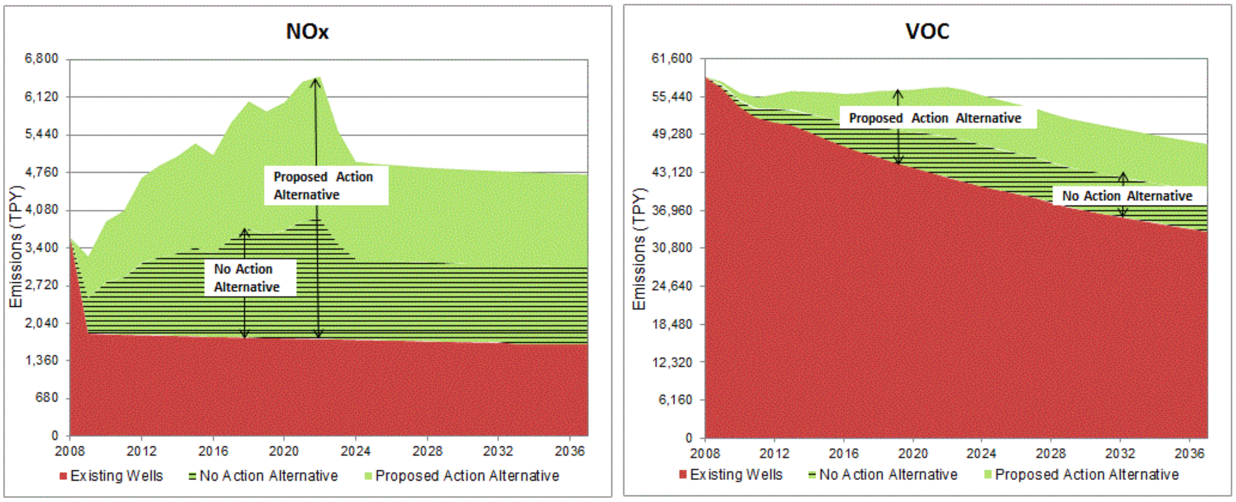

Figure ES-5. Field-wide NO_X and VOC emissions from existing and new CD-C Proposed Action wells over the LOP.

VOC emissions are influenced more strongly by production sources than by drilling and completion sources. The largest sources of VOC emissions are dehydrators, condensate tanks, pneumatic pumps and well venting. These sources all depend on gas/condensate production, so that peak field-wide VOC emissions occur during the years of peak production, which are the years with the highest number of total active wells. The bulk of VOC emissions come from existing wells, which were developed during the year 2008 or prior. These wells are not subject to the controls on VOC emissions required under the WDEQ-AQD (2010) Guidance. The new CD-C Proposed Action wells are subject to these 2010 requirements, and have controls that dramatically reduce their VOC emissions. Therefore, the new wells have lower per well VOC emissions than existing wells. The effect of the emissions controls reduces the field-wide VOC emissions from new wells so that they are lower than the field-wide emissions from existing wells, despite the fact that there are more new wells than existing wells. The peak year of VOC emissions is 2008, when the active well count, gas/condensate production, and VOC emissions from existing wells are at their maximum values.

2022 is the year when the NOx emissions from the Proposed Action Alternative and No Action Alternative as well as total CD-C Project Area are at their peak. Total CD-C Project Area VOC emissions have their maximum value in 2008, and have a secondary peak in 2022. The 2008 peak in VOC emissions is entirely due to emissions from existing wells. 2022 is the year of maximum VOC emissions from total CD-C Project Area wells but has lower overall VOC emissions due to the decline in emissions from existing wells over time. Sensitivity testing carried out during the 2008 baseline modeling indicated that ozone formation in the CD-C Project Area was more sensitive to CD-C Project NO_X emissions than CD-C Project VOC emissions (ENVIRON and Carter Lake, 2011b). Because NOx emissions are highest in 2022 and because VOC emissions are also high in 2022, 2022 is expected to be the year of peak ozone impacts.

A significant uncertainty in the preparation of the CD-C Project emission inventory is the speciation of flaring emissions. Of particular concern is the fraction of flaring emissions made up by formaldehyde, a highly reactive volatile organic compound which is an ozone precursor. In accordance with the BACT requirements, the CD-C Operators have indicated their intent to control future year emissions through flaring for the following emissions source categories: condensate tank flashing and working/breathing losses, pneumatic pumps, dehydrator venting, and well completion. Because flaring is a proposed control strategy in the CD-C Project, it is important to characterize the emissions from flaring as accurately as possible, and in particular, to determine the appropriate fraction of emissions comprised by formaldehyde. The amount of formaldehyde emitted can influence ozone formation due to the CD-C Project emissions and may affect near-field formaldehyde concentrations, the cancer risk assessment and the size of calculated ozone impacts from the CD-C Project.

The natural gas flaring speciation profile (0051) from EPA's SPECIATE database (Hsu et al., 2009) was used to determine the weight fractions of volatile organic compounds to total hydrocarbons in the flared gas and to determine the VOC speciation of the flared gas (i.e. the formaldehyde content of the emissions) in the CD-C Project emission inventory. Speciation profile 0051 specifies a 20% contribution by weight from formaldehyde. The origin of this profile is not readily traceable from SPECIATE database documentation or the published literature. A review of the published literature (ENVIRON and Carter Lake, 2011) indicated that there is no clear scientific consensus on the amount of formaldehyde emissions emitted from oil and gas facility flares, and that the 20% contribution from formaldehyde in SPECIATE profile 0051 likely represents an upper bound estimate of the amount of formaldehyde present in gas facility flaring emissions. Based on this information, the WDEQ-AQD provided direction that the EPA SPECIATE flaring profile 0051 should be used to speciate emissions from flaring in the CD-C Project emission inventory.

We note that the estimates of formaldehyde emissions from flaring are likely to be conservative. This will lead to conservatism in the estimates of CD-C Project ozone impacts as well as in the near-field estimates of formaldehyde concentrations and cancer risk. Speciation of flaring emissions is discussed in more detail in Section 2.1.3.4.

ES2. REGIONAL EMISSION INVENTORIES

In addition to the CD-C Project Area emissions, emission inventories for other regional existing and proposed emissions sources within a continental-scale modeling domain (Figure ES-6) were constructed and used for cumulative modeling analyses. Emission inventories prepared by the Western Regional Air Partnership (WRAP), Carter Lake, and BP and other Operators formed the basis for the regional emission inventories for the CD-C Project far-field air quality impact analysis. Sources of PM_{10}, $PM_{2.5}$, NO_X, CO, SO_2, and VOC emissions within the study area were inventoried. Emission inventories and projections from various State and Federal agencies were used to update the WRAP analyses as appropriate for each of the years modeled. Three categories of regional emissions inventories were compiled: two base case years, a baseline year, and a future year. The base case, baseline and future year air quality modeling is described in Section ES3.2.

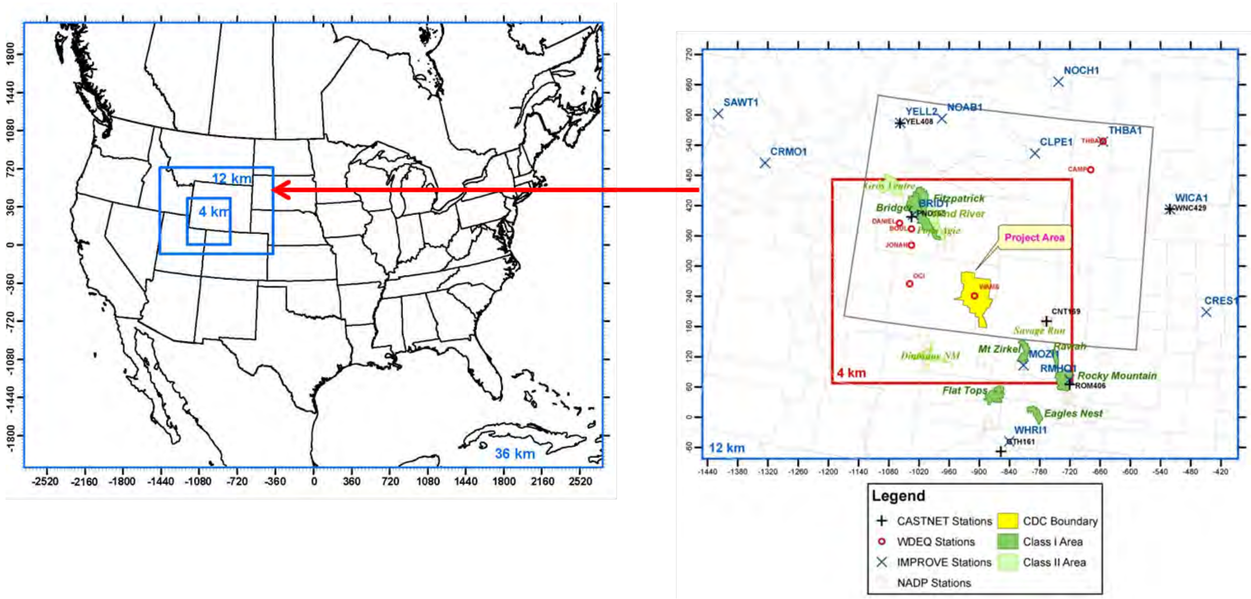

Figure ES-6. Study Area showing 36/12/4 km nested modeling grid used for photochemical grid modeling (left panel) and expanded view of the 12/4 km domain that was the focus of the far-field modeling impact analysis showing boundary of CD-C Project Area (yellow) and nearby Class I/sensitive Class II areas.

ES3. MODELING METHODS

In this section, we provide a brief overview of the models and methods used to carry out the near-field and far-field analyses of potential CD-C Project air quality and AQRVs impacts.

ES3.1 Near-Field Modeling Methods

A near-field ambient air quality impact assessment was performed to quantify maximum pollutant impacts within and near the CD-C Project Area resulting from CD-C Project development and production emissions. EPA's Guideline (EPA, 2005a) model, AERMOD (version 13350), was used to assess the near-field impacts. Regulatory model settings were used with the exception of the non-regulatory Ozone Limiting Method (OLM) model option, which was used for modeling 1-hour NO_2 concentration estimates. Three years (2008–2010) of hourly surface meteorological data measured within the CD-C Project Area near Wamsutter, along with twice daily sounding data from the Riverton, Wyoming National Weather Service (NWS) site were used for the near-field analysis. These surface data include 10 meter level measurements of wind speed, wind direction, standard deviation of wind direction [sigma theta], solar radiation, temperature (10 meter and 2 meter), and temperature difference. The AERMOD preprocessor AERMET (version 13350) was used to process the Wamsutter and Riverton meteorological data into datasets (surface data and profile data) compatible with the AERMOD dispersion model. Background pollutant concentrations provided by the WDEQ-AQD were used as an indicator of existing conditions in the region, and were assumed to include emissions from industrial emission sources in operation and from mobile, urban, biogenic, other non-industrial emission sources, and transport into the region. These background concentrations were added to modeled near-field Project impacts to calculate total ambient air quality impacts.

A near-field criteria pollutant assessment was performed to estimate maximum potential impacts of PM_{10}, $PM_{2.5}$, NO_X, SO_2, and CO from project emissions sources that are likely to operate during the development and production phases of the CD-C Project.

Near-field HAP concentrations were calculated for assessing impacts in the immediate vicinity of CD-C Project for short-term (acute) and long-term exposure assessments and for calculation of long-term risk. Short-term (1-hour) HAP concentrations were compared to acute Reference Exposure Levels (RELs). Long-term exposures to HAPs emitted by the Proposed Action were compared to Reference Concentrations for Chronic Inhalation (RfCs).

ES3.2 Far-Field Modeling Methods

The purpose of the far-field modeling is to quantify potential ambient air quality impacts and potential AQRVs impacts from air pollutant emissions of NO_X, SO_2, PM_{10}, $PM_{2.5}$, VOC and CO due to development of the CD-C Project, as well impacts due to the combined emissions from the CD-C Project and other regional sources.

The far-field air quality impact assessment for the CD-C EIS was performed with the photochemical grid model CAMx (Comprehensive Air quality Model with Extensions; ENVIRON, 2010a; www.camx.com). CAMx is an Eulerian photochemical dispersion model that allows for an integrated "one-atmosphere" assessment of gaseous and particulate air pollution (ozone, $PM_{2.5}$, PM_{10}, air toxics, mercury) over many scales ranging from sub-urban to continental. CAMx simulates the emission, dispersion, chemical reaction, and removal of pollutants in the troposphere by solving the pollutant continuity equation for each chemical species on a system of nested three-dimensional grids. The Eulerian continuity equation describes the time dependency of the average species concentration within each grid cell volume as a sum of all of the physical and chemical processes operating on that volume. CAMx was used to perform modeling of the base case years (2005-2006), the baseline year (2008), and the future year (2022).

ES3.2.1 Base Case Modeling of 2005-2006

In the base case modeling, CAMx was applied for the calendar years 2005 and 2006 using a nested-grid modeling domain with horizontal spatial resolution 36/12/4 km (Figure ES-6). The primary function of the 36 km grid domain is to provide lateral boundary conditions to the 12 km grid domain. The 4 km grid encompasses the CD-C Project Area and nearby Class I and sensitive Class II areas. The 2005 and 2006 base case model runs used actual emissions of NO_X, SO_2, PM_{10}, $PM_{2.5}$, VOC, ethane and CO from all sources for those years and included a comprehensive inventory of oil and gas (O&G) emissions sources within Southwest Wyoming developed by Carter Lake and BP as well as the WRAP Phase III O&G emissions for the Denver-Julesburg, Piceance, and Uinta Basins. The development of the 2005 and 2006 base case emissions inventories is described in Section 2.2.1 with more details provided in Appendix G. The emission inventories were processed through the SMOKE (Sparse Matrix Operator Kernel Emissions; Coats, 1996a,b) emissions model to prepare model-ready, gridded, speciated emissions. Meteorological inputs (temperatures, winds, etc.) were prepared using the PSU/NCAR Mesoscale Model Version 5 (MM5; Anthes and Warner, 1978; Dudhia, 1993) for the two modeled years, 2005 and 2006. The CAMx model was run for the two year period, and CAMx gas phase and particle phase model estimates were compared against observed ambient values for those two years and a model performance evaluation was conducted (Appendix A).

Model performance was deemed satisfactory by the CD-C Stakeholders. The next step in the CD-C analysis was to apply CAMx for a baseline emissions scenario.

ES3.2.2 Baseline Modeling of 2008

At their January 7, 2010 meeting, the CD-C stakeholders determined that the baseline year to be used for the modeled impact analyses would be 2008. Originally, 2006 was to have been the baseline year, but three major factors indicated that 2008 was more appropriate for the CD-C modeling:

1. Extensive development of oil and gas resources in southwest Wyoming occurred during the 2006-2008 period, therefore emissions of criteria pollutants and ozone precursors from this source category were significantly larger in 2008 than in 2006. In addition, the economic slowdown in 2008-2009 led to a reduction in the pace of development such that the 2009 total emissions are smaller than 2008 emissions.
2. 2008 was a National Emission Inventory (NEI) year, in which states submit emission inventories to the EPA and 2008 inventories for the State of Wyoming were available at the time of the baseline modeling.
3. More ambient monitoring data are available for 2008 than for 2006. This is critical for developing future year ozone estimates from projections based on baseline year observed concentrations.

Carter Lake Consulting and ENVIRON developed a regional emission inventory for 2008 for use in CAMx baseline modeling. The 2008 regional inventory is described briefly in Section 2.2 and in more detail in Appendix F.

The CD-C 2008 baseline modeling consisted of two annual simulations. Both simulations were performed with 2008 emissions; one used 2005 meteorology and the other used 2006 meteorology. CAMx was applied using the 36/12/4 km nested-grid modeling domain as shown in Figure ES-6. The main study area was the 12/4 km modeling domain which includes all emissions sources and receptor areas analyzed in the far-field air quality and AQRVs assessment of the CD-C Project emissions and the regional emissions.

The primary reason for performing baseline year modeling is to have a reference level for comparison with the future year CD-C CAMx modeling results. In addition, the 2008 baseline CAMx modeling results were used to assess the state of regional air quality under the 2008 baseline emissions scenario and CAMx probing tools were used to isolate the contribution of 2008 CD-C Project Area emissions on regional air quality. A detailed summary of the results of the 2008 baseline modeling is given in Appendix I.

ES3.2.3 Future Year Modeling of 2022

The future year modeling and impact analyses were performed using emissions estimates for 2022. 2022 was selected because it is the year of peak NOx emissions and high VOC emissions from CD-C Project sources and is therefore the year in which is the overall air quality/AQRVs impacts from CD-C Project sources are likely to be highest.

Future year cumulative inventories were developed for the year 2022. The WRAP 2018 inventory was used as a starting point and all non-oil and gas sources were projected or interpolated to 2022 except the natural source categories: ammonia, wind-blown dust, biogenics, and fires. The natural source categories were held unchanged from the base years. The WRAP 2018 inventory was adjusted for emissions related to oil and gas activity for counties within the 4 km portion of the modeling domain. The WRAP 2018 oil and gas inventory was adjusted for CD-C project emissions and other Reasonably Foreseeable Development (RFD) emission sources. RFD emissions were based on recent and ongoing NEPA analyses performed within the 4 km grid region of the modeling domain.

RFD is defined as 1) air emissions from the undeveloped portions of authorized NEPA projects, and 2) air emissions from not-yet-authorized NEPA projects (if emissions are quantified when modeling commences). RFD information from not-yet-authorized projects was obtained from the BLM and is based on ongoing air quality analyses for NEPA projects. RFD information for authorized development was obtained from final NEPA documents that have been submitted to BLM for planned project development, specifically from the air quality analyses performed for these projects. RFD emissions are discussed further in the Section 2.3.1.4.

Full development of proposed projects inventoried as RFD may or may not coincide with full development of the CD-C Project. As a result, the assumption that all RFD are fully developed during the maximum year of project development results in conservatism in the cumulative impact analysis.

Previous EIS analyses quantified and tracked sources categorized as Reasonably Foreseeable Future Actions (RFFA). RFFA were defined as sources with unexpired permits that were not yet operating within the baseline year defined for modeling. Since the WRAP 2018 emission inventories are based on future projections of source emissions that are not yet operating, the RFFA source category is not necessary for purposes of this EIS.

The 2022 future year simulations account for changes in the anthropogenic regional emissions due to growth and controls between 2008 and 2022 and include RFD sources and CD-C Project emissions. The CAMx meteorology, boundary conditions, and model options were identical in the 2005-2006 base case simulations, 2008 baseline simulations and 2022 future year simulations.

ES4. CD-C PROJECT IMPACT ANALYSIS RESULTS

The results of the near-field and far-field air quality impact analyses are summarized in this Section.

ES4.1 Summary of Near-Field Impacts

Air quality impacts resulting from the CD-C Project production activities would be in compliance with the National Ambient Air Quality Standards (NAAQS) and Wyoming Ambient Air Quality Standards (WAAQS), and would not exceed the Prevention of Significant Deterioration (PSD) Class II Increments.

CD-C Project field development activities would be in compliance with the NAAQS and WAAQS; however, well pad construction and well drilling activities could result in elevated 1-hour NO_2

concentration impacts and 24-hour $PM_{2.5}$ concentration impacts that are above the level of the 1-hour NO_2 NAAQS and WAAQS, 24-hour $PM_{2.5}$ NAAQS and WAAQS, and 24-hour PM_{10} WAAQS at areas immediately adjacent to these activities.

ES4.2 Summary of Far-Field Impacts

Key results of the analysis of the air quality and AQRVs impacts of the CD-C Proposed Action Alternative and No Action Alternative are described below.

ES4.2.1 Criteria Pollutants Including Ozone

The CD-C Proposed Action Alternative makes no significant contribution to modeled exceedances of the National Ambient Air Quality Standards, Wyoming Ambient Air Quality Standards or Colorado Ambient Air Quality Standards for ozone or any other criteria pollutant in the 2022 future year.

The CD-C Proposed Action Alternative contribution to future year ozone design values was assessed using CAMx model output as input to the EPA's Modeled Attainment Test Software (MATS; Abt, 2009) and directly using absolute CAMx modeled concentrations. The MATS-estimated CD-C Proposed Action Alternative maximum impact on the 2022 DVF is less than or equal to 0.8 ppb for both meteorological years. The two year approximation to a 2022 design value obtained using absolute model concentrations shows the CD-C Proposed Action Alternative maximum ozone impact is 1.7 ppb. For both the absolute modeled concentration and MATS results, the largest ozone impacts due to the CD-C Proposed Action Alternative emissions are in the vicinity of the CD-C Project Area. In Sublette County, where the only exceedance of the 75 ppb NAAQS occurs, ozone impacts due to the CD-C Proposed Action Alternative are less than or equal to 0.04 ppb.

Air concentrations attributable to Proposed Action Alternative emissions sources did not exceed the PSD increments at any Class I or sensitive Class II area, using 2005 or 2006 meteorology.

Air pollutant concentrations due to the No Action Alternative emissions were always lower than those due to the Proposed Action Alternative emissions. Consequently, the No Action Alternative emissions do not significantly contribute to exceedances of the ambient air quality standards nor do they ever exceed the PSD increments.

For all pollutants except ozone, the modeling results show attainment throughout the study area except in the immediate vicinity of point sources unrelated to the CD-C Project. Exceedances of the CO, and PM_{10} standards are the result of impacts from 2005 fire in Lincoln County, and the SO_2 exceedances are highly localized and due to emissions from a Fremont County source and a source in western Sweetwater County. The ozone exceedance occurs at Boulder, WY where the CD-C Project emissions make no significant contribution to ozone concentrations.

Examination of the spatial extent and magnitude of the CD-C Proposed Action Alternative and No Action Alternative contributions to criteria pollutant concentrations within the study area shows that none of the exceedances of the ambient air quality standards in the 2022 future year modeling have significant contributions from emissions from the CD-C Project.

ES4.2.2 AQRV Impacts

ES4.2.2.1 Visibility Impacts

The visibility analysis for the CD-C Proposed Action Alternative predicts a total of 8 days with impacts > 0.5 dv and zero days with impacts > 1.0 dv throughout all the Class I and sensitive Class II areas over the course of the 2 year simulation. The areas with visibility impacts exceeding 0.5 dv are Savage Run WA, Dinosaur NM and Mount Zirkel WA. The cumulative visibility analysis shows that: (1) visibility improves at all Class I and sensitive Class II areas in 2022 compared to 2008 on the 20% best and 20% worst days; and (2) average visibility impairment on the 20% best and 20% worst days due to Proposed Action Alternative and RFD emissions sources (combined) ranges from 0.01 to 0.18 dv, over the Class I and sensitive Class II areas.

For the No Action Alternative, zero days > 0.5 dv are predicted throughout the Class I and sensitive Class II areas over the two year simulation due to No Action Alternative emissions contributions to regional haze. The cumulative visibility results for the No Action Alternative are almost identical to the Proposed Action Alternative results.

ES4.2.2.2 Deposition Impacts

The Deposition Analysis Threshold (DAT) for nitrogen was exceeded at 5 Class I or sensitive Class II areas near/downwind of CD-C Project Area due to emissions from the Proposed Action Alternative sources and at 4 areas due to emissions from the No Action Alternative. The DAT for sulfur was not exceeded at any Class I or sensitive Class II area for either the Proposed Action Alternative or No Action Alternative.

Nitrogen deposition in 2022 due to all emissions sources exceeds the 1.5 kg/ha/yr critical load threshold at all Class I and sensitive Class II areas for both meteorological years. Sulfur deposition in 2022 due to all emissions sources exceeds the 3.0 kg/ha/yr critical load threshold at Mount Zirkel WA, Rocky Mountain NP, and Dinosaur NM using 2006 meteorology but does not exceed the 3.0 kg/ha/yr threshold at any area using 2005 meteorology.

ES4.2.2.3 Acid Neutralizing Capacity Changes at Sensitive Lakes

There were no ANC changes exceeding the USFS Level of Acceptable Change (LAC) thresholds due to emissions from Proposed Action Alternative sources or No Action Alternative sources.

1.0 Introduction and Background

This air quality analysis assesses the potential impacts on ambient air quality and Air Quality Related Values (AQRVs) from the Continental Divide-Creston (CD-C) Project air emissions due to development and production activities within the CD-C Project Area (Figure 1-1) and from other documented regional emissions sources. Potential ambient air quality impacts are quantified and compared to applicable state and Federal standards. AQRVs impacts (visibility, atmospheric deposition, and acid neutralizing capacity of sensitive lakes) are quantified and compared to applicable thresholds as defined in the Federal Land Managers' (FLMs') Air Quality Related Values Work Group (FLAG) and Interagency Workgroup on Air Quality Modeling (IWAQM) guidance documents (FLAG, 2010 and IWAQM, 1998), and other state and Federal agency guidance.

The methods used in the CD-C air impact analysis are documented in an Air Quality Impact Assessment Modeling Protocol (Carter Lake and ENVIRON, 2010) that was developed prior to the air impact assessment to ensure that the approach, input data, and computation methods were acceptable to the Wyoming Department of Environmental Quality – Air Quality Division (WDEQ-AQD), the Bureau of Land Management (BLM) and other air quality stakeholders, and that all air quality stakeholders had the opportunity to review the Protocol and provide input before the impact assessment was performed.

1.1 PROJECT DESCRIPTION

1.1.1 Overview of CD-C Project

BP America Production Company and other Operators (identified hereafter as the “Operators”) propose to develop natural gas resources within the existing Continental Divide, Wamsutter, Creston, and Blue Gap natural gas fields, located in Carbon and Sweetwater counties, Wyoming. The Continental Divide-Creston (CD-C) Natural Gas Development Project (CD-C Project) involves approximately 1.1 million acres in an area with a “checkerboard” pattern of surface ownership as shown in Figure 1-1. The BLM, the State of Wyoming, and private owners issued the oil and gas leases covering these lands. The Rawlins Field Office (RFO) manages BLM surface lands and the federal mineral estate in the CD-C Project Area. The Operators propose to drill approximately 8,950 new natural gas wells within the Project Area. The Proposed Action Alternative assesses the impact of these proposed 8,950 new wells. In addition, a No Action Alternative considers development restricted to fee and state gas leases only, which comprises 45.4% of the mineral estate in the project area, or 485,819 acres and consists of 4,063 new natural gas wells. In addition to the new wells proposed as part of the CD-C Project Alternatives, there are 2,850 wells that existed in the Project Area as of 2008. Note that the Proposed Action Alternative and No Action Alternative represent the maximum and minimum levels of development proposed under all the Project Alternatives and therefore impacts from the other Project Alternatives would be within the range of those assessed for the Proposed Action Alternative and No Action Alternative.

The CD-C Project Area includes a mix of Federal, State, and private lands. The Project Area is generally located within Townships 14 through 24 North, Ranges 91 through 97 West, 6th

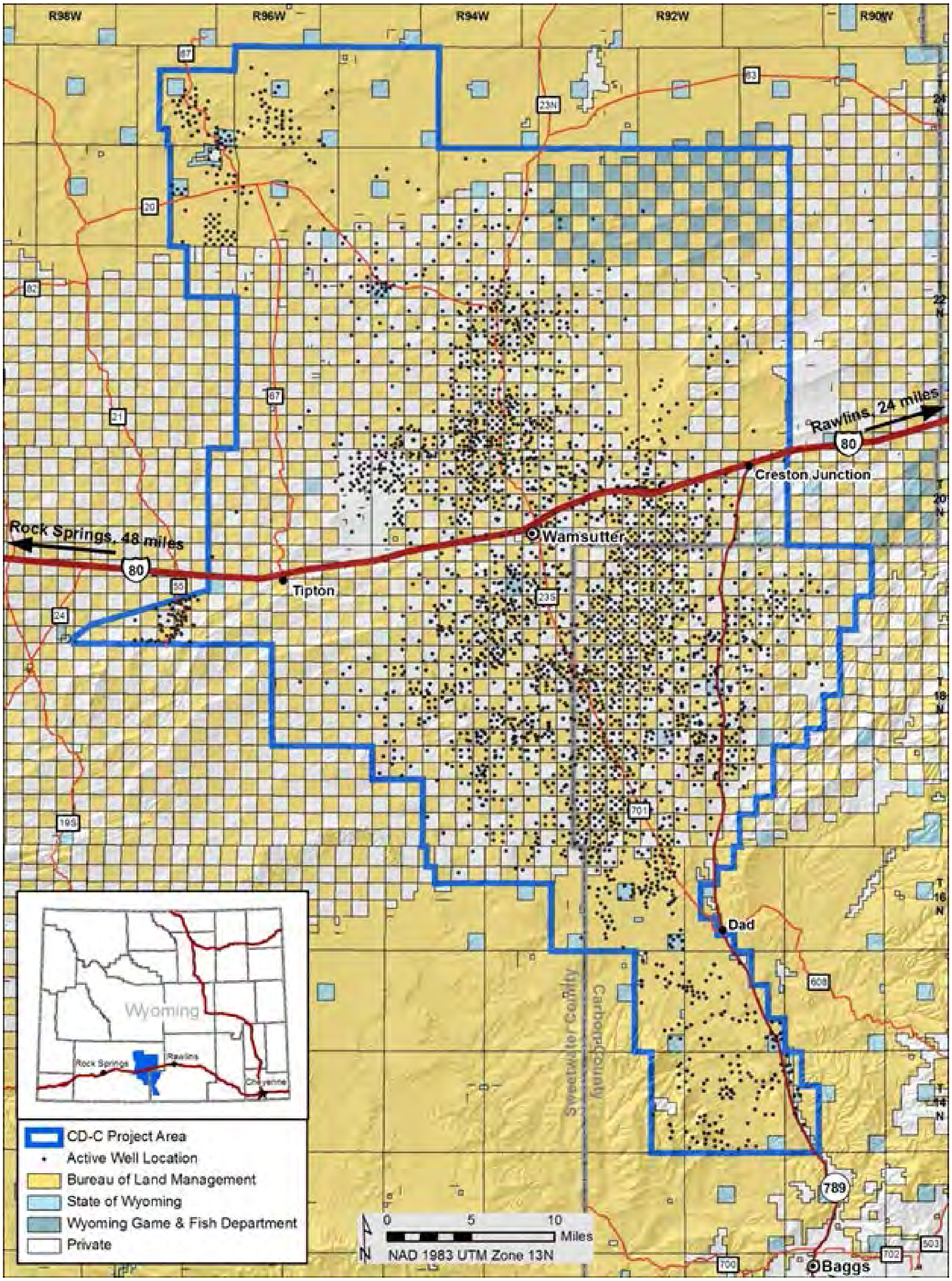

Figure 1-1. CD-C Project location in Southwest Wyoming.

Principal Meridian. The eastern boundary of the Project Area is about 25 air miles west of the city of Rawlins. Interstate 80 crosses through the center of the Project Area.

Collectively, the Operators propose to drill approximately 8,950 new wells to operate in addition to the wells that currently exist in the Project Area. Up to 500of the proposed new wells could be coalbed natural gas (CBNG) wells. The Operators anticipate drilling infill wells at potentially up to 40 acres per downhole well bore. The total number of wells drilled will depend largely on factors outside of the Operators' control that affect the ability to adequately drain the reservoir, including geologic characteristics and reservoir quality, appropriate engineering technology, economic factors, commodity prices, availability of commodity markets, and lease stipulations and restrictions. The drilling assumptions are the same for the Proposed Action Alternative and the No Action Alternative; the only difference between the Alternatives is the number of wells to be drilled.

This proposal assumes that the gas wells may be drilled conventionally, i.e., with a vertical well bore on a single pad, or with multiple directional well bores from a single pad. The gas resource is primarily conventional natural gas; however the project also includes development of CBNG. Directional drilling is not being proposed by the CBNG operators. All proposed wells are anticipated to be drilled during an approximately 10 to 15 year period after Project approval. Although actual operations are subject to change as conditions warrant, the Operators' long-term plan of development is to drill additional wells at the rate of approximately 600 wells per year or until the resource base is fully developed. The average life of a well is expected to be 30 to 40 years for both the conventional gas and CBNG development.

1.1.2 Relationship to Existing Plans and Documents

Oil and gas extraction in the Project Area is currently guided by decisions in relevant programmatic National Environmental Policy Act (NEPA) documents including the Rawlins Resource Management Plan (RMP) (BLM, 2008), and decisions made in applicable project-specific BLM NEPA documents, including the Continental Divide/Wamsutter II Natural Gas Project and the Creston/Blue Gap Natural Gas Project.

Potential impacts to air quality resulting from natural gas development in the Continental Divide area were previously analyzed in the Continental Divide/Wamsutter II Natural Gas Project Environmental Impact Statement (CDWII EIS) (BLM, 1999). The Operators' development plan for that project was approved in May of 2000 (BLM, 2000). The 2,130 wells approved included approximately 930 new wells/well locations within the jurisdictional boundary of the Rock Springs Field Office (RSFO) area and 1,200 new wells/well locations within the jurisdictional boundary of the RFO area. The portion of the CDWII Project Area within the RSFO is not included in the Continental Divide-Creston Project Area.

In April 2005, BLM RFO received a proposal to drill and develop up to 1,250 additional natural gas wells and associated facilities in the Creston and Blue Gap fields from Devon Energy Corporation, representing themselves and other leaseholders. The BLM RFO sent a letter to oil and gas operators with interests in the area stating that further development would require additional analysis and approval under the provisions of NEPA. The BLM had originally approved development of up to 275 natural gas wells and up to 250 well pads in the project area in October 1994. By August of 2004, the approved number of wells had been drilled. The

2005 Devon proposal was initiated in response to the BLM RFO letter and named the "Creston/Blue Gap II Natural Gas Project."

In November 2005, since the Operators had begun to approach the number of wells permitted in the original Continental Divide/Wamsutter EIS, the BLM RFO received a proposal from BP America Production Company (BP), representing themselves and other leaseholders, to drill and develop up to 7,700 additional wells and associated facilities within a portion of the Continental Divide/Wamsutter II Natural Gas Project area. Development in that area had been approved in May of 2000 for up to 2,130 wells. There was no limit on the number of well pads. (The Continental Divide/Wamsutter Area is immediately north and east of the Creston/Blue Gap Project Area). After reviewing the Continental Divide and Creston/Blue Gap II proposals, and in view of their timing, the proximity of the areas, and the similarity of their proposed actions, BLM determined the two projects should be combined into one, the Continental Divide-Creston Natural Gas Development Project.

In December 2012, a Notice of Availability was published in the Federal Register for the BLM Draft EIS (DEIS) for the proposed Continental Divide-Creston Natural Gas Development Project, Wyoming, and a public comment period followed. The DEIS evaluated the potential impacts of 8,950 additional natural gas wells and additional ancillary development and facilities proposed by the Operators under the Proposed Action Alternative. The DEIS evaluated a No Action Alternative that proposed no new development in the CD-C Project Area. Based on comments received on the DEIS modeling analyses, revisions were made to the project emissions, cumulative emissions inventories, and modeling analyses methodologies, and are incorporated in this Final EIS (FEIS).

1.2 OVERVIEW OF MODELING APPROACH

In this subsection, we provide some background on Wyoming ozone air quality issues and outline the methods used in the near-field and far-field air quality modeling.

1.2.1 Near-Field Modeling

The EPA's regulatory guideline model, AERMOD was used to assess near-field impacts of criteria pollutants PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO, and to estimate short-term and long-term HAP impacts.

1.2.2 Far-Field Modeling

The far-field modeling used the Comprehensive Air quality Model with Extensions (CAMx) (ENVIRON, 2010a; www.camx.com) photochemical grid model. CAMx is described in detail in section 1.2.2.2 and has the capability to simulate ozone formation. Recent high levels of observed ozone in Wyoming necessitated using a photochemical grid model for ozone modeling.

1.2.2.1 Ozone Air Quality in Wyoming

Ozone (O_3) is an important component of photochemical smog. Ozone is not emitted directly into the atmosphere, but is formed from photochemical reactions of precursor species in the presence of sunlight. The most important precursors are oxides of nitrogen (NO_X) and volatile organic compounds (VOCs). High ozone episodes occur most typically in urban areas during summer. Under these conditions, there is an abundance of ozone precursors from human activities and the high angle of the summer sun means there is sufficient sunlight available to drive the photochemical reactions which produce ozone. High summer temperatures enhance VOC emissions and speed the chemical reactions which produce ozone from its precursors.

In 2005, high ozone (i.e. 8-hour average concentrations>75 ppb) was measured in Sublette County, WY during winter. The phenomenon of winter high ozone under conditions with low sun angles and cold temperatures was novel, particularly because Sublette County is a relatively rural area whose main source of emissions is oil and gas exploration and production. It was determined by the WDEQ-AQD and its contractors that the high ozone values were not the result of a measurement error, a transport event, or a stratospheric ozone intrusion. High ozone levels were recorded again in Sublette County in 2006, 2008 and 2011. High winter ozone has also been measured in the Uinta Basin region in rural eastern Utah where extensive oil and gas production is also occurring, similar to Wyoming's Upper Green River Basin.

In 2007 and 2008, field studies were carried out in Wyoming's Upper Green River Basin in order to investigate the mechanisms for ozone formation under winter conditions (ENVIRON et al., 2008a). Data from this and subsequent Upper Green River Basin Winter Ozone Studies (ENVIRON et al., 2008a,b; 2010b; MSI et al., 2011) as well as photochemical modeling studies (e.g. Nopmongcol et al., 2010, Carter and Seinfeld, 2012) have been used to develop a conceptual model for ozone formation in winter. The conceptual model (Schnell et al., 2009; Stoeckenius and Ma, 2010) indicates that the following conditions are necessary to produce high winter ozone:

- Shallow temperature inversion (limits vertical mixing)
- White snow on ground (highly reflective snow enhances actinic UV flux and facilitates development and maintenance of inversion)
- Few or no clouds
- Stagnant and/or recirculating slow surface winds (limits dispersion of pollutants)
- High precursor concentrations
- High VOC/NO_X ratio

Although progress has been made in understanding winter ozone formation, many open questions remain, such as the importance of ozone, transport, the chemistry of aromatic compounds at low temperatures and the sources and role of HONO in winter ozone formation (Carter and Seinfeld, 2012). Measurement campaigns, emission inventory development and modeling studies are underway with the aim of improving our understanding of the processes that contribute to winter ozone formation in Wyoming and Utah. To date, there has been limited success in simulating observed winter ozone values using 3-dimensional photochemical grid models. Therefore, the WDEQ-AQD considers the simulation of winter ozone to be an area of active scientific research and not appropriate for a NEPA analysis.

In a memorandum dated March 31, 2009, the WDEQ-AQD (2009) advised the CD-C stakeholders of the AQD's position that the CD-C ozone model performance evaluation should be limited to April-October of the 2005 and 2006 calendar years. The text below is taken verbatim from the memorandum:

> *AQD's position is that any air quality impact analysis for ozone for any project in southwest Wyoming should not require that model performance be compared to the winter time high values measured in 2005, 2006, or 2008. AQD believes that current air quality models have not been formally evaluated for their ability to adequately model ozone formation considering the key met conditions believed to be necessary in the Upper Green River Basin (strong inversions, snow, low wind speeds, strong sunlight). AQD further believes that development of models capable of replicating the episodic conditions which allow elevated ozone levels to be formed should be done in separate research projects, and not as modeling is performed for a specific project under NEPA. For NEPA projects which are assessed prior to development of an adequate winter ozone model, AQD believes that the NEPA air quality protocol should require modeling for the period April 1 through October 31 (Wyoming's 'ozone monitoring season', per 40 CFR Part 58, Appendix D, Table D-3). Similarly, comparisons of model results to the NAAQS, using either RRF or absolute techniques, should be limited to the modeled period.*

The WDEQ-AQD has analyzed the potential for areas outside Sublette and parts of Lincoln County to influence measured high ozone events in Sublette County (WDEQ-AQD, 2009), and has concluded:

> *The analysis conclusively shows that elevated ozone at the Boulder monitor is primarily due to local emissions from oil and gas (O&G) development activities: drilling, production, storage, transport, and treating. The ozone exceedances only occur when winds are low indicating that there is no transport of ozone or precursors from distances outside the proposed nonattainment area. The ozone exceedances only occur in the winter when the following conditions are present: strong temperature inversions, low winds, cold temperatures, clear skies and snow cover. If transport from outside the proposed nonattainment area was contributing to the exceedances, then elevated ozone would be expected at other times of the year. Mountain ranges with peaks over 10,000 feet border the area to the west, north and east influence the local wind patterns. Emission sources in nearby counties are not upwind of the Boulder monitor during episodes which exceed the 8-hour ozone standard in Sublette County.*

The WDEQ-AQD has therefore instructed that no impact assessment of the CD-C Project emissions on winter ozone events should be carried out as part of the CD-C air quality impact analysis.

In March, 2009, the Governor of Wyoming recommended to EPA that Sublette County and parts of northeastern Lincoln and northwestern Sweetwater Counties be designated ozone non-attainment areas under the 2008 75 ppb ozone standard. Because of the importance of ozone as an air quality issue in Wyoming, the CD-C air quality impact analysis included evaluation of the effects of emissions from the CD-C Proposed Action Alternative and No Action Alternative on ozone throughout the study area during the April-October ozone season.

The CD-C Project Area is located in eastern Sweetwater and western Carbon Counties as shown in Figure 1-2 along with the CAMx 4 km modeling domain and monitoring sites. Although the Project does not lie within the non-attainment area (purple outline), the CD-C impact analysis evaluated potential ozone impacts from CD-C Proposed Action Alternative emissions and No Action Alternative emissions on ozone in Sublette, northeastern Lincoln and northwestern Sweetwater Counties as well as the rest of the modeling domain during the April-October ozone season; this analysis can be found in Section 4.5.4. The need to address ozone impacts required the use of a photochemical grid model, which is a type of computer model that simulates the formation, transport, and fate of ozone and other pollutants in the atmosphere.

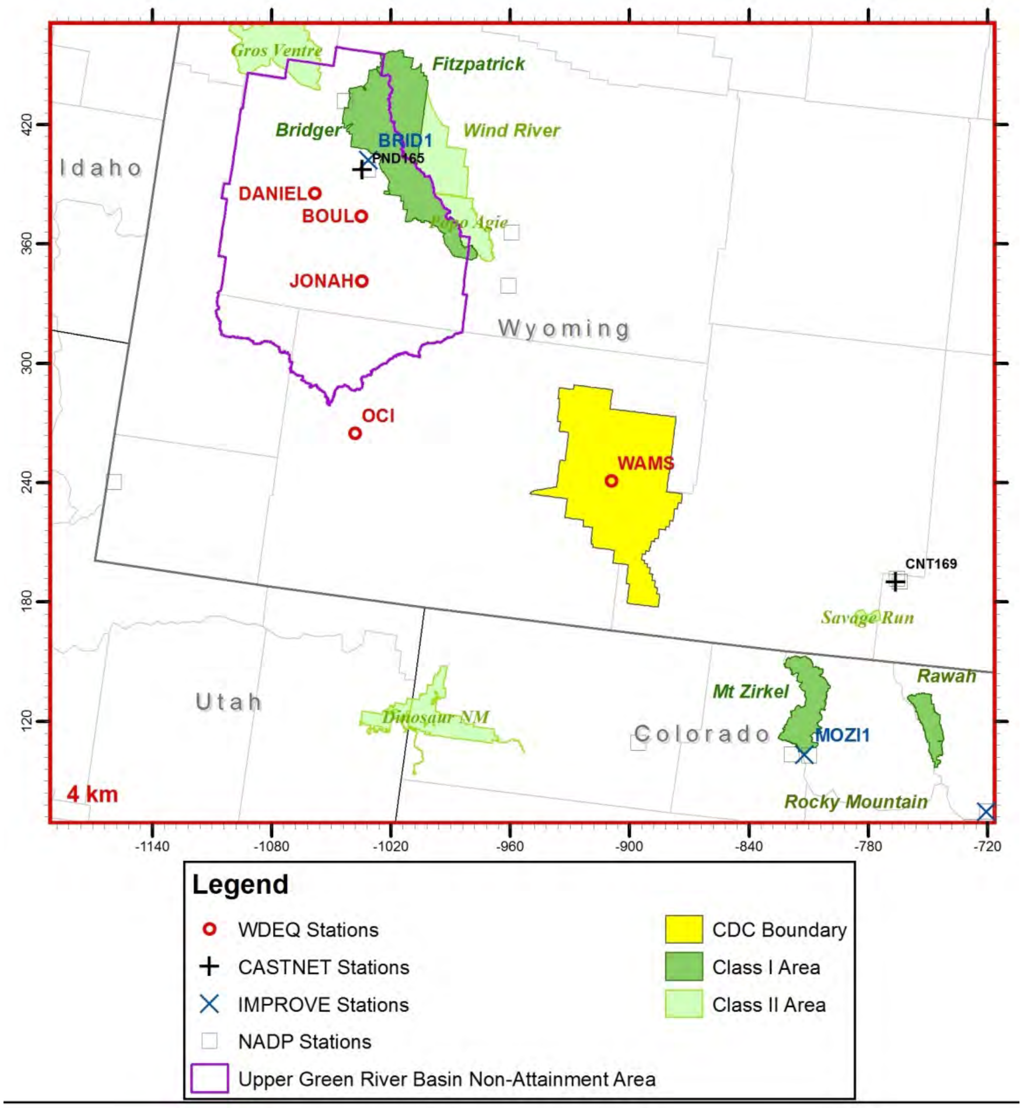

Figure 1-2. CAMx 4 km Modeling Domain showing boundary of CD-C Project Area (yellow), nearby Class I/sensitive Class II areas (green), ozone non-attainment area boundary (purple), WDEQ monitoring sites (red) and CASTNet monitoring sites (black).

1.2.2.2 The CAMx Photochemical Grid Model

The analysis described in this document differs significantly from previous natural gas development air quality analyses performed for EIS for the BLM in Wyoming. Previous BLM analyses used the CALPUFF model to assess potential AQRV impacts in nearby Prevention of Significant Deterioration (PSD) Class I Areas and sensitive PSD Class II Wilderness Areas from project and cumulative source emissions. The BLM and WDEQ-AQD elected to use a photochemical grid model (PGM) because PGMs represent the "state of the science" in tools and methods for both AQ (including ozone) and AQRV analyses.

At the direction of the WDEQ-AQD, the air quality impact assessment for the CD-C EIS was performed with the photochemical grid model CAMx (Comprehensive Air quality Model with Extensions; ENVIRON, 2010a; www.camx.com). The Comprehensive Air quality Model with extensions (CAMx) is an Eulerian photochemical dispersion model that allows for an integrated "one-atmosphere" assessment of gaseous and particulate air pollution (ozone, $PM_{2.5}$, PM_{10}, air toxics, mercury) over many scales ranging from sub-urban to continental. CAMx simulates the emission, dispersion, chemical reaction, and removal of pollutants in the troposphere by solving the pollutant continuity equation for each chemical species on a system of nested three-dimensional grids. The Eulerian continuity equation describes the time dependency of the average species concentration within each grid cell volume as a sum of all of the physical and chemical processes operating on that volume.

1.2.2.3 CD-C EIS Photochemical Modeling Strategy

The basic modeling strategy used in any EIS that employs a photochemical grid model, such as CAMx, is to first evaluate the ability of the model to reproduce ambient observations of trace pollutants during a recent historical episode (the "current year"); then, once confidence in the model is established, a future year case can be run and the potential project impacts evaluated.

A current year base case is simulated using a comprehensive regional emission inventory of actual emissions from all sources (including motor vehicles, power plants, oil and gas exploration and production sources, biogenic sources, etc.). It is preferable to run the model for more than one year so that as many different meteorological regimes as possible are simulated. Pollutants emitted from Project sources may only influence a particular sensitive receptor under certain conditions (wind direction, atmospheric stability) and a conservative estimate of AQ and AQRV impacts requires that those conditions be simulated. While it is not possible to ensure that all possible meteorological conditions that might lead to transport of pollutants from Project sources to sensitive receptors are simulated, modeling two full years increases the likelihood that the relevant conditions will occur.

The base case simulation is evaluated with respect to ambient air quality measurements. If the base case simulation reproduces concentrations of observed species with reasonable accuracy, then the model can be used in the future year impact assessment. The next step is to prepare a baseline model for use in future year projections. The only difference between the base case model and the baseline model is that the baseline model uses typical emissions while the base case model uses actual emissions. An example of an emissions source category for which the base case and baseline emissions are different is electrical generating units (EGUs). The base case emission inventory uses hourly EGU emissions derived from continuous emissions monitoring (CEM) data because the base case model is evaluated against concurrent observations to determine whether the model provides a realistic simulation of atmospheric processes. The purpose of the baseline model, on the other hand, is to serve as the base year from which future year projections are made. The baseline EGU emissions are used to represent typical conditions (no shutdowns for maintenance, for example) in order to be consistent with the future year emissions, which also represent typical conditions. The baseline emission inventory, therefore, is usually identical to the base case emission inventory, except for the difference in emissions from EGUs and other source categories with large variability in time, such as drill rigs.

The future year modeling involves development of a future year Project emission inventory as well as a future year regional emission inventory. In the future year regional emission inventory, the emissions from human activities are projected from the base year to the future year and changes such as population growth and planned emissions controls (such as controls on motor vehicle emissions) are accounted for. Emissions that are not controllable, such as biogenics and wildfire emissions, are held fixed. The Project emissions are included in the future year emission inventory. The model is run using the future year regional emission inventory with the rest of the model (meteorological fields, boundary conditions, model settings, etc.) in the same configuration as in the baseline case. If multiple years were simulated in the baseline case, then the meteorological conditions for those same years are used together with the future year emissions scenario in the future year modeling. Project AQ and AQRV impacts are determined from the future year simulations.

1.2.2.4 Development of CD-C Photochemical Modeling Database

Following the original July, 2007 CD-C Modeling Protocol (Sage and ENVIRON, 2007), Carter Lake Consulting, together with BP and other Operators, developed a detailed inventory of oil and gas emissions sources in Southwest Wyoming for 2005 and 2006. The 2005-2006 oil and gas emissions inventory was reviewed and approved by the WDEQ-AQD in December, 2008. Carter Lake also assembled 2005 and 2006 emission inventories of non-oil and gas point sources in Wyoming and surrounding states. ENVIRON processed these inventories, as well as a comprehensive regional emission inventory within the SMOKE emissions modeling system (Sparse Matrix Operator Kernel Emissions; Coats, 1996a; Coats and Houyoux, 1996b) to generate base case 2005-2006 model-ready emissions files for use in the CAMx photochemical grid model. The 2005-2006 base case regional emissions inventory was reviewed by the WDEQ-AQD and approved in February, 2010. The 2005-2006 base case emissions inventory is described in detail in Section 2.2.1 and Appendix G of this document.

ENVIRON completed development of 36, 12 and 4 km resolution MM5 meteorological databases (Fifth generation Mesoscale Model; Anthes and Warner, 1978) for 2005 and 2006, and processed the meteorological data for use in CAMx. This meteorological database was reviewed by the WDEQ-AQD under the CD-C Project and approved in February, 2010. ENVIRON also prepared other inputs for CAMx such as photolysis rates, land use database, etc. The 2005-2006 emissions inventories developed by Carter Lake, BP and other Operators, and ENVIRON are described in Section 2 of this document, as are the meteorological modeling and the other CAMx inputs. An evaluation of the meteorological model performance in simulating observed meteorological fields is presented in Appendix D.

1. INTRODUCTION AND BACKGROUND

A preliminary CAMx 2005-2006 base case simulation that could potentially be used by multiple Southwest Wyoming EIS projects was performed during May 2009 and an initial model performance evaluation was conducted under the Hiawatha EIS (Kemball-Cook, et al., 2009). On August 20, 2009, the Hiawatha air quality stakeholders group (BLM, EPA, NPS, USFS and WDEQ-AQD) met to discuss the model performance evaluation of the preliminary CAMx run. The stakeholders raised concerns over the CAMx model performance. In particular, concerns were raised regarding the summer ozone performance at the southwest Wyoming industrial monitoring sites (e.g., Boulder, Daniel and Jonah) and the particulate nitrate (NO_3) winter over-prediction and summer under-prediction tendency. The CD-C stakeholders also reviewed the evaluation and determined that diagnostic sensitivity testing should be conducted in order to improve model performance; this testing was carried out under CD-C by ENVIRON during the latter half of 2009, and is documented in detail in Appendix E of this document.

The sensitivity testing was performed in two phases. During the Round 1 sensitivity testing, a new CAMx vertical velocity algorithm was tested (Emery et al., 2009a,b). Use of the new algorithm eliminated spurious high ozone concentrations over high terrain in spring and improved model performance over broad regions of the western U.S. New boundary conditions were developed for the outer 36 km modeling domain based on data specific to the 2005-2006 modeling years. The vertical resolution of the CAMx photochemical grid model was increased and the model's top boundary condition was revised. The treatment of ammonia emissions was updated and simulation of mineral nitrate was added to the model in an effort to improve nitrate performance. At the conclusion of Round 1, the CD-C stakeholders elected to adopt the Round 1 CAMx configuration for CD-C 2005-2006 base case modeling along with the updated ammonia emissions and simulation mineral nitrate. However, additional ozone model performance improvements in southwest Wyoming were requested by the CD-C air quality stakeholders before beginning base case modeling, so a second round of CAMx sensitivity testing was carried out.

During the Round 2 testing, the sensitivity of ozone performance in southwest Wyoming was evaluated in response to changes in the CAMx treatment of dry deposition, vertical mixing, horizontal diffusion, horizontal resolution, emissions of nitrous acid (HONO), and the treatment of plumes from nitrogen oxide (NO_X) emission sources. As a result of changes made during the Round 2 testing, model performance for the southwest Wyoming summer high ozone episode improved to the point where it met EPA goals for 1-hour and daily maximum 8-hour ozone model performance. Nitrate performance also improved somewhat as a result of the Round 1 and Round 2 sensitivity testing, and the model was shown to be conservative in its nitrate predictions.

The results of the Round 1 and Round 2 sensitivity testing (presented in Appendix E) were reviewed by the CD-C stakeholders. On January 7, 2010, the CD-C stakeholders agreed upon a final model configuration to be used to conduct revised 2005-2006 base case modeling for the CD-C project. The final model configuration that was used for the CD-C base case modeling is described in this document. In February, 2010, the WDEQ-AQD authorized ENVIRON to proceed with the 2005-2006 base case modeling under the CD-C project. The 2005-2006 base case model runs were evaluated and the results of the evaluation are presented in Appendix A. The CD-C, stakeholders approved the 2005-2006 base case during the spring of 2010.

1. INTRODUCTION AND BACKGROUND

At their January 7, 2010 meeting, the CD-C stakeholders determined that the baseline year to be used in performing future year modeling and impact analyses would be 2008. Originally, 2006 was to have been the baseline year, but extensive development of oil and gas resources in Southwest Wyoming occurred during the 2006-2008 period, and emissions of criteria pollutants and ozone precursors from this source category were significantly larger in 2008 than in 2006. The economic slowdown in 2008-2009 led to a reduction in the pace of development such that total 2009 emissions are smaller than 2008 emissions. 2008 was a National Emission Inventory (NEI) year, in which states submit emission inventories to the EPA. Because emission inventories for 2008 for the State of Wyoming were available at the time of the baseline modeling, and because 2008 is the year of peak emissions from the energy sector in Wyoming, the stakeholders selected 2008 as the baseline year for the impact analysis modeling. Another important factor is that more ambient monitoring data were available in 2008 than in 2006. This is critical for developing future year ozone projections. Carter Lake Consulting and ENVIRON have developed an emission inventory for the year 2008, and this inventory development is described in Sections 2 and 4 and Appendix F. The WDEQ-AQD reviewed the 2008 baseline emission inventory and approved the use of the inventory for the CD-C 2008 baseline modeling (Personal Communication from Kelly Bott, WDEQ, July 7, 2010). A detailed description of the 2008 emission inventory is provided in Appendix F.

In the winter of 2010-2011, the 2008 baseline far-field modeling was carried out using the CAMx model. In addition to its use as the current year on which future year CD-C modeling is based, the 2008 baseline modeling was also used to assess the impacts of the existing (as of 2008) CD-C Project on regional air quality. The CD-C Project area contains existing development which must be accounted for in the CD-C modeling in addition to the wells proposed as part of the CD-C Project. The purpose of this assessment was to evaluate the state of regional air quality under the baseline emission scenario. The CAMx output concentration fields were used for the evaluation of regional air quality, and the CAMx probing tools (described in Section 4) were used to isolate the contribution of existing 2008 CD-C Project area emissions sources to the total modeled concentrations. An AQRV impact analysis evaluated CD-C project impacts on visibility, deposition and acidification of sensitive lakes. Criteria pollutant levels within the 4 km domain were evaluated and the contributions of the CD-C Project emissions sources were quantified using the CAMx probing tools. Modeled ozone levels and CD-C Project area ozone impacts and results for criteria pollutants other than ozone (NO_2, SO_2, PM_{10}, $PM_{2.5}$ and CO) as well as the 2008 AQRV impacts of the existing CD-C Project are reported in Appendix I.

As the 2008 baseline modeling was completed, the CD-C Project emission inventory was finalized. The year of peak NO_X and VOC emissions (2022) from the CD-C Project was selected for future year modeling so as to conservatively estimate the maximum air quality impacts that would result from the CD-C Project over the LOP. A regional emission inventory of non-CD-C sources was developed for the 36, 12 and 4 km modeling grids and the year 2022.

In late 2011, the 1st round of 2022 future year CAMx modeling was performed, and the results were presented to the CD-C stakeholders at a January 10, 2012 meeting. The results of the 1st round of CD-C 2022 future year modeling and air quality impact analysis were presented in a Draft Environmental Impact Statement (DEIS) and Air Quality Technical Support Document (AQTSD) and made available for public comment.

1. INTRODUCTION AND BACKGROUND

Following the public comment period, the CD-C Project emissions inventories were revised to reflect NOx emission mitigation by the CD-C Operators and corrected assumptions regarding use of evaporation ponds. The regional emission inventories were also updated to reflect the most recent available data on oil and gas development and BLM regional planning efforts in the study area. Revised 2022 future year CAMx modeling was performed for the Final Environmental Impact Statement (FEIS) using the updated CD-C Project and regional emission inventories.

The differences between the 2022 future year CAMx modeling for the DEIS and the revised 2022 future CAMx modeling for the FEIS are as follows:

1. FEIS run has 100% Tier II level emissions for drilling and completion equipment over the LOP
   - DEIS included 50% Tier 0 and 50% Tier II level emissions for drilling and completion equipment for the first 10 years of the project and 100% Tier II rigs thereafter
2. Revised evaporation pond emissions
   - Based on CD-C Operator comments on the DEIS, the number of evaporation ponds was revised downward to assume only 25% of wells are associated with an evaporation pond, compared to 100% in DEIS. Evaporation pond emissions are reduced by 75%
3. Development of a No Action Alternative
   - The No Action Alternative is defined to be 45.4% of the Proposed Action Alternative and to operate under the same emissions assumptions as the Proposed Action Alternative
4. Updated Reasonably Foreseeable Development (RFD) emission inventory
   - Includes recent and ongoing analyses of proposed NEPA oil and gas projects and BLM Field Office (FO) RMPs within the 12 km modeling domain and its immediate vicinity. Total RFD emissions are larger than in DEIS inventory. Newly-available WRAP Phase III oil and gas emissions for Wind River Basin and Powder River Basin were included in the regional emission inventory.
5. Additional Class I and sensitive Class II areas
   - All Class I and sensitive Class II areas within 200 km of the CD-C Project Area were included. Gros Ventre WA, Eagles Nest WA, Flat Tops WA and Rocky Mountain NP were not analyzed in the DEIS, but are included in the FEIS analysis.
6. Cumulative visibility method
   - The BLM and regional haze cumulative visibility impact analysis methods used in the DEIS are replaced in the FEIS with the "Cumulative Visibility Assessment Metric Approach" as described in the USDI Fish and Wildlife Service's February 10, 2012 letter to the Wyoming Department of Environmental Quality – Air Quality Division.

More details regarding the differences between the DEIS and FEIS were provided in a memo

"CD-C Project – Summary of Revisions between Air Quality Modeling Impact Analyses - Draft Environmental Impact Statement and Final Environmental Impact Statement Analyses" to the BLM on December 4, 2013 by Carter Lake Consulting and ENVIRON.

The methodologies and results of the revised FEIS CD-C 2022 future year modeling and air quality impact analysis are presented in this document.

1.3 OUTLINE OF THE CD-C AIR QUALITY TECHNICAL SUPPORT DOCUMENT

In Section 2 of this document, we describe the development of emission inventories used in the CD-C Project impact analysis. An overview of the methods and data used in developing the CD-C Proposed Action Alternative and No Action Alternative emission inventories is given in Section 2. A detailed description of the emissions calculation for each emissions source category is given in Appendices H and M. Because a photochemical grid model was used for the AQ and AQRV impact assessment, regional emission inventories for all anthropogenic, biogenic, and geogenic emissions sources were required. Inventories were developed for the 2005-2006 base case, the 2008 baseline year, and the 2022 future year. A brief description of these inventories may be found in Section 2 and the inventories for the 2005-2006 base case years are described in detail in Appendix G; the 2008 baseline inventory is discussed in depth in Appendix F.

Section 3 of this document describes the AERMOD near-field modeling, including the CD-C Project emissions and meteorological and other data used as inputs in the modeling. Impacts on near-field levels of criteria pollutants and hazardous air pollutants are described, and cancer risks are assessed.

Section 4 describes the methods and the results of the CAMx far-field modeling. An overview of the 2005-2006 base case modeling is given in this Section. Additional detail on the meteorological modeling for the years 2005-2006 may be found in Appendix D, which includes a description of the meteorological model and its configuration for the CD-C simulations, as well as inputs used and an evaluation of the model's performance in simulating observed meteorological data. Appendix A describes the model performance evaluation of the CAMx base case modeling of 2005-2006. Appendix A contains a description of the modeling inputs, model configuration, and methods and data used in the air quality model performance evaluation. Appendix E describes diagnostic and sensitivity testing that was carried out to determine the optimal configuration for performing the CD-C 2005-2006 base case modeling. The 2008 baseline modeling is described in Appendix I. The CD-C future year modeling and impact analysis is also given in Section 4. Methods and results are shown for impacts on criteria pollutants including ozone, visibility, acid deposition and effects of deposition on sensitive lakes.

Section 5 provides a summary of the air quality and AQRVs impacts of the CD-C Proposed Action Alternative and No Action Alternative.

2.0 Emission Inventories

In this section, we provide an overview of the emission inventories for the CD-C Project as well as all other sources of emissions within the 36/12/4 km modeling domain. More detailed information on these inventories is given in Appendices F, G, H and L.

2.1 CD-C PROJECT EMISSION INVENTORY

Emission inventories were developed for the air quality impact assessment for all new sources proposed under the Proposed Action Alternative, the No Action Alternative and all existing sources within the CD-C Project Area as of 2008. A Project emission inventory of field-wide oxides of nitrogen (NO_X), sulfur dioxide (SO_2), carbon monoxide (CO), particulate matter less than or equal to 10 microns in size (PM_{10}), particulate matter less than or equal to 2.5 microns in size ($PM_{2.5}$), volatile organic compounds (VOCs), methane, ethane, and hazardous air pollutants (HAPs) benzene, toluene, ethyl benzene, xylene, n-hexane and formaldehyde was compiled for well development activities, production activities, and ancillary facilities planned as part of the Project as well as for existing wells in the CD-C Project area as of the 2008 baseline year. Lead emissions are expected to be negligible and were not calculated in the inventory. Although not considered a VOC by the EPA, ethane compounds were included in the inventory for use in the far-field ozone analysis that was performed using a photochemical model. In addition, methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) emissions were included in the Project inventory for the purpose of quantifying greenhouse gas (GHG) emissions. CO_2 equivalents for all three GHGs are reported over the life of the project (LOP).

2.1.1 Key Regulations Affecting the CD-C Project Emissions development

In the development of the CD-C Project emission inventory, “on-the-books” Federal and state regulations that would affect the emissions projections were considered in calculating the emissions over the LOP. In Section 2.1.1, we give a brief description of the key regulations affecting the estimation of CD-C Project emissions. Other regulations that were accounted for in the development of the Project emission inventory are noted in the detailed emissions calculations in Appendix H.

2.1.1.1 Wyoming BACT

The CD-C Project Area lies entirely within eastern Sweetwater County and western Carbon County in Wyoming; this area is part of the State of Wyoming’s Concentrated Development Area (CDA; Figure 2-1), and is therefore subject to CDA regulations on emissions set out in the WDEQ-AQD’s March 2010 “Oil and Gas Production Facilities Chapter 6, Section 2 Permitting Guidance” (WDEQ-AQD, 2010). The Guidance states, “…all new or modified sources or facilities which may generate regulated air emissions shall be permitted prior to start up or modification and Best Available Control Technology (BACT) shall be applied to reduce or eliminate emissions”. The Guidance establishes presumptive BACT requirements for emissions from the following source categories for new facilities:

- Tank Working/Breathing/Flashing (pad facilities - 98% control upon startup; single well facilities -98% control of all new/modified tank emissions ≥ 8 tpy VOC within 60 days of startup/modification)

- Dehydration Units (upon first date of production [FDOP], glycol flash separators and still vent condensers must be installed/operating on all dehys; 98% control must be installed/operational on dehys within 30 days of FDOP if total potential uncontrolled dehy VOC emissions are ≥8 tpy; combustion units used to achieve 98% control may be removed upon approval after 1 year if total potential VOC emissions from dehys are <8 tpy)
- Pneumatic Pumps (pad facilities-VOC and HAP emissions associated with the discharge streams of all natural gas-operated pneumatic pumps controlled by at least 98% or the pump discharge streams routed into a closed loop system such as sales line, collection line, fuel supply; single well facilities with combustion units installed for the control of flash or dehydration unit emissions-VOC and HAP emissions associated with the discharge streams from natural gas-operated pneumatic pumps controlled by at least 98% by routing the pump discharge streams into the combustion unit or the discharge streams routed into a closed loop system)
- Pneumatic Controllers (install low- or no-bleed controllers at all new facilities)
- Well Completions (green completions are required in the JPAD area and CDAs)
- Produced Water Tanks (pad facilities- upon FDOP, 98% control of all produced water tank emissions. No water produced into open top tanks; single well facilities-within 60-days of FDOP, 98% control of all produced water tank emissions at sites where flashing emissions must be controlled. No water produced into open top tanks)
- Blow down/Venting (Best Management Practices and information gathering requirements incorporated into permits for new and modified facilities)
- Other sources (for uncontrolled sources emitting greater than or equal to 8 tpy VOC or greater than or equal to 5 tpy total HAPs that do not have presumptive BACT requirements, a BACT analysis must be filed with the permit application for the associated facility).

The provisions of WDEQ-AQD (2010) were applied to all 8950 new wells in the CD-C Project Area that are to be developed under the Proposed Action Alternative and the 4,063 new wells that are to be developed under the No Action Alternative. It was assumed that emissions controls remain in effect over the entire LOP and will not be removed once the well production declines enough that the well emissions drop below the limits that trigger the BACT rules. Existing wells in the CD-C Project Area were not assumed to be controlled under WDEQ-AQD (2010) because existing wells are defined to be those in production by the end of 2008, and are therefore not subject to the same BACT regulations as the new wells.

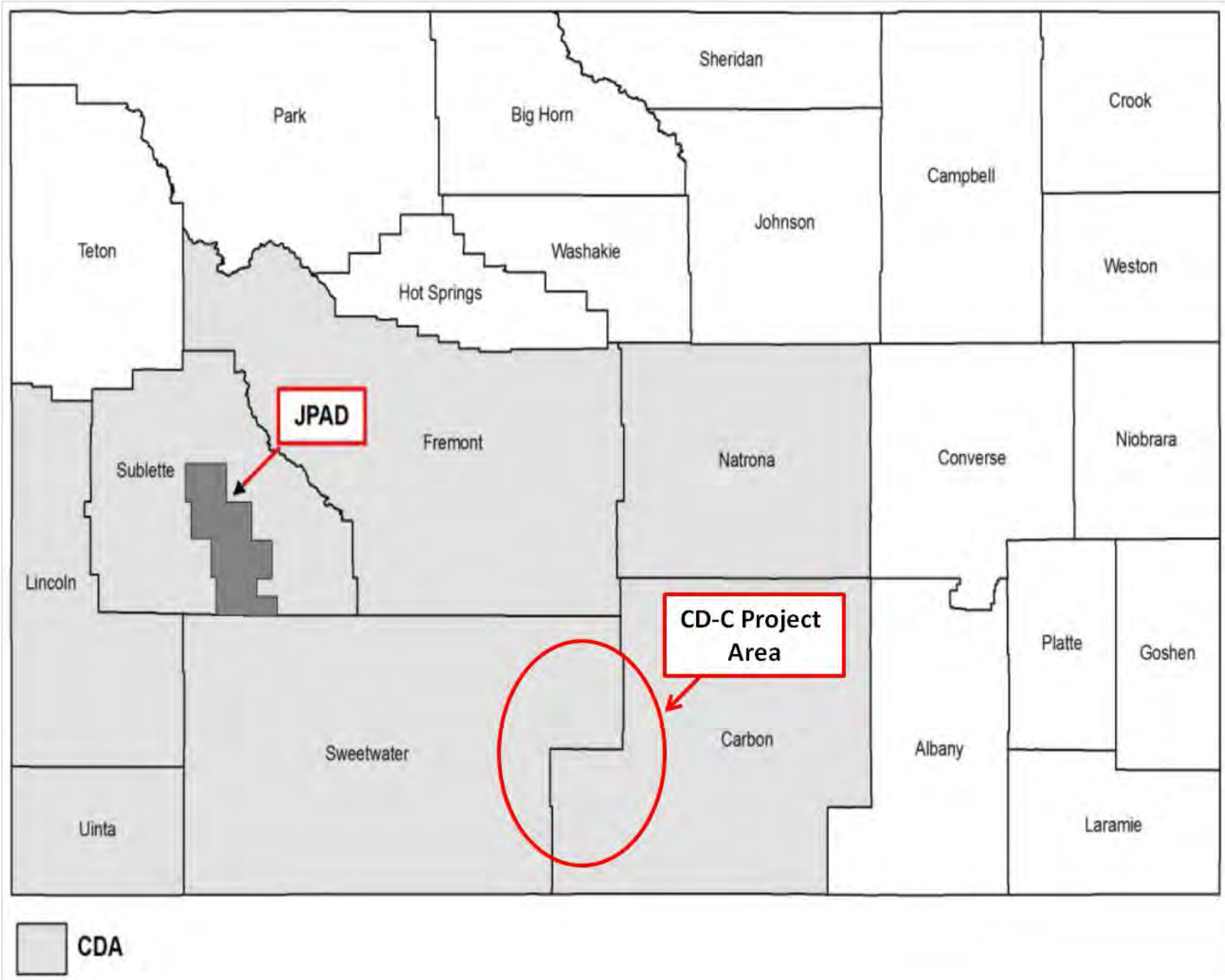

Figure 2-1. The CD-C Project Area location within the Concentrated Development Area, which is shaded in light gray (from WDEQ-AQD, 2010).

2.1.1.2 New Source Performance Standards

Under Section 111 of the Clean Air Act, the EPA has promulgated technology-based emissions standards which apply to specific categories of stationary sources. These standards are referred to as New Source Performance Standards (NSPS; 40 CFR Part 60). In the CD-C Project emission inventory, NSPS are assumed to apply to all stationary, spark-ignited natural gas engines (such as compressor engines). NSPS requires new engines of various horsepower classes to meet increasingly stringent NO_X and VOC emission standards over the phase-in period of the regulations. The emission inventories for the CD-C Project Alternatives were evaluated for compliance with NSPS OOOO and were determined to comply with all applicable tenets of the regulation.

2.1.1.3 Non-Road Engine Tier Standards

The EPA sets emissions standards for nonroad diesel engines for hydrocarbons, NO_X, CO and PM. The emissions standards are implemented in tiers by year, with different standards and start years for various engine power ratings. The new standards do not apply to existing nonroad equipment. Only equipment built after the start date for an engine category (1999-

2006, depending on the category) is affected by the rule. Over the life of the CD-C Project, the fleet of nonroad equipment will turn over and higher-emitting engines will be replaced with lower-emitting engines. This fleet turnover is accounted for in the CD-C Project emissions inventory.

The EPA NONROAD2008a model (EPA, 2005c; http://www.epa.gov/otaq/nonrdmdl.htm#model) was run with year-specific diesel fuel inputs. The model outputs were used to develop emissions per unit population for all relevant source categories for each year over the LOP. These emissions per unit population reflect the predicted fleet mix of engines – for various tier standards from baseline uncontrolled engines through Tier IV engines – and are used as a representation of fleet turnover for each category of engines (such as drill rig engines). The ratios of the per-unit emissions in a future year to those in the baseline year for each were taken to be the control factors accounting for Federal non-road tier standards.

2.1.1.4 Greenhouse Gases

Greenhouse gases (GHGs) present in the earth's atmosphere trap outgoing longwave radiation and warm the earth's atmosphere. Increased concentrations of GHGs in the atmosphere result in more heat being absorbed and cause higher global temperatures. Some GHGs, such as water vapor, occur naturally in the atmosphere, and some GHGs (e.g., CO_2 and CH_4) occur naturally and are also emitted by human activities. The global atmospheric concentration of CO_2 has increased by about 36% over the last 130 years[1], and far exceeds pre-industrial values determined from ice cores spanning many thousands of years. (Walsh et al., 2014)

The 2014 U.S. National Climate Assessment states that warming of the climate system is unequivocal and most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations[1]. The impacts of climate change are expected to vary by region, and there is significant uncertainty regarding the effects of climate change on any particular region. Although the National Climate Assessment identified specific risks for North America (e.g. warming and decrease in snowpack in western mountains), it is unknown how climate change will affect the CD-C Project area or its surrounding environment.

The U.S. Supreme Court ruled in 2007 that EPA has the authority to regulate greenhouse gases such as methane and CO_2 as air pollutants under the Clean Air Act. However, there are currently no ambient air quality standards for GHGs, nor are there currently any emissions limits on GHGs that would apply to sources developed under the CD-C Proposed Action, although a GHG permit may be required for sources that are permitted under the PSD program. Both the exploration/construction and production phases of the CD-C Proposed Action will cause emissions of GHGs. Methane comprises much of the chemical composition of natural gas, and nitrous oxide, CO_2 and methane are emitted by engines used for drill rigs, compressor engines, etc. As part of the development of the CD-C Project emission inventory, an inventory of CO_2, methane and nitrous oxide was prepared for all emissions source categories. GHGs were not modeled in either the near-field or far-field impact analyses, but the GHG inventory is

[1] http://nca2014.globalchange.gov/report

presented here for informational purposes and is compared to the Wyoming and U.S. GHG emission inventories in order to provide context for the CD-C Project GHG emissions.

2.1.2 Modeled Emissions Control Measures

The CD-C Project Proposed Action Alternative and No Action Alternative emission inventories were developed using data provided by the CD-C Operators as the primary source of information. It is important to note that the difference in total emissions between the Proposed Action Alternative and the No Action Alternative is based solely on the different activity levels of development (i.e. well counts) for each scenario. The Proposed Action Alternative includes the development of approximately 8,950 new natural gas wells within the CD-C Project Area. The No Action Alternative restricts development to fee and state minerals only, under the same conditions as the Proposed Action, resulting in an estimated 4,063 new natural wells (45.4% of the well count in the Proposed Action). Hence, emissions on a per-well or per- unit production basis are the same between both scenarios. The inventory accounted for all applicable emissions controls that were in effect at the time of emission inventory development such as New Source Performance Standards and new Tier standards for non-road engines. The most important of these emissions controls are those specifically targeted at Wyoming oil and gas sources. The Wyoming Department of Environmental Quality Air Quality Division (WDEQ-AQD) regulates emissions from oil and gas sources through their Oil and Gas Permitting Guidance (WDEQ-AQD, 2010), and these emissions controls are discussed in Section 2.1.1.1.

Table 2-1 shows the emissions control measures for each emissions source category in the CD-C Project emissions that were modeled in this analysis.

Table 2-1. Table of modeled CD-C Project emissions control measures.

CD-C Project Emissions Source Category	Type of Control Applied
Well Pad Const Equip (diesel ICE)	Change in fuel sulfur content
Completion Equipment (diesel ICE)	Change in fuel sulfur content
Construction Traffic, Road and Well pad	Change in emissions due to fleet turnover
Construction Traffic, Road and Well pad- Fugitive Dust	Watering
Drilling Equipment (diesel ICE)	Change in fuel sulfur content and emissions reductions due to cleaner engine technology
Drilling Traffic	Change in emissions due to fleet turnover
Drilling Traffic- Fugitive Dust	Watering
Completion Traffic	Change in emissions due to fleet turnover
Completion Traffic- Fugitive Dust	Watering
Completion Venting	96% of Gas to Green Completions and 4% of Gas will be Flared
Completion Flaring	N/A
Well Pad and Access Road Construction- Fugitive Dust	Watering
Construction Wind Erosion- Fugitive Dust	None
Workover Equip (diesel ICE)	Change in fuel sulfur content
Workover Rig Traffic	Change in emissions due to fleet turnover
Workover Rig Traffic- Fugitive Dust	Watering
Heaters	None
Fugitives	None
Pneumatic Devices	No bleed devices
Pneumatic Pump	WYDEQ BACT
Dehydrator Venting	WYDEQ BACT
Tank Loadout (vapor losses)	None
Well Venting	None
Production Traffic	Change in emissions due to fleet turnover
Production Traffic- Fugitive Dust	Watering
Condensate Tank Flashing Losses	WYDEQ BACT
Condensate Tank Working Losses	WYDEQ BACT
Condensate Tank Breathing Losses	WYDEQ BACT
Production Flaring	-
Compressor Station	WYDEQ BACT was assumed to limit NOx and CO emissions for reciprocating engines
Gas Plant	WYDEQ BACT was assumed to limit NOx and CO emissions for reciprocating engines
Evaporation Ponds	None

2.1.3 CD-C Project Emission Inventory

There are two different types of activities (field development and production) associated with the CD-C Project for which emission inventories were compiled. The specific components of field development and production emissions and total field-wide emissions are discussed in the following subsections. Emission calculations for all emission-generating activities were derived from Operator-supplied data whenever possible. The origin of the input data and how these data were used in the emissions estimates are presented in detailed calculations shown in Appendix H, covering emissions development for the Proposed Action, and in Appendix L, covering emissions development for the No Action Alternative.

Methods used to estimate emissions from each source category are explained in Sections 2.1.1 to 2.1.3. Methods used for the CD-C Project Area existing wells and new wells were the same unless noted otherwise. More detailed assumptions, emission factors and calculations by source category are described in Appendix H and Appendix L.

For each source category, emissions for the 2008 baseline year were estimated and then uncontrolled emission estimates were made for each year over the LOP. The uncontrolled future year emissions were then adjusted based on the Proposed Action and control factors developed for each regulation to account for how these regulations may affect all source categories considered in this inventory. Then, applicable controls and growth were accounted for in order to produce final field-wide emissions estimates for each year over the LOP.

2.1.3.1 Construction Emissions

Emission-generating activities during field development include well pad and access road construction, vehicle traffic, and wind erosion. Fugitive PM_{10} and $PM_{2.5}$ emissions will result from 1) construction activities and 2) traffic to and from the construction site. On roads within the Project Area, water will be used for fugitive dust control, with a control efficiency of 50%. Emissions of criteria pollutants will occur from exhaust due to diesel combustion in haul trucks and heavy construction equipment.

Table 2-2 shows the emission sources identified for the well pad construction phase of the Project. Pollutant emissions were initially estimated on a per event basis and then multiplied by the projected number of events per year (referred to below as the scaling surrogate) to obtain field-wide annual emissions from each source.

Table 2-2. Construction source categories and scaling surrogates.

Equipment Source Category	Event	Scaling Surrogate
Well Pad Construction	Well pads	Total New Pads Per Year
Well Pad and Access Road Construction Traffic	Well pads	Total New Pads Per Year
Construction Fugitive Dust	Well pads	Total New Pads Per Year
Construction Wind Erosion	Well pads	Total New Pads Per Year

Well Pad Construction Equipment Exhaust Emissions

The Operators provided a description of all equipment types and engines used for well construction. Engine data for each engine type included horsepower rating, hours of operation, fuel type, engine technology, and load factors. The EPA NONROAD2008a model (EPA, 2005c) was used to compile emission factors for each equipment type. NONROAD emission factors from EPA Federal Diesel Engine Standards were applied (EPA, 2011). Emission factors not directly available from the NONROAD2008a model were calculated on a case-by-case basis as shown in the assumptions for this source category included in Appendix H and Appendix L.

Emissions were estimated on a per event (new well pads) basis for a given engine type k according to Equation 1:

Equation (1): $$E_{engine\ k,i} = \frac{EF_i \times HP \times LFk \times t_{event} \times n}{907{,}185}$$

where:

- $E_{engine\ k,i}$ are emissions of pollutant *i* from an engine type k [tons/pad]
- EF_i is the emissions factor of pollutant *i* [g/hp-hr]
- *HP* is the horsepower of the engine k [hp]
- LF_k is the load factor of the engine k
- t_{event} is the number of hours the engine is used for per well pad construction [hr/pad]
- *907,185* is the mass unit conversion [g/ton]
- *n* is the number of type k engines

Annual emissions for well pad construction equipment by pollutant were estimated based on the sum of per event emissions from all engine types (k) ($E_{engineTOTAL,i} = \sum_k E_{engine\ k,i}$) according to Equation 2:

Equation (2): $$E_{well\ pad\ equip,\ \ i} = E_{engineTOTAL,i} \times S_{well\ pad}$$

where:

$E_{well\ pad\ equip}$ is annual emissions of pollutant i from well pad construction equipment [tons/yr]
$E_{engineTOTAL,i}$ is the sum of all engine emissions per event [tons/pad]
$S_{well\ pad}$ is the scaling surrogate for well pad construction [pads/yr]

Well Pad and Access Road Construction Traffic

Emissions result from light-duty and heavy-duty vehicle traffic on unpaved roads during well pad construction. Emission factors were developed using the MOVES2010a model (EPA, 2010c) for Sweetwater and Carbon Counties in the State of Wyoming. The emission factors were prepared for two vehicle classes: Combination Short-Haul Trucks (Heavy Duty) and Light Commercial Trucks (Light Duty). The emission factors represent annual averages from calendar years 2008 to 2037, which encompass the LOP. In the MOVES run, running and idling emissions from evaporative, exhaust, brake wear, and tire wear processes were modeled; running emission factors were calculated using mean vehicle speeds supplied by the Operators.

Fugitive dust emissions from vehicle travel on unpaved roads were estimated based on the AP-42 technical guidance (EPA, 2006a). Road dust emission factors for PM_{10} and $PM_{2.5}$ for vehicles traveling on publicly accessible unpaved roads were individually estimated using Equation 3.

Equation (3): $$EF = \frac{k(\frac{s}{12})^a(\frac{S}{30})^d}{(\frac{M}{0.5})^c} - C$$

where:

EF is the size-specific emission factor [lb/mile]
k is the particle size multiplier or "k-factor" [lb/mile]
s is the surface material silt content (%)
M is the surface material moisture content (%)
S is the mean vehicle speed [mph]
C is the emission factor for vehicle fleet exhaust, brake wear, and tire wear [lb/mile]
a, b, c and *d* are empirical constants

Variables *k, C, a, b, c* and *d* may differ depending on whether fugitive dust calculations are for PM_{10} or $PM_{2.5}$. Calculations details are shown in Appendices H and M.

To account for natural suppression of road dust emissions due to precipitation, Equation 4 was applied:

Equation (4): $$EF_{suppressed} = EF \times \frac{365-P}{365} \times \frac{100-CE}{100}$$

where:

$EF_{suppressed}$ is the annual average road dust emission factor including the effect of natural mitigation via precipitation [lb/mile]
EF is the uncontrolled road dust emission factor (from Equation 3) [lb/mile]
P is number of precipitation days (>0.01" rainfall) at the site (precipitation days at Shoshoni, WY from NCDC climatology)
CE is the control efficiency for watering on unpaved roads (Cowherd et al., 1988)

Annual vehicle miles traveled (VMT) to well site were provided by the Operator for each vehicle type (light duty and heavy duty). Exhaust emissions for each fleet type were calculated using the MOVES2010a emission factors on a grams per mile basis, as shown in Equation 5. Fugitive dust road emissions were calculated using the emissions factor ($EF_{suppressed}$) from Equation 4.

Equation (5): $$E_{traffic,\ i} = \frac{EF_i \times VMT}{2000}$$

where:

$E_{traffic,\ i}$ is traffic emissions for pollutant i per well pad [ton/pad]
EF_i is the average emission factor of pollutant i [lb/mile]. For exhaust emissions, EF_i = MOVES emission factors. For fugitive dust emissions, $EF_i = EF_{suppressed}$.
VMT are the annual vehicle miles traveled by fleet to a well pad site [miles/pad]
2000 is the mass conversion [lb/ton]

Annual emissions for well pad and access road construction traffic by pollutant were propagated with the appropriate scaling surrogate according to Equation 6:

Equation (6): $$E_{well\ pad\ traffic,\ i} = E_{traffic,\ i} \times S_{well\ pad}$$

where:

$E_{well\ pad\ traffic,\ i}$ are annual emissions of pollutant i from well pad and access road construction traffic [ton/yr]
$E_{traffic,\ i}$ are the emissions of pollutant i per new well pad [ton/pad]
$S_{well\ pad}$ is the scaling surrogate for well pad and access road construction traffic [pad/yr]

Construction Fugitive Dust

Fugitive dust emissions from surface disturbance due to well pad construction equipment were estimated based on the AP-42 guidance for estimation of emissions from Western surface coal mining (EPA, 1998b), as no estimation methodology specific to oil and gas well site construction was available. Construction fugitive dust emission factors were estimated according to Equations 7 and 8:

Equation (7): $$EF_{PM10} = \left(\frac{1.0 \times s^{1.5}}{M^{1.4}}\right) \times (1 - C) * r$$

where:

EF_{PM10} is the emissions factor from construction dust for PM_{10} [lb/hr]
s is the material silt content (%)
M is the material moisture content (%)
C is the control efficiency
r is the PM_{10} scaling factor, assumed to be 0.75 lbs/hr per AP-42 Guidance

Equation (8): $$EF_{PM2.5} = \left(\frac{5.7 \times s^{1.2}}{M^{1.3}} \right) \times (1 - C) * r$$

where:

$EF_{PM2.5}$ is the emissions factor from construction dust for $PM_{2.5}$ [lb/hr]
r is the $PM_{2.5}$ scaling factor, assumed to be 0.105 lbs/hr per AP-42 Guidance

Default AP-42 guidance values (EPA, 1998b, Table 11-9.3) for material moisture content and material silt content were used. The Operators indicated that they plan to use watering to control dust emissions, and the control efficiency for watering was assumed to be 50%.

The Operators specified the number of hours that construction equipment is to be used during well pad construction. Fugitive dust emissions for individual construction equipment-types were estimated according to Equation 9:

Equation (9): $$E_{dust,equipment,i} = EF_i * t_{event} * n / 2000$$

where:
$E_{dust,\ equipment,\ i}$ are dust emissions of pollutant *i* per equipment type per well pad [tons/pad]
EF_i is the emissions factor from of pollutant *i* [lb/hr]
n is the total units for the type of construction equipment being analyzed
t_{event} is the equipment time of operation per well pad [hours/pad]
2000 is a mass unit conversion [lb/ton]

Total construction fugitive dust emissions per well pad were estimated by summing over all emissions from individual pieces of construction equipment used during well pad construction ($E_{dustTOTAL,i} = \sum E_{dust,equipment,i}$). The total annual dust emissions were scaled by multiplying emissions by the well pad scaling surrogate as identified in Table 2-2 according to Equation 10:

Equation (10): $$E_{const.dust,\ i} = E_{dust,TOTAL,\ i} \times S_{well\ pad}$$

where:
$E_{const.\ dust,i}$ are the annual emissions of pollutant *i* from fugitive dust construction [ton/yr]
$E_{dust,TOTAL,\ i}$ is the sum of dust emissions of pollutant i from all pieces of construction equipment in well pad [ton/pad]
$S_{well\ pad}$ is the scaling surrogate for construction fugitive dust [pad/yr]

Construction Wind Erosion

Wind erosion dust emissions associated with well pad construction operations were estimated based on AP-42 guidance for estimation of emissions from industrial wind erosion (EPA, 2006c). Wind erosion emissions were estimated based on Equations 11, 12, and 13:

Equation (11): $$E_{dust,i} = \frac{P \times A \times r}{907{,}185}$$

where:

$E_{dust,\,i}$ are dust emissions for pollutant i from construction wind erosion [ton/pad]
A is the well pad construction (disturbed) 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]
P is the erosion potential [g/m^2] as calculated by Equation (12)

Equation (12): $$P = 58 \times (u^* - u_t)^2 + 25(u^* - u_t)$$

where:

u^* is the friction velocity (m/s)
u_t is the threshold friction velocity (m/s)
58 and *25* are empirical constants in units of [$g\ s^2/m^4$] and [$g\ s/m^3$] respectively.

Equation (13): $$P = 0 \quad for \quad (u^* \leq u_t)$$

Friction velocity estimates were made by multiplying the average annual fastest wind speed from Wamsutter Wind Speed Data for 2007, 2008 and 2009 by 0.053 per AP-42 guidance (EPA, 2006c). Particle size multipliers of 0.5 and 0.075 were assumed for PM_{10} and $PM_{2.5}$ respectively, per AP-42 guidance. Because 2007 had the highest wind speeds, emissions estimates were made using 2007 data.

