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 and H.

2.1 CD-C PROJECT EMISSION INVENTORY

Emission inventories were developed for the air quality impact assessment for all new sources proposed under the CD-C Project Proposed Action 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 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. 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 Proposed Action wells.

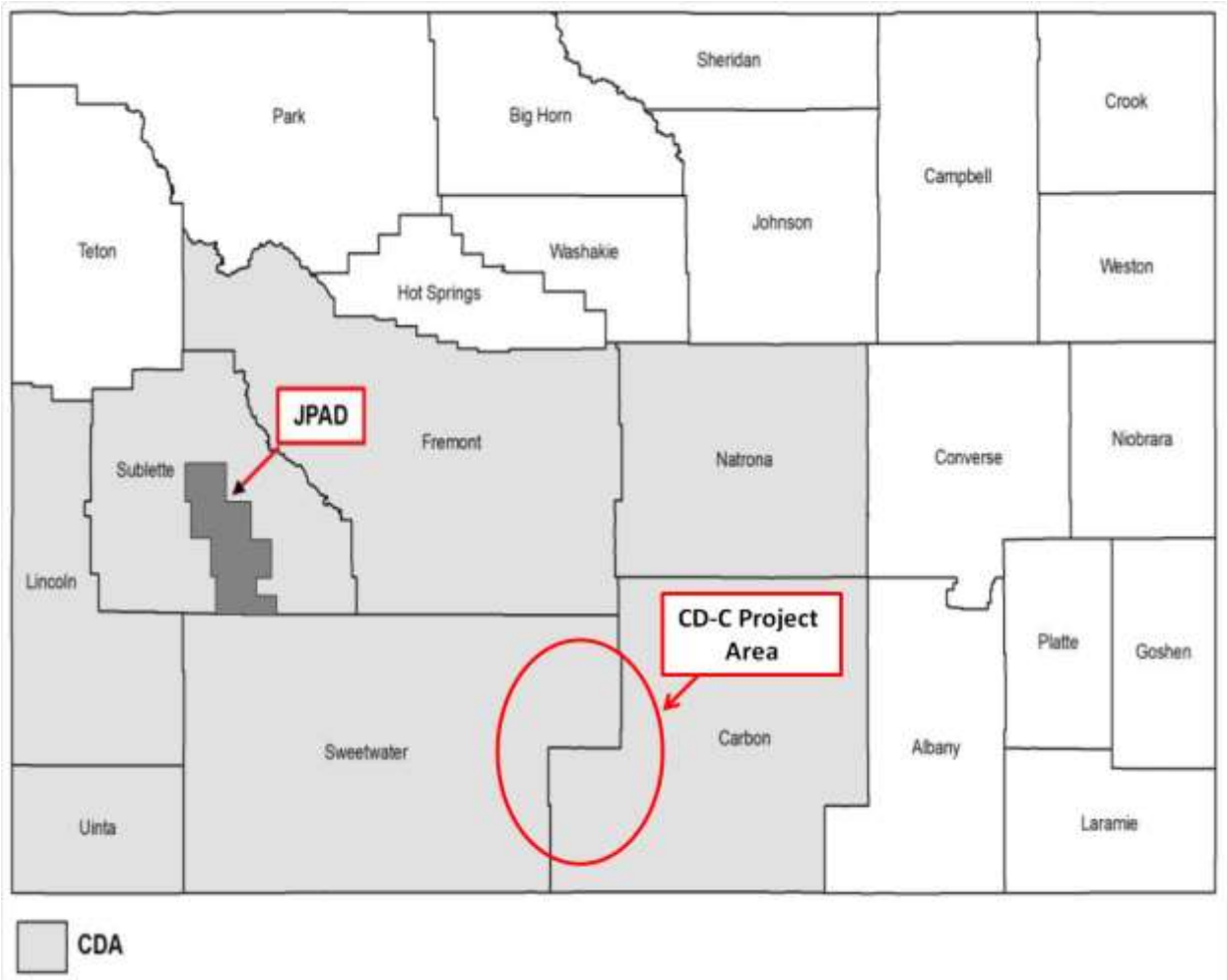

Figure 2-1. The Concentrated Development Area (from WDEQ-AQD, 2010).

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.

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 250 years, and far exceeds pre-industrial values determined from ice cores spanning many thousands of years (IPCC, 2007).

The Intergovernmental Panel on Climate Change (IPCC) has determined 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 (IPCC, 2007). The IPCC further concluded that, "continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century." 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 IPCC 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. 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 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 emission inventory was developed using data provided by the CD-C Operators as the primary source of information. The inventory accounted for all applicable emissions controls 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. In the detailed calculations shown in

Appendix H, we indicate the origin of the input data and how these data were used in the emissions estimates.

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

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.

Emissions were estimated on a per event (new well pads) basis for a given engine type 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 from well pad construction equipment by pollutant were estimated from the total per event engine emissions ($E_{engineTOTAL,i} = \sum_k E_{engine\ k,i}$) 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 vehicles traveling on publicly accessible unpaved roads were 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

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 emission factor including the effect of natural mitigation via precipitation [lb/mile]
EF is the uncontrolled emission factor [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): $$P = 0 \qquad for \qquad (u^* \leq u_t)$$

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 engine exhaust and fugitive emissions from traffic and emission from completion equipment engines. There will 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 similar; 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 0 emission factors were used for NO_X, VOC, CO, PM_{10} and $PM_{2.5}$ (EPA, 2004). For drilling equipment, an average of the EPA NONROAD model fully deteriorated Tier 0 emission factors and Tier 2 standard emission factors was 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.

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 ($E_{engineTOTAL,i} = \sum_k E_{engine\ k,i}$) 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]
$Eflare_{CO2}$ are 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 0 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 Appendix H.

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 ($E_{engineTOTAL,i} = \sum E_{engine\ k,i}$) 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 46:

Equation (46): $$E_{well\ venting,\ i} = E_{venting,\ i} \times S_{well\ count}$$

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]
$E\ source\ flare_{CO2}$ are 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): $$E_{engine,i} = \frac{EF_i \times HP \times LF \times t_{annual}}{907{,}185}$$

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:

$E_{gas\ plant/source,\ i}$ are the annual gas plant emissions of pollutant i per source [tons/yr]
$E_{source,\ i}$ 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. Ratios of CO_2 to VOC and CH_4 to VOC weight fractions from the produced gas were applied to VOC emissions 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 62:

Equation (62): $$E_{evap.ponds,\ i} = E_{average,\ i} \times S_{well\ count}$$

where:

$E_{evap.ponds,\ i}$ are 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 Emissions Summaries

In this sub-section, we present emissions plots and tables summarizing the CD-C Project emissions over the LOP. Figure 2-2 shows drilling activity and total well count for new CD-C Project wells and wells classified as existing that either were drilled or were already producing in the CD-C Project Area as of 2008. These existing wells are not part of the CD-C Proposed Action, but are accounted for in the modeling because they are in the CD-C Project Area. Drilling of new CD-C wells under the Proposed Action begins in the year 2009. Existing wells are drilled in 2008, but drilling of existing wells does not occur after 2008.

The count of 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 reaches its peak in 2023 and then declines for the remainder of the LOP as well abandonment occurs.

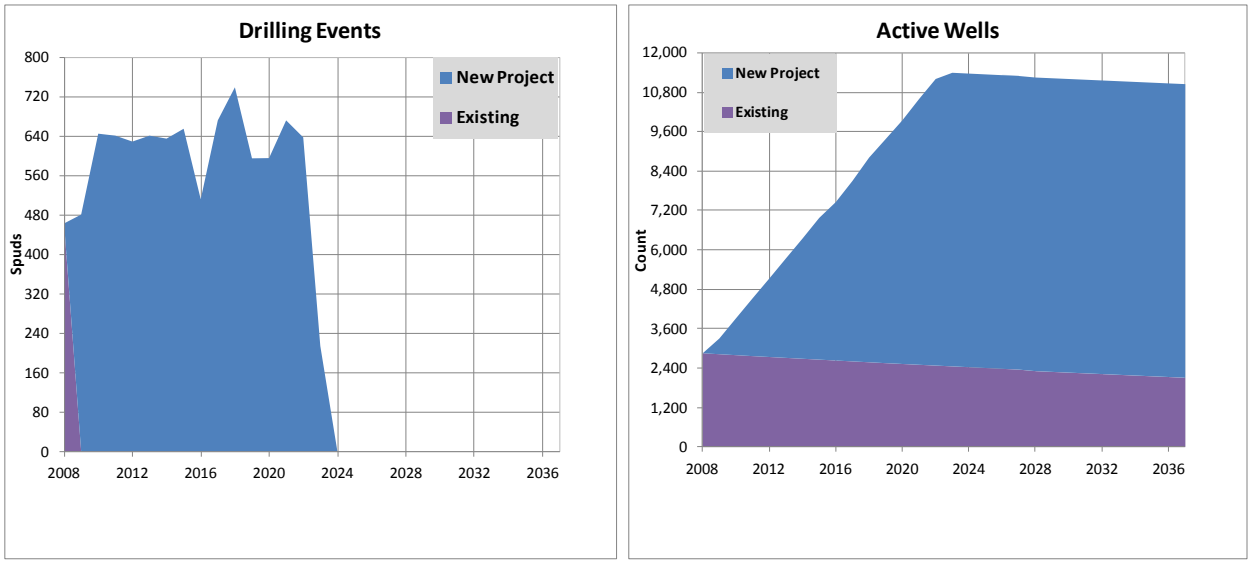

Figure 2-2. Number of CD-C Project Area wells drilled (spuds) in each year over the LOP (left panel) and number of active wells in each year over the LOP (right panel).

