

OGWG Road Map: Phase I Report
Base and Future Year Emission Inventory Review
and Work Plan Development

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1.0 INTRODUCTION

The Western Regional Air Partnership (WRAP) Oil and Gas Work Group (OGWG) prepared the Road Map Scope of Work (Road Map; WRAP OGWG, 2017) to guide technical work to meet air quality planning needs for regional haze. The deliverables developed under the Road Map may also be relevant to regional and local planning for ozone air quality and other air pollution indicators.

The focus of the Road Map is emissions from upstream and midstream oil and gas (O&G) sources. Downstream emissions will not be considered unless specific case(s) warrant special consideration. O&G emission inventories developed under the Road Map will include well site, gathering, and processing subsectors (items 1, 5, and 6 in Figure 1-1). Item 1) On-shore Petroleum and Natural Gas Production are referred to as “well site” sources; emissions from well site sources are typically classified as nonpoint sources¹. Items 5) Gathering and Boosting and 6) Gas Processing Plant are collectively referred to as “midstream” sources; emissions from midstream sources are typically classified as point sources.

¹ There are exceptions; for example, several well site sources in the Uinta Basin are available by facility and will be included in emission inventories as point source emissions.

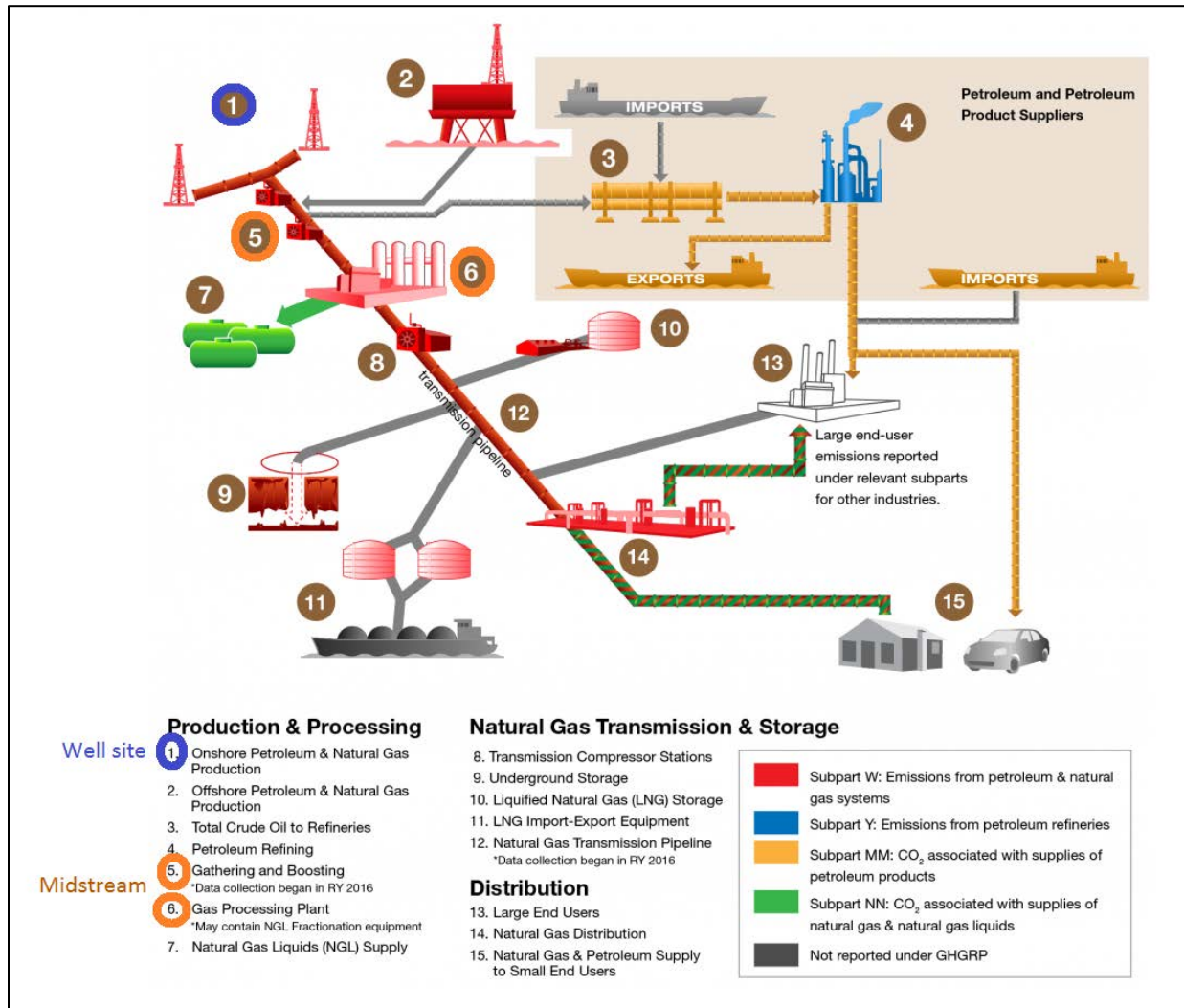


Figure 1-1. Example Petroleum and Natural Gas Industry schematic^{2,3}.