The annual construction dust wind erosion emissions were scaled by multiplying per well pad emissions by the well pad scaling surrogate identified in Table 2-2 according to Equation 14:

Equation (14): $$E_{dust\ erosion\ total,\ i} = E_{dust,\ i} \times S_{well\ pad}$$

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]

2.1.3.2 Drilling Emissions

After the well pad is prepared, drilling can begin. Emissions include exhaust and fugitive dust emissions from vehicle travel to and from the drilling site on unpaved roads, and exhaust emissions from drilling engines. Emissions from well completion and testing will include vehicle exhaust and fugitive dust emissions from traffic, and exhaust emissions from completion equipment engines. There will also be emissions from completion venting and completion flaring. Table 2-3 shows the emission sources identified for the drilling phase of the Project. Pollutant emissions were initially estimated on a per event basis; an event is defined to be a single spud. The scaling surrogate used to obtain Project-wide annual emissions from each source was total spuds per year for the entire Project Area.

Table 2-3. Drilling source categories and scaling surrogates.

Equipment Source Category	Event	Scaling Surrogate
Drilling and Completion Equipment	Spuds	Total Spuds Per Year
Drilling and Well Completion Traffic	Spuds	Total Spuds Per Year
Initial Completion Venting	Spuds	Total Spuds Per Year
Initial Completion Flaring	Spuds	Total Spuds Per Year

Drilling and Completion Equipment

Emissions associated with off-road engines used during drilling and completion activities were calculated separately but the methodology followed was consistent; thus, inputs to equations 15 to 16 were adjusted for each source category as applicable. The Operators provided detailed data for each drilling and completion engine including horsepower rating, hours of operation, fuel type, engine technology and load factors.

The EPA NONROAD2008a model (EPA, 2005c) was used to compile emission factors for each equipment type. For completion equipment, EPA NONROAD fully deteriorated Tier 2 Standard emission factors were used for NO_X, VOC, CO, PM_{10} and $PM_{2.5}$ (EPA, 2004). For drilling equipment, EPA NONROAD model fully deteriorated Tier 2 Standard emission factors were applied for NO_X, VOC, CO, PM_{10} and $PM_{2.5}$. Emission factors not directly available from the NONROAD2008 model were calculated on a case-by-case basis as shown in detail in Appendix H and Appendix L.

Emissions on a per spud basis for each engine type were estimated according to Equation 15:

Equation (15): $$E_{engine\ k,i} = \frac{EF_i \times HP \times LF \times t_{event} \times n}{907{,}185}$$

where:

- E_{engine} are emissions of pollutant *i* from an engine type k [tons/spud]
- 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/spud]
- *907,185* is the mass unit conversion [g/ton]
- *n* is the number of type-k engines

Annual drilling and completion emissions by pollutant were estimated from the sum of engine emissions of various types (k) ($E_{engineTOTAL,i} = \sum_k E_{engine\ k,i}$) and scaled with the appropriate scaling surrogate according to Equation 16:

Equation (16): $E_{category,\ i} = E_{engineTOTAL,i} \times S_{spud}$

where:

$E_{category,i}$ are annual emissions of pollutant i from completion/drilling equipment [tons/yr]
$E_{engineTOTAL,i}$ is sum of all engine emissions per event [tons/spud]
S_{spud} is the scaling surrogate for completion/drilling operations [spuds/yr]

Drilling and Well Completion Traffic

This section refers to traffic emissions from light-duty and heavy-duty vehicle traffic during drilling and completion operations. The method to estimate traffic emissions from these source categories was similar to that of source category *Well Pad and Access Road Construction Traffic.*

Average exhaust emission factors from MOVES2010a model for Sweetwater and Carbon Counties in the State of Wyoming from calendar years 2008 to 2037 were used. Fugitive dust emissions from vehicle travel on unpaved roads were estimated based on the AP-42 guidance (EPA, 2006a) using Equations 3 and 4.

Annual vehicle miles traveled (VMT) to the drilling site were provided by the Operators for each vehicle type (light duty and heavy duty), thus exhaust emissions for each fleet type were calculated using the MOVES2010a emission factors on a grams per mile basis, as shown in Equation 17. Fugitive dust road emissions were calculated using the suppressed emissions factor ($EF_{suppressed}$) from Equation 4.

Equation (17): $E_{traffic,\ i} = \frac{EF_i \times VMT}{2000}$

where:

$E_{traffic,\ i}$ are traffic emissions for pollutant i per spud [tons/spud]
EF_i is the average emission factor of pollutant i [lbs/mile]. For exhaust emissions, EF_i = MOVES emission factors. For fugitive dust emissions, EF_i= $EF_{suppressed}$ as in Equation 4.
VMT are the annual vehicle miles traveled by fleet to drilling site [miles]
2000 is the mass unit conversion [lbs/ton]

Field-wide annual emissions for drilling/completion traffic by pollutant were determined with the spud scaling surrogate according to Equation 18:

Equation (18): $E_{category\ traffic,\ i} = E_{traffic,\ i} \times S_{spud}$

where:

$E_{category\ traffic,\ i}$ are annual emissions of pollutant i from drilling/completion traffic [tons/yr]
$E_{traffic,\ i}$ are the emissions of pollutant i per spud [tons/spud]
S_{spud} is the scaling surrogate for drilling/completion traffic [spuds/yr]

Initial Completion Venting

Initial completion venting emissions during 2008 for existing wells were provided by the Operators. The Operators indicated that completions for all new wells will be entirely controlled by flaring. Therefore, there will be no initial completion venting emissions for new wells.

Initial Completion Flaring

Emissions from initial completion flaring were estimated based on AP-42 Guidance (EPA, 1991b). The Operators provided expected gas flaring rates and the heat content and composition of the gas. Flaring rates (scf/day) were combined with the heat content of the flared gas (Btu/scf) and the appropriate AP-42 emission factor (lb/MMBtu) to determine the NO_X and CO emissions. The natural gas flaring speciation profile (0051) from EPA's SPECIATE database was used to determine the weight fractions of CH_4/THC (total hydrocarbons) and VOC/THC in the flared gas, emissions factors for VOC and CH_4 were calculated with the AP-42 emission factor for THC multiplied by the appropriate fraction. The SPECIATE profile was also used to determine the VOC speciation (e.g., the formaldehyde content of the emissions). A discussion of the uncertainty introduced into the emissions estimates through the use of SPECIATE profile 0051 is provided in Section 2.1.3.4. The N_2O emission factor was obtained from API Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry (API, 2009).

NO_X, CO, CH_4 and N_2O emissions were estimated according to AP-42 methodology for industrial flares, following Equation 19:

Equation (19): $$E_{flare,\ i} = \frac{EF_i \times Q \times HV}{2000}$$

where:

E_{flare} is the flaring emissions of pollutant i per spud [lbs/spud]
EF_i is the emissions factor for pollutant i [lbs/MMBtu]
Q is the volume of gas flared supplied by Operator [MMscf/spud]
HV is the heating value of the gas as provided by the Operators [Btu/scf]
2000 is the mass unit conversion [lbs/ton]

Since no flaring emission factor for CO_2 was available, CO_2 completion flaring emissions were calculated from CO_2 emissions potential of the flared gas, according to Equations 20 - 22:

Equation (20):

$$Eflare_{CO2} = (Total\ CO_2\ Emissions\ Potential\ of\ Entire\ Gas - CO_2\ Emissions\ Potential\ of\ THC - CO_2\ Emissions\ Potential\ of\ CO) \times Production\ Control$$

where:

$Eflare_{CO2}$, *Total CO_2 Emissions Potential of Entire Gas, Total CO_2 Emissions Potential of THC,* and *Total CO_2 Emissions Potential of CO* are in units of [ton/spud]
$Eflare_{CO2}$ is carbon dioxide emissions from completion flaring
Production Control is the fraction of production gas that is flared over gas that is vented.

Equation (21):

$$CO_2 \text{ Emissions Potentials from THC} \left(\frac{\text{tons}}{\text{event}}\right) = \sum \frac{\left(\frac{\text{lb emitted of compound i}}{\text{event}}\right)_i \times \frac{\text{No. of Moles of C in compound i}}{\text{No. of Moles of C in CO2}} \times \text{MW of } CO_2 \text{ (lb/lb-mol)}}{\text{MW (lb/lb-mol)} \times 2000}$$

Equation (22):

$$CO_2 \text{ emissions potentials from CO} \left(\frac{\text{tons}}{\text{event}}\right) = \frac{\text{CO emissions from flaring} \left(\frac{\text{lb}}{\text{event}}\right) \times \frac{\text{No.of Moles of C in CO}}{\text{No.of Moles of C in CO2}} \times \text{MW of CO2 (lb/lb-mol)}}{\text{MW of CO} \left(\frac{\text{lb}}{\text{lb-mol}}\right) \times 2000}$$

where:

Compound i refers to each compound identified in flaring gas speciation profile:
(lbs emitted of compound i/event) = Total TOG Emissions [lb/event] from flaring x Weight Fraction of the Compound i. MW is the molecular weight of a compound [lb/lb-mol]
Event = spuds. Emissions are calculated on a per spud basis for this source category. *2000* is the mass unit conversion [lbs/ton].

Field-wide annual initial completion flaring emissions were derived using Equation 23:

Equation (23): $E_{comp.flaring,\ i} = E_{flare,\ i} \times S_{spud}$

where:

$E_{comp.flaring}$ are the annual completion flaring emissions of pollutant i [tons/yr]
E_{flare} is the flaring emissions of pollutant i per activity [tons/spud]
S_{spud} is the scaling surrogate for initial completions [spuds/yr]

2.1.3.3 Production Emissions

Well site production facilities include dehydration units, heaters, pneumatic devices, and condensate storage tanks. Ancillary facilities will include evaporation ponds, an additional compressor station and a new gas processing plant.

Combustion emissions of NO_X, CO, VOCs, and HAPs will result from separator heaters, dehydration heaters, tanks heaters, combustion controls on VOC emissions and compressor engines. In addition, fugitive VOC and HAP emissions will result from process leaks, pneumatics, dehydration overhead vents, and condensate tank flashing losses. Table 2-4 includes the emission sources identified for the production phase of the Project. Pollutant emissions are estimated on a per event basis (event type varies by source category) and then scaled with the projected number of events per year to obtain Project-wide annual emissions from each source.

Table 2-4. Production source categories and scaling surrogates.

Equipment Source Category	Event	Scaling Surrogate
Workover Equipment	Wells	Active Well Counts
Workover Traffic	Wells	Active Well Counts
Production Traffic	Wells	Active Well Counts
Heaters	Wells	Active Well Counts
Fugitives	Wells	Active Well Counts
Chemical Injection Pneumatic Pumps	Wells	Active Well Counts
Tank Loadout	Barrels	Annual Condensate Production
Well Venting	Wells	Active Well Count
Condensate Tank Flashing Losses	Barrels	Annual Condensate Production
Condensate Tank Working Losses	Totals	Total Turnovers Per Year
Condensate Tank Breathing Losses	Wells	Active Well Counts
Dehydrator Venting	Wells	Active Well Counts
Compressor Stations	Total Units	Totals For Year With Compressor Station
Condensate Tank Flashing Flaring	Barrels	Annual Condensate Production
Condensate Tank Working Flaring	Turnovers/Well	Total Turnovers Per Year
Condensate Tank Breathing Flaring	Wells	Active Well Counts
Dehydrator Flaring	Wells	Active Well Counts
Pneumatic Pump Flaring	Wells	Active Well Counts
Gas Plants	Total Units	Totals for CY 2012+
Evaporation Ponds	Wells	Active Well Counts

Workover Equipment

This category refers to emissions from off-road engines used during well workover operations. The Operators provided a complete list of all engines used for this activity as well as engine-specific data such as horsepower rating, hours of operation, fuel type, engine technology and load factors. The EPA NONROAD2008a model was used to compile emission factors for each equipment type. EPA NONROAD model fully deteriorated Tier 2 Standard emission factors for NO_X, VOC, CO and PM_{10} were applied. Emission factors not directly available from the NONROAD2008 model were calculated on a case-by-case basis as shown in detail for this source category in Appendices H and M.

Emissions on a per well basis for each engine type were estimated according to Equation 24:

Equation (24): $$E_{engine\ k,i} = \frac{EF_i \times HP \times LF \times t_{event} \times n}{907{,}185}$$

where:

- E_{engine} are emissions of pollutant i from an engine type k [ton/well]
- 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 per event [hr/well]
- *907,185* is the mass unit conversion [g/ton]
- n is the number of type-k engines

Annual emissions from well pad construction equipment by pollutant were estimated from the sum of engine emissions of various types (k) ($E_{engineTOTAL,i} = \sum E_{engine\ k,i}$) according to Equation 25:

Equation (25): $E_{workover\ equip,\ i} = E_{engineTOTAL,i} \times S_{well\ count}$

where:

$E_{workover\ equip}$ are annual emissions of pollutant i from workover equipment [ton/yr]
$E_{engineTOTAL,i}$ is sum of all engine emissions per well [ton/well]
$S_{well\ count}$ is the scaling surrogate for workover equipment emissions [wells/yr]

Workover Traffic and Production Traffic

This section refers to on-road emissions from light-duty and heavy-duty vehicle traffic during workover and production operations. The methodology for estimating traffic emissions from these source categories is similar to that of other traffic categories, such as *Well Pad and Access Road Construction Traffic*. However, emissions for *Workover Traffic* and *Production Traffic* were calculated separately since activity varies by source category; thus, inputs to equations 26 to 27 were adjusted as applicable.

Average exhaust emission factors from MOVES2010a model (EPA, 2010c) for Sweetwater and Carbon Counties from calendar years 2008 to 2037 were used. Fugitive dust emissions from vehicle travel on unpaved roads were estimated based on the AP-42 guidance (EPA, 2006a) using Equations 3 and 4.

Annual vehicle miles traveled (VMT) to well site were provided by Operator for each vehicle type (light duty and heavy duty), thus exhaust emissions for each fleet type were calculated using the MOVES2010a emission factors on a grams per mile basis, as shown in Equation 26. Fugitive dust road emissions were calculated using the suppressed emissions factor ($EF_{suppressed}$) from Equation 4.

Equation (26): $E_{traffic,\ i} = \frac{EF_i \times VMT}{2000}$

Where:

$E_{traffic,\ i}$ are traffic emissions for pollutant i per well [ton/well]
EF_i is the average emission factor of pollutant i [lb/mile]. For exhaust emissions, EF_i = MOVES emission factors. For fugitive dust emissions, EF_i= $EF_{suppressed}$ as in Equation 4.
VMT are the annual vehicle miles traveled by fleet to well site [miles/well]
2000 is the mass unit conversion [lb/ton]

Annual emissions for workover/production traffic by pollutant were calculated with the appropriate scaling surrogate (active well counts) according to Equation 27:

Equation (27): $E_{category\ traffic,\ i} = E_{traffic,\ i} \times S_{well\ count}$

where:

$E_{category\ traffic,\ i}$ are annual emissions of pollutant i from workover/production traffic [tons/yr]
$E_{traffic,\ i}$ are the emissions of pollutant i per spud [tons/well]
$S_{well\ count}$ is the scaling surrogate for drilling/completion traffic [wells/yr]

Heaters

This source category refers emissions from heaters for tanks, separators and dehydrators located at well sites. Heater activity data was provided by the Operators including local gas heating value (Btu/scf), heater size (btu/hr), number of units per well, usage time and cycle fraction. The Operators indicated that heaters would be natural-gas fired; hence AP-42 emission factors for an uncontrolled small boiler for natural gas were used for all inventoried pollutants (EPA, 1998a). Note that heaters were not assumed to be operated continuously; data on the annual hours of operation and the cycling fraction of the heaters were supplied by the Operators.

The basic methodology for estimating emissions for a single heater of type k (k= dehydrator heater, separator heater or tank heater) is shown in Equation 28:

Equation (28): $$E_{heater\ k,\ i} = \frac{EF_i \times Q_{heater} \times t_{annual} \times hc}{HV_{local} \times 1.10^6 \times 2000}$$

where:
$E_{heater\ k}$ is the emissions from pollutant i from a given heater [tons/unit]
EF_i is the emission factor for pollutant i for natural gas fired small boilers [lbs/MMscf]
Q_{heater} is the heater size [Btu/hr]
HV_{local} is the local natural gas heating value [Btu_{local}/scf]
t_{annual} is the annual hours of operation of each unit [hrs/unit]
hc is a heater cycling fraction of operating hours that the heater is firing
1.10^6 is a volume conversion factor [scf/MMscf] and *2000* is the conversion factor [lb/ton]

Emissions by pollutant for all heaters operated were estimated according to Equation 29:

Equation (29): $$E_{heaterTOTAL,i} = \sum E_{heater\ k,\ i} \times N_{heaters\ k}$$

where:
$E_{heaterTOTAL,\ i}$ is the total per-well emissions from all heaters for pollutant i [ton/well]
$E_{heater\ k,\ i}$ is the emissions from a single heater (of type k) [tons/unit]
$N_{heater,k}$ is the total number of heaters (of type *k*) per well [units/well]

Annual heater emissions were calculated using Equation 30. The scaling surrogate was the active well count:

Equation (30): $$E_{HEATERS,\ i} = E_{heaterTOTAL,\ i} \times S_{well\ count}$$

where:
$E_{HEATERS,\ i}$ are the annual emissions for pollutant i from heaters [tons/yr]
$E_{heaterTOTALi}$ is the total emissions from all heaters operated per well [tons/well]

$S_{well\ count}$ is the number of active wells for a particular year [wells/yr]

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 by the Operators: well stream, gas stream and condensate stream. VOC, CO_2 and CH_4 emissions per stream were estimated using device-specific total organic carbon (TOC) emission factors for oil and gas production (EPA, Protocol for Equipment Leak Emission Estimates, 1995b) and equipment counts provided in the survey responses. The Operators provided total device counts per well by type of equipment and by the type of service to which the equipment applies – gas, light oil, heavy oil, or water/oil mix, as well as the vented gas composition.

Fugitive VOC emissions for an individual device in a given stream (well, gas, condensate) were estimated according to Equation 31:

Equation (31): $$E_{fugitiveVOC,k} = EF_{TOC} \times N \times t_{annual} \times Y$$

where:
$E_{fugitive\ VOC,\ k}$ is the fugitive VOC emissions for a given device k [tons/well]
EF_{TOC} is the emission factor of TOC [ton/hr/device]
N is the total number of devices type-k for a given stream per well [devices/well]
t_{annual} is the total annual hours of operation [hrs]
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 32:

Equation (32): $$E_{fugitiveVOC,stream} = \sum_k E_{fugitiveVOC,\ k}$$

where:
$E_{fugitive\ VOC,stream}$ is the total fugitive VOC emissions in a given stream per well [ton/well]

CO_2 and CH_4 fugitive emissions per stream were estimated according to Equations 33 and 34:

Equation (33): $$E_{fugitiveCH4,stream} = E_{fugitiveVOC,stream} \times \frac{weight\ fraction_{CH4}}{weight\ fraction_{VOC}}$$

Equation (34): $$E_{fugitiveCO2,stream} = E_{fugitiveVOC,stream} \times \frac{weight\ fraction_{CO2}}{weight\ fraction_{VOC}}$$

where:
$E_{fugitive\ CO2,stream}$ is the total fugitive CO_2 emissions in a given stream per well [ton/well]
$E_{fugitive\ CH4,stream}$ is the total fugitive CH_4 emissions in a given stream per well [ton/well]

Weight fractions per pollutant were provided by the Operators. For the gas and well streams, sales gas composition was used. For the condensate stream, fugitive-post flash compositions were used.

Annual fugitive emissions were calculated using Equation 35, and the scaling surrogate was the active well count:

Equation (35): $$E_{fugitive,\ i} = E_{fugitive\ i,stream} \times S_{well\ count}$$

where:

$E_{fugitive,\ i}$ are the annual emissions for pollutant i in a given stream [tons/yr]
$E_{fugitive\ I,\ stream}$ are fugitive emissions of pollutant i in a stream per well [lton/well]
$S_{well\ count}$ is the number of active well counts for a particular year [wells/yr]

Pneumatic Devices

The Operators indicated that no-bleed devices are to be used exclusively; therefore, no emissions were estimated for this category.

Chemical Injection Pneumatic Pumps

To estimate emissions from pneumatic pumps, the Operator provided data indicating either (1) the average gas consumption rate per gallon of chemical injected, or (2) the volume rate of gas consumption per day per pump. The gas consumption rate per gallon of chemical pumped was multiplied by the total volume of chemical pumped to derive the total vented gas rate for gas-actuated pumps in SCF per year. The volume rate of gas consumption per day was multiplied by the number of days the pump is used to arrive at the total vented gas rate in SCF per year.

Annual vented gas rates per well ($V_{vented\ total}$) were calculated from the sum of gas rates from individual pumps. VOC, CO_2 and CH_4 emissions per well were estimated using Equation 36:

Equation (36): $$E_{pump,i} = \frac{V_{vented\ total} \times MW_i \times R \times Y_i}{2000}$$

where:

$E_{pump,\ i}$ is the gas-actuated pump emissions for pollutant i per well [tons/well]
$V_{vented,TOTAL}$ is the total volume of vented gas from all pumps per well [scf/well]
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 [lbs/ton]

To estimate Project-wide annual emissions from gas-actuated pumps the scaling surrogate, active wells, was used according to Equation 37:

Equation (37): $$E_{pneumaticpumps,\ i} = E_{pump,\ i} \times S_{well\ count}$$

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/well]

$S_{well\ count}$ is the number of active wells for a particular year [wells/yr]

Tank Load-Out

This source category corresponds to condensate tank loading emissions, which were estimated based on the loading loss methodology outlined in AP-42 Guidance (EPA, 2008). The loading loss rate was estimated following Equation 38:

Equation (38) $$L = 12.46 \times \left(\frac{S \times V \times M}{T} \right)$$

where:

L is the loading loss rate [lb/1000 gal]
S is the saturation factor taken from AP-42 default values based on operating mode
V is the true vapor pressure of liquid loaded [psia]
M is the molecular weight of the vapor [lb/lb-mole]
T is the temperature of the bulk liquid [^{o}R]
12.46 is an empirical factor in units of [lb-mol. ^{o}R/psia.10^3 gal]

VOC tank loading emissions were then estimated by Equation 39:

Equation (39): $$E_{loading,\ VOC} = L \times Y_{voc} \times \frac{42}{2000}$$

where:

$E_{loading}$ are the VOC tank loading emissions [ton/barrel]
L is the loading loss rate [lb/1000gal]
Y_{VOC} is the molar fraction of VOC in the vapor
42 is a unit conversion [gal/bbl]
2000 is a unit conversion [lbs/ton]

CO_2 and CH_4 emissions were calculated based on Equations 40-41:

Equation (40): $$E_{loading,CH4} = E_{loading,VOC} \times \frac{weight\ fraction_{CH4}}{weight\ fraction_{VOC}}$$

Equation (41): $$E_{loading,CO2} = E_{loading,VOC} \times \frac{weight\ fraction_{CO2}}{weight\ fraction_{VOC}}$$

where:

$E_{loading,CO2}$ is the total loading CO_2 emissions per barrel of condensate [ton/bbl]
$E_{loadingCH4}$ is the total loading CH_4 emissions per barrel of condensate [ton/bbl]
Weight fractions per pollutant of vapor losses were provided by Operator.

Annual emissions per pollutant i from tank loading were scaled by annual condensate production using Equation 42:

Equation (42): $$E_{tank\ loadout,\ i} = E_{loading,\ i} \times\ S_{bbl\ condensate}$$

where:

$E_{tank\ loadout,\ i}$ are the annual emissions for pollutant i from tank load-out [ton/yr]
$E_{loading,\ i}$ are the emissions for pollutant i from loading per barrel [ton/bbl]
$S_{bbl\ condensate}$ is the total annual of barrels condensate produced [bbls/yr]

Well Venting

Well venting includes all emissions from venting categories other than fugitive pumps, pneumatic devices, chemical injection pumps, tank load out, condensate tanks, completion and dehydrator venting. A Venting emission factor for VOC in tons/yr/well was provided by the Operators as well as wet gas weight fractions for CO_2 and CH_4. VOC, CO_2 and CH_4 emissions per well were estimated based on Equation 43:

Equation (43): $$E_{venting,\ i} = EF_{VOC} \times \frac{weight\ fraction\ i}{weight\ fraction\ VOC}$$

where:

$E_{venting,i}$ is the total well venting emissions of pollutant i per well [ton/well-yr]
EF_{voc} is the VOC venting emission factor provided by the Operators [ton/well-yr]
Weight fractions per pollutant of wet gas were provided by the Operators.

To estimate Project-wide annual emissions from other well venting sources, the scaling surrogate, active wells, was used according to Equation 44:

Equation (44): $$E_{well\ venting,\ i} = E_{venting,\ i} \times S_{well\ count}$$

where:

$E_{well\ venting,\ i}$ are the annual emissions for pollutant i from well venting [ton/yr]
$E_{venting,\ i}$ is the total well venting emissions of pollutant i per well [ton/yr-well]
$S_{well\ count}$ is the number of active wells for a particular year [wells]

Production Flaring

Production flaring emissions result from the control of losses from dehydrator venting, pneumatic pumps, and condensate tank working, breathing and flashing via combustion. Emissions estimations are based on AP-42 Guidance (EPA, 1991b) and condensate tank data such as working loss rates (lbs/well), breathing loss rates (lbs/well), flashing loss rates (scf/well) and venting gas heat content. The natural gas flaring speciation profile (0051) from EPA's SPECIATE database was used to determine the weight fractions of CH_4/THC and VOC/THC in the flared gas, emissions factors for VOC and CH_4 were calculated with the AP-42 emission factor for THC multiplied by the appropriate fraction. The SPECIATE profile was also used to determine the VOC speciation (e.g., the formaldehyde content of the emissions). A discussion of the uncertainty introduced into the emissions estimates through the use of SPECIATE profile 0051 is provided in Section 2.1.3.4. The N_2O emission factor was obtained from the API Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural gas Industry (API, 2009). The activity or event basis differs among production flaring sources as shown in Table 2-5:

Table 2-5. Activity metric and scaling surrogates for production flaring sources.

Flaring Source	Activity (metric)	Scaling surrogate
Condensate Tank Flashing Flaring	Barrels	Annual Condensate Production
Condensate Tank Working Flaring	Turnovers/Well	Total Turnovers Per Year
Condensate Tank Breathing Flaring	Wells	Active Well Counts
Dehydrator Flaring	Wells	Active Well Counts
Pneumatic Pump Flaring	Wells	Active Well Counts

To estimate flaring emissions by pollutant and source, condensate tank losses per activity (scf/activity) were combined with the heat content of the flared gas (MMBtu/scf) and the appropriate emission factor (lb/MMBtu) to determine NO_X, VOC, PM, CO, CH_4 and N_2O emissions according to the AP-42 methodology, following Equation 45:

Equation (45): $$E_{source\ flare,\ i} = \frac{EF_i \times Q \times HV \times PC}{2000}$$

where:

$E_{flashing\ flare}$ is the flaring emissions of pollutant i per activity metric [ton/activity]
EF_i is the emissions factor for pollutant i [lb/MMBtu]
Q is the volume of gas flared per activity [scf/activity]
HV is the heating value of the gas as provided by the Operators [MMBtu/scf]
2000 is a unit conversion [lbs/ton]
PC is the fraction of the production losses that are controlled by flaring

Since no flaring emission factor for CO_2 was available, CO_2 completion flaring emissions were calculated from CO_2 emissions potential of the flared gas, according to Equations 46 - 47:

Equation (46):

$$E\ source\ flare_{CO2} = (Total\ CO_2\ Emissions\ Potential\ of\ Entire\ Gas - CO_2\ Emissions\ Potential\ of\ THC - CO_2\ Emissions\ Potential\ of\ CO) \times Production\ Control$$

where:

$E\ source\ flare_{CO2}$, *Total CO_2 Emissions Potential of Entire Gas, Total CO_2 Emissions Potential of THC* and *Total CO_2 Emissions Potential of CO* are in units of [tons/activity]
$E\ source\ flare_{CO2}$ is carbon dioxide emissions from a specific production flaring source.
Production Control is the fraction of production gas that is flared over gas that is vented.

Equation (47):

$$CO_2\text{ Emissions Potentials from THC}\left(\frac{\text{tons}}{\text{activity}}\right) = \sum \frac{\left(\frac{\text{lb emitted of compound i}}{\text{activity}}\right)_i \times \frac{\text{No. of Moles of C in compound i}}{\text{No. of Moles of C in CO2}} \times \text{MW of } CO_2 \text{ (lb/lb-mol)}}{\text{MW of compound (lb/lb-mol)} \times 2000}$$

Equation (48):

$$CO_2\text{ emissions potentials from CO}\left(\frac{\text{tons}}{\text{activity}}\right) = \frac{\text{CO emissions from flaring}\left(\frac{\text{lb}}{\text{activity}}\right) \times \frac{\text{No.of Moles of C in CO}}{\text{No.of Moles of C in CO2}} \times \text{MW of CO2 (lb/lb-mol)}}{\text{MW of CO}\left(\frac{\text{lb}}{\text{lb-mol}}\right) \times 2000}$$

where:
Compound i refers to each compound identified in flaring gas speciation profile: (lb emissions emitted/activity) = Total TOG Emissions (lb/activity) from flaring x Weight Fraction of the Compound.

Production flaring emissions by source were scaled according to Equation 49 to calculate annual flaring emissions:

Equation (49): $$E_{prod.flaring,\ source,\ i} = E_{source\ flare,\ i} \times S_{activity}$$

where:

$E_{prod,flaring,\ source,i}$ are the annual production flaring emissions by source of pollutant i [ton/yr]
$E_{source\ flare}$ is the flaring emissions of pollutant i per activity [ton/activity]
$S_{activity}$ is the scaling surrogate for the flaring source category according to Table 2-5 [activity/yr]

Condensate Tank Flashing/Working/Breathing

Emissions from this category correspond to condensate tank flashing/working/breathing losses that are vented. Venting emission factors for VOC and CH_4 in ton/activity were provided by the Operators as well as vented gas composition data. VOC, CO_2 and CH_4 emissions per activity metric were estimated according to Table 2-5 for each source (flashing/working/breathing) based on Equation 50:

Equation (50): $$E_{venting/source,\ i} = EF_{source,i} \times PC$$

where:

$E_{venting/source,i}$ is the venting emissions of pollutant i per activity [ton/activity]
$EF_{source,\ i}$ is the venting emission factor provided by the Operators [tons/activity]
PC is the fraction of the losses that are controlled by flaring

Given that no emission factor was available, CO_2 emissions for condensate losses by source were calculated from Equation 51:

Equation (51): $$E_{venting/source,\ CO2} = EF_{venting/source,VOC} \times \frac{weight\ fraction_{CO2}}{weight\ fraction_{VOC}}$$

where:

$E_{venting/source,CO2}$ is the CO_2 venting emissions of pollutant i [tons/activity]
$EF_{venting/source,\ VOC}$ is the VOC venting emission factor provided by Operator [tons/activity]
Weight fractions per pollutant of flash gas and post-flash gas were provided by the Operators.

To estimate project-wide annual emissions from condensate tank venting sources, the appropriate scaling surrogate from Table 2-5 was used according to Equation 52:

Equation (52): $$E_{condensate\ tank/source,\ i} = E_{venting/source,\ i} \times S_{activity}$$

where:

$E_{condensate\ tank/source,\ i}$ are the annual venting emissions of pollutant i per condensate tank source [tons/yr]

$E_{venting/source,\ i}$ is the venting emissions of pollutant i per activity [tons/activity]

$S_{activity}$ is the scaling surrogate for the condensate tank source category according to Table 2-5 [activity/yr]

Dehydrator Venting

This source category refers to emissions from dehydrator operation. Then Operators provided output data from model runs of GRI-GLYCalc Version 4.0 (Gas Research Institute, 2000) that were used to obtain emission from uncontrolled generators; model data enabled the derivation of regression equations to estimate individual pollutant emissions in tons/year-well, including VOC and CH_4 emissions as shown in Equations 53 and 54:

Equation (53): $E_{dehyd.VOC} = 2.0254 \times \ln(Q_{gas}) + 0.9636$

Equation (54): $E_{dehyd.CH4} = 0.0543 \times \ln(Q_{gas}) + 7.3694$

where:

$E_{dehy.VOC}$ is the uncontrolled dehydrator VOC emissions per well [ton/well-yr]

$E_{dehy.CH4}$ is the uncontrolled dehydrator VOC emissions per well [ton/well-yr]

Q_{gas} is the average annual flow of produced gas per well [MMscf/yr/well]

To estimate CO_2 emissions, the CO_2 potential from the regenerator overhead vent stream was estimated [lbs CO_2/MMscf] with composition data provided by the Operators. A relationship for the total waste gas stream was provided by Operators as shown in Equation 55:

Equation (55): $Q_{waste\ gas} = 0.0013 \times\ Q_{gas} + 0.5094$

where:

$Q_{waste\ gas}$ is the flow of waste gas from the dehydrator [MMscf/yr/well]

The uncontrolled CO_2 dehydrator emissions are then calculated per Equation 56:

Equation (56): $E_{dehy.CO2} = \frac{Q_{waste\ gas} \times P_{CO2}}{2000}$

Where:

$E_{dehy.CO2}$ is the uncontrolled dehydrator CO_2 emissions per well [tons/well-yr]

$Q_{waste\ gas}$ is the annual flow of waste gas from dehydrator per well [MMscf/yr/well]

P_{CO2} is the CO_2 potential from the regenerator overhead vent stream [lbs/MMscf]

2000 is the unit conversion [lbs/ton]

To estimate project-wide annual emissions from dehydrator venting, the scaling surrogate, active well counts, was used according to Equation 57:

Equation (57): $E_{dehydrator\ venting,\ i} = E_{dehy,\ i} \times S_{well\ counts}$

where:

$E_{dehydrator\ venting,\ i}$ are the annual venting emissions of pollutant i from dehydrators [tons/yr]

$E_{dehy,\ i}$ is the dehydrator venting emissions of pollutant i per well [tons/well-yr]

$S_{wel\ counts}$ is the number of active well for a particular year [wells]

Compressor Stations

Emissions from compressor engines were directly obtained from the Operators for existing sources. For added compression for new wells developed under the CD-C Proposed Action, emissions were estimated following AP-42 Guidance (EPA, 2000a,b). Data provided by the Operators indicated two types of engines: turbine and reciprocating. As a conservative assumption, rich burn reciprocating engines emission factors from AP-42 were used. It was assumed the engines would be running year-round, and the estimated load factor was 100%.

The basic methodology for estimating emissions from compressor engines is shown in Equation 58:

Equation (58): $E_{engine,i} = \dfrac{EF_i \times HP \times LF \times t_{annual}}{907{,}185}$

where:

$E_{engine,\ i}$ are emissions from a compressor engine for pollutant i [tons/yr]

EF_i is the emissions factor of pollutant *i* [g/hp-hr]

HP is the additional horsepower added by engine type [hp]

LF is the load factor of the engine

t_{annual} is the annual number of hours the engine is used [hrs/yr]

907,185 is the mass unit conversion [g/ton]

Gas composition analyses indicate either no sulfur present in the natural gas or negligible sulfur content, and all engines were assumed to be natural gas-fired; therefore SO_2 emission factors were assumed to be zero.

The annual emissions by pollutant by engine-type were scaled by the scaling surrogate according to Equation 59:

Equation (59): $E_{compressor\ station,\ i} = E_{engine,\ i} \times S_{totals}$

where:

$E_{compressor\ station,\ i}$ are annual emissions of pollutant i from compressor stations [ton/yr]

$E_{engine,\ i}$ is engine emissions per year [ton/yr]

S_{totals} is the scaling surrogate for compressor stations. The compressor station is slated to begin operation in 2012; therefore the scaling surrogate is 0 for 2008-2011 and 1 from 2012 throughout the rest of the LOP.

Gas Plants

This source category refers to emissions related to sources in gas plants; specifically, those from reciprocating engines, turbines, flares, heaters and venting sources. The Operators provided NO_X, VOC and CO emissions for each existing gas plant source in the CD-C Project area. For particulate matter and SO_2 emissions, the ratio of pollutant to NO_X emission factors was multiplied by NO_X emissions to obtain emissions. NO_X emission factors used in previous source categories (*compressor stations, flaring, heaters and venting*) were applied. For CH_4 and CO_2 emissions, flaring AP-42 emission factors (EPA, 1991b) were used, and for remaining sources, the CO_2/VOC and CH_4/VOC weight ratios were multiplied by VOC emissions from each source. As new wells associated with the Proposed Action are built, the Operators anticipate the need for an additional gas plant, which was assumed to be built in 2012. Emissions for the new gas plant were estimated individually by source category:

Compressor emissions (reciprocating and turbine engines): the Operators provided data on total engine capacity, added capacity (hp) and load factor for engines. BACT-level emission factors for compressor engines were assumed and compressor emissions were calculated following the same methodology used for the *Compressor Stations* source category.

Duct burner emissions: the Operators provided data on additional capacity for duct burners in the plant. BACT-level emission factors for duct burners and year-round operation were assumed. Pollutant emissions (tons/yr) from this source were calculated per equation 60:

Equation (60): $$E_{burner,\ i} = \frac{EF_i \times\ t_{annual} \times C}{2000}$$

where

$E_{burner,\ i}$ are annual emissions of pollutant i from new gas plant duct burner [tons/yr]
$EF_{\ i}$ is the BACT level emission factor for pollutant I for duct burners [lbs/MMBtu]
t_{annual} is the total annual hours of operation [hrs/yr]. Assumed 8700 hrs
C is the added capacity of duct burner per new gas plants [MMBtu/hr]
2000 is the unit conversion [lbs/ton]

Heater, Process and Fugitive emissions: The Operators provided detailed by-source emissions for NO_X, VOC and CO for the existing gas plant capacity (740 MMscf/d). To estimate additional emissions from these sources from the additional capacity, existing gas plant emissions were scaled by the ratio of new capacity (760 MMscf/d) to existing capacity, thereby obtaining new gas plant emissions per source.

The new gas plant capacity was assumed to come on-line in 2012. Therefore, annual Project-wide emissions from this source category were calculated using a scaling surrogate that is equal to zero from the 2008 baseline year to 2011, and equal to 1 from 2012 onward to account for emissions from added capacity. Emissions per source for gas plants were obtained from Equation 61:

Equation (61): $$E_{gas\ plant/source,\ i} = E_{source,\ i}\ \times\ S_{totals}$$

where:

$E_{\text{gas plant/source}, i}$ are the annual gas plant emissions of pollutant i per source [tons/yr]
$E_{\text{source}, i}$ is the source emissions of pollutant i [tons/yr]
S_{totals} is the scaling surrogate for gas plants which is equal to 0 from 2008-2011 and 1 from 2012 thereafter.

Evaporation Ponds

The Operators provided data for evaporation facilities at the Wamsutter Operations Center; emissions were estimated using the EPA's WATER9 Model. Average VOC emissions per well (ton/yr-well) were derived from the average emissions from Wamsutter North Pond and South Pond sources and the fraction of evaporation facilities per well. The derivation of VOC emissions rate for evaporation ponds is shown in Equation 62. The fraction of evaporation ponds per well is based on two existing facilities associated with 375 CD-C Project wells.

Equation (62): $$E_{average,\ VOC} = \frac{(E_{SouthPond,VOC} + E_{NorthPond,VOC})}{2} \times \frac{2\ ponds}{375\ wells}$$

where:

$E_{average,\ VOC}$ is the average VOC emissions for evaporations ponds per well [tons/yr-well]
$E_{SouthPond,\ VOC}$ is annual VOC emissions of the Wamsutter South facility [tons/yr-pond]
$E_{NorthPond,\ VOC}$ is annual VOC emissions of the Wamsutter North facility [tons/yr-pond]

Ratios of CO_2 to VOC and CH_4 to VOC weight fractions from produced gas were applied to VOC emissions rate to scale average CO_2 and CH_4 emissions per well.

The Project-wide annual emissions by pollutant (VOC, CO_2 and CH_4) from evaporation ponds were calculated by year with a scaling surrogate according to Equation 63:

Equation (63): $$E_{evap.ponds,\ i} = E_{average,\ i} \times S_{well\ count}$$

where:

$E_{evap.ponds,\ i}$ is the annual emissions of pollutant i from evaporation ponds [tons/yr]
$E_{average,\ i}$ is the average emissions from evaporations ponds per well [tons/yr-well]
S_{totals} is the number of active wells for a particular year (wells)

2.1.3.4 Uncertainty in Flaring Emissions Calculations

An important uncertainty in the preparation of the CD-C Project emission inventory is the speciation of flaring emissions. Of particular concern is the fraction of flaring emissions made up by formaldehyde, a highly reactive volatile organic compound (VOC) which is an ozone precursor.

VOCs have differing tendencies to form ozone due to differences in their reaction rates and chemical mechanisms. The reactivity of a VOC is a measure of its tendency to participate in ozone formation. Carter (1994) developed a ranking system for the ozone-forming potential of VOCs called the maximum incremental reactivity (MIR) scale. The incremental reactivity of a

VOC is defined to be the change in ozone that would result from adding an arbitrarily small amount of the VOC to the emissions of an ozone episode divided by the amount of VOC added. The MIR is essentially the partial derivative of ozone with respect to a given VOC under conditions in which the amount of available NO_X maximizes the reactivity of the VOCs present (Carter, 1994). Highly-reactive VOCs (HRVOCs) such as isoprene (MIR=9.1) and propene (MIR=9.4) have larger values of MIR due to their rapid atmospheric reaction rates and the reactivity of the products of their reactions; these products can, in turn, participate in ozone formation. An example of a less reactive VOC is n-butane, with an MIR of 1.0. Formaldehyde has an MIR of 7.2, indicating a strong tendency to form ozone.

In accordance with the BACT requirements, the CD-C Operators have indicated their intent to control future year emissions through flaring for the following emissions source categories: condensate tank flashing and working/breathing losses, pneumatic pumps, and dehydrator venting. Because flaring is a proposed control strategy in the CD-C Project, it is important to characterize the emissions from flaring as accurately as possible, and in particular, to determine the appropriate fraction of emissions comprised by formaldehyde. The amount of formaldehyde emitted can influence ozone formation due to the CD-C Project emissions and may affect near-field formaldehyde concentrations, the cancer risk assessment and the size of calculated ozone impacts from the Project.

The origin of the EPA natural gas flaring speciation profile in the SPECIATE database that specifies a 20% contribution by weight from formaldehyde is not readily traceable from the published literature. The reference for profile 0051 given in the SPECIATE database is listed as "Information based on composite survey data, engineering evaluation of literature data" and the reference data is January 5, 1989. Flaring experiments carried out by the EPA and its contractors during the 1980s measured THC emissions only and did not use methods aimed at the detection of formaldehyde and so could not have informed a speciation profile for flaring entered into the SPECIATE database in 1989.

Since EPA's work with industrial flares in the 1980s, there have been studies of flares more typical of those used in oil and gas production, but data on the fraction of the flare emissions comprised by formaldehyde are inconclusive. Strosher (2000) detected many hydrocarbon compounds emitted from flares at oil batteries in Alberta, Canada, but the analytic methods used were not designed for the detection of formaldehyde. Kostiuk et al. (2004) used a screening method to detect the presence of formaldehyde in flare emissions in a wind tunnel using a simple pipe flare. They did not detect formaldehyde, nor did they detect any of the other target compounds they sought to measure (other aldehydes, PAHs). Kostiuk et al. point out that the results of their study are not applicable to flaring associated with well testing. If emissions data from Kostiuk et al. were used to construct a speciation profile for flaring for the CD-C Project emission inventory, an upper bound could be placed on formaldehyde emissions from flaring based on the method detection limit or formaldehyde emissions could be set to the lower bound of zero, but no well-defined formaldehyde emission rate is available from this study.

There is no clear scientific consensus on the amount of formaldehyde emissions from oil and gas facility flares at this time. In particular, there is a need for emission inventory studies to be carried out that would quantify emissions from flaring operations associated with oil and gas development in Wyoming. Previous studies have shown that the combustion efficiency and destruction and removal efficiency of flares is sensitive to the composition of flared gas, flare geometry, flow rate, the presence of liquids in the waste gas stream, wind exposure and whether the flare is steam- or air-assisted (Gogolek et al., 2010). It is not clear whether flaring emissions results from the studies that have been carried out to date are applicable to processes such as flaring from dehydration and well completion that will be performed during the CD-C Project.

The AP-42 THC emission factor used in the CD-C Project emission inventory was derived through experiments with industrial flares that are likely very different from the CD-C flares in their configuration, flow rates, and gas composition and the origin of the SPECIATE profile 0051 used to speciate the VOC emissions is unclear. In the absence of scientific consensus regarding the use of an alternative speciation profile, the WDEQ-AQD directed that the EPA default profile for flaring emissions be used with flaring THC emission factors from AP-42 in order to calculate VOC and formaldehyde emissions for the CD-C Project emission inventory. We note that the estimates of formaldehyde emissions from flaring are likely to be conservative (i.e., likely overstate the amount of formaldehyde from flaring). This will lead to conservatism in the estimates of CD-C Project ozone impacts as well as in the near-field estimates of formaldehyde concentrations and cancer risk.

2.1.4 CD-C Proposed Action Alternative and No Action Alternative Emissions Summaries

In this sub-section, we present emissions plots and tables summarizing the CD-C Project emissions over the LOP for the Proposed Action Alternative and the No Action Alternative. Figure 2-2 shows drilling activity and total well count for new CD-C Project wells for both Alternatives and existing wells. These existing wells are not part of the Proposed Action or No Action Alternatives, but are accounted for in the modeling because they are located in the CD-C Project Area. Existing wells were already drilled in the CD-C project area as of 2008 and may have been already producing in 2008. Drilling of new CD-C wells under the Proposed Action and No Action Alternatives begins in the year 2009.

The count of active existing wells decreases over the LOP as wells reach the end of their productive life and are abandoned. The rate of abandonment is 1% of wells per year. The count of new CD-C Project wells increases while drilling is underway from 2009 to 2023. The total well count (existing + new) reaches its peak in 2023 and then declines for the remainder of the LOP as well abandonment occurs.

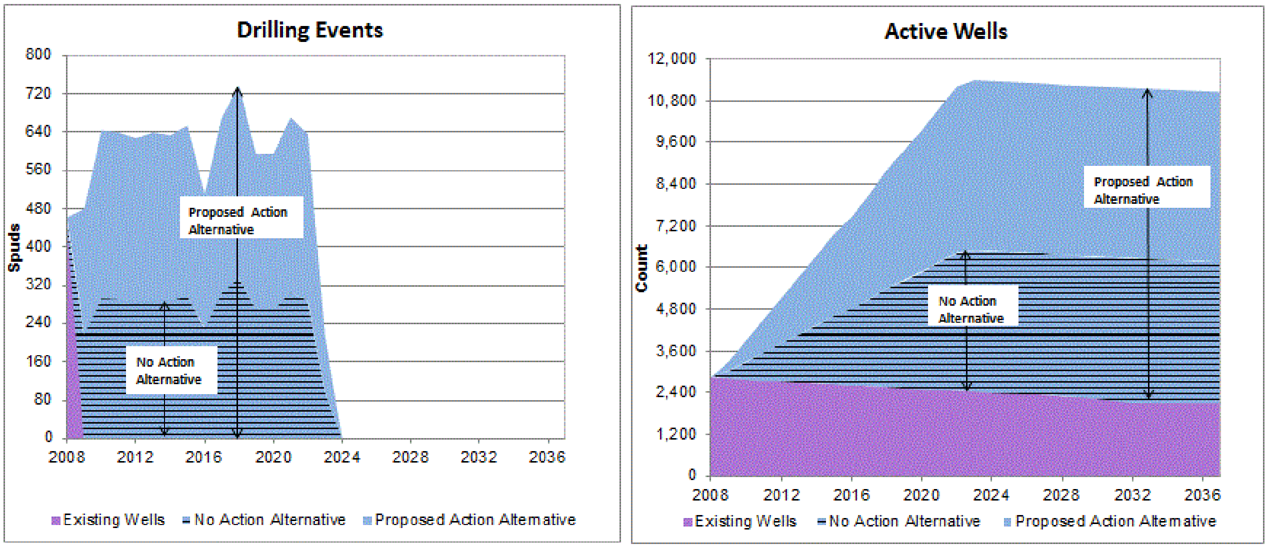

Figure 2-2. Number of CD-C Project Area wells drilled (spuds) in each year over the LOP (left panel) and number of active wells in each year over the LOP (right panel) for Proposed Action Alternative and No Action Alternative.

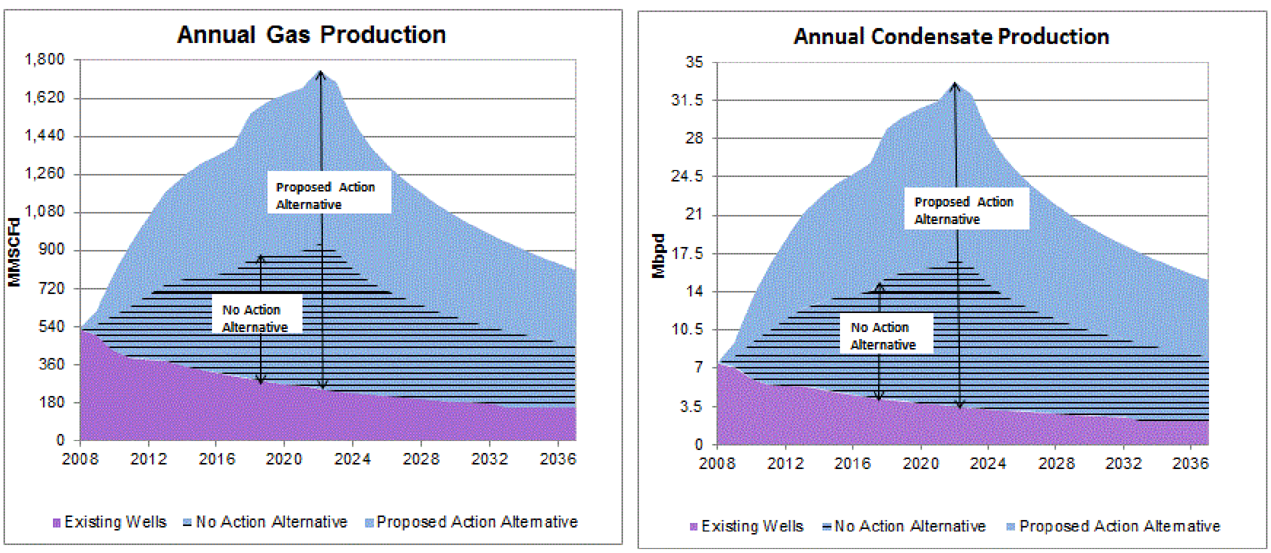

Figure 2-3. Yearly gas (left panel) and condensate (right panel) production of CD-C Project Area wells over the LOP for the Proposed Action Alternative and the No Action Alternative.

The field-wide CD-C Project Area gas and condensate production from existing and new CD-C Proposed Action Alternative and No Action Alternative wells over the LOP are shown in Figure 2-3. From the 2008 baseline year, production of gas and condensate from existing wells decreases. This is because production from a gas well peaks just after drilling is completed and declines as the reservoir is drained. Gas and condensate production from new CD-C Proposed Action Alternative and No Action Alternative wells rises while drilling is underway and new wells are added; once drilling of new wells ceases, field-wide production from all wells declines over the remainder of the LOP.

Field-wide CD-C Project Area emissions are determined by the drilling and production activity. Field-wide total annual NO_X and VOC emissions for new and existing CD-C Project Area sources in the Proposed Action Alternative and the No Action Alternative are shown in Figure 2-4. NO_X emissions show the impact of drilling/completion activities, with peak values occurring during the period when new CD-C Project wells are being drilled. NO_X emissions drop off sharply in 2024 following the end of drilling. NO_X emissions thereafter are controlled by production sources such as compressor engines and well-site heaters. NO_X emissions from new CD-C Proposed Action sources are larger than NO_X emissions from existing sources because of the well construction/drilling activities and because there are many more new wells than existing wells. NO_X emissions from new wells in the No Action Alternative become larger than those from existing sources only during the period of 2018 to 2022 when drilling and construction activities are taking place alongside peak period of active wells. NO_X emissions from existing wells reach their peak during the only year of drilling, 2008. Thereafter, NO_X emissions from existing wells decline steadily over the LOP as production–dependent emissions sources such as compression and well-site heaters and production from existing wells decline.

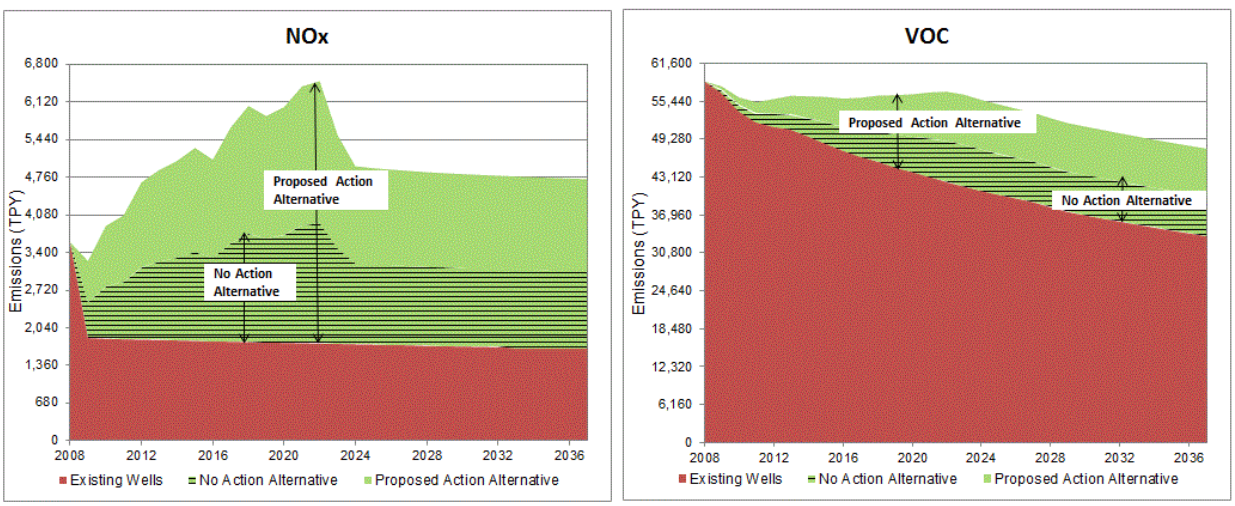

Figure 2-4. Field-wide NO_X and VOC emissions from existing and new CD-C Proposed Action Alternative and No Action Alternative wells over the LOP.

VOC emissions are influenced more strongly by production sources than drilling and completion activities. The largest sources of VOC emissions are dehydrators, condensate tanks, pneumatic pumps and well venting. These sources all depend on gas/condensate production, so that peak field-wide VOC emissions occur during the years of peak production, which are the years with the greatest number of total active wells. The bulk of the VOC emissions come from existing wells, which were developed during the year 2008 or prior. These wells are not subject to the controls on VOC emissions required under the 2010 WDEQ-AQD Permitting Guidance. The new CD-C Proposed Action wells and No Action wells are subject to these 2010 requirements, and have controls that dramatically reduce their VOC emissions. Therefore, the new wells have lower per well VOC emissions than existing wells. The effect of the emissions controls reduces the field-wide VOC emissions from new wells so that they are lower than the field-wide emissions from existing wells, despite the fact that there are more new wells than existing wells. The peak year of VOC emissions from the CD-C Project Area is 2008, when the active well count, gas/condensate production, and VOC emissions from existing wells are at their maximum values. Impacts from the CD-C Project Area during 2008 were evaluated during the CD-C baseline modeling (see Appendix I).

Figure 2-5 breaks down Project-wide NOx emissions (left-side charts) and VOC emissions (right-side charts) by source category. Note that data shown here represent emissions from both new and existing wells (i.e. "All Well") for each category. The top half of Figure 2-5 shows the All Well emissions for the Proposed Action Alternative, while the bottom half of the Figure shows the All Well emissions for the No Action Alternative. For NO_X, drilling and completion emissions are prominent until 2023, when drilling stops. After 2023, well site heaters are the source category with the largest NO_X emissions. Compressor engine, gas plant, and flaring emissions are the other important NO_X source categories during the production-only phase of the Project.

The source category with the largest VOC emissions is dehydrators. Emissions from dehydrators at existing well sites dominate this source category (see Figure 2-6). Emissions for dehydrators at new Proposed Action wells are controlled, and do not make a large contribution to the inventory. Other source categories that make substantial contributions to the Project-wide total VOC emissions are: condensate tanks, well venting, pneumatic pumps and fugitives. While these sources all make relatively important contributions to emissions from existing wells, only well venting and fugitives comprise a large fraction of the VOC emissions from new wells.

Annual NO_X emissions in the All Wells No Action Alternative are much smaller than those in the All Wells Proposed Action Alternative particularly for heaters and flaring source categories. The difference in VOC emissions between the All Wells Proposed Action Alternative and the All Wells No Action Alternative is less pronounced than in the case of NO_X since VOCs are dominated by the existing wells which are unchanged. The effects of lower activity levels for drilling/completion on VOC in the All Wells No Action Alternative is evident for well venting and fugitive emissions (shown in Figure 2-5), which are directly proportional to the number of active wells and appear narrower than in the All Wells Proposed Action Alternative.

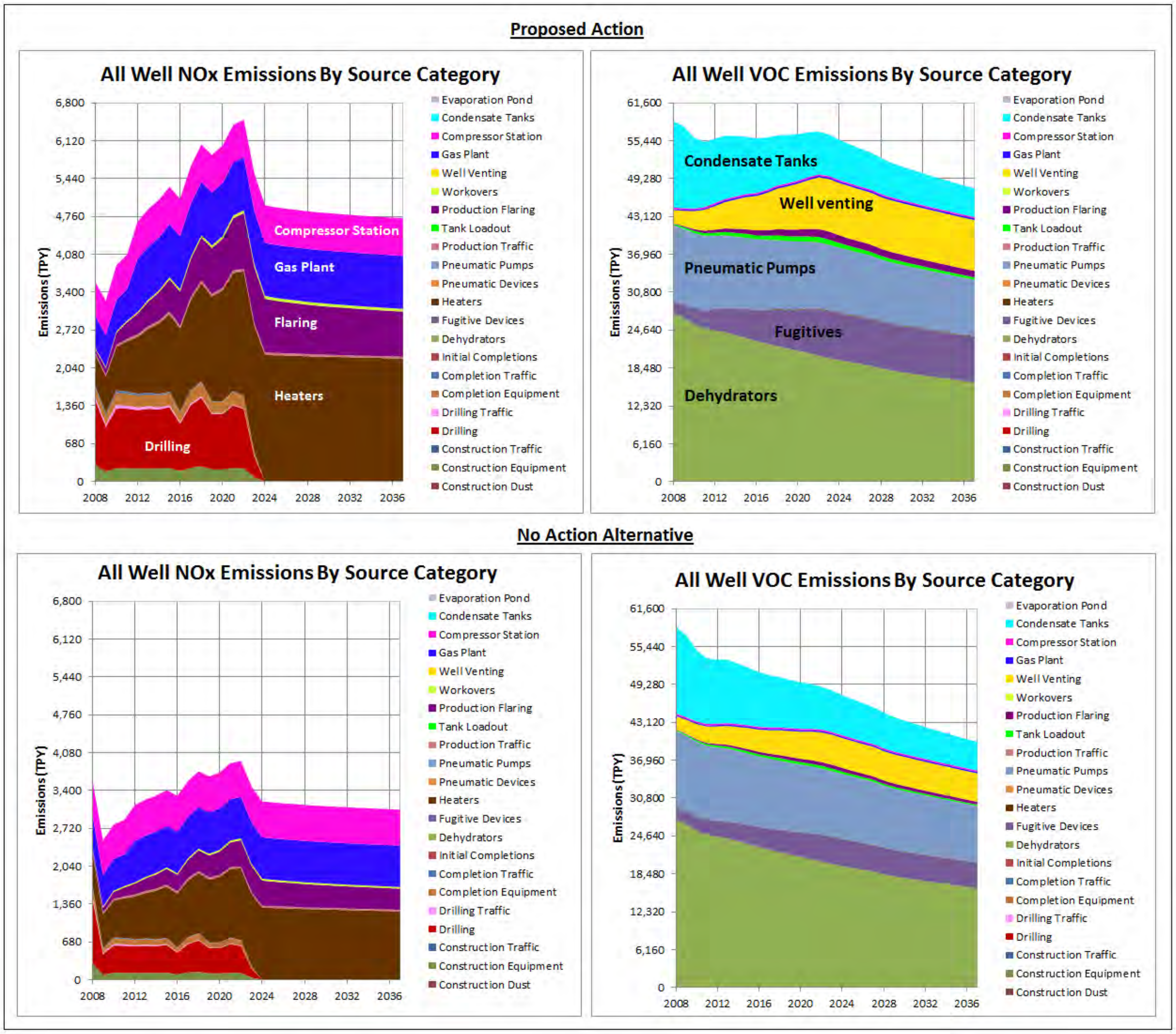

Figure 2-5. NO_X (left panel) and VOC (right panel) emissions From all CD-C Project Area sources over the LOP. Top half shows emissions for all wells for the Proposed Action Alternative and bottom half shows emissions for all wells for the No Action Alternative.

Figure 2-6 shows that NO_X emissions from existing wells have a contribution from well development activities in the first year only and thereafter, gas plants, compression, and well site heaters make up the majority of the NO_X emissions. For new wells in the Proposed Action and No Action Alternatives, gas plants, flaring, and well site heaters contribute to the NO_X inventory over the LOP, with the contribution increasing with time until drilling stops, and then tailing off as production declines and wells are abandoned. For new wells, drilling and completion emissions make up a significant fraction of the inventory during the development phase, which ends in 2023.

Existing well VOC emissions decrease throughout the LOP as production from those wells declines, and are comprised mainly of emissions from condensate tanks, pneumatic pumps and dehydrators. For both Alternatives, new well VOC emissions increase as the new wells are drilled and start producing, and are primarily due to well venting and fugitive devices as many other source categories are subject to 2010 WYDEQ BACT controls. Comparison of the magnitude of VOC emissions from new and existing wells shows that existing wells contribute a larger fraction of emissions than new wells over the LOP despite fact that the number of new wells surpasses that of existing wells in 2013. This is due to the VOC controls required by the 2010 WYDEQ BACT controls.

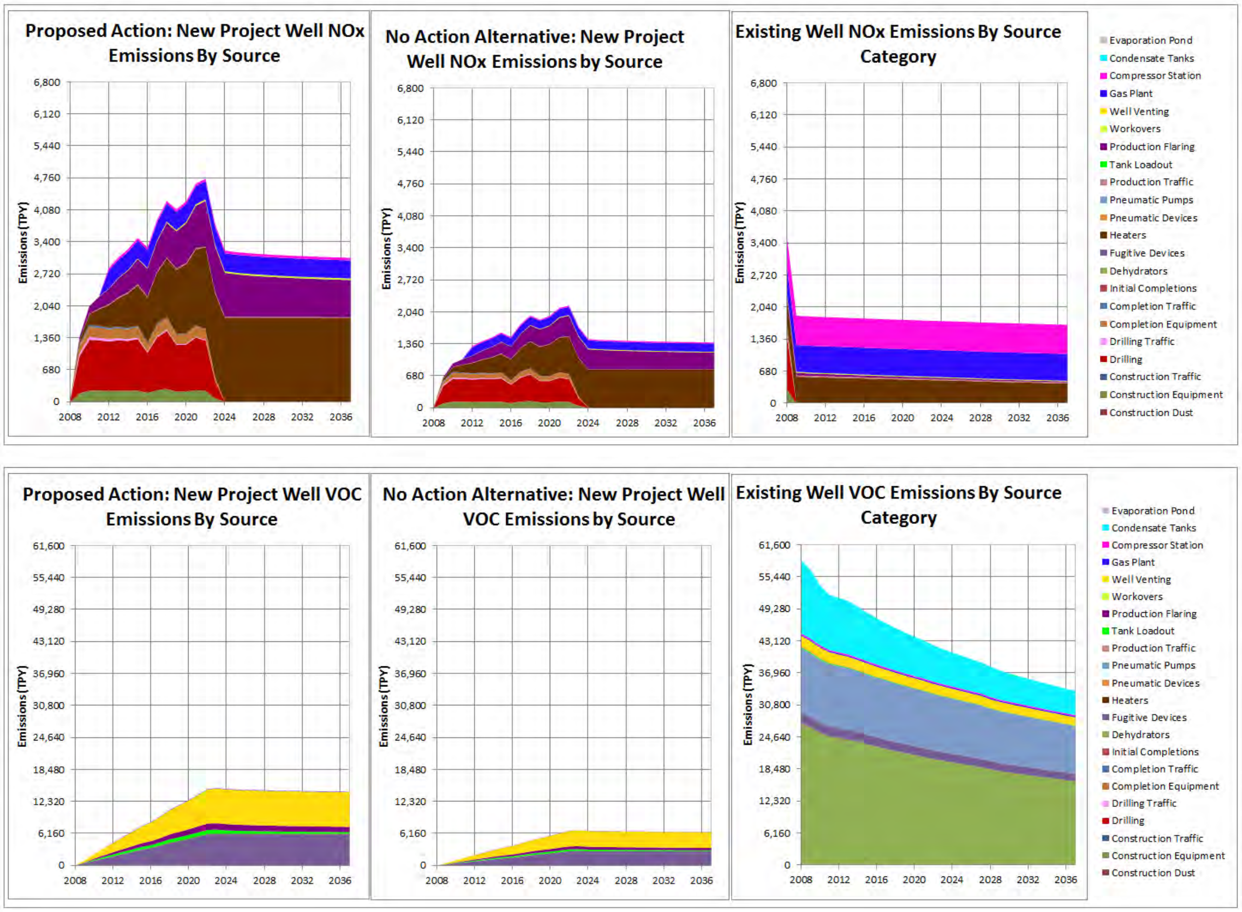

Figure 2-6. NO_X (top) and VOC (bottom) emissions by source category from Proposed Action Alternative new wells, No Action Alternative new wells and existing wells in the CD-C Project Area over the LOP.

2022 is the year when the NOx emissions from the Proposed Action Alternative and No Action Alternative as well as total CD-C Project Area are at their peak. Total CD-C Project Area VOC emissions have their maximum value in 2008, and have a secondary peak in 2022. The 2008 peak in VOC emissions is entirely due to emissions from existing wells. 2022 is the year of maximum VOC emissions from total CD-C Project Area wells but has lower overall VOC emissions due to the decline in emissions from existing wells over time. Sensitivity testing carried out during the 2008 baseline modeling indicated that ozone formation in the CD-C Project Area was more sensitive to CD-C Project NO_X emissions than CD-C Project VOC emissions (ENVIRON and Carter Lake, 2011b). Because NOx emissions are highest in 2022 and because VOC emissions are also high in 2022, 2022 is expected to be the year of peak ozone impacts. In addition, nitrogen-related impacts such as atmospheric NO_2 concentrations, nitrogen deposition and visibility impairment due to particulate nitrate are also expected to be highest in 2022.

Figure 2-7 shows the field-wide (existing wells + new wells) emissions of SO_2 and CO over the LOP for the Proposed Action Alternatives and No Action Alternative. SO_2 emissions peak early in the LOP and then drop off sharply between 2010 and 2012 as the transition to low-sulfur diesel fuel occurs. The most important source of SO_2 emissions is drilling rig engines. Consequently, the No Action Alternative SO_2 emissions during 2009 – 2011 are smaller than the Proposed Action Alternative SO_2 emissions due to the lower drilling rates. The source categories with the largest CO emissions are production flaring and well site heaters. The shape of the CO emission curve indicates that both production and development phases of the Project contribute a large fraction of the total field-wide CO emissions. The difference in activity levels between Proposed Action Alternative and No Action Alternative is also apparent in the resulting emissions for CO.

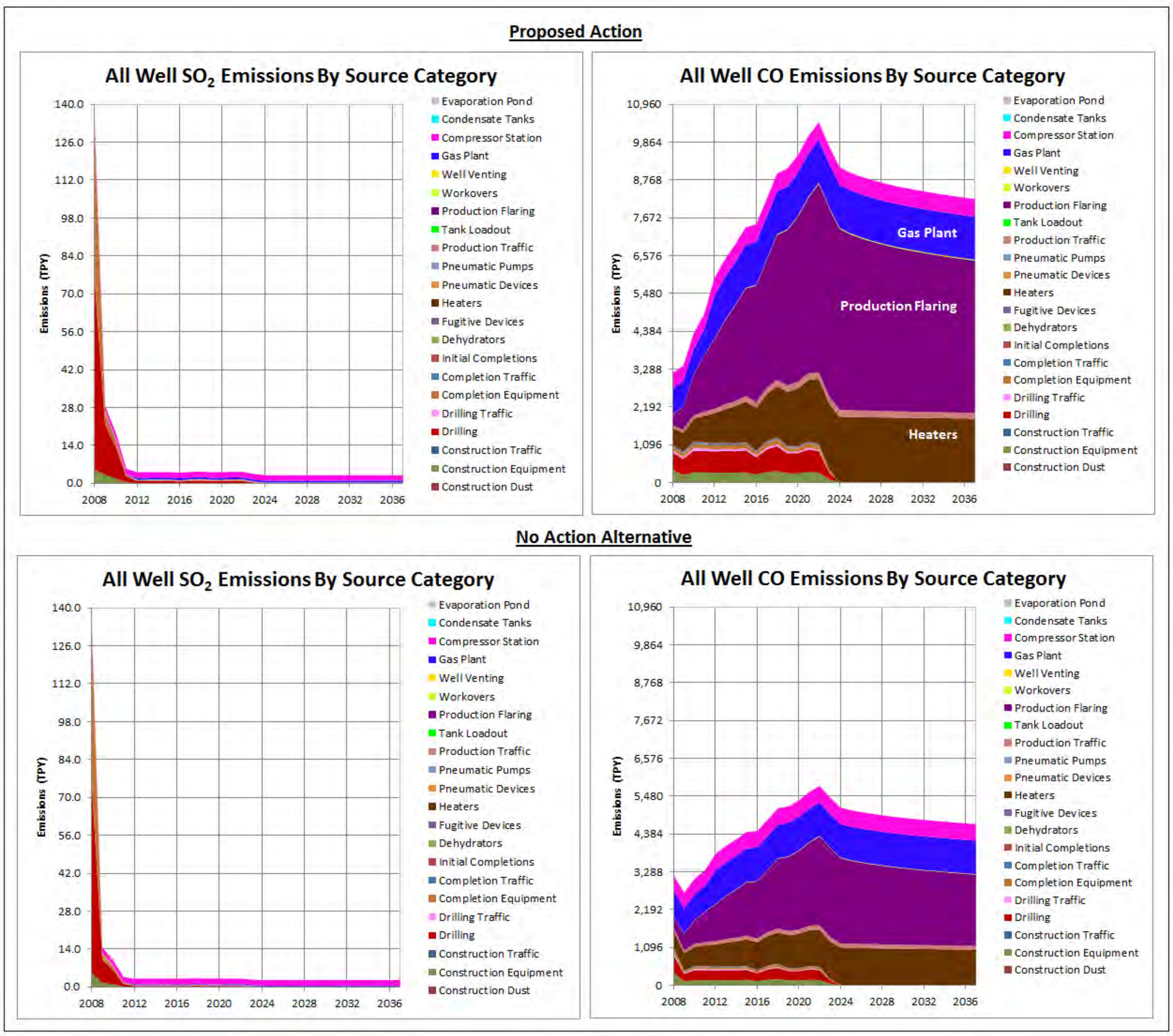

Figure 2-7. SO_2 (left panel) and CO (right panel) emissions from all wells in the CD-C Project Area over the LOP in the Proposed Action Alternative and the No Action Alternative.

PM emissions are shown in Figure 2-8 for the Proposed Action Alternative and the No Action Alternative. As with CO, emissions of PM result from both the development and production phases of the Project. Production traffic emissions produce a large fraction of the $PM_{2.5}$ and PM_{10} inventories. In addition, PM emissions from plants, compressors and heaters contribute a sizable fraction to the inventory during the production phase after drilling ceases in 2023. Construction dust emissions and completion/drilling traffic emissions contribute significantly during the development phase of the Project.

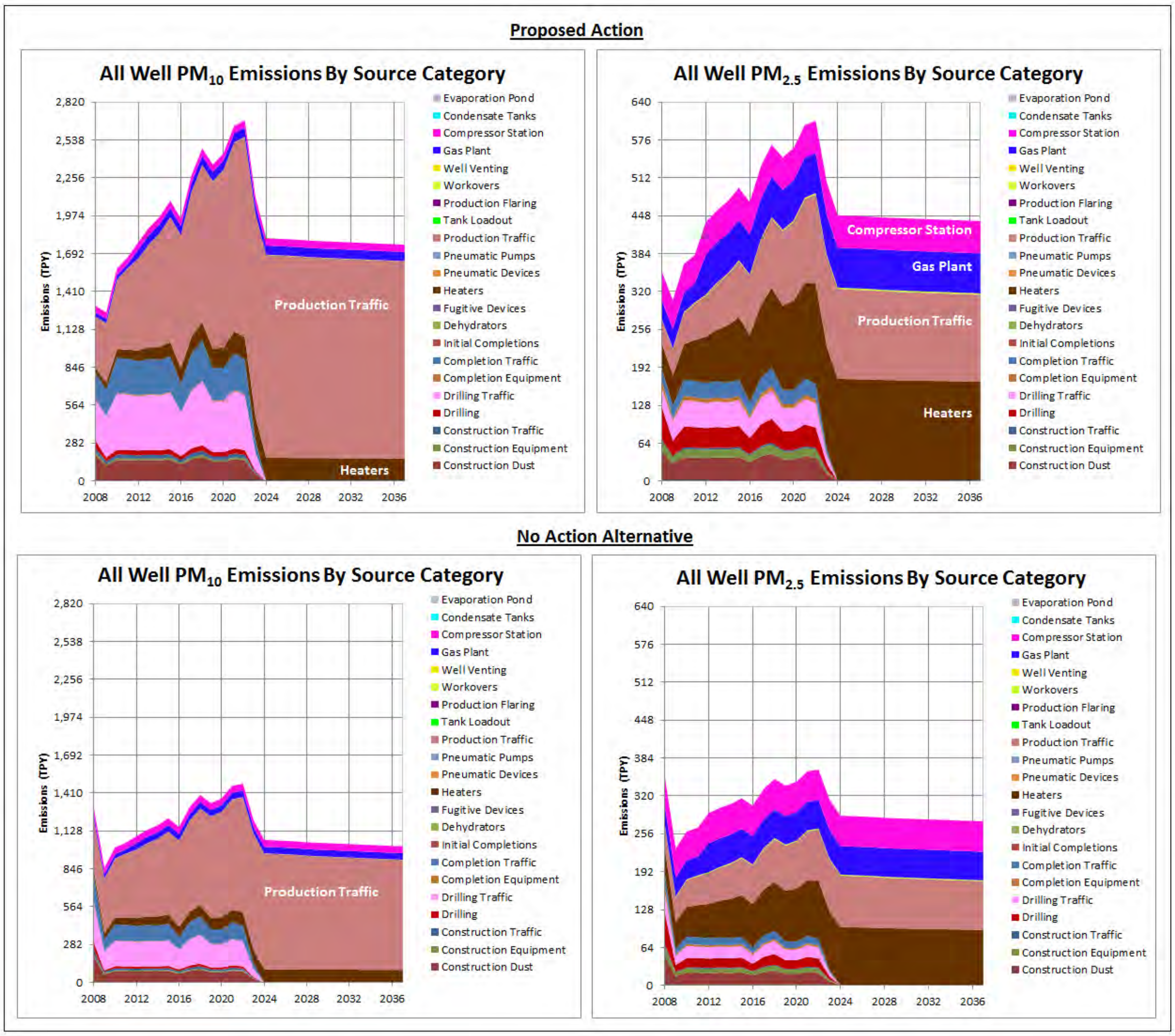

Figure 2-8. PM_{10} (left panel) and $PM_{2.5}$ (right panel) emissions from all CD-C Project Area sources over the LOP in the Proposed Action Alternative and No Action Alternative.

2.1.5 Hazardous Air Pollutant Emission Inventory

Emission inventories for hazardous air pollutants (HAPs) under the Proposed Action Alternative and the No Action Alternative were developed for use in the near-field modeling.

2.1.5.1 BTEX and n-Hexane

Figure 2-9 and Figure 2-10 show emissions of benzene, ethyl benzene, toluene, xylenes, (these four HAPS are referred to collectively as BTEX) and n-hexane for all new and existing sources over the LOP of Proposed Action Alternative (left panels) and No Action Alternative (right panels) by source category. The BTEX emissions are dominated by emissions from dehydrators; dehydrators also contribute a substantial fraction of the total n-hexane emissions, but other source categories such as fugitives, well venting, condensate tanks and pneumatic pumps also contribute. Figures 2-11 and 2-12 indicate that most of the emissions of HAPs are from existing wells rather than new wells, with the contribution from existing wells being less dominant for n-hexane (See Figure 2-12). Most of the emissions are from the existing wells because the HAP emissions are scaled from VOC emissions, and the VOC emissions are highly controlled for new wells and less controlled for existing wells.

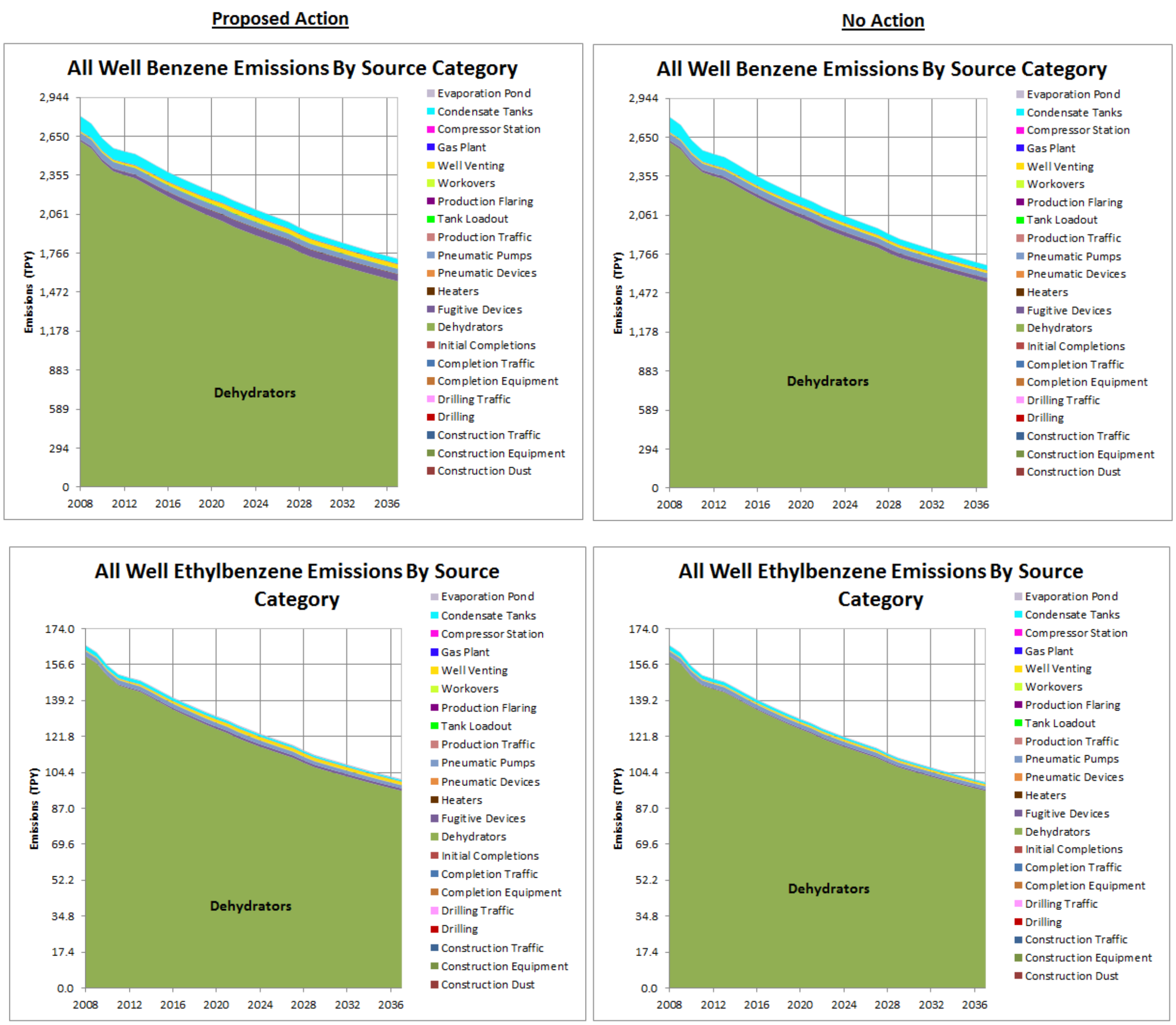

Figure 2-9. HAPs benzene and ethylbenzene emissions for the Proposed Action (left panels) and No Action (right panels) Alternatives from all CD-C Project Area sources over the LOP broken out by emission source category.

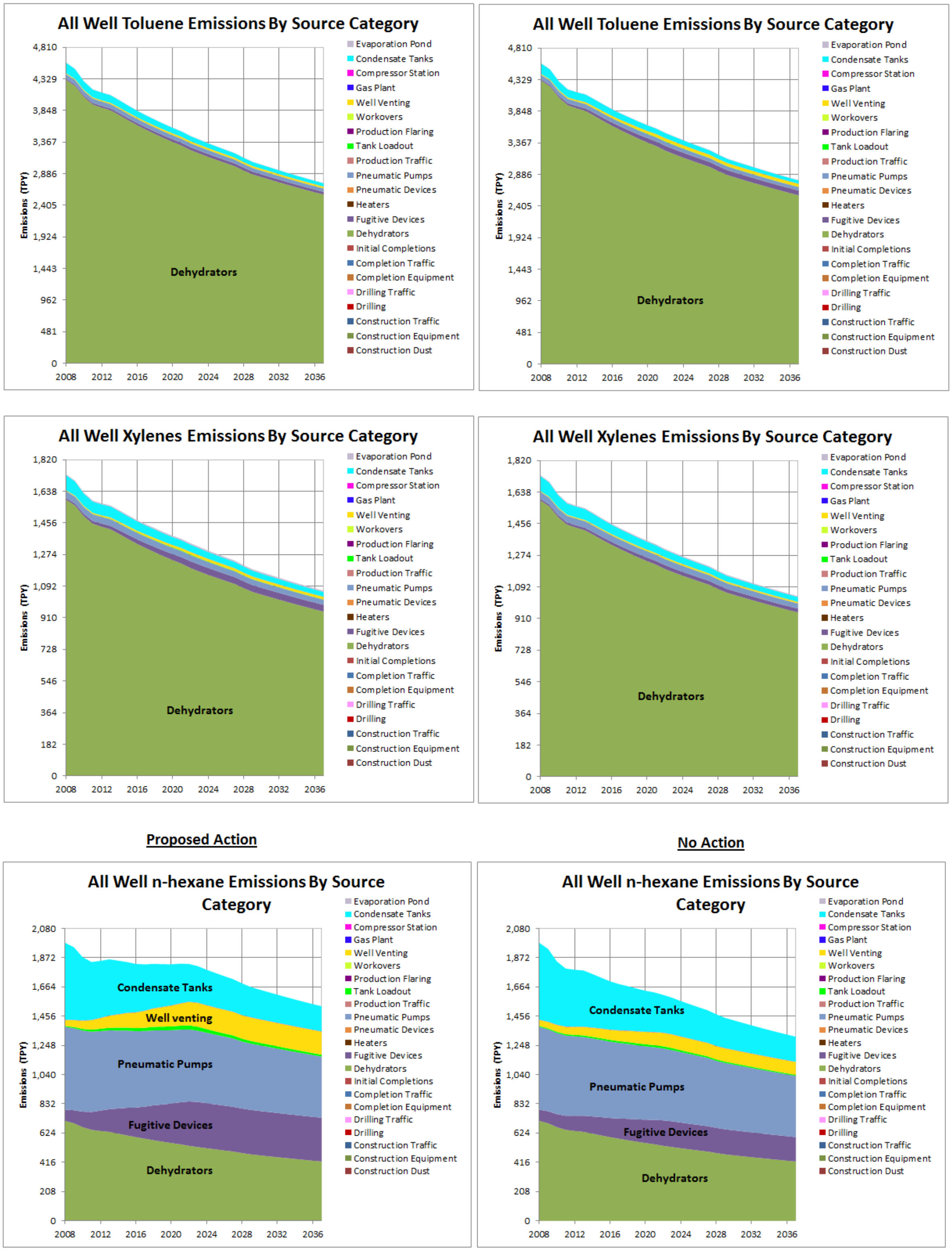

Figure 2-10. HAPs toluene, xylenes, and n-hexane emissions for the Proposed Action (left panels) and No Action (right panels) Alternatives from all CD-C Project Area sources over the LOP broken out by emission source category.

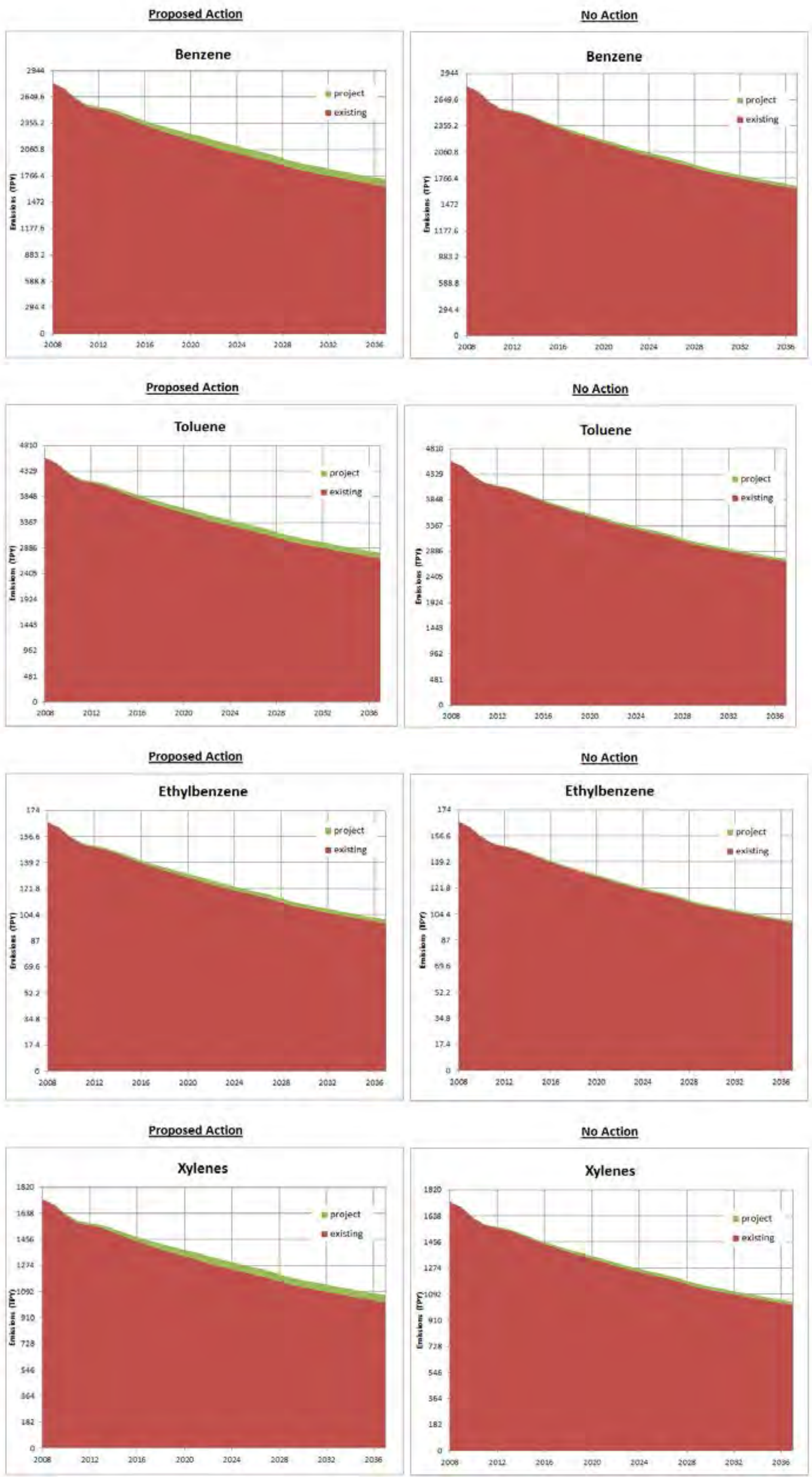

Figure 2-11. BTEX emissions for the Proposed Action Alternative (left panels) and No Action Alternative (right panels) from existing and new CD-C Project Area sources over the LOP.