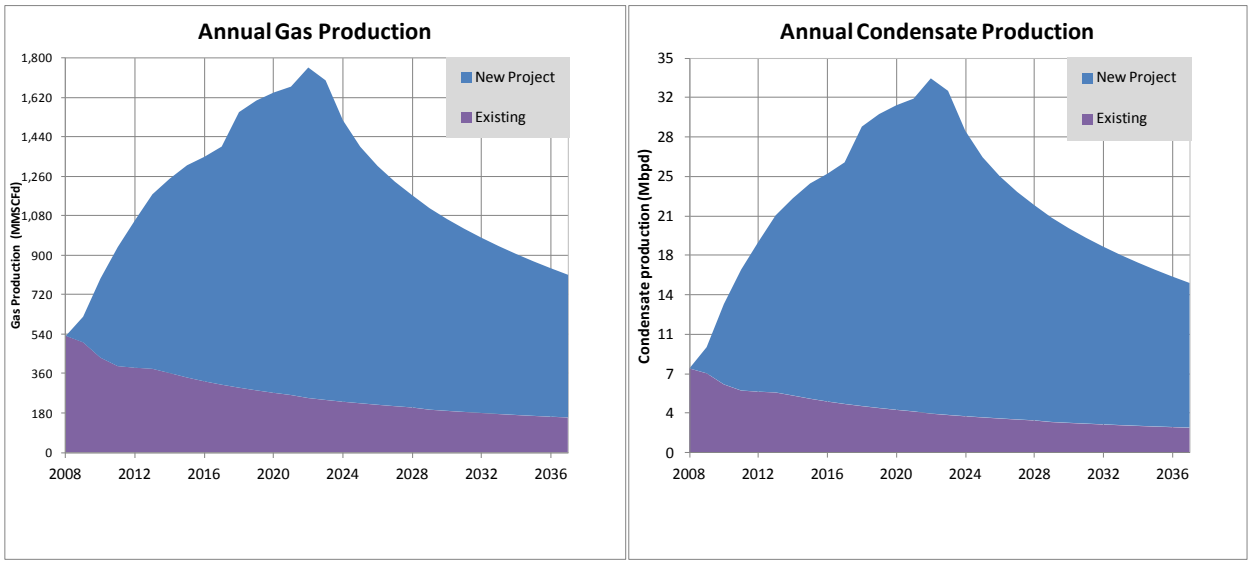

Figure 2-3. Yearly gas (left panel) and condensate (right panel) production of CD-C Project Area wells over the LOP.

The field-wide CD-C Project Area gas and condensate production from existing and new CD-C Proposed Action 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 the new CD-C Proposed Action 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 are shown in Figure 2-4. NO_X emissions show the impact of drilling/completion activities, with peak values coming during the time when new CD-C Proposed Action 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 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 declines.

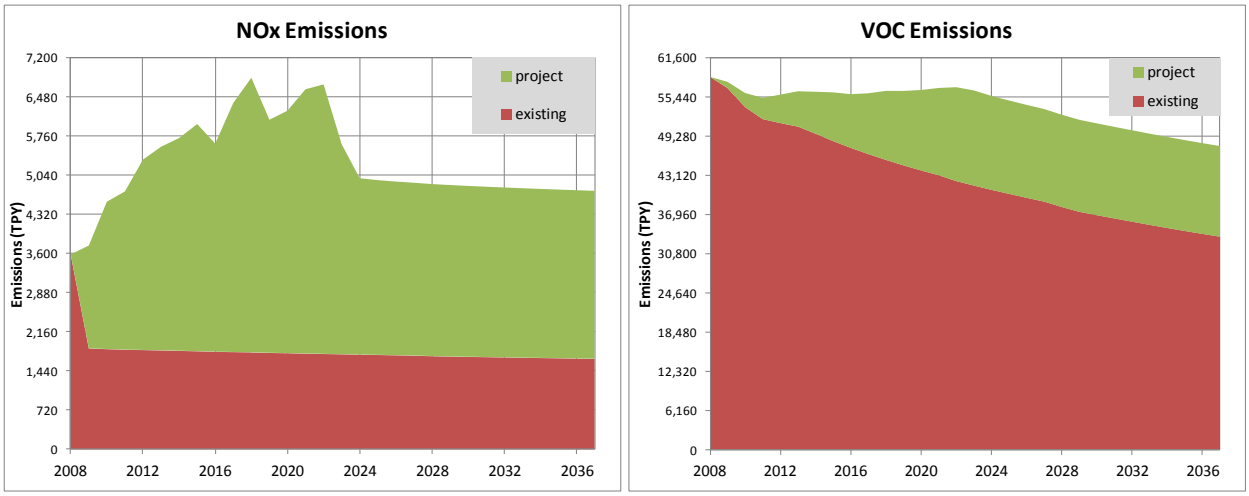

Figure 2-4. Field-wide NO_X and VOC Emissions from Existing and new CD-C Proposed Action Wells Over the LOP.

VOC emissions are influenced more strongly by production sources than 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 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 emissions by source category. Note that data shown here represent emissions from both new and existing wells for each category. 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.

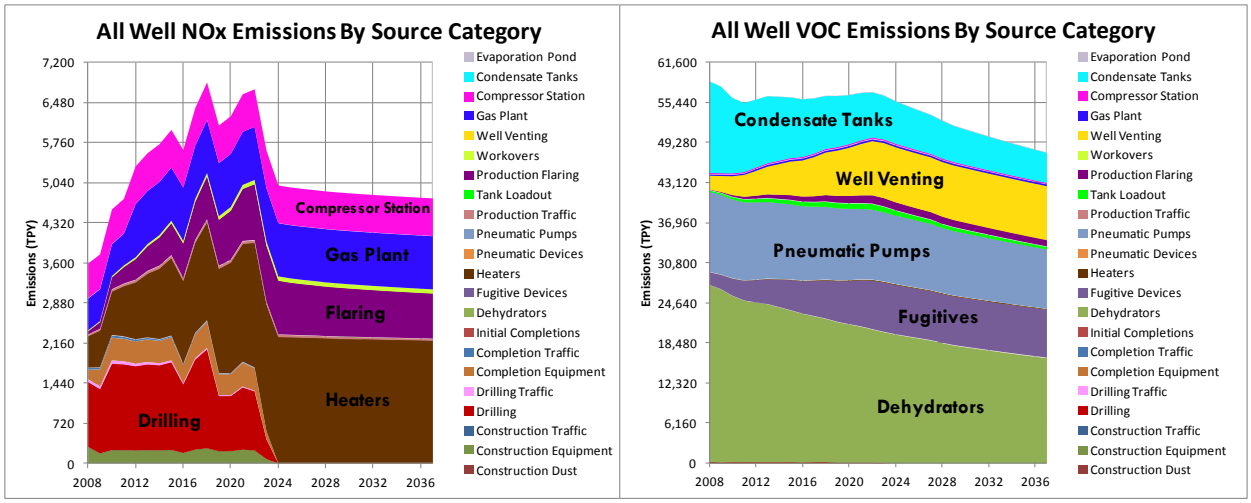

Figure 2-5. NO_X (left panel) and VOC (right panel) Emissions From all CD-C Project Area Sources Over the LOP.

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, 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. 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.

The year 2022 was selected for the future year impact analysis. This is the year when the NO_X and VOC emissions from the Proposed Action taken together are at their peak. 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), so the only years considered for future year modeling were the years 2018 and 2022, which are the two peak NO_X emissions years shown in Figures 2-5 and 2-6. Because VOC emissions from the new wells are significantly higher in 2022, 2022 is expected to be the year of peak ozone impacts from the Proposed Action, and so was selected for future year modeling.