The WRAP region includes 15 states, several of which have substantial O&G production and generate substantial O&G emissions. Figure 1-2 shows on-shore crude oil production and Figure 1-3 shows on-shore natural gas production in the WRAP region by state (source: US Energy Information Administration [EIA]). Total annual WRAP region crude oil production decreased slightly from 2000 to 2009; from 2009 to 2015 crude oil production increased by 71%; crude oil production dropped by 8% from 2015 to 2016 and increased by 4% from 2016 to 2017. Total annual WRAP region natural gas production increased by 20% from 2000 to 2008, then decreased by 5% from 2008 to 2016.

² Source: <https://www.epa.gov/ghgreporting/ghgrp-and-oil-and-gas-industry>

³ This figure shows O&G subsectors for which emissions have been developed in this study. It is important to consider that Petroleum and Natural Gas Industry equipment is typically tailored to meet field, basin, and/or region specific infrastructure requirements.

For the latest year of crude oil production available (2017), WRAP region crude oil production contributions are 34% from North Dakota, 18% from California, 16% from Alaska, 11% from New Mexico, 8% from Colorado, 7% from Wyoming, 4% from Utah, and 3% from Montana; no other WRAP state accounts for more than 1% of crude oil production in the WRAP region. For the latest year of natural gas production available (2016), WRAP region natural gas production contributions are 32% from Alaska, 21% from Wyoming, 19% from Colorado, 14% from New Mexico, 7% from North Dakota, 4% from Utah, and 2% from California; no other WRAP state accounts for more than 1% of natural gas production in the WRAP region.

WRAP region-wide O&G production is presented to provide an overall perspective on O&G production in the region and by state. However, emission inventory accuracy is highly dependent on accurate, basin- or sub-basin-level inventory inputs such as well site equipment configurations, gas composition, midstream facility emissions data, O&G activity forecasts, and state and federal emission control program effects.

The technical work to be performed as part of the Road Map will leverage existing emission inventory data and methods with updates to increase emission inventory accuracy. The result will be base year and future year emission inventories that are based on regionally consistent emission inventory methods, to the extent practicable, feasible, and reasonable, for use in regional haze planning. Inventory improvements could improve the accuracy of future state, local, and tribal (S/L/T) agency National Emission Inventory (NEI) submissions which would also improve emissions accuracy in EPA air quality modeling platforms which are based on the NEI. Additionally, the emission inventories may be used in regional and local planning for ozone air quality and other air pollution indicators.