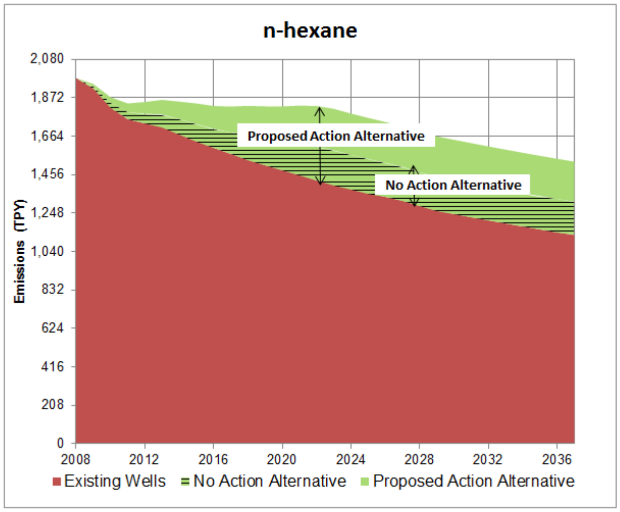

Figure 2-12. n-hexane emissions from existing wells and CD-C Project new wells for the Proposed Action and No Action Alternatives over the LOP.

2.1.5.2 Formaldehyde

Emissions of formaldehyde for all CD-C Project area wells ("All Well"), new wells, and existing wells are shown (left to right) in Figure 2-13. For existing wells, the largest sources of formaldehyde emissions are gas plants and compressors. For new wells for both Proposed Action and No Action Alternatives, the largest contribution to formaldehyde emissions is from production flaring. In the new wells, VOC emissions for a number of source categories (dehydrators, pneumatic pumps, etc.) are controlled by flaring in accordance with WDEQ-AQD (2010) BACT rules. Flaring destroys VOCs but generates emissions of other pollutants, as discussed in Section 2.1.3.4. Because the EPA SPECIATE database profile 0051 for natural gas flaring was used, the emissions from flaring in CD-C contain formaldehyde. The flaring emissions are affected by the uncertainty in speciation as discussed in Section 2.1.3.4, and likely are an overestimate of the true formaldehyde emissions from flaring.

Figure 2-14 shows that nearly all of the formaldehyde emissions occur during the production phase of the Project. Therefore the formaldehyde emissions from existing wells (top right panel) decline slowly over time, while formaldehyde emissions from new sources increase until the year of peak production and then slowly decreases thereafter (bottom right and bottom left panels for Proposed Action Alternative and No Action Alternative, respectively).

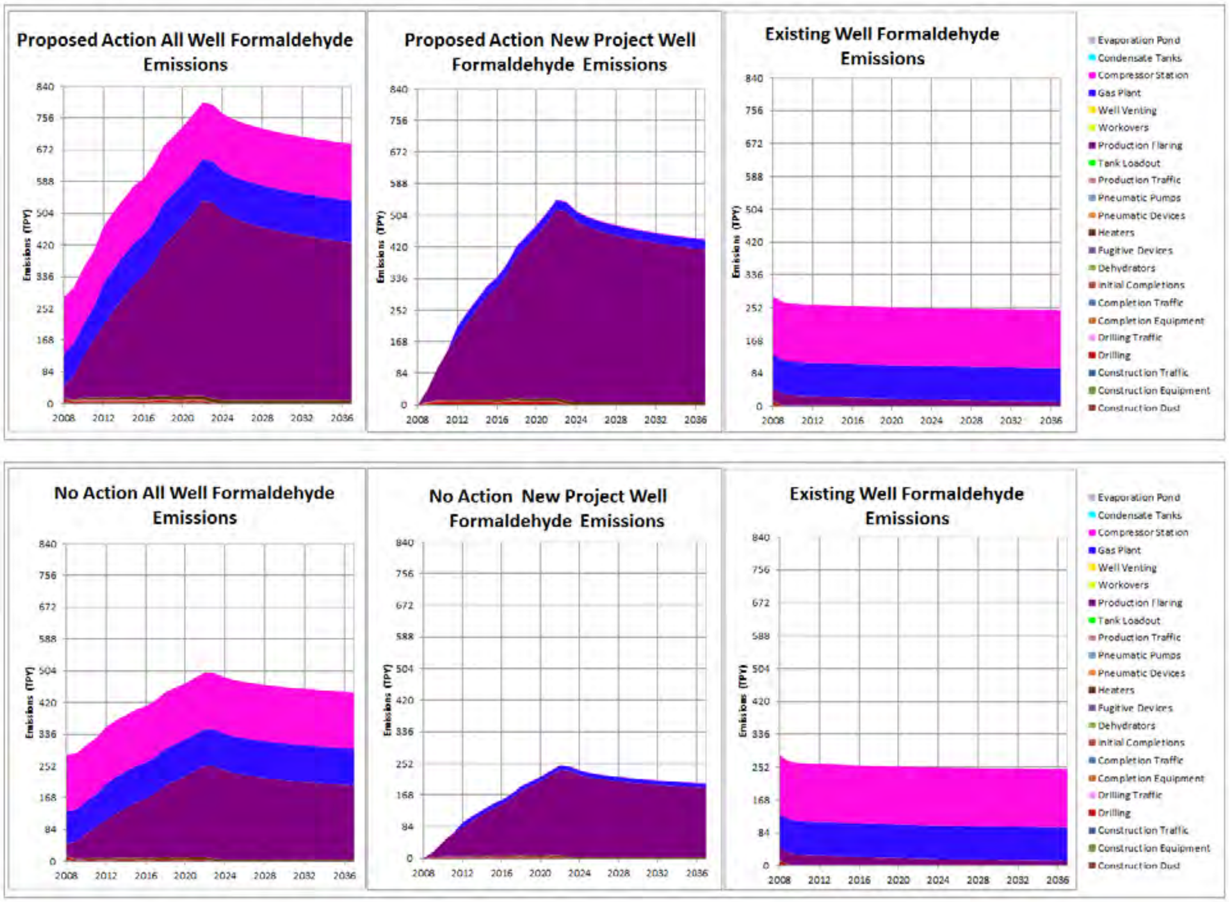

Figure 2-13. Formaldehyde from all CD-C Project Area sources (left panels), CD-C Project sources (center panels) and existing sources (right panels) over the LOP by source category for the Proposed Action Alternative (top) and the No Action Alternative (bottom).

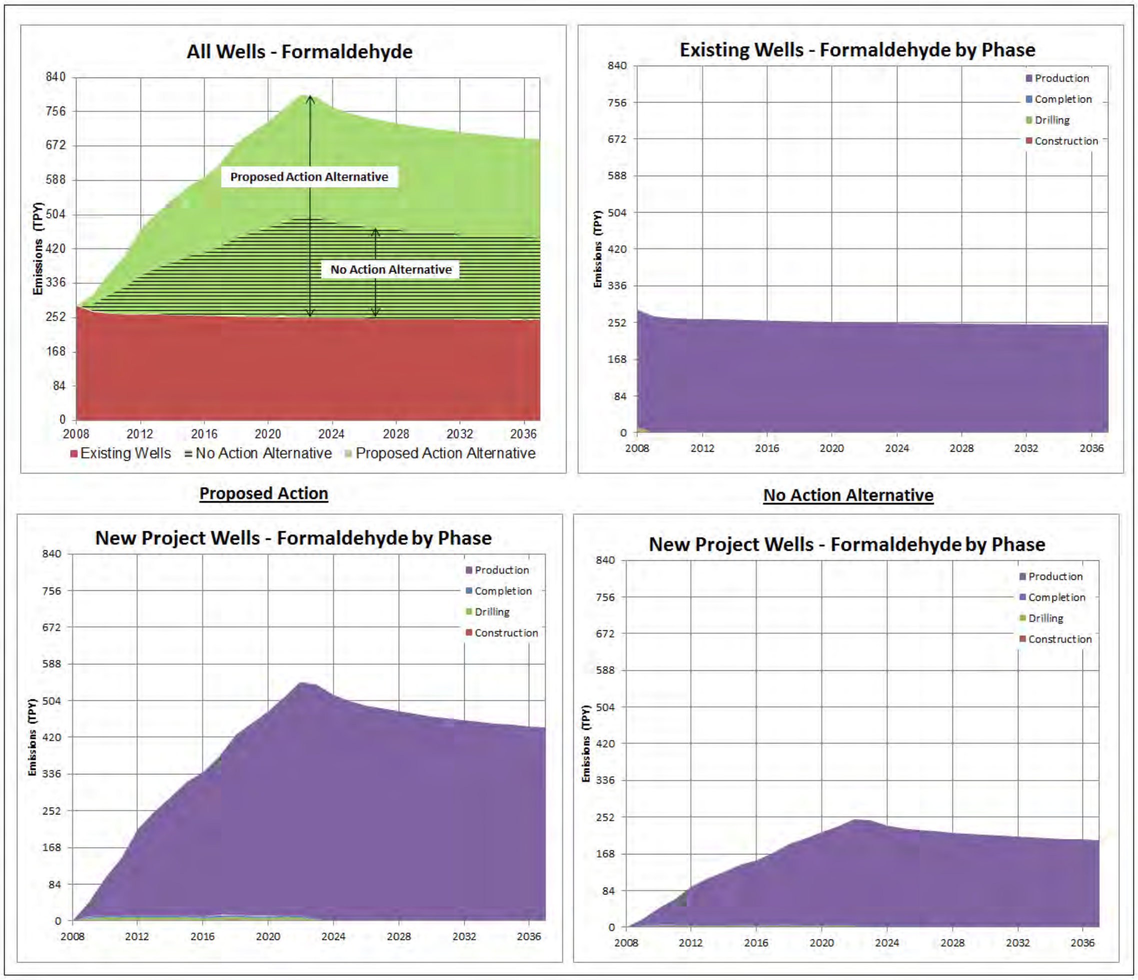

Figure 2-14. Formaldehyde from all CD-C Project Area sources (top left) broken out by Proposed Action Alternative, No Action Alternative, and existing wells. Emissions by phase from existing wells (top right), Proposed Action Alternative (bottom left), and No Action Alternative (bottom right) over the LOP.

2.1.6 Greenhouse Gas Emission Inventory

The CD-C Project emission inventory of greenhouse gases (CO_2, CH_4 and N_2O) from new and existing sources are quantified in terms of CO_2 equivalents. Measuring emissions in terms of CO_2 equivalents allows for the comparison of emissions from different greenhouse gases based on their Global Warming Potential (GWP). GWP is defined as the cumulative radiative forcing of a gas over a specified time horizon relative to a reference gas resulting from the emission of a unit mass of gas. The reference gas is taken to be CO_2. The CO_2 equivalent emissions for a greenhouse gas are derived by multiplying the emissions of the gas by the associated GWP. The GWPs for the inventoried greenhouse gases are CO_2:1, CH_4: 21, N_2O: 310 (EPA, 2011a). Details of the greenhouse gas emissions calculations are provided in Appendix H. Greenhouse gas emissions over the LOP from existing wells and new project wells for the Proposed Action Alternative and No Action Alternative are shown in Figure 2-15.

Emissions for all three of the inventoried GHGs increase steadily for the new sources until the drilling activity stops in 2023, and then decline slowly. GHG emissions from existing wells decline slowly over the LOP. For N_2O, there is an abrupt decrease in emissions in 2009 when drilling of existing wells ceases because N_2O is emitted from combustion in drilling rig engines.

The CD-C Proposed Action Alternative peak CO_2 equivalent emissions year is 2022, in which the combined emissions from new and existing sources are 10 teragrams (Tg)/year. To place the CD-C Proposed Action Alternative GHG emissions in context, the GHG emissions from the top 5 emitting coal-fired power plants in Wyoming range from 3-15 Tg/year (data from http://epa.gov/climatechange/emissions/ghgdata/2010data.html). CD-C Proposed Action Alternative GHGs are comparable to the total GHG emissions from the City of San Francisco (10 tg/year; http://www.sfenvironment.org/downloads/library/climateactionplan.pdf) during the year 2000).

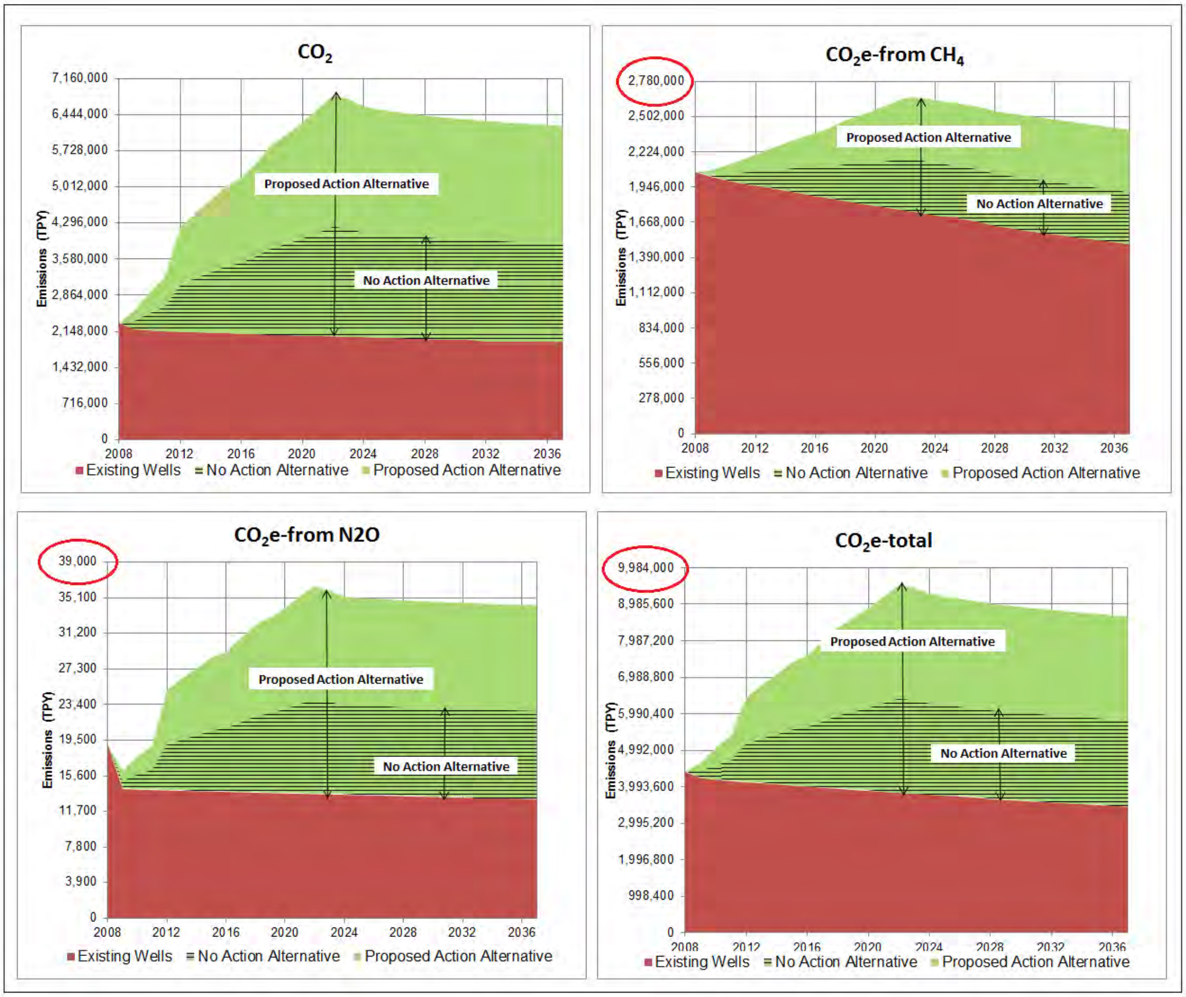

Figure 2-15. CD-C Project Area greenhouse gas emissions over the LOP. Upper left panel: CO_2, Upper right panel: CH_4 emissions shown as CO_2 equivalents, Lower left panel: N_2O emissions shown as CO_2 equivalents, Lower right panel: Total greenhouse gas emissions shown as CO_2 equivalents. Note that each set of emissions is plotted on a different scale in this figure for clarity.

2.2 REGIONAL EMISSION INVENTORIES

Emission inventories prepared by the WRAP, Carter Lake, and BP and other Operators form the basis for the regional emission inventories for the CD-C far-field air quality impact analysis. Sources of PM_{10}, $PM_{2.5}$, NO_X, CO, SO_2, and VOC emissions within the 36/12/4 km grid study area (Figure 4-1) were inventoried. Emission inventories and projections from various state and Federal agencies were used to update the WRAP analyses as appropriate for each of the years that were modeled. Three categories of regional emissions inventories were compiled: two base case years, a baseline year, and a future year. The two base case modeling years are 2005 and 2006, and the baseline year is 2008. The future year selected for modeling was identified upon review of the CD-C Project Area total field emissions estimates for each year over the LOP and is 2022. An overview of the base case, baseline, and future year regional emission inventories is given in the following subsections and a detailed description of the emission inventory processing for input to CAMx is given in Section 2.3.

2.2.1 2005-2006 Base Case Emission inventory

For each of the two base case modeling years (2005 and 2006), emission inputs were developed that represent actual emissions that occurred during each year. These modeling years were used for the CAMx model performance evaluation that is described in Appendix A. The 2005 and 2006 base year inventories were obtained by linearly interpolating the most recent WRAP 2002 and WRAP 2018 emission inventories that were available at the time of the emissions modeling. The most recent WRAP emission databases at the time of this work were the “2002 Plan D” and “2018 PRP” emissions database. The 2018 PRP database was developed for Preliminary Reasonable Progress and was built from the WRAP 2002 inventory by projecting the impacts of activity growth and emission controls. The methodology for projecting emissions is described in the WRAP PRP Technical Memorandum (Fields and Wolf, 2007). Details on data collection, emission processing and quality assurance of the WRAP 2002 emission inventory can be found in Tonnesen et al. (2006). All of the SMOKE inventory files and ancillary files are available from the WRAP Regional Modeling Center (RMC) upon request. The WRAP 2002 and 2018 emissions QA plots are available at http://pah.cert.ucr.edu/aqm/308/emissions.shtml. Non-oil and gas emissions were based on the WRAP 2002 inventory projected to 2005 and 2006. The interpolated WRAP emissions for 2005 and 2006 were replaced by 2005- and 2006-specific emissions for several source categories as described below.

For on-road mobile source emissions within the 36/12/4 km domains, 2005 and 2006 Vehicle Miles Travelled (VMT) and the 2005 and 2006 MM5 meteorological data were used with the SMOKE-MOBILE6 processor to generate the gridded, speciated and day-of-week specific hourly emissions required as input to CAMx. For each month, emissions were generated for a representative weekday, Saturday and Sunday. Holidays were modeled as Sundays.

Carter Lake developed a detailed inventory of point source emissions for the 2005 and 2006 model years for the portion of the modeling domain that lies within the 12 km grid (i.e., all of Wyoming and portions of Colorado, Utah, Idaho, Montana, South Dakota and Nebraska, see Figure 4-2). Inventories of actual emissions for these years were obtained from the representative State agencies and compared with the 2002 WRAP inventory and updated to the extent possible based on the data obtained. Continuous Emissions Monitor (CEM) data from the U.S. EPA’s Clean Air Markets Division (CAMD) were used to supply hourly emissions for electric generating utilities (EGUs). The CEM database contains NO_X and SO_2 emissions and heat input, but does not include PM, VOC or CO emissions. Carter Lake provided the CEM emissions by ORIS/Boiler ID and the base year annual emissions within the 12 km domain.

Oil and Gas Emission Inventories

WRAP Phase II Oil and Gas Emission Inventory

For oil and gas emissions sources outside the 5-county area of Southwest Wyoming (Carbon, Sublette, Lincoln, Uinta and Sweetwater Counties), WRAP oil and gas emissions were used. Beginning in 2005, the Western States Regional Air Partnership initiated a series of projects to develop a regionally consistent emissions inventory of oil and gas exploration and production activities for all of the western U.S. states. The first of these projects, the Phase I inventory, completed in 2005, represented the first regional oil and gas emissions inventory for the western U.S (Russell and Pollack, 2005). This was followed by the Phase II inventory (Bar-Ilan et al., 2007), which focused on improving emissions estimates of drilling rigs and compressors from those in the Phase I work. Both the Phase I and Phase II inventories were focused on estimating oil and gas NO_x and SO_x emissions for regional haze modeling purposes. Final reports of the Phase I and Phase II inventories are available on the WRAP web page at http://www.wrapair.org/forums/ssjf/documents/eictts/oilgas.html.

The WRAP Phase II O&G emissions inventory, which was used in the Regional Haze SIP modeling, is available for all basins in the western U.S. Because the emphasis of the WRAP Phase II O&G emissions inventory development was on visibility impairment precursors the inventory was focused on SO_x, NO_x and PM emissions. The WRAP Phase II O&G emissions inventory is known to be deficient in VOC emissions. O&G VOC emissions are not significant contributors to visibility impairment, but are critically important contributors to ozone formation. The understated VOCs in the WRAP Phase II inventory could potentially cause CAMx to underestimate ozone concentrations. The WRAP Phase II emissions are, however the best source of O&G emissions information for the western U.S. away from the Carter Lake/BP Southwest Wyoming and WRAP Phase III inventory regions, and the WRAP Phase III inventory was not completed in time for the CD-C modeling for regions outside the Piceance, Uinta and Denver-Julesburg Basins. Use of the WRAP Phase II inventory in areas of Wyoming that are predominately downwind of the Wind River Range will not significantly affect ozone upwind in Southwest Wyoming.

WRAP Phase III Oil and Gas Emission Inventory

The WRAP Phase III work, which is currently in progress, expands on the work done under WRAP Phase II, and addresses the limitations of its VOC inventory. A comprehensive 2006 inventory of emissions from oil and gas sources is under development for the following basins:

- Denver-Julesburg Basin
- Uinta Basin
- San Juan Basin (North and South)
- Piceance Basin
- Southwest Wyoming Basin (Green River Basin)
- Powder River Basin
- Williston Basin

- Wind River Basin
- North-Central Montana Basin (Great Plains Basin)

The Phase III inventory is being assembled by combining data on permitted sources from states' permit databases, and data on unpermitted sources obtained from industry surveys. These surveys request information on typical equipment types, counts, configurations, annual activity levels, controls, and emissions factors. The IHS database (described below) is used to determine oil and gas production statistics, which are used to combine these two groups of source categories to generate a complete basin-wide emissions inventory. The IHS database (also known as the P.I. Dwight database) is a high-quality commercially available database of oil and gas statistics for all of the United States and is maintained by IHS Corporation.

At the time of the CD-C modeling, the 2006 WRAP Phase III emissions inventories for the Denver-Julesburg, Uinta, and Piceance Basins were complete, and this data was incorporated into the CD-C O&G emissions inventory. The 2006 Phase III data were used for both 2005 and 2006.

Southwest Wyoming Oil and Gas Emission inventory

Carter Lake and BP have compiled a detailed and comprehensive emissions inventory of O&G sources in Southwest Wyoming for the years 2005 and 2006. Based on field data and well data from the WYOGCC, this inventory includes emissions from drill rigs, well venting, flashing, fugitives, construction and production truck traffic, and well site production equipment such as dehydrators, heaters, and pumps.

Monthly drill rig emissions (NO_x, CO, VOC, SO_2, and PM_{10}) were developed for all drill rigs that operated during 2005 and 2006 in Carbon, Lincoln, Sublette, Sweetwater and Uinta Counties. Monthly drill rig emissions were computed from hourly emissions and well drilling durations. Emissions were allocated to the corresponding latitude and longitude coordinates of each drill rig that operated for at least one hour during the month.

Well spud date and well depth data were obtained from the WOGCC for all wells drilled in Carbon, Lincoln, Sublette, Sweetwater and Uinta Counties beginning in November 2004 through December 2006.

BP drill rig summary data for BP rigs in the CD-C field during 2005 and 2006 were used for drill rig emissions and drilling durations for all BP drill rigs within the CD-C field. BP data for well completion/well fracing emissions were added to each drilling event. The well completion events were assumed to last 24 hours. Monthly emissions were developed for each drill rig that operated during the month. Average drilling rates (ft/hour) and emissions (lbs/hour) were determined from the BP CD-C drill rig summary data.

For other operators within the CD-C project area, Carbon County, Sweetwater County, Lincoln County, Uinta County, and all of Sublette County with the exception of Jonah Field and the Pinedale Anticline Project Area, the basis for calculating the rig emissions is BP's CD-C drill rig summary data. Well depth data and well spud date data from the WOGCC combined with BP average drilling rate information were used to estimate a drilling duration for each well. Average hourly emissions were applied to each hour over the drilling duration. 24 hours of well completion emissions were added to each drilling event. Monthly emissions were developed for each drill rig that operated during the month.

For the Jonah Field, well depth data and well spud data from the WOGCC combined with BP average drilling rate information for wells in the Jonah Field were used to estimate a drilling duration for each well. WDEQ provided individual well drilling emissions for 2005 and 2006 were applied to each well for all hours over each drilling event. Data for well completion emissions obtained from the WDEQ 2007 Ozone Study - Upper Green River Basin emissions inventory were added to each drilling event. The well completion events were assumed to last 96 hours. Monthly emissions were developed for each drill rig that operated during the month.

For the Pinedale Anticline Field, WDEQ provided individual well drilling emissions for 2005 and 2006 were used in combination with WOGCC well spud date data and an assumed 45 day well drilling duration to develop hourly well drilling emission events. Data for well completion emissions obtained from the WDEQ 2007 Ozone Study - Upper Green River Basin emission inventory were added to each drilling event. The well completion events were assumed to last 96 hours. Monthly emissions were developed for each drill rig that operated during the month.

WDEQ requested revisions to the original Carter Lake/BP well VOC emissions inventory that increased the field-wide VOC emissions for both fields by approximately 3%. The additional VOC emissions are due to adjustments to working/breathing losses from well site tanks and dehydration. Carter Lake/BP revised the VOC emissions and has submitted the updated emissions inventories to WDEQ for review.

Truck traffic emissions (NO_x, CO, VOC, SO_2, and PM_{10}) associated with 2005 and 2006 well production activities were developed for each production well in Carbon, Lincoln, Sublette, Sweetwater, and Uinta Counties. Per well annual production truck traffic emissions were computed using the 2005 Pinedale Anticline emissions inventory obtained from the Pinedale Revised Draft Supplemental EIS.

Monthly truck traffic emissions (NO_x, CO, VOC, SO_2, and PM_{10}) were developed for all wells that were constructed during 2005 and 2006 in Carbon, Lincoln, Sublette, Sweetwater and Uinta Counties. The methodology used for computing drill rig emissions was applied to estimate construction traffic emissions. Monthly construction traffic emissions were computed from hourly emissions that were based on well pad construction, well drilling duration, and well completion assumptions. Emissions were allocated to the latitude and longitude coordinates of the drill rigs.

Well spud date data obtained from the WOGCC, for all wells drilled in Carbon, Lincoln, Sublette, Sweetwater and Uinta Counties beginning in November 2004 through December 2006, and used for computing drill rig emissions were used as a basis for calculating construction traffic emissions.

Per well, construction traffic emissions data were obtained from the Pinedale Anticline SDEIS and Jonah EIS emissions inventories. Hourly emissions were calculated and assigned to drill rig locations.

There are three phases of well construction traffic emissions; 1) Well pad and access road construction, 2) drilling traffic, and 3) rig move and completion traffic.

1. For wells in the Pinedale Anticline, well pad and access road construction was estimated to occur for 16 days. Well pad and access road construction for wells in the Jonah Field was estimated to occur for 4 days. Well pad and access road construction hourly emissions for wells in the Pinedale Anticline were assigned to corresponding drill rig locations for the 16 days prior to the well spud date. For Jonah Field wells, well pad and access road construction hourly emissions were applied for the 4 days prior to the well spud date. The Jonah Field emissions assumption was used for all other wells in Sublette County, and for all wells in Carbon, Lincoln, Sweetwater and Uinta Counties.
2. For all counties, hourly emissions for drilling haul trucks were applied for all hours when drilling occurs.
3. For all counties, rig move and completion traffic emissions were added for 10 days after drilling was completed.

Spatial surrogates were not required to process the Carter Lake/BP southwest Wyoming emissions, as the wells were modeled as point sources and the latitude and longitudes of the wells were compiled as part of the inventory development. Emissions from drill rigs, completion, and traffic as well as production emissions were all modeled as point sources sited at the well location. Maps of production well and drill rig locations for 2005 and 2006 are shown in Appendix G.

Emission inventories were developed by Carter Lake and BP for existing oil and gas sources operating in the five county region of southwest Wyoming (Carbon, Lincoln, Sublette, Sweetwater and Uinta counties) during 2005 and 2006. These inventories include emissions from producing wells and from well development activities. The purpose of these inventories was to revise WRAP Phase II oil and gas inventories for these counties with more refined emissions estimates that are based on actual emission inventories and operating assumptions. The oil and gas emission inventory for southwest Wyoming is discussed further in Appendix G.

2.2.2 2008 Baseline Emission inventory

For the 2008 baseline year, Carter Lake and ENVIRON developed emission inputs that represent actual emissions that occurred during this year, with the exception of emissions from electric generating units (EGUs) and drilling rigs, which used typical emissions and are discussed below. The 2005-2006 base case inventories use actual measured EGU emissions and monthly drill rigs emissions because the base case model is evaluated against observations to determine whether the model provides a realistic simulation of the atmospheric processes related to ozone and PM formation, transport, and destruction. The purpose of the 2008 baseline modeling, on the other hand, is to serve as the base year from which future year projections are made and against which future year project alternative and cumulative emissions impacts will be evaluated. For example, baseline EGU emissions are used to represent typical conditions (no shutdowns for maintenance, for example) in order to be consistent with the future year emissions, which also represent typical conditions.

The 2008 baseline simulations consisted of two annual runs. Both annual simulations were performed with 2008 anthropogenic emissions; one year was run with 2005 meteorology and the other year was run with 2006 meteorology. The 2008 modeling established the baseline levels against which future year project alternative and cumulative emissions impacts were evaluated.

Several source categories of the 2008 regional inventory (e.g. non-O&G area sources, non-road mobile) were linearly interpolated from the latest WRAP 2002 and WRAP 2018 emission inventories. The most recent WRAP emission databases available at the time of the baseline emissions modeling were the "2002 Plan D" and "2018 PRP18b" emissions databases. The 2018 PRP18b database was developed for Preliminary Reasonable Progress and was built from the WRAP 2002 inventory by projecting the impacts of activity growth and emission controls. As noted above, the methodology for projecting emissions is described in the WRAP PRP Technical Memorandum (Fields and Wolf, 2007), and information on the WRAP 2002 emission inventory can be found in Tonnesen et al. (2006).

ENVIRON and Carter Lake developed a detailed inventory of point source emissions for the 2008 year for Wyoming. Year 2008 is a national emissions inventory reporting year and emission inventories for Wyoming major and minor point sources were made available by the State. These inventories were quality-assured by ENVIRON in collaboration with the WDEQ-AQD and prepared for processing through SMOKE to create CAMx-ready emissions inputs.

For Wyoming and other states, Continuous Emissions Monitor (CEM) data from the U.S. EPA's Clean Air Markets Division (CAMD) were used to supply hourly emissions for electric generating utilities (EGUs). The hourly emissions were then used to form quarterly averages for year for each of the 24 hours in a day. These quarterly averages constitute typical emissions for a particular EGU; they are averages that retain information about the typical temporal profile of emissions for that facility during a given season. Use of typical EGU emissions is one important difference between the base case and baseline inventories.

Day-specific hourly emissions were used for EGU point sources with CEMS in the 2005-2006 base case inventories, while typical EGU emissions were used in the 2008 baseline run to be consistent with the 2022 CD-C future year emissions scenario. The EPA-recommended methodology for projecting future-year ozone and particulate matter concentrations uses the model in a relative sense to project observed concentrations (this is discussed further in Section 5). Thus, when making projections of future year air quality, the current year (i.e. baseline) emissions need to represent typical conditions in order to be consistent with the future-year emissions, which are necessarily typical emissions.

For on-road mobile source emissions within the 36/12/4 km domains, 2008 Vehicle Miles Travelled (VMT) were developed by interpolating between 2006 VMT developed for the base case modeling and VISTAS 2009 VMT. 2005 and 2006 MM5 meteorological data were used with the SMOKE-MOBILE6 processor to generate the gridded speciated day-of-week emissions required as input to CAMx. For each month, emissions were generated for a representative weekday, Saturday and Sunday in 2008. Holidays were treated as Sundays.

2. EMISSION INVENTORIES

Carter Lake and ENVIRON developed a 2008 emission inventory for Wyoming oil and gas sources. A detailed emission inventory was prepared for the 5-county area of Southwest Wyoming that is similar in scope to the 2005-2006 Southwest Wyoming oil and gas inventory. The 2008 5-county southwest Wyoming inventory was developed using the oil and gas emissions information available from the Wyoming 2008 inventory and from Operator-provided emissions assumptions. For Wyoming oil and gas sources outside the 5-county area of southwest Wyoming, emissions were developed from the Wyoming 2008 point source inventory and from available WRAP inventories. In order to be consistent with future year emission inventories, drill rig emissions were annualized rather than reported by month, as was done for the 2005-2006 base case emission inventory. Emissions for oil and gas sources within the 12 km domain but outside Wyoming were estimated through interpolation of the 2006 and 2012 WRAP Phase III inventory where possible and through interpolation of the 2005 and 2018 WRAP Phase II inventories elsewhere.

For the 2008 baseline simulations using 2005 and 2006 meteorology, the corresponding 2005 and 2006 emission inventories for wildfires, wind-blown dust, biogenics, and ammonia were used. The 2008 baseline emission inventory modeling was carried out so that emissions source categories selected by the WDEQ-AQD were processed separately so that they could be run as separate emissions source groups in the CAMx probing tools.

CAMx Particulate Matter (PM) Source Apportionment Technology (PSAT) and the Anthropogenic Precursor Culpability Assessment (APCA) version of the Ozone Source Apportionment Technology (OSAT; ENVIRON, 2010) probing tools were used to obtain the ozone and PM contributions due to different emissions source groups in the 2008 baseline run. APCA is a source apportionment tool similar to OSAT that focuses on determining the contribution to ozone concentrations from human (i.e. controllable) activities. In Section 4.4.2, we describe ozone source apportionment in CAMx using OSAT and then discuss how APCA differs from the standard OSAT tool.

At the direction of the WDEQ-AQD (Personal communication from Kelly Bott, WDEQ-AQD, July 23, 2010), the 2008 baseline emission inventory modeling was carried out so that the following emissions source categories were processed separately and tracked as separate emissions source groups using the CAMx APCA and PSAT probing tools:

1. CD-C Project-related oil and gas sources within the physical boundary of the CD-C Project area;
2. Non- CD-C Project -related oil and gas sources within the physical boundary of the CD-C Project area. Note that this category includes gas plants and compressor stations which are located within the CD-C Project area, but do not process gas produced by CD-C Project wells.
3. Biogenic sources;
4. All other sources.

2.2.3 2022 Future Year Emission Inventory

Future year cumulative inventories were developed for the year 2022, which is the year of maximum NO_X emissions from the CD-C Project. The WRAP 2018 inventories form the basis of the year 2022 modeling inventory for all non-oil and gas point and area sources except: ammonia, wind-blown dust, biogenics, and fires. These source categories were held unchanged from the base years. The most recent WRAP 2018 modeling inventory available at the time of future year emissions processing was the WRAP region Preliminary Reasonable Progress emissions inventory for 2018, known as PRP18b. The objective of PRP18b inventory was to make a second revision to the 2018 emissions inventory projections for point and area sources in the WRAP region to provide a more current assessment of the reasonable progress toward visibility goals by the WRAP. A technical memorandum on the PRP18b inventory is available on the WRAP website (http://www.wrapair.org/forums/ssjf/documents/Pivot_Tables/PRP18b/2011-03_Final%20PRP18b%20memo%20(10-16w%20Big%20Stone%20Revisions%20&%20corrected%20'draft'%20typos).pdf).

2.2.3.1 Future Year Non-O&G Emissions

The components of the future year regional emission inventory that are not O&G sources are based on the PRP18b inventory. The 2018 PRP18b database recently developed for Preliminary Reasonable Progress was built from the WRAP 2002 inventory by projecting the impacts of activity growth and emission controls. The methodology for projecting emissions is described in the WRAP PRP Technical Memorandum (Fields and Wolf, 2007) and summarized below.

Point: For the PRP18b inventory, the coal-fired electric generating unit (EGU) Best Available Retrofit Technology (BART) SO_2 and NOx emissions rates were compiled based on the feedback from responsible federal or state agency for facilities subject to BART. For the BART-eligible facilities with no specific BART emission limits, the presumptive BART limit of 0.15 lb SO_2/MMBtu mandated by the U.S. EPA BART Guideline was applied. The technical memorandum mentioned above provides a list of EGU facilities with their BART limits and also a list of EGU facilities for which presumptive BART limits were used. The PRP18b inventory also includes the proposed SO_2 and NOx reductions for the non-EGU sector of BART sources.

On-road Mobile: For on-road mobile source emissions within the 36/12/4 km domains, projected Vehicle Miles Travelled (VMT) activity data and other required MOBILE6 inputs - average speed, fuel parameters, and control programs were obtained from the WRAP 2018 modeling. 2005 and 2006 MM5 meteorological data were used with the SMOKE-MOBILE6 processor to generate the gridded speciated day-of-week emissions required as input to CAMx. For each month, emissions were generated for a representative weekday, Saturday and Sunday in 2008. Holidays were treated as Sundays.

Area: Non-O&G area sources and off-road mobile were taken from the latest WRAP 2018 emission inventories without adjusting. This assumes that the effects of future growth and controls cancel one another after 2018.

2.2.3.2 Future Year RFD Sources

The reasonably foreseeable development (RFD) emission inventory incorporates recent and ongoing analyses of proposed NEPA oil and gas projects and BLMRMPs within the 12 km modeling domain and its immediate vicinity. A July 2013 cutoff date was used for determining projects for inclusion in the RFD inventory.

RFD is defined as: 1) air emissions from the undeveloped portions of authorized NEPA projects and RMPs, and 2) air emissions from not-yet-authorized NEPA projects (if emissions were quantified when emissions modeling commenced). RFD information from not-yet-authorized projects was obtained from the BLM for ongoing NEPA project air quality analyses. RFD information for authorized development was obtained from NEPA documents that have been submitted to BLM for planned project development and from BLM RMP documents.

To provide a conservative estimate of emissions, the RFD inventory for a project was compiled for the year of peak NOx emissions over the life of the project or RMP if emissions were available. If an emission inventory was not yet available, the year of peak activity was selected and an emission inventory was developed for that year. Generally, the year for which emissions are at their maximum is the last year of drilling, when the largest number of project wells will be active while drilling is still taking place. Well production decline and well abandonment for the compiled RFD inventories were not considered, which means that production emissions are likely overestimated. Full development of proposed projects inventoried as RFD may or may not coincide with the CD-C future modeling year. As a result, the assumption that all RFD are fully developed during the CD-C modeling year will result in conservatism in the cumulative impact analysis.

A map of the RFD projects that were included in 2022 future year modeling is presented in Figure 2-16. Note that the Colorado River FO, Grand Junction FO and Uncompahgre FO are located south of the 4 km modeling domain. Table 2-6 summarizes the RFD emissions that are included in the 2022 future year CAMx modeling.

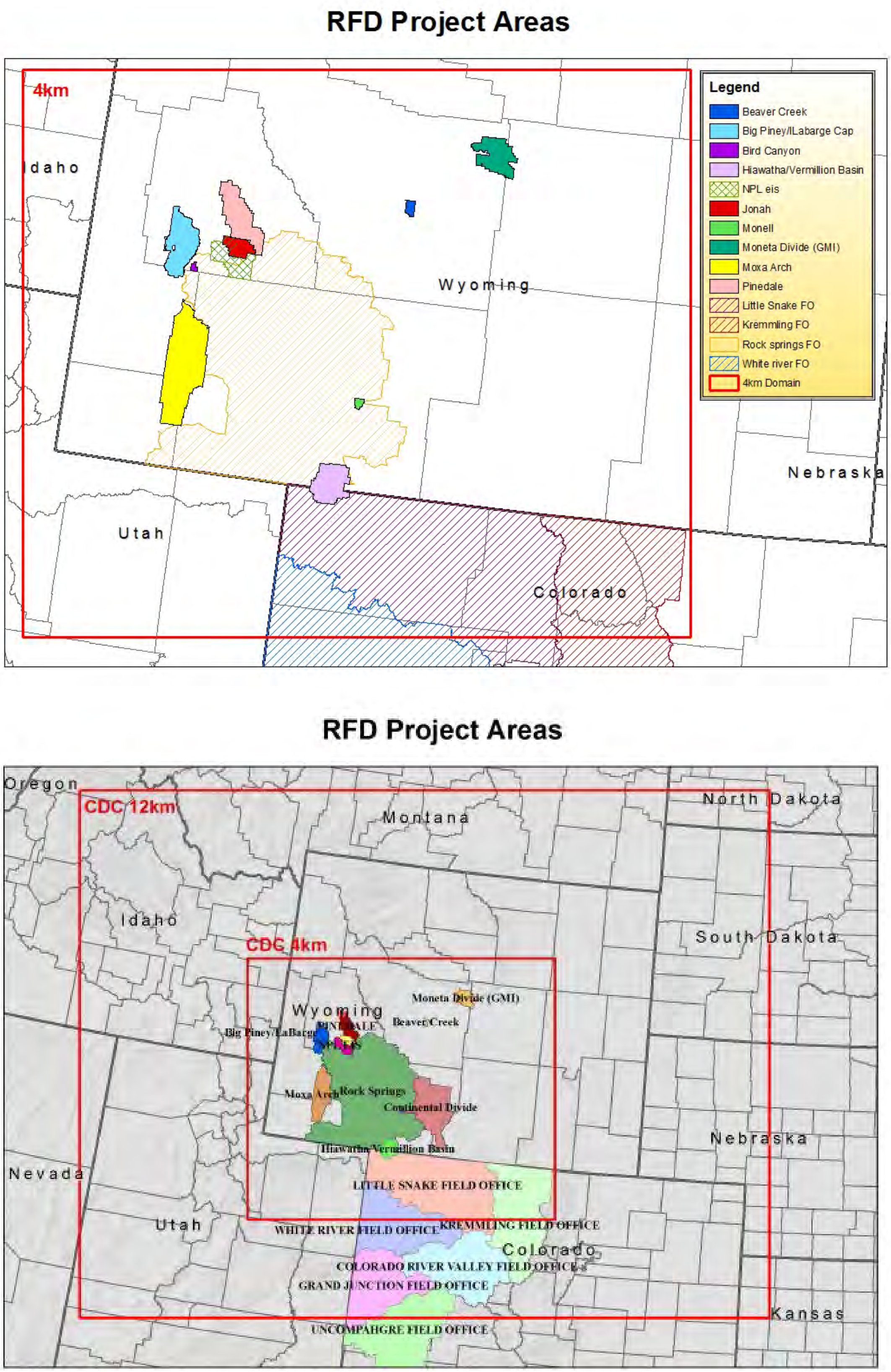

Figure 2-16. RFD Project Areas and CAMx 4 km modeling domain (upper panel) and 12/4 km modeling domain (lower panel).

Table 2-6. RFD project emissions in 2022 future year modeling

RFD Project	Inventory Year	Emissions (tpy)					
		NO_x	VOC	CO	SO_2	PM_{10}	$PM_{2.5}$
Beaver Creek	2016	105	85	103	0	89	14
LaBarge Platform	2027	676	1,534	383	96	110	36
NPL	2022	472	310	623	10	968	145
Monell Arch	2021	253	276	220	8	33	17
Moneta Divide (replaces GMI)	*	1,035	3,662	364	0	1,108	140
Rock Springs Field Office	2031	998	3,318	2,369	1	516	93
Little Snake Field Office - Alt B (Preferred)	2021	559	2,712	1,103	3	378	55
Kremmling Field Office - Alt. C (Preferred)	2028	738	5,914	191	3	2,473	408
White River Field Office	2021	3,320	8,564	7,054	20	1,037	198
Colorado River Valley Field Office	2021	2,287	9,240	4,525	8	916	155
Grand Junction Field Office - Alt B (Preferred)	2018	3,373	2,686	4,160	135	2,397	525
Uncompahgre Field Office - Alt. D (Preferred)	2028	3,271	2,498	3,327	138	1,118	494
Bird Canyon	2020	658	641	481	5	250	64
Moxa Arch Existing Wells	2018	1,550	19,596	1,178	1	232	79
Moxa Arch Proposed Action New Wells	2018	1,186	1,647	1,776	0	583	124
Moxa Arch Proposed Action ROD Wells	2018	64	166	128	0	30	6
Hiawatha Existing Wells (CO &WY)	2017	318	4,136	352	0	41	9
Hiawatha Proposed Action New Wells (CO & WY)	2017	1,555	919	1,861	1	318	100
Pinedale	**	1,381	2,286	1,250	53	53	79
Jonah	2008	1,099	2,705	686	62	62	28
Total		**24,899**	**72,895**	**32,133**	**545**	**12,712**	**2,768**

Compiled RFD inventories: For some RFD projects, complete project emission inventories were available when the CD-C RFD inventory was compiled (ca. July 2013). However, for other RFD projects, complete project emission inventories were not available. This section presents a discussion of the RFD emission inventories for which complete inventories were not available. RFD emission inventories for use in the CD-C modeling were compiled based on available activity information about the project combined with emission factors taken from oil and gas emissions inventories for similar projects (referred to here as base inventories). For these RFD projects, we assumed a development schedule that distributes all of the planned new wells evenly throughout the life of the project. The inventoried year for these RFD projects was selected based on the year of peak activity, which is generally the last year of drilling, when the number of active wells and the gas/condensate production are at their maximum values over the life of the project. For the base inventory, representative year annual emissions were used to develop per-surrogate emission factors (e.g., tons per well, tons per spud, etc.) for each source category. The representative year was selected based on the proximity to the RFD inventory year, if available, or the projected last year of drilling in the base inventory. Detailed engine fleet data (age, tier level, emissions standards, etc.) from operators was often unavailable for the RFD projects. Hence, it was assumed that the engine fleet mix in the RFD project was equivalent to the engine fleet mix in the base inventory, thus assuming the RFD fleet was not modified and was in compliance with NSPS JJJJ and NONROAD tier standards for diesel engines.

Note that we only included emissions from new project wells as RFD and excluded existing wells, as they are accounted for in the regional O&G inventories. The section below lists assumptions for the inventories compiled from activity data.

Rock Springs (Base inventory: Hiawatha Proposed Action new wells – Year 2031)

- We assumed 100% of wells in the Rock Springs EI are completed using green completion techniques per NSPS Subpart OOOO.
- We assumed individual gas plant emissions will be the same as for the Hiawatha Project gas plant(s).
- We assumed Tier 4 standards for diesel engines.
- We determined that the base inventory, Hiawatha 2031, is in compliance with the WYDEQ 2010 BACT Regulations and NSPS Subpart OOOO. Thus, the Rock Springs RFD is in compliance with WYDEQ BACT and Subpart OOOO.

Moneta Divide (Base Inventory: Gun Barrel-Madden-Iron Horse (GMI) EIS Inventory – Year 2018)

The base inventory for the Moneta Divide Project is the GMI inventory. The GMI Project is an earlier project proposed by the same operators for the region, and there is an existing project emission inventory for GMI. After this inventory was developed, the proponents changed the development plan for the area and renamed the project Moneta Divide.

- According to the Moneta Divide Project description (BLM, 2012a), the proponent, Burlington, plans to build 150 wells within the Madden Deep Unit (MDU), with no more than 10 of those wells accessing the Madison reservoir. We assumed that 10 out of 150 project wells drilled by Burlington would be deep vertical wells with equivalent emissions to MDU vertical wells in the GMI Project. The remaining wells (140) are assumed to be directional, with emissions equivalent to MDU shallow (directionally drilled) wells in the GMI project.
- Based the Moneta Divide Project description and the GMI EIS base inventory, the proponent Encana planned oil and gas operations in the Gun Barrel Unit formation. Hence, we assumed Encana's vertical wells are drilled in the Gun Barrel Unit (GBU) formation and thus have the same emissions as GBU vertical wells in the GMI Project and that directional wells are equivalent to shallow directional wells for GBU.
- According to Moneta Divide Project description, Madden Deep Unit wells will be drilled within a period of 10 to 15 years. We assumed a 10 year period of drilling in order to derive a conservative emission estimate corresponding to the most aggressive potential drilling schedule. Assuming a shorter drilling period gives higher emissions estimates due to the higher annual rate of wells drilled.
- We assumed 100% green completions for both initial well completions and recompletions.
- We assumed that the engine fleet mix will be same as for the GMI 2018 inventory.
- We assumed the fuel sulfur content to be 15 ppm for diesel engines in construction equipment, workover rigs, completion equipment, drill rigs, etc.
- We assumed that central facility and compressor engine emissions will be same as in the GMI EI.
- We determined that the GMI EI was in compliance with the WYDEQ 2010 BACT requirements and NSPS Subpart OOOO. No additional controls were applied.

Bird Canyon RFD Emissions Inventory (Base inventory: LaBarge - Frontier Horizontal wells – Base year 2014)

- According to the Bird Canyon Project description (BLM, 2012b), the new wells for the Bird Canyon Project will be drilled directionally. Thus, we used the Frontier horizontal wells calculation spreadsheet from the LaBarge Project emission inventory to calculate emissions factors. The LaBarge Project emission inventory was used because it is the closest project for which a bottom-up emission inventory was available.
- The LaBarge Project documentation says the LOP will range from 6-10 years. We assumed a six year LOP () in order to derive a conservative emissions estimate based on the most aggressive possible drilling schedule.
- The draft plan of development for the LaBarge Project suggests that the majority of well pads planned are to be multi-well pads, so we used the emission factor (EF) for multi-well pads from the LaBarge inventory.
- Emissions from sources controlled by flaring in the LaBarge inventory (condensate tanks, pneumatic pumps and dehydrators) were segregated into separate flaring and venting/leaks emissions source categories so that an appropriate emissions factor could be applied to each category.
- 100% of the completion emissions in the base inventory were controlled by flaring. WYDEQ 2010 BACT and NSPS Subpart OOOO require a combination of green completion and flaring for project wells completed after 2015. Since the Bird Canyon RFD inventory year is 2019, it was assumed that 95 % of venting emissions are captured (instead of flared) and only 5% of completion emissions are flared.
- We determined that the LaBarge emissions are in compliance with the WYDEQ 2010 BACT, EPA Diesel Fuel Standards and NSPS Subpart OOOO for all source categories. Hence, it is assumed the Bird Canyon inventory is also in compliance.

Adjusting LSFO emissions estimates: The Little Snake Field Office (LSFO) RMP area overlaps with the Hiawatha Project Area boundary. Figure 2-17 below delineates the spatial overlap. After reviewing the LSFO AQTSD and spatial allocation data received from BLM, ENVIRON determined that the LSFO RMP includes emissions from the Hiawatha project area. As a result, there is a potential double counting of emissions because Hiawatha was included as a separate project. Therefore, the LSFO RMP emissions estimates were adjusted to remove Hiawatha emissions. This was accomplished by using LSFO spatial distribution information provided by BLM. BLM developed the 4 km spatial distribution data based on the 2011 oil and gas activity for each western Colorado BLM field offices. The sums of grid cell fraction that overlap the Hiawatha Project Area were removed from the LSFO emission inventory to avoid double counting.

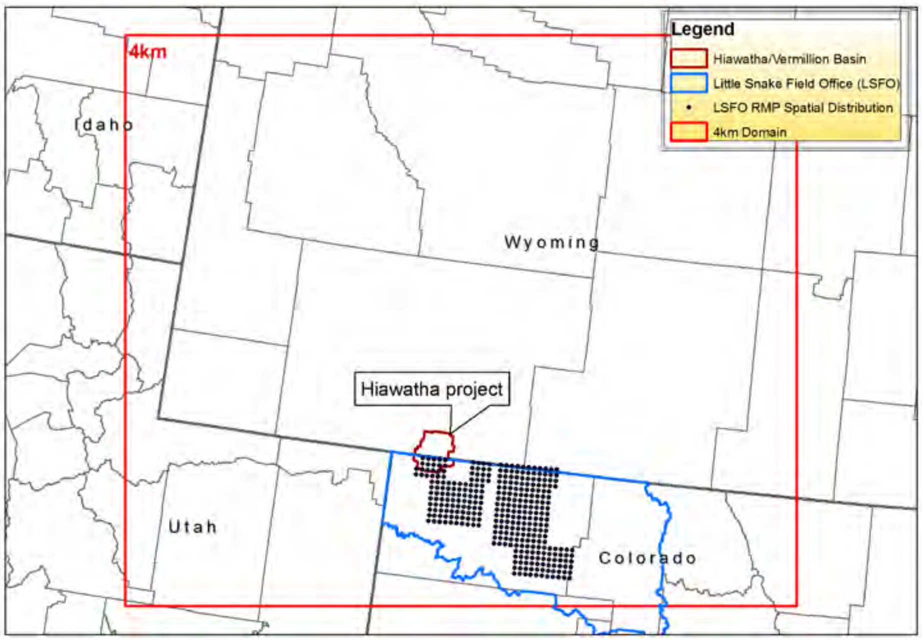

Figure 2-17. Spatial overlap of the LSFO RMP and Hiawatha RFD project areas.

2.2.3.3 Other Future Year O&G Emissions

A future year inventory was required for other O&G sources outside the CD-C Project Area that are not part of the RFD inventory but operate within the 12 km domain. For these O&G sources, the WRAP Phase III "midterm" projections were used where available. Where WRAP Phase III inventories were not available and the O&G sources were within Wyoming the emissions were held constant at 2008 baseline levels, which is equivalent to assuming that the effects of future growth and controls cancel one another. This is considered to be a conservative assumption because the Wyoming 2008 baseline inventory represents the peak oil and gas activity before the subsequent economic downturn and fall in natural gas prices. Where WRAP Phase III inventories were not available and the O&G sources were outside of Wyoming, the 2018 WRAP Phase II O&G inventory was used. A map of the basins for which WRAP Phase III emissions inventories were available is shown in Appendix G.

Wyoming Non-Permitted Sources

In the preparation of the 2022 future year oil and gas inventory, Wyoming oil and gas emissions were held constant at their 2008 levels. These non-permitted source emissions were obtained from Carter Lake and BP estimates for the 2008 baseline inventory. Carter Lake and BP prepared a detailed 2008 emission inventory for oil and gas sources in the 5-county area of southwest Wyoming that is similar in nature and scope to the 2005-2006 southwest Wyoming oil and gas inventory used in the CD-C base case modeling. The 2008 5-county southwest Wyoming inventory was developed using the oil and gas emissions information available from the state of Wyoming and from Operator-provided emissions assumptions. For oil and gas sources in Wyoming outside the 5-county area of southwest Wyoming, emissions were developed from the Wyoming 2008 point source inventory supplied by the WDEQ-AQD. Well VOC emissions outside the 5-County area were calculated by Carter Lake. In the Rock Spring field office area, the 2008 baseline inventory was adjusted to account for the well decline and abandonment on the 2008 wells for future year emissions projections. The well decline and abandonment was applied as was done for the CD-C project emission inventory.

Wyoming Permitted Sources

All Wyoming permitted oil and gas sources were modeled as point sources; this includes compressor engines, production sites, drill rigs, and gas plant and compressor station sources. In Wyoming, emissions for large facilities, such as compressor stations and gas plants, were obtained from the WYDEQ 2008 permit database.

WRAP Oil and Gas Inventories: Non-Permitted Sources

ENVIRON has developed region-wide oil and gas emissions estimates for the Rocky Mountain region as part of Western Regional Air Partnership (WRAP) projects. The emissions were compiled for the oil and gas (O&G) exploration and production source sector and do not include downstream oil and gas emissions (e.g., refining and natural gas transmission & distribution). Tables 2-7 provides list of the WRAP oil and gas basins and summarize source of information.

Table 2-7. List of WRAP oil and gas basins and inventory sources.

O&G Basins	Source	
	Area	Point
D-J basin	2015 CDPHE Projected*	2015 CDPHE Projected*
Piceance basin	2015 CDPHE Projected*	2015 CDPHE Projected*
Uinta basin	2012 WRAP Phase III*	2012 WRAP Phase III*
SW Wyoming	BP/SAGE 2008	WYDEQ 2008
Powder River	2015 WRAP Phase III	2015 WRAP Phase III
Wind River	2012 WRAP Phase III	2012 WRAP Phase III
North San Juan basin	2012 WRAP Phase III*	2012 WRAP Phase III*
South San Juan basin	2012 WRAP Phase III*	2012 WRAP Phase III*
Rest of the western US (WRAP)	2018 WRAP Phase II*	WRAP PRP18b*

* = Projections made before 2008/2009 economic and natural gas downturn
2015/2020 CDPHE Projected based on 2006 WRAP Phase III O&G EI projected using Norwest (2009) projection factors
Good agreement between BP/SAGE 2008 and WRAP Phase III 2008 O&G EI

For the 2022 future year modeling, the oil and gas emissions were obtained from the WRAP Phase III inventories in the basins covered by the WRAP Phase III inventory and from 2018 WRAP Phase II inventories elsewhere. The WRAP Phase III midterm inventories for above basins were available at the time of the modeling. The WRAP Phase III emission inventory is described in Appendices F and G.

WRAP Oil and Gas Inventories: Permitted Sources

In Colorado (i.e. Piceance & D-J Basins) - small compressor engines, compressor station and gas plants were included in the point source inventory because of Colorado's requirement that sources with NOX emissions greater than 2 tpy report emissions to the State. In other states, compressor station and gas plants were included in the point inventory. O&G point source emissions outside of Wyoming and WRAP Phase III basins were obtained from the WRAP PRP18b inventory.

Reasonably Foreseeable Future Actions (RFFA)

Previous EIS analyses quantified and tracked sources categorized as Reasonably Foreseeable Future Actions (RFFA). RFFA were defined as sources with unexpired permits that were not yet operating within the baseline year defined for modeling. Since the WRAP 2018 emission inventories are based on future projections of source emissions that are not yet operating, the RFFA source category is not necessary for purposes of this EIS because these sources are already included in the WRAP 2018 inventory.

2.3 SMOKE PROCESSING OF EMISSION INVENTORIES

Once emission inventories are compiled, they require processing by an emissions model to convert them into a format suitable for photochemical modeling. CAMx requires emissions of NO_X, VOC, SO_2, CO and PM and its precursors from all sources within the modeling domain as well as those transported from outside of the modeling domain through boundary conditions (BCs). Emissions are typically provided as either county-level area sources or point sources.

The Sparse Matrix Operating Kernel Emissions (SMOKE; Coats, 1996a; Coats and Houyoux, 1996b) emissions modeling system (available from http://www.cmascenter.org/) was used to generate model-ready emissions inputs for CAMx. Model-ready emissions are typically specified at hourly time increments, spatially allocated onto the modeling grid at the model grid cell resolution, and chemically speciated into individual chemical species. SMOKE was used in the WRAP, VISTAS and CENRAP RPO regional haze modeling and for the Denver 8-hour ozone SIP modeling and the Four Corners Air Quality Task Force modeling. For the CD-C photochemical modeling, SMOKE was used to generate model-ready emissions inputs for area, off-road mobile, onroad mobile and point sources for both base years (2005 and 2006) and the 2008 baseline year as well as the 2022 future year.

CAMx requires two types of emissions input files:

1. Surface level emissions from area, mobile, off-road, low-level point and biogenic sources. These are gridded for the CAMx nested grid system which means that separate surface emissions files are required for the 36 km, 12 km and 4 km grids. The surface emissions are injected into the lowest layer of the model.
2. Elevated emissions from major point sources. These are injected into CAMx at the coordinates of each source, and the plume rise for each source is calculated by CAMx from stack parameters using hourly meteorology so that the emissions are injected into the appropriate vertical layer.

The emissions model must perform several tasks:

Temporal Adjustments: Adjusts emission rates for seasonal, day-of-week and hour-of-day effects.

Chemical Speciation: Emission estimates for total VOC are converted to the more detailed chemical speciation used by the Carbon Bond 5 (CB05; Yarwood et al., 2005) chemical mechanism in CAMx. Total unspeciated NO_X emissions are allocated to NO and NO_2

components. Particulate Matter (PM) is allocated to coarse PM, nitrate, sulfate, organic carbon, elemental carbon, and other fine particulates.

Gridding: The spatial resolution of the emissions must be matched to the CAMx grid(s). Area and non-road mobile sources are estimated at the county level, and are allocated to the grid cells within each county based on spatial surrogates (e.g., population, land use categories and economic activity). On-road mobile source emissions are also allocated to grid cells using spatial surrogates based on roadway locations and population. The EPA has developed spatial surrogates for emission inventory development (ftp://ftp.epa.gov/EmisInventory/emiss_shp/). These data are based on USGS LULC (Land Use/Land Cover) data and the 1990 US Census. The GIS-based spatial surrogate database developed by the EPA from USGS LULC data and 1990 Census was gridded at a spatial resolution of 4 km for the RPO LCP modeling domain and used as the basis for the gridding surrogates. These surrogates include the most current EPA revisions, dated April 2004 (http://www.epa.gov/ttn/chief/emch/spatial/newsurrogate.html)

Growth and Controls: Emissions estimated for a particular year may need to be adjusted for use in a different year.

Quality Assurance (QA): SMOKE includes QA and reporting features to keep track of the adjustments at each processing stage and ensure that data integrity is not compromised.

The outputs from the emissions model are called the “model-ready” emissions, and are day-specific, gridded, speciated, and temporally (hourly) allocated. SMOKE performs all of the processing steps for the anthropogenic emissions. The biogenic emissions were prepared using a different model (MEGAN, discussed below) because they are based on different input data and have specialized processing requirements (e.g., dependence on temperature, solar radiation and drought conditions).

Emissions for different major source groups (e.g., on-road mobile, off-road mobile, area, point and biogenic) are processed separately and merged together prior to CAMx modeling. This simplifies the processing and assists quality assurance (QA) and reporting tasks as well as preparing the inventory for use with the CAMx source apportionment tools.

For the surface emissions, a separate emission inventory is required for each CAMx grid nest, (i.e., three inventories for the 36/12/4 km grid domains). For elevated point sources, a single emission inventory is prepared covering all grid nests because exact point coordinates are used to inject emissions into the grids and the coordinates of the points do not depend of the grids. The emissions data sources and processing are described separately below for surface and elevated sources.

2.3.1 SMOKE Modeling of Regional Emission Inventory

For both the CD-C Proposed Action Alternative and the No Action Alternative, the year of highest NOx emissions over the LOP is estimated to be 2022. Hence, 2022 was selected as the future-year for modeling. The MOBILE6 module of SMOKE was used to develop the on-road mobile source emissions. For the 2008 baseline and 2022 future-year simulations using 2005 and 2006 meteorology, the corresponding 2005 and 2006 base case emission inventories for wildfires, wind-blown dust, biogenics, and ammonia were used.

2.3.1.1 Summary of On-road Emissions Modeling

The MOBILE6 parameters, vehicle fleet descriptions, and vehicle miles travelled (VMT) estimates were combined with gridded, episode-specific temperature data to obtain the gridded, temporally allocated emission estimates for weekday, Saturday, and Sunday. VMT, along with other required MOBILE6 inputs (average speed, fuel parameters, and control programs) were obtained from the WRAP 2018 modeling. 2005 and 2006 MM5 meteorological data were then used with the SMOKE-MOBILE6 processor to generate the gridded speciated day-of-week emissions required as input to CAMx. For each month, emissions were generated for a representative weekday, Saturday and Sunday. Holidays were treated as Sundays.

2.3.1.2 Summary of Area and Non-Road Emission Modeling

This category comprises stationary sources that are not identified as individual points and so are treated as being distributed over a specified area (usually a county). Examples of stationary area sources include (but are not limited to) residential emissions, fugitive dust, and road dust. Although oil and gas exploration and production sources are often included as part of an area source inventory, they are treated as a separate source category in this study. The 2005 and 2006 base year area source emissions were projected from the 2002 WRAP Plan D inventory. The 2008 baseline emissions were interpolated from the 2002 WRAP Plan D and 2018 WRAP PRP18b inventories. For the 2022 future year modeling, non-O&G area sources and off-road mobile were obtained from the most recent WRAP 2018 (PRP18b) emission inventories at the time of modeling. SMOKE ancillary files from 2018 WRAP modeling were used for speciation, spatial & temporal allocation.

All area source emissions (except oil and gas production) were temporally allocated to a specific month, day, and hour using their annual emissions and allocation factors based on their source category code (SCC). These factors were based on the cross-reference and profile data supplied with the WRAP SMOKE setup. Area sources were spatially allocated in the domain using SCC-based spatial allocation factor files. If an area source SCC did not have an existing cross-reference profile assigned to it, the county-level emissions were allocated by population density in that county.

A crustal PM transport factor has been applied to fugitive dust emission sources that have been identified in U.S. EPA modeling to have only a portion of their mass transported from the source of the emission generation. The EPA's studies (Pace, 2003; 2005) indicate that 60 to 90 percent of PM emissions from fugitive dust sources do not reach an elevated level necessary for transport and are deposited near the source. For this reason, the county-specific fugitive dust emissions transport factors have been applied to these sources to adjust PM emissions prior to the SMOKE modeling. This procedure is consistent with the WRAP fugitive dust inventory. Information on planned dust suppression efforts was provided by several Wyoming Counties and suppression of fugitive dust emissions was accounted for in the regional emission inventory.

Off-road mobile sources include, for example, railroad locomotives, aircraft, commercial marine vessels, farm equipment, recreational boating, and lawn and garden equipment. The 2005 and 2006 base year emissions were interpolated from the WRAP 2002 and 2018 inventories. The off-road mobile source emissions were temporally and spatially allocated in the same manner as the area source emissions.

The marine shipping emissions were held constant from WRAP 2002 inventory, which was estimated using the Waterway Network Ship Traffic, Energy and Environment Model (STEEM) to characterize ship traffic, estimate energy use and assess the environmental impacts of shipping (Corbett et al., 2006).

2.3.1.3 Summary of Oil and Gas Emission Modeling

All wells within Wyoming were modeled as point sources: there are no gridded oil and gas emissions within Wyoming. All Wyoming permitted oil and gas sources were modeled as point sources; this includes compressor engines, production sites, drill rigs, and gas plant and compressor station sources. The WRAP non-permitted inventories were spatially allocated in the domain using SCC-based spatial allocation factor files and temporally allocated using flat temporal profiles. SMOKE ancillary files from the 2008 baseline emissions modeling were used for speciation, spatial & temporal allocation.

2.3.1.5 Summary of non-SMOKE Emissions Modeling for Other Regional Emissions Source Categories

Biogenic Emissions

Biogenic emissions were modeled using the Model of Emissions of Gases and Aerosols from Nature (MEGAN) version 2.03 with modifications made by ENVIRON (Guenther et al, 2006; Guenther and Wiedinmyer, 2007; Mansell et al, 2007). MEGAN was used to prepare gridded hourly biogenic emission inventories suitable for input to CAMx. MEGAN is the latest biogenic emissions model developed by researchers from the National Center for Atmospheric Research (NCAR) and incorporates the full range of ozone and PM precursor species. MEGAN accounts for the spatial variability of biogenic emissions through the use of high resolution estimates of vegetation type and quantity. MEGAN requires as input weather data, Leaf Area Index (LAI), plant functional type (PFT) cover and compound-specific emission factors that are based on plant species composition. All of these variables are provided in a geo-referenced gridded database in several formats (e.g., netcdf, ESRI GRID). The inputs to MEGAN model are:

- Landcover: The land cover available in MEGAN database has global coverage at 30 sec (~ 1km) spatial resolution (Guenther et al, 2006).
- Surface Temperature Data: Gridded, hourly temperature fields were extracted from 2005 and 2006 MM5 predictions for each day for each grid cell.
- Photosynthetically active radiation (PAR): The PAR data represents the intensity of solar radiation in the spectral range that is used by plants for the photosynthesis process. The PAR data were downloaded from the University of Maryland (UMD; 2006) and a FORTRAN program was used to reformat the data. Some of the PAR data were missing. As part of the QA process, the PAR data were inspected, and the missing data were replaced by interpolating the missing data between hours with available data.

Day-specific hourly biogenic emissions were generated for all grid domains for the 2005 and 2006 base years.

Wildfire Emissions

For the 2005 and 2006 calendar years, ENVIRON received estimates of fire emissions from the National Center for Atmospheric Research (NCAR). These emission estimates are derived from analysis of fire locations determined by satellite-borne detectors. The MODerate-resolution Imaging Spectroradiometer (MODIS) instruments fly aboard two polar-orbiting satellites, Terra, and Aqua. These two satellites orbit the Earth, traveling from pole to pole while the earth rotates beneath them; a given area of the Earth will have an overpass from Terra and Aqua approximately twice a day. MODIS instruments detect fires as thermal anomalies (i.e. hot spots seen against a cooler background) at a spatial resolution of about 1 kilometer. Fire emissions derived from the MODIS data include NO_X, CO, VOC and PM species, along with other compounds (e.g., Hg). The NCAR fire emissions inventory development is described by Wiedinmyer and co-workers (2006) and Wiedinmyer and Friedli (2007).

The NCAR satellite-derived fire emissions data for 2005 and 2006 contain daily emissions location, acreage burned, and fuel loading at a resolution of 1 km^2, representing the size of each satellite pixel. SMOKE does not have the capability to handle this type of inventory; therefore, the fire inventory was processed using the Emissions Processing System version 3 (EPS3). Similar to SMOKE, the EPS model can perform the intensive data manipulations required to incorporate spatial, temporal, and chemical resolution into an emissions inventory used for photochemical modeling. Additional detail on the fire emissions modeling is given in Appendix G.

2.3.2 SMOKE Modeling of CD-C Project Emission Inventory

CD-C Project emissions were processed through SMOKE to prepare model-ready emissions for CAMx. The emissions were speciated into CB05 lumped species, temporally allocated into hourly flux and spatially distributed throughout the CD-C project area. The CD-C Project emissions inventory was estimated for three separate source groups: (1) Proposed Action Alternative; (2) No Action Alternative; and (3) Existing. The existing source group consists of existing wells, gas plants and compressor stations. The Proposed Action Alternative and No Action Alternative consist of new wells and other facilities that are proposed to be constructed as part of the CD-C Project.

These emissions were processed separately into three source categories to facilitate source apportionment. The three source categories include:

1. Drill Rigs;
2. Compressor Engines (including compressor station);
3. Production sources including:
    a) Heaters
    b) Gas processing plants
    c) Flashing
    d) Venting
    e) Fugitives

f) Dehydrators

g) Pneumatic pumps

h) Traffic Construction & Production

i) Workover Rigs (used to restore or increase well production)

All the project emissions sources, including individual wells, were modeled as point sources. The first step in emissions processing was to assign appropriate WRAP Phase III source category codes (SCCs) to all source categories in the project emissions inventory. Table 2-8 below provides list of sources categories and SCC assignments.

Table 2-8. Source categories and SCC assignments.

Source Categories	SCC	SCC Description
Drilling Equip (diesel ICE)	2310000110	Industrial Processes, Oil and Gas Production, All Processes, Drill Rigs
Completion Equipment (diesel ICE)	2310000110	Industrial Processes, Oil and Gas Production, All Processes, Drill Rigs
Initial Completion Venting	2310023200	Industrial Processes, Oil and Gas Production, CBM, Venting - Initial Completions
Drilling Traffic (LD)	2201020000	Mobile Sources, Highway Vehicles - Gasoline, Light Duty Gasoline Trucks 1 & 2 (M6) = LDGT1 (M5), Total: All Road Types
Drilling Traffic (HD)	2230070000	Mobile Sources, Highway Vehicles - Diesel, All HDDV including Buses (use subdivisions -071 thru -075 if possible), Total: All Road Types
Drilling Traffic (LD) Dust	2296000000	Mobile Sources, Unpaved Roads, All Unpaved Roads, Total: Fugitives
Drilling Traffic (HD) Dust	2296000000	Mobile Sources, Unpaved Roads, All Unpaved Roads, Total: Fugitives
Completion Traffic (LD)	2201020000	Mobile Sources, Highway Vehicles - Gasoline, Light Duty Gasoline Trucks 1 & 2 (M6) = LDGT1 (M5), Total: All Road Types
Completion Traffic (HD)	2230070000	Mobile Sources, Highway Vehicles - Diesel, All HDDV including Buses (use subdivisions -071 thru -075 if possible), Total: All Road Types
Completion Traffic (LD) Dust	2296000000	Mobile Sources, Unpaved Roads, All Unpaved Roads, Total: Fugitives
Completion Traffic (HD) Dust	2296000000	Mobile Sources, Unpaved Roads, All Unpaved Roads, Total: Fugitives
Well Pad Const Equip (diesel ICE)	2310000110	Industrial Processes, Oil and Gas Production, All Processes, Drill Rigs
Construction Dust, Fugitive	2311000060	Industrial Processes, Construction: SIC 15 - 17, All Processes, Construction
Construction Dust, Wind Erosion	2311000100	Industrial Processes, Construction: SIC 15 - 17, All Processes, Wind Erosion
Construction Traffic, Road and Well pad (LD)	2201020000	Mobile Sources, Highway Vehicles - Gasoline, Light Duty Gasoline Trucks 1 & 2 (M6) = LDGT1 (M5), Total: All Road Types
Construction Traffic, Road and Well pad (HD)	2230070000	Mobile Sources, Highway Vehicles - Diesel, All HDDV including Buses (use subdivisions -071 thru -075 if possible), Total: All Road Types
Construction Traffic, Road and Well pad (LD) Dust	2296000000	Mobile Sources, Unpaved Roads, All Unpaved Roads, Total: Fugitives

Source Categories	SCC	SCC Description
Construction Traffic, Road and Well pad (HD) Dust	2296000000	Mobile Sources, Unpaved Roads, All Unpaved Roads, Total: Fugitives
Workover Equipment (diesel ICE)	2310000120	Industrial Processes, Oil and Gas Production, All Processes, Workover Rigs
WorkoverTraffic (LD)	2201020000	Mobile Sources, Highway Vehicles - Gasoline, Light Duty Gasoline Trucks 1 & 2 (M6) = LDGT1 (M5), Total: All Road Types
WorkoverTraffic (HD)	2230070000	Mobile Sources, Highway Vehicles - Diesel, All HDDV including Buses (use subdivisions -071 thru -075 if possible), Total: All Road Types
WorkoverTraffic (LD) Dust	2296000000	Mobile Sources, Unpaved Roads, All Unpaved Roads, Total: Fugitives
WorkoverTraffic (HD) Dust	2296000000	Mobile Sources, Unpaved Roads, All Unpaved Roads, Total: Fugitives
Well Stream Fugitive Devices	2310020700	Industrial Processes, Oil and Gas Production, Natural Gas, Fugitives
Gas Stream Fugitive Devices	2310020700	Industrial Processes, Oil and Gas Production, Natural Gas, Fugitives
Condensate Fugitive Devices	2310020710	Industrial Processes, Oil and Gas Production, Natural Gas Liquid, Fugitives
Pneumatic Devices	2310023800	Industrial Processes, Oil and Gas Production, CBM, Pneumatic Devices
Heaters	2310024110	Industrial Processes, Oil and Gas Production, Natural Gas, Heaters – Tanks
Heaters	2310024120	Industrial Processes, Oil and Gas Production, Natural Gas, Heaters - Separator & Dehy reboiler
Pneumatic Pumps	2310020900	Industrial Processes, Oil and Gas Production, Natural Gas, Pneumatic Pumps
Well Venting	2310020400	Industrial Processes, Oil and Gas Production, Natural Gas, Venting – Blowdowns
Condensate Tank Flashing Losses	2310030310	Industrial Processes, Oil and Gas Production, Natural Gas Liquids, Tanks – Flashing
Condensate Tank Working Losses	2310030320	Industrial Processes, Oil and Gas Production, Natural Gas Liquids, Tanks - Standing/Working/Breathing
Condensate Tank Breathing Losses	2310030320	Industrial Processes, Oil and Gas Production, Natural Gas Liquids, Tanks - Standing/Working/Breathing
Tank Loadout (vapor losses)	2310030320	Industrial Processes, Oil and Gas Production, Natural Gas Liquids, Tanks - Standing/Working/Breathing
Production Traffic (LD)	2201020000	Mobile Sources, Highway Vehicles - Gasoline, Light Duty Gasoline Trucks 1 & 2 (M6) = LDGT1 (M5), Total: All Road Types
Production Traffic (HD)	2230070000	Mobile Sources, Highway Vehicles - Diesel, All HDDV including Buses (use subdivisions -071 thru -075 if possible), Total: All Road Types
Production Traffic, Central Facility (HD)	2230070000	Mobile Sources, Highway Vehicles - Diesel, All HDDV including Buses (use subdivisions -071 thru -075 if possible), Total: All Road Types
Production Traffic (LD) Dust	2296000000	Mobile Sources, Unpaved Roads, All Unpaved Roads, Total: Fugitives
Production Traffic (HD) Dust	2296000000	Mobile Sources, Unpaved Roads, All Unpaved Roads, Total: Fugitives
Production Traffic, Central Facility (HD) Dust	2296000000	Mobile Sources, Unpaved Roads, All Unpaved Roads, Total: Fugitives
Condensate Tank Flashing	2310024300	Industrial Processes, Oil and Gas Production, Natural Gas,

Source Categories	SCC	SCC Description
Flaring		Condensate Tank Flaring
Condensate Tank Working Flaring	2310024300	Industrial Processes, Oil and Gas Production, Natural Gas, Condensate Tank Flaring
Condensate Tank Breathing Flaring	2310024300	Industrial Processes, Oil and Gas Production, Natural Gas, Condensate Tank Flaring
Evaporation Ponds	31088811	Industrial Processes, Oil and Gas Production, Fugitive Emissions, Fugitive Emissions
Dehydrator Venting - Well Site	2310020100	Industrial Processes, Oil and Gas Production, Natural Gas, Dehydrators
Compressor Station (Reciprocating Engine Rich Burn)	20200253	Internal Combustion Engines, Industrial, Natural Gas, 4-cycle Rich Burn
Compressor Station (Reciprocating Engine Lean Burn)	20200254	Internal Combustion Engines, Industrial, Natural Gas, 4-cycle Lean Burn
Compressor Station (Turbine)	20200201	Internal Combustion Engines, Industrial, Natural Gas, Turbine
Compressor Station (Venting)	2310020500	Industrial Processes, Oil and Gas Production, Natural Gas, Venting - Compressor Startup
Compressor Station (External NG Combustion)	31000404	Industrial Processes, Oil and Gas Production, Process Heaters, Natural Gas
Compressor Station (Flashing)	2310030310	Industrial Processes, Oil and Gas Production, Natural Gas Liquids, Tanks – Flashing
Compressor Station (Working/Breathing)	2310030320	Industrial Processes, Oil and Gas Production, Natural Gas Liquids, Tanks - Standing/Working/Breathing
Compressor Station (Flaring)	31000205	Industrial Processes, Oil and Gas Production, Natural Gas Production, Flares
Gas Plant (Reciprocating Engine)	20200202	Internal Combustion Engines, Industrial, Natural Gas, Reciprocating
Gas Plant (Turbine)	20200201	Internal Combustion Engines, Industrial, Natural Gas, Turbine
Gas Plant (flaring)	31000205	Industrial Processes, Oil and Gas Production, Natural Gas Production, Flares
Gas Plant (natural gas external combustion (boiler/heater))	31000404	Industrial Processes, Oil and Gas Production, Process Heaters, Natural Gas
Gas Plant (venting)	2310020500	Industrial Processes, Oil and Gas Production, Natural Gas, Venting - Compressor Startup

Spatial Allocation: The project emissions were spatially distributed through the CD-C Project Area assuming new wells will be co-located with existing wells. This was based on information received from CD-C Operators that new wells will be drilled in close proximity to existing wells. No gridding surrogates were necessary since all the project emissions were modeled as point sources.

Speciation: Project area-specific VOC composition profiles were used to the fullest extent possible, rather than the SMOKE default VOC speciation that is cross-referenced by SCC category. VOC speciation profiles were prepared using Operator-provided gas composition analyses of produced gas, condensate and flashing gas for SMOKE processing. These project area-specific VOC profiles were used for those source categories that relied on estimates of volume of gas vented or leaked (i.e. blowdowns, completions, and fugitive emissions). EPA SPECIATE database profiles were used for all other categories. Table 2-9 below provides the linkage between source categories and speciation profiles.

Table 2-9. CD-C project emissions speciation cross reference.

CD-C project EI Source Categories	Profile #	VOC Speciation Profile
Drilling Equip (diesel ICE)	4674	SPECIATE4, Profile 4674
Completion Equipment (diesel ICE)	4674	SPECIATE4, Profile 4674
Initial Completion Venting	WAM01	Wamsutter Produced Gas Composition
Drilling Traffic (LD)	1101	SPECIATE4, Profile 1101
Drilling Traffic (HD)	1201	SPECIATE4, Profile 1201
Completion Traffic (LD)	1101	SPECIATE4, Profile 1101
Completion Traffic (HD)	1201	SPECIATE4, Profile 1201
Well Pad Const Equip (diesel ICE)	4674	SPECIATE4, Profile 4674
Construction Traffic, Road and Well pad (LD)	1101	SPECIATE4, Profile 1101
Construction Traffic, Road and Well pad (HD)	1201	SPECIATE4, Profile 1201
Workover Equipment (diesel ICE)	4674	SPECIATE4, Profile 4674
WorkoverTraffic (LD)	1101	SPECIATE4, Profile 1101
WorkoverTraffic (HD)	1201	SPECIATE4, Profile 1201
Well Stream Fugitive Devices	WAM01	Wamsutter Produced Gas Composition
Gas Stream Fugitive Devices	WAM01	Wamsutter Produced Gas Composition
Condensate Fugitive Devices	WAM02	Wamsutter Condensate Composition (Post Flash)
Pneumatic Devices	WAM01	Wamsutter Produced Gas Composition
Heaters	0003	SPECIATE4, Profile 0003
Pneumatic Pumps	WAM01	Wamsutter Produced Gas Composition
Well Venting	WAM01	Wamsutter Produced Gas Composition
Condensate Tank Flashing Losses	WAM03	Flash speciation from Wamsutter HYSYS
Condensate Tank Working Losses	WAM02	Wamsutter Condensate Composition (Post Flash)
Condensate Tank Breathing Losses	WAM02	Wamsutter Condensate Composition (Post Flash)
Tank Loadout (vapor losses)	WAM02	Wamsutter Condensate Composition (Post Flash)
Production Traffic (LD)	1101	SPECIATE4, Profile 1101
Production Traffic (HD)	1201	SPECIATE4, Profile 1201
Production Traffic, Central Facility (HD)	1201	SPECIATE4, Profile 1201
Condensate Tank Flashing Flaring	0051	SPECIATE4, Profile 0051
Condensate Tank Working Flaring	0051	SPECIATE4, Profile 0051
Condensate Tank Breathing Flaring	0051	SPECIATE4, Profile 0051
Compressor Station (Reciprocating Engine Rich Burn)	1001	SPECIATE4, Profile 1001
Compressor Station (Reciprocating Engine Lean Burn)	1001	SPECIATE4, Profile 1001
Compressor Station (Turbine)	0007	SPECIATE4, Profile 0007
Compressor Station (Venting)	WAM01	Wamsutter Produced Gas Composition
Compressor Station (External NG Combustion)	0003	SPECIATE4, Profile 0003
Compressor Station (Flashing)	WAM03	Flash speciation from Wamsutter HYSYS
Compressor Station (Working/Breathing)	WAM02	Wamsutter Condensate Composition (Post Flash)
Compressor Station (Flaring)	0051	SPECIATE4, Profile 0051
Gas Plant (Reciprocating Engine)	1001	SPECIATE4, Profile 1001
Gas Plant (Turbine)	0007	SPECIATE4, Profile 0007
Gas Plant (flaring)	0051	SPECIATE4, Profile 0051
Gas Plant (natural gas external combustion (boiler/heater))	0003	SPECIATE4, Profile 0003
Gas Plant (venting)	WAM01	Wamsutter Produced Gas Composition
Dehydrator Venting - Well Site	WAM01	Wamsutter Produced Gas Composition

<u>Temporal</u>: Flat (i.e. non-varying) temporal profiles were assumed for all source categories except heaters. Heater emissions were divided into tank and separator/dehydrator heaters to temporally allocate them separately. Tank heater emissions were allocated to winter months only whereas separator heater emissions were allocated using flat temporal profiles. A maximum drilling intensity scenario was modeled in which all rigs were assumed to be active throughout the year.

The project emissions for the CD-C Proposed Action Alternative Sources, No Action Alternative Source and Existing Sources are summarized in Table 2-10. This emission table was compiled from SMOKE output reports and represents the model-ready emission inputs.

Table 2-10. CD-C Project emission summary for year 2022 (tpy).

Source Grouping	Compressor	Production	Spuds
NO_X			
CD-C Proposed Action - Existing Sources	1,058	704	0
CD-C No Action - New Sources	133	1,336	690
CD-C Proposed Action - New Sources	294	2,943	1,520
CO			
CD-C Proposed Action - Existing Sources	1,027	830	0
CD-C No Action - New Sources	174	3,256	482
CD-C Proposed Action - New Sources	383	7,171	1,062
TOG			
CD-C Proposed Action - Existing Sources	1,755	230,793	0
CD-C No Action - New Sources	45	29,259	50
CD-C Proposed Action - New Sources	99	64,448	109
SO_2			
CD-C Proposed Action - Existing Sources	2	0	0
CD-C No Action - New Sources	0	0	0
CD-C Proposed Action - New Sources	0	1	1
$PM_{2.5}$			
CD-C Proposed Action - Existing Sources	74	80	0
CD-C No Action - New Sources	15	167	25
CD-C Proposed Action - New Sources	33	368	55

2.4 EMISSION SUMMARY TABLES FOR FAR-FIELD MODELING

Tables 2-11 through 2-16 summarize the emission inventories for the 4 km modeling domain. The tables contain emissions for all portions of Wyoming, Colorado, Utah, and Idaho that are within the 4 km modeling domain. The tables were produced from the SMOKE model output and report the model-ready emissions for each area and emissions source category. Emissions tables were prepared for 2008, 2022 and the difference between the 2022 future year and 2008 baseline inventories (2022-2008). For each year and for the 2022-2008 difference, we report emissions for both the 2005 and 2006 meteorological years. This is necessary because some emissions categories depend on the calendar year and/or its meteorological conditions. Biogenic emissions, for example, depend on the temperature and insolation at a given grid cell on a given day and annual totals are therefore year-specific. Actual fire emissions for the years 2005 and 2006 were used in both the 2008 and 2022 emissions scenarios. On-road motor vehicle emissions are affected by day of week and temperature and vary between the 2005 and 2006 meteorological years.

In Tables 2-15 and 2-16, there are only zero entries for the 2022-2008 change in biogenic or fire emissions because the 2005 and 2006 actual emissions were used in both 2008 and 2022 emission scenarios. The only trona facilities in the 4 km grid are located in Wyoming; therefore, trona emissions for Colorado, Idaho and Utah are zero.

On-road mobile emissions show decreases for all pollutants in all areas between 2008 and 2022 due to increasingly stringent emissions controls with time (i.e., fleet turnover). Non-road emissions also decline for all areas for all pollutants except CO. This occurs because of the implementation of non-road engine tier standards that require increasingly cleaner-burning engines as fleet turnover occurs. Non-oil and gas area source emissions increase for all pollutants within Wyoming going from 2008 to 2022, except $PM_{2.5}$. NO_X and TOG emissions increase for non-oil and gas area source emissions for all four states in 2022 relative to 2008. This is reasonable, because area source emissions are often projected using population changes as a surrogate. 2008 to 2022 changes in EGU emissions and non-EGU (NEGU) point source emissions vary by state and pollutant.

Table 2-11. Regional emissions summary table for 2008met05 (tpy).

STATE	Source Category						
	Oil and Gas	Area	Onroad	Offroad	EGU	NEGU	Natural
CO							
Colorado	1,029	2,448	18,082	7,931	1,356	58	12,277
Idaho	263	487	2,563	4,545	0	10,909	23,477
Utah	18,383	1,974	19,482	12,212	426	645	20,297
Wyoming	12,314	13,842	71,563	36,344	3,338	17,374	26,789
NOx							
Colorado	1,712	152	1,730	1,245	28,689	86	632
Idaho	1,282	340	300	675	0	1,932	927
Utah	11,490	214	1,920	1,771	7,209	1,130	655
Wyoming	21,636	7,135	8,560	19,095	38,528	14,813	1,229
TOG							
Colorado	77,019	1,608	1,390	1,703	137	267	53,123
Idaho	547	3,895	207	1,458	0	10	32,887
Utah	410,056	2,015	1,430	3,533	64	2,057	13,954
Wyoming	1,127,405	18,564	5,755	5,816	1,079	22,735	81,173
PM_{10}							
Colorado	62	10,626	48	135	410	3,852	320
Idaho	0	9,359	9	96	0	469	1,950
Utah	442	7,454	55	203	570	225	2,602
Wyoming	524	52,967	241	978	9,598	14,740	1,032
SO_2							
Colorado	20	80	11	33	7,794	4	20
Idaho	1	15	2	18	0	8,918	125
Utah	181	144	12	44	973	6	159
Wyoming	5,502	6,419	52	407	43,978	15,571	65
$PM_{2.5}$							
Colorado	61	1,415	31	128	0	0	293
Idaho	0	184	6	91	0	376	1,716
Utah	435	972	36	192	471	145	2,396
Wyoming	524	7,084	163	939	9,598	2,678	914

Table 2-12. Regional emissions summary table 2008met06 (tpy).