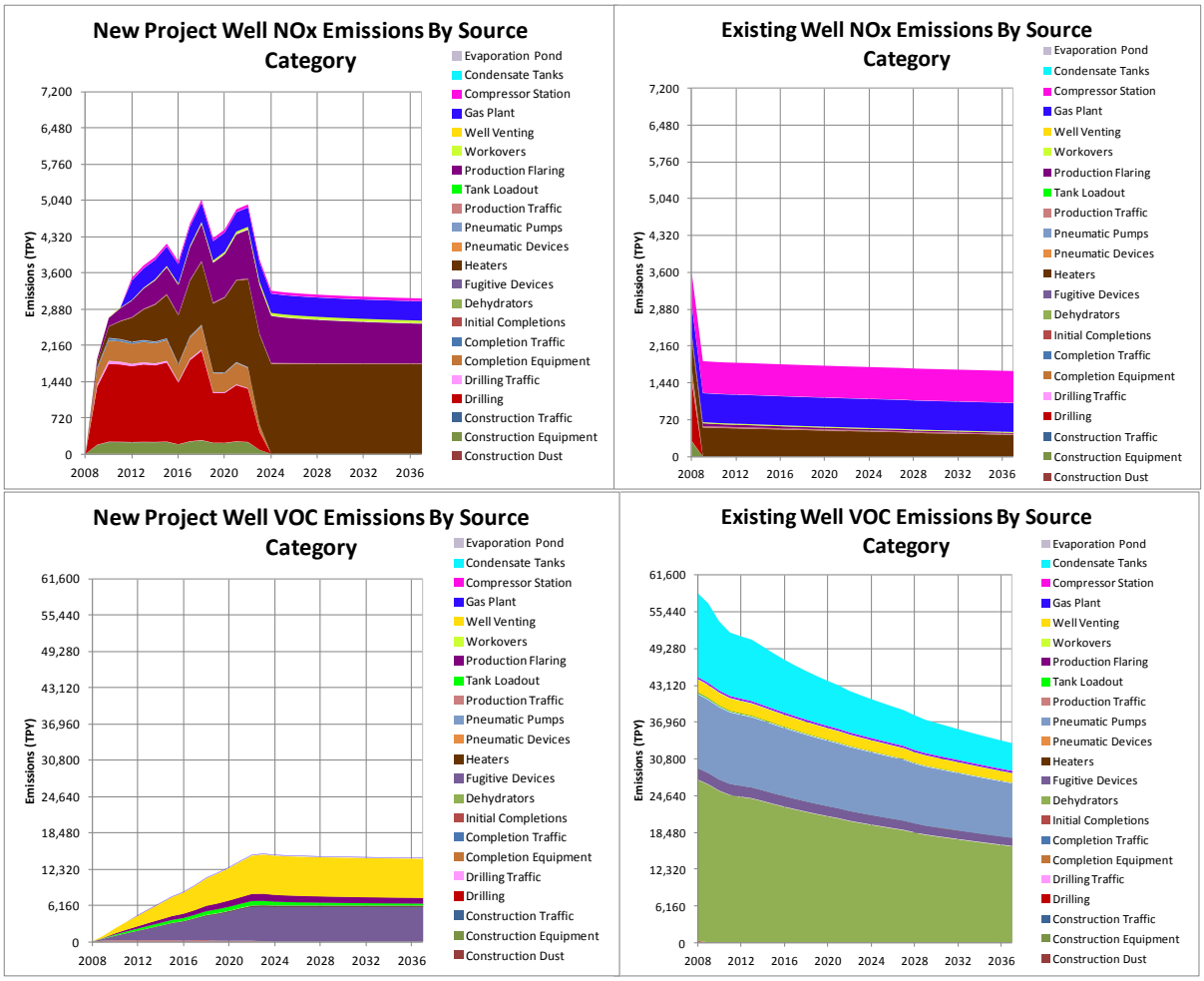

Figure 2-6. NO_X and VOC Emissions From new and existing CD-C Project Area Sources Over the LOP.

Figure 2-7 shows the field-wide emissions of SO_2 and CO over the LOP. 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. 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.

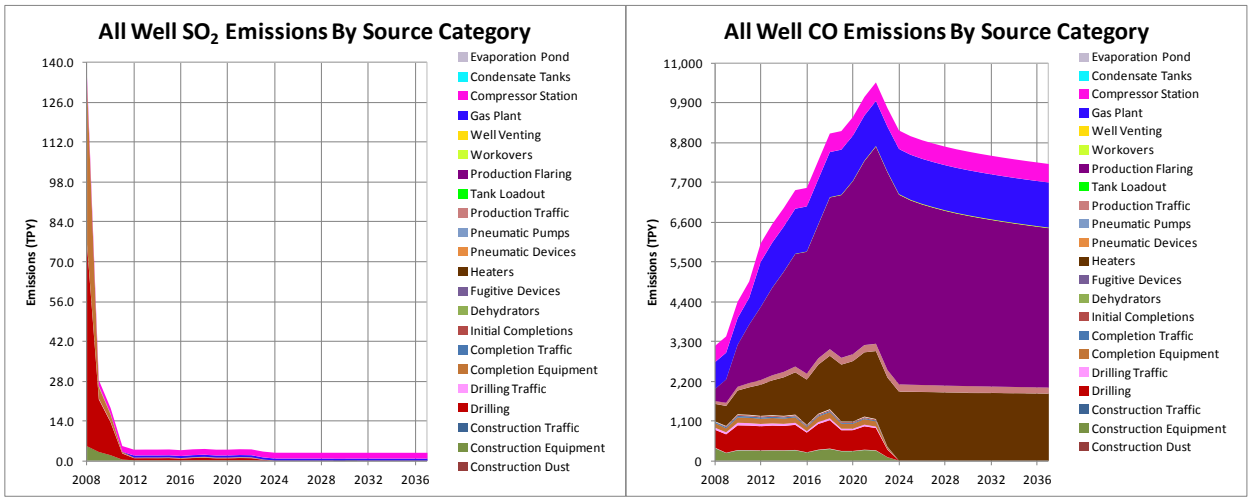

Figure 2-7. SO_2 (left panel) and CO (right panel) Emissions From all CD-C Project Area Sources Over the LOP.

PM emissions are shown in Figure 2-8. As with CO, emissions of PM result from both the development and production phases of the Project. 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 drilling emissions contribute during the drilling phase of the Project.

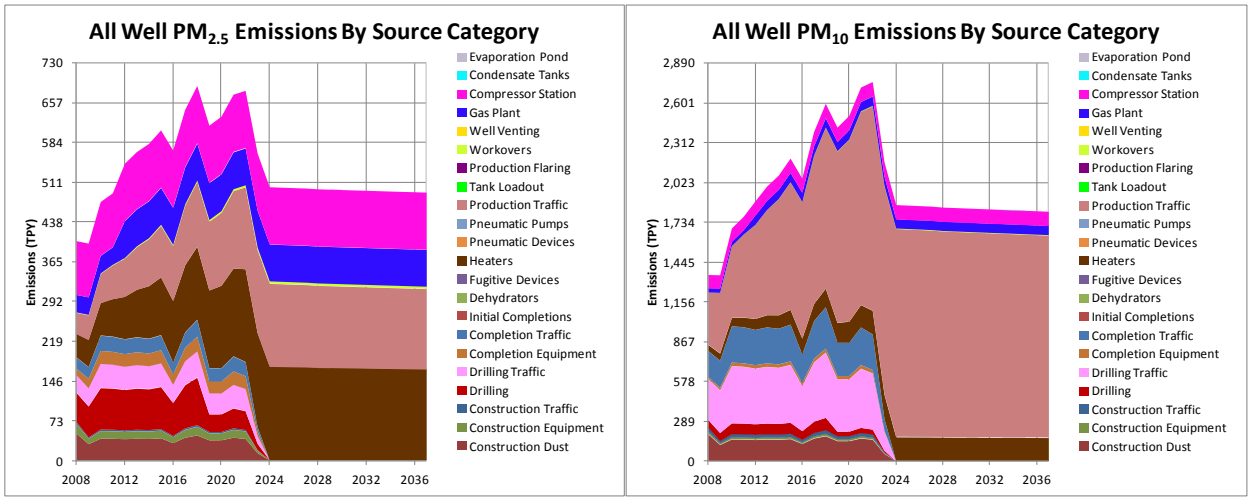

Figure 2-8. $PM_{2.5}$ (left panel) and PM_{10} (right panel) emissions from all CD-C Project Area Sources Over the LOP.

2.1.5 Hazardous Air Pollutant Emission Inventory

An emission inventory for hazardous air pollutants (HAPs) was developed for use in the near-field modeling.

2.1.5.1 BTEX and n-Hexane

Figure 2-9 shows emissions of benzene, ethyl benzene, toluene, xylenes (BTEX) and n-hexane for all new and existing sources over the LOP. BTEX emissions are dominated by emissions from dehydration at existing wells (Figure 2-10). Condensate tanks, pneumatic pumps, fugitive devices and well venting are also sources of BTEX emissions, albeit much smaller than dehydration. Dehydration also contributes a substantial fraction of the total n-hexane emissions, but other source categories such as fugitives, well venting, condensate tanks and pneumatic pumps are also sizable contributors.. Figure 2-10 indicates that most of the emissions of HAPs are from existing wells rather than new wells. This is because the HAP emissions are scaled from new and existing well VOC emissions, and the VOC emissions are highly controlled for new wells, and less controlled for existing wells.

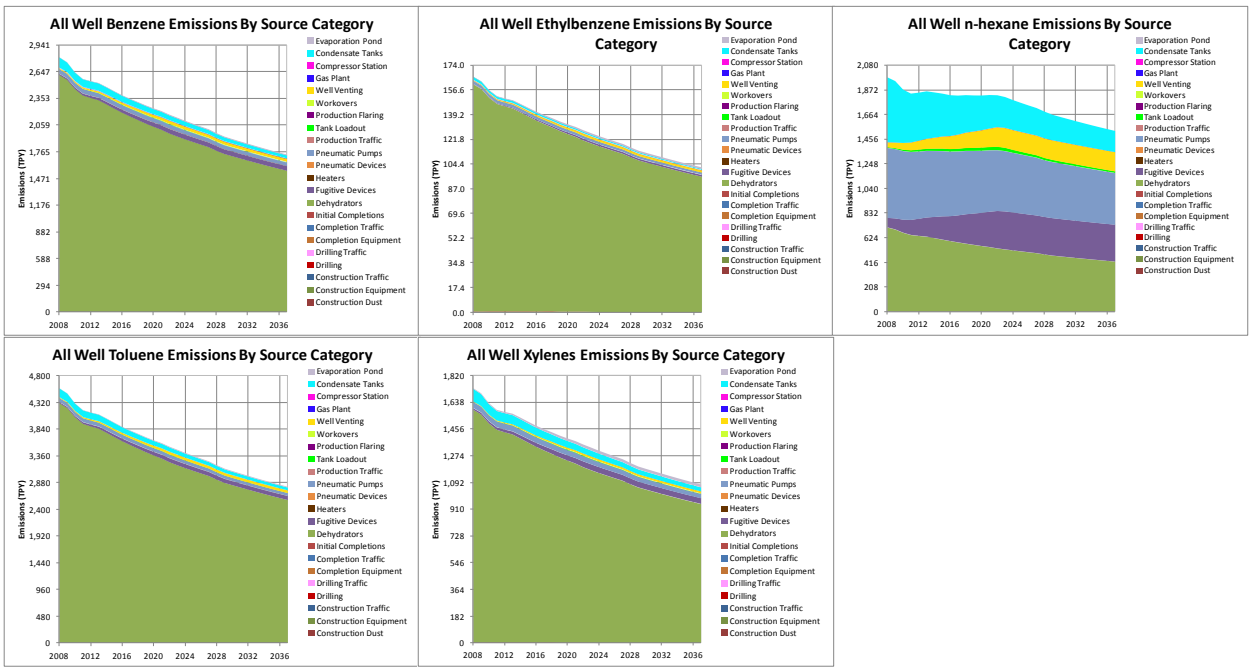

Figure 2-9. HAPs (right panel) emissions from all CD-C Project Area Sources Over the LOP broken out by emission source category.