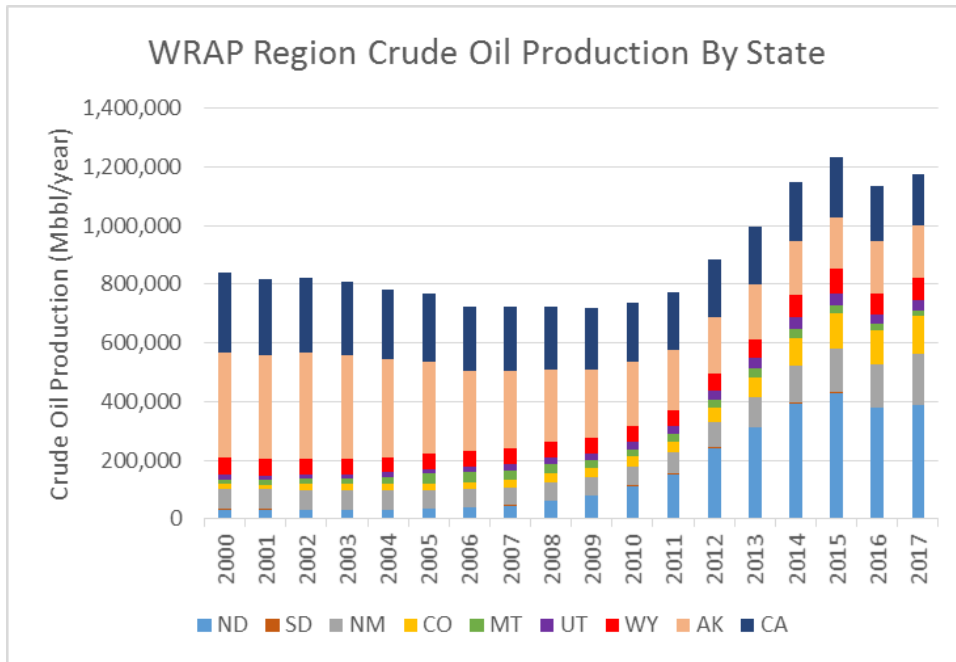


Figure 1-2. WRAP region on-shore crude oil production.^{4,5}

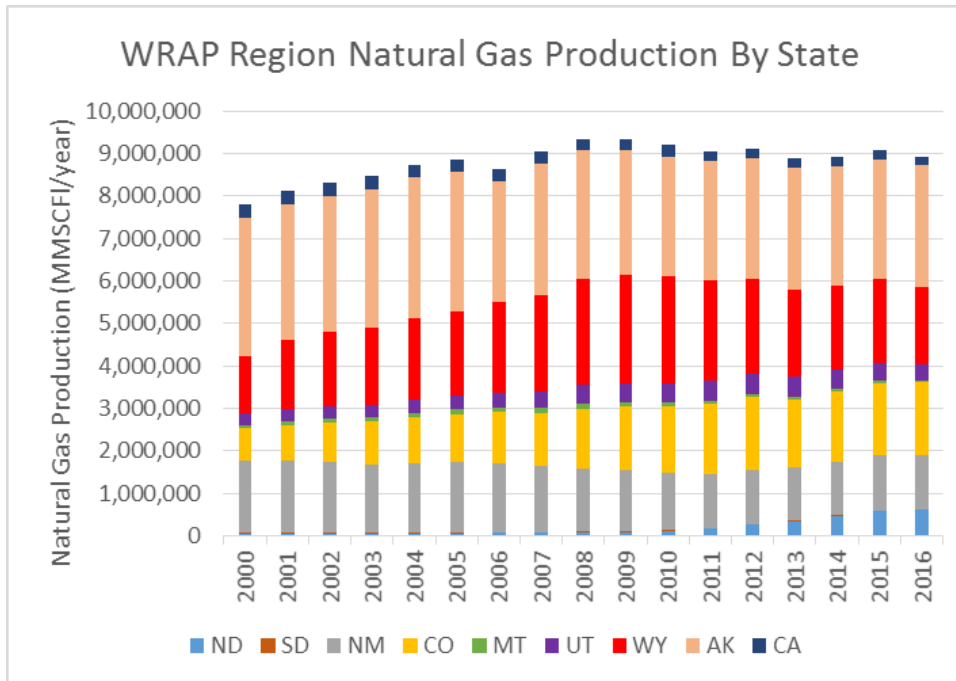


Figure 1-3. WRAP region on-shore natural gas production.^{4,6}

⁴ Small quantities of crude oil and natural gas are produced in Arizona, Idaho, Nevada, and Oregon. No crude oil or natural gas is produced in Hawaii or Washington.

⁵ EIA (2018). Crude Oil Production. https://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbbl_a.htm

⁶ EIA (2018). Natural Gas Gross Withdrawals and Production, https://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_a.htm

1.1 Report Organization

Chapter 2 provides a review of base and future year emission inventories and control methodologies and Chapter 3 provides a draft work plan for completion of tasks specified in the WRAP OGWG Road Map (WRAP OGWG, 2017).

2.0 WRAP REGION O&G EMISSION INVENTORY REVIEW

2.1 Base Year Inventories

In collaboration with the OGWG, Ramboll identified the latest O&G emission inventories available for the WRAP region; two emission inventories developed by the WRAP for Intermountain West O&G basins (Grant et al., 2018, Parikh et al., 2017), the Uinta Basin 2014 Air Agencies Oil and Gas Emissions Inventory (Utah Division of Air Quality [UDAQ], 2017), and the US Environmental Protection Agency (EPA) NEI O&G Inventory (EPA, 2018).

For most WRAP region emission inventories, point source emissions are primarily midstream sources such as compressor stations and gas processing plants and nonpoint sources are primarily well site exploration and production phase emission sources. Point source emission inventories include both major Title V midstream source emissions and minor source facilities that report under applicable minor source thresholds such as EPA Tribal Minor New Source Rule and state specific minor source permitting requirements. Grant et al. (2017) provided information on state agency minor source reporting to the 2014 NEI by state agency (Table 2-1).

Table 2-2 shows WRAP Region 2014 base year emission inventories, associated pollutants, and applicable basins. Table 2-3 shows the basis of nonpoint well site equipment configurations and point source midstream permit emissions.

Table 2-1. Reporting thresholds for O&G point source facilities in the WRAP region⁷.

State	Agency	NEI2014 Point Source Submittal Threshold
Alaska	Alaska Department of Environmental Conservation	Attempted capture of all facilities
California	California Air Resources Board ³	<i>not available</i>
Colorado	Colorado Department of Public Health and Environment	Attainment: 2 tpy (CAPs), 250 lb/year (HAPs) Non-attainment: 1 tpy (CAPs), 250 lb/year (HAPs)
Montana	Montana Department of Environmental Quality	25 tpy (CAPs), 10/25 tpy (HAPs)
Wyoming	Wyoming Department of Environmental Quality	0.001 tpy of any pollutant
North Dakota	North Dakota Department of Health	Reported only Title V Facilities to 2014 NEI
Idaho	Idaho Department of Environmental Quality	
New Mexico ¹	New Mexico Environment Department Air Quality Bureau	
Utah ²	Utah Division of Air Quality	

⁷ Source: Grant et al. (2017)

State	Agency	NEI2014 Point Source Submittal Threshold
Hawaii, Nevada, Oregon, Washington, South Dakota, Arizona	No information provided, limited oil and gas emission sources	

¹ Minor source point source emissions for sources in New Mexico are included in Grant et al. (2018) Greater San Juan Basin and Permian Basin emission inventories.

² Comprehensive point source emissions are reported in UDAQ (2017) Uinta Basin emission inventory estimates.