STATE	Source Category						
	Oil and Gas	Area	Onroad	Offroad	EGU	NEGU	Natural
CO							
Colorado	1,029	2,448	18,362	7,931	1,356	58	12,535
Idaho	263	487	2,580	4,545	0	10,909	20,513
Utah	18,383	1,974	19,598	12,212	426	645	8,608
Wyoming	12,314	13,842	72,668	36,344	3,338	17,374	82,627
NOx							
Colorado	1,712	152	1,735	1,245	28,689	86	677
Idaho	1,282	340	301	675	0	1,932	864
Utah	11,490	214	1,924	1,771	7,209	1,130	347
Wyoming	21,636	7,135	8,588	19,095	38,528	14,813	2,911
TOG							
Colorado	77,019	1,608	1,403	1,703	137	267	54,199
Idaho	547	3,895	208	1,458	0	10	32,486
Utah	410,056	2,015	1,436	3,533	64	2,057	13,407
Wyoming	1,127,405	18,564	5,796	5,816	1,079	22,735	89,977
PM_{10}							
Colorado	62	8,495	48	135	410	3,852	261
Idaho	0	9,060	9	96	0	469	1,513
Utah	442	6,091	55	203	570	225	756
Wyoming	524	49,342	241	978	9,598	14,740	9,139
SO_2							
Colorado	20	80	11	33	7,794	4	16
Idaho	1	15	2	18	0	8,918	97
Utah	181	144	12	44	973	6	48
Wyoming	5,502	6,419	52	407	43,978	15,571	556
$PM_{2.5}$							
Colorado	61	1,201	31	128	0	0	233
Idaho	0	184	6	91	0	376	1,311
Utah	435	836	36	192	471	145	675
Wyoming	524	6,721	163	939	9,598	2,678	8,377

Table 2-13. Regional emissions summary table 2022met05 (tpy).

STATE	Source Category						
	Oil and Gas	Area	Onroad	Offroad	EGU	NEGU	Natural
CO							
Colorado	3,443	2,519	15,010	8,426	1,735	67	12,277
Idaho	326	535	2,057	4,583	0	17,670	23,477
Utah	41,880	1,960	16,241	11,877	1,469	109	20,297
Wyoming	30,377	14,596	55,748	37,856	3,816	14,182	26,789
NOx							
Colorado	3,308	177	773	849	24,166	89	632
Idaho	896	402	128	478	0	2,378	927
Utah	12,972	244	855	1,272	8,386	112	655
Wyoming	30,498	8,261	3,576	15,066	39,072	12,748	1,229
TOG							
Colorado	37,314	1,850	823	1,147	183	323	53,123
Idaho	673	5,214	120	1,174	0	7	32,887
Utah	1,059,791	2,668	859	2,300	114	1,673	13,954
Wyoming	1,335,304	22,192	3,240	4,261	683	25,291	81,173
PM_{10}							
Colorado	2,449	10,544	37	75	592	3,504	320
Idaho	0	9,454	6	62	0	0	1,950
Utah	5	7,134	41	112	887	267	2,602
Wyoming	5,415	73,379	164	610	3,399	13,320	1,032
SO_2							
Colorado	25	83	10	3	7,002	5	20
Idaho	2	15	2	1	0	3,921	125
Utah	18	142	11	3	1,645	10	159
Wyoming	3,652	7,458	45	19	22,374	23,588	65
$PM_{2.5}$							
Colorado	529	1,404	18	70	0	0	293
Idaho	0	206	3	58	0	0	1,716
Utah	459	908	21	106	561	169	2,396
Wyoming	1,721	6,773	83	611	4,114	1,776	914

Table 2-14. Regional emissions summary table 2022met06 (tpy).

STATE	Source Category						
	Oil and Gas	Area	Onroad	Offroad	EGU	NEGU	Natural
CO							
Colorado	3,443	2,519	15,246	8,426	1,735	67	12,535
Idaho	326	535	2,070	4,583	0	17,670	20,513
Utah	41,880	1,960	16,338	11,877	1,469	109	8,608
Wyoming	30,377	14,596	56,568	37,856	3,816	14,182	82,627
NOx							
Colorado	3,308	177	776	849	24,166	89	677
Idaho	896	402	128	478	0	2,378	864
Utah	12,972	244	857	1,272	8,386	112	347
Wyoming	30,498	8,261	3,590	15,066	39,072	12,748	2,911
TOG							
Colorado	37,314	1,850	830	1,147	183	323	54,199
Idaho	673	5,214	120	1,174	0	7	32,486
Utah	1,059,791	2,668	861	2,300	114	1,673	13,407
Wyoming	1,335,304	22,192	3,257	4,261	683	25,291	89,977
PM_{10}							
Colorado	2,449	10,544	37	75	592	3,504	261
Idaho	0	9,454	6	62	0	0	1,513
Utah	5	7,134	41	112	887	267	756
Wyoming	5,415	73,379	164	610	3,399	13,320	9,139
SO_2							
Colorado	25	83	10	3	7,002	5	16
Idaho	2	15	2	1	0	3,921	97
Utah	18	142	11	3	1,645	10	48
Wyoming	3,652	7,458	45	19	22,374	23,588	556
$PM_{2.5}$							
Colorado	529	1,191	18	70	0	0	233
Idaho	0	206	3	58	0	0	1,311
Utah	459	772	21	106	561	169	675
Wyoming	1,721	6,410	83	611	4,114	1,776	8,377

Table 2-15. Regional 2022-2008 emissions difference summary table for met05 (tpy).

STATE	Source Category						
	Oil and Gas	Area	Onroad	Offroad	EGU	NEGU	Natural
CO							
Colorado	2,414	71	-3,072	495	379	9	0
Idaho	63	48	-506	38	0	6,760	0
Utah	23,497	-14	-3,241	-335	1,043	-535	0
Wyoming	18,063	754	-15,815	1,512	478	-3,191	0
NOx							
Colorado	1,595	25	-956	-396	-4,523	4	0
Idaho	-386	63	-173	-197	0	445	0
Utah	1,482	30	-1,065	-499	1,177	-1,017	0
Wyoming	8,862	1,126	-4,985	-4,028	544	-2,065	0
TOG							
Colorado	-39,705	241	-567	-555	46	56	0
Idaho	126	1,320	-87	-284	0	-3	0
Utah	649,735	653	-571	-1,233	49	-384	0
Wyoming	207,899	3,629	-2,516	-1,555	-396	2,555	0
PM_{10}							
Colorado	2,387	-82	-11	-60	182	-348	0
Idaho	0	95	-3	-34	0	-468	0
Utah	-438	-320	-14	-90	316	42	0
Wyoming	4,891	20,412	-77	-369	-6,199	-1,419	0
SO_2							
Colorado	5	3	-1	-30	-792	1	0
Idaho	0	1	0	-17	0	-4,997	0
Utah	-163	-2	-1	-42	672	4	0
Wyoming	-1,850	1,039	-7	-387	-21,604	8,017	0
$PM_{2.5}$							
Colorado	468	-11	-13	-58	0	0	0
Idaho	0	22	-3	-33	0	-376	0
Utah	24	-64	-16	-86	90	24	0
Wyoming	1,197	-311	-79	-328	-5,484	-902	0

Table 2-16. Regional 2022-2008 emissions difference summary table for met06 (tpy).

STATE	Source Category						
	Oil and Gas	Area	Onroad	Offroad	EGU	NEGU	Natural
CO							
Colorado	2,414	71	-3,116	495	379	9	0
Idaho	63	48	-510	38	0	6,760	0
Utah	23,497	-14	-3,260	-335	1,043	-535	0
Wyoming	18,063	754	-16,099	1,512	478	-3,191	0
NOx							
Colorado	1,595	25	-959	-396	-4,523	4	0
Idaho	-386	63	-173	-197	0	445	0
Utah	1,482	30	-1,067	-499	1,177	-1,017	0
Wyoming	8,862	1,126	-4,999	-4,028	544	-2,065	0
TOG							
Colorado	-39,705	241	-574	-555	46	56	0
Idaho	126	1,320	-88	-284	0	-3	0
Utah	649,735	653	-574	-1,233	49	-384	0
Wyoming	207,899	3,629	-2,539	-1,555	-396	2,555	0
PM_{10}							
Colorado	2,387	2,048	-11	-60	182	-348	0
Idaho	0	394	-3	-34	0	-468	0
Utah	-438	1,043	-14	-90	316	42	0
Wyoming	4,891	24,037	-77	-369	-6,199	-1,419	0
SO_2							
Colorado	5	3	-1	-30	-792	1	0
Idaho	0	1	0	-17	0	-4,997	0
Utah	-163	-2	-1	-42	672	4	0
Wyoming	-1,850	1,039	-7	-387	-21,604	8,017	0
$PM_{2.5}$							
Colorado	468	-11	-13	-58	0	0	0
Idaho	0	22	-3	-33	0	-376	0
Utah	24	-64	-16	-86	90	24	0
Wyoming	1,197	-311	-79	-328	-5,484	-902	0

3.0 NEAR-FIELD MODELING ANALYSES

3.1 MODELING METHODOLOGY

A near-field ambient air quality impact assessment was performed to quantify maximum pollutant impacts within and nearby the CD-C Project area resulting from Project-related development and production emissions. Air quality impacts due to criteria pollutant emissions of PM_{10}, $PM_{2.5}$, NO_x, SO_2, and CO, and emissions of hazardous air pollutants (HAPs) (benzene, toluene, ethyl benzene, xylene, n-hexane, and formaldehyde) were evaluated as part of the near-field study. These impacts would result from emissions associated with Project construction and production activities, and are compared to applicable ambient air quality standards and significance thresholds. All modeling analyses were performed in general accordance with the CD-C Air Quality Impact Assessment Modeling Protocol (Carter Lake and ENVIRON, 2010) with input from the WDEQ-AQD, BLM and members of the Air Quality Stakeholders Group, including the EPA, USDA-FS, USDOI-FWS, and USDOI-NPS.

Ozone is also a criteria pollutant and may form from NO_x, VOC, and CO emissions in the presence of sunlight. Analyses of potential ozone formation from Project alternative sources and regional sources were performed using the CAMx photochemical grid model as part of the far-field analysis. Ozone impacts within and outside the CD-C Project area were evaluated. Detailed information regarding the modeling methodologies used in the CAMx ozone analyses is provided in Section 4.

The EPA's Guideline (EPA, 2005a) model, AERMOD (version 13350), was used to assess near-field impacts of criteria pollutants PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO, and to estimate short-term and long-term HAP impacts. Regulatory model settings were used with the exception of the non-regulatory Ozone Limiting Method (OLM) model option, which was used for modeling NO_2 concentration estimates. Three years of meteorology data (2008-2010) collected near Wamsutter, Wyoming that is located within the CD-C Project area were used with the AERMOD dispersion model to estimate these pollutant impacts. Modeling analyses for NO_2 concentration estimates also utilized hourly ozone concentration data collected at the Wamsutter monitoring site from 2008 through 2010. Various construction and production activities were modeled to provide analyses for a complete range of alternatives and activities

Modeling analyses were performed to quantify near-field pollutant concentrations within and nearby the CD-C Project area from Project-related emissions sources for a range of scenarios to assure that the maximum near-field impacts were estimated. Impacts from scenarios including the construction of well pads, well drilling activities, well production facilities, an evaporation pond, proposed compression, and a proposed gas plant were modeled. Drill rigs with emissions at EPA Tier 2 and Tier 4 levels were evaluated. For sources where buildings and structures could potentially influence dispersion (i.e., drill rigs, compressors, and gas plant), the Building Profile Input Program (BPIP) (version 04112) was used to determine appropriate direction-specific building dimension downwash parameters for each affected source. Modeling scenarios were constructed using maximum Project Alternative proposed development (i.e., down-hole well spacing) in one-section land areas (1 square mile) and locating sources throughout the areas. Various scenarios were evaluated for well pad/access road construction activities based on operator provided well density and well pad construction assumptions to provide a range of impacts from typical field construction activities. Representative modeling scenarios of one-section land areas that include well development activities combined with well production operations were also modeled.

Modeling receptor sets were developed for each modeling scenario based on proposed pad sizes and ambient air boundary assumptions. Discrete modeling receptors were placed at 25-meter intervals along boundaries with receptors placed at 100-meter intervals extending outward 1.5 kilometers. Flat terrain receptors were used for all near-field modeling analyses, given that the proposed source locations cannot be adequately defined.

A discussion of the meteorological data used for the near-field analysis, the ambient background data used for combining with modeled concentrations impacts, and the Project emissions data is provided in the following sections. The criteria pollutant impact assessment is provided in Section 3.5 and the HAPs analysis is presented in Section 3.6.

3.2 METEOROLOGY DATA

Three years (2008-2010) of hourly surface meteorological data collected near Wamsutter, Wyoming, along with twice daily sounding data from the Riverton, Wyoming National Weather Service (NWS) site were used in the analysis. The Wamsutter data include 10 meter level measurements of wind speed, wind direction, standard deviation of wind direction [sigma theta], solar radiation, temperature (10 meter and 2 meter), and temperature difference. The data meet the 90 percent completeness criteria established by EPA in the “Meteorological Monitoring Guidance for Regulatory Modeling Applications” report (EPA, 2000c). A wind rose for the Wamsutter site is presented in Figure 3-1.

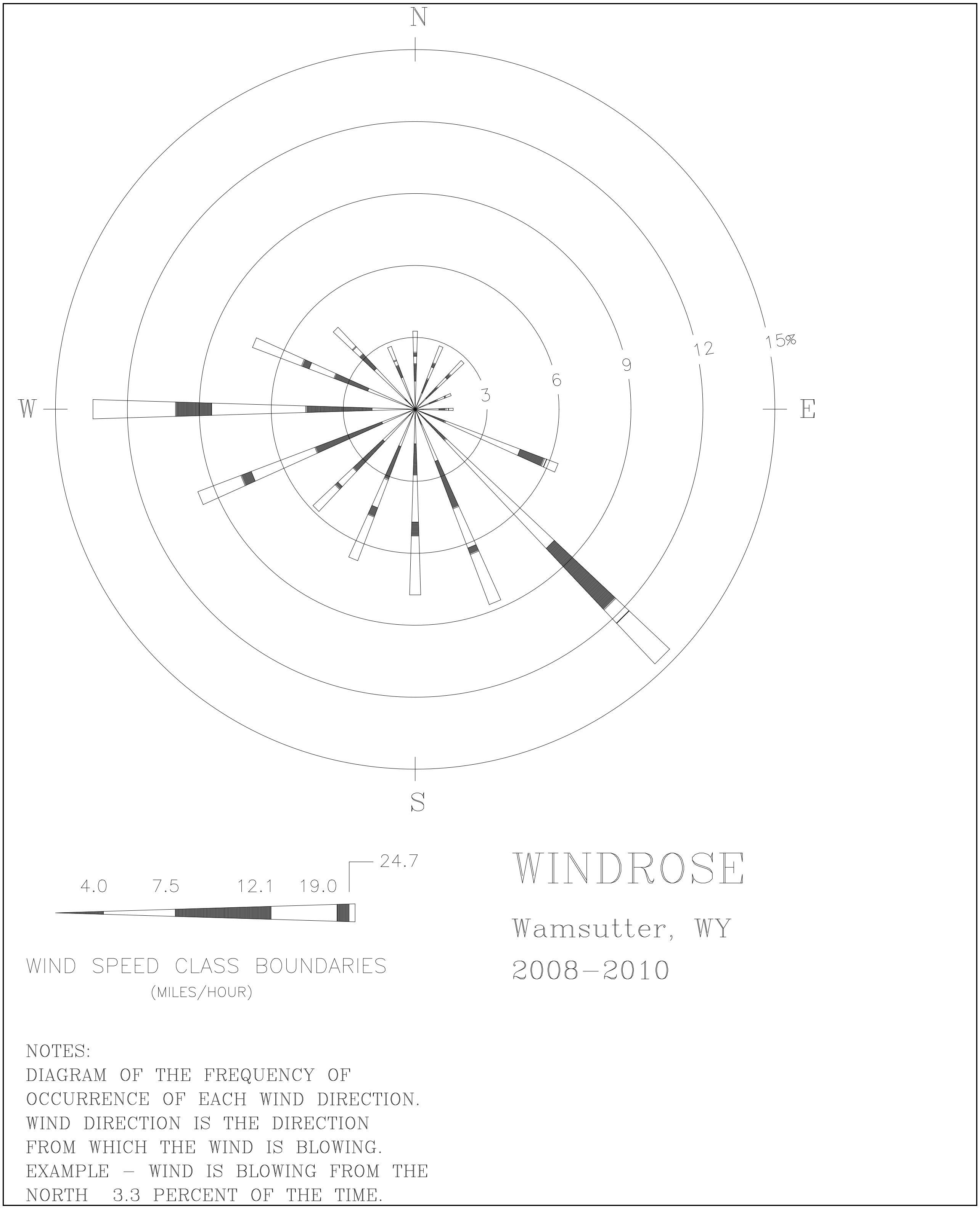

Figure 3-1. Wamsutter, WY meteorological data wind rose.

The AERMOD preprocessor AERMET (version 11059) was used to process the meteorological data into datasets (surface data and profile data) compatible with the AERMOD dispersion model. Given that temperature difference and solar radiation data were available at the Wamsutter site, AERMET was applied following Bulk Richardson method switch settings to combine the hourly Wamsutter data with twice daily Riverton sounding data. AERSURFACE (Version 13016) was used to develop twelve sector seasonal surface characteristics for the Wamsutter station location, and these surface characteristics were used in the AERMET processing.

3.3 BACKGROUND POLLUTANT CONCENTRATIONS

Background pollutant concentrations are used as an indicator of existing conditions in the region, and are assumed to include emissions from industrial emission sources in operation and from mobile, urban, biogenic, other non-industrial emission sources, and transport into the region. These background concentrations are added to modeled near-field Project impacts to calculate total ambient air quality impacts. The most representative monitored regional background concentrations available for criteria pollutants as identified by WDEQ-AQD are shown in Table 3-1.

Table 3-1. Near-Field analysis background ambient air quality concentrations (micrograms per cubic meter [$\mu g/m^3$]).

Pollutant	Averaging Period	Measured Background Concentration
CO[1]	1-hour	1,026
	8-hour	798
NO_2[2]	1-hour	75
	Annual	9.1
PM_{10}[3]	24-hour	56
	Annual	13.5
$PM_{2.5}$[4]	24-hour	9.2
	Annual	4.2
SO_2[5]	1-hour	19.7
	3-hour	11.5
	24-hour	4.2
	Annual	3.8

[1]Data collected during 2008 at Murphy Ridge, Wyoming, concentrations are maximum values.
[2]Data collected at Wamsutter, Wyoming: 1-hour concentration is the three year average (2008-2010) of daily maximum 98th percentile 1-hour concentrations, annual value is for 2010.
[3]Data collected at Wamsutter, Wyoming during 2010, 24-hour value is maximum concentration.
[4]Data collected at Cheyenne, Wyoming: 24-hour value is the three year average (2008-2010) of daily maximum 98th percentile 24-hour concentrations, annual value is three year average of annual means (2008-2010).
[5]Data collected at Wamsutter, Wyoming: 1-hour value is the three year average (2007-2009) of daily maximum 98th percentile 1-hour concentrations, 3-hour, 24-hour and annual concentrations were collected during 2009, 3-hour and 24-hour data are maximum values.

For modeling assessments of 1-hour NO_2 impacts, following EPA's March 1, 2011 Memorandum "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard" (EPA, 2011b), seasonal, diurnal background NO_2 concentrations were developed for the Wamsutter site for the three year period 2008-2010, and are added to modeled impacts. The EPA guidance recommends use of background 1-hour NO_2 values by season and hour-of-day based on the 3rd highest value for each season and hour-of-day combination for a 3-year data set. The 3-year average, 3rd highest 1-hour NO_2 values by season and hour-of-day for the 2008-2010 Wamsutter dataset are provided in Table 3-2.

Table 3-2. Wamsutter, Wyoming 2008-2010, seasonal, 3-year average, 3rd highest 1-hour NO_2 concentrations ($\mu g/m^3$).

Hour	Winter	Spring	Summer	Fall
1	58.3	52.0	49.5	47.6
2	48.9	55.8	53.3	48.9
3	42.6	52.0	47.6	48.3
4	44.5	43.9	50.8	47.0
5	52.0	43.9	47.0	45.8
6	50.1	50.1	43.9	45.1
7	56.4	41.4	40.7	41.4
8	55.2	35.1	23.2	33.8
9	52.0	18.8	14.4	23.2
10	27.0	13.8	10.0	15.0
11	17.5	8.8	8.1	12.5
12	14.4	8.1	6.3	8.8
13	12.5	6.3	8.1	6.9
14	13.2	7.5	5.0	5.6
15	13.8	7.5	6.3	6.3
16	18.8	8.8	6.3	8.8
17	30.7	9.4	7.5	16.9
18	51.4	13.2	8.8	33.2
19	56.4	28.8	14.4	48.3
20	67.7	36.4	30.1	61.4
21	65.2	40.7	35.4	53.3
22	63.3	59.5	60.2	60.2
23	52.6	53.9	55.8	57.7
24	57.0	53.3	54.5	57.0

3.4 PROJECT EMISSIONS

Methods used to develop the Project emissions inventory are described in Section 2 and details of the emissions calculations are presented in Appendix H. The Project emissions inventory was reviewed in order to select the emissions activities that could result in the maximum criteria pollutant and HAP impacts. The activities that would generate that largest pollutant impacts include well development activities such the construction of well pads, well drilling activities and well completions, and field production activities such as well production facilities, an evaporation pond, proposed compression, and a proposed gas plant. The maximum criteria pollutant (CO, NO_x, SO_2, PM_{10}, and $PM_{2.5}$) impacts would occur from both project development and production activities, and from combinations of these activities. The maximum HAP impacts would occur from production activities. Table 3-3 presents the project field development activities that were considered as part of the near-field analysis. Table 3-3 presents the production activities that were analyzed for criteria pollutant impacts and for HAP impacts.

Table 3-3 presents drill rigs emissions for Tier 2 and Tier 4 emissions levels. As part of the Project Alternatives, operators have proposed the use of drill rigs with Tier 2 emissions. For informational purposes, near-field analyses were performed using the emissions for Tier 2 and Tier 4 levels. In addition, the hourly drill rig emissions for NO_x, CO, and SO_2 were computed using a maximum operating load factor of 0.6, versus a normal operating load factor of 0.3. Both operating load conditions were developed from data provided by the operators. Maximum operating load conditions were used for modeling pollutants that have short duration (less than 24-hour) ambient air quality standards.

The well construction and well production emissions presented in the Tables 3-3 and 3-4 are for developing and operating a single well in the CD-C field. The emissions shown in Table 3-4 for proposed compression and a gas plant are field-wide totals. Operators have proposed a new gas processing facility (760 mmscfd) and to add up to 24,936 hp of compression as part of the Project Alternatives. Table 3-4 also includes the HAP emissions for one 12 acre evaporation pond.

The near-field modeling analysis described in the following sections analyzes wells under development and wells in production, assumes one compression facility, a single gas processing facility, and one 12 acre evaporation pond. Total emissions that are modeled for each scenario can be easily determined from these tables by simply multiplying the single well values by the number of wells included in the analyzed scenario.

Table 3-3. CD-C Project - field development criteria pollutant emissions by activity.

Source	Activity Duration	Pollutant	Emissions (lbs/hour)	Emissions (tons/event)
Drill Rigs – Tier 2 emissions[1]	7-10 days	NO_x	27.2	1.7
		CO	15.8	1.0
		SO_2	0.6	0.04
		PM_{10}	0.5	0.06
		$PM_{2.5}$	0.5	0.05
Drill Rigs – Tier 4 emissions[1]	7-10 days	NO_x	15.3	1.0
		CO	15.8	1.0
		SO_2	0.6	0.04
		PM_{10}	0.2	0.03
		$PM_{2.5}$	0.2	0.03
Completion Engines	1 day	NO_x	52.6	0.6
		CO	19.7	0.2
		SO_2	0.02	0.0003
		PM_{10}	3.2	0.04
		$PM_{2.5}$	3.1	0.04
Drilling and Completion	3 days	NO_x	1.4	0.1
Fugitives (Traffic, Flaring)		CO	3.1	0.2
(Traffic emissions for 20 mile round trip distance)		SO_2	0.005	0.0005
		PM_{10}	16.6	1.0
		$PM_{2.5}$	1.7	0.1
Single Well Pad Construction (Pad/Road Construction, Traffic, Wind Erosion) (Traffic emissions for 20 mile round trip distance)	5-days	NO_x	21.5	0.7
		CO	26.6	0.8
		SO_2	0.4	0.01
		PM_{10}	8.5	0.3
		$PM_{2.5}$	3.7	0.1
Multi-well P ad Construction (Pad/Road Construction, Traffic.)	7-days	NO_x	21.5	0.9
(Pad/Road Construction, Traffic.)		CO	26.6	1.1
Traffic, Wind Erosion)		SO_2	0.4	0.02
(Traffic emissions for 20 mile round trip distance)		PM_{10}	8.6	0.4
		$PM_{2.5}$	3.7	0.2

[1] Maximum operational load of 0.6 used for estimating drill rig NO_x, CO, SO_2 hourly emissions. For other pollutants and for total event emissions an average load factor of 0.3 is used.

Table 3-4. CD-C Project - field production criteria pollutant and HAP emissions (tons/year).

	Compression	Gas Plant	Production Well	Evaporation Pond[1]
NO_x	54.6	383.0	0.3	--
CO	62.4	503.7	0.9	--
SO_2	0.0	0.7	0.00004	--
PM_{10}	6.1	35.5	0.1	--
$PM_{2.5}$	6.1	35.5	0.03	--
VOC	2.7	72.2	1.7	--
HAPs				
Benzene	0.01	0.8	0.01	0.8
Toluene	0.0	0.4	0.01	1.1
Ethyl Benzene	0.0	0.01	0.0003	0.09
Xylene	0.0	0.04	0.01	1.3
n-Hexane	0.0	0.2	0.05	0.0
Formaldehyde	2.2	24.9	0.07	0.0

[1] Annual emissions are calculated based on operating April through November since the evaporations pond is frozen during the winter

3.5 CRITERIA POLLUTANT IMPACT ASSESSMENT

The near-field criteria pollutant impact assessment was performed to estimate maximum potential impacts of PM_{10}, $PM_{2.5}$, SO_2, NO_2, and CO from Project emissions sources including emissions resulting from proposed well site construction and production activities, proposed compression, and a proposed gas plant. Maximum predicted concentrations in the vicinity of project emissions sources were compared with the Wyoming Ambient Air Quality Standards (WAAQS), National Ambient Air Quality Standards (NAAQS), and applicable Prevention of Significant Deterioration (PSD) Class II increments shown in Table 3-5. This NEPA analysis compared potential air quality impacts from Project alternatives to applicable ambient air quality standards and PSD increments. The comparisons to the PSD Class II increments are intended to evaluate a threshold of concern for potential impacts, and do not represent a regulatory PSD increment comparison. Such a regulatory analysis is the responsibility of the state air quality agency (under EPA oversight).

Table 3-5. Ambient Air Quality Standards and Class II PSD Increments for comparison to near-field analysis results ($\mu g/m^3$).

Pollutant/Averaging Time	NAAQS	WAAQS	PSD Class II Increment[1]
CO			
1-hour[2]	40,000	40,000	--[3]
8-hour[2]	10,000	10,000	--[3]
NO_2			
1-hour[4]	188	188	--
Annual[5]	100	100	25
PM_{10}			
24-hour[2]	150	150	30
Annual[5]	--[6]	50	17
$PM_{2.5}$			
24-hour[7]	35	35	9
Annual[5]	12	15	4
SO_2			
1-hour[8]	196	196	--[3]
3-hour[2]	1,300	1,300	512
24-hour[2]	--[6]	**--[9]**	91
Annual[5]	--[6]	**--[9]**	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 year.
[3]No PSD increments have been established for this pollutant - averaging time.
[4]An area is in compliance with the standard if the 98th percentile of daily maximum 1-hour NO_2 concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.
[5]Annual arithmetic mean.
[6]The NAAQS for this averaging time for this pollutant has been revoked by EPA.
[7]An area is in compliance with the standard if the 98th percentile 24-hour $PM_{2.5}$ concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.
[8]An area is in compliance with the standard if the 99th percentile daily maximum 1-hour SO_2 concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.
[9] No ambient air quality standards are established for this pollutant-averaging time.

The AERMOD model was used to estimate near-field concentrations of PM_{10}, $PM_{2.5}$, SO_2, NO_2, and CO from Project Alternative emission sources. AERMOD was run using three years of AERMET- processed Wamsutter meteorology data. Regulatory model settings were used with the exception of the non-regulatory OLM model option, which was used for modeling NO_2 concentration estimates. Modeling analyses for NO_2 concentration estimates utilized hourly ozone concentration data concurrent with the meteorological data from the Wamsutter monitoring site. The NO_2 analyses with OLM also utilized in-stack NO/NO_2 concentration ratios for source emissions that were determined from data provided by the operators. For modeling of drill rig NO_2 emissions an in-stack ratio of 10 percent NO_2 was used, for all other sources an in-stack ratio of 20 percent NO_2 was used.

For each criteria pollutant, the magnitude and duration of emissions from project development and production emissions activities shown in Tables 3-3 and 3-4 were examined to determine the maximum emissions scenario for modeling. Multiple years of project emissions activities were evaluated for purposes of demonstrating compliance with the NAAQS for 1-hour NO_2 concentrations.

3. NEAR-FIELD MODELING ANALYSES

The production activities modeled for criteria pollutant comparisons with the NAAQS and WAAQS and PSD Class II increments, along with the pollutants analyzed include the following:

- Compressor station (NO_2, CO, PM_{10}, $PM_{2.5}$)
- Gas processing facility (NO_2, SO_2, CO, PM_{10}, $PM_{2.5}$)
- 16 single wells in production (NO_2, CO , PM_{10}, $PM_{2.5}$)
- 1 multi-well pad with 16 wells in production (NO_2, CO, PM_{10}, $PM_{2.5}$)

Combinations of field development activities and production activities were also modeled for criteria pollutant comparisons with the NAAQS and WAAQS. Note that the emissions from field development activities are temporary and do not consume PSD increment, and as a result are excluded from increment comparisons. The selected scenarios along with the pollutants analyzed include:

- Drill rig operating on a single well pad, surrounded by four multi-well pads in production (up to 4 wells per pad in production) (NO_2, CO, SO_2, PM_{10}, $PM_{2.5}$)
- Drilling on one 16-well pad (NO_2, CO, SO_2, PM_{10}, $PM_{2.5}$)
- Drilling on four 4-well pads (NO_2, CO, SO_2, PM_{10}, $PM_{2.5}$)
- Drill rig operating on a 12-well pad, surrounded by four single-well pads in production (NO_2)
- Drill rig operating on an 8-well pad, surrounded by four 2-well pads in production (NO_2)
- Drill rig operating on a 4-well pad, surrounded by four 3-well pads in production (NO_2)

Each of the above modeling scenarios is described in the following sections.

For 1-hour NO_2 NAAQS compliance demonstrations, all modeled impacts represent the 3-year average of the eighth-highest daily maximum 1-hour concentrations. For scenarios where drilling operations were modeled, drilling operations were assumed to occur for a maximum of one year on single well pads and two years on multi-well pads during the 3-year averaging period. Since drill rigs move to different locations during field development, it is not likely that a drilling operation would occur over 3 consecutive years in the same location. The yearly maximum eighth-highest daily maximum 1-hour NO_2 concentrations for all modeled scenarios that included drilling operations are also provided.

3.5.1 Compression

Operators have proposed to add up to 24,936 hp of compression as part of the Project Alternatives. The added compression would be combination of reciprocating and turbine engines. The estimated criteria pollutant emissions for the proposed compression are shown in Table 3-4.

Compressor engines were modeled as point sources, using typical compressor engine exhaust parameters, with aerodynamic building downwash from the compressor building, and assuming that all emissions are collocated. The receptor grid consisted of 25-meter spaced receptors placed along a boundary defined at 50 meters from the source and 100-meter spaced receptors extending outward approximately 1 kilometer from the facility.

Table 3-6 presents the maximum modeled NO_2, CO, PM_{10} and $PM_{2.5}$ concentrations from proposed compressor engine emissions. When the maximum modeled concentrations are added to representative background concentrations, it is demonstrated that all comply with the WAAQS and NAAQS. In addition, the direct modeled impacts are below the applicable PSD increments.

Table 3-6. CD-C Project-criteria pollutant modeling results for proposed compressor station.

Pollutant	Averaging Time	Direct Modeled (µg/m³)[1]	PSD Class II Increment[1] (µg/m³)[2]	Background (µg/m³)	Total Predicted (µg/m³)	WAAQS (µg/m³)	NAAQS (µg/m³)
CO	1-hour	119.2	--[3]	1,026.0	1,145.2	40,000	40,000
	8-hour	76.8	--[3]	798.0	874.8	10,000	10,000
NO_2	1-hour	72.4[4]	--[3]	11.9[5]	84.3	188	188
	Annual	4.5	25	9.1	13.6	100	100
PM_{10}	24-hour	5.4	30	56.0	61.4	150	--[5]
	Annual	0.5	17	13.5	14.0	50	50
$PM_{2.5}$	24-hour	5.4	9	9.2	14.6	35	35
	Annual	0.5	4	4.2	4.7	15	12

[1] Modeled highest second-high values are shown for all short-term averaging times with the exception of 1-hour NO_2 and SO_2 concentrations.
[2] The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis
[3] No PSD increments have been established for this pollutant-averaging time.
[4] NO_2 1-hour concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations.
[5] NO_2 1-hour background value is the 3-year average of the 3rd highest 1-hour concentrations for each season and hour of day combination.
[6] No ambient air quality standards are established for this pollutant-averaging time.

3.5.2 Gas Plant

A new gas processing facility, with a gas throughput capacity of 760 mmscfd, has been proposed as part of the CD-C Project Alternatives. The facility would be similar to the existing Echo Springs gas plant that currently processes gas from wells operating in the CD-C field. The estimated total criteria pollutant emissions for the proposed gas plant are shown in Table 3-4. The emissions for the proposed gas processing facility are described in detail in Appendix H.

Modeling parameters for source emissions at the existing Echo Springs gas plant were obtained from the WDEQ-AQD permit files and were used as a basis for modeling the proposed gas processing facility. The source parameters included point sources, with representative release parameters for each source type, and aerodynamic building downwash parameters calculated for each affected source at the facility. Figure 3-2 shows the locations for the gas plant sources modeled and the receptor grid.

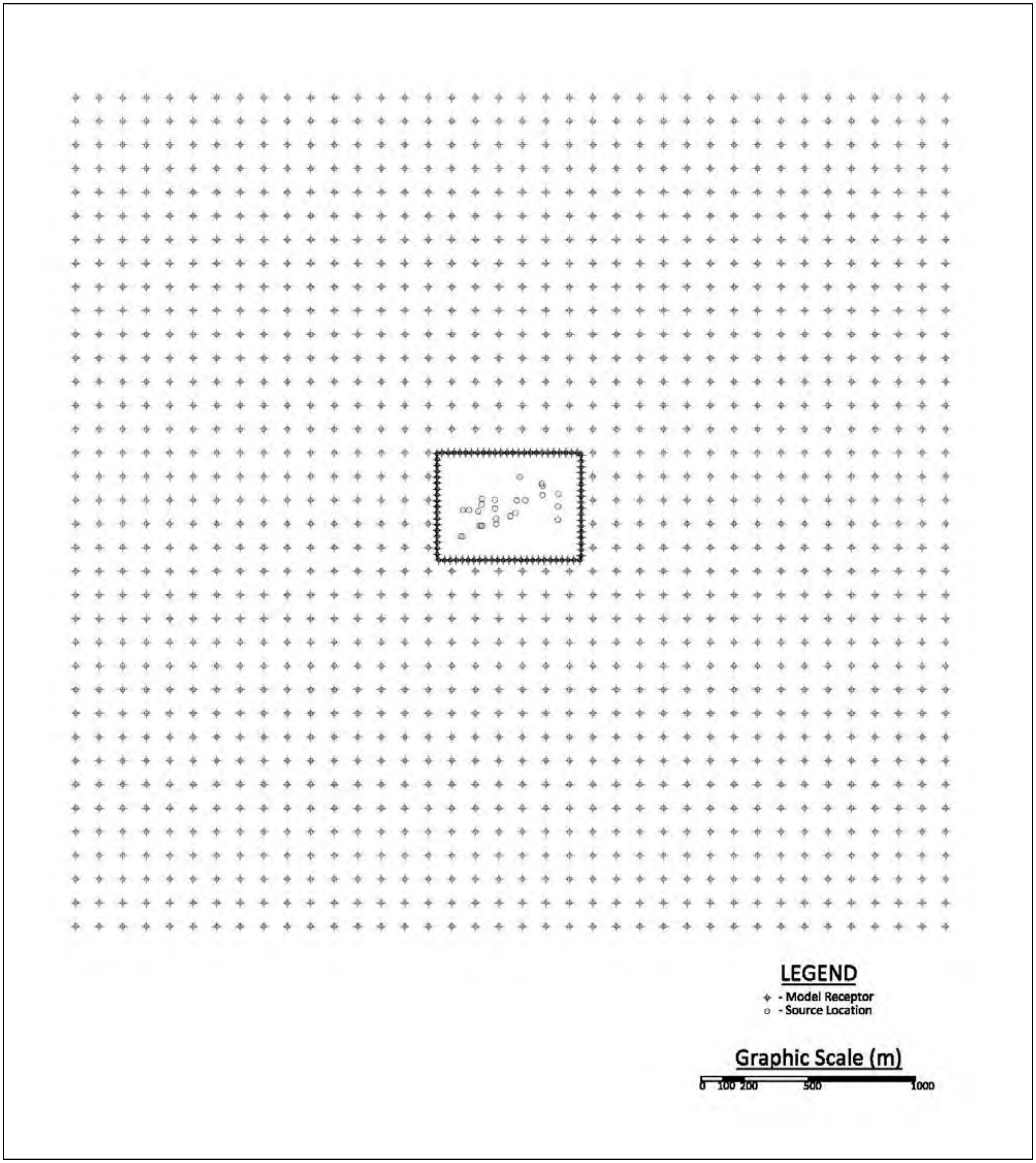

Figure 3-2. Gas plant modeling scenario.

Table 3-7 presents the maximum modeled NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$ concentrations from the proposed gas processing facility source emissions. When the maximum modeled concentrations were added to representative background concentrations, it is demonstrated that all comply with the WAAQS and NAAQS. In addition, the direct modeled impacts are below the applicable PSD increments.

Table 3-7. CD-C Project - criteria pollutant modeling results for proposed gas plant.

Pollutant	Averaging Time	Direct Modeled (µg/m³)[1]	PSD Class II Increment[2] (µg/m³)	Background (µg/m³)	Total Predicted (µg/m³)	WAAQS (µg/m³)	NAAQS (µg/m³)
CO	1-hour	511.7	--[3]	1,026.0	1,537.7	40,000	40,000
	8-hour	315.9	--[3]	798.0	1,113.9	10,000	10,000
NO_2	1-hour	105.8[4]	--[3]	56.2[5]	162.0	188	188
	Annual	11.9	25	9.1	21.0	100	100
SO_2	1-hour	0.7[6]	--[3]	19.7	20.4	196	196
	3-hour	0.7	512	11.5	12.2	1,300	1,300
	24-hour	0.2	91	n/a	n/a	--[7]	--[7]
	Annual	0.03	20	n/a	n/a	--[7]	--[7]
PM_{10}	24-hour	8.1	30	56.0	64.1	150	--[7]
	Annual	1.3	17	13.5	14.8	50	50
$PM_{2.5}$	24-hour	8.1	9	9.2	17.3	35	35
	Annual	1.3	4	4.2	5.5	15	12

[1] Modeled highest second-high values are shown for all short-term averaging times with the exception of 1-hour NO_2 and SO_2 concentrations.
[2] The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis.
[3] No PSD increments have been established for this pollutant-averaging time.
[4] NO_2 1-hour concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations.
[5] NO_2 1-hour background value is the 3-year average of the 3rd highest 1-hour concentrations for each season and hour of day combination.
[6] SO_2 1-hour concentration is 4th highest daily maximum 1-hour concentration.
[7] No ambient air quality standards are established for this pollutant-averaging time.

3.5.3 Production Wells

Analyses were performed quantify the maximum CO, NO_2, PM_{10} and $PM_{2.5}$ impacts that could occur within and nearby the CD-C Project Area from wells under production. These were the only pollutants analyzed for production wells since SO_2 emissions are negligible.

Two scenarios were analyzed for production wells based on the maximum projected down-hole well spacing (40 acre/section) in one-section land areas. The first case assumes 16 single wells in production. The second scenario is one multi-well pad with 16 wells in production. These two cases represent the maximum proposed development (40 acre/section spacing) for the range of CD-C Project alternatives.

Volume sources were used to model fugitive emissions and vehicle traffic emissions from the well production activities, and point sources were used to model well site heater and flare emissions. Representative stack parameter data for the heaters and flares were provided by the operators. Stack parameters for the flares were calculated from flare heat release data. Aerodynamic building downwash parameters were used for modeling the well site heaters, and monthly emissions scalars were applied to well site heater emissions to account for seasonal operations for these sources. A typical well pad layout was used for locating sources on a well pad. This source layout is shown in figure 3-3. The same source layout was used for modeling production emissions from both single well and multi-well pads, which includes a well pad size of 2.5 acres.

Receptors were placed along the edge of the well pad at 25-meter spacing and 100 meter receptors were used throughout the modeling grid extending outward approximately 1.5 kilometers from the wells. Figure 3-4 illustrates the modeling scenario and receptor grid for the 16 single wells in production case.

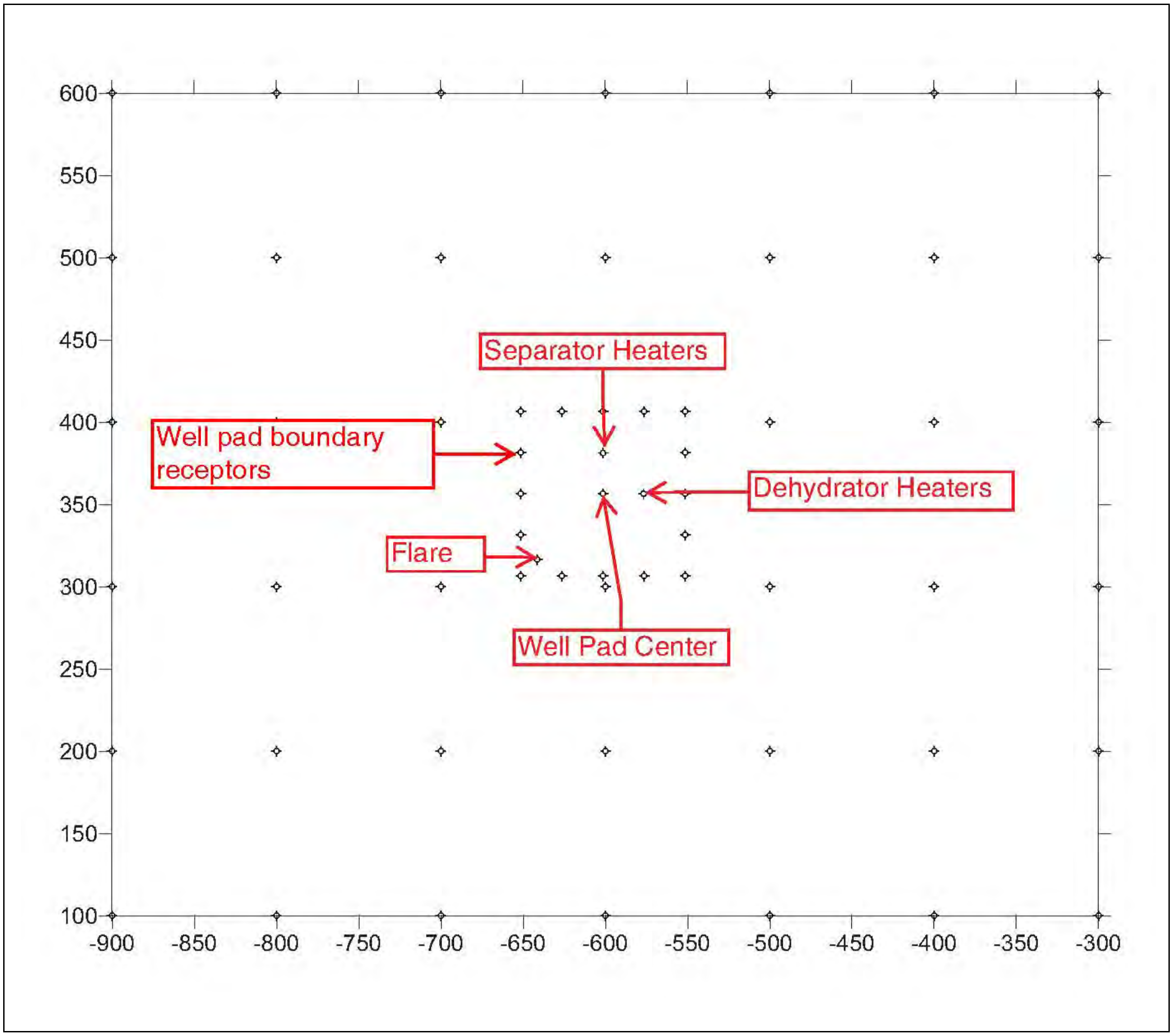

Figure 3-3. Production well source layout.

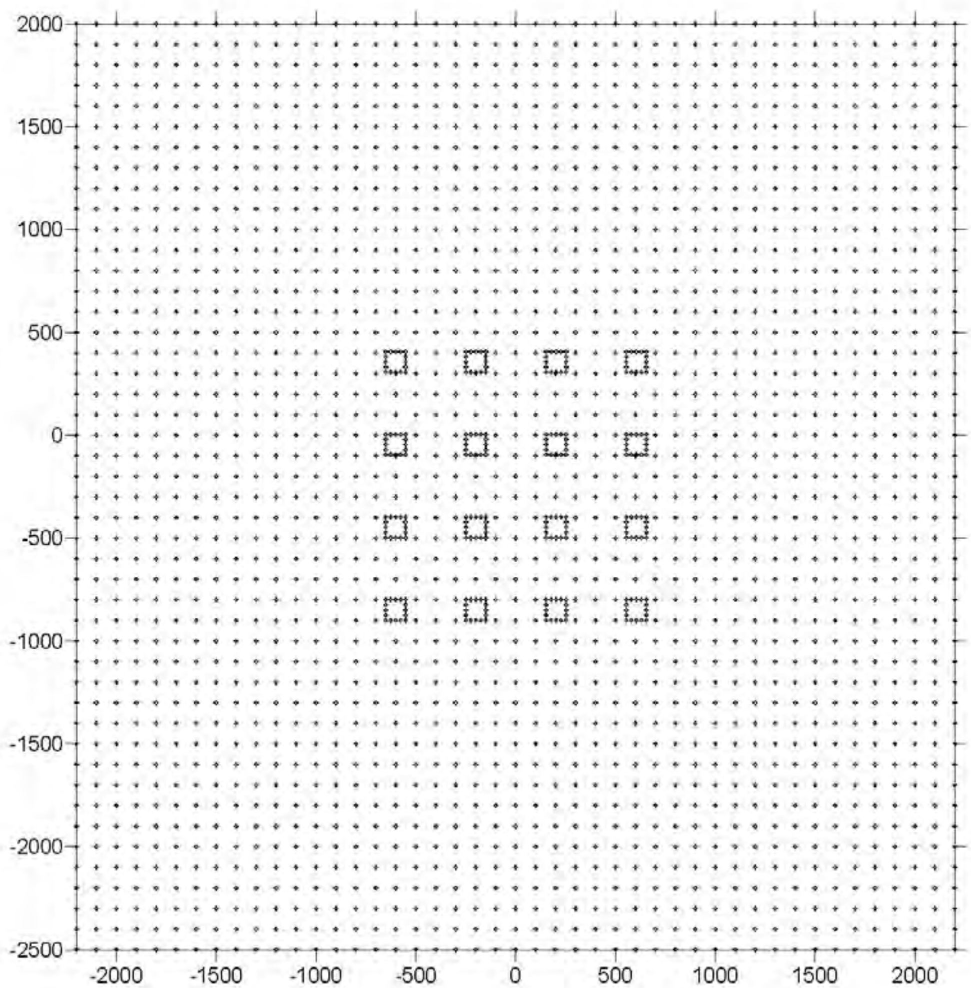

Figure 3-4. 16 production wells – single wells, 40 acre/section spacing.

Tables 3-8 and 3-9 present the maximum modeled CO, NO_2, PM_{10} and $PM_{2.5}$ concentrations from the two production cases. When the maximum modeled concentrations were added to representative background concentrations, it is demonstrated that these cases comply with the WAAQS and NAAQS, and direct modeled impacts are below the applicable PSD increments.

Table 3-8. CD-C Project - criteria pollutant modeling results for production well case: 16 single wells.

Pollutant	Averaging Time	Direct Modeled (μg/m³)[1]	PSD Class II Increment[1] (μg/m³)[2]	Background (μg/m³)	Total Predicted (μg/m³)	WAAQS (μg/m³)	NAAQS (μg/m³)
CO	1-hour	4.7	--[3]	1,026.0	1,030.7	40,000	40,000
	8-hour	2.8	--[3]	798.0	800.8	10,000	10,000
NO_2	1-hour	3.5[4]	--[3]	29.0[5]	32.5	188	188
	Annual	0.3	25	9.1	9.4	100	100
PM_{10}	24-hour	1.9	30	56.0	57.9	150	--[5]
	Annual	0.4	17	4.2	13.9	50	50
$PM_{2.5}$	24-hour	1.9	9	9.2	11.1	35	35
	Annual	0.4	4	4.2	4.6	15	12

[1] Modeled highest second-high values are shown for all short-term averaging times with the exception of 1-hour NO_2 and SO_2 concentrations.
[2] The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis
[3] No PSD increments have been established for this pollutant-averaging time.
[4] NO_2 1-hour concentrations are calculated as the 3-year average of the 8[th] highest daily maximum 1-hour concentrations.
[5] NO_2 1-hour background value is the 3-year average of the 3[rd] highest 1-hour concentrations for each season and hour of day combination.
[6] No ambient air quality standards are established for this pollutant-averaging time.

Table 3-9. CD-C Project - criteria pollutant modeling results for production well case: 16 wells, 1 multi-well pad.

Pollutant	Averaging Time	Direct Modeled (μg/m³)[1]	PSD Class II Increment[1] (μg/m³)[2]	Background (μg/m³)	Total Predicted (μg/m³)	WAAQS (μg/m³)	NAAQS (μg/m³)
CO	1-hour	75.0	--[3]	1,026.0	1,101.0	40,000	40,000
	8-hour	42.9	--[3]	798.0	840.9	10,000	10,000
NO_2	1-hour	52.8[4]	--[3]	52.0[5]	104.8	188	188
	Annual	3.8	25	9.1	12.9	100	100
PM_{10}	24-hour	7.7	30	56.0	63.7	150	--[5]
	Annual	1.4	17	13.5	14.9	50	50
$PM_{2.5}$	24-hour	7.7	9	9.2	16.9	35	35
	Annual	1.4	4	4.2	5.6	15	12

[1] Modeled highest second-high values are shown for all short-term averaging times with the exception of 1-hour NO_2 and SO_2 concentrations.
[2] The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis
[3] No PSD increments have been established for this pollutant-averaging time.
[4] NO_2 1-hour concentrations are calculated as the 3-year average of the 8[th] highest daily maximum 1-hour concentrations.
[5] NO_2 1-hour background value is the 3-year average of the 3[rd] highest 1-hour concentrations for each season and hour of day combination.
[6] No ambient air quality standards are established for this pollutant-averaging time.

3.5.4 Well Drilling Operations and Well Production

Modeling scenarios were developed that included well drilling operations in close proximity to wells in production. The purpose of these analyses was to determine whether impacts from combined well drilling activities and well production could contribute to air quality impacts that are above the level of the NAAQS or WAAQS. As part of these analyses, the impacts from drilling operations alone are also disclosed. The majority of these analyses were focused on NO_2 impacts since NO_x emissions are the primary concern given the emissions levels that could occur from well drilling and well production activities. For one of the more concentrated well development cases analyses, CO, SO_2, PM_{10}, and $PM_{2.5}$ impacts are also presented, and these impacts would represent the maximum concentrations for these pollutants that could occur in the CD-C field from well production and well drilling activities.

Volume sources were used to model the fugitive emissions from the well production activities and point sources were used to model the well site heaters and flares. Monthly emissions scalars were applied to well site heater emissions to account for seasonal operations for these sources. Drill rig engines were modeled as point sources, using typical drill rig engine exhaust parameters, and using aerodynamic building downwash parameters that were calculated from drilling rig structures.

Receptors were placed along the edge of production well pads at 25-meter spacing and along the edge of the well pads under development, and 100 meter receptors were used throughout the modeling grid extending outward approximately 1.5 kilometers from the wells. A 2.5 acre pad size was used for production well pads for both single and multi-well pads. For wells under development, a 5.4 acre pad size was used for single well pads, and 2 acres per well bore was used for multi-well pad sizes.

Similar to the production well analyses that were presented in Section 3.5.3 above, scenarios were developed for the range of Project Alternatives based on the maximum projected down-hole well spacing in one-section land areas. Six combined well development and well production scenarios were analyzed and these are described below:

Scenario 1: Combined single well drilling and multi-well pad production scenario for 16 wells in one-land section. This case included a drill rig operating on a single well pad, surrounded by 4 multi-well pads (up to 4 wells each) with a maximum of 15 wells (total) in production. Under this scenario, CO, NO_2, SO_2, PM_{10}, and $PM_{2.5}$ impacts were analyzed. Drill rig emissions were modeled at Tier 2 and Tier 4 emissions levels. Figure 3-5 illustrates this modeling scenario.

Scenario 2: Multi-well drilling on a 16-well pad. This case included a drill rig operating on a 16-well pad. Under this scenario, CO, NO_2, SO_2, PM_{10}, and $PM_{2.5}$ impacts were analyzed. Drill rig emissions were modeled at Tier 2 and Tier 4 emissions levels.

Scenario 3: Multi-well drilling on four 4-well pads in one-land section. This case included four drill rigs operating on four 4-well pads. Under this scenario, CO, NO_2, SO_2, PM_{10}, and $PM_{2.5}$ impacts were analyzed. Drill rig emissions were modeled at Tier 2 and Tier 4 emissions levels. Figure 3-6 illustrates this modeling scenario.

Scenario 4: Combined multi-well drilling and single-well production scenario for 16 wells in one-land section. This case included a drill rig operating on a 12-well pad, surrounded by 4 single-well pads in production. Under this scenario NO_2 impacts were analyzed. Drill rig emissions were modeled at Tier 2 and Tier 4 emissions levels. Figure 3-7 illustrates this modeling scenario.

Scenario 5: Combined multi-well drilling and multi-well pad production scenario for 16 wells in one-land section. This case included a drill rig operating on an 8-well pad, surrounded by 4 2-well pads in production. Under this scenario NO_2 impacts were analyzed. Drill rig emissions were modeled at Tier 2 and Tier 4 emissions levels.

Scenario 6: Combined multi-well drilling and multi-well pad production scenario for 16 wells in one-land section. This case included a drill rig operating on a 4-well pad, surrounded by 4 3-well pads in production. Under this scenario NO_2 impacts were analyzed. Drill rig emissions were modeled at Tier 2 and Tier 4 emissions levels.

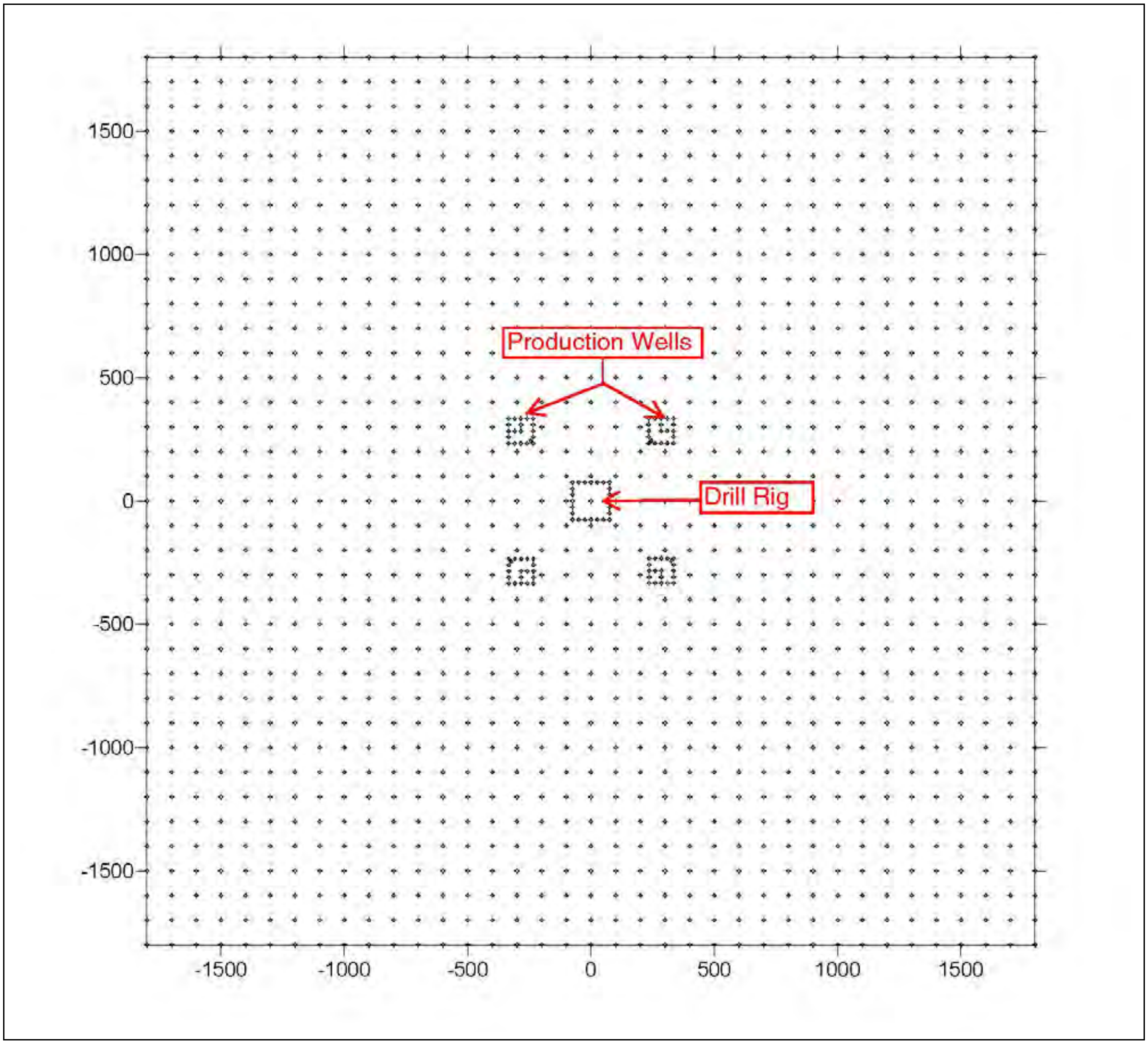

Figure 3-5. Production wells and well drilling – single well drilling.

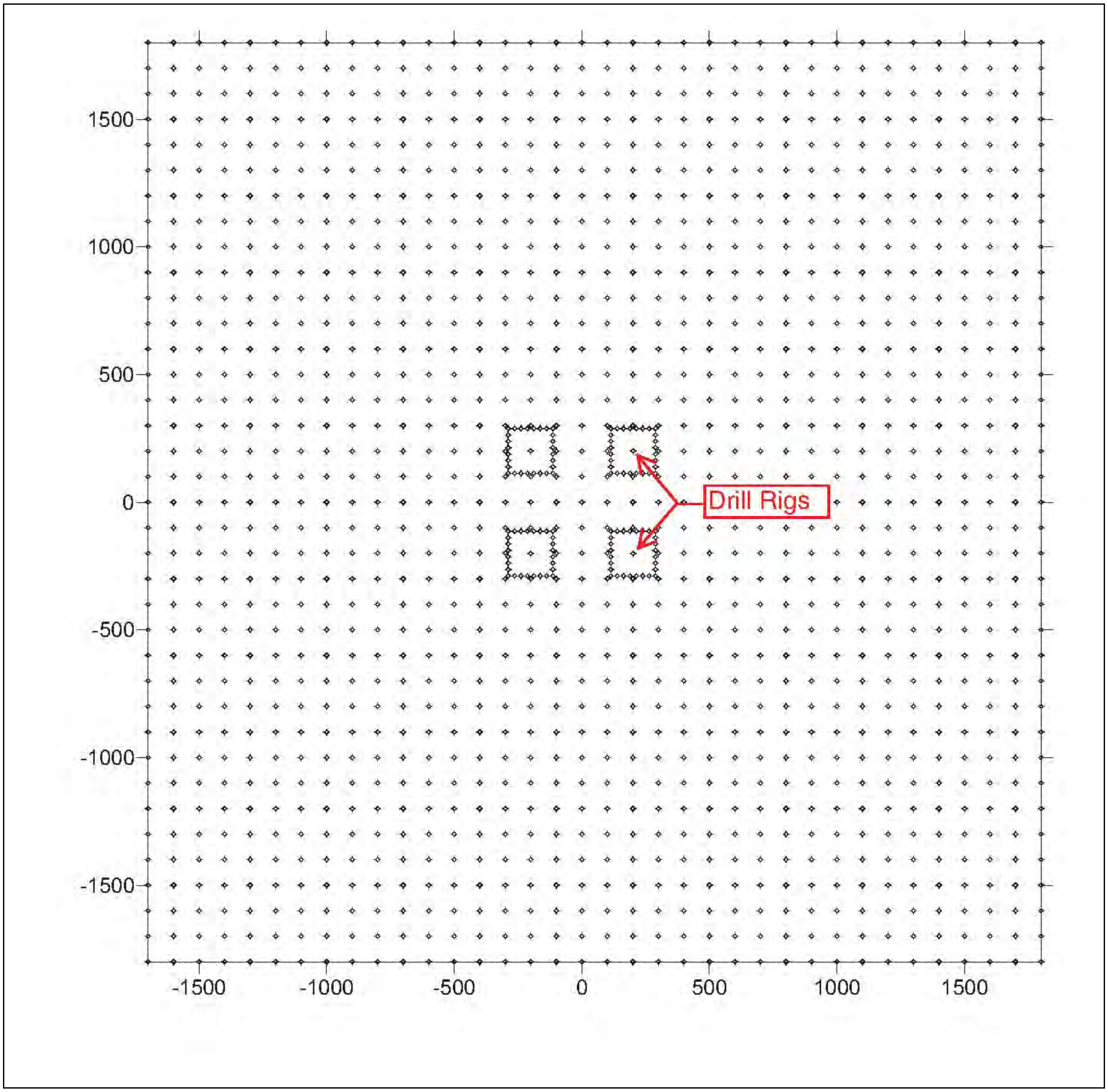

Figure 3-6. Well drilling – four 4-well pads.

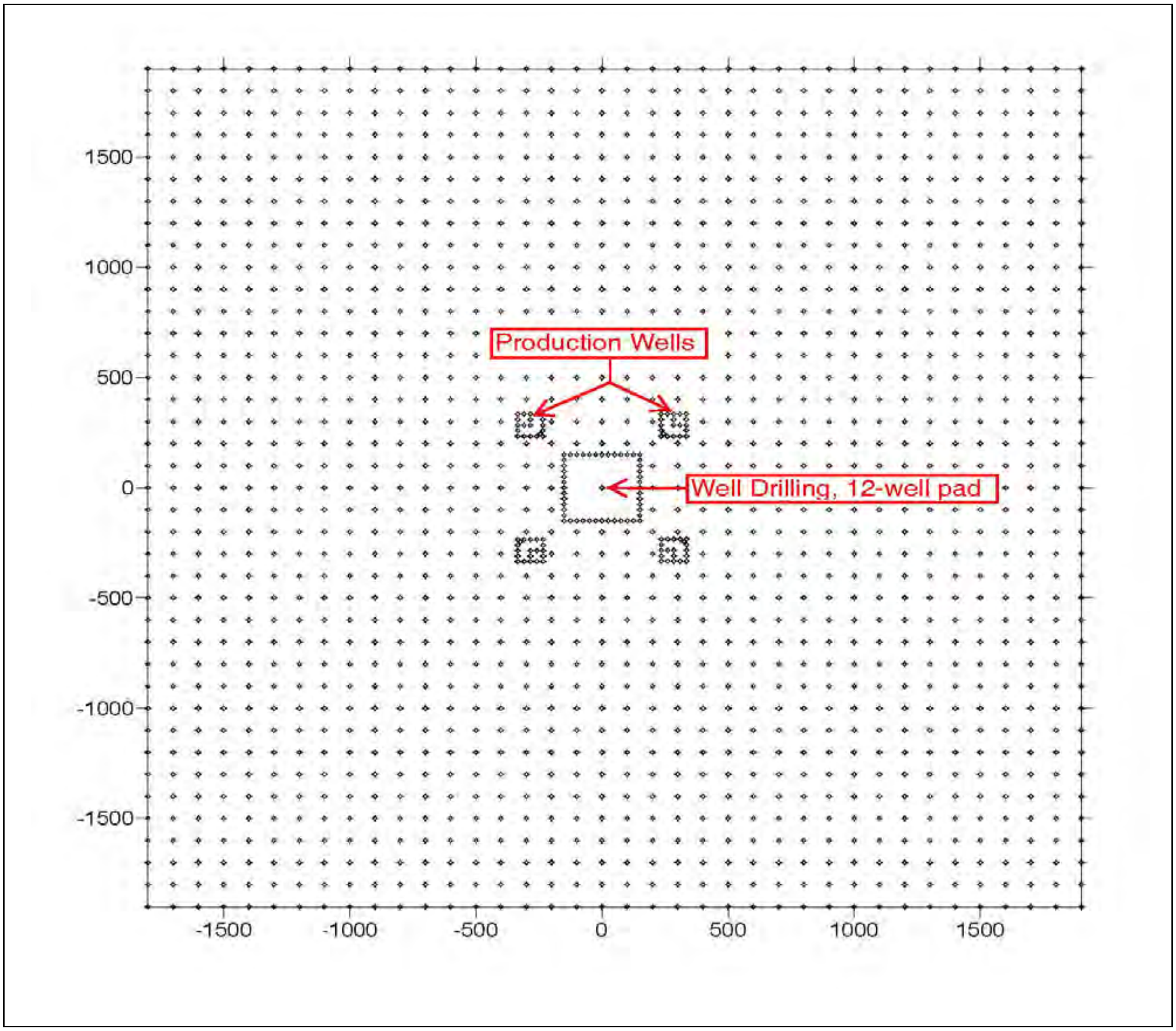

Figure 3-7. Production wells and well drilling – 12-wells/pad drilling, 4 single wells in production.

For 1-hour NO_2 modeling analyses, all six modeling scenarios were run for each of the three years of meteorological data. An additional full production case modeling scenario was run for each of the six above described modeling scenarios, assuming well production was occurring (16 wells per land-section) at the well pad where drilling operations were previously modeled. For determining compliance with the 1-hour NO_2 NAAQS and WAAQS it was assumed that well drilling could occur for a maximum of 1 year for single well drilling and 2 years for multi-well drilling at any location. The 3-year average eighth-highest daily maximum 1-hour NO_2 concentrations for comparisons to the NAAQS and WAAQS were determined by averaging modeled impacts from 2 years (single wells) or 1 year (multi-wells) using the scenario with only well production occurring at each well pad together with the modeled impacts from 1 year (single-wells) or 2 years (multi-wells) with the scenarios that included well development occurring. These 3-year averaged eighth-highest, daily maximum 1-hour concentrations were determined by averaging the maximum 1 or 2 years of eight-highest daily maximum 1-hour concentrations for the combined well drilling and production cases together with the maximum 1 or 2 years of eight-highest daily maximum 1-hour values from production alone.

The yearly maximum eighth-highest daily maximum 1-hour NO_2 concentrations for each of the modeled scenarios are provided in addition to the 3-year average values shown for comparison to the NAAQS and WAAQS.

For all annual pollutant concentrations, the maximum annual values for any of the three years of modeled impacts were reported. Given that the reported annual values include intermittent drilling activities that would not occur continuously over a year, these concentrations represent conservative upper bound estimates of the actual impacts.

Tables 3-10 and 3-11 (Tier 2 and 4 level drill rig emissions respectively) present the CO, NO_2, SO_2, PM_{10}, and $PM_{2.5}$ modeling results for Scenario 1, a single-well drilling scenario case that analyzed 5 total well pads in a land section, a drill rig operating at one pad, and 15 wells in production at 4 well pads (3-4 wells at each production pad). As shown in these tables, all modeled concentrations are below the applicable NAAQS and WAAQS.

Tables 3-12 and 3-13 (Tier 2 and 4 level drill rig emissions respectively) present the CO, NO_2, SO_2, PM_{10}, and $PM_{2.5}$ modeling results for Scenario 2, a multi-well drilling scenario case that analyzed drilling a 16 well pad. As shown in these tables all modeled concentrations are below the applicable NAAQS and WAAQS.

Tables 3-14 and 3-15 (Tier 2 and 4 level drill rig emissions respectively) present the CO, NO_2, SO_2, PM_{10}, and $PM_{2.5}$ modeling results for Scenario 3, a drilling scenario that analyzed drilling four 4-well pads simultaneously in a land section. As shown in these tables all modeled concentrations are below the applicable NAAQS and WAAQS.

Table 3-16 presents NO_2 modeling results for Scenarios 4, 5 and 6, which analyzed multi-well drilling and well production on 5 total well pads in a land section. As shown in this table all modeled NO_2 concentrations are below the applicable NAAQS and WAAQS.

Table 3-10. CD-C Project - modeling results for single well drilling (Tier 2 emissions) and multi-well pad production.

Pollutant	Averaging Time	Direct Modeled (μg/m³)[1]	Background (μg/m³)	Total Predicted (μg/m³)	WAAQS (μg/m³)	NAAQS (μg/m³)
CO	1-hour	706.0	1,026.0	1,732.0	40,000	40,000
	8-hour	456.8	798.0	1,254.8	10,000	10,000
NO_2	1-hour	59.4[2]	42.4[3]	101.8	188	188
	Annual	27.0	9.1	36.1	100	100
SO_2	1-hour	23.4[4]	19.7	43.1	196	196
	3-hour	22.4	11.5	33.9	1,300	1,300
PM_{10}	24-hour	8.5	56.0	64.5	150	--[5]
	Annual	1.3	13.5	14.8	50	50
$PM_{2.5}$	24-hour	8.5	9.2	17.7	35	35
	Annual	1.3	4.2	5.5	15	12

[1] Modeled highest second-high values are shown for all short-term averaging times with the exception of 1-hour NO_2 and SO_2 concentrations.
[2] NO_2 1-hour concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations.
[3] NO_2 1-hour background value is the 3-year average of the 3rd highest 1-hour concentrations for each season and hour of day combination.
[4] SO_2 1-hour concentration is 4th highest daily maximum 1-hour concentration.
[5] No ambient air quality standards are established for this pollutant-averaging time.

Table 3-11. CD-C Project - modeling results for single well drilling (Tier 4 emissions) and multi-well pad production.

Pollutant	Averaging Time	Direct Modeled (μg/m³)[1]	Background (μg/m³)	Total Predicted (μg/m³)	WAAQS (μg/m³)	NAAQS (μg/m³)
CO	1-hour	706.0	1,026.0	1,732.0	40,000	40,000
	8-hour	456.8	798.0	1,254.8	10,000	10,000
NO_2	1-hour	49.6[2]	42.4[3]	95.8	188	188
	Annual	20.7	9.1	29.8	100	100
SO_2	1-hour	23.4[4]	19.7	43.1	196	196
	3-hour	22.4	11.5	33.9	1,300	1,300
PM_{10}	24-hour	4.0	56.0	60.0	150	--[5]
	Annual	0.7	13.5	14.2	50	50
$PM_{2.5}$	24-hour	4.0	9.2	13.2	35	35
	Annual	0.7	4.2	4.9	15	12

[1] Modeled highest second-high values are shown for all short-term averaging times with the exception of 1-hour NO_2 and SO_2 concentrations.
[2] NO_2 1-hour concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations.
[3] NO_2 1-hour background value is the 3-year average of the 3rd highest 1-hour concentrations for each season and hour of day combination.
[4] SO_2 1-hour concentration is 4th highest daily maximum 1-hour concentration.
[5] No ambient air quality standards are established for this pollutant-averaging time.

Table 3-12. CD-C Project - modeling results for drilling 16 wells/pad (Tier 2 emissions).

Pollutant	Averaging Time	Direct Modeled (µg/m³)[1]	Background (µg/m³)	Total Predicted (µg/m³)	WAAQS (µg/m³)	NAAQS (µg/m³)
CO	1-hour	435.7	1,026.0	1,461.7	40,000	40,000
	8-hour	201.5	798.0	999.5	10,000	10,000
NO_2	1-hour	92.2[2]	37.4[3]	129.6	188	188
	Annual	18.3	9.1	27.4	100	100
SO_2	1-hour	14.5[4]	19.7	34.2	196	196
	3-hour	12.7	11.5	24.2	1,300	1,300
PM_{10}	24-hour	3.7	56.0	59.7	150	--[5]
	Annual	0.6	13.5	14.1	50	50
$PM_{2.5}$	24-hour	3.7	9.2	12.9	35	35
	Annual	0.6	4.2	4.8	15	12

[1] Modeled highest second-high values are shown for all short-term averaging times with the exception of 1-hour NO_2 and SO_2 concentrations.
[2] NO_2 1-hour concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations.
[3] NO_2 1-hour background value is the 3-year average of the 3rd highest 1-hour concentrations for each season and hour of day combination.
[4] SO_2 1-hour concentration is 4th highest daily maximum 1-hour concentration.
[5] No ambient air quality standards are established for this pollutant-averaging time.

Table 3-13. CD-C Project - modeling results for drilling 16 wells/pad (Tier 4 emissions).

Pollutant	Averaging Time	Direct Modeled (µg/m³)[1]	Background (µg/m³)	Total Predicted (µg/m³)	WAAQS (µg/m³)	NAAQS (µg/m³)
CO	1-hour	435.7	1,026.0	1,461.7	40,000	40,000
	8-hour	201.5	798.0	999.5	10,000	10,000
NO_2	1-hour	80.3[2]	44.5[3]	124.8	188	188
	Annual	13.0	9.1	22.1	100	100
SO_2	1-hour	14.5[4]	19.7	34.2	196	196
	3-hour	12.7	11.5	24.2	1,300	1,300
PM_{10}	24-hour	1.8	56.0	57.8	150	--[5]
	Annual	0.3	13.5	13.8	50	50
$PM_{2.5}$	24-hour	1.8	9.2	11.0	35	35
	Annual	0.3	4.2	4.5	15	12

[1] Modeled highest second-high values are shown for all short-term averaging times with the exception of 1-hour NO_2 and SO_2 concentrations.
[2] NO_2 1-hour concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations.
[3] NO_2 1-hour background value is the 3-year average of the 3rd highest 1-hour concentrations for each season and hour of day combination.
[4] SO_2 1-hour concentration is 4th highest daily maximum 1-hour concentration.
[5] No ambient air quality standards are established for this pollutant-averaging time.

Table 3-14. CD-C Project - modeling results for four drill rigs operating on four 4-well pads (Tier 2 emissions).

Pollutant	Averaging Time	Direct Modeled ($\mu g/m^3$)[1]	Background ($\mu g/m^3$)	Total Predicted ($\mu g/m^3$)	WAAQS ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)
CO	1-hour	707.9	1,026.0	1,733.9	40,000	40,000
	8-hour	428.6	798.0	1,226.6	10,000	10,000
NO_2	1-hour	119.1[2]	56.8[3]	175.9	188	188
	Annual	33.9	9.1	43.0	100	100
SO_2	1-hour	26.6[4]	19.7	46.3	196	196
	3-hour	20.7	11.5	32.2	1,300	1,300
PM_{10}	24-hour	9.0	56.0	65.0	150	--[5]
	Annual	1.5	13.5	15.0	50	50
$PM_{2.5}$	24-hour	9.0	9.2	18.2	35	35
	Annual	1.5	4.2	5.7	15	12

[1] Modeled highest second-high values are shown for all short-term averaging times with the exception of 1-hour NO_2 and SO_2 concentrations.
[2] NO_2 1-hour concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations.
[3] NO_2 1-hour background value is the 3-year average of the 3rd highest 1-hour concentrations for each season and hour of day combination.
[4] SO_2 1-hour concentration is 4th highest daily maximum 1-hour concentration.
[5] No ambient air quality standards are established for this pollutant-averaging time.

Table 3-15. CD-C Project - modeling results for four drill rigs operating on four 4-well pads (Tier 4 emissions).

Pollutant	Averaging Time	Direct Modeled ($\mu g/m^3$)[1]	Background ($\mu g/m^3$)	Total Predicted ($\mu g/m^3$)	WAAQS ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)
CO	1-hour	707.9	1,026.0	1,733.9	40,000	40,000
	8-hour	428.6	798.0	1,226.6	10,000	10,000
NO_2	1-hour	95.6[2]	22.6[3]	118.2	188	188
	Annual	24.8	9.1	33.9	100	100
SO_2	1-hour	26.6[4]	19.7	46.3	196	196
	3-hour	20.7	11.5	32.2	1,300	1,300
PM_{10}	24-hour	4.3	56.0	60.3	150	--[5]
	Annual	0.7	13.5	14.2	50	50
$PM_{2.5}$	24-hour	4.3	9.2	13.5	35	35
	Annual	0.7	4.2	4.9	15	12

[1] Modeled highest second-high values are shown for all short-term averaging times with the exception of 1-hour NO_2 and SO_2 concentrations.
[2] NO_2 1-hour concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations.
[3] NO_2 1-hour background value is the 3-year average of the 3rd highest 1-hour concentrations for each season and hour of day combination.
[4] SO_2 1-hour concentration is 4th highest daily maximum 1-hour concentration.
[5] No ambient air quality standards are established for this pollutant-averaging time.

Table 3-16. CD-C Project – NO_2 modeling results for well drilling and well production Scenarios 4, 5, and 6.

Scenario	Averaging Time	Direct Modeled ($\mu g/m^3$)[1]	Background ($\mu g/m^3$)[2]	Total Predicted ($\mu g/m^3$)	WAAQS/ NAAQS ($\mu g/m^3$)
Scenario 4: 12 Wells/Pad Drilling (Tier 2 Emissions), 4 Single Wells in Production	1-hour	95.8	27.8	123.6	188
	Annual	20.6	9.1	29.7	100
Scenario 4: 12 Wells/Pad Drilling (Tier 4 Emissions), 4 Single Wells in Production	1-hour	83.0	36.6	119.6	188
	Annual	14.9	9.1	24.0	100
Scenario 5: 8 Wells/Pad Drilling (Tier 2 Emissions), 4, 2-Well Pads in Production	1-hour	99.0	34.5	133.4	188
	Annual	23.1	9.1	32.2	100
Scenario 5: 8 Wells/Pad Drilling (Tier 4 Emissions), 4, 2-Well Pads in Production	1-hour	88.2	40.9	129.1	188
	Annual	17.1	9.1	26.2	100
Scenario 6: 4 Wells/Pad Drilling (Tier 2 Emissions), 4, 3-Well Pads in Production	1-hour	111.6	37.6	149.2	188
	Annual	26.5	9.1	35.6	100
Scenario 6: 4 Wells/Pad Drilling (Tier 4 Emissions), 4, 3-Well Pads in Production	1-hour	95.6	22.6	118.2	188
	Annual	20.1	9.1	29.2	100

[1] NO_2 1-hour concentrations are calculated as the 3-year average of the 8th highest daily maximum 1-hour concentrations.
[2] NO_2 1-hour background value is the 3-year average of the 3rd highest 1-hour concentrations for each season and hour of day combination.

As described above, for determining compliance with the 1-hour NO_2 NAAQS and WAAQS, it was assumed that well drilling could occur for a maximum of 1 year for single well drilling and 2 years for multi-well drilling at any location. The 3-year average eighth-highest daily maximum 1-hour NO_2 concentrations for comparisons to the NAAQS were determined by averaging modeled impacts from 2 years (single wells) or 1 year (multi-wells) using the scenario with only well production occurring at each well pad together with the modeled impacts from 1 year (single-wells) or 2 years (multi-wells) with the scenarios that included well development occurring. The highest NO_2 impacts from any of the scenarios modeled resulted from drilling operations. Table 3-17 provides the modeled eight-highest daily maximum 1-hour NO_2 concentrations for each of the modeling scenarios. These 1-hour NO_2 concentrations are the maximum values that were predicted for the three years of meteorological data. As indicated in Table 3-17 there are 1-hour NO_2 concentrations that are above the level of the 1-hour NO_2 NAAQS and WAAQS for single well drilling, 4 wells/pad drilling, and 8 wells/pad drilling scenarios that include drill rigs with Tier 2 emissions levels.

Table 3-17. CD-C Project – maximum yearly 1-Hour NO_2 modeling results for well drilling and well production scenarios.

Case	Drill Rig	Direct Modeled ($\mu g/m^3$)[1]	Background ($\mu g/m^3$)[2]	Total Predicted ($\mu g/m^3$)
Scenario 1: Single Well Drilling, 4 Wells in Production (3-4 wells at each pad)	Tier 2 Tier 4	173.3 143.7	44.5 28.8	217.8 172.6
Scenario 2: 16 Wells/Pad Drilling	Tier 2 Tier 4	128.8 110.1	36.4 53.0	165.2 162.1
Scenario 3: Drilling 4, 4-Well Pads	Tier 2 Tier 4	180.5 142.0	36.4 6.3	216.8 148.3
Scenario 4: 12 Wells/Pad Drilling, 4 Single Wells in Production	Tier 2 Tier 4	140.4 121.0	13.8 30.1	154.2 151.1
Scenario 5: 8 Wells/Pad Drilling, 4, 2-Well Pads in Production	Tier 2 Tier 4	146.1 129.4	51.4 35.1	197.5 164.5
Scenario 6: 4 Wells/Pad Drilling, 4, 3-Well Pads in Production	Tier 2 Tier 4	176.1 142.0	44.5 6.3	216.1 148.2

[1] Maximum 8th highest daily maximum 1-hour concentrations.
[2] NO_2 1-hour background value is the 3rd highest 1-hour concentration for each season and hour of day combination.

3.5.5 Well Pad Construction

The maximum localized particulate matter (PM_{10} and $PM_{2.5}$) impacts that would result from well pad and road construction activities and from wind erosion are discussed in this section. These emissions would be temporary in nature, and the impacts would be greatest at and immediately adjacent to their source and would decrease rapidly with distance. Modeling scenarios to evaluate well pad and road construction activities for PM_{10}/$PM_{2.5}$ impacts were developed for two project development levels; (1) 4 single well pads, and (2) multiple well pads, assuming 4 wells per pad. Each of these cases is for a 40 acre/section down-hole spacing development level. The single well pad case included 4 well pads and access roads under construction spaced one quarter mile apart, and the multiple well pad case included 4 multi-well pads spaced one half mile apart (16 total wells per section).

The single well pad case included well pads that are 5.4 acres, with 0.9 acre (0.14 mile) access roads. The multiple well pad case included 8 acre (2 acre per well bore) well pads (4-well pads), with a 1.8 acre (0.27 mile) access road.

The receptor grids for both the single well and multi-well pads scenarios included 25-meter spaced receptors placed 100 meters from the edge of the well pads and access roads, and rows of 100-meter spaced receptors that extended outward approximately 1 kilometer. Figures 3-8 and 3-9 illustrate these modeling scenarios. An additional receptor grid for the single well pads case was developed using 25-meter spaced receptors placed 175 meters from the edge of the well pads and access roads, and rows of 100-meter spaced receptors that extended outward approximately 1 kilometer. This receptor grid was developed after initial modeling results indicated impacts above the level of the 24-hour NAAQS and WAAQS for PM_{10} and $PM_{2.5}$ at 100 meters for the single well pad case, and was used to define the minimum distance required to be below the NAAQS and WAAQS.

Volume sources were used to represent emissions from well pads and roads. The emissions used for modeling the well pad and resource road construction are shown in Table 3-3 and are further detailed in Appendix H. Hourly emission rate adjustment factors were applied to limit construction emissions to daytime hours. Wind erosion emissions were modeled for all hours where the wind speed exceeded a threshold velocity of 16 meters/second, which was as part of the wind erosion emissions calculations described in Section 2.

For modeling PM_{10} and $PM_{2.5}$ impacts, emissions from well pad and access road construction, and wind erosion were modeled for each of the three years of AERMET-processed meteorological data and the maximum concentrations were reported.

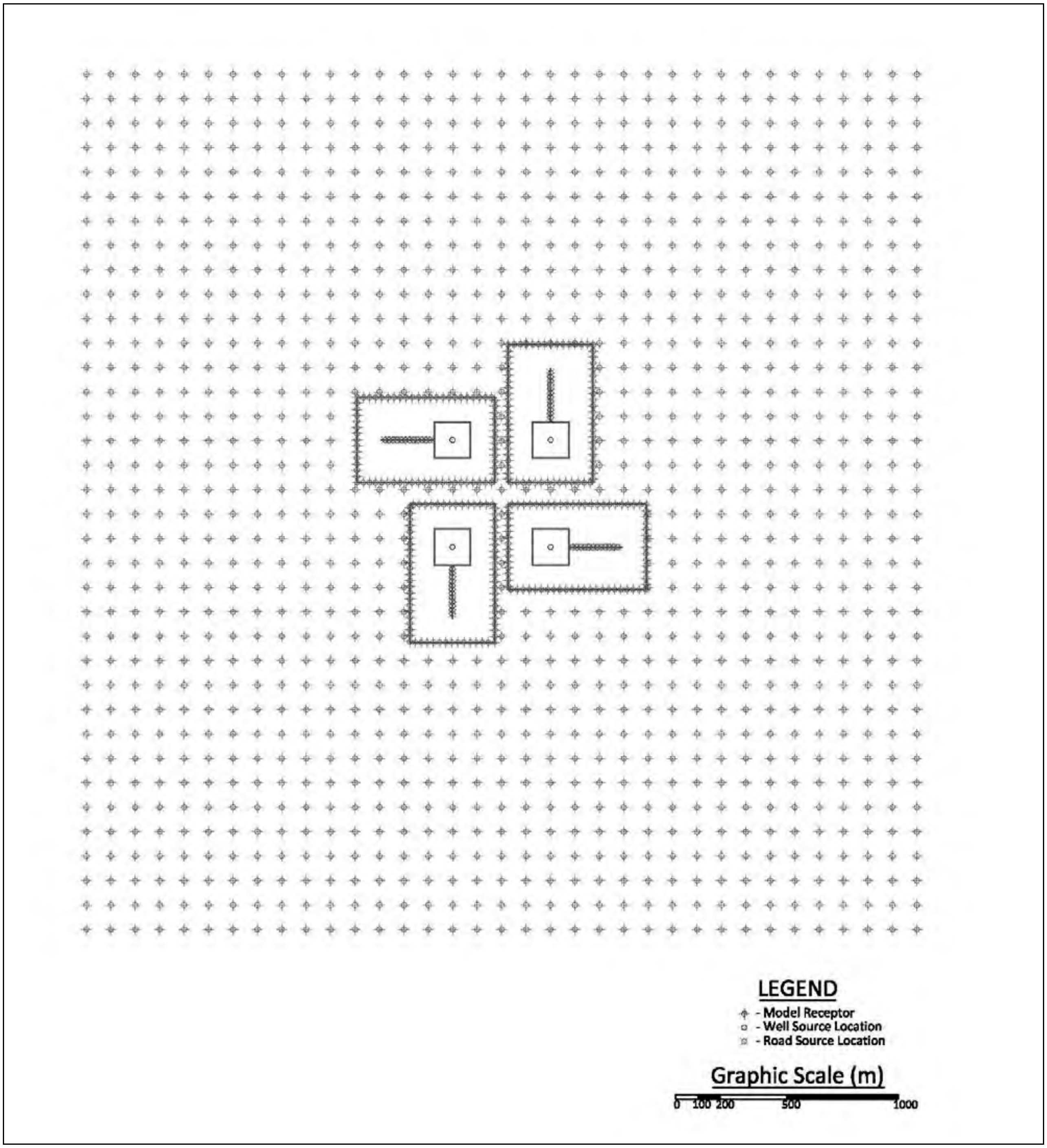

Figure 3-8. Source and receptor layout – single-well pad and access road construction – 4-single well pads.