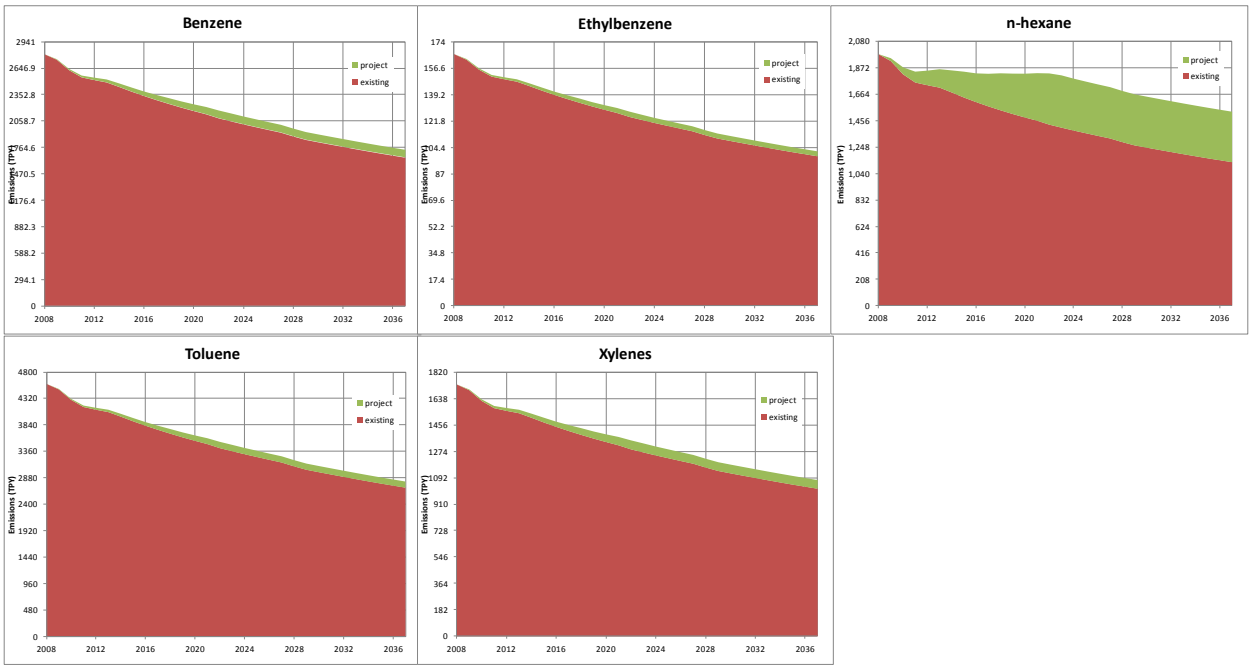

Figure 2-10. HAPs (right panel) emissions from all CD-C Project Area Sources Over the LOP showing contributions broken out by new and existing sources.

2.1.5.2 Formaldehyde

Emissions of formaldehyde for all CD-C Project area wells and for new and existing wells are shown in Figure 2-11. For existing wells, the largest sources of formaldehyde emissions are gas plants and compressors. For new wells, 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 2-12 shows that nearly all of the formaldehyde emissions occur during the production phase of the Project. Therefore the formaldehyde emissions from existing wells decline slowly over time, while formaldehyde emissions from new sources increases until the year of peak productions and then slowly decreases thereafter.

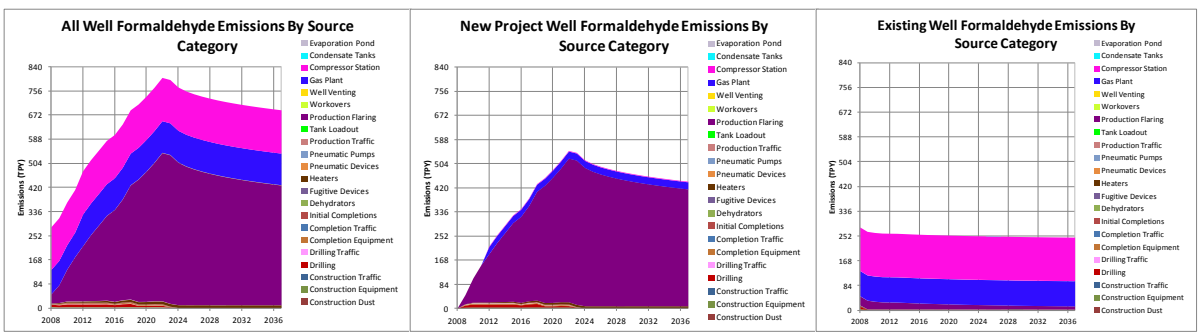

Figure 2-11. Formaldehyde from all CD-C Project Area Sources (left panel), new Proposed Action sources (center panel) and from existing sources (right panel) over the LOP broken out by source category.

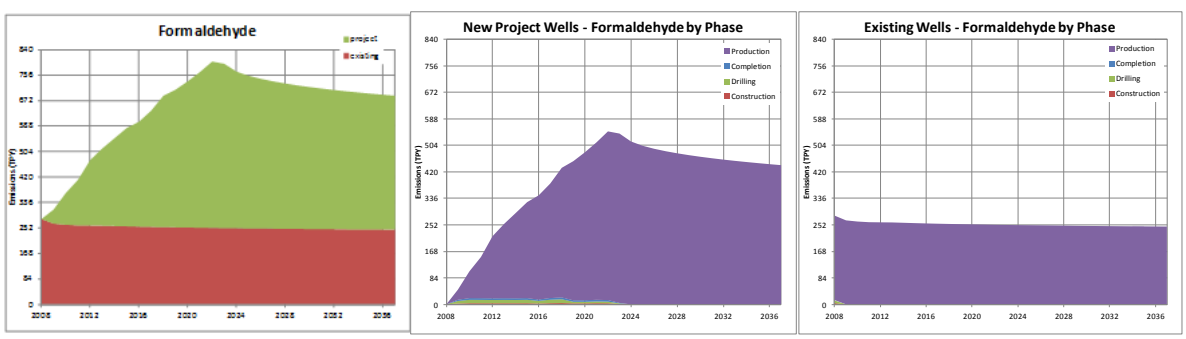

Figure 2-12. Formaldehyde from all CD-C Project Area Sources broken out by new and existing sources (left panel), new Proposed Action sources emissions by phase (center panel) and from existing sources by phase (right panel) over the LOP.

2.1.6 Greenhouse Gas Emission Inventory

In the CD-C Project emission inventory, emissions of the 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 are shown in Figure 2-13.

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 Project's 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 Project 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 Project 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).

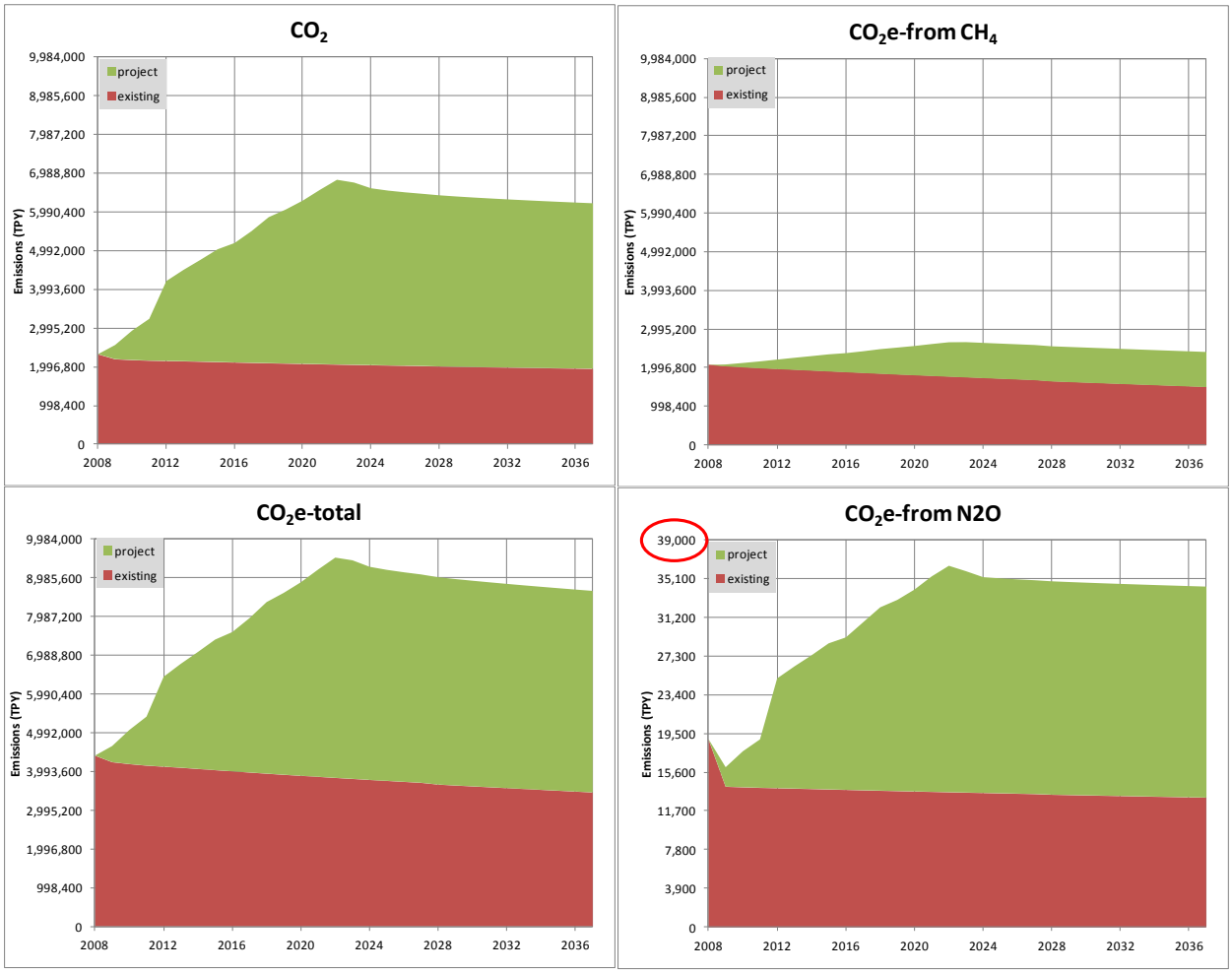

Figure 2-13. CD-C Project Area greenhouse gas emissions over the LOP. Upper left panel: CO_2, Upper right panel: CH4 emissions shown as CO_2 equivalents, Lower left panel: Total greenhouse gas emissions shown as CO_2 equivalents, Lower right panel: N_2O emissions shown as CO_2 equivalents. Note that when N_2O is plotted on the same scale as CO_2 and CH_4, the N_2O data are not visible, so N_2O is plotted on a different scale from the other three plots shown in this figure.