³ Primary responsibility for permitting stationary sources are Air Pollution Control Districts (APCD) or Air Quality Management Districts (AQMD).

Table 2-2. WRAP region base year emission inventory study basic information.

Reference	Study Name	Applicable States	Applicable Basins	Year	Pollutant / GHG ¹									
					NOx	VOC	CO	SOx	PM ₁₀	PM _{2.5}	CO ₂	CH ₄	N ₂ O	HAPs
Grant et al. (2018)	San Juan and Permian Basin 2014 Oil and Gas Emission Inventory	Colorado and New Mexico	Greater San Juan, Permian	2014	✓	✓	✓	✓	✓		✓	✓	✓	
Parikh et al. (2017)	2014 Oil and Gas Intermountain West Criteria Pollutant Emission Inventories for Colorado, Montana, New Mexico, North Dakota, South Dakota, Utah, and Wyoming	Colorado, Montana, New Mexico, North Dakota, South Dakota, Utah, and Wyoming	Denver-Julesburg, Piceance, Paradox, Uinta, Raton, Big Horn, Powder River, Green River, Central Western Overthrust, Wind River, Williston, Sweetgrass Arch and Central Montana Uplift	2014	✓	✓	✓	✓	✓					
UDAQ (2017)	Uinta Basin 2014 Air Agencies Oil and Gas Emissions Inventory	Utah	Uintah and Duchesne Counties	2014	✓	✓	✓	✓	✓	✓				
EPA (2018)	2014 National Emissions Inventory (NEI) V2	US-wide	All Basins in the Country	2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

¹ NOx- oxides of nitrogen; VOC- volatile organic compounds; CO – carbon monoxide; SOx- sulfur oxides; PM₁₀ – particulate matter less than 10 microns; PM_{2.5} – particulate matter less than 2.5 microns; CO₂ – carbon dioxide ; CH₄- methane; N₂O- nitrous oxide and HAPs- hazardous air pollutants

Table 2-3. WRAP region base year emission inventory study details.

Reference	State & Basin(s)	Basis of Nonpoint Equipment Configurations	Basis of Point Source Emissions	Excluded Source Categories	Uncertainties
Grant et al. (2018)	San Juan (CO, NM)	<ul style="list-style-type: none"> Operator surveys GHGRP Subpart W data EPA Oil and Gas Estimation Tool CARMMS 1.0 	<ul style="list-style-type: none"> New Mexico Environment Department (NMED) Colorado Department of Public Health and Environment (CDPHE) US EPA Region 6, 8, 9 2014 National Emission Inventory (NEI) v1.0 	<ul style="list-style-type: none"> Water disposal pits/evaporation ponds Pipeline fugitives Mud degassing 	<ul style="list-style-type: none"> High emitters not included
	Permian (NM portion only)	<ul style="list-style-type: none"> TCEQ oil and gas emission inventory GHGRP Subpart W data EPA Oil and Gas Emissions Estimation Tool 	<ul style="list-style-type: none"> NMED 	<ul style="list-style-type: none"> Workover rigs Refracing engines Water disposal pits/evaporation ponds Pipeline fugitives Mud degassing 	<ul style="list-style-type: none"> Well site equipment configurations based primarily on Texas specific data High emitters not included
Parikh et al. (2017)	DJ (CO)	2014 NEI V1	CDPHE	<ul style="list-style-type: none"> Water disposal pits/evaporation ponds Pipeline fugitives Mud degassing 	<ul style="list-style-type: none"> High emitters not included (except Colorado tank emissions)³
	Piceance (CO)	2014 NEI V1	CDPHE		
	Paradox (CO, UT)	2014 NEI V1	CDPHE, 2014 NEI V1		
	Raton (CO, NM)	2014 NEI V1	CDPHE, 2014 NEI V1		
	Uinta (UT)	2014 Air Agencies Oil and Gas Emissions Inventory	2014 Air Agencies Oil and Gas Emissions Inventory		
	Big Horn (WY)	WYDEQ	WYDEQ		
	Powder River (WY, MT)	WYDEQ, 2014 NEI V1	WYDEQ, 2014 NEI V1, EPA Region 8		
	Green River (WY, CO)	WYDEQ, 2014 NEI V1	WYDEQ, CDPHE		
	Wind River (WY)	WYDEQ	WYDEQ, EPA Region 8		
	Central Western Overthrust (MT)	WYDEQ	WYDEQ		
	Williston (ND, MT, SD)	2014 NEI V1	2014 NEI V1, EPA Region 8		
	Sweetgrass Arch (MT)	2014 NEI V1	2014 NEI V1, EPA Region 8		

Reference	State & Basin(s)	Basis of Nonpoint Equipment Configurations	Basis of Point Source Emissions	Excluded Source Categories	Uncertainties
	Central Montana Uplift (MT)	2014 NEI V1	2014 NEI V1		
UDAQ (2017) ¹	Uinta (UT)	Emissions were estimated based on (1) input factors derived from WRAP Phase III ² , and (2) from the EPA O&G Tool for mud degassing.	Operator surveys for well site sources. Operator surveys, UDAQ and EPA permit reporting for midstream facilities.	None identified	<ul style="list-style-type: none"> • High emitters not included
EPA (2016)	2014 National Emissions Inventory (NEI) V2	Emissions from S/L/T agencies or the EPA Oil and Gas Emissions Estimation Tool	Emissions from S/L/T agencies	<ul style="list-style-type: none"> • Water pump engines • Refracting engines • Workover rigs 	<ul style="list-style-type: none"> • High emitters not included

¹ several nonpoint well site emission source categories are included in point sources in UDAQ (2017).