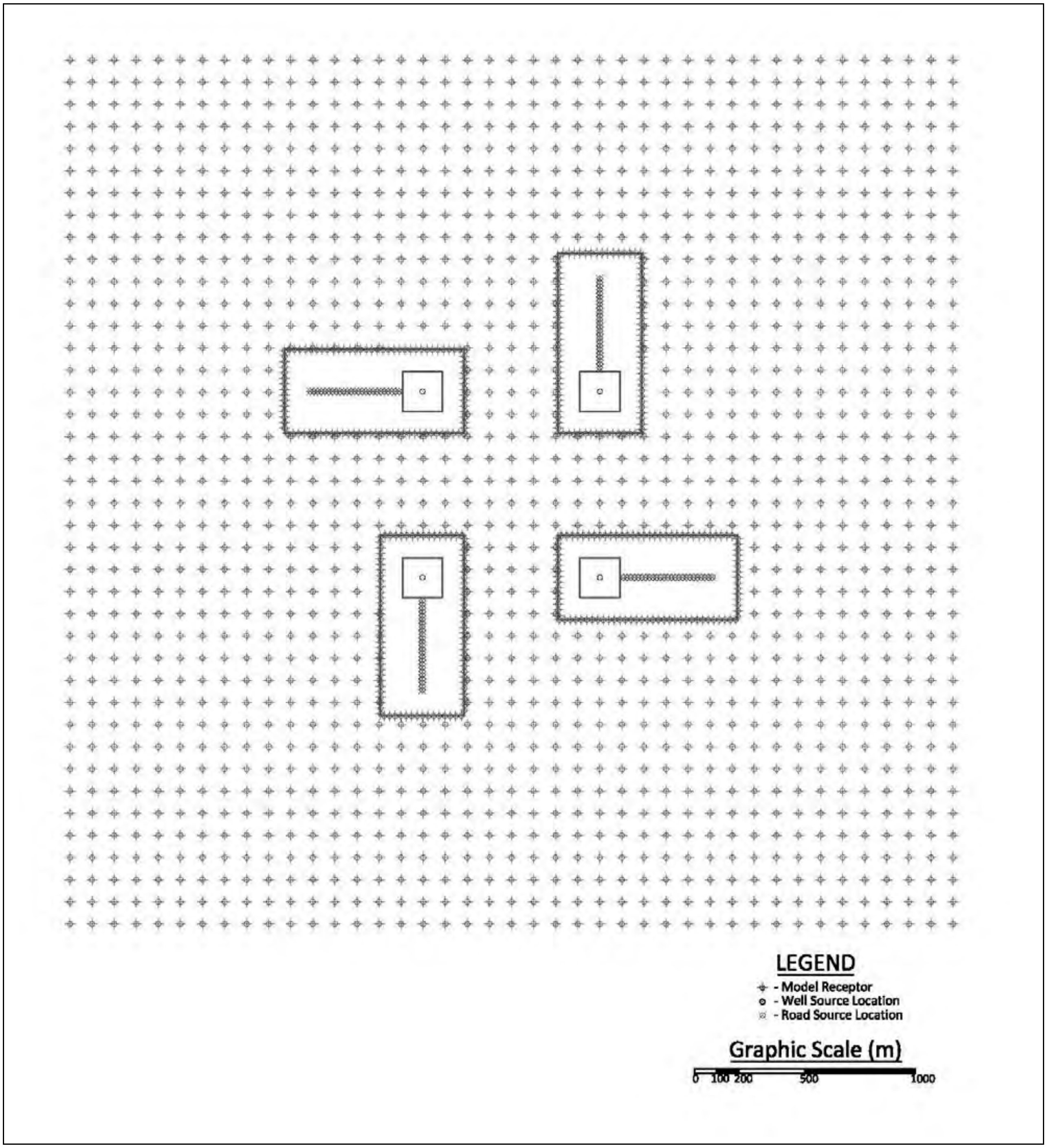

Figure 3-9. Source and receptor layout – multi-well pad and access road construction – 4 multi-well pads.

Table 3-18 presents the maximum modeled PM_{10}/$PM_{2.5}$ concentrations, for the single well pad and access road construction modeling scenarios. When the modeled concentrations are added to representative background concentrations, it was demonstrated that 24-hour PM_{10} and $PM_{2.5}$ concentrations are above the level of the PM_{10} WAAQS, and $PM_{2.5}$ WAAQS and NAAQS at 100 meters, and are below the WAAQS and NAAQS at 175 meters. All annual concentrations are below the WAAQS and NAAQS. Given that reported annual values include intermittent construction operations that would not occur continuously over a year, these concentrations are likely overstated.

Table 3-18. CD-C Project - PM_{10} and $PM_{2.5}$ modeling results for single-well pad and access road construction.

Scenario	Pollutant	Averaging Time	Direct Modeled (µg/m³)	Background (µg/m³)	Total Predicted (µg/m³)	WAAQS (µg/m³)	NAAQS (µg/m³)
100 meter	PM_{10}	24-Hour	116.1[1]	56.0	172.1	150	--[2]
		Annual	8.2	13.5	21.7	50	50
	$PM_{2.5}$	24-Hour	30.8[3]	9.2	40.0	35	35
		Annual	5.2	4.2	9.4	15	12
175 meter	PM_{10}	24-Hour	92.4[1]	56.0	148.4	150	--[2]
		Annual	5.0	13.5	18.5	50	50
	$PM_{2.5}$	24-Hour	20.5[3]	9.2	29.7	35	35
		Annual	3.2	4.2	7.4	15	12

[1] Modeled highest second-high value.
[2] No ambient air quality standards are established for this pollutant-averaging time.
[3] Modeled highest eighth-high value.

Table 3-19 presents the maximum modeled PM_{10}/$PM_{2.5}$ concentrations, for the multi-well pad and access road construction modeling scenarios. When the modeled concentrations are added to representative background concentrations, it was demonstrated that all PM_{10} and $PM_{2.5}$ concentrations are below the WAAQS and NAAQS.

Table 3-19. CD-C Project - PM_{10} and $PM_{2.5}$ modeling results for multi-well pad and access road construction.

Scenario	Pollutant	Averaging Time	Direct Modeled (µg/m³)	Background (µg/m³)	Total Predicted (µg/m³)	WAAQS (µg/m³)	NAAQS (µg/m³)
100 meter	PM_{10}	24-Hour	84.0[1]	56.0	140.0	150	--[2]
		Annual	5.3	13.5	18.8	50	50
	$PM_{2.5}$	24-Hour	21.5[3]	9.2	30.7	35	35
		Annual	3.4	4.2	7.6	15	12

[1] Modeled highest second-high value.
[2] No ambient air quality standards are established for this pollutant-averaging time.
[3] Modeled highest eighth-high value.

3.6 HAP IMPACT ASSESSMENT

Near-field HAP concentrations were calculated for assessing impacts both in the immediate vicinity of Project Area emission sources for short-term (acute) and long term (annual)) exposure assessments and for calculation of long-term risk. Since HAPs will be emitted predominantly during the Project production phases, analyses were performed for only for production activities. Sources of HAPs include well-site production emissions (benzene, toluene, ethyl benzene, xylene, n-hexane, and formaldehyde), compressor station and gas plant combustion emissions (formaldehyde), and evaporation pond emissions (benzene, toluene, ethyl benzene, and xylene).

The modeling scenarios used for the HAP impact assessment were developed as part of the criteria pollutant analysis for the proposed compression emissions, for the gas plant, for 16 single wells in production, and for a multi-well pad with 16 wells in production. The receptor grids used for the criteria pollutant modeling were used for each of these modeling scenarios. In addition, for long-term incremental risk, polar receptor grids at quarter mile increments were used to determine the distance required to be below a one-in-one-million cancer risk factor.

For the 12-acre evaporation pond, area source parameters were used to model the HAP emissions. Monthly emissions scalars were applied to account for seasonal emissions (April through November) since the evaporation pond is frozen during the winter. A receptor grid was developed using 25-meter spaced receptors placed 100 meters from the edge of the pond and rows of 100-meter spaced receptors that extended outward approximately 1.5 kilometers. For long-term incremental risk, a polar receptor grid, with receptors placed at quarter mile increments, was used to determine the distance required to be below a one-in-one-million cancer risk factor.

AERMOD was used to determine model short-term (1-hour) and long-term (annual) HAP impacts. The three years of AERMET-processed Wamsutter meteorological data (2008-2010) used for the criteria pollutant assessment were used for the HAPs analyses.

Short-term (1-hour) HAP concentrations were compared to acute Reference Exposure Levels (RELs) (EPA, 2011c) shown in Table 3-20. RELs are defined as concentrations at or below which no adverse health effects are expected. No RELs are available for ethyl benzene and n-hexane; instead, the available Immediately Dangerous to Life or Health divided by 10 (IDLH/10) values are used. These IDLH values were determined by the National Institute for Occupational Safety and Health (NIOSH) and were obtained from EPA's Air Toxics Database (EPA, 2011c). These values are approximately comparable to mild effects levels for 1-hour exposures.

Long-term HAPs concentrations were compared to Reference Concentrations for Chronic Inhalation (RfCs). An RfC is defined by EPA as the daily inhalation concentration at which no long-term adverse health effects are expected. RfCs exist for both non-carcinogenic and carcinogenic effects on human health (EPA, 2010b). Annual modeled HAP concentrations for all HAPs emitted were compared directly to the non-carcinogenic RfCs shown in Table 3-21. RfCs for suspected carcinogens benzene, ethyl benzene, and formaldehyde are expressed as unit risk factors, shown in Table 3-26, and were used to evaluate the potential incremental risk from these pollutants.

Table 3-20. Acute RELs (1-Hour Exposure).

HAP	REL (µg/m^3)
Benzene	1,300[1]
Toluene	37,000[1]
Ethyl Benzene	350,000[2]
Xylene	22,000[1]
n-Hexane	390,000[2]
Formaldehyde	55[1]

[1] EPA Air Toxics Database, Table 2 (EPA, 2011c).
[2] No REL available for these HAPs. Values shown are from Immediately Dangerous to Life or Health (IDLH/10), EPA Air Toxics Database, Table 2 (EPA, 2011c).

Table 3-21. Non-Carcinogenic HAP RfCs (Annual Average).[1]

HAP	Non-CarcinogenicRfC[1] (µg/m^3)
Benzene	30
Toluene	5000
Ethyl Benzene	1,000
Xylenes	100
n-Hexane	700
Formaldehyde	9.8

[1]EPA Air Toxics Database, Table 1 (EPA, 2010b).

Table 3-22 presents the modeled formaldehyde impacts for the proposed compression station and gas plant. As shown in these tables both the short-term (1-hour) and long-term (annual) formaldehyde impacts are well below the RELs and RfCs for both the proposed compressor station and gas plant.

Tables 3-23 and 3-24 present the short-term and long-term HAP modeling results for 16 wells in production, both from single well pads and from a multi-well pad with 16 wells. As shown in these tables HAP impacts are below the applicable short-term RELs or IDLH/10 values, and the long-term non-carcinogenic RfCs.

Table 3-22. CD-C Project – formaldehyde modeling results for proposed compression and gas plant emissions.

Scenario	Modeled 1-hour Concentration (µg/m^3)	REL (µg/m^3)	Modeled Annual Concentration (µg/m^3)	Non-carcinogenic RfC (µg/m^3)
Compression	5.5	55	0.2	9.8
Gas Plant	5.9	55	0.4	9.8

Table 3-23. CD-C Project – Short-Term (1-hour) HAP modeling results for production wells.

HAP	Modeled Concentration by Scenario (μg/m³)		REL or IDLH (μg/m³)
	16 Single Wells	16-Well Pad	
Benzene	1.3	13.5	1,300[1]
Toluene	1.8	18.8	37,000[1]
Ethyl Benzene	0.04	0.4	350,000[2]
Xylene	0.8	8.5	22,000[1]
n-Hexane	7.8	77.4	390,000[2]
Formaldehyde	0.04	0.5	55[1]

[1] Reference Exposure Level
[2] Immediately Dangerous to Life or Health value divided by 10.

Table 3-24. CD-C Project – long-term (annual) HAP modeling results for production wells.

HAP	Modeled Concentration by Scenario (μg/m³)		Non-carcinogenic RfC (μg/m³)
	16 Single Wells	16-Well Pad	
Benzene	0.07	0.8	30
Toluene	0.09	1.1	5,000
Ethyl Benzene	0.002	0.02	1,000
Xylene	0.04	0.5	100
n-Hexane	0.4	4.3	700
Formaldehyde	0.003	0.02	9.8

Table 3-25 presents the modeled benzene, toluene, ethyl benzene, and xylene impacts from a 12 acre evaporation pond. As shown in these tables both the short-term (1-hour) and long-term impacts are well below the RELs and RfCs.

Table 3-25. CD-C Project – HAP modeling results for 12 acre evaporation pond.

HAP	Modeled 1-hour Concentration (μg/m³)	REL (μg/m³)	Modeled Annual Concentration (μg/m³)	Non-carcinogenic RfC (μg/m³)
Benzene	228.0	1,300[1]	5.5	30
Toluene	301.3	37,000[1]	7.3	5,000
Ethyl Benzene	24.4	350,000[2]	0.6	1,000
Xylene	339.2	22,000[1]	8.2	100

[1] Reference Exposure Level
[2] Immediately Dangerous to Life or Health value divided by 10.

Long-term exposures to emissions of suspected carcinogens (benzene ethyl benzene and formaldehyde) were evaluated based on estimates of the increased latent cancer risk over a 70-year lifetime. This analysis presents the potential incremental risk from these pollutants, and does not represent a total risk analysis. The cancer risks were calculated using the maximum predicted annual concentrations and EPA's chronic inhalation unit risk factors (URF) for carcinogenic constituents (EPA 2010b. Estimated cancer risks were evaluated based on the Superfund National Oil and Hazardous Substances Pollution Contingency Plan (EPA 1990a), where a cancer risk range of 1 to 100 x 10^{-6} is generally acceptable. Two estimates of cancer risk are presented: 1) a most likely exposure (MLE) scenario; and 2) a maximum exposed individual (MEI) scenario. The estimated cancer risks are adjusted to account for duration of exposure and time spent at home.

The adjustment for the MLE scenario is assumed to be 9 years, which corresponds to the mean duration that a family remains at a residence (EPA 1993). This duration corresponds to an adjustment factor of 9/70 = 0.13. The duration of exposure for the MEI scenario is assumed to be 60 years (i.e., the LOP), corresponding to an adjustment factor of 60/70 = 0.86. A second adjustment is made for time spent at home versus time spent elsewhere. For the MLE scenario, the at-home time fraction is 0.64 (EPA 1993), and it is assumed that during the rest of the day the individual would remain in an area where annual HAP concentrations would be one quarter as large as the maximum annual average concentration. Therefore, the final MLE adjustment factor is (0.13) x [(0.64 x 1.0) + (0.36 x 0.25)] = 0.0949. The MEI scenario assumes that the individual is at home 100% of the time, for a final MEI adjustment factor of (0.86 x 1.0) = 0.86. Table 3-26 provides RfCs for suspected carcinogens benzene, ethyl benzene, and formaldehyde, expressed as unit risk factors, and the exposure adjustment factors used to evaluate the potential incremental risk from these pollutants.

Table 3-26. Carcinogenic HAP RfCs and exposure adjustment factors.

Analysis[1]	HAP Constituent	Carcinogenic RfC (Unit Risk Factor)[2] $1/(\mu g/m^3)$[3]	Exposure Adjustment Factor
MLE	Benzene	7.8×10^{-6}	0.0949
MLE	Ethyl Benzene	2.5×10^{-6}	0.0949
MLE	Formaldehyde	1.3×10^{-5}	0.0949
MEI	Benzene	7.8×10^{-6}	0.86
MEI	Ethyl Benzene	2.5×10^{-6}	0.86
MEI	Formaldehyde	1.3×10^{-5}	0.86

[1] LE = most likely exposure; MEI = maximally exposed individual.
[2] EPA Air Toxics Database, Table 1 (EPA, 2010).
[3] Annual Average Concentration.

For each constituent, the cancer risk is computed by multiplying the maximum predicted annual concentration by the URF and by the overall exposure adjustment factor. The cancer risks for both constituents are then summed to provide an estimate of the total inhalation cancer risk.

The modeled long-term risk from formaldehyde concentrations resulting from the proposed compression and gas plant emissions are shown in Table 3-27. The distance required to be below a one-in-one-million cancer risk level for either the MLE or MEI analysis was 0.25 miles for the compressor station, and 1.0 miles for the proposed gas plant.

Table 3-27. CD-C Project - Long-term modeled formaldehyde MLE and MEI cancer risk analyses for proposed compression and gas plant.

Modeling Scenario	Distance	Analysis	Modeled Concentration ($\mu g/m^3$)	Unit Risk Factor 1/($\mu g/m^3$)	Exposure Adjustment Factor	Cancer Risk
Compression	Fenceline	MLE	0.19	1.3×10^{-5}	0.0949	0.2×10^{-6}
Compression	Fenceline	MEI	0.19	1.3×10^{-5}	0.86	2.1×10^{-6}
Gas Plant	100 meters	MLE	0.36	1.3×10^{-5}	0.0949	0.4×10^{-6}
Gas Plant	100 meters	MEI	0.36	1.3×10^{-5}	0.86	4.0×10^{-6}
Compression	0.25 miles	MLE	0.08	1.3×10^{-5}	0.0949	0.1×10^{-6}
Compression	0.25 miles	MEI	0.08	1.3×10^{-5}	0.86	0.9×10^{-6}
Gas Plant	1.0 miles	MEI	0.08	1.3×10^{-5}	0.0949	0.1×10^{-6}
Gas Plant	1.0 miles	MEI	0.08	1.3×10^{-5}	0.86	0.9×10^{-6}

The modeled long-term risk from benzene, ethyl benzene, and formaldehyde emissions resulting from the well production scenarios is shown in Table 3-28. For the 16 single wells in production case, long-term risk estimates are below the one-in-one-million cancer risk level for both the MLE or MEI analyses. For the 16 wells in production on a 16-well pad scenario long-term risk estimates are below the one-in-one-million cancer risk level for the MLE analysis and above for the MEI analysis. The distance required to be below a one-in-one-million cancer risk level for the MEI analysis was 0.25 miles from the 16-well pad.

Table 3-28. CD-C Project - long-term modeled MLE and MEI cancer risk analyses for production well case.

Modeling Scenario	Analysis	HAP Constituent	Modeled Concentration (μg/m^3)	Unit Risk Factor 1/(μg/m^3)	Exposure Adjustment Factor	Cancer Risk
16 single wells	MLE	Benzene	0.066	7.8 x 10^{-6}	0.0949	0.05 x 10^{-6}
		Ethyl Benzene	0.002	2.5 x 10^{-6}	0.0949	0.0001 x 10^{-6}
		Formaldehyde	0.003	1.3 x 10^{-5}	0.0949	0.003 x 10^{-6}
Total Combined[1]						0.05 x 10^{-6}
16 single wells	MEI	Benzene	0.066	7.8 x 10^{-6}	0.86	0.4 x 10^{-6}
		Ethyl Benzene	0.002	2.5 x 10^{-6}	0.86	0.004 x 10^{-6}
		Formaldehyde	0.003	1.3 x 10^{-5}	0.86	0.03 x 10^{-6}
Total Combined[1]						0.5 x 10^{-6}
16 wells/pad	MLE	Benzene	0.75	7.8 x 10^{-6}	0.0949	0.6 x 10^{-6}
		Ethyl Benzene	0.02	2.5 x 10^{-6}	0.0949	0.006 x 10^{-6}
		Formaldehyde	0.02	1.3 x 10^{-5}	0.0949	0.02 x 10^{-6}
Total Combined[1]						0.6 x 10^{-6}
16 wells/pad	MEI	Benzene	0.75	7.8 x 10^{-6}	0.86	5.0 x 10^{-6}
		Ethyl Benzene	0.02	2.5 x 10^{-6}	0.86	0.05 x 10^{-6}
		Formaldehyde	0.02	1.3 x 10^{-5}	0.86	0.2 x 10^{-6}
Total Combined[1]						5.3 x 10^{-6}
16 wells/pad (receptors 0.25 miles from well pad)	MLE	Benzene	0.074	7.8 x 10^{-6}	0.0949	0.05 x 10^{-6}
		Ethyl Benzene	0.002	2.5 x 10^{-6}	0.0949	0.0001 x 10^{-6}
		Formaldehyde	0.004	1.3 x 10^{-5}	0.0949	0.0005 x 10^{-6}
Total Combined[1]						0.06 x 10-^{6}
16 wells/pad (receptors 0.25 miles from well pad	MEI	Benzene	0.074	7.8 x 10^{-6}	0.86	0.5 x 10^{-6}
		Ethyl Benzene	0.002	2.5 x 10^{-6}	0.86	0.0005 x 10^{-6}
		Formaldehyde	0.004	1.3 x 10^{-5}	0.86	0.04 x 10^{-6}
Total Combined[1]						0.5 x 10^{-6}

[1]Total risk is calculated here; however, the additive effects of multiple chemicals are not fully understood and this should be taken into account when viewing these results.

The modeled long-term risk from benzene and ethyl benzene resulting from evaporation pond emissions is shown in Table 3-29. At a 100 meter distance, long-term risk estimates are above the one-in-one-million cancer risk level for both the MLE or MEI analyses. The distance required to be below a one-in-one-million cancer risk level for both the MLE and MEI analyses was 1.0 miles from the evaporation pond.

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Table 3-29. CD-C Project - long-term modeled MLE and MEI cancer risk analyses for 12 acre evaporation pond.

Distance	Analysis	HAP Constituent	Modeled Concentration ($\mu g/m^3$)	Unit Risk Factor $1/(\mu g/m^3)$	Exposure Adjustment Factor	Cancer Risk
100 meters	MLE	Benzene	5.5	7.8×10^{-6}	0.0949	4.1×10^{-6}
		Ethyl Benzene	0.6	2.5×10^{-6}	0.0949	0.1×10^{-6}
Total Combined[1]						4.2×10^{-6}
100 meters	MEI	Benzene	5.5	7.8×10^{-6}	0.86	36.9×10^{-6}
		Ethyl Benzene	0.6	2.5×10^{-6}	0.86	1.3×10^{-6}
Total Combined[1]						38.1×10^{-6}
1.0 mile	MLE	Benzene	0.13	7.8×10^{-6}	0.0949	0.1×10^{-6}
		Ethyl Benzene	0.01	2.5×10^{-6}	0.0949	0.003×10^{-6}
Total Combined[1]						0.1 x 10-^{6}
1.0 mile	MEI	Benzene	0.13	7.8×10^{-6}	0.86	0.9×10^{-6}
		Ethyl Benzene	0.01	2.5×10^{-6}	0.86	0.03×10^{-6}
Total Combined[1]						0.9×10^{-6}

[1]Total risk is calculated here; however, the additive effects of multiple chemicals are not fully understood and this should be taken into account when viewing these results.

4.0 FAR-FIELD MODELING

4.1 MODELING METHODOLOGY

In this section, we describe in more detail the modeling approach that was briefly outlined in Section 1.3.2. For the 2005-2006 base case, 2008 baseline and 2022 future year modeling, CAMx was applied using a nested-grid modeling domain with horizontal spatial resolution 36/12/4 km (Figure 4-1). The 2022 future year CAMx results were post-processed to derive: (1) air concentrations for comparison to ambient air quality standards and Class I and II Prevention of Significant Deterioration (PSD) Increments; (2) AQRV impacts due to sulfur and nitrogen deposition for comparison to sulfur and nitrogen deposition thresholds and to calculate acid neutralizing capacity (ANC) for sensitive water bodies; and (3) AQRV impacts due to light extinction change for comparison to visibility impact thresholds in Class I and sensitive Class II areas. The modeling methodology followed regional PGM modeling procedures for ozone, particulate matter (PM) and regional haze that were established prior to initiation of the CD-C modeling. These include:

- “Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for ozone, $PM_{2.5}$, and Regional Haze” (EPA, 2007c).
- “Quality Assurance Project Plan for the Western Regional Air Partnership Regional Modeling Center” (Tonnesen, Morris and Adelman, 2004).
- “Modeling Protocol for the CENRAP 2002 Emissions and Air Quality Modeling” (Morris et al., 2004b).
- “Modeling Protocol for the VISTAS Phase II Regional Haze Modeling” (Morris et al., 2004a).
- “Air Quality Modeling Analysis for the Denver Early Action Ozone Compact: Modeling Protocol, Episode Selection and Domain Definition” (Tesche et al., 2003).
- Modeling Protocol for the Denver 8-Hour Ozone Attainment Demonstration Modeling (Morris et al., 2007).

4.1.1 Modeling Domains

The main study area for the analysis is the 4 km modeling domain shown in Figures 4-1 through 4-3. The 4 km domain includes the CD-C Project Area and most PSD Class I and sensitive Class II (Class I/II) areas for which the far-field air quality and AQRVs assessment is performed. There are four Class I/II areas which are not entirely contained within the 4 km modeling domain and are also included in the analysis. 12 km grid cell results were used to provide complete coverage of those additional four areas where 4 km grid cell results were not available. Although the main focus of the analysis is the 4 km grid, the modeling strategy accounts for the fact that pollutant concentrations within the 4 km domain may be influenced by transport of pollutants and their precursors from outside the 4 km domain. A nested model grid system was designed to account for the effects of transport on determining pollutant concentrations and atmospheric background reactivity within the 4 km domain.

The primary function of the continental-scale 36 km grid domain shown in Figure 4-1 is to provide lateral boundary conditions to the 12/4 km nested grids. This was accomplished by running CAMx for the 36 km domain and processing the hourly model output to define Boundary Conditions (BCs) for the 12 km domain (i.e., one-way nesting between the 36 km and

12 km domains). The 12/4 km CAMx simulation was then run with two-way interactive grid nesting where pollutants flow between the 12 km and 4 km grid domains in the simulation.

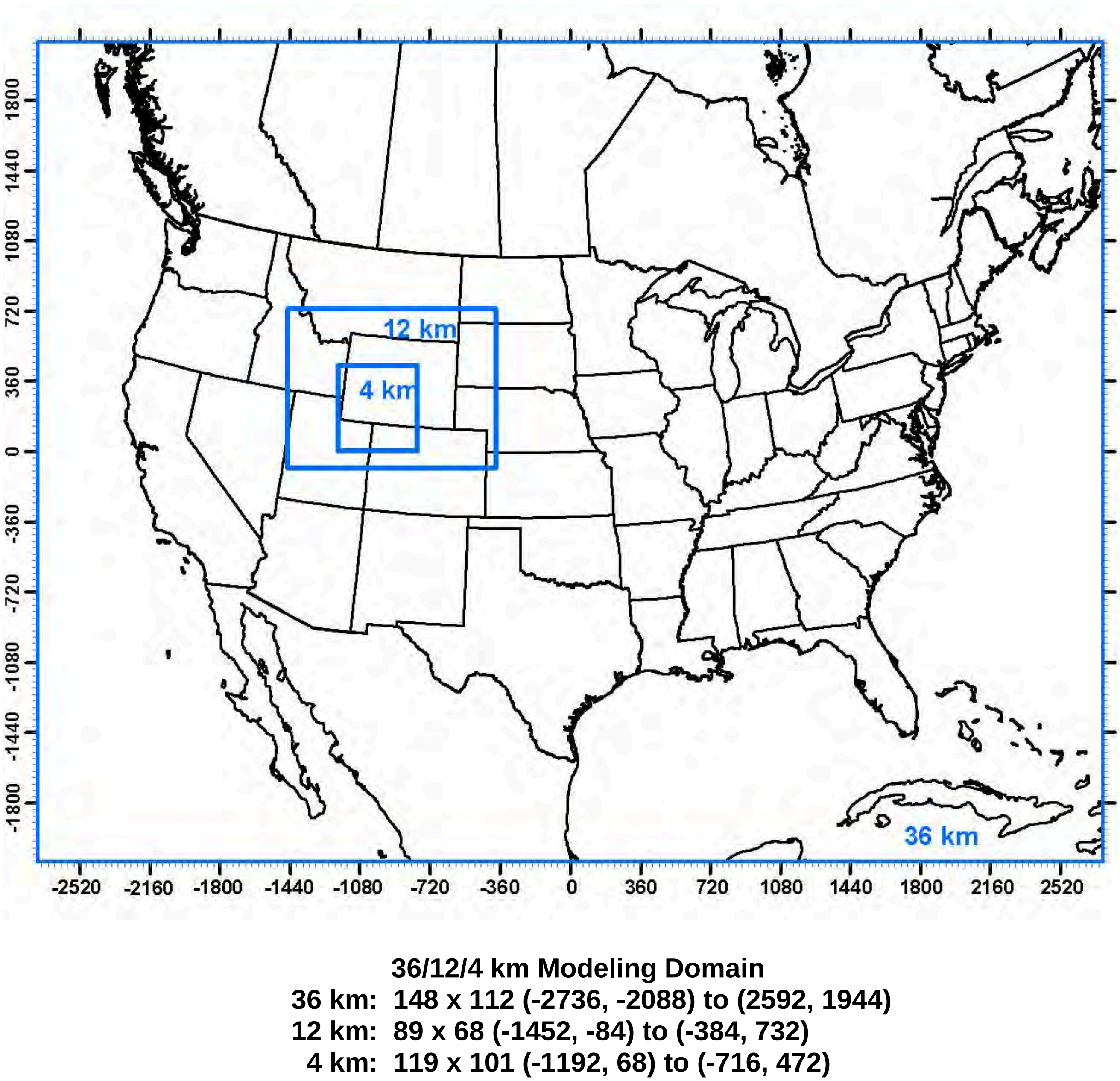

Figure 4-1. Nested 36/12/4 km CD-C CAMx modeling domains.

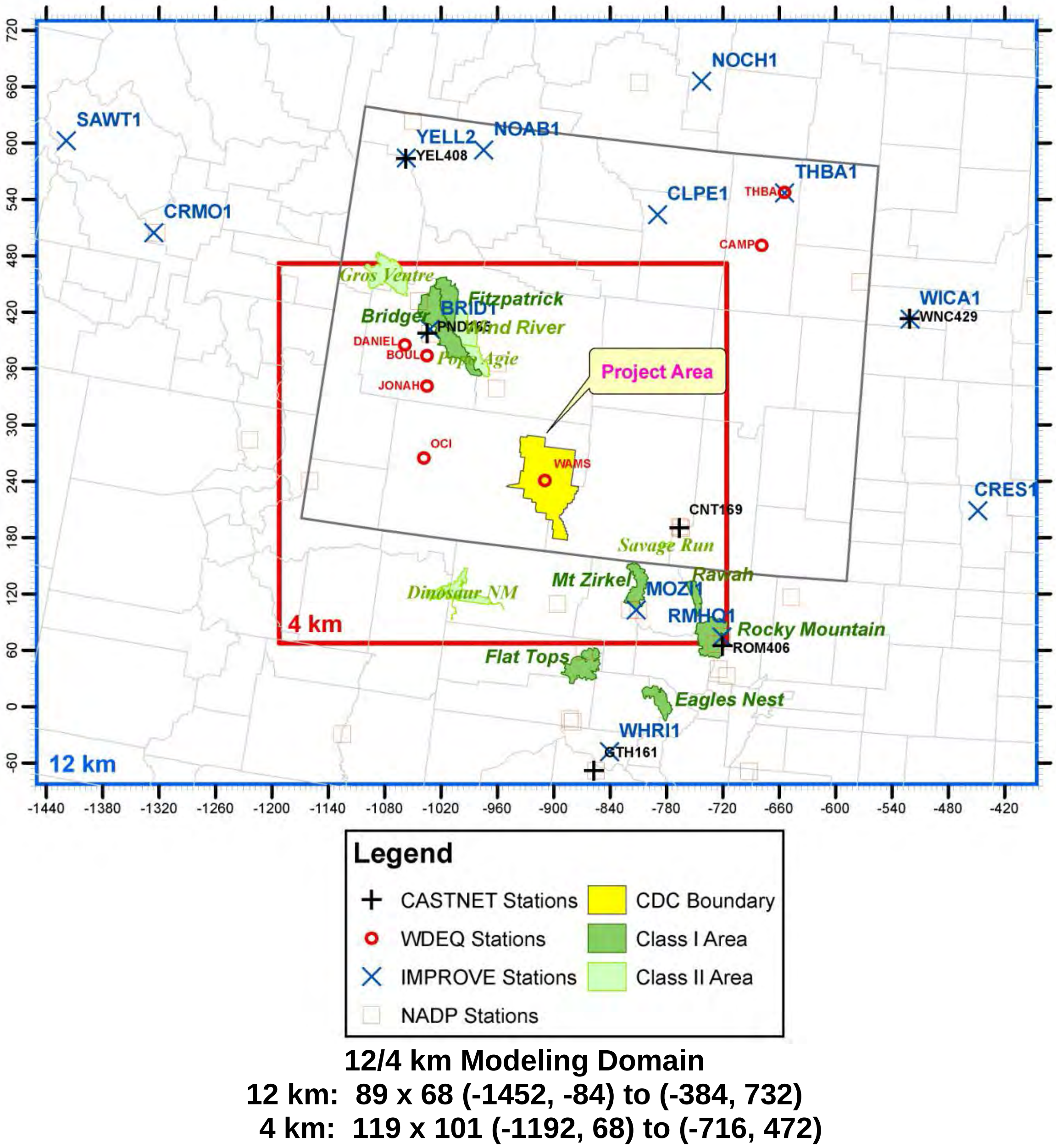

Figure 4-2. Nested regional 12/4 km CAMx modeling domain showing locations of ambient air monitoring sites from several monitoring networks and Class I and sensitive Class II areas included in the analysis.

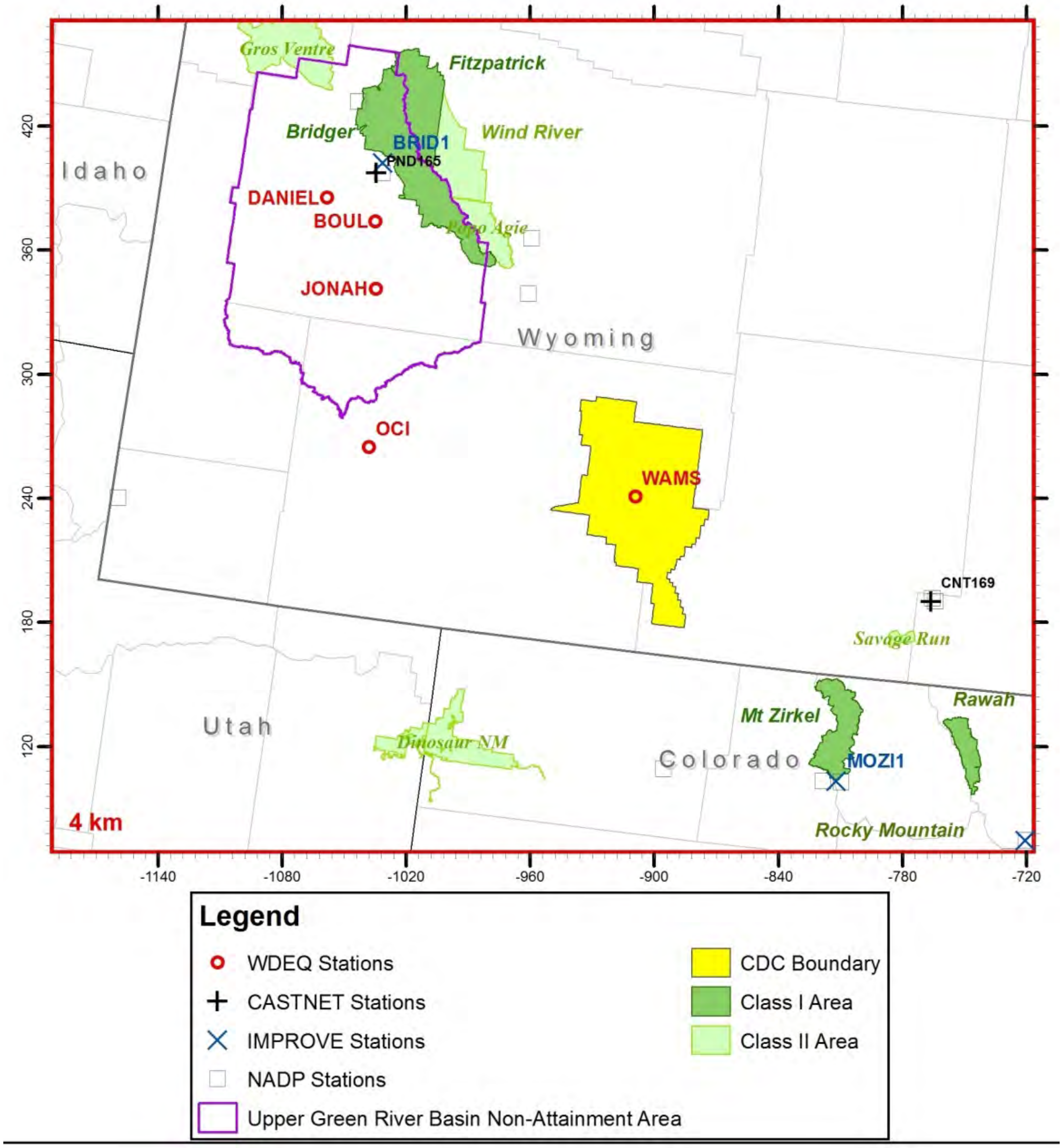

Figure 4-3. The CD-C 4 km CAMx modeling domain showing locations of ambient air monitoring sites from several monitoring networks and Class I and sensitive Class II areas. The CD-C Project Area is shaded yellow and the nonattainment area boundary is shown in purple.

4.2 BASE CASE MODELING OF 2005-2006

For the CD-C EIS, a base case simulation and model performance evaluation was carried out for the 2005 and 2006 calendar years. We summarize results in Section 4.2.1, and provide a detailed analysis of model performance in Appendix A. CAMx was applied for the calendar years 2005 and 2006 using a nested-grid modeling domain with horizontal spatial resolution 36/12/4 km (Figures 4-1 through 4-3). The 2005 and 2006 base case model runs used actual emissions of NO_X, SO_2, PM_{10}, $PM_{2.5}$, VOC and CO from all sources within the modeling domains for those years and included a comprehensive inventory of oil and gas (O&G) emissions sources within Southwest Wyoming developed by Carter Lake and BP as well as the WRAP Phase III O&G emissions (Bar-Ilan et al. 2008; 2009a; 2009b) for the Denver-Julesburg, Piceance, and Uinta Basins.

4.2.1 Meteorological Modeling for the 2005-2006 Years

CAMx requires meteorological input data for the fields shown in Table 4-1. Meteorological input data for CAMx were developed for the 2005 and 2006 base case modeling years using the PSU/NCAR Mesoscale Model Version 5 (MM5; Anthes and Warner, 1978; Dudhia, 1993).

Table 4-1. CAMx meteorological input data requirements.

CAMx Input Parameter	Description
Layer interface height (m)	3-D gridded time-varying layer heights for the start and end of each hour
Winds (m/s)	3-D gridded wind vectors (u,v) for the start and end of each hour
Temperature (K)	3-D gridded temperature and 2-D gridded surface temperature for the start and end of each hour
Pressure (mb)	3-D gridded pressure for the start and end of each hour
Vertical Diffusivity (m^2/s)	3-D gridded vertical exchange coefficients for each hour
Water Vapor (ppm)	3-D gridded water vapor mixing ratio for each hour
Clouds and Rainfall (g/m^3)	3-D gridded cloud and rain liquid water content for each hour

For 2005, the 36 km and 12 km MM5 output generated for the NMED Giant PSD Increment Consumption Study (McNally, 2007) and used in the Four Corners Air Quality Task Force (FCAQTF) modeling was used for CD-C. For the 4 km grid for 2005, as well as all three grids (36/12/4 km) for the 2006 modeling year, output from MM5 modeling conducted specifically for the CD-C EIS was used. For CD-C, the MM5 model was set up for 2005 and 2006 using a 36/12/4 km grid structure (Figure 4-4) that is applicable for use on the CD-C air quality modeling domains (Figures 4-1 through 4-3). The 12 km domain is not centered over the CD-C Project area because the domain was designed to be used for multiple projects in the Intermountain West. The MM5 configuration for the 2005 and 2006 CD-C runs followed the WRAP 2002 MM5 modeling approach (Kemball-Cook et al., 2004). The MM5 column physics options selected for the CD-C MM5 modeling are shown in Table 4-2.

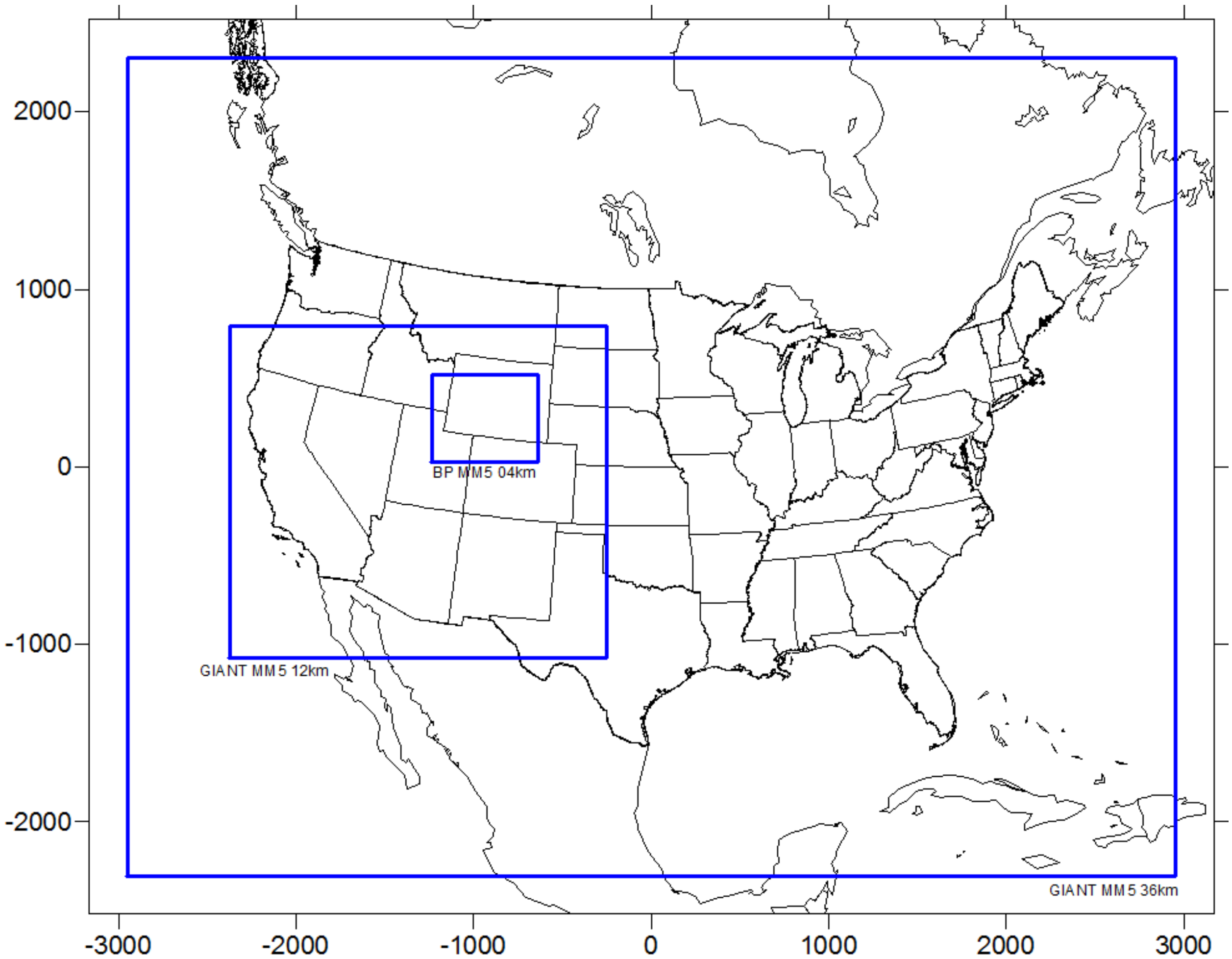

Figure 4-4. MM5 meteorological nested 36/12/4/ km modeling domains.

Table 4-2. CD-C MM5 modeling column physics configuration.

Column Physics Process	Parameterization
Moist Physics	Reisner I
Longwave Radiation	RRTM
Shortwave Radiation	Dudhia
Land Surface Model/PBL	Pleim-Xiu/ACM
Soil Moisture Nudging	Yes
Cumulus Parameterization	Kain-Fritsch II
Shallow Convection Parameterization	No

4.2.1.1 Four-Dimensional Data Assimilation

MM5's FDDA capability is used to nudge model predictions toward observational analyses and/or discrete measurements to control model "drift" from conditions that actually occurred during the simulation period (Stauffer and Seaman, 1990). This approach has consistently been shown to provide powerful advantages in running mesoscale models for multi-day episodes, and has become the standard for photochemical applications. MM5 may be nudged toward gridded analyses ("analysis nudging") or toward individual observations ("observation nudging"). When analysis nudging is performed using three-dimensional gridded fields from a data set such as the Eta Data Assimilation System (EDAS), the technique is referred to as 3D analysis nudging. Analysis nudging may also be performed using gridded surface data; this is known as surface analysis nudging. The EDAS analysis was used for this MM5 simulation, and was supplemented by including the National Center for Environmental Prediction's (NCEP) Automatic Data Processing (ADP) surface and upper air observations through the use of MM5's LITTLE_R preprocessing program.

Observation nudging to the National Center for Atmospheric Research (NCAR) ds472 airport data was performed for the 2005 and 2006 runs. The 2005 4 km MM5 run was also nudged to observed winds from the Jonah, Boulder, and Daniel monitors in southwest Wyoming. For the 2006 MM5 4 km run, additional stations were available and nudging was performed to surface wind data from the Jonah, Boulder, Daniel, Wamsutter, Simplot, Riverton, Evanston, OCI, Whitney, Rock Springs, and Centennial stations. For both 2005 and 2006, analysis nudging was performed for winds, temperature, and humidity above the boundary layer. MM5 default nudging coefficients were used. The MM5 outputs were processed with the MM5CAMx processor to generate the 36/12/4 km meteorological inputs for CAMx modeling of 2005 and 2006.

4.2.1.2 Segmented MM5 Simulation Approach

The MM5 solution is subject to increasing error over the course of an extended simulation due to uncertainties in initial/boundary conditions, limits in spatial and temporal resolution, and simplification and discretization in the governing equations. To reduce error propagation through the simulation, the model run was made in sequential 5-day run segments, and MM5 was re-initialized at the beginning of each 5-day period. Each 5-day segment had an initial spinup period of 24 hours that overlapped the last 24 hours of the preceding run. This segmented approach was successfully used in annual RPO MM5 simulations for WRAP, CENRAP, and VISTAS regional haze modeling, and was shown to produce meteorological databases suitable for air quality modeling over extended time periods (Kemball-Cook et al. 2004).

4.2.1.3 Model Vertical Structure

MM5 was run with 34 vertical layers up to a model top at a pressure level of 100 millibars (mb) (approximately 15 km above ground level (AGL)). In the Hiawatha base case preliminary modeling (Kemball-Cook et al., 2009) , layer collapsing was employed in which some vertical layers used in the MM5 simulation were combined in CAMx so that there were fewer vertical layers in CAMx (19) than in MM5 (34). The purpose of this procedure was to improve the computational efficiency of the simulation. During the CD-C Round 1 sensitivity testing, the effects on the CAMx model performance due to no layer collapsing (34 vertical layers) versus layer collapsing (22 vertical layers) were evaluated (see Appendix E). Some of the Cooperating Agencies expressed a preference for performing the CAMx modeling with no layer collapsing. Therefore, layer collapsing was not used in the CD-C CAMx modeling. Note that EPA's current recommendation for CMAQ modeling is to use no layer collapsing (Young, Pleim and Mathur, 2009). The vertical layer structure used in the CD-C MM5 and CAMx modeling is shown in Table 4-3.

Table 4-3. 34 layer vertical structure used by the MM5 meteorological model and CAMx air quality model. No layer collapsing is used in the air quality modeling.

MM5 and CAMx: 34 Layers				
Layer	Sigma	Pressure (mb)	Height (m)	Depth (m)
34	0.000	100	14662	1841
33	0.050	145	12822	1466
32	0.100	190	11356	1228
31	0.150	235	10127	1062
30	0.200	280	9066	939
29	0.250	325	8127	843
28	0.300	370	7284	767
27	0.350	415	6517	704
26	0.400	460	5812	652
25	0.450	505	5160	607
24	0.500	550	4553	569
23	0.550	595	3984	536
22	0.600	640	3448	506
21	0.650	685	2942	480
20	0.700	730	2462	367
19	0.740	766	2095	266
18	0.770	793	1828	259
17	0.800	820	1569	169
16	0.820	838	1400	166
15	0.840	856	1235	163
14	0.860	874	1071	160
13	0.880	892	911	158
12	0.900	910	753	78
11	0.910	919	675	77
10	0.920	928	598	77
9	0.930	937	521	76
8	0.940	946	445	76
7	0.950	955	369	75
6	0.960	964	294	74
5	0.970	973	220	74
4	0.980	982	146	37
3	0.985	986.5	109	37
2	0.990	991	73	36
1	0.995	995.5	36	36
0	1.000	1000	0	0

4.2.1.4 MM5 Model Performance Evaluation Summary

Once the CD-C MM5 modeling for the years 2005 and 2006 was completed, the performance of the model in simulating observed surface, upper air and precipitation data within the 12/4 km grid was evaluated. Annual MM5 runs generate a very large amount of data to be analyzed, so overall model performance was evaluated by month by comparing modeled output fields (surface winds, temperature, humidity, precipitation, upper air soundings) with observations. The evaluation focused on model performance in southwest Wyoming. A brief overview of the model performance evaluation is given below and a more detailed discussion is presented in Appendix D.

Overall, MM5 performance for surface winds was reasonably good at the Wamsutter, Jonah, Daniel, and Boulder monitors. The model has an overall low wind speed bias at all southwest Wyoming sites, and an important part of the low wind speed bias is the model's underprediction of peak wind speeds. The wind direction variability is underestimated in the model with the model understating the amplitude of the diurnal cycle in wind direction at the Sublette County monitors. This is likely because at 4 km resolution, it is difficult for MM5 to resolve local-scale flows related to mountainous terrain.

In winter, the CD-C MM5 runs show considerable skill in reproducing the observed precipitation field. In summer, rainfall is overpredicted over much of Wyoming on the 4 km grid. This excess rainfall may be expected to cause CAMx to overestimate wet deposition of pollutants during summer. The excessive summertime rainfall is due to MM5's tendency to overestimate rain from small-scale summer storms driven by convection. The scale of these storms is comparable to the model grid size, with cumulus towers that are perhaps 1 km across and cirrus outflows that can be on the order of 10 km. When the meteorological model is running at larger grid sizes (e.g., 36 km) the summer storms are much smaller than the grid size, and their effects are characterized by turning on one of the MM5 cumulus convection parameterizations. For grid sizes in the 4-12 km range, the grid size is not fine enough to resolve the physical processes associated with summer storms, and is not coarse enough to truly justify the use of a cumulus parameterization. Note that in winter, the spatial scale of storms is typically on the order of 1000 km, and MM5 is able to resolve the relevant physical processes-precipitation performance in the winter was good in the MM5 run to be used for CD-C modeling. This problem has been noted across many MM5 runs (e.g. Kemball-Cook et al., 2004) and has been resistant to attempts to solve it.

In summary, model performance for both 2005 and 2006 was found to be good and generally comparable with other annual MM5 modeling efforts such as the 2002 annual WRAP, VISTAS, and CENRAP RPO MM5 runs carried out to support regional haze modeling.

4.2.2 CAMx Model Configuration for 2005-2006 Base Case Modeling

4.2.2.1 Boundary Conditions

Boundary conditions (BCs) for the outer lateral edges of the 36 km continental U.S. modeling domain for the CD-C base case CAMx run were developed using the global 3-D chemical transport model GEOS-Chem (Bey et al., 2001). For the 2005 and 2006 modeling years, diurnally varying monthly average BCs from a 2002 GEOS-Chem simulation were used along the boundaries of the 36 km modeling domain. BCs for the 12 km domain were derived from the results of the 36 km CAMx simulation. The 12 km and 4 km grids were run in two-way nested mode with the 36 km run used only to supply boundary conditions to the 12 km grid (i.e., one-way grid nesting between the 36 km and 12 km domains).

Description of Boundary Condition Processing Procedure

Output data from GEOS-Chem were used to derive boundary conditions for the CD-C 36 km grid for the 2005 and 2006 ozone seasons. For periods when the GEOS-Chem data for 2005 and 2006 were unavailable, monthly average 2002 GEOS-Chem data were used to substitute missing periods. At the time of the modeling, day-specific GEOS-Chem data for gas phase species were available for April 1 to August 31, 2005 and April 1 to October 31, 2006. For particulate species, monthly average 2002 GEOS-Chem data were used.

In the horizontal, the CAMx BC processor was used to map the GEOS-Chem model data, which is at a relatively coarse resolution, onto the relatively finer resolution (36 km) of the CAMx air quality model. In the vertical, the BC processor reads in the air quality model layer structure, and linearly interpolates the GEOS-Chem concentrations from the two nearest levels. The BC processor applies a vertical weighting so that if a layer of the air quality model encompasses more than 2 GEOS-Chem layers, concentrations are weighted (by layer thickness) from all GEOS-Chem layers within the CAMx layer. The BC processor accounts for the fact that GEOS-Chem heights are reckoned relative to sea level and the air quality model heights are reckoned relative to the ground.

4.2.2.2 Photolysis Rates

Photolysis rates were calculated using the Tropospheric visible Ultra-Violet (TUV) model developed by the National Center for Atmospheric Research (Madronich, 1993). TUV is a state-of-the-science solar radiation model that is designed for photolysis rate calculations. TUV accounts for environmental parameters that influence photolysis rates including solar zenith angle, altitude above the ground, surface UV albedo, aerosols (haze), and stratospheric ozone column.

The albedo/haze/ozone input file is used in conjunction with the photolysis rates input file to specify several of the environmental factors that influence photolysis rates. The photolysis rates and albedo/haze/ozone files must be coordinated to function together correctly. The surface UV albedo was calculated based on the gridded land use data using land use-specific UV albedo values. The albedo varies spatially according to the land cover distribution. The MM5 snow cover estimates were used to override the land use category albedo values for values appropriate for average snow cover conditions when snow cover is present. The total ozone column was based on satellite data from the Total Ozone Mapping Spectrometer (TOMS), which are available from a web site maintained by the NASA Goddard Space Flight Center (http://jwocky.gsfc.nasa.gov). Daily ozone column data are available at 1.25° longitude by 1° latitude resolution and were mapped to the CAMx grids.

4.2.2.3 CAMx Model Options

The CAMx model configuration for the CD-C modeling (for all years) is summarized in Table 4-4. The CB05 gas-phase (Yarwood et al., 2005), RADM aqueous-phase (Chang et al., 1987) and ISORROPIA aerosol-phase (Nenes, Pilinis and Pandis, 1998; 1999) chemical mechanisms were used. CAMx was run with the Euler Backward Iterative chemistry solver and the PPM advection solver. The most recent version of CAMx available at the time of the modeling was used.

Dry Deposition Algorithm

Dry deposition refers to the direct removal of air pollutants through contact with various terrestrial surfaces and uptake into biota. Dry deposition is an important process that removes ozone from the atmosphere and limits buildup of ozone concentrations. The treatment of dry deposition in a regional air quality model can therefore have a significant effect on model performance. The scheme used in the Hiawatha preliminary CAMx 2005 and 2006 base case modeling (Kemball-Cook et al., 2009) was the Wesely algorithm, which was developed in 1989 (Wesely, 1989; W89). W89 has been widely used for regional-scale air quality modeling, but no longer represents the current state of the science. Furthermore, the W89 algorithm is defined for a limited number of land cover types that are in turn characterized by typical eastern U.S. vegetation types, density, and seasonal conditions. The deposition velocities calculated with W89 may not be sufficiently accurate outside the east or for atypical conditions (e.g., seasonal transitions, drought stress).

During the CD-C diagnostic sensitivity testing, the Zhang (2003) scheme used in Environment Canada's AURAMS air quality model was tested in the CAMx model (see Appendix E for details). The Zhang scheme is a state-of-the-science algorithm that has an improved representation of non-stomatal deposition pathways and has been tested extensively through its use in daily air quality forecasting and has been shown to reproduce observed fluxes of ozone and SO_2 with reasonable accuracy. Use of the Zhang scheme tended to reduce dry deposition of ozone relative to the Wesely scheme across broad regions of the CD-C modeling domain, thereby increasing surface layer ozone and improving model performance in southwest Wyoming. At the January 2010 stakeholder meeting, the decision was made to adopt the Zhang dry deposition scheme for the CD-C modeling.

Model Spin-Up

The 36 km simulations were performed by quarter using a 15-day spin-up period. A 5-day spin-up period was used for the 12 and 4 km grids, since it takes a shorter period to eliminate the influence of the initial concentrations on the smaller domains.

4.2.3 Evaluation of the CAMx 2005-2006 Base Case Modeling

The CAMx gas phase and particle phase model estimates were compared against observed ambient values for those two years and a model performance evaluation was conducted. The methods, data and results of the model performance evaluation are described in detail in Appendix A. Model performance was determined to be satisfactory and the base case modeling was approved by the CD-C stakeholders at their April 15, 2010 meeting. The next step in the CD-C analysis was to apply CAMx for a baseline emissions scenario, to provide a comparable scenario for future year emissions scenarios

4.3 BASELINE MODELING OF 2008

At their January 7, 2010 meeting, the CD-C stakeholders determined that the baseline year to be used in performing CD-C impact analyses would be 2008. Originally, 2006 was to have been the baseline year, but extensive development of oil and gas resources in southwest Wyoming occurred during the 2006-2008 period, and emissions of criteria pollutants and ozone precursors from this source category were significantly larger in 2008 than in 2006. The economic slowdown in 2008-2009 led to a reduction in the pace of development such that total 2009 emissions were smaller than 2008 emissions. 2008 was a National Emission Inventory Year, in which states submit comprehensive emission inventories to the EPA. Because draft emission inventories for 2008 for the state of Wyoming were available at the time of the modeling, and because 2008 was estimated to be the year of peak emissions from the energy sector in Wyoming, the stakeholders selected 2008 as the baseline year for the CD-C impact analysis modeling. Another important factor is that more ambient monitoring was available in 2008 than in 2006. Carter Lake Consulting and ENVIRON developed a regional emission inventory for the year 2008 for use in CAMx baseline modeling, and the 2008 inventory is described briefly in Section 2.2.2 and in detail in Appendix F.

The CD-C 2008 baseline modeling consisted of two year-long CAMx runs. Both annual simulations were performed with 2008 emissions; one year was run with 2005 meteorology and the other year was run with 2006 meteorology. CAMx was applied using a 36/12/4 km nested-grid modeling domain as shown in Figure 4-1.

In addition to its use as the current year on which future year CD-C modeling was based, the 2008 baseline modeling was also used to assess the impacts of the existing (as of 2008) CD-C Project on regional air quality. The CD-C Project area contains existing development which must be accounted for in the CD-C modeling in addition to the new wells proposed as part of the CD-C Proposed Action. The purpose of this assessment was to evaluate the state of regional air quality under the baseline emission scenario and determine whether mitigation measures were required for the CD-C Project area in advance of the future year modeling. The CAMx output concentration fields were used for the evaluation of regional air quality, and the CAMx probing tools were used to isolate the contribution of existing 2008 CD-C Project area emissions sources to the total modeled concentrations. The methods and results of the 2008 baseline modeling are described in Appendix I. The impact of existing CD-C wells to regional air quality was determined to be minimal and no mitigation of existing emissions was required in advance of the future year modeling.

4.4 FUTURE YEAR MODELING OF 2022

4.4.1 Overview of Model Configuration

The purpose of the future year modeling is to understand impacts on air quality due to changes in anthropogenic emissions between the baseline and future years. In the case of the CD-C modeling, it is to determine the impacts of the CD-C Proposed Action Alternative emissions, No Action Alternative emissions and other regional emissions sources on air quality and AQRVs within the study area. To achieve this goal, the model configuration for the baseline and future year CD-C modeling must be identical except for the anthropogenic emission inventory. Therefore, for the 2022 future year, the model was run in nearly the same configuration as in 2008 (see Table 4-4), but with anthropogenic emission inventories that were projected out to the year 2022. CAMx version v5.30 was used in the 2008 modeling while v5.40 was used in the 2022 modeling. V5.40 was the most recent version of the model available at the time of the 2022 modeling, and was used because it has improved computational efficiency that allowed the runs to be completed more quickly than with v5.30. Other differences between the two versions are either not relevant to the CD-C runs (e.g. new version of the CB6 chemical mechanism, which was not used for CD-C) or are expected to cause negligible differences.

Emissions from the CD-C new and existing wells in the year 2022 were added to the regional emission inventory that was developed for the year 2022. The future year regional inventory is described in Section 2.2.3 and the CD-C Project Area emission inventories are described in Sections 2.1.3, 2.1.4, and Appendix H. CAMx was run with 2022 emissions (including the CD-C Project Area emissions) for two years using 2005 and 2006 meteorology. We will refer to the two annual future year simulations using 2022 emission and 2005 and 2006 meteorology as 2022met05 and 2022met06, respectively.

Table 4-4. CAMx air quality model configuration for the CD-C 2008/2022 simulations.

Science Options	CD-C 2008 and 2022 Configuration
Model Code	CAMx V5.30 (2008) and CAMx V5.40 (2022)
Horizontal Grid Mesh	36/12/4 km
36 km grid	148 x 112 cells
12 km grid	89 x 68 cells
4 km grid	119 x 101 cells
Vertical Grid Mesh	34 Layers (no layer collapsing)
Grid Interaction	One-way 36/12 km Two-Way 12/4 km
Initial Conditions	15 days spin-up for 36 km domain 5 days spin-up for 12/4 km domain
Boundary Conditions	Day-specific 2005 and 2006 3-hourly GEOS-CHEM w/ 2002 GEOS-Chem monthly average for PM species
Emissions	
Baseline Emissions Processing	SMOKE V2.4
NH3 Inventory	WRAP Ammonia Model with updated seasonal adjustments
Chemistry	
Gas Phase Chemistry	CB05
Aerosol Chemistry	ISORROPIA
Mineral Nitrate	Yes
Secondary Organic Aerosols	SOAP
Aqueous Chemistry	RADM
Meteorological Processor	MM5CAMx
Horizontal Transport	
Eddy Diffusivity Scheme	K-theory with K_h grid size dependence
Vertical Transport	
Advection Scheme	Vertical Velocity Update
Eddy Diffusivity Scheme	CMAQ-like
Diffusivity Lower Limit	$K_{z\ min}$ = 0.1 to 2.0 w/ k_v100
Dry Deposition Scheme	Zhang
Numerics	
Gas Phase Chemistry Solver	Euler Backward Iterative (EBI) solver
Horizontal Advection Scheme	PPM
Simulation Periods	2005 and 2006 using 2008 or 2022 emissions
Integration Time Step	Determined by met conditions

4.4.2 Use of CAMx Source Apportionment Tools in 2022 Future Year Simulations

CAMx Particulate Matter (PM) Source Apportionment Technology (PSAT) and the Anthropogenic Precursor Culpability Assessment (APCA) version of the Ozone Source Apportionment Technology (OSAT; ENVIRON, 2010a) probing tools were used to obtain the ozone and PM contributions due to different emission source groups in the 2022 future year runs. APCA is a source apportionment tool similar to OSAT that focuses on determining the contribution to ozone concentrations from human (i.e. controllable) activities. Below, we describe ozone source apportionment in CAMx using OSAT and then discuss how APCA differs from the standard OSAT tool.

4.4.2.1 Source Apportionment for Ozone

OSAT uses multiple tracer species to track the fate of ozone precursor emissions (VOC and NO_X) and the ozone formation caused by these emissions within a simulation. The tracers operate as spectators to the normal CAMx calculations so that the underlying CAMx-predicted relationships between emission groups (sources) and ozone concentrations at specific locations (receptors) are not perturbed. Tracers of this type are conventionally referred to as “passive tracers,” however, it is important to realize that the tracers in the OSAT track the effects of chemical reaction, transport, diffusion, emissions and deposition within CAMx. In recognition of this, they are described as “ozone reaction tracers.” The ozone reaction tracers allow ozone formation from multiple “source groupings” to be tracked simultaneously within a single simulation. A source grouping can be defined in terms of geographical area and/or emission category. So that all sources of ozone precursors are accounted for, the CAMx boundary conditions and initial conditions are always tracked as separate source groupings. This allows an assessment of the role of transported ozone and precursors in contributing to high ozone episodes within the CD-C modeling domain.

The methodology is designed so that all ozone and precursor concentrations are attributed among the selected source groupings at all times. Thus, for all receptor locations and times, the ozone (or ozone precursor concentrations) predicted by CAMx is attributed among the source groupings selected for OSAT. The methodology also estimates the fractions of ozone arriving at the receptor that were formed en-route under VOC- or NO_X-limited conditions. This information indicates how ozone concentrations at the receptor will respond to reductions in VOC and NO_X precursor emissions, and can be useful in the event that an exploration of mitigation strategies is required.

APCA differs from the standard CAMx Ozone Source Apportionment Tool in recognizing that certain emission groups are not controllable (e.g., biogenic emissions) and that apportioning ozone production to these groups does not provide information that is relevant to development of control strategies. To address this, in situations where OSAT would attribute ozone production to non-controllable (i.e., biogenic) emissions, APCA re-allocates that ozone production to the controllable portion of precursors that participated in ozone formation with the non-controllable precursor. For example, when ozone formation is due to biogenic VOC and anthropogenic NO_X under VOC-limited conditions (a situation in which OSAT would attribute ozone production to biogenic VOC), APCA re-directs that attribution to the anthropogenic NO_X precursors present. The use of APCA instead of OSAT results in more ozone formation attributed to anthropogenic NO_X sources and less ozone formation attributed to biogenic VOC sources, but generally does not change the partitioning of ozone attributed to local sources and the transported background for a given receptor.

4.4.2.2 Source Apportionment for Particulate Matter

The PM Source Apportionment Technology (PSAT) uses reactive tracers to apportion primary PM, secondary PM and gaseous precursors to secondary PM among different source categories and source regions. The PSAT methodology is described below. PSAT was developed from the related ozone source apportionment method (OSAT) already implemented in CAMx (Dunker at al., 2002). PSAT is designed to source apportion the following PM species modeled in CAMx:

- Sulfate (SO_4)
- Particulate nitrate (NO_3)
- Ammonium (NH_4)
- Particulate mercury (Hg(p))
- Secondary organic aerosol (SOA)
- Six categories of primary PM
    - Elemental carbon (EC)
    - Primary organic aerosol (POA)
    - Crustal fine
    - Other fine
    - Crustal coarse
    - Other coarse

PSAT "reactive tracers" are added to the model for each source category/region. In general, a single tracer can track primary PM species whereas secondary PM species require several tracers to track the relationship between gaseous precursors and the resulting PM.

The 2022 future year emission inventory modeling was carried out so that the following emissions source categories were processed separately and tracked as separate emissions source groups using the CAMx APCA and PSAT probing tools:

1. CD-C Proposed Action Alternative: CD-C Project-related oil and gas sources within the physical boundary of the CD-C Project area (8,950 wells, includes the wells in #2 below);
2. CD-C No Action Alternative: CD-C Project-related oil and gas sources within the physical boundary of the CD-C Project area, restricted to non-Federal land (4,063 wells) – 45.5% of Proposed Action Alternative wells;
3. Existing Sources: Existing oil and gas sources within the physical boundary of the CD-C Project area as of 2008, accounting for abandonment between 2008 and 2022 (2,475 wells);
4. RFD Sources;
5. Natural Sources including biogenic and wildfire sources;
6. All other sources.

4.5 CRITERIA POLLUTANT MODELING

4.5.1 Introduction

Criteria air pollutants (CAPs) are pollutants regulated under the Clean Air Act for which National Ambient Air Quality Standards (NAAQS) have been set. The CAPs are: ozone, NO_2, CO, PM_{10}, $PM_{2.5}$ and SO_2 and lead. Lead is not considered in this work because lead emissions from the CD-C Project are negligible. The 2022 future year model output surface layer concentrations for the 4 km modeling domain were averaged over the required time period for each standard so that the results for each pollutant could be compared to the relevant NAAQS. The purpose of this analysis is to determine whether the 2022 CD-C Proposed Action Alternative and No Action Alternative emissions sources contribute to any modeled exceedances of the NAAQS in the 4 km domain.

The ozone modeling results were processed for comparison with the 8-hour ozone NAAQS using two different methods. The first method was to follow EPA's modeling guidance for projecting future year ozone design values (EPA, 2007) by using EPA's Modeled Attainment Software (MATS; Abt, 2009) to project the 2022 design values starting from observed 2008 ozone design values and using the modeling results via the calculation of relative response factors (RRFs). The EPA projection procedures used in MATS are described further in Section 4.5.4.2 and the results of the ozone analysis are presented in Section 4.5.4.3. Although MATS has the capability to project $PM_{2.5}$ values, the EPA MATS method for $PM_{2.5}$ could not be used due to insufficient ambient monitoring data in the CD-C 4 km domain. The second method used in the ozone evaluation was to use the absolute modeling concentrations to calculate the annual 4^{th} highest daily maximum 8-hour ozone concentration for each grid cell in the 4 km domain for the 2022met05 and 2022met06 simulations. The annual 4^{th} highest daily maximum 8-hour ozone concentrations for the two meteorological years were then averaged to approximate a design value for each grid cell; these values are compared with the NAAQS and with the MATS results. The ozone design value is defined as the 4^{th} highest daily maximum 8-hour ozone concentrations averaged over three consecutive years.

For modeled non-ozone CAPs (NO_2, SO_2, $PM_{2.5}$, PM_{10}, and CO), the hourly raw 4 km domain model results were averaged for comparison with the relevant NAAQS, WAAQS and CAAQS for 2005 and 2006 in turn; then the results for 2005 and 2006 were combined in order to form an approximation to the relevant standard. For example, the annual NO_2 standard is defined in terms of a three year average of annual results, but only two years of CD-C modeling data are available; the comparison with the NO_2 NAAQS is therefore performed based on two years of CD-C data. In Appendix J, we present the results for each single year for the 2022met05 and 2022met06 simulations separately from the average. Table 4-5 shows the applicable ambient air quality standards: the NAAQS, WAAQS, and CAAQS.

Areas regulated to ensure the preservation of certain levels of AQRVs are called "Prevention of Significant Deterioration (PSD)" Class I areas. Such areas are granted special air quality protections under Section 162(a) of the federal Clean Air Act. PSD Class I areas include federal lands such as national parks, national wilderness areas, and national monuments. There are also sensitive Class II areas that are evaluated for the Class I area metrics, although they are not afforded the special protection by the Clean Air Act. PSD Class I and sensitive Class II areas allow additional, well-controlled industrial growth through the incremental addition of some area-specific pollutants. Specific increments exist for NO_2, SO_2, and PM. The increments vary depending upon the pollutant and classification of an area. The PSD Class I and II increments are shown in Table 4-5. The CAMx 2022met05 and 2022met06 estimates of incremental concentrations attributable to the CD-C Proposed Action Alternative and No Action Alternative within the Class I and sensitive Class II areas are compared against the applicable Class I and II area PSD increments.

Table 4-5. NAAQS, CAAQS, WAAQS, and PSD Class I and Class II Increments.

Averaging Time	NAAQS	CAAQS	WAAQS	PSD Class I Increment[1] ($\mu g/m^3$)	PSD Class II Increment[1] ($\mu g/m^3$)
CO					
1-hour[2]	**35 ppm** (40,000 $\mu g/m^3$)	*	*	--[3]	--[3]
8-hour[2]	**9 ppm** (10,000 $\mu g/m^3$)	*	*	--[3]	--[3]
NO_2					
1-hour[4]	**100 ppb** (188 $\mu g/m^3$)	*	*	--[3]	--[3]
Annual[5]	**53 ppb** (100 $\mu g/m^3$)	*	*	2.5	25
O_3					
8-hour[6]	**75 ppb** (147 $\mu g/m^3$)	*	*	--[3]	--[3]
PM_{10}					
24-hour[2]	**150 $\mu g/m^3$**	*	*	8	30
Annual[5]	--[7]	--[8]	**50 $\mu g/m^3$**	4	17
$PM_{2.5}$					
24-hour[9,13]	**35 $\mu g/m^3$**	*	*	2	9
Annual[5,10]	**12 $\mu g/m^3$**	*	**15 $\mu g/m^3$**	1	4
SO_2					
1-hour[11]	**75 ppb** (196 $\mu g/m^3$)	*	*	--[3]	--[3]
3-hour[2]	**0.5 ppm** (1,300 $\mu g/m^3$)	**700 $\mu g/m^3$**	*	25	512
24-hour[2]	**0.14 ppm** [7,12] (365 $\mu g/m^3$)	*	--[8]	5	91
Annual[5]	**0.03ppm** [7,12] (80 $\mu g/m^3$)	*	--[8]	2	20

* State Standard no more stringent than NAAQS; NAAQS in effect.

[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 year.

[3] No PSD increments have been established for this pollutant-averaging time.

[4] An area is in compliance with the standard if the 98th percentile of daily maximum 1-hour NO_2 concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.

[5] Annual arithmetic mean.

[6] An area is in compliance with the standard if the fourth-highest daily maximum 8-hour ozone concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard

[7] The NAAQS for this averaging time for this pollutant has been revoked by EPA.

[8] No standards are established for this pollutant-averaging time.

[9] An area is in compliance with the standard if the 98th percentile of 24-hour PM2.5 concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.

[10] EPA revised the NAAQS for this pollutant (effective March 18 2013) and the WDEQ has not yet adopted the revised NAAQS as part of their rulemaking. All compliance demonstrations of modeled concentrations will use the more stringent NAAQS value.

[11] An area is in compliance with the standard if the 99th percentile of daily maximum 1-hour SO_2 concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.

[12] The 24 and annual NAAQS remain in effect in Colorado until 1 year after the area is designated for the 2010 (1-hour) standard. Designations for the 1-hour SO_2 NAAQS in CO have not occurred.

[13] 24 hr and 3 hr PSD increments are 2nd high values

Bold indicates the units in which the standard is defined. Conversion from ppb to ug/m3

Units conversion uses the formula: 1 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

Standards may be rounded to 2 significant digits.

4.5.2 PSD Increment Analysis

The CAMx estimates of incremental concentrations of PSD pollutants attributable to the CD-C Proposed Action Alternative and No Action Alternative emissions are compared against PSD Class I and II area increments for the 2022met05 and 2022met06 simulations. These demonstrations are for informational purposes only and are not regulatory PSD Increment consumption analyses, which are completed as necessary during the permitting process by the State of Wyoming.

Tables 4-6a and 4-6b compare the maximum CD-C Proposed Action Alternative and No Action Alternative air quality impacts against the Class I PSD increments for NO_2 and PM_{10} within the Class I areas. Tables 4-7a and 4-7b compare the maximum CD-C Proposed Action Alternative and No Action Alternative air quality impacts against the Class I PSD increments for $PM_{2.5}$ within the Class I areas. And Tables 4-8a and 4-8b compare the maximum CD-C Proposed Action Alternative and No Action Alternative air quality impacts against the Class I PSD increments for SO_2 within the Class I areas. Table 4-9a, 4-9b, 4-10a, 4-10b, 411a and 4-11b show the equivalent impacts at the sensitive Class II areas. Note that Savage Run WA is a Wyoming Class I area but is not a Federal Class I area and Dinosaur NM is a Colorado Class I area for SO_2 only, but is not a Federal Class I area. 2022met05 and 2022met06 results were calculated for each pollutant and averaging time and the higher of the two results is shown. Note that although PSAT does not track NO_2, it does track NO_X (NO_2+NO). We have compared the CD-C Project NO_X contribution with the NO_2 PSD; if the CD-C NO_X contribution is smaller than the PSD increment, then the CD-C NO_2 contribution must also be less than the PSD increment.

For all Class I and sensitive Class II areas, the maximum 2022 CD-C Proposed Action Alternative and No Action Alternative impacts are far less than the relevant PSD increments for all pollutants and averaging times. For NO_2 (Tables 4-6a, 4-6b, 4-9a, 4-9b), the CD-C NO_X Proposed Action Alternative impact at all Class I and Class II areas is less than 1% of the applicable PSD increment. For annual average PM_{10} (Tables 4-6a, 4-6b, 4-9a, 4-9b), the Class I area with the largest impact is Savage Run WA, for which the CD-C Proposed Action Alternative impact is 0.31% of the PSD increment and the Class II area with the largest annual average PM_{10} Proposed Action Alternative impact is Dinosaur NM, with 0.06% of the Class II annual average PM_{10} increment. For 24-hour average PM_{10} (Tables 4-6a, 4-6b, 4-9a, 4-9b), the Class I area with the largest Proposed Action Alternative impact is Mount Zirkel WA, for which the CD-C Proposed Action Alternative impact is 1.75% of the PSD increment; the largest 24-hour PM_{10} Proposed Action Alternative impact at any Class II area occurs at Dinosaur NM and is 0.66% of the PSD Class II increment. For 24-hour average $PM_{2.5}$ (Tables 4-7a, 4-7b, 4-10a, 4-10b)), the highest Proposed Action Alternative impact at a Class I area is 3.6% of the Class I increment at Mount Zirkel WA, and the highest Proposed Action Alternative at a Class II area is 1.28% at Dinosaur NM. For SO_2 (Tables 4-8a, 4-8b, 4-11a,4-11b), all CD-C Project impacts at Class I and sensitive Class II areas are orders of magnitude lower than the relevant PSD Class I and Class II PSD increments. For every pollutant and averaging time, the No Action Alternative consumes less of the PSD increments that the Proposed Action Alternative.

The largest impacts across all pollutants are: Dinosaur NM, Rawah WA, Savage Run WA, and Mount Zirkel WA. Bridger WA, Fitzpatrick WA, Eagles Nest WA, Flat Tops WA, Rocky Mountain

NP and the Wind River Roadless Area tend to have lower impacts as they are further from the CD-C Project Area and are located generally upwind.

Table 4-6a. Maximum 2022 CD-C Proposed Action Alternative contribution during 2005 and 2006 meteorological years across all Class I Areas. (µg m^{-3}).

Class I Areas	Annual Average NO_2/NOx		Annual Average PM_{10}		24-hr Average PM_{10} (2nd Highest Value)	
	Class I PSD	Max CD-C	Class I PSD	Max CD-C	Class I PSD	Max CD-C
Bridger WA	2.5	0.0011	4	0.0009	8	0.0471
Fitzpatrick WA	2.5	0.0002	4	0.0005	8	0.0263
Mount Zirkel WA	2.5	0.0158	4	0.0092	8	0.1402
Rawah WA	2.5	0.0074	4	0.0051	8	0.0527
Savage Run WA	2.5	0.0223	4	0.0124	8	0.1037
Eagles Nest WA	2.5	0.0014	4	0.0017	8	0.0327
Flat Tops WA	2.5	0.0045	4	0.0034	8	0.0872
Rocky Mountain NP	2.5	0.0033	4	0.0030	8	0.0396

Table 4-6b. Maximum 2022 CD-C No Action Alternative contribution during 2005 and 2006 meteorological years across all Class I Areas. (µg m^{-3}).

Class I Areas	Annual Average NO_2/NOx		Annual Average PM_{10}		24-hr Average PM_{10} (2nd Highest Value)	
	Class I PSD	Max CD-C	Class I PSD	Max CD-C	Class I PSD	Max CD-C
Bridger WA	2.5	0.0005	4	0.0004	8	0.0214
Fitzpatrick WA	2.5	0.0001	4	0.0002	8	0.0119
Mount Zirkel WA	2.5	0.0072	4	0.0042	8	0.0636
Rawah WA	2.5	0.0034	4	0.0023	8	0.0239
Savage Run WA	2.5	0.0101	4	0.0056	8	0.0471
Eagles Nest WA	2.5	0.0006	4	0.0008	8	0.0148
Flat Tops WA	2.5	0.0020	4	0.0016	8	0.0396
Rocky Mountain NP	2.5	0.0015	4	0.0014	8	0.0180

Table 4-7a. Maximum 2022 CD-C Proposed Action Alternative contribution during 2005 and 2006 meteorological years across all Class I Areas. (µg m^{-3}).

Class I Areas	Annual Average $PM_{2.5}$		24-hr Average $PM_{2.5}$ (2nd Highest Value)	
	Class I PSD	Max CD-C	Class I PSD	Max CD-C
Bridger WA	1	0.0004	2	0.0238
Fitzpatrick WA	1	0.0003	2	0.0156
Mount Zirkel WA	1	0.0041	2	0.0720
Rawah WA	1	0.0025	2	0.0365
Savage Run WA	1	0.0053	2	0.0641
Eagles Nest WA	1	0.0009	2	0.0197
Flat Tops WA	1	0.0015	2	0.0378
Rocky Mountain NP	1	0.0014	2	0.0247

Table 4-7b. Maximum 2022 CD-C No Action Alternative contribution during 2005 and 2006 meteorological years across all Class I Areas. (µg m^{-3}).

Class I Areas	Annual Average $PM_{2.5}$		24-hr Average $PM_{2.5}$ (2nd Highest Value)	
	Class I PSD	Max CD-C	Class I PSD	Max CD-C
Bridger WA	1	0.0002	2	0.0108
Fitzpatrick WA	1	0.0001	2	0.0071
Mount Zirkel WA	1	0.0019	2	0.0327
Rawah WA	1	0.0011	2	0.0166
Savage Run WA	1	0.0024	2	0.0291
Eagles Nest WA	1	0.0004	2	0.0089
Flat Tops WA	1	0.0007	2	0.0172
Rocky Mountain NP	1	0.0007	2	0.0112

Table 4-8a. Maximum 2022 CD-C Proposed Action Alternative contribution during 2005 and 2006 meteorological years across all Class I Areas. (µg m^{-3}).

Class I Areas	Annual Average SO_2		24-hr Average SO_2 (2nd Highest Value)		3-hr Average SO_2 (2nd Highest Value)	
	Class I PSD	Max CD-C	Class I PSD	Max CD-C	Class I PSD	Max CD-C
Bridger WA	2	6.77E-07	5	3.22E-05	25	1.58E-04
Dinosaur NM*	2	8.88E-06	5	2.14E-04	25	4.85E-04
Fitzpatrick WA	2	2.59E-07	5	1.25E-05	25	4.48E-05
Mount Zirkel WA	2	9.11E-06	5	1.28E-04	25	3.51E-04
Rawah WA	2	4.30E-06	5	4.22E-05	25	1.66E-04
Savage Run WA	2	1.36E-05	5	1.05E-04	25	3.56E-04
Eagles Nest WA	2	1.17E-06	5	2.18E-05	25	5.16E-05
Flat Tops WA	2	3.10E-06	5	9.64E-05	25	2.28E-04
Rocky Mountain NP	2	2.28E-06	5	3.21E-05	25	9.08E-05

*Dinosaur NM is a Colorado Class I Area for SO_2 only.

Table 4-8b. Maximum 2022 CD-C No Action Alternative contribution during 2005 and 2006 meteorological years across all Class I Areas. (µg m^{-3}).

Class I Areas	Annual Average SO_2		24-hr Average SO_2 (2nd Highest Value)		3-hr Average SO_2 (2nd Highest Value)	
	Class I PSD	Max CD-C	Class I PSD	Max CD-C	Class I PSD	Max CD-C
Bridger WA	2	3.07E-07	5	1.46E-05	25	7.18E-05
Dinosaur NM*	2	4.03E-06	5	9.73E-05	25	2.20E-04
Fitzpatrick WA	2	1.17E-07	5	5.70E-06	25	2.04E-05
Mount Zirkel WA	2	4.13E-06	5	5.80E-05	25	1.60E-04
Rawah WA	2	1.95E-06	5	1.91E-05	25	7.55E-05
Savage Run WA	2	6.16E-06	5	4.77E-05	25	1.62E-04
Eagles Nest WA	2	5.32E-07	5	9.90E-06	25	2.34E-05
Flat Tops WA	2	1.41E-06	5	4.38E-05	25	1.04E-04
Rocky Mountain NP	2	1.04E-06	5	1.46E-05	25	4.12E-05

*Dinosaur NM is a Colorado Class I Area for SO_2 only.

Table 4-9a. Maximum 2022 CD-C Proposed Action Alternative contribution during 2005 and 2006 meteorological years across all Class II Areas. (μg m^{-3}).

Sensitive Class II Areas	Annual Average NO_2/NOx		Annual Average PM_{10}		24-hr Average PM_{10} (2nd Highest Value)	
	Class II PSD	Max CD-C	Class II PSD	Max CD-C	Class II PSD	Max CD-C
Dinosaur NM	25	0.0160	17	0.0104	30	0.1986
Popo Agie WA	25	0.0011	17	0.0010	30	0.0593
Wind River RA	25	0.0003	17	0.0005	30	0.0325
Gros Ventre WA	25	0.0003	17	0.0005	30	0.0251

Table 4-9b. Maximum 2022 CD-C No Action Alternative contribution during 2005 and 2006 meteorological years across all Class II Areas. (μg m^{-3}).

Sensitive Class II Areas	Annual Average NO_2/NOx		Annual Average PM_{10}		24-hr Average PM_{10} (2nd Highest Value)	
	Class II PSD	Max CD-C	Class II PSD	Max CD-C	Class II PSD	Max CD-C
Dinosaur NM	25	0.0073	17	0.0047	30	0.0902
Popo Agie WA	25	0.0005	17	0.0004	30	0.0269
Wind River RA	25	0.0001	17	0.0002	30	0.0147
Gros Ventre WA	25	0.0001	17	0.0002	30	0.0114

Table 4-10a. Maximum 2022 CD-C Proposed Action Alternative contribution during 2005 and 2006 meteorological years across all Class II Areas. (μg m^{-3}).

Sensitive Class II Areas	Annual Average $PM_{2.5}$		24-hr Average $PM_{2.5}$ (2nd Highest Value)	
	Class II PSD	Max CD-C	Class II PSD	Max CD-C
Dinosaur NM	4	0.0046	9	0.1152
Popo Agie WA	4	0.0004	9	0.0229
Wind River RA	4	0.0003	9	0.0173
Gros Ventre WA	4	0.0003	9	0.0200

Table 4-10b. Maximum 2022 CD-C No Action Alternative contribution during 2005 and 2006 meteorological years across all Class II Areas. (μg m^{-3}).

Sensitive Class II Areas	Annual Average $PM_{2.5}$		24-hr Average $PM_{2.5}$ (2nd Highest Value)	
	Class II PSD	Max CD-C	Class II PSD	Max CD-C
Dinosaur NM	4	0.0021	9	0.0523
Popo Agie WA	4	0.0002	9	0.0104
Wind River RA	4	0.0001	9	0.0079
Gros Ventre WA	4	0.0001	9	0.0091

Table 4-11a. Maximum 2022 CD-C Proposed Action Alternative contribution during 2005 and 2006 meteorological years across all Class II Areas. (μg m-3).

Sensitive Class II Areas	Annual Average SO_2		24-hr Average SO_2 (2^{nd} Highest Value)		3-hr Average SO_2 (2^{nd} Highest Value)	
	Class II PSD	Max CD-C	Class II PSD	Max CD-C NOx	Class II PSD	Max CD-C
Popo Agie WA	20	6.82E-07	91	4.10E-05	512	1.43E-04
Wind River RA	20	2.82E-07	91	1.61E-05	512	6.63E-05
Gros Ventre WA	20	2.86E-07	91	2.09E-05	512	4.84E-05

Table 4-11b. Maximum 2022 CD-C No Action Alternative contribution during 2005 and 2006 meteorological years across all Class II Areas. (μg m^{-3}).

Sensitive Class II Areas	Annual Average SO_2		24-hr Average SO_2 (2nd Highest Value)		3-hr Average SO_2 (2nd Highest Value)	
	Class II PSD	Max CD-C	Class II PSD	Max CD-C NOx	Class II PSD	Max CD-C
Popo Agie WA	20	3.10E-07	91	1.86E-05	512	6.49E-05
Wind River RA	20	1.28E-07	91	7.29E-06	512	3.01E-05
Gros Ventre WA	20	1.30E-07	91	9.51E-06	512	2.20E-05

The estimated potential air quality impacts in 2022 due to emissions from CD-C Proposed Action Alternative and No Action Alternative sources do not exceed any PSD Class I or Class II area increments at any Class I or Class II areas using 2005 or 2006 meteorology. The maximum impacts due to the CD-C Proposed Action Alternative and No Action Alternative are for $PM_{2.5}$ and are less than 4% and 2%, respectively, of the relevant PSD increment. Maximum NOx impacts are at least 2 orders of magnitude smaller that the NO_2 PSD increments and maximum SO_2 impacts are at least 4 orders of magnitude less than the SO_2 PSD increments for both the Proposed Action Alternative and the No Action Alternative.

4.5.3 Comparison of Non-Ozone CAPs Concentrations with Ambient Air Quality Standards

In this section, 2008 baseline run concentrations, 2022 future year run concentrations, and differences between them for the 4 km grid are displayed for each non-ozone criteria pollutant that was modeled. The CAMx output concentrations are averaged in a manner that most closely matches the form of the NAAQS for that pollutant. The NAAQS and averaging periods for each of the criteria pollutants are shown in Table 4-5.

For 1-hour NO_2, the NAAQS is 188 μg m^{-3}, and there are no applicable WAAQS or CAAQS. In 2022, the maximum value of 1-hour NO_2 within the 4 km domain is 123 μg m^{-3}; therefore, the NAAQS is attained throughout the domain. 1-hour NO_2 concentrations within the 4 km domain are generally below 60 μg m^{-3} except near large point sources such as EGUs and in regions of oil and gas production.

Major differences between 2022 and 2008 (right hand panel of Figure 4-5) occur due to changes in EGU, trona and oil and gas emissions sources. Increases in 1-hour NO_2 are visible where oil and gas development is projected to occur in eastern Fremont County (Gun Barrel-Madden Deep-Iron Horse Project), on the Lincoln/Sublette border (LaBarge Platform), in Southern Sweetwater County along the Colorado-Wyoming border (Hiawatha Project), and in the vicinity of the CD-C Project. Reductions in 1-hour NO_2 occur in Sublette County in the JPAD area. The high NO_X emitter whose impact appears in central Lincoln County in the NO_2 results of the 2022 simulation is "Pittsburgh & Midway Kemmerer/Skull Point" with NO_X emissions of ~1650 tpy and a source category code that indicates coal mining industrial processes. This source is associated with the Naughton coal-fired power plant and appears to be incorrectly located in the future year inventory.