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 (Figures 4-1 through 4-3) 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 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 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 projected from the 2002 WRAP inventory, i.e., linearly interpolated from 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 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 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.

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 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 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
- Paradox 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 2006 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.

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, the year of maximum NO_X emissions from the CD-C Project Area. The WRAP 2018 inventory was used as a starting point and all non-oil and gas sources were projected or interpolated to the 2022 modeling year except: ammonia, wind-blown dust, biogenics, and fires. These 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). RFD emissions were based on recent and ongoing NEPA analyses performed within the 4 km grid region of the 36/12/4 km 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 was 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 next section.

Full development of proposed projects inventoried as RFD may or may not coincide with full development of the Project. As a result, the assumption that all RFD are fully developed during the maximum year of project development may result in some 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 because these sources are already included in the WRAP 2018 inventory.

2.3 SMOKE PROCESSING OF EMISSION INVENTORIES

Once the emission inventories were prepared, they were processed for use in CAMx using an emissions model. CAMx requires emissions of NO_X, VOC, SO_2, CO and PM and its precursors from all sources as well as specification of the transport of pollutants from outside of the modeling domain (i.e., boundary conditions, or 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 www.cmascenter.org) was used to generate the hourly, gridded, speciated model-ready emissions inputs for CAMx. SMOKE was used in the WRAP, VISTAS and CENRAP RPO regional haze modeling and is being used in the Denver 8-hour ozone SIP and Four Corners Air Quality Task Force modeling. SMOKE was used to generate 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.

2. EMISSION INVENTORIES

The purpose of emissions processing is to format the emission inventory ready for CAMx photochemical modeling. 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, 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: 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

The future-year modeling runs consist of two annual CAMx runs. Both annual simulations were performed with the future-year emission inventory; one simulation was run with 2005 meteorology and the other simulation was run with 2006 meteorology. The Sparse Matrix Operating Kernel Emissions (SMOKE; Coats, 1996a; Coats and Houyoux, 1996b) emissions modeling system (available from www.cmascenter.org) was used to generate the hourly, gridded, speciated model-ready emissions inputs for CAMx. SMOKE was applied for the area, off-road mobile, onroad mobile source categories and for point sources.

In the CD-C Proposed Action, peak production activity would occur in 2022. Hence, the future-year modeled is 2022 for the Proposed Action alternative. 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. The most recent WRAP emission databases currently available are the “2018 PRP18b” emissions databases. 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). The MOBILE6 module of SMOKE was used to develop the on-road mobile source emissions. O&G emissions for Wyoming were obtained from the 2008 baseline emissions modeling and from WRAP O&G inventories everywhere else in the 12 km domain. 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 of travel (VMT) estimates were combined with gridded, episode-specific temperature data to obtain the gridded, temporally allocated emission estimates for weekday, Saturday, and Sunday. Vehicle Miles Travelled (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.

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

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 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. All wells within Wyoming were modeled as point sources: there are no gridded oil and gas emissions within Wyoming.

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

Gridded area source emissions for oil and gas sources within the 12 km domain but outside Wyoming were obtained from the 2012 (Uinta Basin) and 2015 (Denver-Julesburg & Piceance Basins) WRAP Phase III inventories in the basins covered by this inventory and from 2018 WRAP Phase II inventories elsewhere. Although the WRAP Phase III inventory now covers additional basins within the 12 km domain, only the Uinta, Piceance and D-J Basin emission inventories 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 (and therefore modeled as point sources) because of Colorado's requirement that sources with NO_X emissions greater than 2 tpy report emissions to the State. In Utah (Uinta Basin), compressor station and gas plants were included in the point inventory. All other sources were modeled as gridded area sources. O&G point source emissions outside of Wyoming and WRAP Phase III basins were obtained from the WRAP PRP18b inventory.

SMOKE ancillary files from the 2008 baseline emissions modeling were used for speciation, spatial & temporal allocation.

2.3.1.4 RFD Emissions

Emissions from Reasonably Foreseeable Development (RFD) emissions sources were based on recent and ongoing NEPA analyses performed within the 4 km 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 contractors working 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.

Full development of proposed projects inventoried as RFD may or may not coincide with full development of the Project. As a result, the assumption that all RFD are fully developed during the maximum year of project development results in some conservatism in the cumulative impact analysis. A listing and emissions summary of the RFD projects that were included in this study, as defined in the paragraph above, is presented in Table 2-6.

The emission inventory for the Hiawatha Proposed Action was developed during the year 2009. Therefore, it does not account for the effect of the 2010 Wyoming Oil and Gas Permitting Guidance BACT rules on future year wells associated with the Proposed Action. Because of the lack of emissions controls on these future year wells, the Hiawatha Proposed Action inventory overestimates emissions from these future year wells. This overestimate of emissions will artificially increase the background reactivity of the atmosphere. Because the CD-C Project Area lies relatively close to and is frequently downwind of the Hiawatha Project Area, this overestimate of Hiawatha emissions will tend to cause the model to overestimate ozone formation from the CD-C Project. The magnitude of this overestimate is uncertain, but is likely to be small.

The Gun Barrel-Madden Deep-Iron Horse Project emission inventory was developed in 2009. Although this emission inventory has been updated to include the effects of the 2010 Wyoming BACT rules, the project is currently being redefined and re-scoped as the Moneta Divide project. It is not clear whether the use of the GMI Project emission inventory represents an under- or overestimate of the re-scoped Project's emissions. Since the GMI Project area is relatively distant from the CD-C Project Area and is generally downwind of CD-C, the effects of using this GMI Project emission inventory is likely small.

Table 2-6. RFD Emissions for the 4 km grid for 2022.

RFD Source	Modeled Emissions (tpy)				
	NOx	VOC	CO	SO2	PM2_5
Moxa Arch Existing Wells	1,519	16,444	1,152	1	75
Moxa Arch Preferred Alternative	1,257	2,099	2,002	0	131
Moxa Arch ROD Wells	63	166	123	0	6
Beaver Creek	68	228	60	1	11
Eagle Prospect	409	196	395	5	97
Gun Barrel-Madden Deep-Iron Horse	850	3,700	2,085	1	160
Pinedale	1,381	2,286	1,250	53	79
Hiawatha Proposed Action	2,157	15,904	915	85	3,398
Jonah	1,099	2,705	686	62	28

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

Non-O&G area sources and off-road mobile were obtained from the latest WRAP 2018 (PRP18b) emission inventories. SMOKE ancillary files from 2018 WRAP modeling were used for speciation, spatial & temporal allocation.

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 Area emissions for the Proposed Action and existing sources were processed through SMOKE to prepare model-ready emissions input for CAMx. The peak year project emissions were speciated into CB05 lumped species, temporally allocated into hourly flux and spatially distributed throughout the CD-C project area for modeling. The peak emissions year for the Proposed Action alternative was 2022. The project emissions inventory was estimated for two separate source groups - existing sources and new proposed sources. The existing source grouping consists of existing wells, gas plants and compressor stations. The proposed new sources consist of sources that would be constructed as part of the 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 (only available for SW Wyoming basin)
    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 2-7 below provides list of sources categories and SCC assignments.

Table 2-7. 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
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:

Source Categories	SCC	SCC Description
		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 Flaring	2310024300	Industrial Processes, Oil and Gas Production, Natural Gas, 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	20200254	Internal Combustion Engines, Industrial, Natural Gas, 4-cycle

Source Categories	SCC	SCC Description
(Reciprocating Engine Lean Burn)		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 2-8 below provides the linkage between source categories and speciation profiles.

Table 2-8. 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

Temporal: 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 are summarized in Table 2-9. This emission table was compiled from SMOKE output reports and represents the model-ready emission inputs.

Table 2-9. CD-C Proposed Action project Emission Summary for year 2022 (tpy).