² <https://www.wrapair2.org/phaseiii.aspx>

³ Condensate tank emissions in Colorado include capture efficiency estimates to account for flash gas that does not reach a control device.

A comprehensive WRAP region-wide O&G emission inventory should leverage (1) Grant et al. (2018) for Permian and Greater San Juan basins, (2) Parikh et al. (2017) for O&G basins in Colorado, Utah⁸, and Wyoming, and (3) EPA NEI v2 for remaining WRAP region basins.

2014 base year emission inventory data gaps are summarized below:

- CO₂ and CH₄ emissions are not included in Parikh et al. (2017) or UDAQ (2017).
- PM_{2.5} emissions are not included in Grant et al. (2018) and Parikh et al. (2017).
- A small number of nonpoint source categories with relatively small emissions are omitted from Grant et al. (2018), Parikh et al. (2017), and EPA (2016). In general emission from these source categories (1) are expected to be small (mud degassing, workover rigs, and refracing engines), (2) are difficult to estimate due to lack of readily available activity and/or emission factor data (water disposal pits/evaporation ponds, pipeline fugitives). Water pump emissions are missing from the EPA (2016) emission inventory. However, emissions from these engines are most commonly associated with CBM well sites. CBM production areas are located in basins for which emissions are generally available from another inventory source (Greater San Juan Basin, Powder River Basin, and Piceance Basin).

2014 base year emission inventory emission factor uncertainties are summarized below:

- High emitters are likely underrepresented in emission rate estimates applied in WRAP region 2014 emission inventories for several fugitive and venting emission source categories. Analyses of O&G hydrocarbon fugitive and vent source emissions measurements collected in several studies show that a small percentage of O&G sites contribute a large fraction of hydrocarbon emissions (Brandt et al., 2014). Analysis of hydrocarbon emission measurements from 18 studies across several O&G production areas in the US indicated that the largest 5% of emission sources comprised over 50% of fugitive and vent source methane emissions (Brandt et al. 2016). Results of helicopter-based infrared surveys of more than 8,000 O&G well pads across several O&G areas in the U.S. showed that 4% of all surveyed O&G well pads were high emitters with over 92% of high emitters due to tank vents and hatches and the remaining high emitters due to dehydrators, separators, trucks unloading oil from tanks, and unlit or malfunctioning flares (Lyon et al., 2016). High emitters are primarily stochastic (i.e. random); leak detection and repair (LDAR) surveys have been identified as a method by which fat-tail emissions may be controlled.
- Pneumatic controller emission factors have been updated in emission inventories in some areas (e.g. Colorado and Oklahoma) based on recent studies (e.g., Oklahoma Independent Petroleum Association [OIPA; 2014], Allen et al. [2015]).

⁸ Parikh et al. (2017) includes the results of UDAQ (2017) prior to finalization of evaporation pond emissions. Updated evaporation pond emissions from UDAQ (2017) would be included in the WRAP region-wide emission inventory.

We suggest prioritizing the following base year inventory updates to the extent feasible in subsequent OGWG activities.

- **High priority**
 - Add CO₂, CH₄, and PM_{2.5} emissions as necessary.
- **Medium priority**
 - Determine feasibility of developing emission factor updates to account for high emitters.
 - Determine areas where pneumatic controller emission factors should be updated.
- **Low priority**
 - Determine the feasibility of adding emissions for water disposal pits/evaporation ponds and pipeline fugitives.

2.2 Projection Methodologies

In collaboration with the OGWG, Ramboll identified emission projections documentation for review. Ramboll compiled a summary of emission projections (Table 2-4), emission projections O&G activity forecast information (Table 2-5), and emission projections control factor information (Table 2-6).

Two of seven emission inventory studies reviewed included multiple future scenarios:

- Vijayaraghavan et al. (2017), the Colorado Air Resource Management Modeling Study 2.0, includes low, medium, and high scenarios. The low and high scenario are based on low and high O&G activity development, respectively; both low and high scenarios assume emission control per on-the-books (OTB) regulations. The medium scenario assumes the same activity as the high scenario; the medium scenario includes additional controls for wells producing from federal mineral estate.
- Grant et al. (2015) includes a low, moderate, and high scenario. All scenarios include the same level of control based on OTB regulations. O&G activity forecasts differ by scenario. The low scenario is based on a continuation of slow development under low O&G price conditions. The medium scenario is based on additional production needed to meet anticipated Liquefied Natural Gas (LNG) Plant capacities. The high scenario is based on a return to historical development levels that occurred when O&G prices were high.