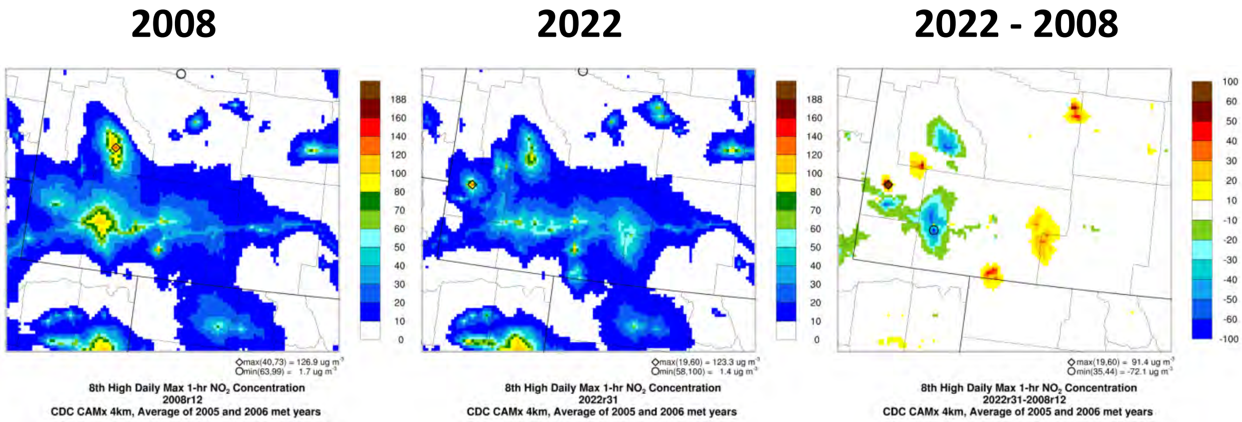

Figure 4-5. CAMx model results for 1-hour NO_2. Left and center panels: 2008 and 2022 absolute model results for 1-hour NO_2 from all regional emissions sources, including CD-C Project. Right panel: 2022-2008 difference in 1-hour NO_2. All three panels show average of results for the 2005 and 2006 meteorological years.

Figure 4-6 shows the contribution of the CD-C Proposed Action Alternative (8950 new wells) and the CD-C No Action Alternative (4063 new wells) emissions to regional NO_X. For comparison, the NO_2 field for 2022 is shown in the left hand panel; this panel is identical to the middle panel of Figure 4-5. The maximum CD-C NO_X contributions (which are conservative estimates of the CD-C contributions to regional NO_2) from the Proposed Action Alternative and No Action Alternative emissions are 44 and 20 µg m^{-3}, respectively. Although the CD-C Proposed Action makes a discernible contribution to regional 1-hour NO_2, the impacts are localized and there is no exceedance of the 1-hour NO_2 NAAQS.

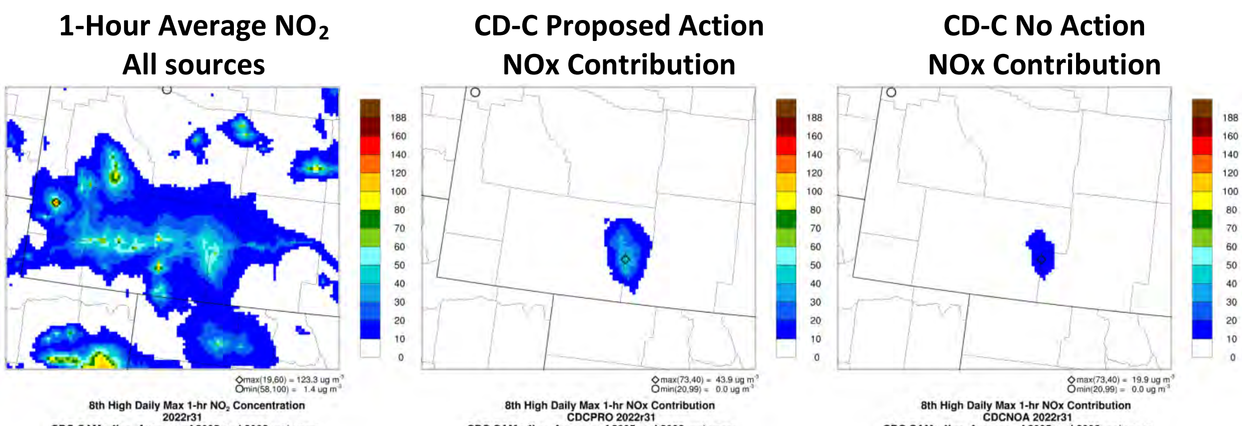

Figure 4-6. Left panel: 2022 absolute model results for 1-hour NO_2 from all regional emissions sources, including CD-C Project. Center panel: CD-C Proposed Action Alternative contribution to 2022 1-hour NO_X. Right panel: CD-C No Action Alternative contribution to the 2022 1-hour NO_X. All three panels show average of results for the 2005 and 2006 meteorological years.

Results for regional annual average NO_2 are shown in Figure 4-7. The spatial pattern of the annual NO_2 results is similar to that of the 1-hour NO_2 results, although the maxima are lower due to the longer averaging time. The NAAQS, WAAQS, and CAAQS for annual average NO_2, are identical and are 100 µg m^{-3}. The maximum value within the 4 km domain in 2022 is 32 µg m^{-3}: the NAAQS is therefore attained throughout the 4 km domain. In 2022, modeled annual average NO_2 is generally below 15 µg m^{-3} except near large point sources and regions of oil and gas and trona development.

As with 1-hour NO_2, the CD-C Project emissions contribute NO_X to regional levels (Figure 4-8). The peak values of the Proposed Action Alternative and No Action Alternative NO_X contributions are 6.3 and 2.9 µg m^{-3}, respectively. The Proposed Action Alternative contribution is approximately half of the regional value of annual average NO_2 in the vicinity of the CD-C Project. However, the annual average NO_2 values of 10-15 µg m^{-3} near the CD-C Project Area are well below the NAAQS of 100 µg m^{-3}.

2008 **2022** **2022 - 2008**

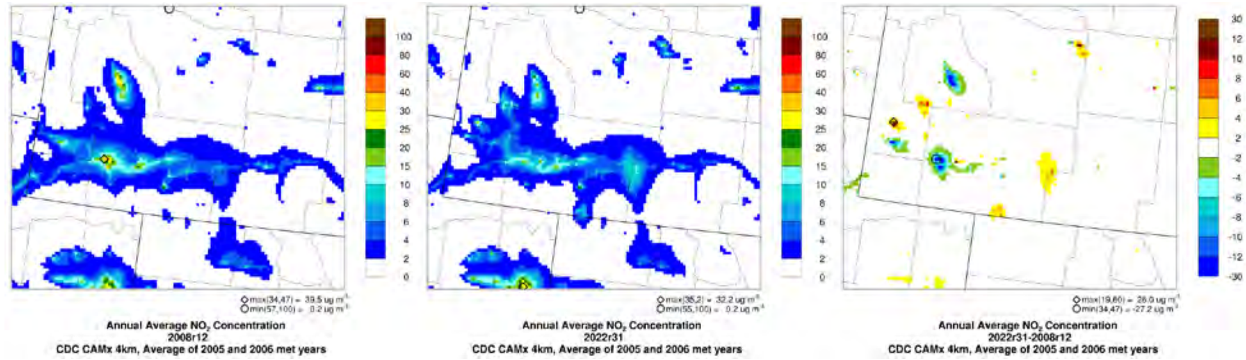

Figure 4-7. CAMx model results for annual average NO_2. Left and center panels: 2008 and 2022 absolute model results for annual average NO_2 from all regional emissions sources, including CD-C Project. Right panel: 2022-2008 difference in annual average NO_2; all three panels show average of results for the 2005 and 2006 meteorological years.

1-Hour Average NO_2 All sources **CD-C Proposed Action NOx Contribution** **CD-C No Action NOx Contribution**

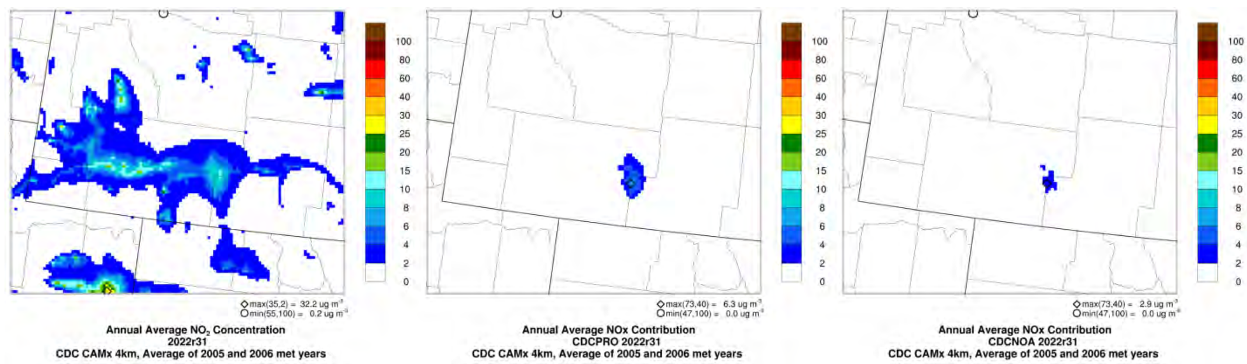

Figure 4-8. 2022 absolute model results for annual average NO_2 from all regional emissions sources, including the CD-C Project. Center panel: CD-C Proposed Action Alternative contribution to 2022 annual average NO_X. Right panel: CD-C No Action Alternative contribution to the 2022 annual average NO_X. All three panels show average of results for the 2005 and 2006 meteorological years.

Figure 4-9 shows the results for 1-hour average SO_2. The NAAQS for 1-hour average SO_2 is 196 µg m^{-3}; there is no applicable WAAQS or CAAQS. 1-hour average SO_2 values are generally below 100 µg m^{-3} except near large point sources. There are two localized regions with 1-hour SO_2 exceeding 196 µg m^{-3} within the 4 km domain in 2022; the maximum value is 230 µg m^{-3} in central Fremont County, the other exceedance is 222 µg m^{-3} in western Sweetwater County, both exceedances are on a single grid cell only. The NAAQS is attained everywhere else within the domain. High 1-hour SO_2 in Fremont County occurs in the vicinity of a high-emitting (~1400 tpy) point source associated with Peak Sulfur, Inc. and with a single grid cell containing high (~1500 tpy) area source SO_2 emissions due to industrial fuel combustion. High SO_2 is present in this Fremont County location in both the 2008 baseline and 2022 future year emission inventories.

The right hand panel of Figure 4-9 shows changes in 1-hour SO_2 between the 2008 base year and the 2022 future year. There are SO_2 emissions reductions at the Jim Bridger and Naughton EGUs in Wyoming, and there are large SO_2 increases in 2022 at point sources in Carbon and Uinta Counties.

The CD-C Proposed Action and No Action contributions to 1-hour SO_2 are shown in Figure 4-10. The SO_2 contribution from CD-C sources is extremely small, and is not visible on the same scale used to view regional SO_2. The small CD-C contribution to SO_2 is consistent with the fact that the Project's SO_2 emissions are small, since the Project does not access reservoirs containing sour gas. Based on the size of the CD-C contribution to regional 1-hour SO_2, we conclude that neither the Proposed Action Alternative nor the No Action Alternative emissions contribute to modeled exceedances of 1-hour SO_2 NAAQS in Fremont or Sweetwater counties.

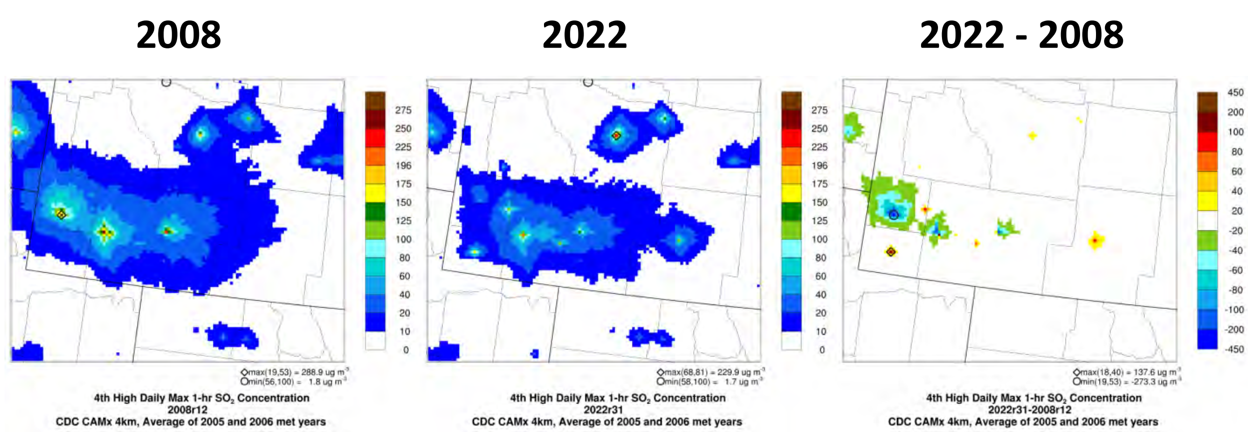

Figure 4-9. CAMx model results for 1-hour SO_2. Left and center panels: 2008 and 2022 absolute model results for 1-hour SO_2 from all regional emissions sources, including CD-C Project. Right panel: 2022-2008 difference in 1-hour SO_2. All three panels show average of results for the 2005 and 2006 meteorological years.

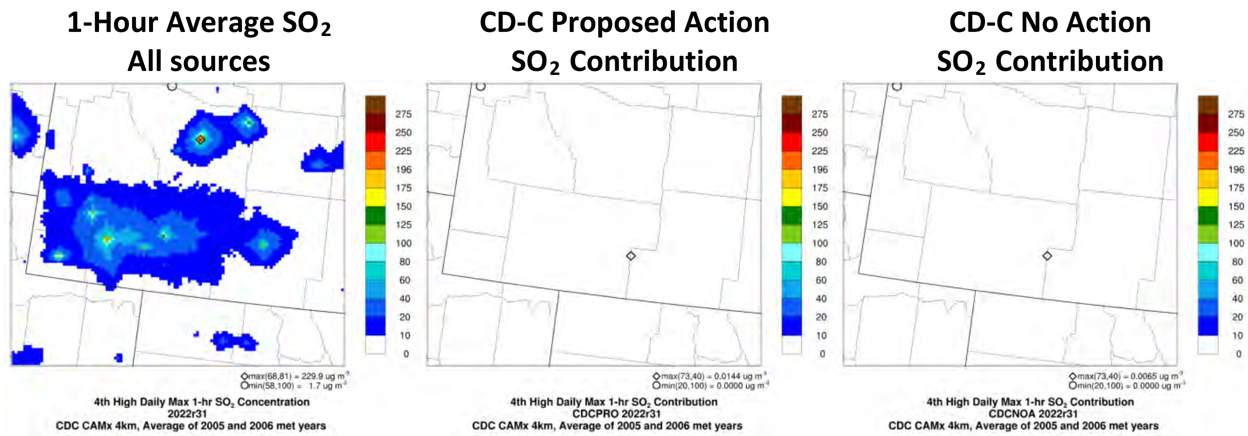

Figure 4-10. Left panel: 2022 absolute model results for 1-hour SO_2 from all regional emissions sources, including CD-C Project. Center panel: CD-C Proposed Action Alternative contribution to the 2022 1-hour SO_2 shown in the left hand panel. Right panel: CD-C No Action Alternative contribution to the 2022 1-hour SO_2 shown in the left hand panel. All three panels show average of results for the 2005 and 2006 meteorological years.

CAMx results for 3-hour SO_2 are shown in Figure 4-11. The NAAQS and WAAQS for 3-hour SO_2 are 1,300 µg m^{-3}, while the CAAQS is 700 µg m^{-3}. 3-hour SO_2 values within the 4 km domain are generally below 200 µg m^{-3} except in the vicinity of large point sources. The maximum value within the 4 km domain in 2022 is 216 µg m^{-3}; all 3-hour SO_2 standards are attained throughout the 4 km domain. The largest SO_2 increase going from 2008 to 2022 occurs in Uinta County, as noted in the discussion of 1-hour SO_2. As for 1-hour SO_2, contributions to 3-hour SO_2 from the Proposed Action Alternative emissions and the No Action Alternative emissions are too small to be seen on the same scale as regional SO_2 (Figure 4-12).

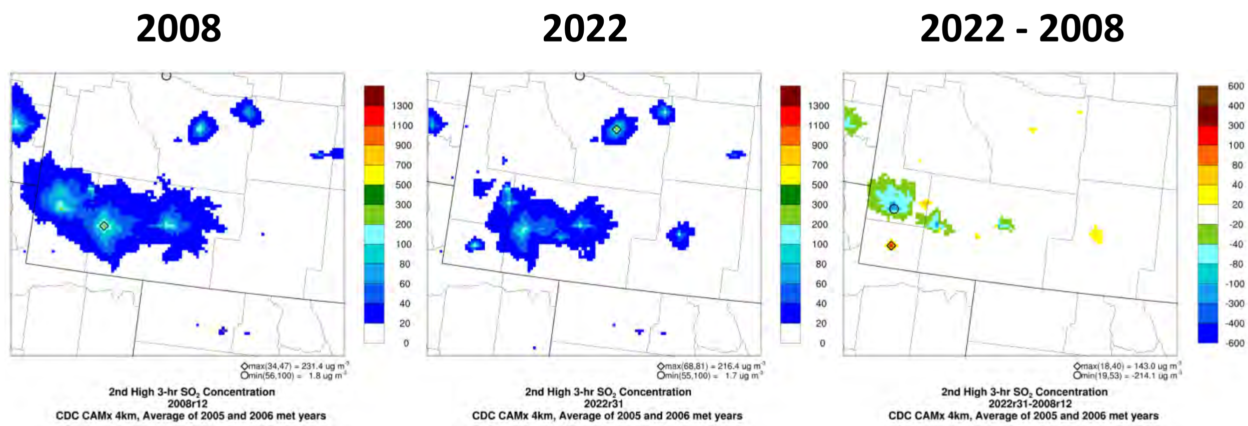

Figure 4-11. CAMx model results for 3-hour SO_2. Left and center panels: 2008 and 2022 absolute model results for 3-hour SO_2 from all regional emissions sources, including CD-C Project. Right panel: 2022-2008 difference in 3-hour SO_2. All three panels show average of results for the 2005 and 2006 meteorological years.

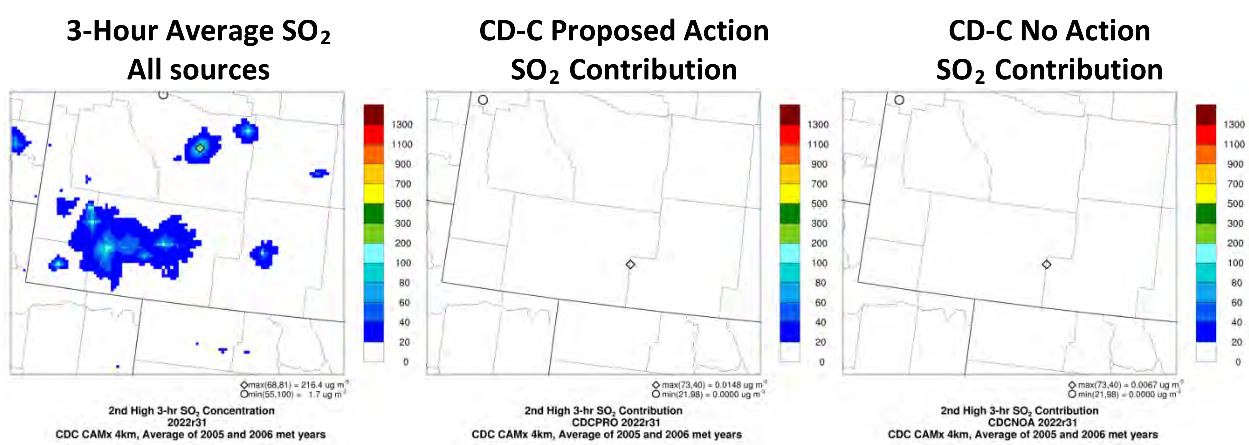

Figure 4-12. Left panel: 2022 absolute model results for 3-hour SO_2 from all regional emissions sources, including CD-C Project. Center panel: CD-C Proposed Action Alternative contribution to the 2022 3-hour SO_2 shown in the left hand panel. Right panel: CD-C No Action Alternative contribution to the 2022 3-hour SO_2 shown in the left hand panel. All three panels show average of results for the 2005 and 2006 meteorological years.

CAMx results for 24-hour SO_2 are shown in Figure 4-13. The NAAQS and CAAQS for 24-hour SO_2 are 365 µg m^{-3}, while the WAAQS is 260 µg m^{-3}. 24-hour SO_2 values within the 4 km domain are generally below 40 µg m^{-3} except in the vicinity of large point sources. The maximum value within the 4 km domain in 2022 is 126 µg m^{-3}; all 24-hour SO_2 standards are attained throughout the 4 km domain. The largest SO_2 increases going from 2008 to 2022 occur in Uinta and Fremont Counties, as noted in the discussion of 1-hour SO_2. As for the 1-hour and 3-hour SO_2, contributions to 24-hour SO_2 from the Proposed Action Alternative and No Action Alternative emissions are too small to be seen on the same scale as regional SO_2 (Figure 4-14).

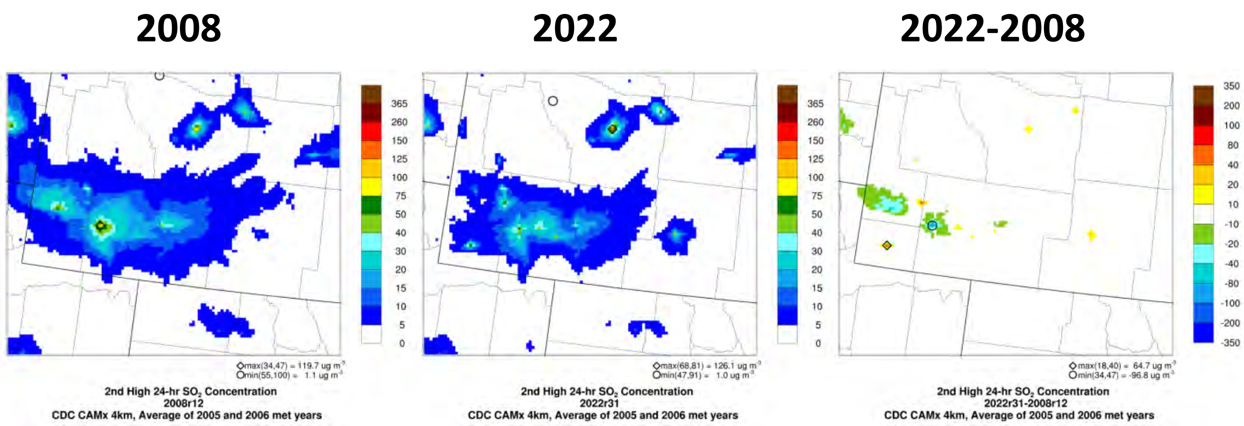

Figure 4-13. CAMx model results for 24-hour SO_2. Left and center panels: 2008 and 2022 absolute model results for 24-hour SO_2 from all regional emissions sources, including CD-C Project. Right panel: 2022-2008 difference in 24-hour SO_2. All three panels show average of results for the 2005 and 2006 meteorological years.

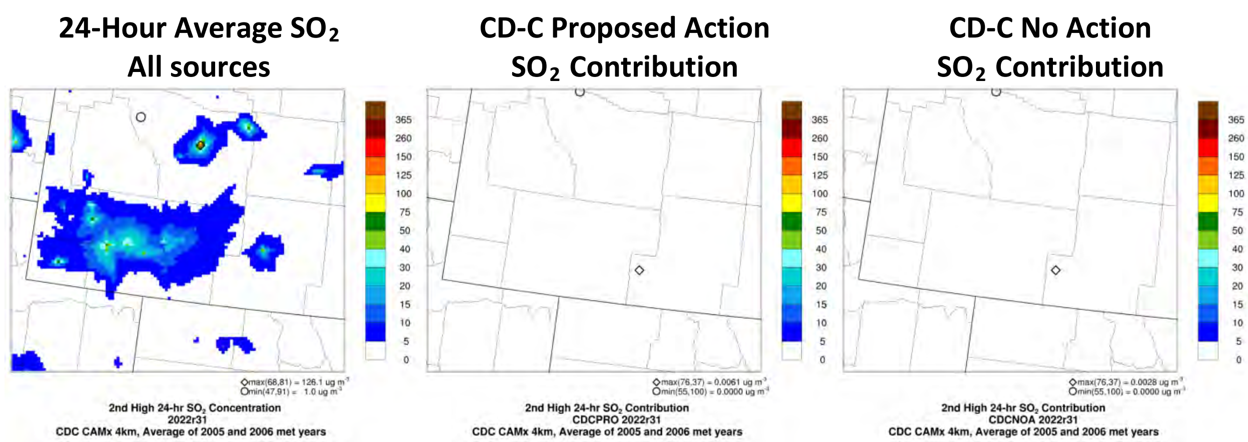

Figure 4-14. Left panel: 2022 absolute model results for 24-hour SO_2 from all regional emissions sources, including CD-C Project. Center panel: CD-C Proposed Action Alternative contribution to the 2022 24-hour SO_2 shown in the left hand panel. Right panel: CD-C No Action Alternative contribution to the 2022 24-hour SO_2 shown in the left hand panel. All three panels show average of results for the 2005 and 2006 meteorological years.

CAMx results for annual average SO_2 are shown in Figure 4-15. The NAAQS for annual average SO_2 is 80 µg m^{-3}. Annual average SO_2 values within the 4 km domain are generally below 10 µg m^{-3} except in the vicinity of large point sources. The maximum value within the 4 km domain in 2022 is 48 µg m^{-3}; all annual SO_2 standards are attained throughout the 4 km domain. The largest SO_2 increase going from 2008 to 2022 occurs in Lincoln County. As for short-term SO_2, contributions to annual average SO_2 from the Proposed Action Alternative and No Action Alternative emissions are too small to be seen on the same scale as regional SO_2 (Figure 4-16).

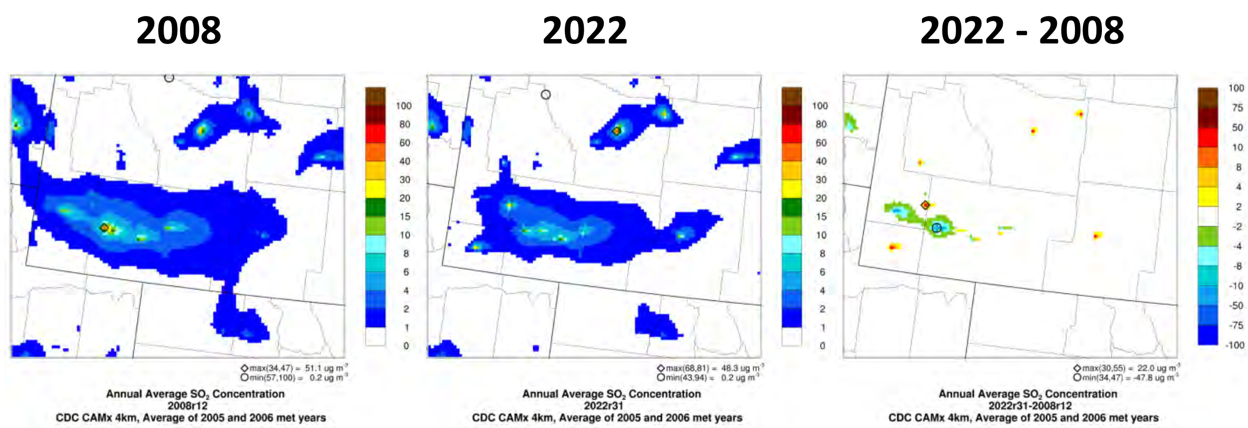

Figure 4-15. CAMx model results for annual average SO_2. Left and center panels: 2008 and 2022 absolute model results for annual average SO_2 from all regional emissions sources, including CD-C Project. Right panel: 2022-2008 difference in annual average SO_2; all three panels show average of results for the 2005 and 2006 meteorological years.

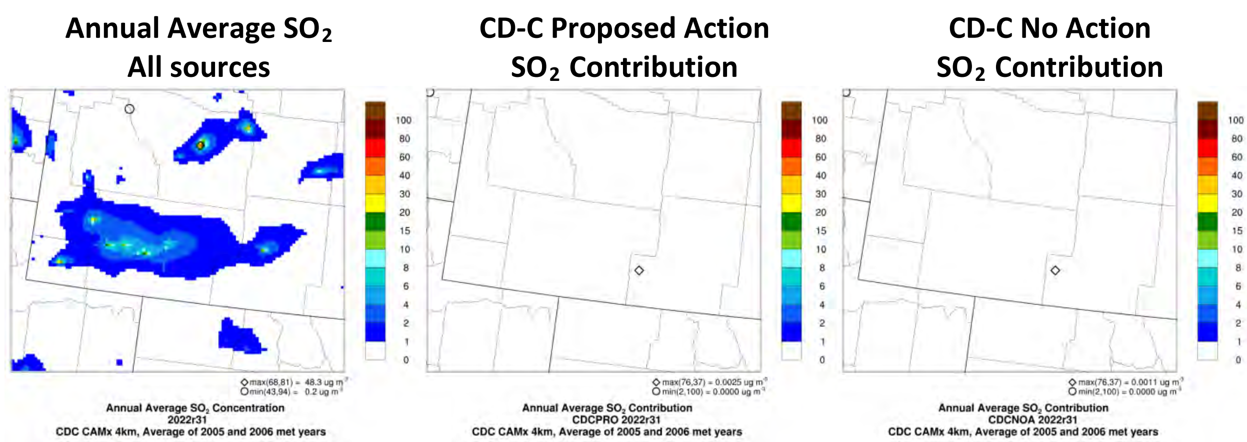

Figure 4-16. Left panel: 2022 absolute model results for annual average SO_2 from all regional emissions sources, including CD-C Project. Center panel: CD-C Proposed Action Alternative contribution to the 2022 annual average SO_2 shown in the left hand panel. Right panel: CD-C No Action Alternative contribution to the 2022 annual average SO_2 shown in the left hand panel. All three panels show average of results for the 2005 and 2006 meteorological years.

CAMx results for 98th percentile 24-hour $PM_{2.5}$ are shown in Figure 4-17. The NAAQS, WAAQS and CAAQS for 24-hour $PM_{2.5}$ are 35 µg m^{-3}. The 98th percentile 24-hour $PM_{2.5}$ values within the 4 km domain are generally below 10 µg m^{-3} and the maximum concentration within the 4 km domain in 2022 is 20 µg m^{-3} near the Jim Bridger Power Plant; the 24-hour $PM_{2.5}$ standard is attained throughout the 4 km domain. Peak contributions to the 24-hour $PM_{2.5}$ from the CD-C Proposed Action Alternative and No Action Alternative emissions are 1.4 µg $m^{-3}$and 0.6 µg m^{-3}, respectively. The CD-C $PM_{2.5}$ contribution is too small to be visible on same scale as regional $PM_{2.5}$ (Figure 4-18).

2008 **2022** **2022 - 2008**

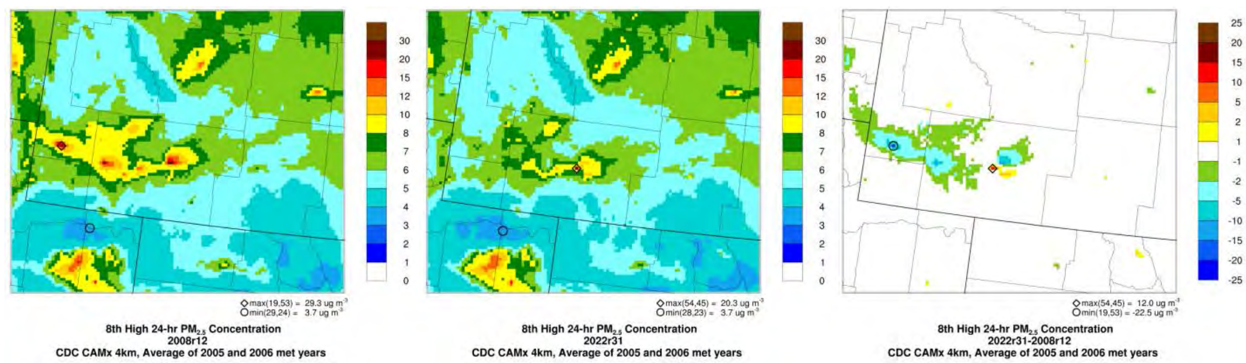

Figure 4-17. CAMx model results for the 98th percentile 24-hour $PM_{2.5}$. Left and center panels: 2008 and 2022 absolute model results for 98th percentile 24-hour $PM_{2.5}$ from all regional emissions sources, including CD-C Project. Right panel: 2022-2008 difference in 98th percentile 24-hour $PM_{2.5}$. All three panels show average of results for the 2005 and 2006 meteorological years.

24-Hour Average $PM_{2.5}$ All sources **CD-C Proposed Action $PM_{2.5}$ Contribution** **CD-C No Action $PM_{2.5}$ Contribution**

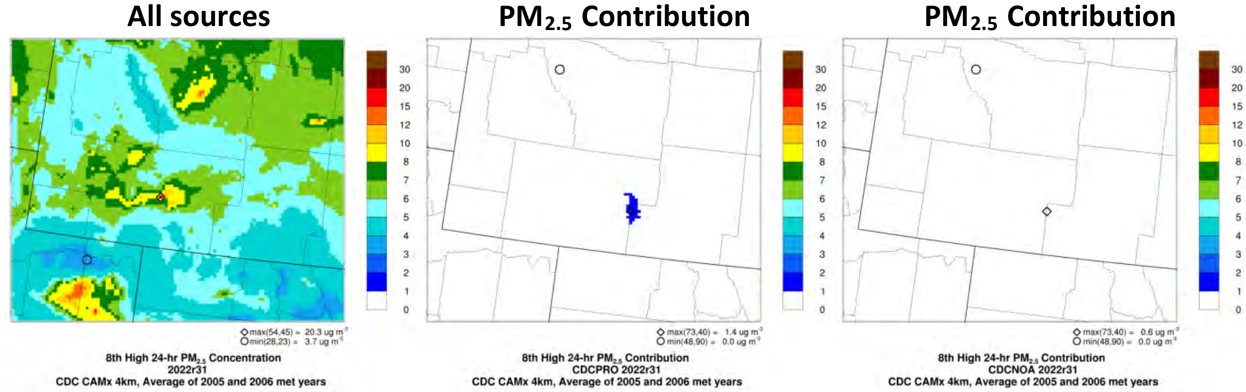

Figure 4-18. Left panel: 2022 absolute model results for 98th percentile 24-hour $PM_{2.5}$ from all regional emissions sources, including CD-C Project. Center panel: CD-C Proposed Action Alternative contribution to the 2022 24-hour $PM_{2.5}$ shown in the left hand panel. Right panel: CD-C No Action Alternative contribution to the 2022 highest 24-hour $PM_{2.5}$ shown in the left hand panel. All three panels show average of results for the 2005 and 2006 meteorological years.

CAMx results for annual average $PM_{2.5}$ are shown in Figure 4-19. The NAAQS for annual average $PM_{2.5}$ is 12 µg m^{-3}; neither Colorado nor Wyoming has a more stringent standard. The annual average $PM_{2.5}$ concentrations within the 4 km domain in 2022 are generally below 4 µg m^{-3} and the maximum value is 10 µg m^{-3}; therefore, the standard is attained. Peak contributions to the annual $PM_{2.5}$ from the CD-C Proposed Action Alternative and No Action Alternative emissions are 0.5 µg m^{-3} and 0.2 µg m^{-3}, respectively. The CD-C $PM_{2.5}$ contribution is too small to be visible on same scale as regional $PM_{2.5}$ (Figure 4-20) except for within a small area located around the CD-C Project Area in the Proposed Action Alternative case.

2008 **2022** **2022 - 2008**

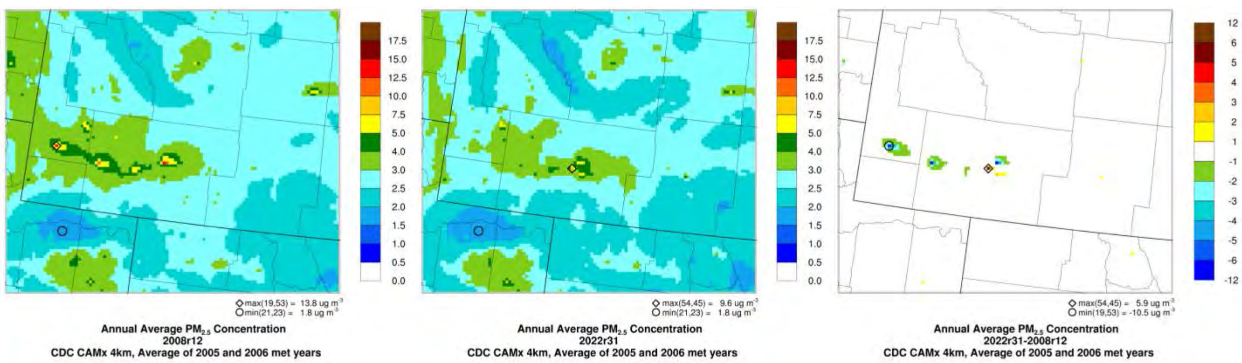

Figure 4-19. CAMx model results for annual average $PM_{2.5}$. Left and center panels: 2008 and 2022 absolute model results for annual average $PM_{2.5}$ from all regional emissions sources, including CD-C Project. Right panel: 2022-2008 difference in annual average $PM_{2.5}$. All three panels show average of results for the 2005 and 2006 meteorological years.

Annual Average $PM_{2.5}$ All sources **CD-C Proposed Action $PM_{2.5}$ Contribution** **CD-C No Action $PM_{2.5}$ Contribution**

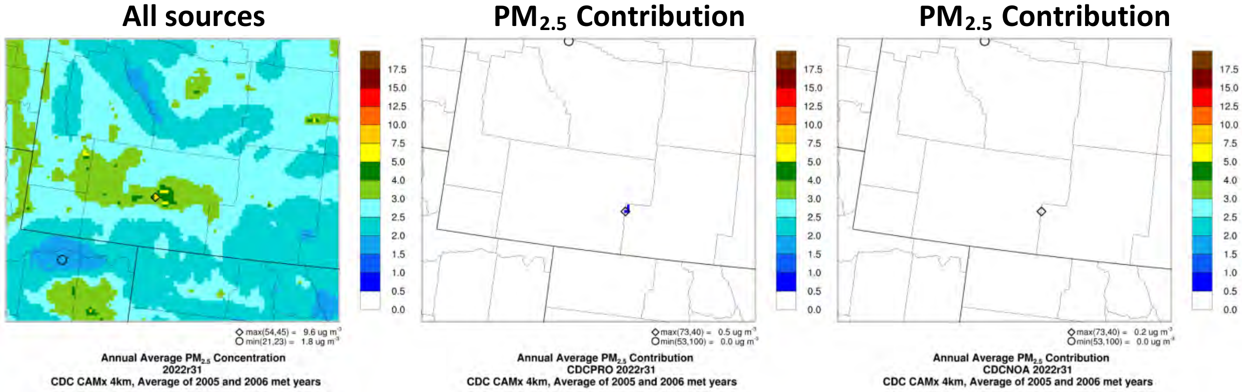

Figure 4-20. Left panel: 2022 absolute model results for annual average $PM_{2.5}$ from all regional emissions sources, including CD-C Project. Center panel: CD-C Proposed Action Alternative contribution to the 2022 annual average $PM_{2.5}$. Right panel: CD-C No Action Alternative contribution to the 2022 annual average $PM_{2.5}$. All three panels show average of results for the 2005 and 2006 meteorological years.

CAMx results for the 2nd highest 24-hour PM_{10} value are shown in Figure 4-21. The NAAQS, WAAQS and CAAQS for 24-hour PM_{10} are 150 µg m^{-3}. 2nd highest 24-hour average PM_{10} values within the 4 km domain are generally below 35 µg m^{-3} and the maximum value within the 4 km domain in 2022 is 458 µg m^{-3} ; the standards are not attained. However, the only exceedance of the standards is associated with a fire that occurred in northeastern Lincoln County in 2005. There are no exceedances of the PM_{10} NAAQS in 2006 (not shown; see Appendix J). Fire emissions were held fixed from the 2005-2006 base case emission inventories in both the 2008 and 2022 emission inventories. Therefore, the PM impacts from the fire are absent in the 2022-2008 difference plot in the right panel. Contributions to 24-hour PM_{10} from the CD-C Proposed Action and No Action emissions are 6.6 µg $m^{-3}$and 3.0 µg m^{-3}, respectively (Figure 4-22). Figure 4-22 shows that the CD-C Proposed Action Alternative emissions do not contribute significantly to the exceedance in Lincoln County.

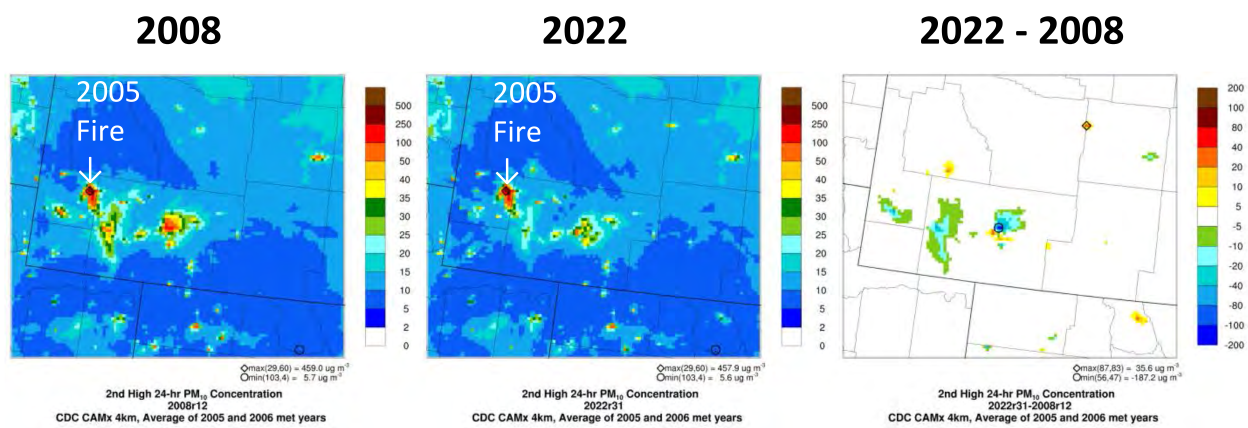

Figure 4-21. CAMx 2008 and 2022 model results for 2nd high 24-hour average PM_{10}. Left and center panels: 2008 and 2022 absolute model results for 2nd high 24-hour average PM_{10} from all regional emissions sources, including CD-C Project. Right panel: 2022-2008 difference in 2nd high 24-hour average PM_{10}. All three panels show average of results for the 2005 and 2006 meteorological years.

24-Hour Average PM_{10} All sources | **CD-C Proposed Action PM_{10} Contribution** | **CD-C No Action PM_{10} Contribution**

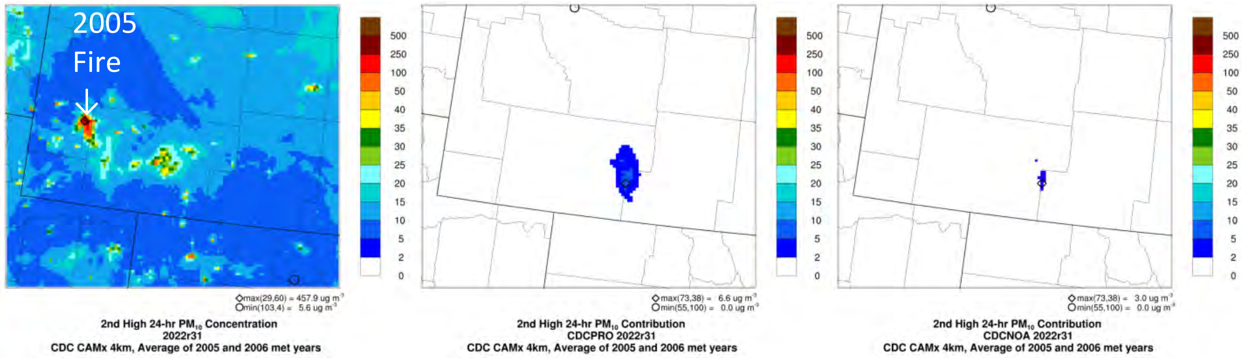

Figure 4-22. Left panel: 2022 absolute model results for 2nd high 24-hour average PM_{10} from all regional emissions sources, including CD-C Project. Center panel: CD-C Proposed Action Alternative contribution to the 2022 2nd high 24-hour average PM_{10} shown in the left hand panel. Right panel: CD-C No Action Alternative contribution to the 2022 2nd high 24-hour average PM_{10} shown in the left hand panel. All three panels show average of results for the 2005 and 2006 meteorological years.

CAMx results for annual average PM_{10} are shown in Figure 4-23. The WAAQS for annual average PM_{10} is 50 µg m^{-3}. There is no CAAQS or NAAQS for this averaging time. Annual average PM_{10} values within the 4 km domain are generally below 10 µg m^{-3} and the maximum value within the 4 km domain in 2022 is 28 µg m^{-3}, therefore, the standards are attained throughout the 4 km domain. Contributions to 24-hour PM_{10} from the CD-C Proposed Action Alternative and No Action Alternative emissions are 2.4 µg $m^{-3}$and 1.1 µg m^{-3}, respectively (Figure 4-24). The CD-C PM_{10} contribution is too small to be visible on same scale as regional PM_{10}.

2008 | **2022** | **2022 - 2008**

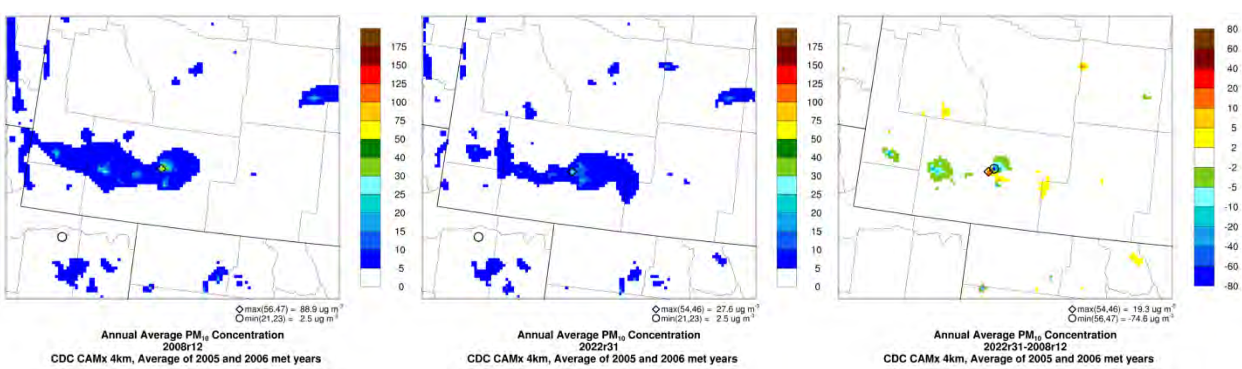

Figure 4-23. CAMx 2008 and 2022 model results for annual average PM_{10}. Left and center panels: 2008 and 2022 absolute model results for annual average PM_{10} from all regional emissions sources, including CD-C Project. Annual average PM_{10} results from the 2005 and 2006 meteorological years using 2008 emissions were averaged together to produce these plots. Right panel: 2022-2008 difference in annual average PM_{10} contribution from the CD-C Project sources, Average of results for the 2005 and 2006 meteorological years.

Annual Average PM_{10} All sources | **CD-C Proposed Action PM_{10} Contribution** | **CD-C No Action PM_{10} Contribution**

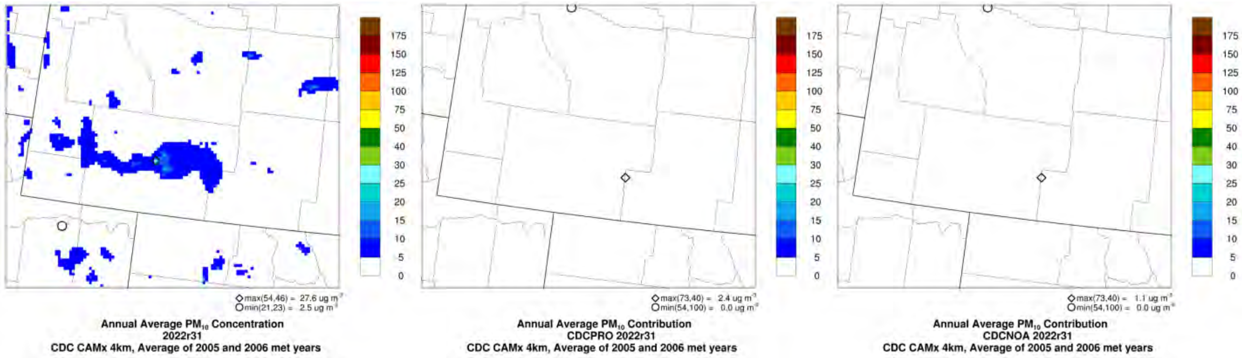

Figure 4-24. Left panel: 2022 absolute model results for annual average PM_{10} from all regional emissions sources, including CD-C Project. Center panel: CD-C Proposed Action contribution to the 2022 annual average PM_{10} shown in the left hand panel. Right panel: CD-C No Action (existing wells) contribution to the 2022 annual average PM_{10} shown in the left hand panel. All three panels show average of results for the 2005 and 2006 meteorological years.

CAMx results for 1-hour average CO concentrations are shown in Figure 4-25. The NAAQS, WAAQS and CAAQS for 1-hour CO are 40,000 µg m^{-3}. 1-hour average CO concentrations within the 4 km domain are generally below 4,000 µg m^{-3} except the near the location of the 2005 fire in Lincoln County. The maximum value within the 4 km domain in 2022 is 24,838 µg m^{-3}, therefore, the standards are attained throughout the domain. The CD-C CO contribution cannot be shown because PSAT does not track CO.

2008 | **2022** | **2022 – 2008**

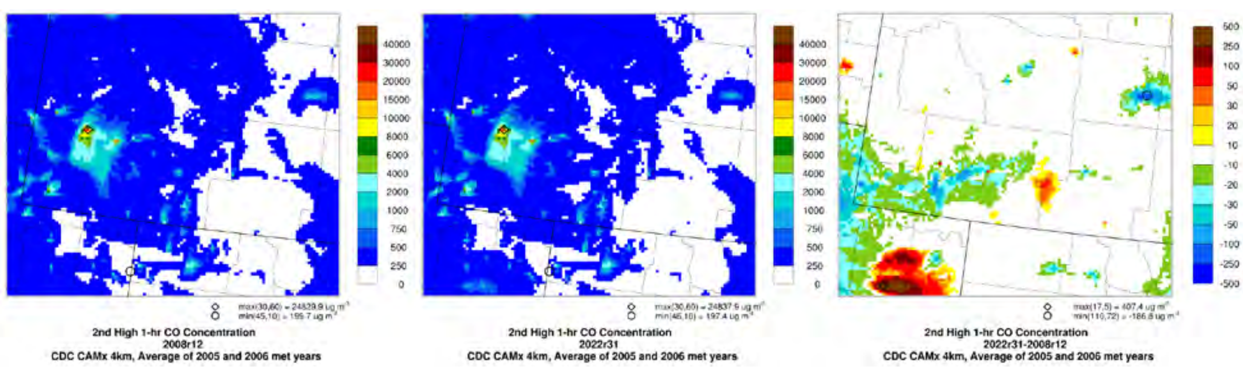

Figure 4-25. CAMx model results for 1-hour average CO. Left and center panels: 2008 and 2022 absolute model results for 1-hour average CO from all regional emissions sources, including CD-C Project. Right panel: 2022-2008 difference in 1-hour average CO. All three panels show average of results for the 2005 and 2006 meteorological years.

CAMx results for the 8-hour CO are shown in Figure 4-26. The NAAQS, WAAQS and CAAQS for 8-hour CO are 10,000 µg m^{-3}. 8-hour average CO values within the 4 km domain are generally below 4,000 µg m^{-3} except the near the location of the 2005 fire in Lincoln County. The maximum value within the 4 km domain in 2022 is 18,949 µg m^{-3}, therefore the standards are not attained. The CD-C CO contribution cannot be shown because PSAT does not track CO. However the CD-C Project area is located far away from the location of the exceedance and has much lower values of 8-hour CO. It is reasonable to conclude that the CD-C Project does not play a significant role in the CO exceedance in Lincoln County.

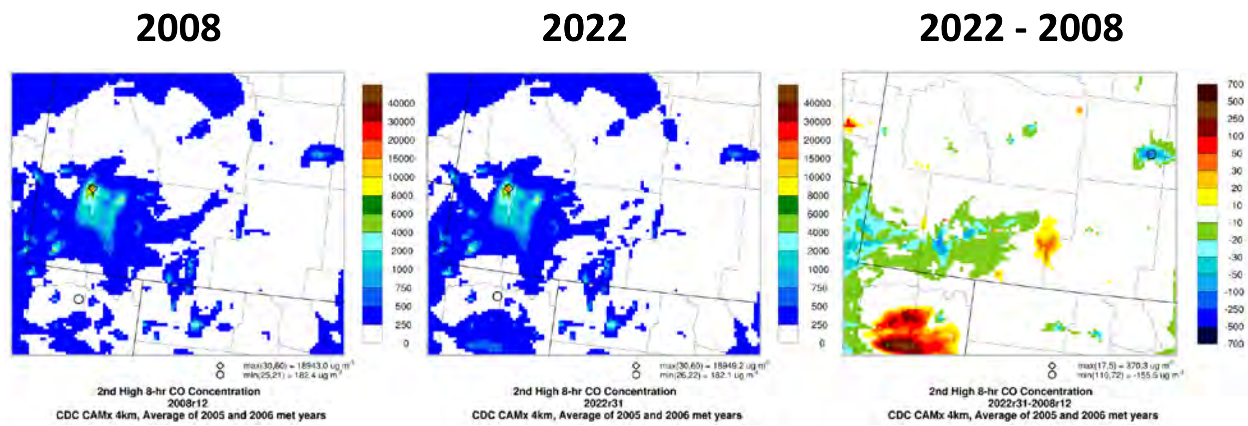

Figure 4-26. CAMx model results for 8-hour average CO. Left and center panels: 2008 and 2022 absolute model results for 8-hour average CO from all regional emissions sources, including CD-C Project. Right panel: 2022-2008 difference in 8-hour average CO. All three panels show average of results for the 2005 and 2006 meteorological years.

For pollutants that show an exceedance of the NAAQS (1-hour SO_2, 24-hour PM_{10} and 8-hour CO), the magnitude and spatial extent of the CD-C Proposed Action Alternative and No Action Alternative impacts make it clear that the CD-C Project Alternatives do not significantly contribute to the exceedances. For 24-hour PM_{10} and 8-hour average CO, the exceedance is caused by the 2005 fire in Lincoln County and is not related to CD-C Project Alternative emissions.

4.5.4 Ozone Impact Analysis

4.5.4.1 Introduction

The CAMx modeling outputs from the two future year annual simulations using 2022 emissions and 2005 and 2006 meteorology were post-processed to derive ozone concentrations for comparison to the ambient air quality standards (WAAQS, CAAQS and NAAQS) across the 4 km domain. In this Section, we present CAMx modeling results for comparison with the applicable air quality standards in two ways:

1. Following EPA's modeling guidance for projecting future-year Design Values for criteria pollutants that are compared against the NAAQS, WAAQS and CAAQS (EPA, 2007); and
2. Using the absolute modeling results that are averaged in accordance with the form of the standard and then compared directly with NAAQS, WAAQS and CAAQS.

In Method (1), 2022 ozone concentrations for the 2005 and 2006 meteorological years were projected using procedures in EPA's latest modeling guidance (EPA, 2007). An overview of the EPA method is given in Section 4.5.4.2. The EPA procedures use the modeling results together with observed base year ozone Design Values (defined below) to derive an interpolated base year ozone Design Value field which can then be compared to the NAAQS, which are identical to or more stringent than the CAAQS and WAAQS for 8-hour ozone. The current 8-hour ozone NAAQS was promulgated March 2008 has a threshold of 0.075 ppm and is defined as the annual 4th highest daily maximum 8-hour average ozone concentration averaged over three consecutive years. Wyoming has not revised the standard for 8-hour ozone, and still retains the standard of 0.08 ppm.

In Method (2), the 4th high daily maximum 8-hour ozone was calculated for each grid cell for the 2022met05 and 2022met06 model runs, and then the 2022met05 and 2022met06 results were averaged and compared to the results of method (1) and the NAAQS.

The CAMx model's APCA ozone source apportionment capability was used to determine the contribution of CD-C Proposed Action emissions to regional ozone levels within the 4 km domain during the 2022met05 and 2022met06 model runs. For days and locations in which the absolute model-estimated daily maximum 8-hour ozone concentrations or observed 2005-2006 daily maximum 8-hour ozone concentrations exceeded a threshold, the CAMx ozone source apportionment contributions were used to estimate the contribution of emissions from 2022 CD-C Proposed Action emissions sources to the exceedances of that threshold. The threshold for high ozone is the 2008 ozone standard (75 ppb).

4.5.4.2. EPA Guidance Ozone Projection Approach

The ozone NAAQS are formulated in terms of a Design Value, which is calculated as the 3-year average of the fourth highest monitored daily maximum 8-hour concentration at each monitoring site. To attain the 2008 ozone standard, the Design Value for a given monitor must not exceed 75 ppb. EPA's latest modeling guidance (EPA, 2007) for projecting future year 8-hour ozone Design Values recommends the use of modeling results in a relative sense to scale the observed current year 8-hour ozone Design Value (DVC) to obtain a future year 8-hour ozone Design Value (DVF). The model-derived scaling factors are referred to as Relative Response Factors (RRF) and are defined as the ratio of daily maximum 8-hour ozone concentrations near a monitor averaged over several days of modeling results for the future year emissions scenario to the current year base case:

$$RRF_{monitor\ i} = \frac{\sum_{days}\left(daily \max 8 - hour\ ozone\right)_{future\ \ year}}{\sum_{days}\left(daily \max 8 - hour\ ozone\right)_{current\ \ year}}$$

$$DVF_{monitor\ i} = DVC_{monitor\ i} \times RRF_{monitor\ i}$$

This technique is used to minimize the effect of model uncertainty on future year ozone projections. For example, if the model has a bias toward underestimating ozone at a given monitor, using the raw future year ozone predictions may result in an underestimate of future year ozone at that monitor. However, if the ratio of the future year to base year modeled ozone values at that monitor is multiplied by the observed base year design value to produce a predicted future year value, that future year value will better reflect the change in ozone due to changes in emissions between base and future year cases, and the effect of the model's bias toward lower ozone values will have been reduced.

For the CD-C modeling, 2008 baseline year DVCs and 2022 future year DVFs were calculated for comparison with the NAAQS; these results are presented later in this Section. The model output from the CAMx 2008 baseline run and 2022 future year run that includes the CD-C Alternative emissions were used to construct the RRFs, which were then used with the observed DVCs to produce projected DVFs for the 2022 future year. The DVFs were used to evaluate future year compliance with the ozone NAAQS. Below, we describe the EPA guidance for performing these DVC and future year calculations as well as the procedure for calculating the 2008 DVC across the entire modeling domain based on the DVCs at the monitors.

The basic steps in performing future year 8-hour ozone projections using EPA's recommended projection approach are summarized as follows:

1. Develop observed current year 8-hour ozone Design Values (DVC) at each monitoring site as the starting point for the ozone projections. EPA guidance recommends using a three year average of three consecutive years of Design Values centered on the baseline modeling year. For the CD-C modeling, this means Design Values from the five year period of 2006-2010 are required to calculate the three consecutive years of observed DVCs for 2007-2010 required for the three year average centered on the 2008 baseline modeling year.
2. Select the maximum modeled 8-hour ozone concentrations near a monitor for several days from the base year and future year emission scenarios and take the ratio of their averages to construct the monitor-specific RRFs:
   - EPA guidance defines "near a monitor" to be an array of 7 x 7 grid cells centered on the monitoring location for modeling that uses a 4 km grid resolution as in the CD-C modeling.
   - EPA recommends that RRFs be based on at least 10 modeled days and recommends selecting days in which the baseline year highest daily maximum 8-hour ozone concentrations near a monitor is greater than an ozone threshold (cut off). This is done so that the model response to future changes in emissions is considered only on high ozone days with conditions comparable to those days that produced the design values. Initially, an ozone threshold of 85 ppb is used. If less than 10 modeling days are obtained the threshold is reduced by 1 ppb until at least 10 days are obtained for the RRF. When the 70 ppb threshold floor is reached and there are at least 5 days then the RRF is used. In the CD-C 4 km modeling domain, many sites did not meet this 5 day minimum. To ensure that the greatest number of monitors possible was used to constrain the DVC field, this requirement was relaxed so that

the threshold floor was 60 ppb and minimum number of days above the threshold was 1 day.

- o Note that this modeling day selection approach for the RRFs automatically eliminates using modeling days in which the model is greatly underestimating the observed ozone concentrations when constructing the RRFs.

3. The RRF is applied to the DVC to obtain the projected DVF at each monitoring site for the future year emission scenarios. The projected DVF is truncated to the nearest ppb.
4. If the future year ozone projections are carried out as part of an attainment demonstration, DVFs are compared with the NAAQS for ozone. If the DVFs at all monitoring sites are less than or equal to the ozone NAAQS, then the modeled attainment demonstration test is passed. If a DVF at any monitor exceeds the ozone NAAQS, the modeled attainment test is not passed. Note that the current EPA guidance (EPA, 2007) addresses the 84 ppb 8-hour ozone NAAQS and we address the 75 ppb 8-hour ozone NAAQS that is in effect at the time of the CD-C modeling in 2012.
5. The method of projecting future year design values discussed above applies only to grid cells containing monitors, and it is necessary to project future ozone values for areas in the domain that lie between the monitors. This is known as an unmonitored area analysis (UAA) and is performed by interpolating DVCs from monitoring sites to each grid cell in the modeling domain using the Voronoi Neighbor Averaging interpolation technique. The modeled ozone gradients are taken into account in the interpolation in order to reflect modeled higher and lower ozone areas in the interpolated DVC field.
6. An unmonitored area analysis was performed that interpolates the 2008 DVCs across the modeling domain and performs ozone projections in each grid cell using the procedures given above, except using the modeling results within each grid cell only rather than using the surrounding grid cells in addition to the grid cell itself. For the CD-C 2008 DVC ozone calculations, the unmonitored area analysis is important given the paucity of ozone observations in the region. EPA provides two caveats to be considered when interpreting an unmonitored area analysis:
   - EPA believes that the unmonitored area analysis is more uncertain than the monitor-based ozone projections. EPA indicates that in an attainment demonstration additional emissions reductions are likely required to eliminate any projected monitored ozone exceedances, while the same is not true in the unmonitored area test.
   - EPA recommends that the reasons behind any unmonitored area test exceedances be understood and explained.

To facilitate the implementation of EPA's recommended ozone projections approach, EPA has developed the Modeled Attainment Test Software (MATS; Abt, 2009) that codifies the EPA recommended projection approach. EPA's MATS tool includes observed ozone data from which DVCs can be calculated along with several options that can be specified in making the ozone projections.

4.5.4.2.1. Issues Associated with Applying EPA's MATS Procedures to Southwest Wyoming

There are several issues associated with using the EPA-recommended ozone projection procedure for making future year projections in southwest (SW) Wyoming. These issues are primarily related to the fact that EPA's procedures were designed for making projections for ozone State Implementation Planning (SIP) modeling that in the past occurred primarily in urban areas where there are relatively dense monitoring networks for ozone. The MATS software includes ozone design value data that is used to construct DVCs for monitors in the region of interest. The monitoring network is relatively sparse in SW Wyoming (see Table 2-1 and Figure 4-2) and for many of these monitors, the monitoring history is relatively short. For example, many of the WDEQ SW Wyoming industrial monitoring sites started operation from late 2004 through 2007 and therefore may not have the five year record needed to construct the EPA default DVCs. For CD-C, the EPA projection procedure was therefore adapted to use additional available data to construct the DVC field.

In addition to the scarcity of monitoring data and the short data record for some SW Wyoming monitors, another issue that needs to be addressed in making the DVC calculations projections is the portion of the calendar year to be included in the analysis. The WDEQ-AQD has determined that the simulation of winter ozone is a research area that is not appropriate for inclusion in a NEPA analysis (WDEQ-AQD, 2009). Therefore, modeled winter ozone was not analyzed as part of the CD-C EIS. However, the regulatory definition of the ozone Design Values is based on the three-year average of the *annual* fourth highest daily maximum 8-hour ozone concentrations that includes the high winter ozone concentrations for the affected monitors. In developing the 2008 DVC values, we have used data for the full year in calculating the DVCs at the monitors. However, for construction the RRFs and the unmonitored areas (i.e. grid cells that do not contain a monitor), the model output-based gradients that were used to interpolate ozone design values between monitors use data from the April 1-October 31 ozone season only.

4.5.4.2.2. Enhanced Ozone Projection Approach

In order to address the issues noted in the previous section, the following approach was used to develop 2008 DVCs in the 4 km CD-C domain for evaluation against the NAAQS. DVCs were calculated using relaxed requirements regarding length of data record and including additional WDEQ industrial monitors and CASTNet monitoring sites not present in the default EPA database used in MATS. These additional monitors are listed in Table 4-12 along with the default monitors. DVCs were calculated using data from the full year, but in unmonitored grid cells, modeling results from April 1-October 31 were used to derive DVCs based on the MATS interpolation procedure that uses gradients in the modeled ozone output.

MATS was then applied using the CAMx 2008 baseline and 2022 future year modeling results for the 2005 and 2006 meteorological years using a 60 ppb floor. As noted above, EPA 2007 Guidance uses a 70 ppb floor for 85 ppb NAAQS; however, for the 75 ppb NAAQS, EPA suggests lowering floor to 60 ppb as they develop new guidance (B. Timin, personal communication). DVFs were calculated at Southwest Wyoming monitors and a UAA was performed for the future year.

Table 4-12. Monitors used in the 2008 CD-C Baseline modeling analysis. 4th high DM8 values (blue shading) and design value (DVC) data used in MATS (gray shading) for the CD-C 4 km modeling domain.

Site	Name	Begin Date	End Date	4th High Value					Design Value		
				2006	2007	2008	2009	2010	2008	2009	2010
08_013_7002	Boulder7002	20070301	20071231		77						
08_069_0011	Ft. Collins W.	20060512	20061231	87							
		20070101	20071231		85						
		20080101	20081231			76			82		
		20090101	20091231				73			78	
		20100101	20101231					75			74
08_069_0012	Larimer0012	20090514	20091231				69			69	
		20100101	20101231					71			70
08_069_1004	Ft. Collins	20060101	20061231	78							
		20070101	20071221		69						
		20080103	20081231			66			71		
		20090101	20091231				63			66	
		20100101	20101231					66			65
49_003_0003	Box Elder 0003	20060501	20060930	78							
		20070501	20070930		78						
		20080413	20080930			72			76		
		20090422	20090930				67			72	
		20100501	20100930					67			68
49_003_7001	Box Elder 7001	20060503	20061031	76							
		20070401	20070930		78						
		20080501	20080930			73			75		
		20090501	20090831				62			71	
		20100501	20101231					67			67
49_005_0004	Cache0004	20060101	20061231	73							
		20070101	20071231		77						
		20080101	20081231			66			72		
		20090101	20091231				61			68	
		20100101	20100930					61			62
49_011_0004	Davis 0004	20060501	20060930	82							
		20070501	20070930		82						
		20080403	20080930			78			80		
		20090413	20090930				71			77	
		20100501	20100930					67			72
49_035_0003	Salt lake 0003	20060501	20060930	84							
		20070501	20070930		82						
		20080501	20080930			80			82		
		20090423	20090930				71			77	
		20100501	20100930					72			74
49_035_2004	Salt lake 2004	20060501	20060930	82							
		20070501	20070930		82						
		20080421	20080930			74			79		
		20090429	20090930				74			76	
		20100501	20100930					67			71
49_035_3006	Salt lake 3006	20060101	20061231	82							
		20070101	20071231		79						
		20080101	20081231			75			78		

Site	Name	Begin Date	End Date	4th High Value					Design Value		
				2006	2007	2008	2009	2010	2008	2009	2010
		20090101	20091231				75			76	
		20100101	20100630					63			71
49_035_3007	Salt lake 3007	20060501	20060930	80							
		20070501	20070930		80						
49_035_3008	Salt lake 3008	20060501	20060930	82							
		20070501	20070930		79						
49_045_0003	Tooele 0003	20060501	20060930	79							
		20070501	20070930		77						
		20080501	20080930			70			75		
		20090428	20090930				70			72	
		20100501	20100930					67			69
49_049_0002	Utah 0002	20060501	20060930	74							
		20070501	20070930		75						
		20080501	20081231			74			74		
		20090101	20091231				68			72	
		20100101	20100930					69			70
49_049_5008	Utah 5008	20060501	20060930	77							
		20070501	20070930		78						
		20080410	20080930			71			75		
		20090409	20090930				69			72	
		20100501	20100930					68			69
49_049_5010	Utah 5010	20060501	20060930	79							
		20070501	20070930		77						
		20080409	20080930			72			76		
		20090423	20090930				69			72	
		20100501	20100930					70			70
49_057_0002	Weber 0002	20090101	20091231				69			71	
		20100101	20100930					73			72
49_057_0007	Weber 0007	20060501	20060930	83							
		20070501	20070930		80						
49_057_1003	Weber 1003	20060501	20060930	83							
		20070501	20070930		82						
		20080501	20080930			75			80		
		20090408	20090930				72			76	
		20100501	20100930					66			71
56_005_0456	South Campbell	20060101	20061231	65							
		20070101	20071231		72						
		20080101	20081231			64			67		
		20090101	20091231				60			65	
		20100101	20100930					61			61
56_007_0099	Atlantic Rim	20080101	20081231			70			59		
		20090101	20090224				50			56	
56_007_0100	Sun Dog	20100101	20100930					66			56
56_013_0099	South Pass	20070312	20071231		72						
		20080101	20081231			67			69		
		20090101	20091231				80			73	
		20100101	20100930					68			71
56_013_0232	Spring Creek	20090205	20091231				60			60	
		20100101	20100930					63			61

Site	Name	Begin Date	End Date	4th High Value					Design Value		
				2006	2007	2008	2009	2010	2008	2009	2010
56_035_0098	Jonah	20060101	20061231	69							
		20070101	20071231		68						
		20080101	20080423			82			73		
56_035_0099	Boulder	20060101	20061231	72							
		20070101	20071231		67						
		20080101	20081231			102			80		
		20090101	20091231				66			78	
		20100101	20100930					67			78
56_035_0100	Daniel	20060101	20061231	74							
		20070101	20071231		66						
		20080101	20081231			74			71		
		20090101	20091231				62			67	
		20100101	20100930					63			66
56_035_0101	Pinedale North	20100101	20100930					62			59
56_035_1002	Juel Spring	20100101	20100930					64			64
56_037_0200	Wamsutter	20060307	20061231	67							
		20070101	20071231		65						
		20080101	20081231			64			65		
		20090101	20091231				62			63	
		20100101	20100930					67			64
56_037_0300	Moxa Arch	20100528	20100930					66			66
56_037_0898	OCI	20070101	20071231		66						
		20080101	20081231			72			69		
		20090101	20090930				60			66	
56_041_0101	Murphy Ridge	20070101	20071231		70						
		20080101	20081231			64			67		
		20090101	20091231				60			64	
		20100101	20100930					65			63
56_021_0100	Cheyenne Ncore	20106027	20100930					64			64
56_005_0123	Thunder Basin	20060101	20060930	72							
		20070101	20070930		72						
		20080101	20080930			66			70		
		20090101	20090930				64			67	
		20100101	20100930					63			64

4.5.4.3. MATS Ozone Design Value Results

In this section, we present MATS current and future year Design Values using CAMx results for the 2008 and 2022 emissions scenarios with 2005 and 2006 meteorology. The DVC and DVF are compared with the 75 ppb ozone NAAQS. An 8-hour ozone Design Value attains the NAAQS if it is 75 ppb or lower. 8-hour ozone Design Values are expressed to the nearest ppb and the EPA convention is to truncate to the nearest ppb; therefore, exceedances of the 8-hour ozone NAAQS occur when ozone is 76.0 ppb or higher and attainment is achieved with 8-hour ozone Design Values of 75.9 ppb or lower.

Table 4-13 shows the results of the MATS ozone analysis at monitors within the 4 km domain. Orange shading indicates design values ≥76 ppb in the 2008 baseline or 2022 future year. All monitors attain the 75 ppb NAAQS in both 2008 and 2022 except the Boulder monitor in Sublette County, WY. Note that the Boulder 2008 DVC includes winter ozone data. High winter ozone values drive the design value during 2005-2010. The 75 ppb NAAQS is achieved for both the CD-C Proposed Action Alternative and No Action Alternative for all monitors except Boulder. In Figures 4-27 through 4-34, we present the results of the unmonitored area analysis.

Table 4-13. MATS 2008 DVC and projected 2022 DVF at ozone monitors in the 4 km domain for 2005 (2022met05) and 2006 (2022met06) meteorological years. Results are shown for the CD-C Proposed Action Alternative and CD-C No Action Alternative emission scenarios.

Site ID	Site Name	2008 DVC (ppb)	2022 DVF (ppb)			
			2022met05 Proposed Action	2022met06 Proposed Action	2022met05 No Action	2022met06 No Action
560070099	Atlantic Rim	70.0	69.6	68.9	69.3	68.4
560070100	Sun Dog	66.0	65.4	65.0	65.2	64.7
560130099	South Pass	71.0	69.7	70.5	69.7	70.5
560130232	Spring Creek	60.5	59.8	59.4	59.8	59.4
560350098	Jonah	68.0	66.5	67.3	66.5	67.3
560350099	Boulder	78.7	77.2	77.7	77.2	77.7
560350100	Daniel	68.0	66.9	67.4	66.9	67.4
560350101	Pinedale North	62.0	60.7	61.4	60.7	61.4
560351002	Juel Spring	64.0	62.7	63.3	62.7	63.3
560370200	Wamsutter	64.0	63.2	62.8	63.1	62.7
560370300	Moxa Arch	66.0	65.3	64.1	65.3	64.1
560370898	OCI	67.0	66.2	65.2	66.2	65.2
560410101	Murphy Ridge	64.7	62.1	62.9	62.1	62.9
CNT169	Centennial	67.7	66.7	66.5	66.6	66.4
PND165	Pinedale	64.7	63.1	64.3	63.1	64.3
ROM206	Rocky Mtn NP Collocated	72.3	70.4	70.6	70.4	70.6
ROM406	Rocky Mtn NP	74.3	72.3	72.5	72.3	72.5

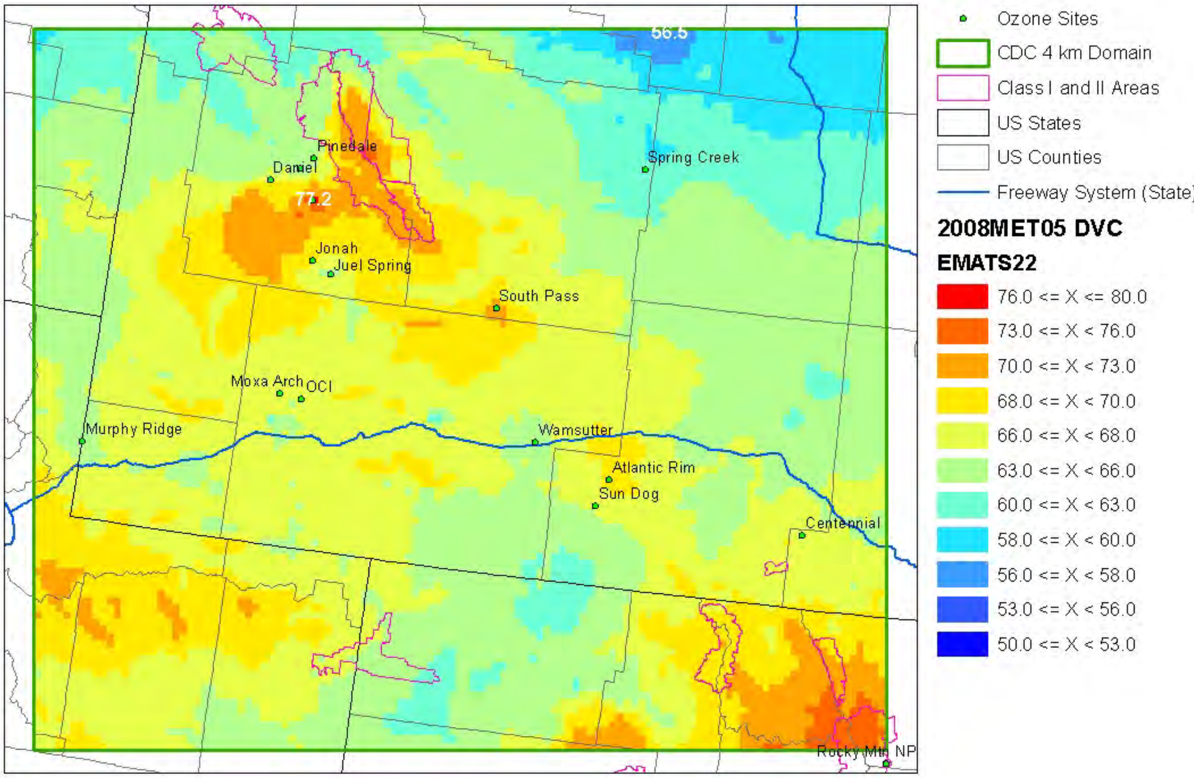

Figure 4-27. Unmonitored area analysis. 2008 ozone DVC for 2005 meteorology (ppb).

The MATS 2008 DVC results using 2005 meteorology (Figure 4-27) show the highest ozone design values in regions of high terrain (Uinta Mountains and the high elevation areas of the Bridger and Fitzpatrick Wilderness Areas) and in the vicinity of the urban areas of Salt Lake City, UT and Denver, CO. The only exceedance of the 75 ppb NAAQS occurs in Sublette County near Boulder. DVCs higher than 70 ppb are found across a large area of the Upper Green River Basin in Sublette County; this is an area of intensive oil and gas development. The lowest design values are found in the northeastern portion of the 4 km domain and in the rural areas of northwestern Colorado. DVCs in the vicinity of the CD-C Project are in the 60-69 ppb range.

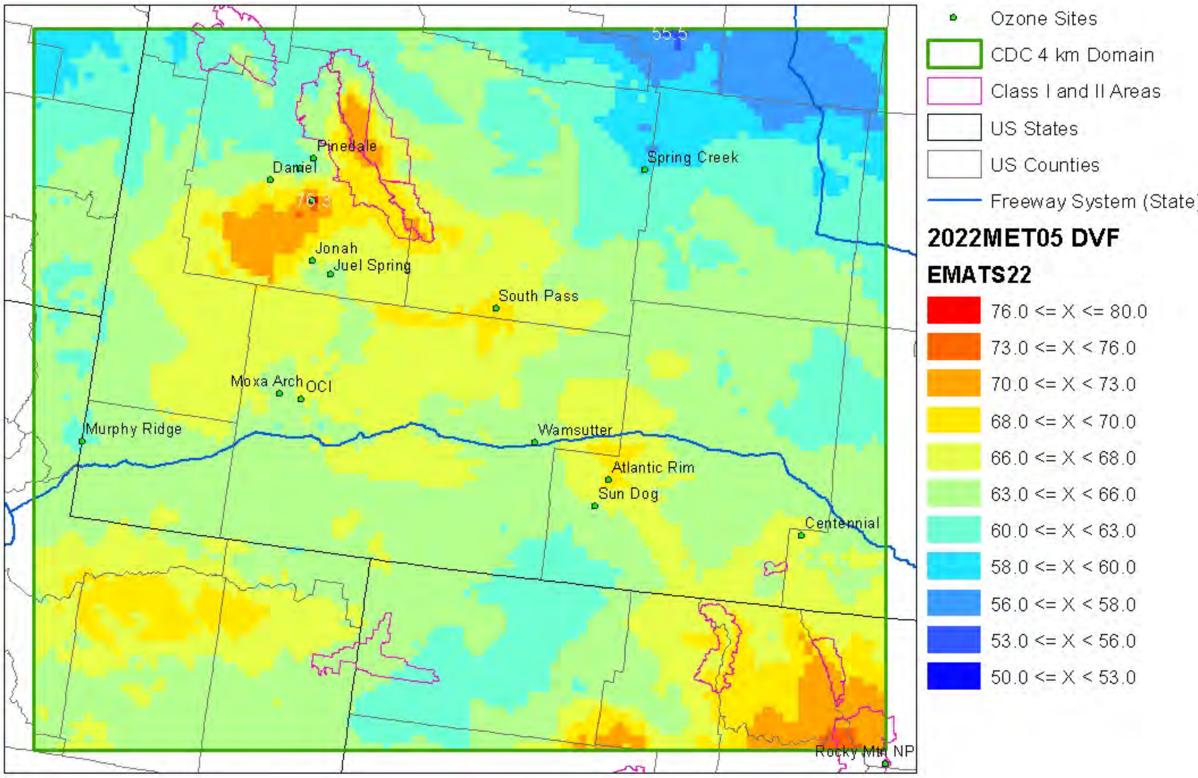

Figure 4-28. Unmonitored area analysis. 2022 Proposed Action Alternative ozone DVF for 2005 meteorology (ppb).

The spatial pattern of the projected 2022 ozone Design Values using the 2005 meteorology is similar to 2008, with the 75 ppb ozone NAAQS exceeded only near Boulder in Sublette County (Figure 4-28). As in the 2008met05 scenario, DVFs in the vicinity of the CD-C Project are in the 60-69 ppb range

Figure 4-29 shows the difference (2022-2008) between current and future year design values using the 2005 meteorological conditions. Design values show a general decrease from 2008 to 2022 except near large EGUs such as Jim Bridger (Sweetwater County, WY) and Naughton (Lincoln County, WY), trona processing facilities in western Sweetwater County, and regions of oil and gas development. Increases in the 2022 Design Values relative to 2008 in the vicinity of the CD-C project are less than 0.5 ppb. Note that design value changes between 2008 and 2022 are due to changes in the regional emissions inventories (plus boundary conditions) as well as changes in emissions from the CD-C Project Area.

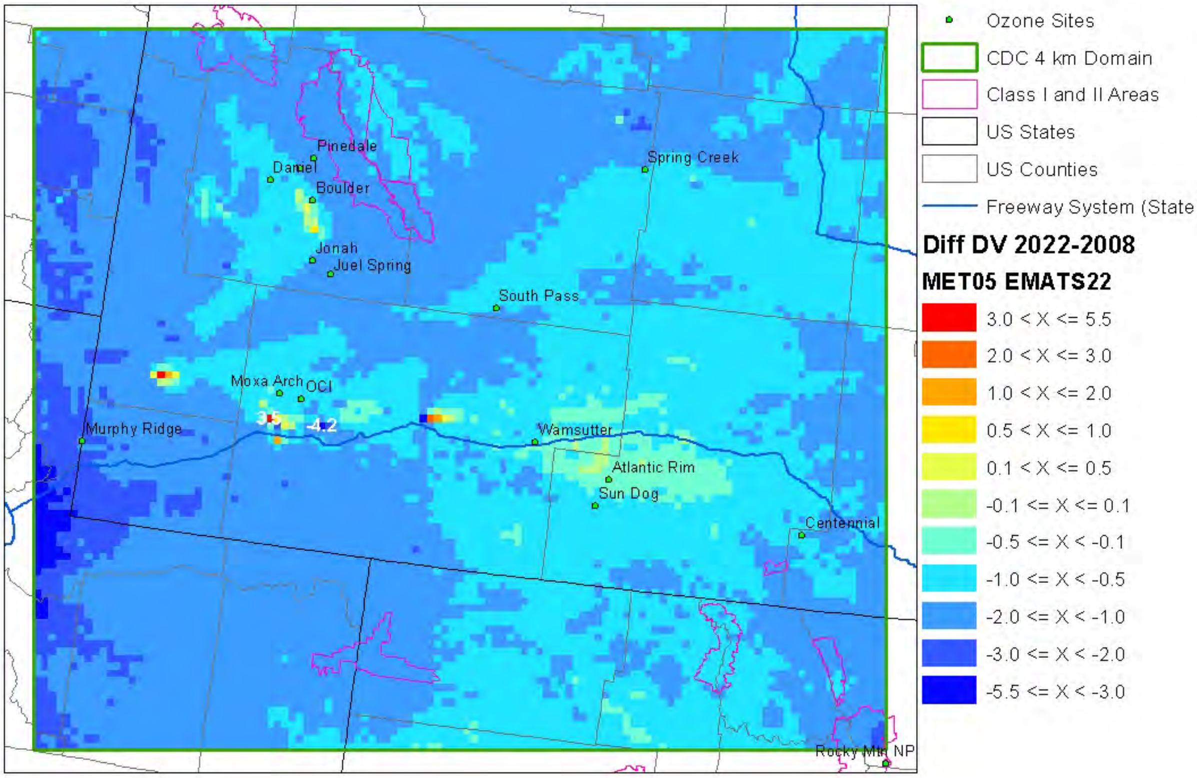

Figure 4-29. Unmonitored area analysis. Difference in Design Values: 2022 Proposed Action Alternative ozone DVF - 2008 ozone DVC, for the 2005 meteorological year (ppb).

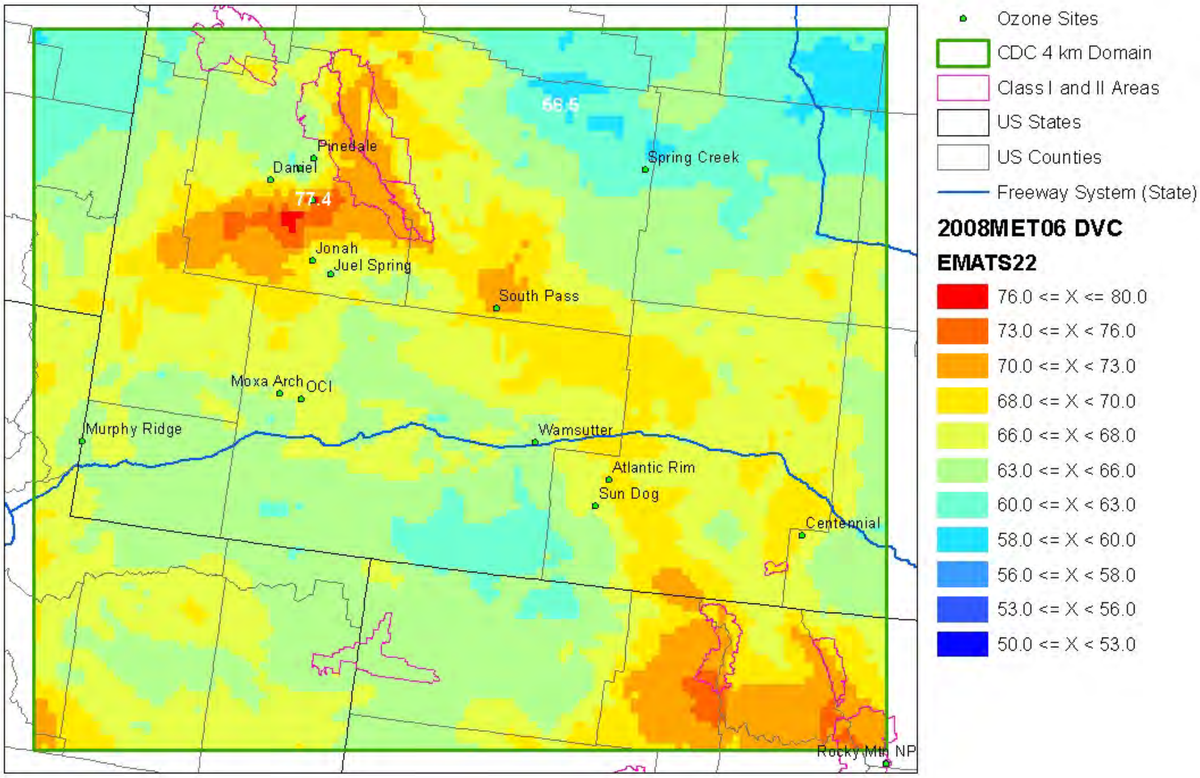

Figure 4-30. Unmonitored area analysis. 2008 ozone DVC for 2006 meteorology (ppb).

The DVC pattern using 2008 emissions and 2006 meteorology (Figure 4-30) is similar to that obtained with 2005 meteorology. The highest values of the DVC are found in Sublette and Fremont Counties in Wyoming and in the Denver metropolitan area. The only exceedance of 75 ppb NAAQS occurs in Sublette County near Boulder. As with 2005 meteorology, the lowest values of the DVC are found in southeastern Sweetwater County, northwestern Colorado and in the northeastern area of the 4 km domain.