Source Grouping	Source Categories		
	Compressor	Production	Spuds
NO_X			
CD-C Proposed Action - Existing Sources	1,055	702	0
CD-C Proposed Action - New Sources	293	2,962	1,704
CO			
CD-C Proposed Action - Existing Sources	1,024	828	0
CD-C Proposed Action - New Sources	382	7,153	1,087
TOG			
CD-C Proposed Action - Existing Sources	1,761	232,068	0
CD-C Proposed Action - New Sources	99	65,752	131
SO_2			
CD-C Proposed Action - Existing Sources	2	0	0
CD-C Proposed Action - New Sources	0	1	1
PM			
CD-C Proposed Action - Existing Sources	123	79	0
CD-C Proposed Action - New Sources	33	370	72

2.4 EMISSION SUMMARY TABLES FOR FAR-FIELD MODELING

Tables 2-10 through 2-15 summarize the emission inventories for 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 2-10 through 2-15, oil and gas emissions are further broken down into drilling, compressor engine, and production emissions. The tables contain emissions for all portions of Wyoming, Colorado, Utah, and Idaho that are within the 4 km modeling domain. The 5

counties in Southwest Wyoming covered by the BP-Carter Lake oil and gas emission inventory are broken out separately from the rest of Wyoming in all of the tables.

Note that in Tables 2-10 and Table 2-11, which are for the 2008 baseline year, there are no emissions for either CD-C (refers to Proposed Action) or the RFD sources. In Tables 2-14 and 2-15, 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. 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 2-10. 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**
Carbon Co, Wyoming	1,172	857	9,378	3,849	0	650	2,675
Lincoln Co, Wyoming	1,144	2,125	5,011	2,533	579	328	1,970
Sublette Co, Woming	4,428	723	2,680	3,400	20	84	5,525
Sweetwater Co, Wyoming	3,178	1,795	16,678	4,447	2,725	14,793	4,579
Uinta Co, Wyoming	590	1,313	7,498	3,004	0	103	73
Wyoming (rest)	1,802	7,029	30,318	19,110	15	1,416	11,965
RFD	0	0	0	0	0	0	0
CDC Project	0	0	0	0	0	0	0
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**
Carbon Co, Wyoming	2,615	564	1,155	4,098	0	622	94
Lincoln Co, Wyoming	2,269	1,040	640	1,731	14,494	1,415	73
Sublette Co, Woming	7,611	121	344	507	204	104	259
Sweetwater Co, Wyoming	5,379	1,353	1,973	6,995	23,803	11,185	217
Uinta Co, Wyoming	793	409	906	2,256	0	46	10
Wyoming (rest)	2,969	3,647	3,543	3,507	27	1,441	576
RFD	0	0	0	0	0	0	0
CDC Project	0	0	0	0	0	0	0
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**
Carbon Co, Wyoming	158,425	1,535	700	770	0	1,329	6,807
Lincoln Co, Wyoming	168,336	1,470	428	551	121	79	807
Sublette Co, Woming	183,876	554	228	1,015	194	45	17,315
Sweetwater Co, Wyoming	361,812	4,515	1,266	780	757	18,520	13,647
Uinta Co, Wyoming	42,332	1,644	591	400	0	148	70
Wyoming (rest)	212,625	8,846	2,543	2,299	6	2,615	42,181
RFD	0	0	0	0	0	0	0
CDC Project	0	0	0	0	0	0	0
PM10							
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**
Carbon Co, Wyoming	101	8,729	32	192	0	268	75
Lincoln Co, Wyoming	80	3,221	19	96	6,541	1,348	203
Sublette Co, Woming	152	5,273	10	64	3	34	370
Sweetwater Co, Wyoming	89	13,067	54	277	3,047	12,436	94
Uinta Co, Wyoming	4	1,570	25	105	0	54	8
Wyoming (rest)	99	21,106	100	244	7	600	282
RFD	0	0	0	0	0	0	0
CDC Project	0	0	0	0	0	0	0
SO2							
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**
Carbon Co, Wyoming	60	332	7	85	0	1,102	5
Lincoln Co, Wyoming	1,547	1,494	4	38	22,770	194	13
Sublette Co, Woming	136	61	2	14	0	16	23
Sweetwater Co, Wyoming	269	561	12	140	21,207	12,397	7
Uinta Co, Wyoming	99	229	5	48	0	15	0
Wyoming (rest)	3,393	3,742	22	81	1	1,848	18
RFD	0	0	0	0	0	0	0
CDC Project	0	0	0	0	0	0	0
PM2_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**
Carbon Co, Wyoming	101	993	22	185	0	4	66
Lincoln Co, Wyoming	80	582	13	92	6,541	299	178
Sublette Co, Woming	152	627	7	61	3	22	341
Sweetwater Co, Wyoming	89	1,531	36	268	3,047	2,185	76
Uinta Co, Wyoming	4	319	17	102	0	1	6
Wyoming (rest)	99	3,032	67	232	7	167	247
RFD	0	0	0	0	0	0	0
CDC Project	0	0	0	0	0	0	0

Table 2-11. 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**
Carbon Co, Wyoming	1,172	857	9,526	3,849	0	650	3,131
Lincoln Co, Wyoming	1,144	2,125	5,090	2,533	579	328	297
Sublette Co, Woming	4,428	723	2,722	3,400	20	84	16,203
Sweetwater Co, Wyoming	3,178	1,795	16,939	4,447	2,725	14,793	4,076
Uinta Co, Wyoming	590	1,313	7,615	3,004	0	103	803
Wyoming (rest)	1,802	7,029	30,777	19,110	15	1,416	58,117
RFD	0	0	0	0	0	0	0
CDC Project	0	0	0	0	0	0	0
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**
Carbon Co, Wyoming	2,615	564	1,158	4,098	0	622	111
Lincoln Co, Wyoming	2,269	1,040	642	1,731	14,494	1,415	16
Sublette Co, Woming	7,611	121	345	507	204	104	574
Sweetwater Co, Wyoming	5,379	1,353	1,979	6,995	23,803	11,185	207
Uinta Co, Wyoming	793	409	909	2,256	0	46	26
Wyoming (rest)	2,969	3,647	3,555	3,507	27	1,441	1,977
RFD	0	0	0	0	0	0	0
CDC Project	0	0	0	0	0	0	0
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**
Carbon Co, Wyoming	158,425	1,535	705	770	0	1,329	7,497
Lincoln Co, Wyoming	168,336	1,470	431	551	121	79	871
Sublette Co, Woming	183,876	554	229	1,015	194	45	18,763
Sweetwater Co, Wyoming	361,812	4,515	1,276	780	757	18,520	14,900
Uinta Co, Wyoming	42,332	1,644	595	400	0	148	73
Wyoming (rest)	212,625	8,846	2,561	2,299	6	2,615	44,609
RFD	0	0	0	0	0	0	0
CDC Project	0	0	0	0	0	0	0
PM10							
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**
Carbon Co, Wyoming	101	8,377	32	192	0	268	131
Lincoln Co, Wyoming	80	2,897	19	96	6,541	1,348	16
Sublette Co, Woming	152	4,349	10	64	3	34	1,915
Sweetwater Co, Wyoming	89	12,684	54	277	3,047	12,436	30
Uinta Co, Wyoming	4	1,540	25	105	0	54	110
Wyoming (rest)	99	19,495	100	244	7	600	6,936
RFD	0	0	0	0	0	0	0
CDC Project	0	0	0	0	0	0	0
SO2							
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**
Carbon Co, Wyoming	60	332	7	85	0	1,102	8
Lincoln Co, Wyoming	1,547	1,494	4	38	22,770	194	1
Sublette Co, Woming	136	61	2	14	0	16	117
Sweetwater Co, Wyoming	269	561	12	140	21,207	12,397	2
Uinta Co, Wyoming	99	229	5	48	0	15	7
Wyoming (rest)	3,393	3,742	22	81	1	1,848	422
RFD	0	0	0	0	0	0	0
CDC Project	0	0	0	0	0	0	0
PM2_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**
Carbon Co, Wyoming	101	958	22	185	0	4	118
Lincoln Co, Wyoming	80	549	13	92	6,541	299	15
Sublette Co, Woming	152	535	7	61	3	22	1,768
Sweetwater Co, Wyoming	89	1,493	36	268	3,047	2,185	24
Uinta Co, Wyoming	4	316	17	102	0	1	101
Wyoming (rest)	99	2,871	67	232	7	167	6,351
RFD	0	0	0	0	0	0	0
CDC Project	0	0	0	0	0	0	0

Table 2-12. Regional emissions summary table 2022met05 (tpy).