Studies based on a single scenario generally account for on-the-books regulations and are based on the continuation of recent historical activity trends and/or EIA Annual Energy Outlook (AEO) forecasts. Forecasts are generally basin specific except in cases where EIA AEO forecasts by EIA O&G Supply region (there are 8 onshore O&G Supply regions in the US) or EIA census division (there are 9 EIA census divisions in the US) are used.

Potential areas of improvement for application of control estimates include:

- Explicitly accounting for fleet turnover to estimate emission reductions resulting from New Source Performance Standard (NSPS) modified provisions. Typically, NSPS emission reductions are applied to new sources only. Information has not been readily available to estimate fleet turnover rates.
- Emission control estimates are typically based on estimates of rule penetration and control efficiency. Discussion in Section 2.4.1 provides several other control parameters that can be used to refine estimates of emission reductions resulting from control programs.
- Fleet turnover estimates for hydraulic fracturing and drill rigs to new engines meeting cleaner emission standards are not well characterized. In several studies, EPA NONROAD model default oil field equipment fleet turnover rates have been applied. Better information of the current drill rig fleet age distribution would allow for a more informed fleet turnover methodology.

Table 2-4. Select future year emission inventory study basic information.

Reference	Study Name	Applicable States	Applicable Basins	Future Year(s)	Forecast Well Type(s)	Scenarios
Grant et al. (2018)	Future Year 2028 Emissions from Oil and Gas Activity in the Greater San Juan Basin and Permian Basin (Draft)	Colorado New, Mexico	Greater San Juan	2028	Shale, non-shale oil, non-shale gas and CBM	Single scenario
			Permian	2028	Oil, gas	Single scenario
Vijayraghavan et al. (2017)	Colorado Air Resource Management Modeling Study (CARMMS) 2.0	Colorado New Mexico	DJ, Piceance, Greater San Juan, Paradox, Raton	2016-2025	Shale, non-shale oil, non-shale gas and CBM	High development scenario; Low development scenario; and Medium development scenario (same O&G activity forecast as high scenario with additional emissions controls)
EPA (2016)	Air Quality Modeling Platform (2011 Version 6.3 Platform)	US-wide	All Basins in the Country	2017	Oil, gas	Single scenario
Grant et al. (2014a; 2014b)	Development of Baseline 2011 and Future Year 2015 Emissions from Oil and Gas Activity in the Williston Basin/Great Plains Basin	Montana, North Dakota, South Dakota	Williston and Great Plains	2015	Oil, gas, CBM	Single scenario
Grant et al. (2015)	Final Report: Emissions from Oil and Gas Exploration and Production Activity in Northeast Texas	Texas	East Texas	2012-2021	Shale, non-shale oil, and non-shale gas	Aggressive (high) growth scenario Moderate growth scenario Low growth scenario
University of North Carolina and ENVIRON (2014)	Three-State Air Quality Modeling Study (3SAQS) Final Modeling Protocol 2011 Emissions & Air Quality Modeling Platform	Colorado, Montana, New Mexico, North Dakota, South Dakota, Utah, Wyoming	DJ, Piceance, North San Juan, Uinta, South San Juan, Wind River, Powder River, Greater Green River, Big Horn, Paradox and Raton	2020	Oil, gas, CBM	Single scenario

Table 2-5. Select future year emission inventory study O&G activity forecast methods.

Reference	O&G Activity Forecast Method		
	O&G Activity Forecast Basis	Geographical Basis of Forecast	O&G Metrics
Grant et al. (2018)	<ul style="list-style-type: none"> • <u>Shale</u> drilling and production based on CARMMS 2.0 • <u>CBM</u> drilling based on CARMMS 2.0 • <u>CBM and non-shale oil and gas production</u> estimated based on historical activity trends 	Basin-level	By well type (shale, oil, gas, CBM): <ul style="list-style-type: none"> • Spuds • Active well count • Gas production • Oil production
	EIA AEO forecasts by: <ul style="list-style-type: none"> • Oil and gas supply region (all gas and non-shale oil) • Shale play (shale oil) 	EIA AEO Oil and Gas Supply Module region adjusted and EIA AEO play-level shale oil forecasts	<ul style="list-style-type: none"> • Total gas production • Oil production by well type
Vijayraghavan et al. (2017)	<u>All areas except Southern Ute Indian Tribe (SUIT) lands</u> <ul style="list-style-type: none"> • Low scenario growth based on historical 5-year average drilling • Medium and high scenarios based on Reasonably Foreseeable Development (RFD) drilling estimates • Production forecasts based on scenario specific well counts and well decline curves by well type <u>SUIT Shale</u> <ul style="list-style-type: none"> • O&G activity forecast based on Supplemental Environmental Impact Statement (SEIS) for Shale Formation Oil and Gas Plan of Development 	Bureau of Land Management (BLM) field office / planning area	By well type (shale, oil, gas, CBM): <ul style="list-style-type: none"> • Spuds • Active well count • Gas production • Oil production
EPA (2016)	<u>Natural gas and crude oil for all sources except point source internal combustion engine/turbine and boiler/process heaters</u> <ul style="list-style-type: none"> • AEO O&G Plays: EIA AEO play-level forecasts • Outside of AEO O&G Plays: EIA AEO Supply Module Region forecasts adjusted for play level forecasts • All growth factors capped at 150% growth <u>Natural gas fueled point source internal combustion engine/turbine and boiler/process heaters</u> <ul style="list-style-type: none"> • Forecast parameter: lease plant fuel + pipeline fuel natural gas consumption • AEO O&G Plays: EIA AEO play-level consumption forecasts 	EIA AEO Oil and Gas Supply Module region, EIA AEO Census Division, and EIA AEO play-level shale oil forecasts	By play/area: <ul style="list-style-type: none"> • Gas production • Oil production