2008 ozone DVC are generally higher in Sublette County with 2006 meteorology than with 2005 meteorology, and show more grid cells that exceed the 75 ppb NAAQS.

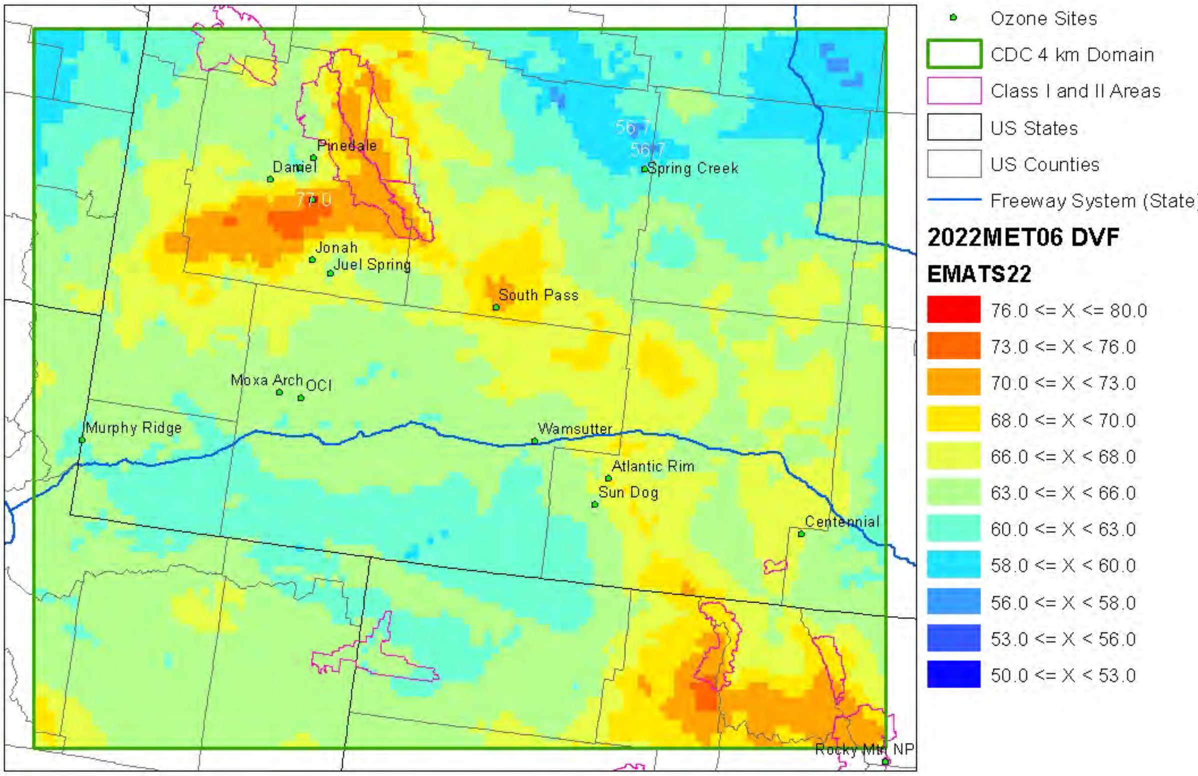

Figure 4-31. Unmonitored area analysis. 2022 Proposed Action Alternative ozone DVF for 2006 meteorology (ppb).

Similar to the 2005 meteorology case, the DVF with 2022 emissions and 2006 meteorology (Figure 4-31) have maxima in Sublette and Fremont Counties and near the Denver metropolitan area. The NAAQS are exceeded only near Boulder in Sublette County, and the DVF are in 60-69 ppb range in vicinity of CD-C Project. Ozone DVFs are higher in Sublette County using 2006 meteorology than with 2005 meteorology, but are generally lower in the CD-C Project area.

Figure 4-32 shows the difference (2022-2008) between current and future year design values for 2006 meteorology. Comparison of Figures 4-29 and 4-32 shows that the difference patterns for DVF(2022)-DVC(2008) are similar for 2005 and 2006 meteorology, with ozone design values generally decreasing within the 4 km domain except near large EGUs, trona sources and the oil and gas production region in Sublette County. The 2005 meteorology case shows increases in ozone in the CD-C Project area, while the 2006 meteorology case shows decreases. Again, we note that changes in the DVs in Figures 4-29 and 4-32 are due to all emissions sources and boundary conditions in addition to changes in emissions from the CD-C project.

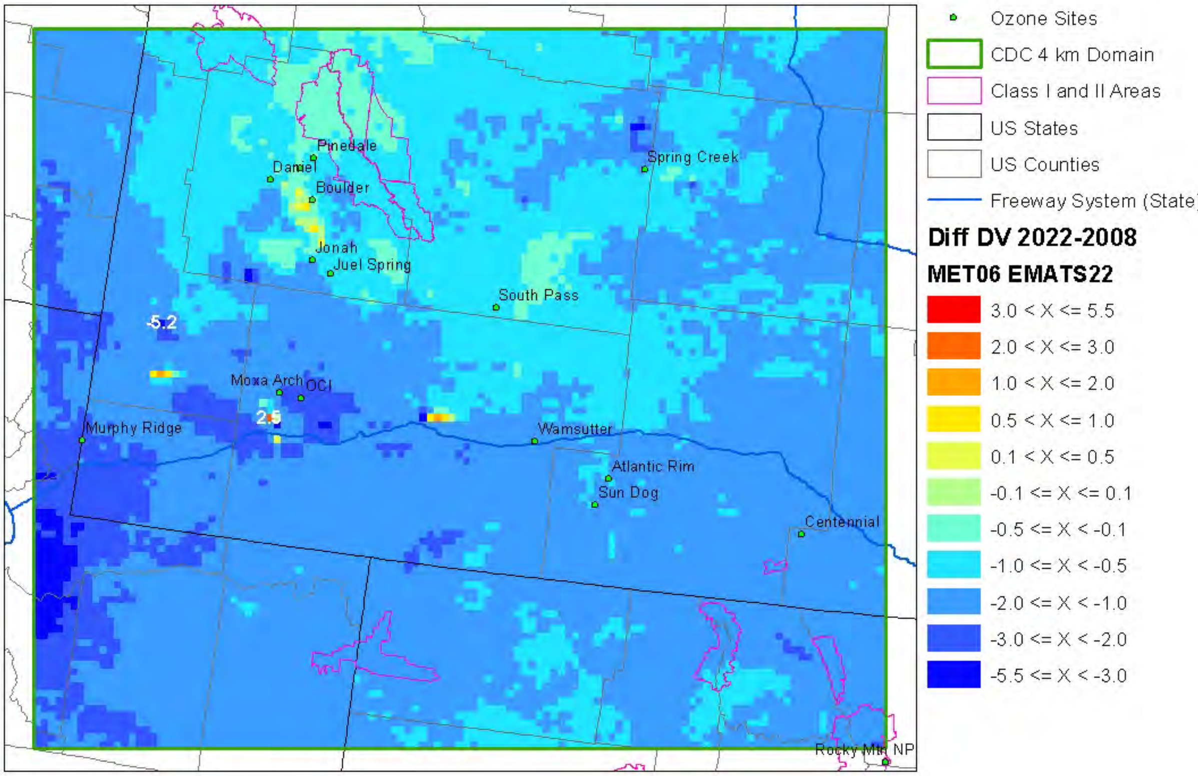

Figure 4-32. Unmonitored area analysis. Difference in Design Values: 2022 Proposed Action Alternative ozone DVF - 2008 ozone DVC, for the 2006 meteorological year (ppb).

CD-C Contribution to the MATS Design Values

The effect of CD-C Proposed Action Alternative and No Action Alternative emissions on ozone Design Values was assessed with EPA's MATS. The CD-C Project contribution to Design Values in all grid cells in the 4 km domain was isolated using the CAMx APCA source apportionment capability. MATS was run initially using the full CAMx 2022 run output that accounts for the effects of all emissions sources and boundary conditions as well as the CD-C Proposed Action Alternative emissions, results are shown in Figures 4-28 and Figures 4-31, for 2005 and 2006 meteorology, respectively. Next, the APCA contribution from the CD-C Proposed Action Alternative was subtracted from the full CAMx 2022 run output. MATS was then run a second time to produce a set of design values for DVF(Base - CD-C Proposed Action). The contribution from the CD-C Proposed Action Alternative was obtained by taking the difference:

DVF(CD-C Proposed Action) = DVF(Base) - DVF(Base - CD-C Proposed Action).

An analogous procedure was followed to get the contribution from the CD-C No Action Alternative.

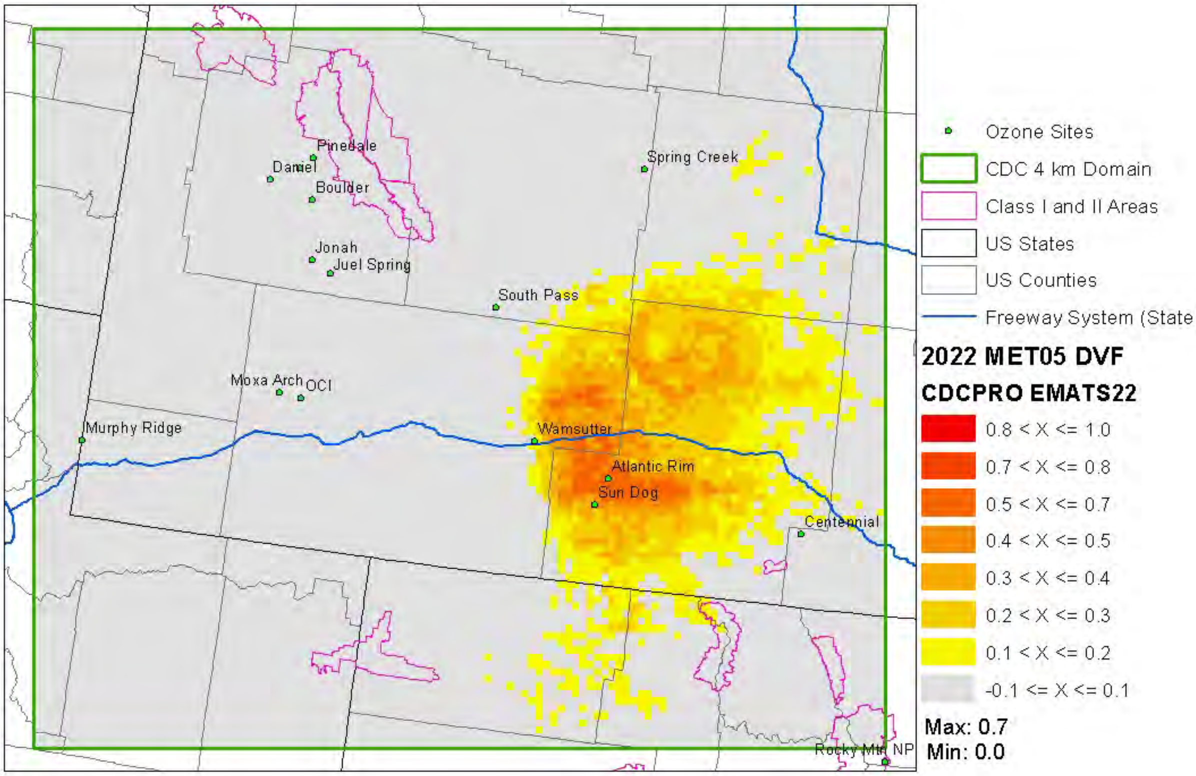

Figure 4-33. Impact of CD-C Proposed Action Project emissions on DVF: 2022met05.

The CD-C contributions for the 2022met05 and 2022met06 scenarios are shown in Figures 4-33 and 4-34, respectively. In both scenarios, the CD-C impacts are largest within and to the east of the CD-C Project Area, although the 2022met05 shows more ozone transport to the south and 2022met06 shows more transport to the northwest. The maximum CD-C Project impact on ozone DVFs is 0.8 ppb in 2022met06 and 0.7 ppb in 2022met05. In both the 2022met05 and the 2022met06 scenarios, CD-C Project impacts on DVFs in the proposed non-attainment areas in Sublette, Lincoln, and Sweetwater Counties in Wyoming are too small to be visible on this scale.

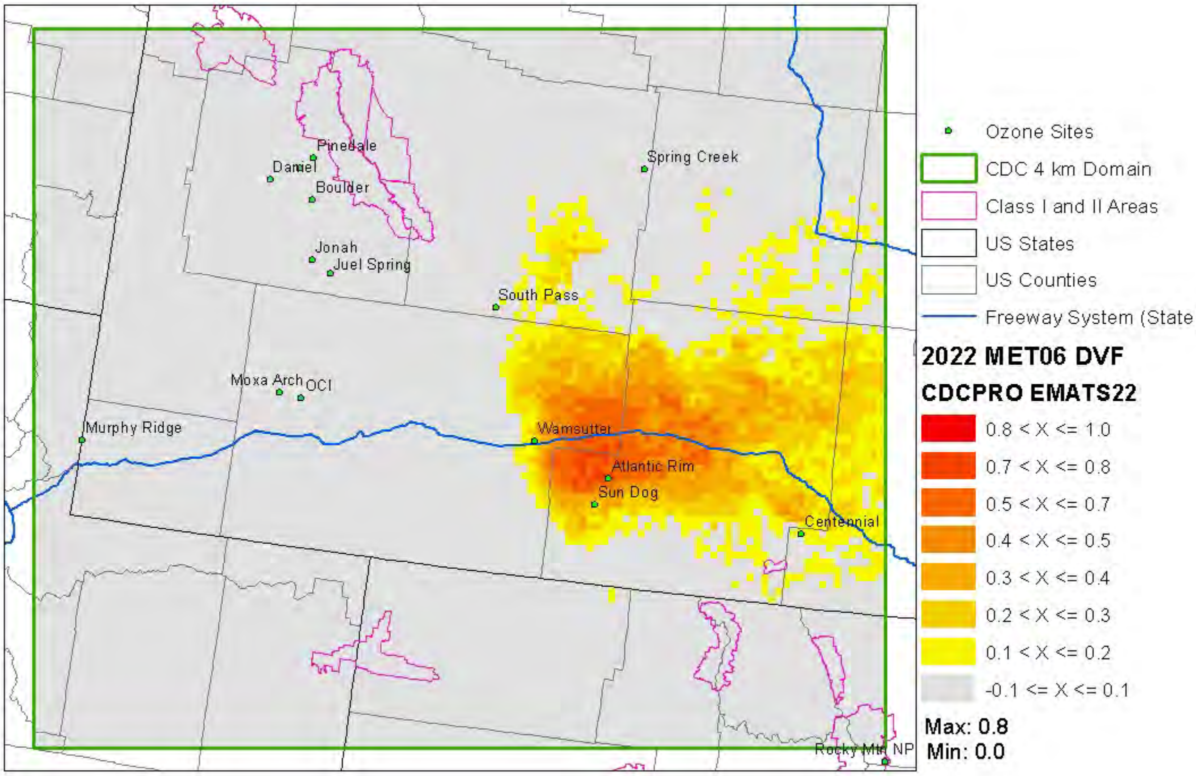

Figure 4-34. Impact of CD-C Proposed Action Project emissions on DVF: 2022met06.

Summary of MATS Results

The MATS results indicate that ozone DVs generally decrease within the 4 km domain in 2022 relative to 2008 except for increases near the Jim Bridger and Naughton EGUs, trona facilities in western Sweetwater County, and in regions where oil and gas development is occurring (e.g. Sublette County). The MATS results show that the 75 ppb ozone NAAQS is attained throughout the 4 km domain in 2022 except near Boulder in both meteorological years. The CAMx source apportionment capability was used to isolate the contribution of CD-C Proposed Action Alternative emissions to 2022 DVFs, and this was determined to be 0.8 ppb or less. CD-C Proposed Action Alternative impacts on DVFs were highest within and east (generally downwind) of the CD-C Project area. The CD-C Proposed Action Alternative emissions had no significant contributions to the projected 2022 ozone Design Values in the vicinity of the Boulder monitoring site.

4.5.4.4. Absolute Modeling Results

In the previous section, the modeled ozone results were used together with the EPA MATS tool to calculate current year (2008) and future year (2022) Design Values based on observed ozone at Southwest Wyoming monitors and modeled ozone fields. In this section, we present the absolute CAMx modeling results for 2008 and 2022. The 4th highest daily maximum 8-hour average ozone value (DM8) was computed for each grid cell from the CAMx runs for both the 2005 and 2006 meteorological years. Only modeled data from the Wyoming ozone season (April 1-October 31) were used in this calculation, per the WDEQ-AQD (see Section 1.2.2.1). This is consistent with the processing of the CAMx modeling results used in the MATS analysis.

The left hand panel of Figure 4-35 shows the 4th highest daily maximum 8-hour average results for the 2008 emissions scenario for the 2005 meteorological year. The middle panel shows the 2022 results for the 2005 meteorological year and the right hand panel shows the 2022-2008 difference in the 4th highest DM8.

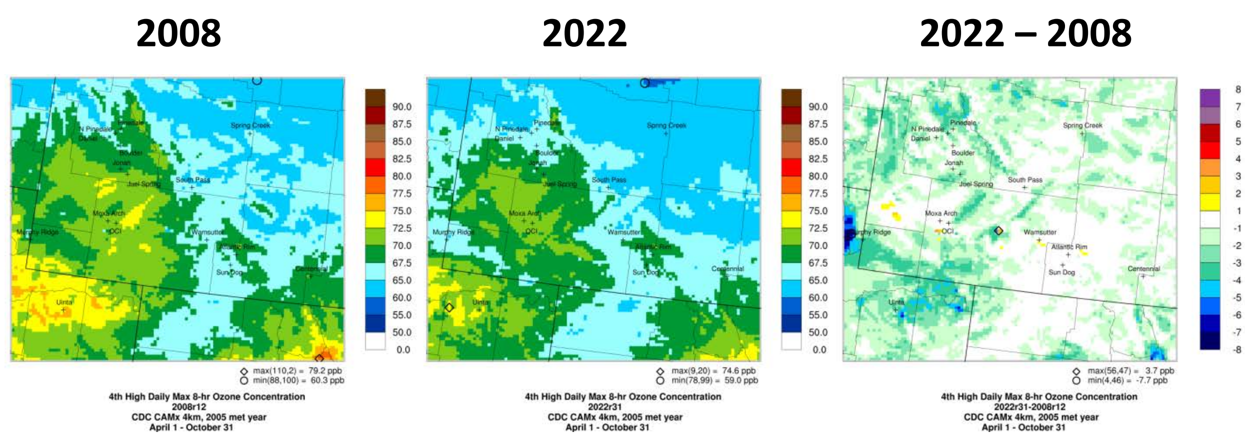

Figure 4-35. 4th highest daily maximum 8-hour average ozone: met05.

The 2008 4th highest DM8 results are similar in spatial pattern to the 2008 MATS DVC results shown in Figure 4-27 in that relatively high ozone values are shown in the Denver metropolitan area and over the high terrain of the Uinta Mountains in northeastern Utah. Values for 2008 in Sublette County are higher in the MATS analysis because the Design Values include values from the full year, while the absolute model results only draw from the April 1-October 31, 2005 period. The high ozone DVC in Sublette County is driven by winter ozone events. In both the MATS and absolute modeling results for 4th high DM8, ozone is lower in the northeastern region of the 4 km domain and in the rural area south of the CD-C Project Area. In 2008, the 4th high DM8 results show exceedances of the 75 ppb ozone NAAQS only near the Denver metropolitan area and east of Salt Lake City. There are no exceedances of the NAAQS in 2022 within the 4 km domain.

The 4th high DM8 ozone difference plot in Figure 4-35 shows many areas of decreasing ozone in the 4 km grid in 2022 relative to 2008. The largest ozone increases occur near EGUs and the Sweetwater County trona facilities. There are areas of 1-1.5 ppb increase near CD-C Project Area (see Figure 4-36 for expanded view of the 2022-2008 difference in the CD-C Project Area).

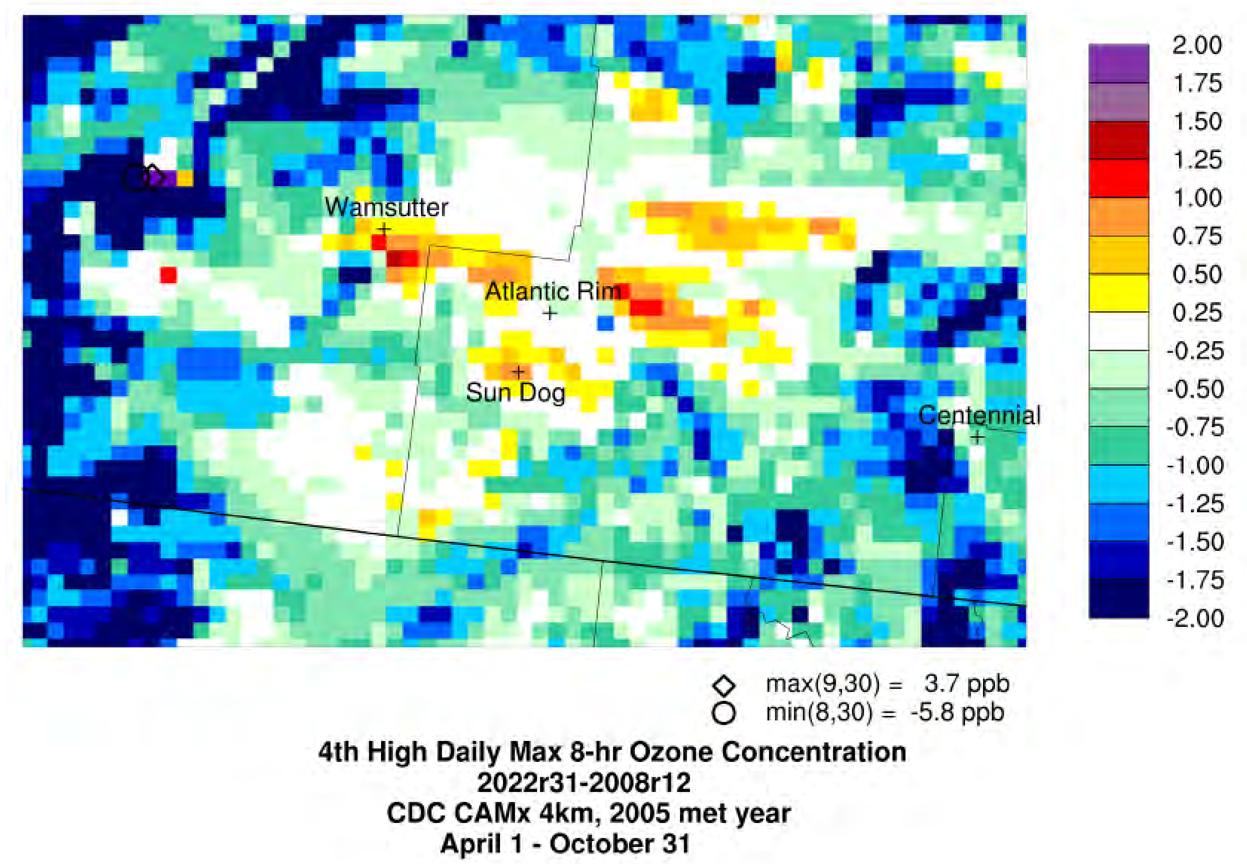

Figure 4-36. 4th high daily maximum 8-hour average ozone: met05 (ppb). CD-C Project Area.

Absolute modeling results for the 4th highest DM8 for the 2022met06 scenario are presented in Figure 4-37. For both the 2008 and 2022 emissions scenarios, modeled ozone is generally higher in the 4 km domain using 2006 meteorology than with 2005 meteorology. With 2006 meteorology, much of the 4 km domain has 4th High DM8 greater than 67.5 ppb in both 2008 and 2022, while with 2005 meteorology, much of the northeastern part of the domain has values <67.5 ppb. In particular, in Sublette and Fremont Counties ozone is generally higher with 2006 meteorology than with 2005 meteorology, and the 75 ppb NAAQS is exceeded across broad areas of both Sublette and Fremont Counties.

The 2022-2008 difference plot in the right hand panel of Figure 4-37 shows many areas in the 4 km grid where the 4th high DM8 decreases going from 2008 to 2022. There are both large increases and large decreases in the DM8 in the Jonah-Pinedale area of Sublette County. There are no increases >1.0 ppb in the CD-C Project Area or its vicinity using the 2006 meteorological year.

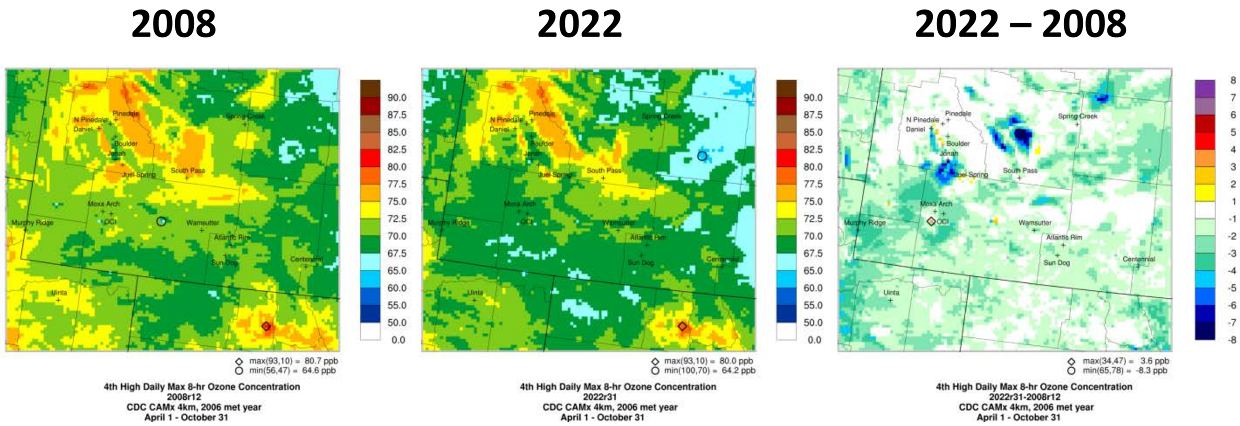

Figure 4-37. 4th highest daily maximum 8-hour average ozone: met06.

Figure 4-38 is similar to Figures 4-35 and 4-37, but shows the results of the average of the 2005 and 2006 meteorological year results. The 2005-2006 average is an approximation to a Design Value produced with the two available years of absolute modeling results, instead of three as required for a Design Value, and is compared with the MATS design values in Figures 4-27 through 4-32. The middle panel of Figure 4-38 shows that the 75 ppb NAAQS is not exceeded anywhere in the 4 km domain in 2022 using the absolute modeling results. There are no increases in the 2-year average 4th high DM8 in the in CD-C Project area >0.5 ppb.

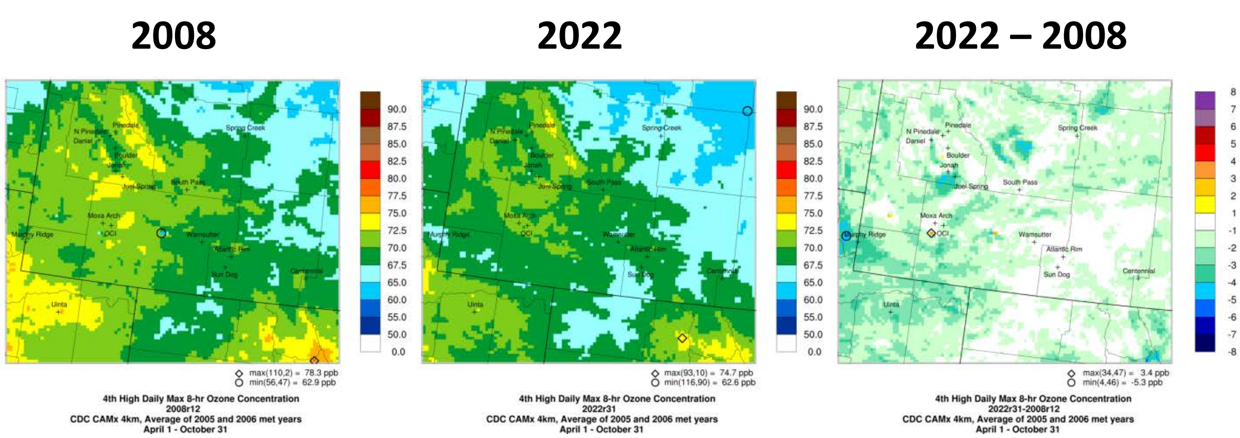

Figure 4-38. 4th highest daily maximum 8-hour average ozone: average of met05 and met06.

4.5.4.5 Impact of the CD-C Project Proposed Action on Southwest Wyoming 8-Hour Ozone

The CAMx absolute modeled concentrations can be used to determine the impact of CD-C Proposed Action emissions to 4th high DM8 ozone on days with high observed and/or modeled ozone.

The APCA source apportionment tool can isolate the contribution of the CD-C Project Alternative emissions to total ozone at each grid cell and time step. To assess the CD-C Project Alternatives' impact on the 4th high DM8, we calculate the 4th high DM8 at each grid cell using the APCA ozone contributions from 2 different sets of emissions. First, we calculate the 4th high DM8 using the ozone contribution from all emissions sources including the CD-C Project Alternative emissions. Next, we calculate the 4th high DM8 using the ozone contribution from the total emissions minus the CD-C Project emissions as quantified by the APCA source apportionment tool. The first calculation represents the CAMx-predicted 4th high DM8 for the emissions scenario including development of the proposed CD-C Project, and the second calculation represents the CAMx-predicted 4th high DM8 assuming no development of the CD-C Project Alternatives. The difference between scenario 1 and 2 gives the impact of the CD-C Project Alternatives on the 4th high DM8 over the modeling domain.

CD-C Project Impact on 4th high DM8 ozone =

4th High DM8 of (All Emis) – 4th High DM8 of (All Emis – CD-C Project Emis)

Note that this impact is different from the CD-C contribution to the total emissions DM8 on the day of the 4th high DM8 of the total emissions, and it better reflects the impact the CD-C Project would have on ozone Design Values. It is different because the 2 different scenarios, in general, experience the 4th high DM8 on different days throughout the modeling year. In most cases, the difference method (defined above) gives a similar or smaller impact for the CD-C Project than the contribution of the CD-C Project to DM8 on the day of the 4th highest DM8.

CD-C Proposed Action Alternative impacts on the DM8 throughout the 4 km domain are shown in Figures 4-39 and 4-40 for the 2022met05 and 2022met06 scenarios, respectively. In the 2022met05 scenario (Figure 4-39), the highest Proposed Action Alternative impacts are 1.7 ppb in the vicinity of the CD-C Project Area. CD-C Project impacts are largest in the vicinity of the Project Area and downwind (east). While there are some areas of impacts in the 0.25-0.75 ppb range in Fremont County, impacts in Sublette, western Sweetwater and Lincoln Counties are <0.1 ppb (not shown).

The 2022met06 results (Figure 4-40) show that CD-C Proposed Action Alternative impacts reach a maximum of 2.3 ppb in the vicinity of the CD-C Project Area. Impacts are more strongly focused to the east of the Project Area than in the 2022met05 case, although there is an area of impacts in Fremont County that occurs due to an isolated northerly transport event (see Appendix I). As with 2005 meteorology, CD-C Proposed Action Alternative impacts on the 4th highest DM8 are <0.02 ppb in Sublette, northwestern Sweetwater and Lincoln Counties.

The two year average of the Proposed Action Alternative impacts for 2022met05 and 2022met06 is shown in Figure 4-41. The maximum impact of the CD-C Proposed Action Alternative is 1.7 ppb and the impacts are highest in the vicinity of the Project area and to its east. CD-C Proposed Action Alternative impacts on the 4th highest DM8 are <0.04 ppb in Sublette, northwestern Sweetwater and Lincoln Counties.

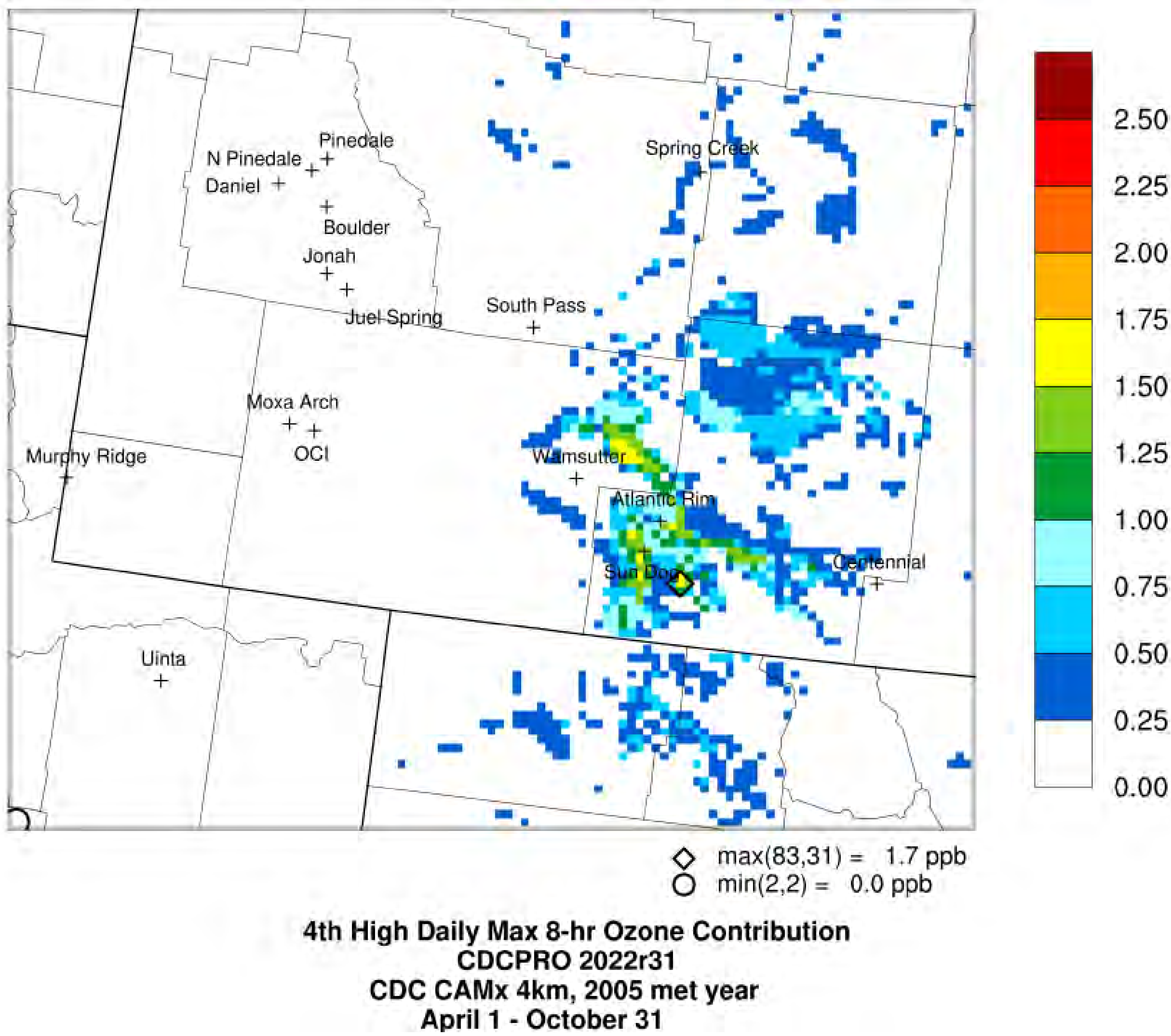

Figure 4-39. Impact of CD-C Proposed Action Alternative emissions on the 4th highest daily maximum 8-hour average ozone: 2022met05.

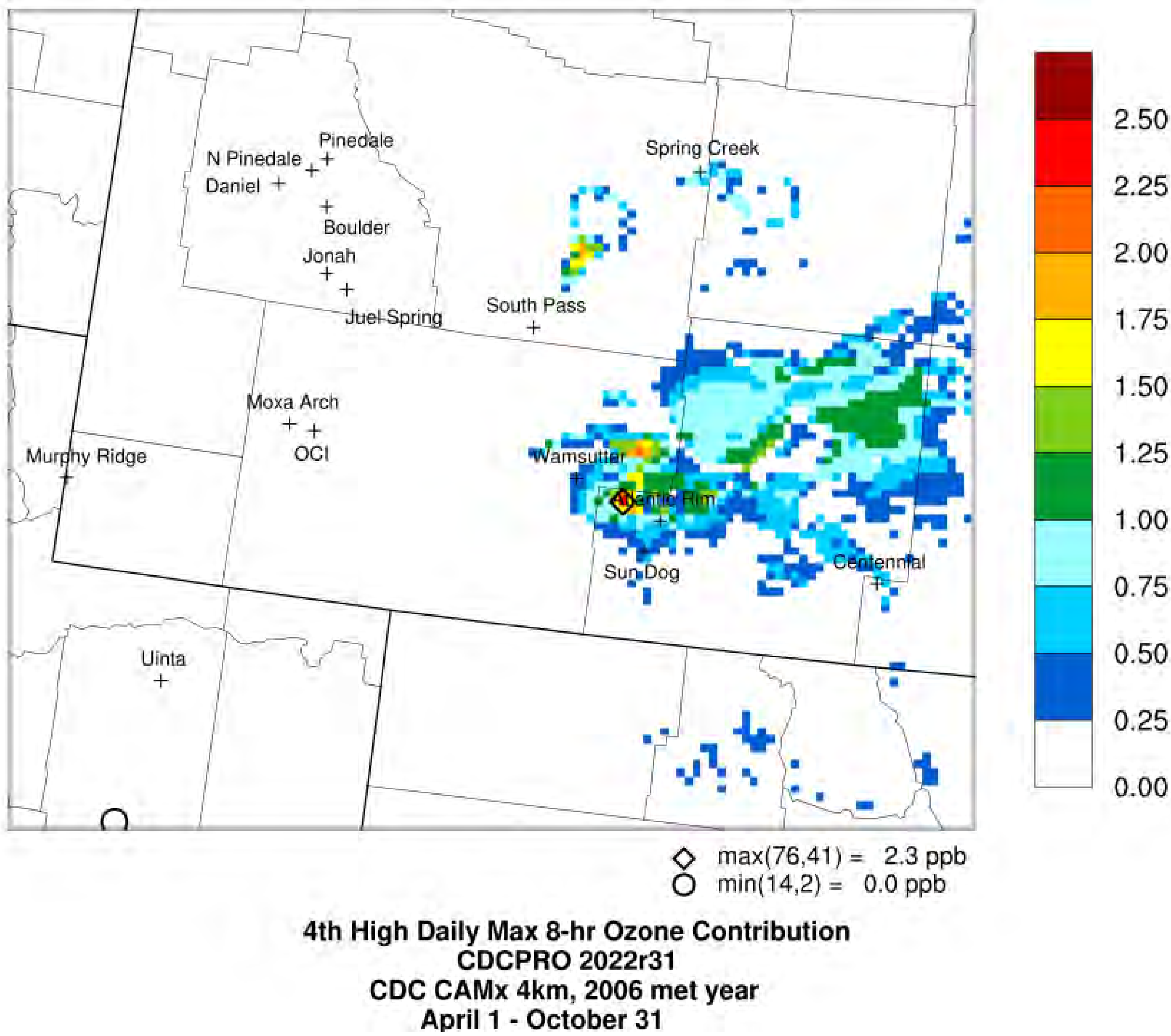

Figure 4-40. Impact of CD-C Proposed Action emissions on the 4th highest daily maximum 8-hour average ozone: 2022met06.

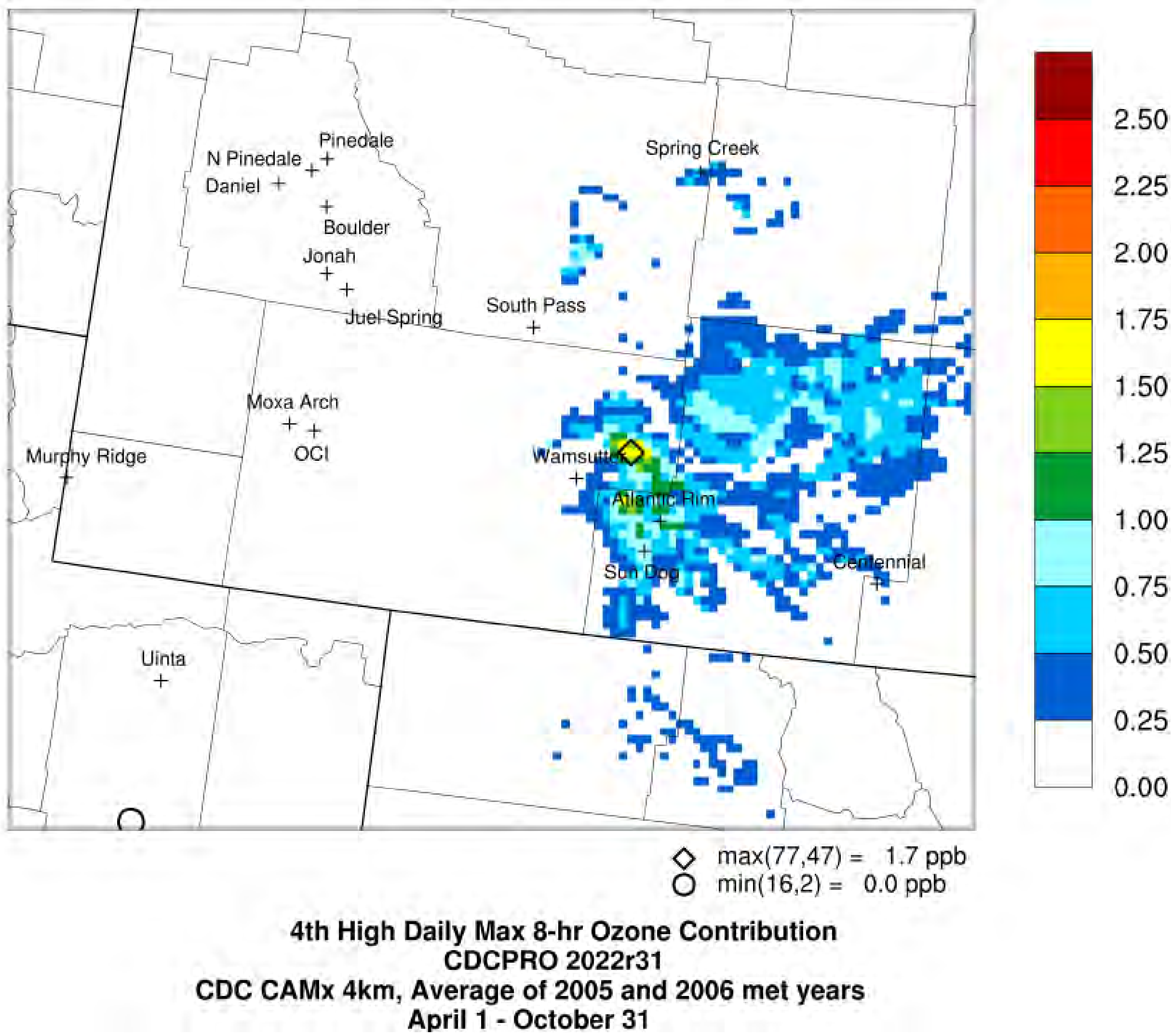

Figure 4-41. Impact of CD-C Proposed Action emissions on the 4th highest daily maximum 8-hour average ozone: Two year average 2022met05 and 2022met06.

The No Action Alternative impacts on the 4th high DM8 are shown in Figures 4-42 and 4-43, for 2005 meteorology and 2006 meteorology, respectively. Impacts show a similar spatial pattern to the Proposed Action Alternative but have smaller magnitude, with highest met05 impact of 1.1 ppb and highest met06 impact of 1.2. Figure 4-44 shows the average of the 2005 meteorology and 2006 meteorology results and approximates the form of the NAAQS as a two year average instead of a three year average for the No Action Alternative emissions; highest impacts are 0.8 ppb.

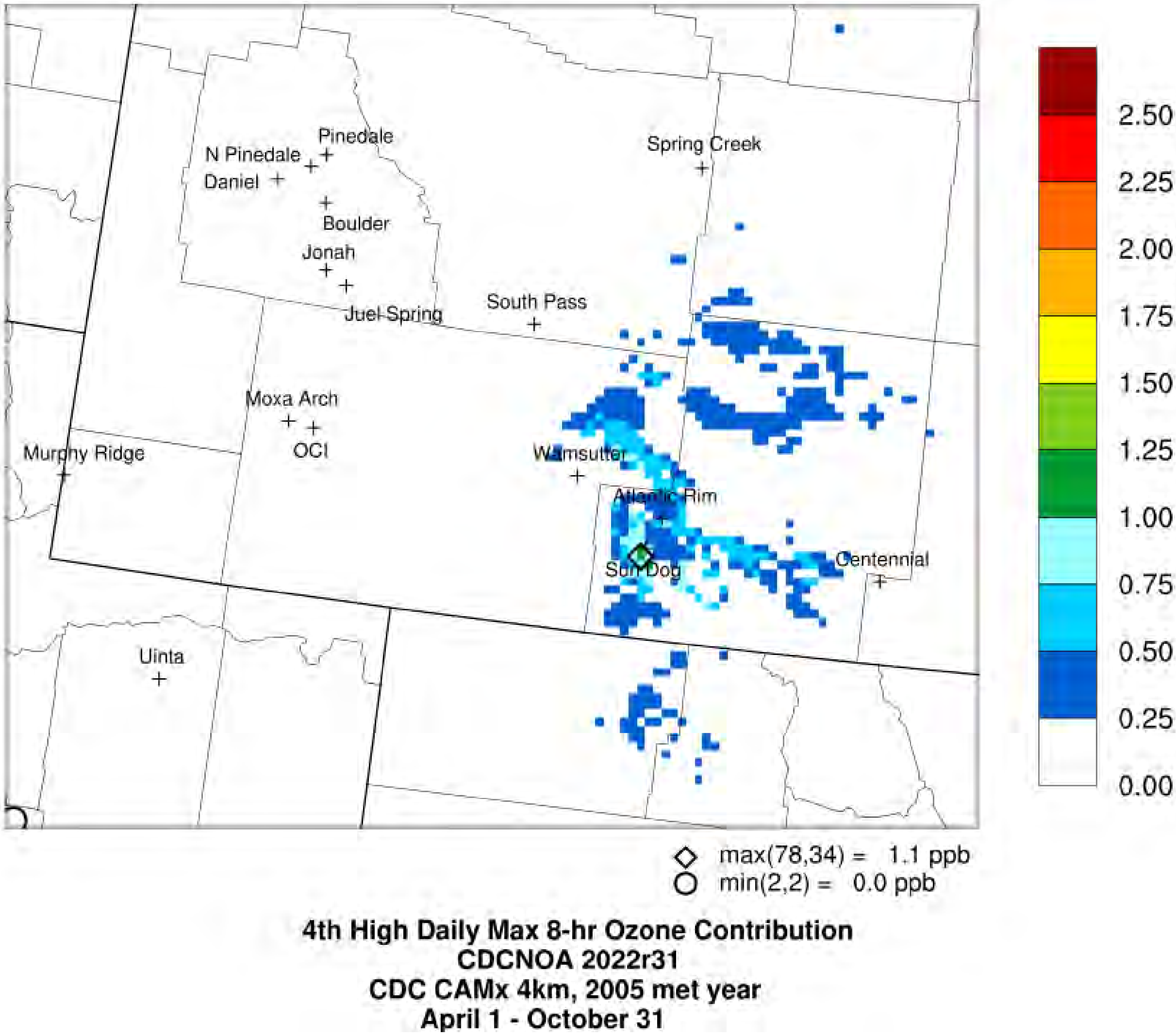

Figure 4-42. Impact of CD-C No Action Alternative emissions on the 4th highest daily maximum 8-hour average ozone: 2022met05.

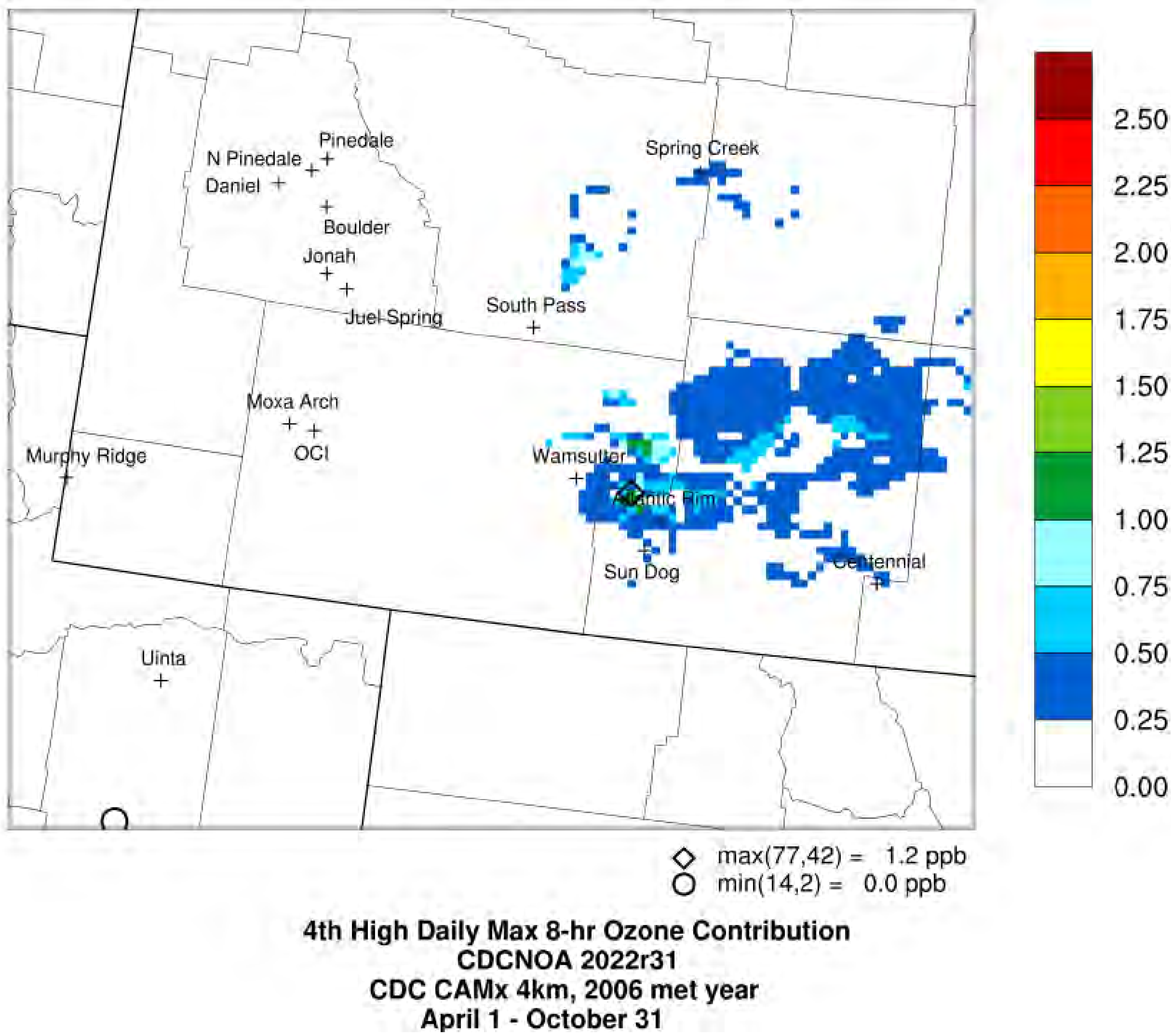

Figure 4-43. Impact of CD-C No Action Alternative emissions on the 4th highest daily maximum 8-hour average ozone: 2022met06.

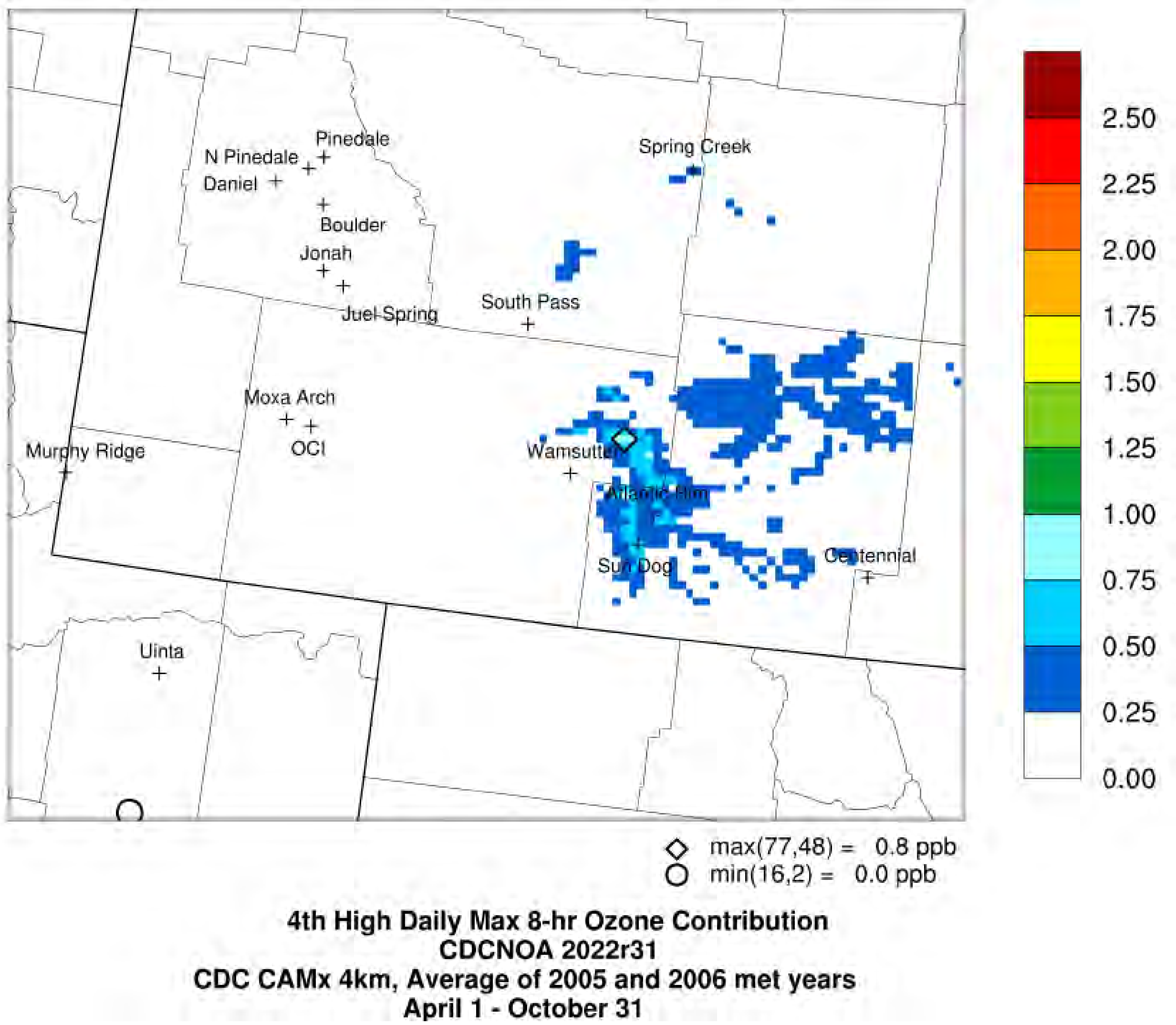

Figure 4-44. Impact of CD-C No Action Alternative emissions on the 4th highest daily maximum 8-hour average ozone: 2022met06

Contribution of CD-C Project Emissions to High Ozone Days in Southwest Wyoming

We now seek to understand whether the peak CD-C Project ozone impacts come during periods of high regional ozone. To address this issue, we examine times when the contribution of the CD-C Project Alternative emissions to the DM8 is ≥1 ppb, and determine the magnitude of the total DM8 at that time/location. We also assess the ozone impacts of the CD-C Project Alternative emissions when the observed and/or modeled DM8 is high at a monitor; we define DM8>75 ppb to be the threshold for high ozone.

Figure 4-45 shows the contribution of the CD-C Proposed Action Alternative emissions to the DM8 at all ozone monitors within the 4 km domain. Each point represents one day at one monitor. The plot shows all monitors and all days from April 1-October 31 for the 2022met05 and 2022met06 simulations. Figure 4-42 indicates that the CD-C Proposed Action does not contribute ≥0.5 ppb to the DM8 when DM8 >75 ppb at any monitor in the 4 km domain. The CD-C contribution is at its maximum when the DM8<60 ppb. Similarly, Figure 4-46 shows the contribution of the CD-C No Action Alternative emissions to the DM8 at all ozone monitors within the 4km domain, the distribution of impacts is similar to that of the Proposed Action Alternative, but the impacts are smaller.

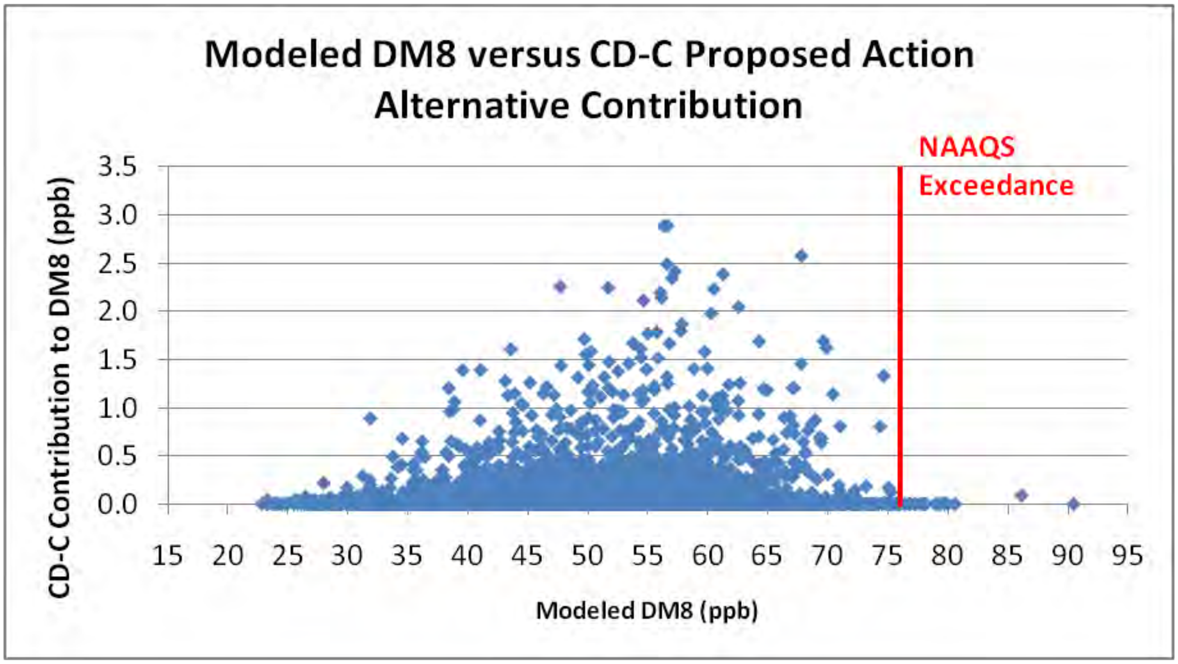

Figure 4-45. Contribution of CD-C Proposed Action Alternative emissions to modeled daily max 8-hour ozone at Southwest Wyoming monitors.

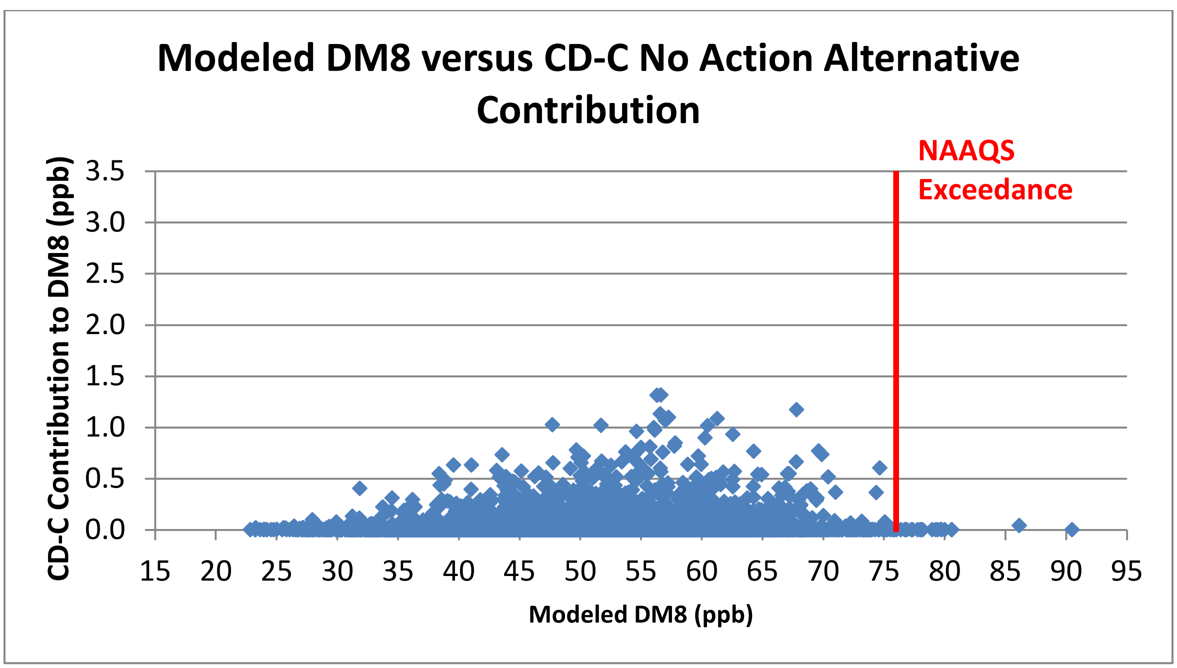

Figure 4-46. Contribution of CD-C No Action Alternative emissions to modeled daily max 8-hour ozone at Southwest Wyoming monitors.

Table 4-14 lists the days during 2005 and 2006 when a monitor within the 4 km domain had an observed value of the DM8>75 ppb. For each of these days, the modeled contribution of the CD-C Proposed Action Alternative and No Action Alternative emissions is shown as an absolute value and as a percentage of the observed DM8 at that monitor. During the 2 year 2005-2006 period, only the Boulder, Pinedale and Centennial monitors had measured ambient DM8 over 75 ppb during the April 1-October 31 ozone season. None of these monitors is in the immediate vicinity of the CD-C Project Area, and Boulder and Pinedale are typically upwind of the CD-C Project Area given the prevailing westerly winds. On high ozone days at these monitors, the CD-C Proposed Action Alternative and No Action Alternative emissions contribute less than 0.01 ppb (<0.02%) to the modeled DM8 ozone.

Table 4-14. CD-C Proposed Action Alternative and No Action Alternative emission impacts on days with high observed daily max 8-hour ozone (days with observed DM8>75 ppb).

Year	Site ID	Site Name	Date	Observed Daily Max 8-hr Ozone (ppb)	Modeled Daily Max 8-hr Ozone (ppb)	CD-C Proposed Action Contribution (ppb)	CD-C Proposed Action Contribution (% of Modeled DM8)	CD-C No Action Contribution (ppb)	CD-C No Action Contribution (% of Modeled DM8)
2005	CNT169	Centennial	5/11/2005	88	55	0.0059	0.0108	0.0027	0.0049
2005	PND165	Pinedale	6/27/2005	76	65	0.0000	0.0000	0.0000	0.0000
2006	56_035_0099	Boulder	4/21/2006	80	66	0.0001	0.0001	0.0000	0.0001
2006	56_035_0099	Boulder	6/18/2006	79	60	0.0000	0.0000	0.0000	0.0000
2006	PND165	Pinedale	4/21/2006	80	65	0.0001	0.0001	0.0000	0.0001

In Table 4-15, the CD-C Proposed Action Alternative and No Action Alternative contributions to the DM8 on days with high modeled ozone (DM8>75 ppb) is shown in terms of its absolute magnitude and the percentage of the modeled DM8 at the monitor. Table 4-15 indicates that modeled ozone was higher at the Southwest Wyoming monitors using 2006 meteorology than 2005 meteorology (consistent with the absolute modeling results shown in Figures 4-35 and 4-37). The CD-C Proposed Action Alternative emissions contributed 0.09 ppb or less (0.1% or less) to monitors with high modeled ozone while the CD-C No Action Alternative emissions contributed 0.05 ppb or less (0.05% or less).

Except for Wamsutter, monitors with high modeled ozone are distant from and generally upwind of the CD-C Project Area.

Table 4-15. CD-C Proposed Action emission impacts on days with high observed daily max 8-hour ozone (days with modeled DM8>75 ppb).

Year	Site ID	Site Name	Date	Observed Daily Max 8-hr Ozone (ppb)	Modeled Daily Max 8-hr Ozone (ppb)	CD-C Proposed Action Contribution (ppb)	CD-C Proposed Action Contribution (% of Modeled DM8)	CD-C No Action Contribution (ppb)	CD-C No Action Contribution (% of Modeled DM8)
2005	UIN162	Uinta	6/27/2005	--	76	0.0000	0.0000	0.0000	0.0000
2005	UIN162	Uinta	8/30/2005	--	77	0.0000	0.0000	0.0000	0.0000
2005	56_041_0101	Murphy Ridge	6/26/2005	--	76	0.0000	0.0000	0.0000	0.0000
2006	UIN162	Uinta	6/14/2006	--	77	0.0000	0.0000	0.0000	0.0000
2006	56_041_0101	Murphy Ridge	8/19/2006	--	76	0.0001	0.0001	0.0000	0.0000
2006	56_037_0200	Wamsutter	8/14/2006	55	86	0.0900	0.1047	0.0409	0.0475
2006	56_013_0099	South Pass	8/14/2006	--	79	0.0007	0.0008	0.0003	0.0004
2006	56_013_0099	South Pass	8/15/2006	--	79	0.0075	0.0095	0.0034	0.0043
2006	56_035_1002	Juel Spring	8/14/2006	--	79	0.0012	0.0015	0.0005	0.0007
2006	56_035_1002	Juel Spring	8/18/2006	--	78	0.0000	0.0000	0.0000	0.0000
2006	56_035_0098	Jonah	8/14/2006	61	76	0.0012	0.0016	0.0006	0.0007
2006	56_035_0098	Jonah	8/18/2006	67	78	0.0000	0.0000	0.0000	0.0000
2006	56_035_0099	Boulder	8/14/2006	63	77	0.0002	0.0003	0.0001	0.0001
2006	56_035_0099	Boulder	8/18/2006	71	90	0.0000	0.0000	0.0000	0.0000
2006	56_035_0100	Daniel	8/18/2006	67	79	0.0000	0.0000	0.0000	0.0000
2006	56_035_0100	Daniel	8/19/2006	64	76	0.0015	0.0020	0.0007	0.0009
2006	56_035_0101	Pinedale North	8/14/2006	--	78	0.0002	0.0002	0.0001	0.0001
2006	56_035_0101	Pinedale North	8/18/2006	--	80	0.0000	0.0000	0.0000	0.0000
2006	PND165	Pinedale	8/14/2006	61	80	0.0002	0.0002	0.0001	0.0001
2006	PND165	Pinedale	8/18/2006	67	80	0.0000	0.0000	0.0000	0.0000
2006	PND165	Pinedale	8/19/2006	65	77	0.0003	0.0003	0.0001	0.0002

Table 4-16a. Number of Days with CD-C Proposed Action Contribution to the daily maximum 8-hour average ozone > 1 ppb.

Monitor	2005				2006			
	Number of Days >= 1ppb	Max CD-C Proposed Action Contribution (ppb)	Max CD-C Proposed Action Contribution (% DM8)	Max Modeled DM8 on those Days	Number of Days >= 1ppb	Max CD-C Proposed Action Contribution (ppb)	Max CD-C Proposed Action Contribution (% DM8)	Max Modeled DM8 on those Days
Rio Blanco0006	0	--	--	--	0	--	--	--
Uintah2003	0	--	--	--	0	--	--	--
Uintah2002	0	--	--	--	0	--	--	--
Uintah1002	0	--	--	--	0	--	--	--
Uinta	0	--	--	--	0	--	--	--
Centennial	0	--	--	--	1	1.2	1.8	64
Sun Dog	15	2.9	5.1	67	23	2.4	4.7	70
Atlantic Rim	17	2.9	5.1	69	20	2.5	4.4	69
Murphy Ridge	0	--	--	--	0	--	--	--
Wamsutter	3	2.4	4.2	57	10	2.1	3.8	74
Moxa Arch	0	--	--	--	0	--	--	--
OCI	0	--	--	--	0	--	--	--
South Pass	0	--	--	--	1	1.1	2.6	43
Juel Spring	0	--	--	--	0	--	--	--
Jonah	0	--	--	--	0	--	--	--
Boulder	0	--	--	--	0	--	--	--
Daniel	0	--	--	--	0	--	--	--
Pinedale North	0	--	--	--	0	--	--	--
Spring Creek	0	--	--	--	0	--	--	--
Pinedale	0	--	--	--	0	--	--	--

Tables 4-16a and 4-16b show the number of days at each monitor in the 4 km domain when the CD-C Proposed Action Alternative and No Action Alternative contributions to the DM8 at that monitor was greater than 1 ppb, respectively. The results in these tables indicate that the maximum CD-C Proposed Action Alternative and No Action Alternative ozone contributions generally come on days when regional ozone is low at those monitors.

Table 4-16b. Number of Days with CD-C No Action Contribution to the daily maximum 8-hour average ozone > 1 ppb.

Monitor	2005				2006			
	Number of Days >= 1ppb	Max CD-C No Action Contribution (ppb)	Max CD-C No Action Contribution (% DM8)	Max Modeled DM8 on those Days	Number of Days >= 1ppb	Max CD-C No Action Contribution (ppb)	Max CD-C No Action Contribution (% DM8)	Max Modeled DM8 on those Days
Rio Blanco0006	0	--	--	--	0	--	--	--
Uintah2003	0	--	--	--	0	--	--	--
Uintah2002	0	--	--	--	0	--	--	--
Uintah1002	0	--	--	--	0	--	--	--
Uinta	0	--	--	--	0	--	--	--
Centennial	0	--	--	--	0	--	--	--
Sun Dog	2	1.3	2.3	67	2	1.1	2.2	61
Atlantic Rim	1	1.3	2.3	56	4	1.1	2.0	60
Murphy Ridge	0	--	--	--	0	--	--	--
Wamsutter	1	1.1	1.9	57	0	--	--	--
Moxa Arch	0	--	--	--	0	--	--	--
OCI	0	--	--	--	0	--	--	--
South Pass	0	--	--	--	0	--	--	--
Juel Spring	0	--	--	--	0	--	--	--
Jonah	0	--	--	--	0	--	--	--
Boulder	0	--	--	--	0	--	--	--
Daniel	0	--	--	--	0	--	--	--
Pinedale North	0	--	--	--	0	--	--	--
Spring Creek	0	--	--	--	0	--	--	--
Pinedale	0	--	--	--	0	--	--	--

Summary of Ozone Modeling Results

The MATS results indicate that the 75 ppb NAAQS are attained throughout the 4 km domain except near Boulder in both the 2022met05 and 2022met06 simulations. The maximum impact of the CD-C Proposed Action Alternative (8950 new wells) on 2022 DVFs is less than or equal to 0.8 ppb for both 2005 and 2006 meteorological years. The 2-year average of absolute model that approximates a Design Value using 2 years of available modeled concentrations shows attainment of the 75 ppb NAAQS throughout the 4 km domain in 2022. In addition, absolute model results for the 2-year average also estimate the maximum value of the contribution to the modeled 4th high DM8 from the CD-C Proposed Action to be 1.7 ppb and to occur in the vicinity of the CD-C Project Area. The CD-C Proposed Action Alternative ozone impact is <0.04 ppb in Sublette and Lincoln Counties. We note that the MATS method is designed to produce results less influenced by model biases than absolute model concentration results, and may be more reliable than the absolute model concentrations in determining future year ozone and Project impacts.

4.5.5. Summary of Criteria Pollutant Modeling Results

Table 4-17 summarizes the results of the comparison of CAPs concentrations within the 4 km modeling domain to the NAAQS, CAAQS, and WAAQS, refer back to Table 4-5 for details on particular forms of the averages. Exceedances of ambient air quality standards are noted for 8-hour CO, 8-hour ozone, 24-hour PM_{10}, and 1-hour SO_2.

For all pollutants except ozone, the modeling results show attainment throughout the 4 km domain except in the immediate vicinity of point sources unrelated to the CD-C Project. Exceedances of the CO, and PM_{10} standards are the result of impacts from 2005 fire in Lincoln County, and the SO_2 exceedances are highly localized and due to emissions from a Fremont County source and a source in western Sweetwater County. The ozone exceedance occurs at Boulder, WY, where CD-C has no significant contribution to ozone concentrations. Examination of the spatial extent and magnitude of the CD-C Proposed Action Alternative and No Action Alternative contributions to criteria pollutant concentrations within the 4 km grid shows that none of the exceedances of the ambient air quality standards in the 2022 future year modeling have significant contributions from emissions from the CD-C Project Alternatives.

Table 4-17. Comparison of modeled concentrations within the 4 km grid in the 2022 future year simulation with ambient air quality standards. Red shading indicates that the ambient air quality standard was exceeded.

Pollutant/ Averaging Time	NAAQS	CAAQS	WAAQS	2022 CAMx All 4 km Grid Cells
CO ($\mu g\ m^{-3}$)				
1-hour	40,000	40,000	40,000	24,838
8-hour	10,000	10,000	10,000	18,949
NO_2 ($\mu g\ m^{-3}$)				
1-hour	188	188	188	123.3
Annual	100	100	100	32.2
O_3 (ppb)				
8-hour	75	84	84	75-77*
PM_{10} ($\mu g\ m^{-3}$)				
24-hour	150	150	150	458
Annual	--	--	50	27.6
PM_{25} ($\mu g\ m^{-3}$)				
24-hour	35	35	35	20.3
Annual	12	12	15	9.6
SO_2 ($\mu g\ m^{-3}$)				
1-hour	196	196	196	230
3-hour	1,300	700	1,300	216
24-hour	365	365	--	126
Annual	80	80	--	48.3

* For the ozone analysis, MATS results estimate 77 ppb and absolute model results predict 75 ppb. 75-77 ppb = 147-151 $\mu g\ m^{-3}$ at 25°C.

4.6 AIR QUALITY-RELATED VALUES

The results of the 2022 CAMx model simulations were evaluated to assess the AQ and AQRVs impacts of the peak year CD-C Project NO_X/VOC emissions and the cumulative impacts of the 2022 CD-C Proposed Action Alternative and No Action Alternative emissions each taken together with the impacts of all other 2022 regional emissions. In this Section, the CAMx-estimated AQRV impacts due to CD-C Project emissions sources at Class I and sensitive Class II areas and sensitive lakes are compared with visibility thresholds, deposition thresholds, and lake acid neutralizing capacity (ANC) thresholds.

The Class I areas and sensitive Class II areas analyzed are:

- Bridger Wilderness Area, Wyoming (Class I);
- Fitzpatrick Wilderness Area, Wyoming (Class I);
- Savage Run Wilderness Area, Wyoming (Federal Class II, Wyoming Class I)
- Mount Zirkel Wilderness Area, Colorado (Class I);
- Rawah Wilderness Area, Colorado (Class I);
- Rocky Mountain National Park, Colorado (Class I);
- Flat Tops Wilderness Area, Colorado (Class I);
- Eagles Nest Wilderness Area, Colorado (Class I);
- Popo Agie Wilderness Area , Wyoming (Class II);
- Gros Ventre Wilderness Area, Wyoming (Class II);
- Wind River Roadless Area, Wyoming (Class II); and
- Dinosaur National Monument, Colorado-Utah (Federal Class II, Colorado Class I (SO_2 only).

In addition, 19 lakes that are designated as acid sensitive and are located within the sensitive Class I and Class II Wilderness areas are assessed for potential changes in lake acid neutralizing capacity as a result of atmospheric acid deposition. These lakes are:

- Deep Lake in the Bridger Wilderness Area, Wyoming;
- Black Joe Lake in the Bridger Wilderness Area, Wyoming;
- Hobbs Lake in the Bridger Wilderness Area, Wyoming;
- Upper Frozen Lake in the Bridger Wilderness Area, Wyoming;
- Lazy Boy Lake in the Bridger Wilderness Area, Wyoming;
- Booth Lake in the Eagles Nest Wilderness Area, Colorado;
- Upper Willow Lake in the Eagles Nest Wilderness Area, Colorado;
- Ross Lake in the Fitzpatrick Wilderness Area, Wyoming;
- Ned Wilson Lake in the Flat Tops Wilderness Area, Colorado;
- Upper Ned Wilson Lake in the Flat Tops Wilderness Area, Colorado;
- Lower Packtrail Pothole in the Flat Tops Wilderness Area, Colorado;
- Upper Packtrail Pothole in the Flat Tops Wilderness Area, Colorado;
- Lower Saddlebag Lake in the Popo Agie Wilderness Area, Wyoming;

- Lake Elbert in the Mount Zirkel Wilderness Area, Colorado;
- Seven Lakes in the Mount Zirkel Wilderness Area, Colorado;
- Summit Lake in the Mount Zirkel Wilderness Area, Colorado;
- Kelly Lake in the Rawah Wilderness Area, Colorado;
- Island Lake in the Rawah Wilderness Area, Colorado; and
- Rawah Lake #4 in the Rawah Wilderness Area, Colorado.

The grid cells covering the Class I and sensitive Class II receptor areas are shown in Figure 4-47 below. In general, the maximum incremental concentration, deposition or visibility impact in any CAMx grid cell that intersects with the Class I or II receptor area of interest was used to represent the impact at that receptor area. The CAMx incremental concentration and deposition output was post-processed in order to:

- Analyze for visibility impacts and compare against visibility thresholds.
- Determine total nitrogen and sulfur deposition impacts and compare to deposition analysis thresholds.
- Analyze for changes in Acid Neutralizing Capacity (ANC) at sensitive lakes in the region.

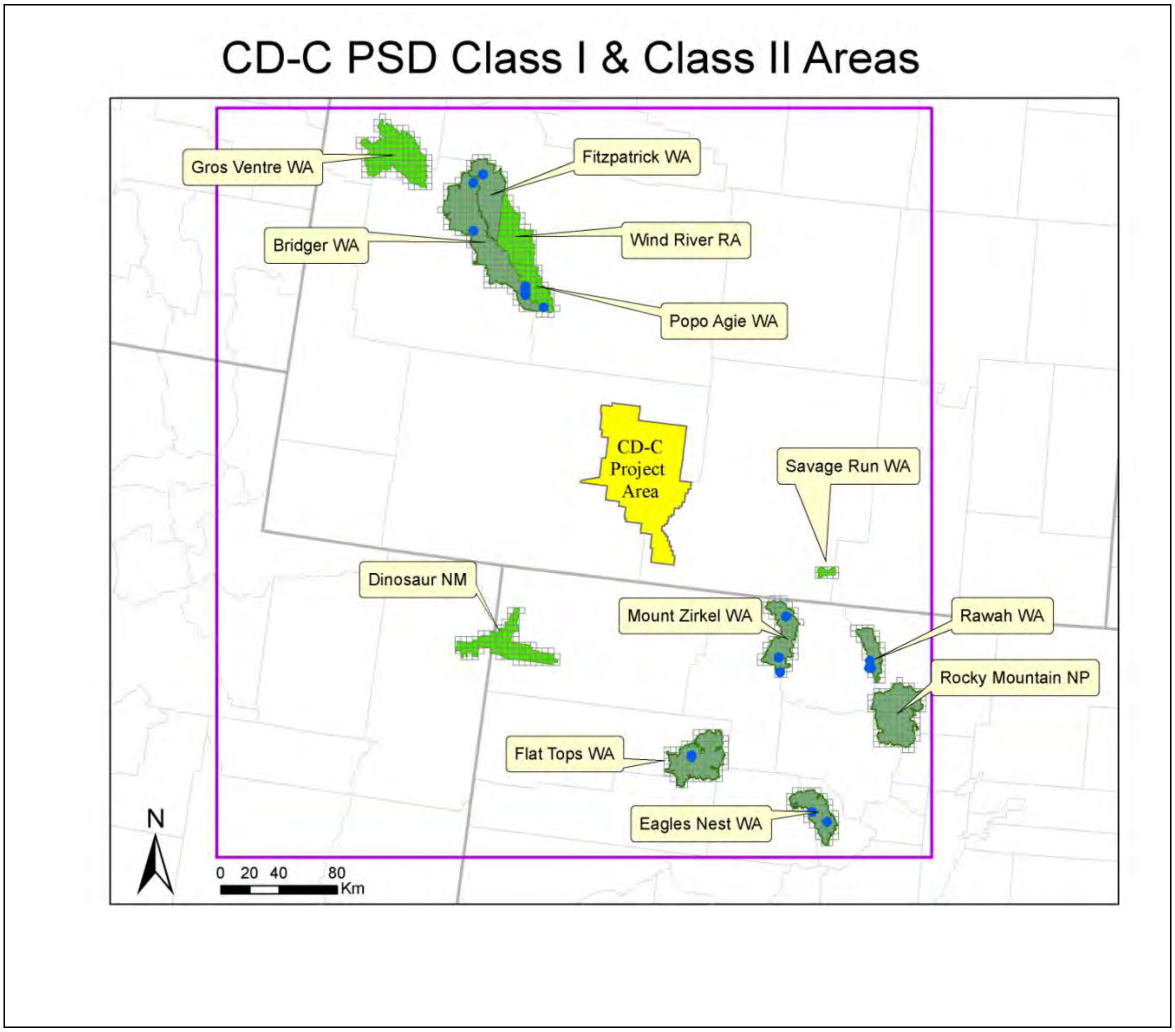

Figure 4-47. Locations of CAMx grid cells that contain Class I and sensitive Class II receptors. Blue circles indicate the locations of sensitive lakes. The purple box shows the extent of the 12 km grid cells extracted in order to perform the impact analysis for Class I/II areas outside the 4 km domain.

4.6.1 Visibility

4.6.1.1 Overview of Approach

Visibility impacts were calculated for CD-C Proposed Action Alternative emissions sources and for CD-C No Action Alternative emissions sources. The assessment of potential visibility impacts due to CD-C Project emission sources is based on the incremental concentrations as quantified by the CAMx PSAT tool. The changes in light extinction from CAMx PSAT incremental concentrations were calculated for each day and on all grid cells that intersect Class I and sensitive Class II areas within the 4 km modeling domain (Figure 4-43).

The visibility evaluation metric used in this analysis is 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. b_{ext} is related to the visual range (VR) measured in km, by the formula VR = 3912 / $b_{ext.}$ The Haze Index is the visibility metric that is used in the EPA's Regional Haze Rule, and is designed so that equal deciview changes correspond to approximately equal changes in perceived haze over the full range of visibility conditions, from pristine to highly impaired.

To evaluate increased haze due to a project's emissions compared to background conditions, incremental project concentrations are added to background concentrations in the extinction equation (b_{ext}) and the difference between the Haze Index with added project concentrations and the Haze Index based solely on background concentrations is calculated. This quantity is the change in Haze Index, that we refer to as "delta deciview" (Δdv) :

$$\Delta dv = 10 \times \ln[b_{ext(Project+background)}/10] - 10 \times \ln[b_{ext(background)}/10]$$

$$\Delta dv = 10 \times \ln[b_{ext(Project+background)}/b_{ext(background)}]$$

Here $b_{ext(project+background)}$ refers to atmospheric light extinction due to project plus background concentrations, and $b_{ext(background)}$ refers to atmospheric light extinction due to background concentrations only.

Estimated visibility degradation at the Class I and sensitive Class II areas is presented in terms of the number of days that exceed a threshold change in (Δdv), relative to background conditions. Although procedures and thresholds have not been established for sensitive Class II areas, BLM is including these areas in its visibility analysis. In the next section we describe the method for calculating the extinction, b_{ext}.

4.6.1.2 Revised IMPROVE Equation for Evaluating Light Extinction

The FLAG procedure for evaluating visibility impacts at Class I areas uses the revised IMPROVE reconstructed mass extinction equation to convert PM species in µg m^{-3} to light extinction (b_{ext}) in inverse megameters (Mm^{-1}) as follows:

$$b_{ext} = b_{SO4} + b_{NO3} + b_{EC} + b_{OCM} + b_{Soil} + b_{CM} + b_{SeaSalt} + b_{Rayleigh} + b_{NO2}$$

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 and nitrate aerosols are hygroscopic and are more effective at scattering radiation at higher relative humidities. 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 reports 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 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 µg/m3:

$$[\text{Large Sulfate}] = ([\text{Total Sulfate}] / 20\ \mu g/m3) \times [\text{Total Sulfate}]$$

For Total Sulfate ≥ 20 µg/m3:

[Large Sulfate] = [Total Sulfate]

For all values of Total Sulfate:

[Small Sulfate] = [Total Sulfate] – [Large Sulfate]

The procedure is identical for nitrate and organic mass.

Sulfate, nitrate and organic mass concentrations for a single oil and gas development project are expected to be relatively small (<< 20 µg/m3), so most of the mass for each species will be found in the small size regime.

4.6.1.3. CAMx Species Used in Visibility Analysis

Table 4-18 gives the species mapping between the species used in the CAMx APCA and PSAT ozone and PM source apportionment probing tools and those in the IMPROVE reconstructed mass extinction equation given above. The IMPROVE equation assumes that sufficient ammonium is present to completely neutralize sulfate and nitrate. This means that if a quantity of sulfate (SO_4) is present in a grid cell, we assume there is enough ammonium present to completely convert the sulfate to ammonium sulfate ($[NH_4]_2SO_4$) so that the visibility impairment due to ammonium is assigned to the SO_4. The ratio of the molecular weights of SO_4 to $[NH_4]_2SO_4$ is 1.375, so the sulfate concentration output of CAMx must be scaled by 1.375 to produce the sulfate input to the IMPROVE equation in the visibility impact assessment. A similar procedure is performed for nitrate, in which NO_3 is assumed to be neutralized to ammonium nitrate (NH_4NO_3), and the CAMx nitrate (NO_3) concentration is scaled by the factor 1.290 prior to use in the IMPROVE equation. Although CAMx explicitly models ammonium (NH_4), the CAMx estimated NH_4 concentration is not considered in the visibility impact analysis. This may overstate the visibility degradation because sulfate is not always completely neutralized by ammonium.

The NO_2 concentration is approximated by using the CAMx NO_X species in the ozone source apportionment APCA tool. This is a conservative assumption equivalent to saying that all NO_X is composed entirely of NO_2 for the purposes of the visibility calculation. 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 domain does not compromise the accuracy of the analysis as IMPROVE measurements show that sea salt concentrations are extremely small in this inland area and there would be no sea salt associated with the CD-C Project emissions.

Table 4-18. Mappings of species from the CAMx source apportionment to the IMPROVE visibility equation.

IMPROVE Component	Name	CAMx Species
$[SO_4]$ (as $[NH_4]_2SO_4$)	Sulfate (as $[NH_4]_2SO_4$)	PS4*1.375
$[NO_3]$ (as NH_4NO_3)	Nitrate (as NH_4NO_3)	PN3*1.290
[EC]	Elemental Carbon	PEC
[OCM]	Organic Mass	POA
[Soil]	Fine Soil	PFC+PFN
[CM]	Coarse Mass	PCC+PCS
$[NO_2]$	Nitrogen Dioxide	NOX
Sea Salt	Sea Salt	None

4.6.1.4. CD-C Project-Specific Visibility Impact Analysis

Incremental daily average modeled concentrations due to CD-C Proposed Action Alternative emissions sources and CD-C No Action Alternative emissions sources on all grid cells covering the Class I and sensitive Class II areas were processed using the revised IMPROVE reconstructed mass extinction equation and the Haze index equation to estimate visibility impacts at each Class I and sensitive Class II area.

The methodology follows recommendations in the Federal Land Managers' Air Quality Related Values Work Group (FLAG) Phase I Report – Revised 2010, hereafter referred to as FLAG 2010. Incremental changes in Haze Index (Δdv) are compared to 0.5 dv and 1.0 dv thresholds. A 1.0 dv change in Haze Index corresponds to a change in visibility impairment that is just perceptible to the human eye.

FLAG 2010 Screening Method for Visibility Impact Analysis

The FLAG Screening Method uses the revised IMPROVE equation together with annual average natural conditions (Table 6; FLAG, 2010) and monthly relative humidity factors for each Class I area (Tables 7-9; FLAG, 2010). The FLAG 2010 approach for visibility is summarized in Table 4-19. The Δdv was calculated for each grid cell that overlaps a Class I/II area and for each day of each annual CAMx run and the highest Δdv across all grid cells overlapping a Class I/II area was selected to represent the daily value at that area. The number of days in each annual run for CD-C Project emissions sources with Δdv values greater than 0.5 dv and 1.0 dv, and the maximum and 98th percentile (8^{th} highest day) Δdv values are reported.

Table 4-19. Summary of FLAG (2010) method for assessing project-specific visibility impacts.