STATE	Source Category						
	Oil and Gas	Area	Onroad	Offroad	EGU	NEGU	Natural
CO							
Colorado	**799**	**2,519**	**15,010**	**8,426**	**1,735**	**67**	**12,277**
Idaho	**411**	**535**	**2,057**	**4,583**	**0**	**17,670**	**23,477**
Utah	**41,451**	**1,960**	**16,241**	**11,877**	**1,469**	**109**	**20,297**
Wyoming	**27,624**	**14,596**	**55,748**	**37,856**	**3,816**	**14,182**	**26,789**
Carbon Co, Wyoming	829	856	55,748	3,713	135	1,552	2,675
Lincoln Co, Wyoming	711	2,129		2,270	819	380	1,970
Sublette Co, Woming	1,885	716		2,828	0	389	5,525
Sweetwater Co, Wyoming	2,731	1,801		4,670	2,498	11,418	4,579
Uinta Co, Wyoming	534	1,307		2,877	330	99	73
Wyoming (rest)	1,797	7,789		21,498	33	345	11,965
RFD	8,665	0	0	0	0	0	0
CDC Project	10,474	0	0	0	0	0	0
NOx							
Colorado	**1,291**	**177**	**773**	**849**	**24,166**	**89**	**632**
Idaho	**152**	**402**	**128**	**478**	**0**	**2,378**	**927**
Utah	**13,706**	**244**	**855**	**1,272**	**8,386**	**112**	**655**
Wyoming	**30,556**	**8,261**	**3,576**	**15,066**	**39,072**	**12,748**	**1,229**
Carbon Co, Wyoming	2,297	620	3,576	3,149	153	478	94
Lincoln Co, Wyoming	1,820	1,187		1,278	10,880	1,662	73
Sublette Co, Woming	2,476	130		330	0	469	259
Sweetwater Co, Wyoming	4,748	1,478		5,444	27,338	9,601	217
Uinta Co, Wyoming	733	447		1,691	667	120	10
Wyoming (rest)	2,962	4,398		3,173	34	419	576
RFD	8,805	0	0	0	0	0	0
CDC Project	6,717	0	0	0	0	0	0
TOG							
Colorado	**20,767**	**1,850**	**823**	**1,147**	**183**	**323**	**53,123**
Idaho	**44**	**5,214**	**120**	**1,174**	**0**	**7**	**32,887**
Utah	**1,060,778**	**2,668**	**859**	**2,300**	**114**	**1,673**	**13,954**
Wyoming	**1,473,030**	**22,192**	**3,240**	**4,261**	**683**	**25,291**	**81,173**
Carbon Co, Wyoming	27,263	22,192	3,240	4,261	12,495	25,291	6,807
Lincoln Co, Wyoming	75,250						881
Sublette Co, Woming	159,573						17,449
Sweetwater Co, Wyoming	313,200						13,681
Uinta Co, Wyoming	8,310						73
Wyoming (rest)	209,909						42,282
RFD	379,714	0	0	0	0	0	0
CDC Project	299,812	0	0	0	0	0	0
PM10							
Colorado	**37**	**10,544**	**37**	**75**	**592**	**3,504**	**320**
Idaho	**0**	**9,454**	**6**	**62**	**0**	**0**	**1,950**
Utah	**469**	**7,134**	**41**	**112**	**887**	**267**	**2,602**
Wyoming	**8,929**	**73,379**	**164**	**610**	**3,399**	**13,320**	**1,032**
Carbon Co, Wyoming	91	8,616	164	118	3	683	75
Lincoln Co, Wyoming	72	3,323		53	1,457	440	203
Sublette Co, Woming	22	5,276		30	0	0	370
Sweetwater Co, Wyoming	80	11,445		184	1,939	12,086	94
Uinta Co, Wyoming	3	1,461		62	0	1	8
Wyoming (rest)	90	43,256		163	0	111	282
RFD	5,818	0	0	0	0	0	0
CDC Project	2,753	0	0	0	0	0	0
SO2							
Colorado	**15**	**83**	**10**	**3**	**7,002**	**5**	**20**
Idaho	**0**	**15**	**2**	**1**	**0**	**3,921**	**125**
Utah	**731**	**142**	**11**	**3**	**1,645**	**10**	**159**
Wyoming	**5,602**	**7,458**	**45**	**19**	**22,374**	**23,588**	**65**
Carbon Co, Wyoming	60	394	45	3	246	3,354	5
Lincoln Co, Wyoming	1,543	1,838		1	6,357	65	13
Sublette Co, Woming	4	63		1	0	240	23
Sweetwater Co, Wyoming	267	590		5	15,771	14,592	7
Uinta Co, Wyoming	98	237		2	0	876	0
Wyoming (rest)	3,419	4,337		7	0	4,461	18
RFD	208	0	0	0	0	0	0
CDC Project	4	0	0	0	0	0	0
PM2_5							
Colorado	**37**	**1,404**	**18**	**70**	**0**	**0**	**293**
Idaho	**0**	**206**	**3**	**58**	**0**	**0**	**1,716**
Utah	**460**	**908**	**21**	**106**	**561**	**169**	**2,396**
Wyoming	**1,951**	**6,773**	**83**	**611**	**4,114**	**1,776**	**914**
Carbon Co, Wyoming	91	975	83	118	0	111	66
Lincoln Co, Wyoming	72	592		53	821	2	178
Sublette Co, Woming	22	625		30	0	0	341
Sweetwater Co, Wyoming	80	1,351		184	3,295	1,658	76
Uinta Co, Wyoming	3	301		62	0	0	6
Wyoming (rest)	90	2,929		164	0	6	247
RFD	916	0	0	0	0	0	0
CDC Project	677	0	0	0	0	0	0

Table 2-13. Regional emissions summary table 2022met06 (tpy).

STATE	Source Category						
	Oil and Gas	Area	Onroad	Offroad	EGU	NEGU	Natural
CO							
Colorado	**799**	**2,519**	**15,246**	**8,426**	**1,735**	**67**	**12,535**
Idaho	**411**	**535**	**2,070**	**4,583**	**0**	**17,670**	**20,513**
Utah	**41,451**	**1,960**	**16,338**	**11,877**	**1,469**	**109**	**8,608**
Wyoming	**27,624**	**14,596**	**56,568**	**37,856**	**3,816**	**14,182**	**82,627**
Carbon Co, Wyoming	829	856	56,568	3,713	135	1,552	3,131
Lincoln Co, Wyoming	711	2,129		2,270	819	380	297
Sublette Co, Woming	1,885	716		2,828	0	389	16,203
Sweetwater Co, Wyoming	2,731	1,801		4,670	2,498	11,418	4,076
Uinta Co, Wyoming	534	1,307		2,877	330	99	803
Wyoming (rest)	1,797	7,789		21,498	33	345	58,117
RFD	8,665	0	0	0	0	0	0
CDC Project	10,474	0	0	0	0	0	0
NOx							
Colorado	**1,291**	**177**	**776**	**849**	**24,166**	**89**	**677**
Idaho	**152**	**402**	**128**	**478**	**0**	**2,378**	**864**
Utah	**13,706**	**244**	**857**	**1,272**	**8,386**	**112**	**347**
Wyoming	**30,556**	**8,261**	**3,590**	**15,066**	**39,072**	**12,748**	**2,911**
Carbon Co, Wyoming	2,297	620	3,590	3,149	153	478	111
Lincoln Co, Wyoming	1,820	1,187		1,278	10,880	1,662	16
Sublette Co, Woming	2,476	130		330	0	469	574
Sweetwater Co, Wyoming	4,748	1,478		5,444	27,338	9,601	207
Uinta Co, Wyoming	733	447		1,691	667	120	26
Wyoming (rest)	2,962	4,398		3,173	34	419	1,977
RFD	8,805	0	0	0	0	0	0
CDC Project	6,717	0	0	0	0	0	0
TOG							
Colorado	**20,767**	**1,850**	**830**	**1,147**	**183**	**323**	**54,199**
Idaho	**44**	**5,214**	**120**	**1,174**	**0**	**7**	**32,486**
Utah	**1,060,778**	**2,668**	**861**	**2,300**	**114**	**1,673**	**13,407**
Wyoming	**1,473,030**	**22,192**	**3,257**	**4,261**	**683**	**25,291**	**89,977**
Carbon Co, Wyoming	27,263	22,192	3,257	4,261	12,495	25,291	7,497
Lincoln Co, Wyoming	75,250						878
Sublette Co, Woming	159,573						19,459
Sweetwater Co, Wyoming	313,200						14,911
Uinta Co, Wyoming	8,310						113
Wyoming (rest)	209,909						47,120
RFD	379,714	0	0	0	0	0	0
CDC Project	299,812	0	0	0	0	0	0
PM10							
Colorado	**37**	**10,544**	**37**	**75**	**592**	**3,504**	**261**
Idaho	**0**	**9,454**	**6**	**62**	**0**	**0**	**1,513**
Utah	**469**	**7,134**	**41**	**112**	**887**	**267**	**756**
Wyoming	**8,929**	**73,379**	**164**	**610**	**3,399**	**13,320**	**9,139**
Carbon Co, Wyoming	91	8,616	164	118	3	683	131
Lincoln Co, Wyoming	72	3,323		53	1,457	440	16
Sublette Co, Woming	22	5,276		30	0	0	1,915
Sweetwater Co, Wyoming	80	11,445		184	1,939	12,086	30
Uinta Co, Wyoming	3	1,461		62	0	1	110
Wyoming (rest)	90	43,256		163	0	111	6,936
RFD	5,818	0	0	0	0	0	0
CDC Project	2,753	0	0	0	0	0	0
SO2							
Colorado	**15**	**83**	**10**	**3**	**7,002**	**5**	**16**
Idaho	**0**	**15**	**2**	**1**	**0**	**3,921**	**97**
Utah	**731**	**142**	**11**	**3**	**1,645**	**10**	**48**
Wyoming	**5,602**	**7,458**	**45**	**19**	**22,374**	**23,588**	**556**
Carbon Co, Wyoming	60	394	45	3	246	3,354	8
Lincoln Co, Wyoming	1,543	1,838		1	6,357	65	1
Sublette Co, Woming	4	63		1	0	240	117
Sweetwater Co, Wyoming	267	590		5	15,771	14,592	2
Uinta Co, Wyoming	98	237		2	0	876	7
Wyoming (rest)	3,419	4,337		7	0	4,461	422
RFD	208	0	0	0	0	0	0
CDC Project	4	0	0	0	0	0	0
PM2_5							
Colorado	**37**	**1,191**	**18**	**70**	**0**	**0**	**233**
Idaho	**0**	**206**	**3**	**58**	**0**	**0**	**1,311**
Utah	**460**	**772**	**21**	**106**	**561**	**169**	**675**
Wyoming	**1,951**	**6,410**	**83**	**611**	**4,114**	**1,776**	**8,377**
Carbon Co, Wyoming	91	940	83	118	0	111	118
Lincoln Co, Wyoming	72	560		53	821	2	15
Sublette Co, Woming	22	532		30	0	0	1,768
Sweetwater Co, Wyoming	80	1,313		184	3,295	1,658	24
Uinta Co, Wyoming	3	298		62	0	0	101
Wyoming (rest)	90	2,768		164	0	6	6,351
RFD	916	0	0	0	0	0	0
CDC Project	677	0	0	0	0	0	0

Table 2-14. Regional 2022-2008 emissions difference summary table for met05 (tpy).