Reference	O&G Activity Forecast Method		
	O&G Activity Forecast Basis	Geographical Basis of Forecast	O&G Metrics
	<ul style="list-style-type: none"> • Outside of AEO O&G Plays: EIA AEO Census Division • Growth factors capped at 25% growth 		
Grant et al. (2014a; 2014b)	Estimated future year O&G activity from historical activity trends	County grouping	By Well type (oil, gas): <ul style="list-style-type: none"> • Spuds • Active well count • Gas production • Oil production
Grant et al. (2015)	<p><u>Low Scenario</u>: Forecast development assumed equal to slow development during period with historical low natural gas price</p> <p><u>Moderate Scenario</u>: Based on development needed to meet additional permitted LNG facility capacities.</p> <p><u>High Scenario</u>: Based on gradual return in 7 years to development levels during high natural gas prices</p>	Play / Basin	By Well type (shale, non-shale oil, non-shale gas): <ul style="list-style-type: none"> • Spuds • Active well count • Gas production • Oil production
University of North Carolina and ENVIRON (2014)	Estimated future year O&G activity from historical activity trends	Basin	By Well type (oil, gas, CBM): <ul style="list-style-type: none"> • Spuds • Active well count • Gas production • Oil production

Table 2-6. Select future year emission inventory study, application of federal and state regulation controls.

Regulation	Controlled Well site Source Categories	O&G Emission Inventory Study Reference					
		Grant et al. (2018)	Vijayraghavan et al. (2017)	EPA (2016)	Grant et al. (2014a; 2014b)	Grant et al. (2015)	University of North Carolina and ENVIRON (2014)
Nonroad engine Tier standards and Diesel Fuel Sulfur	Off-road mobile source diesel engines <ul style="list-style-type: none"> • Drill rigs • Fracing engine • Workover rigs 	✓	✓		✓	✓	✓
NSPS OOOO	<ul style="list-style-type: none"> • Completions • Tanks • Pneumatic Controllers • Compressor Seals 	✓	✓	✓	✓	✓	✓
NSPS OOOOa	<ul style="list-style-type: none"> • Completions • Tanks • Pneumatic Controllers • Compressor Seals¹ • Fugitive Components • Pneumatic Pumps 	✓	✓				
NSPS JJJJ	Natural gas-fueled stationary IC engines: <ul style="list-style-type: none"> • Compressor engines • Water pump engines • Artificial lift engines 	✓	✓	✓	✓	✓	✓
Natural Gas Turbine and Boiler/Process Heater NOx	Point source turbines and process heaters ¹			✓			

Regulation	Controlled Well site Source Categories	O&G Emission Inventory Study Reference					
		Grant et al. (2018)	Vijayraghavan et al. (2017)	EPA (2016)	Grant et al. (2014a; 2014b)	Grant et al. (2015)	University of North Carolina and ENVIRON (2014)
BLM Methane Rule ²	<ul style="list-style-type: none"> • Completions • Casinghead gas • Tanks • Pneumatic Controllers • Compressor Seals • Fugitive Components • Pneumatic Pumps • Liquids Unloading 	✓					
RICE NESHAP	Reciprocating Internal Combustion Engines ¹			✓			
State Agency Regulations	<ul style="list-style-type: none"> • CDPHE Regulation 7 • Montana ARM • NDAC 33-15-07 Bakken Pool Guidance • NDIC Order 24665 • East Texas Combustion Rule • Wyoming BACT Guidance 	✓	✓		✓	✓	✓

¹ Not applicable / limited applicability to well sites

² Applicable to only wells producing from federal mineral estate

2.3 Control Methodologies

A comprehensive list of local, state, and federal regulations applicable to developing a controls analysis for O&G emission inventory forecasts in the WRAP region was developed using a previous compilation from WRAP (2013) as a starting point with updates provided by state and federal agencies. Appendix Table A1 provides a summary of regulations applicable to VOCs and Table A2 provides a summary of regulations applicable to NOx and minor sources.

As part of the next phase of this work, Ramboll will collaborate with OGWG members to develop a comprehensive controls input matrix for (1) on-the-books and on-the way (OTW) controls for Road Map Task II.b. (Forecast Year [OTB & OTW Controls] Oil & Gas Emissions Inventory) and (2) additional reasonable controls for Road Map Task II.c. (Forecast Year [Additional Reasonable Controls] Oil & Gas Emissions Inventory).

The controls matrix format will be developed in collaboration with the OGWG so that it can be efficiently applied to estimate emission reductions in several future year emission inventory scenarios. The controls matrix would include all inputs necessary to estimate emission reductions resulting from emission controls at the basin level. Control matrix elements would be tailored to each scenario in collaboration with OGWG members. Base year and future year control metrics by source category are listed below. Estimates for italicized items may not be readily available.