Method	Background Data	Relative Humidity Factor f(RH)	Calculation Method for bext	Delta Deciview Calculation
FLAG 2010	Annual Average	Monthly	Revised IMPROVE Equation	$\Delta dv = 10 x \ln[b_{ext(project+background)}/b_{ext(background)}]$

Results of Project-Specific Visibility Impact Analysis

The tables in this section summarize Project-specific visibility impacts at Class I and sensitive Class II areas within the 4 km domain using 2005 and 2006 meteorology and 2022 Project emissions. For each of the meteorological years, and both the Proposed Action Alternative and the No Action Alternative, two tables are presented, with the 5 left-most columns in the two tables being identical. The remaining columns differ in the presentation of the components of the extinction; these data are located under the green bar. f(RH) and extinction components shown in Tables 4-20, 4-22, 4-24 and 4-28 refer to the 98th percentile (8th high) value of b_{ext}, while those in Tables 4-21, 4-23, 4-25, and 4-27 refer to the maximum (highest) value of b_{ext}.

F(RH)_l is the relative humidity factor for large particles and f(RH)_s is the relative humidity for small particles. These factors vary by month and by Class I and sensitive Class II area. b_src refers to the calculated light extinction attributable to the CD-C Project emissions. Back_bext refers to the background extinction at the class I or sensitive Class II area on that particular day. b_so4 and b_no3 are the components of the CD-C Project light extinction attributable to ammonium sulfate, and ammonium nitrate, respectively. b_other is the CD-C Project light extinction attributable to all the other contributing species combined, except the Rayleigh scattering term. b_so4, b_no3 and b_other sum to b_src, although small discrepancies can occur due to numerical rounding.

Tables 4-20 and 4-21 summarize the results of the Proposed Action Alternative using 2005 meteorology. Mount Zirkel WA, Savage Run WA and Dinosaur NM are the only areas with visibility impacts due to the CD-C Proposed Action Alternative emissions sources that are >0.5 dv. There are a total of 7 days >0.5 dv at these areas. There are no days with visibility impacts >1.0 dv due to the CD-C Proposed Action Alternative emissions sources at any Class I or sensitive Class II area. The largest visibility impacts occurred on winter days. Inspection of the components of the extinction shows that nitrate extinction was larger than that of sulfate for all areas. This is reasonable considering that CD-C Project NO_X emissions are much larger than its SO_2 emissions, due to the fact that the reservoirs to be accessed do not contain sour gas.

Table 4-20. 2022met05 CD-C Proposed Action visibility impacts using FLAG (2010) screening method. Data reported under green bar refer to the 98th percentile b_{ext}.

CDC Proposed Action Alternative												
Class I or Class	#days > 1.0	#days > 0.5	Max Δdv	98th Δdv	day	frh_l	frh_s	b_src	back_bext	b_so4	b_no3	b_other
					Refers to 98th percentile delta dv							
Bridger WA	0	0	0.160	0.024	1/4/2005	2.220	2.780	0.033	13.969	0.001	0.027	0.005
Fitzpatrick WA	0	0	0.146	0.015	5/15/2005	1.940	2.440	0.020	13.787	0.003	0.006	0.011
Mount Zirkel	0	1	0.632	0.190	3/21/2005	1.890	2.310	0.252	13.173	0.016	0.150	0.086
Rawah WA	0	0	0.222	0.108	2/27/2005	1.960	2.390	0.143	13.213	0.006	0.121	0.016
Dinosaur NM	0	5	0.675	0.325	2/23/2005	1.990	2.440	0.438	13.238	0.042	0.237	0.158
Popo Agie WA	0	0	0.174	0.022	5/15/2005	1.950	2.450	0.030	13.792	0.004	0.015	0.012
Savage Run WA	0	1	0.576	0.196	2/15/2005	1.990	2.440	0.262	13.238	0.012	0.185	0.065
Wind River RA	0	0	0.136	0.019	5/14/2005	1.950	2.450	0.027	13.792	0.002	0.019	0.006
Rocky Mountain	0	0	0.152	0.046	2/6/2005	1.850	2.240	0.067	14.310	0.001	0.060	0.005
Eagles Nest WA	0	0	0.204	0.047	11/27/2005	1.960	2.420	0.061	12.920	0.003	0.042	0.017
Flat Tops WA	0	0	0.181	0.091	10/23/2005	1.720	2.060	0.116	12.730	0.005	0.093	0.018
Gros Ventre WA	0	0	0.216	0.017	4/24/2005	1.950	2.430	0.023	13.783	0.001	0.018	0.004

Table 4-21. 2022met05 CD-C Proposed Action visibility impacts using FLAG (2010) screening method. Data reported under green bar refer to the maximum value of b_{ext}.

CDC Proposed Action Alternative												
Class I or Class	#days > 1.0	#days > 0.5	Max Δdv	98th Δdv	day	frh_l	frh_s	b_src	back_bext	b_so4	b_no3	b_other
					Refers to Maximum delta dv							
Bridger WA	0	0	0.160	0.024	2/7/2005	2.100	2.600	0.223	13.875	0.008	0.181	0.034
Fitzpatrick WA	0	0	0.146	0.015	12/18/2005	2.160	2.680	0.205	13.918	0.003	0.193	0.009
Mount Zirkel	0	1	0.632	0.190	11/19/2005	1.970	2.410	0.863	13.223	0.019	0.757	0.087
Rawah WA	0	0	0.222	0.108	11/20/2005	1.940	2.370	0.296	13.203	0.004	0.271	0.021
Dinosaur NM	0	5	0.675	0.325	12/18/2005	1.950	2.370	0.921	13.203	0.037	0.722	0.162
Popo Agie WA	0	0	0.174	0.022	2/7/2005	2.100	2.600	0.244	13.875	0.009	0.198	0.037
Savage Run WA	0	1	0.576	0.196	2/8/2005	1.990	2.440	0.785	13.238	0.033	0.604	0.148
Wind River RA	0	0	0.136	0.019	12/18/2005	2.160	2.680	0.190	13.918	0.002	0.180	0.008
Rocky Mountain	0	0	0.152	0.046	11/20/2005	1.840	2.230	0.219	14.310	0.003	0.202	0.014
Eagles Nest WA	0	0	0.204	0.047	11/20/2005	1.960	2.420	0.266	12.920	0.004	0.245	0.018
Flat Tops WA	0	0	0.181	0.091	11/19/2005	1.970	2.420	0.237	12.920	0.005	0.211	0.021
Gros Ventre WA	0	0	0.216	0.017	12/18/2005	2.160	2.680	0.304	13.918	0.004	0.285	0.014

Tables 4-22 and 4-23 show the Proposed Action Alternative visibility impacts for the 2022met06 simulation. There are fewer days exceeding the 0.5 dv threshold than in the 2022met05 scenario; there is only one day (at Dinosaur NM) with impacts >0.5 dv. There are no days over 1.0 dv. As for the 2022met05 scenario, nitrate impacts are larger than sulfate impacts.

Table 4-22. 2022met06 CD-C Proposed Action visibility impacts using FLAG (2010) screening method. Data reported under green bar refer to the 98th percentile b_{ext}.

CDC Proposed Action Alternative												
Class I or Class	#days > 1.0	#days > 0.5	Max Δdv	98th Δdv	day	frh_l	frh_s	b_src	back_bext	b_so4	b_no3	b_other
					Refers to 98th percentile delta dv							
Bridger WA	0	0	0.187	0.024	3/12/2006	2.040	2.550	0.034	13.847	0.002	0.023	0.008
Fitzpatrick WA	0	0	0.107	0.027	3/19/2006	2.040	2.540	0.037	13.842	0.001	0.033	0.003
Mount Zirkel	0	0	0.408	0.224	11/1/2006	1.970	2.410	0.299	13.223	0.012	0.222	0.065
Rawah WA	0	0	0.174	0.085	1/12/2006	1.910	2.310	0.112	13.173	0.005	0.080	0.027
Dinosaur NM	0	1	0.812	0.230	2/19/2006	1.990	2.440	0.307	13.238	0.011	0.258	0.038
Popo Agie WA	0	0	0.210	0.025	3/12/2006	2.040	2.550	0.034	13.847	0.002	0.025	0.007
Savage Run WA	0	0	0.266	0.190	12/23/2006	1.950	2.370	0.253	13.203	0.011	0.192	0.051
Wind River RA	0	0	0.095	0.036	3/3/2006	2.040	2.550	0.050	13.847	0.001	0.047	0.002
Rocky Mountain	0	0	0.091	0.059	12/25/2006	1.760	2.080	0.084	14.230	0.002	0.071	0.011
Eagles Nest WA	0	0	0.138	0.057	12/25/2006	1.970	2.420	0.074	12.920	0.002	0.061	0.011
Flat Tops WA	0	0	0.279	0.127	12/21/2006	2.030	2.510	0.165	12.960	0.012	0.108	0.045
Gros Ventre WA	0	0	0.112	0.026	4/8/2006	1.950	2.430	0.036	13.783	0.002	0.026	0.008

Table 4-23. 2022met06 CD-C Proposed Action visibility impacts using FLAG (2010) screening method. Data reported under green bar refer to the maximum value of b_{ext}.

CDC Proposed Action Alternative												
Class I or Class	#days > 1.0	#days > 0.5	Max Δdv	98th Δdv	day	frh_l	frh_s	b_src	back_bext	b_so4	b_no3	b_other
					Refers to Maximum delta dv							
Bridger WA	0	0	0.187	0.024	3/21/2006	2.040	2.550	0.262	13.847	0.012	0.195	0.055
Fitzpatrick WA	0	0	0.107	0.027	3/18/2006	2.040	2.540	0.149	13.842	0.005	0.127	0.017
Mount Zirkel	0	0	0.408	0.224	2/16/2006	1.990	2.440	0.551	13.238	0.019	0.420	0.112
Rawah WA	0	0	0.174	0.085	2/16/2006	1.960	2.390	0.232	13.213	0.008	0.186	0.038
Dinosaur NM	0	1	0.812	0.230	2/18/2006	1.990	2.440	1.120	13.238	0.043	0.877	0.201
Popo Agie WA	0	0	0.210	0.025	3/21/2006	2.040	2.550	0.294	13.847	0.013	0.224	0.057
Savage Run WA	0	0	0.266	0.190	2/3/2006	1.990	2.440	0.357	13.238	0.017	0.255	0.084
Wind River RA	0	0	0.095	0.036	3/11/2006	2.040	2.550	0.132	13.847	0.007	0.097	0.028
Rocky Mountain	0	0	0.091	0.059	1/16/2006	1.770	2.090	0.130	14.240	0.005	0.093	0.031
Eagles Nest WA	0	0	0.138	0.057	11/29/2006	1.960	2.420	0.180	12.920	0.005	0.153	0.021
Flat Tops WA	0	0	0.279	0.127	11/29/2006	1.970	2.420	0.365	12.920	0.015	0.267	0.084
Gros Ventre WA	0	0	0.112	0.026	2/18/2006	2.100	2.600	0.156	13.875	0.003	0.146	0.007

Tables 4-24 through 4-27 show the visibility impacts for 2005 and 2006 meteorology and 2022 CD-C No Action Alternative emissions source. There are no days with impacts over 0.5 dv at any of the Class I or sensitive Class II areas, for either meteorological year. As for the Proposed Action Alternative emissions sources, the largest impacts occur on winter days, nitrate extinction is larger than that of sulfate for all Class I/sensitive Class II Areas, and impacts are highest at Dinosaur NM.

Table 4-24. 2022met05 CD-C No Action visibility impacts using FLAG (2010) screening method. Data reported under green bar refer to the 98th percentile b_{ext}.

CDC No Action Alternative												
Class I or Class	#days > 1.0	#days > 0.5	Max Δdv	98th Δdv	day	frh_l	frh_s	b_src	back_bext	b_so4	b_no3	b_other
					Refers to 98th percentile delta dv							
Bridger WA	0	0	0.073	0.011	1/4/2005	2.220	2.780	0.015	13.969	0.001	0.012	0.002
Fitzpatrick WA	0	0	0.067	0.007	5/15/2005	1.940	2.440	0.009	13.787	0.002	0.003	0.005
Mount Zirkel	0	0	0.291	0.087	3/21/2005	1.890	2.310	0.114	13.173	0.007	0.068	0.039
Rawah WA	0	0	0.101	0.049	2/27/2005	1.960	2.390	0.065	13.213	0.003	0.055	0.007
Dinosaur NM	0	0	0.311	0.149	2/23/2005	1.990	2.440	0.199	13.238	0.019	0.108	0.072
Popo Agie WA	0	0	0.079	0.010	5/15/2005	1.950	2.450	0.014	13.792	0.002	0.007	0.005
Savage Run WA	0	0	0.265	0.090	2/15/2005	1.990	2.440	0.119	13.238	0.005	0.084	0.030
Wind River RA	0	0	0.062	0.009	5/14/2005	1.950	2.450	0.012	13.792	0.001	0.008	0.003
Rocky Mountain	0	0	0.069	0.021	2/6/2005	1.850	2.240	0.030	14.310	0.001	0.027	0.002
Eagles Nest WA	0	0	0.093	0.022	11/27/2005	1.960	2.420	0.028	12.920	0.001	0.019	0.008
Flat Tops WA	0	0	0.083	0.041	10/23/2005	1.720	2.060	0.053	12.730	0.002	0.042	0.008
Gros Ventre WA	0	0	0.099	0.008	4/24/2005	1.950	2.430	0.011	13.783	0.001	0.008	0.002

Table 4-25. 2022met05 CD-C No Action visibility impacts using FLAG (2010) screening method. Data reported under green bar refer to the maximum value of b_{ext}.

CDC No Action Alternative												
Class I or Class	#days > 1.0	#days > 0.5	Max Δdv	98th Δdv	day	frh_l	frh_s	b_src	back_bext	b_so4	b_no3	b_other
					Refers to Maximum delta dv							
Bridger WA	0	0	0.073	0.011	2/7/2005	2.100	2.600	0.101	13.875	0.004	0.082	0.015
Fitzpatrick WA	0	0	0.067	0.007	12/18/2005	2.160	2.680	0.093	13.918	0.001	0.088	0.004
Mount Zirkel	0	0	0.291	0.087	11/19/2005	1.970	2.410	0.391	13.223	0.009	0.343	0.039
Rawah WA	0	0	0.101	0.049	11/20/2005	1.940	2.370	0.134	13.203	0.002	0.123	0.009
Dinosaur NM	0	0	0.311	0.149	12/18/2005	1.950	2.370	0.418	13.203	0.017	0.327	0.074
Popo Agie WA	0	0	0.079	0.010	2/7/2005	2.100	2.600	0.111	13.875	0.004	0.090	0.017
Savage Run WA	0	0	0.265	0.090	2/8/2005	1.990	2.440	0.356	13.238	0.015	0.274	0.067
Wind River RA	0	0	0.062	0.009	12/18/2005	2.160	2.680	0.086	13.918	0.001	0.082	0.003
Rocky Mountain	0	0	0.069	0.021	11/20/2005	1.840	2.230	0.099	14.310	0.001	0.092	0.006
Eagles Nest WA	0	0	0.093	0.022	11/20/2005	1.960	2.420	0.121	12.920	0.002	0.111	0.008
Flat Tops WA	0	0	0.083	0.041	11/19/2005	1.970	2.420	0.107	12.920	0.002	0.096	0.010
Gros Ventre WA	0	0	0.099	0.008	12/18/2005	2.160	2.680	0.138	13.918	0.002	0.130	0.007

Table 4-26. 2022met06 CD-C No Action visibility impacts using FLAG (2010) screening method. Data reported under green bar refer to the 98th percentile b_{ext}.

CDC No Action Alternative												
Class I or Class	#days > 1.0	#days > 0.5	Max Δdv	98th Δdv	day	frh_l	frh_s	b_src	back_bext	b_so4	b_no3	b_other
					Refers to 98th percentile delta dv							
Bridger WA	0	0	0.086	0.011	3/12/2006	2.040	2.550	0.015	13.847	0.001	0.011	0.004
Fitzpatrick WA	0	0	0.049	0.012	3/19/2006	2.040	2.540	0.017	13.842	0.001	0.015	0.001
Mount Zirkel	0	0	0.187	0.102	11/1/2006	1.970	2.410	0.136	13.223	0.005	0.101	0.030
Rawah WA	0	0	0.080	0.039	1/12/2006	1.910	2.310	0.051	13.173	0.002	0.036	0.012
Dinosaur NM	0	0	0.376	0.105	2/19/2006	1.990	2.440	0.140	13.238	0.005	0.117	0.017
Popo Agie WA	0	0	0.096	0.011	3/12/2006	2.040	2.550	0.016	13.847	0.001	0.011	0.003
Savage Run WA	0	0	0.122	0.087	12/23/2006	1.950	2.370	0.115	13.203	0.005	0.087	0.023
Wind River RA	0	0	0.043	0.016	3/3/2006	2.040	2.550	0.023	13.847	0.000	0.021	0.001
Rocky Mountain	0	0	0.041	0.027	12/25/2006	1.760	2.080	0.038	14.230	0.001	0.032	0.005
Eagles Nest WA	0	0	0.063	0.026	12/25/2006	1.970	2.420	0.034	12.920	0.001	0.028	0.005
Flat Tops WA	0	0	0.128	0.058	12/21/2006	2.030	2.510	0.075	12.960	0.005	0.049	0.021
Gros Ventre WA	0	0	0.051	0.012	4/8/2006	1.950	2.430	0.016	13.783	0.001	0.012	0.004

Table 4-27. 2022met06 CD-C No Action visibility impacts using FLAG (2010) screening method. Data reported under green bar refer to the maximum value of b_{ext}.

CDC No Action Alternative												
Class I or Class	#days > 1.0	#days > 0.5	Max	98th Δdv	day	frh_l	frh_s	b_src	back_bext	b_so4	b_no3	b_other
					Refers to Maximum delta dv							
Bridger WA	0	0	0.086	0.011	3/21/2006	2.040	2.550	0.119	13.847	0.006	0.089	0.025
Fitzpatrick WA	0	0	0.049	0.012	3/18/2006	2.040	2.540	0.068	13.842	0.002	0.058	0.007
Mount Zirkel	0	0	0.187	0.102	2/16/2006	1.990	2.440	0.250	13.238	0.009	0.190	0.051
Rawah WA	0	0	0.080	0.039	2/16/2006	1.960	2.390	0.106	13.213	0.003	0.085	0.017
Dinosaur NM	0	0	0.376	0.105	2/18/2006	1.990	2.440	0.507	13.238	0.019	0.397	0.091
Popo Agie WA	0	0	0.096	0.011	3/21/2006	2.040	2.550	0.134	13.847	0.006	0.102	0.026
Savage Run WA	0	0	0.122	0.087	2/3/2006	1.990	2.440	0.162	13.238	0.008	0.116	0.038
Wind River RA	0	0	0.043	0.016	3/11/2006	2.040	2.550	0.060	13.847	0.003	0.044	0.013
Rocky Mountain	0	0	0.041	0.027	1/16/2006	1.770	2.090	0.059	14.240	0.002	0.042	0.014
Eagles Nest WA	0	0	0.063	0.026	11/29/2006	1.960	2.420	0.082	12.920	0.002	0.070	0.010
Flat Tops WA	0	0	0.128	0.058	11/29/2006	1.970	2.420	0.166	12.920	0.007	0.121	0.038
Gros Ventre WA	0	0	0.051	0.012	2/18/2006	2.100	2.600	0.071	13.875	0.001	0.066	0.003

Summary of CD-C Project-Specific Visibility Impacts

The largest visibility impacts area at Dinosaur NM, Mount Zirkel WA and Savage Run WA. The areas with impacts over the 0.5 dv threshold are:

- Mount Zirkel: 1 day > 0.5 dv during the two year simulation period, no days > 1.0 dv
- Dinosaur: 6 days > 0.5 dv during the two year simulation period, no days > 1.0 dv
- Savage Run: 1 day > 0.5 dv during the two year simulation period, no days > 1.0 dv

No other Class I or sensitive Class II area has any day with visibility impacts >0.5 dv due to the CD-C Proposed Action emissions. The No Action Alternative emissions scenario had no days >0.5 dv for any Class I or sensitive Class II area.

4.6.1.5. Cumulative Visibility Impact Analysis

In order to assess cumulative impacts as required under NEPA for the CD-C Project, a visibility analysis was performed that considers the impacts of CD-C Project emissions sources taken together with impacts of all other sources in the region. In the past, such EIS visibility impacts were estimated using the CALPUFF Lagrangian puff model. To determine the Project-specific visibility impacts, CALPUFF was run using only the EIS Project-specific emissions. Daily visibility impacts were estimated at Class I/II areas using the IMPROVE equation, and the number of days that exceeded the 0.5 and 1.0 deciview (dv) thresholds were reported. Cumulative visibility impacts were defined to be those of the Project taken together with those of other sources in its vicinity. To determine other sources for inclusion in the cumulative modeling, industrial sources and oil and gas wells permitted within a defined time frame through state air quality regulatory agencies and state oil and gas permitting agencies were researched. The subset of these sources which had begun operation as of a defined inventory end-date were classified as state-permitted sources, and those not yet in operation were classified as Reasonably Foreseeable Future Actions (RFFA). The undeveloped portions of projects proposed under NEPA were classified as Reasonably Foreseeable Development (RFD). These three categories (state-permitted, RFFA and RFD) of emissions sources comprised the cumulative source inventory.

These analyses were undertaken because it is possible that there could be a number of proposed developments occurring in a region; while each development may have a relatively small impact, the visibility impacts from all developments taken together may be significant. To estimate cumulative visibility impacts, CALPUFF was run with emissions for the EIS Project as well as RFD, RFFA, and recent state-permitted sources and the resultant visibility impacts were compared against the 0.5 and 1.0 dv thresholds for the cumulative visibility analysis.

For the CD-C EIS, the CAMx photochemical grid model (PGM) is being used to estimate ozone, far-field air quality and AQRVs (i.e., visibility and deposition). Unlike CALPUFF, PGMs simulate the effects of all emission sources in the region as well as sources outside of the study region through boundary conditions. The availability of PGM modeling results for all sources means that a different approach to cumulative visibility analysis may be used. This approach was developed by the United States Department of the Interior (USDI) Fish and Wildlife Service (FWS) and National Park Service (NPS) and is documented in a letter sent on February 10, 2012 to the Wyoming Department of Environmental Quality – Air Quality Division. The approach follows the approach used in the EPA Regional Haze Rule. In the section below, we provide a brief description of the method, and present the results of its application to the CD-C modeling.

Regional Haze Rule Metric Approach

The approach used for the cumulative visibility assessment is derived from the Regional Haze Rule (RHR) method. The RHR goal is to achieve natural visibility conditions at Class I areas by 2064 and the demonstration of progress toward this goal uses two metrics:

- Improvement in visibility for the 20% worst visibility days
- No worsening in visibility for the 20% best visibility days

The first RHR State Implementation Plan (SIP), which was due to EPA in 2007, demonstrates progress toward natural conditions in 2064 at Class I areas through the achievement of reasonable progress toward that goal by 2018. To demonstrate reasonable progress for the first RHR metric, a visibility Glide Path is constructed for the 20% worst visibility days in dv from the 2000-2004 observed 20% worst baseline conditions to 20% worst natural conditions in 2064; the value where that Glide Path crosses 2018 is called the uniform rate of progress. The second RHR goal is demonstrated by showing that 2018 visibility for the best 20% days is no worse than the 2000-2004 baseline visibility for the best 20% days.

The RHR SIPs used PGM modeling for a 2002 calendar year and performed a 2002 base case simulation and model performance evaluation. Emissions were then projected to 2018 and the PGM was exercised for the 2018 base case. The PGM 2002 and 2018 modeling results were used to project the observed 20% worst and 20% best days from the 2000-2004 baseline to 2018 following EPA's procedures[2] and the resulting projected 2018 visibility at Class I areas was compared to the 2018 reasonable progress goals.

The RHR method uses the peer-reviewed EPA MATS tool that is designed to reduce the effects of model bias in projecting future year visibility impacts. This is because the model results are used in a relative sense, so that the projected visibility impacts are rooted in observations and calculated based on model changes between base and future years rather than on the absolute modeled concentrations.

Below, we present cumulative visibility impacts using the two RHR visibility metrics - the 20% best and 20% worst days. MATS was used with the CD-C 2008 and 2022 CAMx modeling results to project the observed visibility for the 20% worst and 20% best days for the baseline years with and without the contributions of CD-C Project emissions. Note that this type of analysis cannot conflict with any state's RHR SIP 2018 reasonable progress goal; this analysis is completely separate from and is not directly comparable to the states' RHR SIP reasonable progress visibility projections for the following reasons:

- The RHR SIP used projections to the 2018 year versus 2022 for the CD-C EIS.
- The RHR SIP started with a 2000-2004 observed visibility baseline versus a 2006-2010 observed visibility baseline for the CD-C EIS.

[2] http://www.epa.gov/ttn/scram/guidance/guide/final-03-pm-rh-guidance.pdf

- The RHR SIP uses a 2018 emission projection for estimated actual emissions, whereas the CD-C EIS has future year state-permitted and RFD maximum project development emissions so will overstate the 2022 future year actual emissions.

For these reasons, the CD-C 2022 visibility projections are not comparable to any state's RHR SIP 2018 visibility projections.

The CAMx 2008 and 2022 model outputs were used to project the observed visibility conditions at IMPROVE sites within the 4 km domain from the baseline period (2006-2010) to 2022 for the worst 20% and best 20% days. 2022 visibility projections for the worst 20% and best 20% days were also made without the CD-C Project emissions and without the combined effects of the CD-C Project emissions and RFD sources. This allows an assessment of the effects of emissions from the CD-C Project emissions and the combined CD-C Project emission plus RFD emissions on the RHR visibility metrics.

To carry out the projections, EPA's Modeled Attainment Test Software (MATS) was run in the following configuration:

- Revised IMPROVE Equation
- Use model grid cells at IMPROVE Class I/II area centroid
- 7 x 7 grid cells for 4 km resolution
- Start monitor year = 2006
- End model year = 2010
- Base Year = 2008
- Minimum years required for valid monitor = 3

Results of the cumulative visibility assessment are shown in Tables 4-28 through 4-31. The third column from the left in these tables reports the MATS-projected visibility for the 2022 future year, including the effects of all regional emissions as well as transport (through boundary conditions) and assuming development of the Proposed Action Alternative. The next column to the right reports the MATS-projected visibility for the 2022 future year, accounting for the effects of all regional and transport and assuming the CD-C Project Area development is restricted to the No Action Alternative. The next column to the right reports the MATS-projected visibility for the 2022 future year, based on the same emissions as the other projections except that the impacts of the Proposed Action Alternative emissions and the RFD emissions are excluded. This MATs run is performed so that the results can be compared to the results including the Proposed Action Alternative emissions and RFD emissions to assess the contribution to haze from these two sources combined.

Differences between the CD-C Proposed Action Alternative cumulative 2022 visibility and the CD-C No Action Alternative cumulative 2022 visibility (column 6) are often too small to be accurately assessed with this method due to the precision available within MATS. MATS reports projected future year haze in deciviews to two decimal places. Since the Proposed Action Alternative emissions sources and No Action Alternative emissions sources contribute only a small fraction to the total regional emissions and a correspondingly small fraction to the total atmospheric particulate concentrations, the MATS-projected future year visibility for those two Alternatives reported at 2 decimal places is almost identical at most Class I areas. Note that differences of up to 0.1 dv could potentially be numerical rounding artifacts and not represent actual 0.1 dv differences.

The results indicate that visibility improves in 2022 relative to the baseline years, since the 2022 cumulative haze index (in dv) is lower than the 2006 - 2010 baseline years haze index, for both the Proposed Action Alternative and No Action Alternative, for each meteorological year and for the best 20% days and the worst 20% days. Therefore, both RHR metrics are satisfied. The difference between Proposed Action Alternative cumulative 2022 visibility and No Action Alternative cumulative 2022 visibility is ≤ 0.1 dv at all Class I/II areas for each meteorological year and for both 20% best and 20% worst days, except for Dinosaur NM, where the Proposed Action Alternative cumulative 2022 visibility ranges from 0.1 – 0.2 dv higher than the No Action Alternative cumulative 2022 visibility.

The Proposed Action Alternative plus RFD contributions to 2022 haze (rightmost column in Tables 4-28 through 4-31) on the 20% best days and 20% worst days in the Class I/II areas range from 0.01 to 0.18 dv. The areas that are most affected are Popo Agie WA, Savage Run WA, Flat Tops WA and Rocky Mountain NP, each with at least one exceedance of 0.15 dv.

Table 4-28. Best 20% days for CD-C Proposed Action Alternative, No Action Alternative, and No Proposed Action nor RFD sources. Proposed Action Alternative plus RFD impacts (rightmost column). Using 2005 meteorology.

Best 20% Days - 2005 Meteorology						
Class I or Class II Area	**Baseline Visibility (2006-2010) (dv)**	**Proposed Action Alternative (Cumulative 2022 Visibility) (dv)**	**No Action Alternative (Cumulative 2022 Visibility) (dv)**	**No Proposed Action and No RFD Sources (Cumulative 2022 Visibility) (dv)**	**Difference Between Proposed Action Alternative and No Action Alternative (dv)**	**Difference Between Proposed Action Alternative and No Proposed Action and No RFD Sources (dv)**
Bridger WA	**1.39**	1.17	1.17	1.14	0.00	0.03
Fitzpatrick WA	**1.39**	1.19	1.19	1.16	0.00	0.03
Mount Zirkel WA	**0.95**	0.74	0.74	0.66	0.00	0.08
Rawah WA	**0.95**	0.67	0.67	0.58	0.00	0.09
Dinosaur NM	**0.95**	0.82	0.81	0.76	0.01	0.06
Popo Agie WA	**1.39**	1.28	1.28	1.15	0.00	0.13
Savage Run WA	**0.95**	0.62	0.61	0.49	0.01	0.13
Wind River RA	**1.39**	1.17	1.17	1.13	0.00	0.04
Rocky Mountain NP	**1.91**	1.77	1.77	1.61	0.00	0.16
Eagles Nest WA	**0.69**	0.48	0.48	0.47	0.00	0.01
Flat Tops WA	**0.69**	0.41	0.41	0.30	0.00	0.11
Gros Ventre WA	**1.39**	1.18	1.18	1.16	0.00	0.02

Table 4-29. Worst 20% days for CD-C Proposed Action Alternative, No Action Alternative, and No Proposed Action nor RFD sources. Proposed Action Alternative plus RFD impacts (rightmost column). Using 2005 meteorology.

Worst 20% Days - 2005 Meteorology						
Class I or Class II Area	Baseline Visibility (2006-2010) (dv)	Proposed Action Alternative (Cumulative 2022 Visibility) (dv)	No Action Alternative (Cumulative 2022 Visibility) (dv)	No Proposed Action and No RFD Sources (Cumulative 2022 Visibility) (dv)	Difference Between Proposed Action Alternative and No Action Alternative (dv)	Difference Between Proposed Action Alternative and No Proposed Action and No RFD Sources (dv)
Bridger WA	**10.58**	10.28	10.28	10.23	0.00	0.05
Fitzpatrick WA	**10.58**	10.27	10.27	10.24	0.00	0.03
Mount Zirkel WA	**9.36**	9.09	9.09	9.01	0.00	0.08
Rawah WA	**9.36**	9.05	9.05	8.95	0.00	0.10
Dinosaur NM	**9.36**	9.09	9.07	9.02	0.02	0.07
Popo Agie WA	**10.58**	10.45	10.45	10.29	0.00	0.16
Savage Run WA	**9.36**	8.97	8.97	8.83	0.00	0.14
Wind River RA	**10.58**	10.26	10.26	10.21	0.00	0.05
Rocky Mountain NP	**12.04**	11.89	11.89	11.73	0.00	0.16
Eagles Nest WA	**8.68**	8.34	8.33	8.32	0.01	0.02
Flat Tops WA	**8.68**	8.48	8.48	8.33	0.00	0.15
Gros Ventre WA	**10.58**	10.31	10.31	10.29	0.00	0.02

Table 4-30. Best 20% days for CD-C Proposed Action Alternative, No Action Alternative, and No Proposed Action nor RFD sources. Proposed Action Alternative plus RFD impacts (rightmost column). Using 2006 meteorology.

Best 20% Days - 2006 Meteorology						
Class I or Class II Area	Baseline Visibility (2006-2010) (dv)	Proposed Action Alternative (Cumulative 2022 Visibility) (dv)	No Action Alternative (Cumulative 2022 Visibility) (dv)	No Proposed Action and No RFD Sources (Cumulative 2022 Visibility) (dv)	Difference Between Proposed Action Alternative and No Action Alternative (dv)	Difference Between Proposed Action Alternative and No Proposed Action and No RFD Sources (dv)
Bridger WA	**1.39**	1.22	1.22	1.19	0.00	0.03
Fitzpatrick WA	**1.39**	1.24	1.23	1.22	0.01	0.02
Mount Zirkel WA	**0.95**	0.75	0.75	0.67	0.00	0.08
Rawah WA	**0.95**	0.68	0.68	0.59	0.00	0.09
Dinosaur NM	**0.95**	0.85	0.84	0.80	0.01	0.05
Popo Agie WA	**1.39**	1.34	1.34	1.21	0.00	0.13
Savage Run WA	**0.95**	0.66	0.66	0.53	0.00	0.13
Wind River RA	**1.39**	1.21	1.21	1.17	0.00	0.04
Rocky Mountain NP	**1.91**	1.80	1.80	1.65	0.00	0.15
Eagles Nest WA	**0.69**	0.52	0.52	0.50	0.00	0.02
Flat Tops WA	**0.69**	0.48	0.48	0.36	0.00	0.12
Gros Ventre WA	**1.39**	1.24	1.23	1.22	0.01	0.02

Table 4-31. Worst 20% days for CD-C Proposed Action Alternative, No Action Alternative, and No Proposed Action nor RFD sources. Proposed Action Alternative plus RFD impacts (rightmost column). Using 2006 meteorology.

Worst 20% Days - 2006 Meteorology						
Class I or Class II Area	Baseline Visibility (2006-2010) (dv)	Proposed Action Alternative (Cumulative 2022 Visibility) (dv)	No Action Alternative (Cumulative 2022 Visibility) (dv)	No Proposed Action and No RFD Sources (Cumulative 2022 Visibility) (dv)	Difference Between Proposed Action Alternative and No Action Alternative (dv)	Difference Between Proposed Action Alternative and No Proposed Action and No RFD Sources (dv)
Bridger WA	**10.58**	10.30	10.30	10.28	0.00	0.02
Fitzpatrick WA	**10.58**	10.32	10.32	10.31	0.00	0.01
Mount Zirkel WA	**9.36**	9.16	9.16	9.05	0.00	0.11
Rawah WA	**9.36**	9.11	9.11	8.99	0.00	0.12
Dinosaur NM	**9.36**	9.10	9.08	9.02	0.02	0.08
Popo Agie WA	**10.58**	10.56	10.55	10.40	0.01	0.16
Savage Run WA	**9.36**	9.01	9.00	8.83	0.01	0.18
Wind River RA	**10.58**	10.27	10.27	10.24	0.00	0.03
Rocky Mountain NP	**12.04**	11.68	11.68	11.53	0.00	0.15
Eagles Nest WA	**8.68**	8.29	8.29	8.26	0.00	0.03
Flat Tops WA	**8.68**	8.37	8.36	8.20	0.01	0.17
Gros Ventre WA	**10.58**	10.32	10.32	10.31	0.00	0.01

Summary of CD-C Cumulative Visibility Impact Analysis Results

The cumulative visibility assessment estimates improved visibility in 2022 compared to the 2006 – 2010 baseline years at all the Class I and Class II areas for both the Proposed Action Alternative and the No Action Alternative for both the best and worst 20% days. Differences in visibility between the Proposed Action Alternative and No Action Alternative with other regional and transported emissions sources are generally too small to be computed with the precision available in the MATS tool for all Class I and Class II areas. The one exception is Dinosaur NM, where a 0.01 to 0.02 dv increase for the Proposed Action Alternative is predicted over the No Action Alternative. Impacts from the Proposed Action Alternative plus RFD sources on 2022 haze are estimated to vary between 0.01 dv and 0.18 dv among the Class I and Class II areas.

As noted above, the CD-C analysis is designed so that the results are specific to this EIS and are not appropriate for comparison to any existing RHR SIP analysis performed by the States because of differences in base year, emission inventories, and methodology.

4.6.2 Deposition

The effects of atmospheric deposition of nitrogen and sulfur compounds on terrestrial and aquatic ecosystems are well-documented and have been shown to cause leaching of nutrients from soils, acidification of surface waters, injury to high elevation vegetation, and changes in nutrient cycling and species composition. FLAG (2010) recommends that applicable sources assess impacts of nitrogen and sulfur deposition at Class I areas. Although the CD-C Project is not an “applicable source” under New Source Review, BLM is analyzing nitrogen and sulfur deposition impacts attributable to the CD-C Project at Class I and sensitive Class II areas.

4.6.2.1 Overview of Approach

CAMx-predicted wet and dry fluxes of sulfur- and nitrogen-containing species were processed to estimate total annual sulfur (S) and nitrogen (N) deposition at each Class I and sensitive Class II area and at each acid sensitive lake. The maximum annual S and N deposition from any grid cell that intersects a Class I or Class II receptor area was used to represent deposition for that area. The average annual deposition of all grid cells that intersect a Class I or Class II receptor area are also presented. Maximum and average predicted S and N deposition impacts were estimated for the Proposed Action Alternative the No Action Alternative and for the cumulative effects of all sources in the region.

Nitrogen deposition impacts were calculated by taking the sum of the nitrogen contained in the fluxes of all nitrogen species modeled by CAMx. CAMx species used in the nitrogen deposition flux calculation are: reactive gaseous nitrogen species, RGN (NO_X, NO_3, HONO, N_2O_5), TPN (PAN, PANX, PNA), organic nitrates (NTR), particulate nitrate formed from primary emissions plus secondarily formed nitrate (PN3), gaseous nitric acid (HN3), gaseous ammonia (NH3) and particulate ammonium (PN4). CAMx species used in the sulfur deposition calculation are primary sulfur dioxide emissions (SO_2) and particulate sulfate ion from primary emissions plus secondarily formed sulfate (PS4).

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) developed by the National Park Service and the Fish and Wildlife Service. The DATs represent screening level values for nitrogen and sulfur deposition from project alone emission sources below which estimated impacts are considered negligible. The DAT established for both nitrogen and sulfur in western Class I areas is 0.005 kilograms per hectare per year (kg/ha/yr). As a screening analysis, results for project alone sources were compared to these thresholds.

In addition to the screening level analysis, cumulative modeled results were compared to critical load thresholds to assess total deposition impacts. Deposition results were compared to critical load thresholds established for the Rocky Mountain region. BLM has compiled currently available research data on critical load values for Class I areas in the vicinity of this project. Critical load thresholds published by Fox et al. (Fox et al., 1989) established pollutant loadings for total nitrogen of 3-5 kilograms per hectare per year (kg/ha/yr) and for total sulfur of 5 kg/ha/yr for Bob Marshall Wilderness Area in Montana and Bridger Wilderness Area in Wyoming. If current deposition of N or S is > 3 kg/ha/yr, or applicable critical loads values or other scientific information is available that suggests the ecosystem is being harmed by current deposition levels, and the proposed Project's contribution to deposition is above the DAT screening levels, the impact to the ecosystem can range from moderate to major depending on the existing conditions. Research conducted by Baron (2006) using hindcasting of diatom communities suggests 1.5 kg/ha/yr as a critical loading value for wet nitrogen deposition for high elevation lakes in Rocky Mountain National Park, Colorado. Recent research conducted by Saros et. al. (2010) using fossil diatom assemblages suggests that a critical load value of 1.4 kg/ha/yr for wet nitrogen is applicable to the eastern Sierra Nevada and Greater Yellowstone ecosystems. Cumulative N and S deposition impacts were compared to the following critical load values: 1.5 kg/ha/yr was used as a surrogate for total N deposition and 3 kg/ha/yr was used for total S deposition for the Class I areas evaluated in this analysis. For N and S, we report both the average deposition as well as the maximum deposition, although only the maximum deposition is compared with the applicable level of concern.

4.6.3.2 Project-Specific Nitrogen Deposition Impacts

Table 4-32 shows the incremental 2022 nitrogen deposition impacts of the CD-C Proposed Action Alternative emissions sources for the 2005 and 2006 meteorological years.

Table 4-32. CD-C Proposed Action Alternative nitrogen deposition impacts for 2022met05 and 2022met06.

	CD-C Proposed Action Alternative			
	Total Deposition Met 2005		Total Deposition Met 2006	
Class I or Class II Area	Nitrogen- Max (kgN/ha)	Nitrogen- Avg (kgN/ha)	Nitrogen- Max (kgN/ha)	Nitrogen- Avg (kgN/ha)
Bridger WA	0.0012	0.0006	0.0019	0.0011
Fitzpatrick WA	0.0006	0.0004	0.0012	0.0008
Mount Zirkel WA	0.0116	0.0079	0.0148	0.0105
Rawah WA	0.0078	0.0058	0.0125	0.0086
Dinosaur NM	0.0116	0.0063	0.0126	0.0069
Popo Agie WA	0.0015	0.0008	0.0027	0.0016
Savage Run WA	0.0154	0.0135	0.0197	0.0168
Wind River RA	0.0007	0.0005	0.0011	0.0009
Gros Ventre WA	0.0006	0.0004	0.0014	0.0008
Rocky Mountain NP	0.0050	0.0034	0.0074	0.0044
Eagles Nest WA	0.0022	0.0019	0.0023	0.0020
Flat Tops WA	0.0040	0.0026	0.0057	0.0032

The largest nitrogen deposition impacts occur at Savage Run WA, Rawah WA, Mount Zirkel WA, Rocky Mountain NP and Dinosaur NM, which are the areas that are closest to and/or generally downwind of the CD-C Project Area. These areas exceed the DAT of 0.005 kg/ha/yr.

The corresponding results for the No Action Alternative are shown in Table 4-33. The largest nitrogen deposition impacts occur at Savage Run WA, Rawah WA, Mount Zirkel WA and Dinosaur NM. All of these sites exceed the DAT of 0.005 kg/ha/yr in at least one of the two meteorological years.

Table 4-33. CD-C No Action Alternative nitrogen deposition impacts for 2022met05 and 2022met06.

Class I or Class II Area	CD-C No Action Alternative			
	Total Deposition Met 2005		Total Deposition Met 2006	
	Nitrogen- Max (kgN/ha)	Nitrogen- Avg (kgN/ha)	Nitrogen- Max (kgN/ha)	Nitrogen- Avg (kgN/ha)
Bridger WA	0.0005	0.0003	0.0009	0.0005
Fitzpatrick WA	0.0003	0.0002	0.0005	0.0004
Mount Zirkel WA	0.0053	0.0036	0.0067	0.0047
Rawah WA	0.0035	0.0026	0.0057	0.0039
Dinosaur NM	0.0053	0.0028	0.0057	0.0031
Popo Agie WA	0.0007	0.0004	0.0012	0.0007
Savage Run WA	0.0070	0.0061	0.0089	0.0076
Wind River RA	0.0003	0.0002	0.0005	0.0004
Gros Ventre WA	0.0003	0.0002	0.0007	0.0004
Rocky Mountain NP	0.0023	0.0015	0.0033	0.0020
Eagles Nest WA	0.0010	0.0009	0.0010	0.0009
Flat Tops WA	0.0018	0.0012	0.0026	0.0015

4.6.2.3 Project-Specific Sulfur Deposition Impacts

Table 4-34 shows the incremental sulfur deposition impacts of the 2022 CD-C Proposed Action Alternative emissions sources for the 2005 and 2006 meteorological years. The largest sulfur deposition impacts occur at Savage Run WA, Rawah WA, Dinosaur NM, Rocky Mountain NP, and Mount Zirkel WA; however, no area exceeds the DAT of 0.005 kg/ha/yr. The same is true for the No Action Alternative emissions sources. (Table 4-35).

Table 4-34. CD-C Proposed Action Alternative sulfur deposition impacts for 2022met05 and 2022met06.

Class I or Class II Area	CD-C Proposed Action Alternative			
	Total Deposition Met 2005		Total Deposition Met 2006	
	Sulfur- Max (kgS/ha)	Sulfur- Avg (kgS/ha)	Sulfur- Max (kgS/ha)	Sulfur- Avg (kgS/ha)
Bridger WA	0.0000	0.0000	0.0000	0.0000
Fitzpatrick WA	0.0000	0.0000	0.0000	0.0000
Mount Zirkel WA	0.0002	0.0001	0.0004	0.0002
Rawah WA	0.0001	0.0001	0.0003	0.0002
Dinosaur NM	0.0001	0.0001	0.0003	0.0001
Popo Agie WA	0.0000	0.0000	0.0001	0.0000
Savage Run WA	0.0002	0.0002	0.0002	0.0002
Wind River RA	0.0000	0.0000	0.0000	0.0000
Gros Ventre WA	0.0000	0.0000	0.0000	0.0000
Rocky Mountain NP	0.0001	0.0000	0.0002	0.0001
Eagles Nest WA	0.0000	0.0000	0.0000	0.0000
Flat Tops WA	0.0001	0.0000	0.0001	0.0000

Table 4-35. CD-C No Action Alternative sulfur deposition impacts for 2022met05 and 2022met06.

Class I or Class II Area	CD-C No Action Alternative			
	Total Deposition Met 2005		Total Deposition Met 2006	
	Sulfur- Max (kgS/ha)	Sulfur- Avg (kgS/ha)	Sulfur- Max (kgS/ha)	Sulfur- Avg (kgS/ha)
Bridger WA	0.0000	0.0000	0.0000	0.0000
Fitzpatrick WA	0.0000	0.0000	0.0000	0.0000
Mount Zirkel WA	0.0001	0.0000	0.0002	0.0001
Rawah WA	0.0001	0.0000	0.0001	0.0001
Dinosaur NM	0.0001	0.0000	0.0001	0.0000
Popo Agie WA	0.0000	0.0000	0.0000	0.0000
Savage Run WA	0.0001	0.0001	0.0001	0.0001
Wind River RA	0.0000	0.0000	0.0000	0.0000
Gros Ventre WA	0.0000	0.0000	0.0000	0.0000
Rocky Mountain NP	0.0000	0.0000	0.0001	0.0000
Eagles Nest WA	0.0000	0.0000	0.0000	0.0000
Flat Tops WA	0.0000	0.0000	0.0000	0.0000

4.6.2.4 Cumulative Nitrogen Deposition Impacts

Table 4-36 shows the total nitrogen deposition impacts from all emissions sources for 2022 for both the 2005 and 2006 meteorological years. All Class I and sensitive Class II areas within the 4 km domain exceed the 1.5 kg/ha/yr threshold in the 2022met05 and 2022met06 scenarios. The largest impacts occur at Rawah WA, Mount Zirkel WA, Gros Ventre WA, Rocky Mountain NP, and Dinosaur NM.

Table 4-36. All emissions sources nitrogen deposition impacts for 2022met05 and 2022met06.

Class I or Class II Area	Total Deposition Met 2005		Total Deposition Met 2006	
	Nitrogen- Max (kgN/ha)	Nitrogen- Avg (kgN/ha)	Nitrogen- Max (kgN/ha)	Nitrogen- Avg (kgN/ha)
Bridger WA	2.7353	2.1652	2.8497	2.1761
Fitzpatrick WA	2.3482	1.9292	3.1655	2.5343
Mount Zirkel WA	4.2035	3.2899	5.3972	3.7190
Rawah WA	3.2132	2.5934	4.4318	3.4495
Dinosaur NM	4.4678	2.5312	5.9186	2.9802
Popo Agie WA	2.5567	2.1771	3.6249	2.8170
Savage Run WA	2.5066	2.2064	2.6662	2.1332
Wind River RA	2.2597	1.8856	3.4945	2.5278
Gros Ventre WA	3.3894	2.2032	4.8252	2.7870
Rocky Mountain NP	3.7335	2.3201	5.8610	3.1288
Eagles Nest WA	1.8991	1.6117	1.7168	1.4867
Flat Tops WA	2.8602	2.2820	3.3589	2.4833

Table 4-37 shows the 2022-2008 change in maximum and average nitrogen deposition at all Class I/II areas. All areas show a reduction in nitrogen deposition in 2022 relative to the 2008 baseline run using 2005 and 2006 meteorology.

Table 4-37. Change in nitrogen deposition from all emissions sources 2022-2008 for 2022met05 and 2022met06

Absolute Change in Deposition

Class I or Class II Area	Total Deposition Met 2005		Total Deposition Met 2006	
	Nitrogen-Max (kgN/ha)	Nitrogen-Avg (kgN/ha)	Nitrogen-Max (kgN/ha)	Nitrogen-Avg (kgN/ha)
Bridger WA	-0.3221	-0.2465	-0.3104	-0.2355
Fitzpatrick WA	-0.2674	-0.2002	-0.3118	-0.2399
Mount Zirkel WA	-0.4775	-0.3805	-0.6458	-0.4433
Rawah WA	-0.3260	-0.2762	-0.5373	-0.3840
Dinosaur NM	-0.4022	-0.2290	-0.5890	-0.2910
Popo Agie WA	-0.2906	-0.2395	-0.3619	-0.3028
Savage Run WA	-0.2691	-0.2232	-0.2901	-0.2199
Wind River RA	-0.2498	-0.1888	-0.3039	-0.2357
Gros Ventre WA	-0.3499	-0.2431	-0.4639	-0.2756
Rocky Mountain	-0.4910	-0.3610	-0.9541	-0.5796
Eagles Nest WA	-0.2281	-0.2515	-0.2125	-0.2350
Flat Tops WA	-0.3241	-0.3114	-0.5193	-0.3833

Percentage Change in Deposition

Class I or Class II Area	Total Deposition Met 2005		Total Deposition Met 2006	
	Nitrogen-Max (%)	Nitrogen-Avg (%)	Nitrogen-Max (%)	Nitrogen-Avg (%)
Bridger WA	-10.54%	-10.22%	-9.82%	-9.76%
Fitzpatrick WA	-10.22%	-9.40%	-8.97%	-8.65%
Mount Zirkel WA	-10.20%	-10.37%	-10.69%	-10.65%
Rawah WA	-9.21%	-9.62%	-10.81%	-10.02%
Dinosaur NM	-8.26%	-8.30%	-9.05%	-8.90%
Popo Agie WA	-10.21%	-9.91%	-9.08%	-9.71%
Savage Run WA	-9.69%	-9.19%	-9.81%	-9.34%
Wind River RA	-9.95%	-9.10%	-8.00%	-8.53%
Gros Ventre WA	-9.36%	-9.94%	-8.77%	-9.00%
Rocky Mountain	-11.62%	-13.46%	-14.00%	-15.63%
Eagles Nest WA	-10.72%	-13.50%	-11.01%	-13.65%
Flat Tops WA	-10.18%	-12.01%	-13.39%	-13.37%

4.6.2.5 Cumulative Sulfur Deposition Impacts

Table 4-38 shows the total sulfur deposition impacts from all emissions sources for 2022 for both the 2005 and 2006 meteorological years. Mount Zirkel WA, Rocky Mountain NP, and Dinosaur NM exceed the 3.0 kg/ha/yr threshold in 2022met06.

Table 4-38. All emissions sources sulfur deposition impacts for 2022met05 and 2022met06.

Class I or Class II Area	Total Deposition Met 2005		Total Deposition Met 2006	
	Sulfur- Max (kgS/ha)	Sulfur- Avg (kgS/ha)	Sulfur- Max (kgS/ha)	Sulfur- Avg (kgS/ha)
Bridger WA	1.6060	1.0779	1.4238	0.9284
Fitzpatrick WA	1.1800	0.8021	1.6627	1.1887
Mount Zirkel WA	2.0720	1.6030	3.2482	2.0465
Rawah WA	1.6033	1.1064	2.6735	1.8302
Dinosaur NM	2.9751	1.1369	4.0346	1.5612
Popo Agie WA	1.1352	0.8799	1.9540	1.3831
Savage Run WA	1.1134	1.0159	1.2412	0.9228
Wind River RA	1.2438	0.7831	2.0418	1.2523
Gros Ventre WA	2.0108	1.0557	2.8548	1.4432
Rocky Mountain NP	2.0752	1.0512	3.8012	1.6888
Eagles Nest WA	0.7370	0.5744	0.5175	0.4433
Flat Tops WA	1.5752	1.0328	2.0690	1.2227

Table 4-39 shows the 2022-2008 change in maximum and average sulfur deposition at all Class I/II areas. All areas show a reduction in sulfur deposition in 2022 relative to the 2008 baseline run using 2005 and 2006 meteorology.

Table 4-39. Change in sulfur deposition from all emissions sources 2022-2008 for 2022met05 and 2022met06.

Absolute Change in Deposition

Class I or Class II Area	Total Deposition Met 2005		Total Deposition Met 2006	
	Sulfur-Max (kgS/ha)	Sulfur-Avg (kgS/ha)	Sulfur-Max (kgS/ha)	Sulfur-Avg (kgS/ha)
Bridger WA	-0.2726	-0.1941	-0.1578	-0.1247
Fitzpatrick WA	-0.1755	-0.0858	-0.1189	-0.0965
Mount Zirkel WA	-0.2679	-0.1934	-0.3921	-0.2535
Rawah WA	-0.1871	-0.1172	-0.3077	-0.2106
Dinosaur NM	-0.2589	-0.1173	-0.4281	-0.1622
Popo Agie WA	-0.2254	-0.1476	-0.1604	-0.1384
Savage Run WA	-0.1073	-0.1081	-0.1355	-0.1052
Wind River RA	-0.1146	-0.0913	-0.1439	-0.1044
Gros Ventre WA	-0.2658	-0.1391	-0.2850	-0.1530
Rocky Mountain	-0.1855	-0.1061	-0.3590	-0.1872
Eagles Nest WA	-0.0872	-0.0658	-0.0747	-0.0657
Flat Tops WA	-0.1896	-0.1337	-0.3127	-0.1818

Percentage Change in Deposition

Class I or Class II Area	Total Deposition Met 2005		Total Deposition Met 2006	
	Sulfur-Max (%)	Sulfur-Avg (%)	Sulfur-Max (%)	Sulfur-Avg (%)
Bridger WA	-14.51%	-15.26%	-9.98%	-11.84%
Fitzpatrick WA	-12.95%	-9.67%	-6.67%	-7.51%
Mount Zirkel WA	-11.45%	-10.77%	-10.77%	-11.02%
Rawah WA	-10.45%	-9.58%	-10.32%	-10.32%
Dinosaur NM	-8.00%	-9.35%	-9.59%	-9.41%
Popo Agie WA	-16.57%	-14.37%	-7.59%	-9.10%
Savage Run WA	-8.79%	-9.62%	-9.84%	-10.23%
Wind River RA	-8.44%	-10.44%	-6.58%	-7.70%
Gros Ventre WA	-11.68%	-11.64%	-9.08%	-9.58%
Rocky Mountain	-8.20%	-9.17%	-8.63%	-9.98%
Eagles Nest WA	-10.58%	-10.28%	-12.62%	-12.90%
Flat Tops WA	-10.75%	-11.46%	-13.13%	-12.94%

4.6.2.6 Summary of Deposition Impacts

For the CD-C Proposed Action Alternative, the DAT for nitrogen was exceeded at Savage Run WA, Rawah WA, Mount Zirkel WA, Rocky Mountain NP, and Dinosaur NM, which are the areas that are closest to and/or generally downwind of the CD-C Project Area. For the No Action Alternative, the DAT for nitrogen was exceeded at Savage Run WA, Rawah WA, Mount Zirkel WA and Dinosaur NM. There were no sulfur deposition impacts that exceeded the DAT for either the CD-C Proposed Action Alternative or the No Action Alternative. For all areas, nitrogen deposition impacts from the CD-C Proposed Action Alternative were larger than sulfur deposition impacts. This is consistent with the low levels of SO_2 emissions relative to NO_X emissions from the CD-C Project sources. Nitrogen deposition in 2022 due to all emissions sources exceeds the 1.5 kg/ha/yr threshold at all Class I and sensitive Class II areas for both meteorological years. Sulfur deposition in 2022 due to all emissions sources exceeds the 3.0

kg/ha/yr threshold at Mount Zirkel WA, Rocky Mountain NP, and Dinosaur NM using 2006 meteorology but does not exceed the 3.0kg/ha/yr threshold at any area using 2005 meteorology. Deposition due to all emissions sources in 2022 - including emissions transported from outside the 36 km grid through the boundary conditions - decreased for both nitrogen and sulfur in all Class I/II areas relative to 2008. Nitrogen deposition is between 8 and 16% lower in 2022 than 2008, and sulfur deposition is between 6 and 17% lower in 2022 than 2008, across the Class I and Class II area.

4.6.3 ANC at Sensitive Lakes

This analysis estimates the potential changes in the Acid Neutralizing Capacity (ANC) of sensitive lakes due to atmospheric deposition from: (1) Proposed Action Alternative emission sources; (2) No Action Alternative emissions sources; (3) cumulative emission sources. ANC is a measure of the ability of water to neutralize acid inputs; lakes with low ANC have poor acid buffering capacity and are susceptible to becoming acidified, whereas lakes with high ANC can maintain a neutral pH even with additional acid rain input. The estimate of potential changes in ANC was made by following the procedure developed by the USFS Rocky Mountain Region (USFS 2000). The procedure gives a simplistic step-by-step process and is a conservative screening methodology; as such, the method can be used to determine if a proposed source does not have the potential to impact a wilderness lake.

Predicted changes in ANC for each case were compared to the USFS's Level of Acceptable Change (LAC) thresholds of:

1. No more than 10 % for lakes with existing ANC values 25 ueq/l or greater

2. No more than 1 ueq/l for lakes with existing ANC values less than 25 ueq/l

The most recent lake chemistry background ANC data were obtained from the Visibility Information Exchange Web System (VIEWS, 2014) for each of the sensitive lakes. The 10^{th} percentile lowest ANC values were calculated for each lake following procedures provided from the USFS. The lowest 10 % values are used as the baseline lake ANC value since they represent the most sensitive conditions that may occur at a lake on an episodic or seasonal basis. The baseline ANC values and the number of samples used in the calculation of the 10^{th} percentile lowest ANC values are provided in Table 4-40. Annual precipitation at each lake was obtained from the Parameter-elevation Regressions on Independent Slopes Model (PRISM) (PRISM, 2014) climate mapping system database, based on the 30 year normal dataset for long-term average precipitation over the 1981 – 2010 time period.

Table 4-40. Sensitive lakes ANC analysis: lake parameters.

CD-C Sensitive Lakes							
Wilderness Area	**Lake**	**Latitude (Deg N, NAD27)**	**Longitude (Deg W, NAD27)**	**Elev. (m)**	**10th Percentile Lowest ANC Value (µeq/L)**	**# of Samples**	**Period of Monitoring**
Bridger	Black Joe	42º44'22"	109º10'16"	3128.0	62.6	78	1984-2009
Bridger	Deep	42º43'9"	109º10'19"	3202.8	57.7	68	1984-2009
Bridger	Hobbs	43º02'06"	109º40'23"	3068.0	69.9	80	1984-2009
Bridger	Lazy Boy	43º19'57"	109º43'44"	3535.7	9.1	5	1997-2009
Bridger	Upper Frozen	42º41'13"	109º09'40"	3486.9	7.5	12	1997-2009
Eagles Nest	Booth	39º41'55"	106º18'18"	3493.0	86.8	49	1993-2010
Eagles Nest	Upper Willow	39º38'45"	106º10'29"	3469.0	134.1	52	1990-2011
Fitzpatrick	Ross	43º23'35"	109º39'29"	2950.6	53.0	61	1989-2010
Flat Tops	Ned Wilson	39º57'41"	107º19'26"	3385.0	39.0	191	1981-2007
Flat Tops	Upper Ned Wilson	39º57'46"	107º19'25"	3386.0	12.9	143	1983-2007
Flat Tops	L. Packtrail Pothole	39º58'5"	107º19'27"	3378.7	29.7	96	1987-2007
Flat Tops	U. Packtrail Pothole	39º57'56"	107º19'26"	3380.2	48.7	96	1987-2007
Mount Zirkel	Lake Elbert	40º38'03"	106º42'25"	3291.8	56.6	67	1985-2007
Mount Zirkel	Seven Lakes-LG East	40º53'45"	106º40'55"	3273.3	36.2	67	1985-2007
Mount Zirkel	Summit	40º32'43"	106º40'55"	3144.3	48.0	107	1985-2007
Popo Agie	Lower Saddlebag	42º37'24"	108º59'42"	3432.7	54.6	64	1989-2010
Rawah	Island	40º37'38"	105º56'28"	3392.0	71.0	30	1995-2010
Rawah	Kelly	40º37'32"	105º57'34"	3293.0	179.9	30	1995-2010
Rawah	Rawah #4	40º40'16"	105º57'28"	3497.0	41.3	30	1995-2010

CD-C Project Emission Sources ANC Impacts

Tables 4-41 and 4-42 show that no lake undergoes a ΔANC that exceeds the applicable LAC threshold due to the impact of the CD-C Proposed Action Alternative emissions in either the 2022met05 or 2022met06 scenarios. The largest applicable ΔANC (%) impact over the two years occurs at Seven Lakes (LG East) and is 0.266%, and the largest applicable absolute change over the two years is 0.027µeq/l at Upper Ned Lake, both are well below the threshold values. For the No Action Alternative, Tables 4-43 and 4-44 show that changes in ANC of the sensitive lakes are less than under the Proposed Action Alternative, therefore impacts of the No Action Alternative are also well below the threshold values.

Table 4-41. Sensitive lakes ANC analysis: CD-C Proposed Action for 2022met05.

CDC Proposed Action Alternative: 2005 Meteorology									
Lake	Baseline 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 (ueq/l)*	USFS LAC Threshold	Below Threshold?	2022 Predicted 10th Percentile Lowest ANC Value (µeq/L)
Black Joe Lake	62.62	9.52E-06	6.97E-04	0.85	0.014%	0.009	<10%	yes	62.61
Deep Lake	57.67	1.10E-05	7.54E-04	0.94	0.015%	0.009	<10%	yes	57.66
Hobbs Lake	69.87	8.47E-06	5.32E-04	0.93	0.009%	0.006	<10%	yes	69.86
Lazy Boy Lake	9.08	5.96E-06	4.24E-04	0.89	0.057%	0.005	<1(µeq/L)	yes	9.07
Upper Frozen Lake	7.47	1.22E-05	9.30E-04	0.92	0.146%	0.011	<1(µeq/L)	yes	7.45
Booth Lake	86.78	2.10E-05	1.92E-03	0.88	0.027%	0.024	<10%	yes	86.76
Upper Willow Lake	134.10	1.28E-05	1.73E-03	0.74	0.019%	0.025	<10%	yes	134.07
Ross Lake	53.00	7.02E-06	3.90E-04	0.88	0.009%	0.005	<10%	yes	53.00
Ned Wilson Lake	39.00	2.41E-05	2.34E-03	1.18	0.055%	0.021	<10%	yes	38.98
Upper Ned Wilson Lake	12.88	2.41E-05	2.34E-03	1.18	0.166%	0.021	<1(µeq/L)	yes	12.86
Lower Packtrail Pothole	29.65	2.41E-05	2.34E-03	1.18	0.072%	0.021	<10%	yes	29.63
Upper Packtrail Pothole	48.70	2.41E-05	2.34E-03	1.18	0.044%	0.021	<10%	yes	48.68
Lake Elbert	56.58	1.04E-04	7.45E-03	1.73	0.082%	0.047	<10%	yes	56.53
Seven Lakes (LG East)	36.24	1.22E-04	9.79E-03	1.55	0.188%	0.068	<10%	yes	36.17
Summit Lake	48.00	1.11E-04	7.26E-03	1.39	0.117%	0.056	<10%	yes	47.94
Lower Saddlebag Lake	54.61	1.95E-05	1.04E-03	1.09	0.019%	0.010	<10%	yes	54.60
Island Lake	71.03	7.71E-05	5.39E-03	1.07	0.077%	0.055	<10%	yes	70.97
Kelly Lake	179.85	7.71E-05	5.39E-03	1.07	0.030%	0.055	<10%	yes	179.80
Rawah Lake #4	41.29	8.04E-05	5.80E-03	1.10	0.138%	0.057	<10%	yes	41.23

* USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC.

Table 4-42. Sensitive lakes ANC analysis: CD-C Proposed Action for 2022met06.

CDC No Action Alternative: 2006 Meteorology									
Lake	Baseline 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 (ueq/l)*	USFS LAC Threshold	Below Threshold?	2022 Predicted 10th Percentile Lowest ANC Value (μeq/L)
Black Joe Lake	62.62	5.44E-05	1.56E-03	0.85	0.032%	0.020	<10%	yes	62.59
Deep Lake	57.67	6.10E-05	1.75E-03	0.94	0.035%	0.020	<10%	yes	57.64
Hobbs Lake	69.87	2.30E-05	1.18E-03	0.93	0.020%	0.014	<10%	yes	69.86
Lazy Boy Lake	9.08	1.19E-05	7.05E-04	0.89	0.095%	0.009	<1(μeq/L)	yes	9.07
Upper Frozen Lake	7.47	4.47E-05	1.86E-03	0.92	0.296%	0.022	<1(μeq/L)	yes	7.44
Booth Lake	86.78	1.20E-05	2.02E-03	0.88	0.028%	0.025	<10%	yes	86.76
Upper Willow Lake	134.10	1.19E-05	1.84E-03	0.74	0.020%	0.027	<10%	yes	134.07
Ross Lake	53.00	1.41E-05	6.66E-04	0.88	0.016%	0.008	<10%	yes	52.99
Ned Wilson Lake	39.00	3.41E-05	3.00E-03	1.18	0.070%	0.027	<10%	yes	38.97
Upper Ned Wilson Lake	12.88	3.41E-05	3.00E-03	1.18	0.213%	0.027	<1(μeq/L)	yes	12.85
Lower Packtrail Pothole	29.65	3.41E-05	3.00E-03	1.18	0.092%	0.027	<10%	yes	29.62
Upper Packtrail Pothole	48.70	3.41E-05	3.00E-03	1.18	0.056%	0.027	<10%	yes	48.67
Lake Elbert	56.58	2.77E-04	1.10E-02	1.73	0.123%	0.069	<10%	yes	56.51
Seven Lakes (LG East)	36.24	3.17E-04	1.37E-02	1.55	0.266%	0.096	<10%	yes	36.14
Summit Lake	48.00	1.48E-04	9.00E-03	1.39	0.145%	0.070	<10%	yes	47.93
Lower Saddlebag Lake	54.61	6.38E-05	2.12E-03	1.09	0.039%	0.021	<10%	yes	54.59
Island Lake	71.03	1.76E-04	8.08E-03	1.07	0.116%	0.082	<10%	yes	70.94
Kelly Lake	179.85	1.76E-04	8.08E-03	1.07	0.046%	0.082	<10%	yes	179.77
Rawah Lake #4	41.29	1.93E-04	8.85E-03	1.10	0.212%	0.088	<10%	yes	41.20

* USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC.

Table 4-43. Sensitive lakes ANC analysis: CD-C No Action for 2022met05.

CDC No Action Alternative: 2005 Meteorology									
Lake	Baseline 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 (ueq/l)*	USFS LAC Threshold	Below Threshold?	2022 Predicted 10th Percentile Lowest ANC Value (µeq/L)
Black Joe Lake	62.62	4.32E-06	3.17E-04	0.85	0.006%	0.004	<10%	yes	62.61
Deep Lake	57.67	4.97E-06	3.42E-04	0.94	0.007%	0.004	<10%	yes	57.66
Hobbs Lake	69.87	3.85E-06	2.42E-04	0.93	0.004%	0.003	<10%	yes	69.87
Lazy Boy Lake	9.08	2.71E-06	1.92E-04	0.89	0.026%	0.002	<1(µeq/L)	yes	9.08
Upper Frozen Lake	7.47	5.53E-06	4.22E-04	0.92	0.066%	0.005	<1(µeq/L)	yes	7.46
Booth Lake	86.78	9.53E-06	8.74E-04	0.88	0.012%	0.011	<10%	yes	86.77
Upper Willow Lake	134.10	5.79E-06	7.87E-04	0.74	0.008%	0.011	<10%	yes	134.09
Ross Lake	53.00	3.19E-06	1.77E-04	0.88	0.004%	0.002	<10%	yes	53.00
Ned Wilson Lake	39.00	1.09E-05	1.06E-03	1.18	0.025%	0.010	<10%	yes	38.99
Upper Ned Wilson Lake	12.88	1.09E-05	1.06E-03	1.18	0.075%	0.010	<1(µeq/L)	yes	12.87
Lower Packtrail Pothole	29.65	1.09E-05	1.06E-03	1.18	0.033%	0.010	<10%	yes	29.64
Upper Packtrail Pothole	48.70	1.09E-05	1.06E-03	1.18	0.020%	0.010	<10%	yes	48.69
Lake Elbert	56.58	4.71E-05	3.38E-03	1.73	0.037%	0.021	<10%	yes	56.56
Seven Lakes (LG East)	36.24	5.54E-05	4.45E-03	1.55	0.086%	0.031	<10%	yes	36.21
Summit Lake	48.00	5.02E-05	3.30E-03	1.39	0.053%	0.026	<10%	yes	47.97
Lower Saddlebag Lake	54.61	8.84E-06	4.72E-04	1.09	0.009%	0.005	<10%	yes	54.60
Island Lake	71.03	3.50E-05	2.45E-03	1.07	0.035%	0.025	<10%	yes	71.00
Kelly Lake	179.85	3.50E-05	2.45E-03	1.07	0.014%	0.025	<10%	yes	179.83
Rawah Lake #4	41.29	3.65E-05	2.63E-03	1.10	0.063%	0.026	<10%	yes	41.26

* USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC.

Table 4-44. Sensitive lakes ANC analysis: CD-C No Action for 2022met06.

CDC No Action Alternative: 2006 Meteorology									
Lake	Baseline 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 (ueq/l)*	USFS LAC Threshold	Below Threshold?	2022 Predicted 10th Percentile Lowest ANC Value (µeq/L)
Black Joe Lake	62.62	2.47E-05	7.07E-04	0.85	0.015%	0.009	<10%	yes	62.61
Deep Lake	57.67	2.77E-05	7.94E-04	0.94	0.016%	0.009	<10%	yes	57.66
Hobbs Lake	69.87	1.05E-05	5.37E-04	0.93	0.009%	0.006	<10%	yes	69.86
Lazy Boy Lake	9.08	5.40E-06	3.20E-04	0.89	0.043%	0.004	<1(µeq/L)	yes	9.08
Upper Frozen Lake	7.47	2.03E-05	8.46E-04	0.92	0.134%	0.010	<1(µeq/L)	yes	7.45
Booth Lake	86.78	5.43E-06	9.17E-04	0.88	0.013%	0.011	<10%	yes	86.77
Upper Willow Lake	134.10	5.41E-06	8.37E-04	0.74	0.009%	0.012	<10%	yes	134.09
Ross Lake	53.00	6.38E-06	3.02E-04	0.88	0.007%	0.004	<10%	yes	53.00
Ned Wilson Lake	39.00	1.55E-05	1.36E-03	1.18	0.032%	0.012	<10%	yes	38.99
Upper Ned Wilson Lake	12.88	1.55E-05	1.36E-03	1.18	0.097%	0.012	<1(µeq/L)	yes	12.87
Lower Packtrail Pothole	29.65	1.55E-05	1.36E-03	1.18	0.042%	0.012	<10%	yes	29.64
Upper Packtrail Pothole	48.70	1.55E-05	1.36E-03	1.18	0.026%	0.012	<10%	yes	48.69
Lake Elbert	56.58	1.26E-04	5.00E-03	1.73	0.056%	0.032	<10%	yes	56.55
Seven Lakes (LG East)	36.24	1.44E-04	6.21E-03	1.55	0.121%	0.044	<10%	yes	36.20
Summit Lake	48.00	6.72E-05	4.09E-03	1.39	0.066%	0.032	<10%	yes	47.97
Lower Saddlebag Lake	54.61	2.90E-05	9.64E-04	1.09	0.018%	0.010	<10%	yes	54.60
Island Lake	71.03	7.99E-05	3.67E-03	1.07	0.053%	0.037	<10%	yes	70.99
Kelly Lake	179.85	7.99E-05	3.67E-03	1.07	0.021%	0.037	<10%	yes	179.81
Rawah Lake #4	41.29	8.76E-05	4.02E-03	1.10	0.096%	0.040	<10%	yes	41.25

* USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC.

Cumulative Emission Sources ANC Impacts

To assess cumulative changes in the ANC of sensitive lakes in the 2022 future year relative to the 2008 baseline year, the ANC calculations were performed using the 2022-2008 differences in total annual deposition. As shown in Tables 4-45 and 4-46 for the 2005 and 2006 meteorological years, respectively, sulfur and nitrogen deposition is represented as a negative value since all lakes receive less total sulfur and nitrogen deposition in 2022 than in 2008 due to reductions in the region-wide emissions inventories. The negative sulfur and nitrogen deposition translates to a negative change in ANC (i.e. negative delta ANC), which corresponds to greater ANC within the lakes in 2022 compared to the baseline years, since the definition of delta ANC is that positive delta ANC represents a decrease in ANC , and vice versa. In this case, comparing the baseline ANC values and the 2022 predicted ANC in Tables 4-45 and 4-46, shows improvement in the lake acid buffering capabilities since the ANC in the 2022 future year is higher than in the baseline year.

Table 4-45. Sensitive lakes ANC analysis for 2022met05. Cumulative impacts due to all emissions sources are calculated using 2022 – 2008 CAMx deposition differences in each grid cell that intersects a Class I/II Area.

Cumulative Impacts 2022 - 2008 emissions: 2005 Meteorology									
Lake	Baseline 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 (ueq/l)*	USFS LAC Threshold	Below Threshold?	2022 Predicted 10th Percentile Lowest ANC Value (µeq/L)
Black Joe Lake	62.62	-1.3E-01	-2.3E-01	0.85	-6.92%	-4.33	<10%	yes	66.95
Deep Lake	57.67	-1.5E-01	-2.5E-01	0.94	-7.44%	-4.29	<10%	yes	61.96
Hobbs Lake	69.87	-2.2E-01	-2.7E-01	0.93	-7.68%	-5.37	<10%	yes	75.24
Lazy Boy Lake	9.08	-7.8E-02	-2.1E-01	0.89	-36.25%	-3.29	<1(µeq/L)	yes	12.37
Upper Frozen Lake	7.47	-2.0E-01	-2.9E-01	0.92	-72.79%	-5.43	<1(µeq/L)	yes	12.90
Booth Lake	86.78	-7.3E-02	-2.6E-01	0.88	-4.50%	-3.90	<10%	yes	90.68
Upper Willow Lake	134.10	-4.5E-02	-2.1E-01	0.74	-2.66%	-3.57	<10%	yes	137.67
Ross Lake	53.00	-6.5E-02	-2.0E-01	0.88	-5.88%	-3.11	<10%	yes	56.11
Ned Wilson Lake	39.00	-1.3E-01	-3.1E-01	1.18	-9.90%	-3.86	<10%	yes	42.86
Upper Ned Wilson Lake	12.88	-1.3E-01	-3.1E-01	1.18	-29.97%	-3.86	<1(µeq/L)	yes	16.74
Lower Packtrail Pothole	29.65	-1.3E-01	-3.1E-01	1.18	-13.02%	-3.86	<10%	yes	33.51
Upper Packtrail Pothole	48.70	-1.3E-01	-3.1E-01	1.18	-7.93%	-3.86	<10%	yes	52.56
Lake Elbert	56.58	-2.1E-01	-4.6E-01	1.73	-7.02%	-3.97	<10%	yes	60.55
Seven Lakes (LG East)	36.24	-2.1E-01	-4.2E-01	1.55	-11.46%	-4.15	<10%	yes	40.39
Summit Lake	48.00	-1.9E-01	-4.6E-01	1.39	-9.88%	-4.74	<10%	yes	52.74
Lower Saddlebag Lake	54.61	-1.6E-01	-2.7E-01	1.09	-7.37%	-4.03	<10%	yes	58.63
Island Lake	71.03	-1.2E-01	-3.2E-01	1.07	-6.02%	-4.27	<10%	yes	75.30
Kelly Lake	179.85	-1.2E-01	-3.2E-01	1.07	-2.38%	-4.27	<10%	yes	184.12
Rawah Lake #4	41.29	-1.3E-01	-3.3E-01	1.10	-10.33%	-4.27	<10%	yes	45.56

* USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC. Negative values for Delta ANC (%) and Delta ANC(ueq/l) represent an increase in lake ANC.

Table 4-46. Sensitive lakes ANC analysis for 2022met06. Cumulative impacts due to all emissions sources are calculated using 2022 – 2008 CAMx deposition differences in each grid cell that intersects a Class I/II Area.

Cumulative Impacts 2022 - 2008 emissions: 2006 Meteorology									
Lake	Baseline 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 (ueq/l)*	USFS LAC Threshold	Below Threshold?	2022 Predicted 10th Percentile Lowest ANC Value (μeq/L)
Black Joe Lake	62.62	-1.53E-01	-3.12E-01	0.85	-8.956%	-5.608	<10%	yes	68.22
Deep Lake	57.67	-1.83E-01	-3.36E-01	0.94	-9.756%	-5.626	<10%	yes	63.29
Hobbs Lake	69.87	-1.42E-01	-2.57E-01	0.93	-6.268%	-4.379	<10%	yes	74.25
Lazy Boy Lake	9.08	-7.59E-02	-2.34E-01	0.89	-39.691%	-3.604	<1(μeq/L)	yes	12.68
Upper Frozen Lake	7.47	-1.96E-01	-3.57E-01	0.92	-82.025%	-6.123	<1(μeq/L)	yes	13.59
Booth Lake	86.78	-6.96E-02	-2.42E-01	0.88	-4.229%	-3.670	<10%	yes	90.45
Upper Willow Lake	134.10	-5.23E-02	-2.09E-01	0.74	-2.730%	-3.662	<10%	yes	137.76
Ross Lake	53.00	-9.15E-02	-2.48E-01	0.88	-7.545%	-3.999	<10%	yes	57.00
Ned Wilson Lake	39.00	-1.72E-01	-3.61E-01	1.18	-11.865%	-4.627	<10%	yes	43.63
Upper Ned Wilson Lake	12.88	-1.72E-01	-3.61E-01	1.18	-35.927%	-4.627	<1(μeq/L)	yes	17.51
Lower Packtrail Pothole	29.65	-1.72E-01	-3.61E-01	1.18	-15.607%	-4.627	<10%	yes	34.28
Upper Packtrail Pothole	48.70	-1.72E-01	-3.61E-01	1.18	-9.502%	-4.627	<10%	yes	53.33
Lake Elbert	56.58	-3.06E-01	-5.69E-01	1.73	-9.132%	-5.167	<10%	yes	61.75
Seven Lakes (LG East)	36.24	-3.11E-01	-5.17E-01	1.55	-15.023%	-5.444	<10%	yes	41.68
Summit Lake	48.00	-2.52E-01	-5.42E-01	1.39	-12.150%	-5.832	<10%	yes	53.83
Lower Saddlebag Lake	54.61	-1.77E-01	-3.33E-01	1.09	-8.704%	-4.753	<10%	yes	59.36
Island Lake	71.03	-2.51E-01	-4.58E-01	1.07	-9.529%	-6.768	<10%	yes	77.79
Kelly Lake	179.85	-2.51E-01	-4.58E-01	1.07	-3.763%	-6.768	<10%	yes	186.62
Rawah Lake #4	41.29	-2.57E-01	-4.79E-01	1.10	-16.551%	-6.834	<10%	yes	48.12

* USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC. Negative values for Delta ANC (%) and Delta ANC(ueq/l) represent an increase in lake ANC.

Summary of Sensitive Lakes Impacts

The USFS conservative screening methodology predicts no exceedances of the LAC thresholds for either the CD-C Proposed Action Alternative or the No Action Alternative emissions scenarios in either the met05 or met06 simulations. Therefore, neither the Proposed Action Alternative nor No Action Alternative emissions is predicted to impact the sensitive lakes in a significant and adverse manner. In addition, the cumulative assessment shows that nitrogen and sulfur deposition into the sensitive lakes in 2022 will be lower than in 2008 due to regional emissions reductions. This results in an increase in ANC of the sensitive lakes over this time frame, with the lakes becoming more resilient to acid deposition in future years than during the baseline period.

4.6.4 Summary of Air Quality-Related Values Impacts

The visibility analysis for the CD-C Proposed Action Alternative predicts a total of 8 days with impacts > 0.5 dv and zero days > 1.0 dv due to the Proposed Action emissions over the course of the 2 year simulation throughout all the Class I and sensitive Class II areas. The areas with visibility impacts exceeding 0.5 dv are: Savage Run WA, Dinosaur NM and Mount Zirkel WA. The cumulative visibility analysis shows that: (1) visibility improves at all Class I and sensitive Class II areas in 2022 compared to 2008 for the Proposed Action Alternative on the 20% best and 20% worst days; and (2) average visibility impairment on the 20% best and 20% worst days due to Proposed Action Alternative and RFD emissions sources (combined) ranges from 0.01 to 0.18 dv, over the Class I and sensitive Class II areas. Improvement in visibility occurs due to region-wide emissions reductions unrelated to the CD-C Project alternatives.

For the No Action Alternative, zero days > 0.5 dv are predicted throughout the Class I and sensitive Class II areas over the two year simulation due to No Action Alternative emissions contributions to regional haze. The cumulative visibility results for the No Action Alternative are almost identical to the Proposed Action Alternative results.

The DAT for nitrogen was exceeded at 5 Class I or sensitive Class II areas near/downwind of CD-C Project Area due to emissions from the Proposed Action Alternative sources and at 4 areas due to emissions from the No Action Alternative. The DAT for sulfur was not exceeded at any Class I or sensitive Class II area due to either the Proposed Action Alternative or No Action Alternative emissions.

Cumulative nitrogen deposition in 2022 due to all regional emissions sources exceeds the 1.5 kg/ha/yr threshold at all Class I and sensitive Class II areas for both meteorological years. Sulfur deposition in 2022 due to all emissions sources exceeds the 3.0 kg/ha/yr threshold at Mount Zirkel WA, Rocky Mountain NP, and Dinosaur NM using 2006 meteorology but does not exceed the 3.0kg/ha/yr threshold at any area using 2005 meteorology.

There were no ANC changes exceeding the USFS LAC thresholds due to emissions from the Proposed Action Alternative sources or the No Action Alternative sources.

4.7 MID-FIELD IMPACTS

CAMx-estimated criteria pollutant impacts within the CD-C Project Area from Proposed Action Alternative sources, No Action Alternative sources, and all emissions sources are shown in Table 4-47. The purpose of the mid-field analysis is to supplement the AERMOD near-field analysis by providing CAMx-estimated impacts within the CD-C Project Area using the complete CAMx emissions inventory for CD-C Project emissions and cumulative emissions, since AERMOD impacts are based on emissions from a subset of CD-C Project sources. The mid-field analysis treats all CD-C sources during/near their year of maximum total emissions, and is intended to be a supplemental analysis that provides an additional ambient air quality standard compliance demonstration. The cumulative impacts resulting from all emissions sources are below the applicable ambient air quality standards and the isolated CD-C Project impacts are below the PSD Class II Increments.

Table 4-47. CD-C Project Area criteria pollutant modeling results.

Pollutant	Averaging Time	Modeled Concentration from CD-C Proposed Action Alternative Sources[2]	Modeled Concentration from CD-C No Action Alternative Sources[2]	Modeled Concentration from All Sources	PSD[1] Class II Increment	WAAQS	NAAQS
CO ($\mu g/m^3$)	1-hour	--[3]	--[3]	715.0	n/a	40,000	40,000
	8-hour	--[3]	--[3]	408.7	n/a	10,000	10,000
NO_2 ($\mu g/m^3$)	1-hour	44.2	20.1	65.8	n/a	n/a	188
	Annual	6.4	2.9	13.8	25	100	100
O_3 (ppb)	8-hour	2.6	1.2	72.9	n/a	75	75
SO_2 ($\mu g/m^3$)	1-hour	0.02	0.01	49.5	n/a	n/a	196
	3-hour	0.02	0.01	30.5	512	1,300	1,300
	24-hour	0.01	0.00	14.4	91	260	365
	Annual	0.003	0.001	2.5	20	60	80
PM_{10} ($\mu g/m^3$)	24-hour	7.3	3.3	55.8	30	150	n/a
	Annual	2.5	1.1	7.6	17	50	50
PM_{25} ($\mu g/m^3$)	24-hour	2.1	0.9	8.4	9	n/a	35
	Annual	0.5	0.2	3.8	4	n/a	12

[1] The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis

[2] NO_2 1-hour concentration is 8th highest daily maximum 1-hour concentration. CD-C Project source results include contribution from NO

[3] No value is given for the CD-C Project source CO concentration contributions because the CAMx source apportionment tool does not track CO.

5.0 Summary of CD-C Air Quality Impact Analysis

In this Section, we summarize the results of the CD-C Air Quality Impact Analysis.

5.1 SUMMARY OF NEAR-FIELD MODELING RESULTS

Air quality impacts resulting from the CD-C Project production activities would be in compliance with the National Ambient Air Quality Standards (NAAQS) and Wyoming Ambient Air Quality Standards (WAAQS), and would not exceed the Prevention of Significant Deterioration (PSD) Class II Increments.

CD-C Project field development activities would be in compliance with the NAAQS and WAAQS, however well pad construction and well drilling activities could result in elevated 1-hour NO_2 concentration impacts and 24-hour $PM_{2.5}$ concentration impacts that are above the level of the 1-hour NO_2 NAAQS and WAAQS, 24-hour $PM_{2.5}$ NAAQS and WAAQS, and 24-hour PM_{10} WAAQS, at areas immediately adjacent to these activities.

5.2 SUMMARY OF FAR-FIELD MODELING RESULTS

CD-C Proposed Action Alternative emissions make no significant contribution to modeled exceedances of the NAAQS for ozone or any other criteria pollutant in the 2022 future year. The MATS-estimated CD-C Proposed Action Alternative maximum impact on the 2022 DVF is less than or equal to 0.8 ppb for both meteorological years. The two year approximation to a 2022 design value obtained using absolute model concentrations shows the CD-C Proposed Action Alternative maximum ozone impact is 1.7 ppb. For both the absolute modeled concentration and MATS results, the largest ozone impacts due to the CD-C Proposed Action Alternative emissions are in the vicinity of the CD-C Project Area. In Sublette County, where the only exceedance of the 75 ppb NAAQS occurs, ozone impacts due to the CD-C Proposed Action Alternative are less than or equal to 0.04 ppb.

Air concentrations attributable to Proposed Action Alternative emissions sources did not exceed the PSD increments at any Class I or sensitive Class II area, using 2005 or 2006 meteorology.

Air pollutant concentrations due to the No Action Alternative emissions are always lower than those due to the Proposed Action Alternative emissions. Consequently, the No Action Alternative emissions do not significantly contribute to exceedances of the ambient air quality standards nor do they ever exceed the PSD increments.

For all pollutants except ozone, the modeling results show attainment throughout the 4 km domain except in the immediate vicinity of point sources unrelated to the CD-C Project. Exceedances of the CO, and PM_{10} standards are the result of impacts from 2005 fire in Lincoln County, and the SO_2 exceedances are highly localized and due to emissions from a Fremont County source and a source in western Sweetwater County. The ozone exceedance occurs at Boulder, WY where CD-C has no significant contribution to ozone concentrations.

Examination of the spatial extent and magnitude of the CD-C Proposed Action Alternative and No Action Alternative contributions to criteria pollutant concentrations within the 4 km grid shows that none of the exceedances of the ambient air quality standards in the 2022 future year modeling have significant contributions from emissions from the CD-C Project Alternatives.

The visibility analysis for the CD-C Proposed Action Alternative predicts a total of 8 days with impacts > 0.5 dv and zero days > 1.0 dv due to the CD-C Proposed Action emissions over the course of the 2 year simulation. The areas with visibility impacts exceeding 0.5 dv are: Savage Run WA, Dinosaur NM and Mount Zirkel WA. The cumulative visibility analysis shows that: (1) visibility improves at all Class I and sensitive Class II areas in 2022 compare to 2008 for the Proposed Action Alternative on the 20% best and 20% worst days; and (2) average visibility impairment on the 20% best and 20% worst days due to Proposed Action Alternative and RFD emissions sources (combined) ranges from 0.01 to 0.18 dv, over the Class I and sensitive Class II areas.

For the No Action Alternative, zero days > 0.5 dv are predicted throughout the Class I and sensitive Class II areas over the two year simulation due to No Action Alternative emissions contributions to regional haze. The cumulative visibility results for the No Action Alternative are almost identical to the Proposed Action Alternative results.

The DAT for nitrogen was exceeded at 5 Class I or sensitive Class II areas near/downwind of CD-C Project Area due to emissions from the Proposed Action Alternative sources and at 4 areas due to emissions from the No Action Alternative. The DAT for sulfur was not exceeded at any Class I or sensitive Class II area for either the Proposed Action Alternative or No Action Alternative.

Cumulative nitrogen deposition in 2022 due to all emissions sources exceeds the 1.5 kg/ha/yr threshold at all Class I and sensitive Class II areas for both meteorological years. Sulfur deposition in 2022 due to all emissions sources exceeds the 3.0 kg/ha/yr threshold at Mount Zirkel WA, Rocky Mountain NP, and Dinosaur NM using 2006 meteorology but does not exceed the 3.0kg/ha/yr threshold at any area using 2005 meteorology.

There were no ANC changes exceeding the USFS LAC thresholds due to emissions from Proposed Action Alternative sources or the No Action Alternative sources.

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