STATE	Source Category						
	Oil and Gas	Area	Onroad	Offroad	EGU	NEGU	Natural
CO							
Colorado	-230	71	-3,072	495	379	9	0
Idaho	149	48	-506	38	0	6,760	0
Utah	23,068	-14	-3,241	-335	1,043	-535	0
Wyoming	15,311	754	-15,815	1,512	478	-3,191	0
Carbon Co, Wyoming	-343	-1	-15,815	-136	135	902	0
Lincoln Co, Wyoming	-434	3		-263	241	52	0
Sublette Co, Woming	-2,543	-8		-572	-20	305	0
Sweetwater Co, Wyoming	-447	6		223	-227	-3,375	0
Uinta Co, Wyoming	-57	-6		-127	330	-4	0
Wyoming (rest)	-5	759		2,387	19	-1,070	0
RFD	8,665	0	0	0	0	0	0
CDC Project	10,474	0	0	0	0	0	0
NOx							
Colorado	-422	25	-956	-396	-4,523	4	0
Idaho	-1,129	63	-173	-197	0	445	0
Utah	2,216	30	-1,065	-499	1,177	-1,017	0
Wyoming	8,921	1,126	-4,985	-4,028	544	-2,065	0
Carbon Co, Wyoming	-319	55	-4,985	-950	153	-144	0
Lincoln Co, Wyoming	-449	147		-453	-3,614	247	0
Sublette Co, Woming	-5,134	9		-177	-204	365	0
Sweetwater Co, Wyoming	-632	125		-1,551	3,535	-1,584	0
Uinta Co, Wyoming	-60	38		-564	667	74	0
Wyoming (rest)	-7	752		-334	7	-1,022	0
RFD	8,805	0	0	0	0	0	0
CDC Project	6,717	0	0	0	0	0	0
TOG							
Colorado	-56,252	241	-567	-555	46	56	0
Idaho	-504	1,320	-87	-284	0	-3	0
Utah	650,722	653	-571	-1,233	49	-384	0
Wyoming	345,625	3,629	-2,516	-1,555	-396	2,555	0
Carbon Co, Wyoming	-131,161	3,629	-2,516	-1,555	11,417	2,555	0
Lincoln Co, Wyoming	-93,086						75
Sublette Co, Woming	-24,304						134
Sweetwater Co, Wyoming	-48,612						34
Uinta Co, Wyoming	-34,022						3
Wyoming (rest)	-2,716						102
RFD	379,714	0	0	0	0	0	0
CDC Project	299,812	0	0	0	0	0	0
PM10							
Colorado	-25	-82	-11	-60	182	-348	0
Idaho	0	95	-3	-34	0	-468	0
Utah	26	-320	-14	-90	316	42	0
Wyoming	8,406	20,412	-77	-369	-6,199	-1,419	0
Carbon Co, Wyoming	-10	-113	-77	-74	3	415	0
Lincoln Co, Wyoming	-8	103		-43	-5,085	-908	0
Sublette Co, Woming	-130	3		-34	-3	-34	0
Sweetwater Co, Wyoming	-9	-1,622		-93	-1,107	-350	0
Uinta Co, Wyoming	-1	-109		-43	0	-53	0
Wyoming (rest)	-9	22,150		-81	-7	-489	0
RFD	5,818	0	0	0	0	0	0
CDC Project	2,753	0	0	0	0	0	0
SO2							
Colorado	-5	3	-1	-30	-792	1	0
Idaho	-1	1	0	-17	0	-4,997	0
Utah	550	-2	-1	-42	672	4	0
Wyoming	100	1,039	-7	-387	-21,604	8,017	0
Carbon Co, Wyoming	0	62	-7	-82	246	2,252	0
Lincoln Co, Wyoming	-4	343		-36	-16,413	-129	0
Sublette Co, Woming	-132	2		-13	0	224	0
Sweetwater Co, Wyoming	-1	29		-135	-5,436	2,195	0
Uinta Co, Wyoming	0	8		-46	0	862	0
Wyoming (rest)	26	595		-75	-1	2,613	0
RFD	208	0	0	0	0	0	0
CDC Project	4	0	0	0	0	0	0
PM2_5							
Colorado	-24	-11	-13	-58	0	0	0
Idaho	0	22	-3	-33	0	-376	0
Utah	25	-64	-16	-86	90	24	0
Wyoming	1,428	-311	-79	-328	-5,484	-902	0
Carbon Co, Wyoming	-10	-18	-79	-67	0	107	0
Lincoln Co, Wyoming	-8	11		-40	-5,720	-297	0
Sublette Co, Woming	-130	-2		-31	-3	-22	0
Sweetwater Co, Wyoming	-9	-180		-84	248	-528	0
Uinta Co, Wyoming	-1	-18		-40	0	-1	0
Wyoming (rest)	-9	-103		-68	-7	-162	0
RFD	916	0	0	0	0	0	0
CDC Project	677	0	0	0	0	0	0

Table 2-15. Regional 2022-2008 emissions difference summary table for met06 (tpy).

STATE	Source Category						
	Oil and Gas	Area	Onroad	Offroad	EGU	NEGU	Natural
CO							
Colorado	-230	71	-3,116	495	379	9	0
Idaho	149	48	-510	38	0	6,760	0
Utah	23,068	-14	-3,260	-335	1,043	-535	0
Wyoming	15,311	754	-16,099	1,512	478	-3,191	0
Carbon Co, Wyoming	-343	-1	-16,099	-136	135	902	0
Lincoln Co, Wyoming	-434	3		-263	241	52	0
Sublette Co, Woming	-2,543	-8		-572	-20	305	0
Sweetwater Co, Wyoming	-447	6		223	-227	-3,375	0
Uinta Co, Wyoming	-57	-6		-127	330	-4	0
Wyoming (rest)	-5	759		2,387	19	-1,070	0
RFD	8,665	0	0	0	0	0	0
CDC Project	10,474	0	0	0	0	0	0
NOx							
Colorado	-422	25	-959	-396	-4,523	4	0
Idaho	-1,129	63	-173	-197	0	445	0
Utah	2,216	30	-1,067	-499	1,177	-1,017	0
Wyoming	8,921	1,126	-4,999	-4,028	544	-2,065	0
Carbon Co, Wyoming	-319	55	-4,999	-950	153	-144	0
Lincoln Co, Wyoming	-449	147		-453	-3,614	247	0
Sublette Co, Woming	-5,134	9		-177	-204	365	0
Sweetwater Co, Wyoming	-632	125		-1,551	3,535	-1,584	0
Uinta Co, Wyoming	-60	38		-564	667	74	0
Wyoming (rest)	-7	752		-334	7	-1,022	0
RFD	8,805	0	0	0	0	0	0
CDC Project	6,717	0	0	0	0	0	0
TOG							
Colorado	-56,252	241	-574	-555	46	56	0
Idaho	-504	1,320	-88	-284	0	-3	0
Utah	650,722	653	-574	-1,233	49	-384	0
Wyoming	345,625	3,629	-2,539	-1,555	-396	2,555	0
Carbon Co, Wyoming	-131,161	3,629	-2,539	-1,555	11,417	2,555	0
Lincoln Co, Wyoming	-93,086						6
Sublette Co, Woming	-24,304						696
Sweetwater Co, Wyoming	-48,612						11
Uinta Co, Wyoming	-34,022						40
Wyoming (rest)	-2,716						2,510
RFD	379,714	0	0	0	0	0	0
CDC Project	299,812	0	0	0	0	0	0
PM10							
Colorado	-25	2,048	-11	-60	182	-348	0
Idaho	0	394	-3	-34	0	-468	0
Utah	26	1,043	-14	-90	316	42	0
Wyoming	8,406	24,037	-77	-369	-6,199	-1,419	0
Carbon Co, Wyoming	-10	240	-77	-74	3	415	0
Lincoln Co, Wyoming	-8	426		-43	-5,085	-908	0
Sublette Co, Woming	-130	928		-34	-3	-34	0
Sweetwater Co, Wyoming	-9	-1,239		-93	-1,107	-350	0
Uinta Co, Wyoming	-1	-78		-43	0	-53	0
Wyoming (rest)	-9	23,761		-81	-7	-489	0
RFD	5,818	0	0	0	0	0	0
CDC Project	2,753	0	0	0	0	0	0
SO2							
Colorado	-5	3	-1	-30	-792	1	0
Idaho	-1	1	0	-17	0	-4,997	0
Utah	550	-2	-1	-42	672	4	0
Wyoming	100	1,039	-7	-387	-21,604	8,017	0
Carbon Co, Wyoming	0	62	-7	-82	246	2,252	0
Lincoln Co, Wyoming	-4	343		-36	-16,413	-129	0
Sublette Co, Woming	-132	2		-13	0	224	0
Sweetwater Co, Wyoming	-1	29		-135	-5,436	2,195	0
Uinta Co, Wyoming	0	8		-46	0	862	0
Wyoming (rest)	26	595		-75	-1	2,613	0
RFD	208	0	0	0	0	0	0
CDC Project	4	0	0	0	0	0	0
PM2_5							
Colorado	-24	-11	-13	-58	0	0	0
Idaho	0	22	-3	-33	0	-376	0
Utah	25	-64	-16	-86	90	24	0
Wyoming	1,428	-311	-79	-328	-5,484	-902	0
Carbon Co, Wyoming	-10	-18	-79	-67	0	107	0
Lincoln Co, Wyoming	-8	11		-40	-5,720	-297	0
Sublette Co, Woming	-130	-2		-31	-3	-22	0
Sweetwater Co, Wyoming	-9	-180		-84	248	-528	0
Uinta Co, Wyoming	-1	-18		-40	0	-1	0
Wyoming (rest)	-9	-103		-68	-7	-162	0
RFD	916	0	0	0	0	0	0
CDC Project	677	0	0	0	0	0	0