- Applicable rule(s)
- Control efficiency
- Applicability to new/modified/existing sources
- *Control capture efficiency*
- *Control effectiveness*
- *Rule penetration*
- *Rule effectiveness*
- *Fleet turnover rate*

2.4 Colorado 2017 Emission Inventory Updates

Wells (2017) presents several concepts that are important to consider in developing O&G emission inventories. The methodology and factors by which emission controls are applied to an inventory and the effect of the evolution of O&G production from vertical to horizontal wells on well site configuration and emissions are addressed in Wells (2017). These topics are summarized below along with potential approaches to incorporate lessons learned in Colorado across WRAP region O&G basins.

2.4.1 Control Program Emission Reduction Accounting

Wells (2017) notes the following parameters that should be accounted for to accurately estimate emission reductions resulting from control programs:

- “**Control efficiency** means the efficiency by which a control device or measure reduces emissions for a particular pollutant.
- **Control capture efficiency** means the percentage of an exhaust gas stream actually collected for routing to a set of control devices. In the EIS, it is a percent and should be reported as a value greater than or equal to 0.1 and less than or equal to 99.9.
- **Control effectiveness** means the percentage of time or activity throughput that a control approach is operating as designed, including the capture and reduction devices.
- **Rule penetration** means the percentage of a nonpoint source category activity that is covered by the reported control measures.
- **Rule effectiveness** means a rating of how well a regulatory program achieves all possible emissions reductions.”

Wells (2017) reports substantial under-estimation of emissions from tanks in Colorado prior to including estimates of *control capture efficiency* in emission inventory calculations.

Most WRAP region emission inventories have not explicitly accounted for *control capture efficiency* or *rule effectiveness*. The use of the control metrics presented in Wells (2017) would allow for greater flexibility and accuracy in emission control program reduction accounting.

2.4.2 Well site Configuration Changes Resulting from Increased Prevalence of Horizontal Wells

As described in Wells (2017), prior to 2013, O&G production in the North Front Range non-attainment area (NAA) was primarily from vertical wells. Since 2013, O&G development has focused on horizontal wells in the Niobrara Shale. Older vertical wells typically included one stage of separation prior to liquid hydrocarbon storage. Horizontal wells include one, two, or three stages of separation prior to liquid hydrocarbon storage and increasingly horizontal well sites are tankless (i.e., liquid hydrocarbons are sent directly to highly controlled centralized facilities with no well site storage). Despite substantial increases in O&G production in the NAA since 2013, tank VOC emissions have decreased, primarily as a result of lower emission rates from horizontal wells resulting from tankless and multi-stage separation sites.

Accounting for changes to well site configurations in basins where there have been or are expected to be a substantial evolution from vertical wells to horizontal wells could yield improvements in emission inventory accuracy.

3.0 WORK PLAN

This section provides a description of how the OGWG Road Map SOW will be completed. The methodology by which each step of the work plan will be carried out is described for the base year emission inventory (Section 3.1), the future year inventory with OTB and OTW controls (Section 3.2), the future year inventory with additional controls (Section 3.3), identification and review of member agency O&G programs and emissions management (Section 3.4), and administration and meetings (Section 3.5). Section 3.6 summarizes the entire effort, including deliverables, schedule, costs, and OGWG collaboration and review. Section 3.7 describes a potential future task for developing an online emission inventory platform.

3.1 Task 1: 2014 (Planning) Base Year Oil & Gas Emissions Inventory

The major steps recommended for developing a comprehensive WRAP region calendar year 2014 annual planning O&G emission inventory are described below.

The planning inventory scope will be as follows:

- Temporal:
 - Year: Calendar year 2014
 - Period: Annual emissions
- Geographical:
 - Area: All WRAP states
 - Granularity: By county and tribal/non-tribal land designation
- Source Categories:
 - Coverage: Well site and midstream
 - Granularity: EPA Source Classification Code (SCC)
- Pollutants:
 - NO_x
 - SO_x
 - PM₁₀⁹
 - PM_{2.5}
 - VOC
 - CO
 - CH₄
 - CO₂
- File Formats:
 - Excel or database format emission inventory
 - Sparse Matrix Operator Kernel (SMOKE) ready format files
 - Emission inventory
 - Spatial surrogates
 - Speciation

⁹ Not included in OGWG Road Map (WRAP OGWG, 2017). Added because PM₁₀ is necessary to develop air quality model-ready emission inventories.

3.1.1 Task 1a: Inventory Compilation, Reconciliation, Data Gaps

The 2014 planning year inventory sources discussed in Section 2.1 will be the basis of the inventory compilation in this task. Ramboll will develop a WRAP region-wide 2014 O&G emission inventory by compiling emissions from Grant et al. (2018), Parikh et al. (2017), and EPA (2018). Emission inventories will be compiled from Grant et al. (2018) and Parikh et al. (2017) for all basins for which emissions are available in these studies; emissions for remaining basins will be compiled from EPA (2018). Emission inventory estimates will be compiled by county, by tribal/ non-tribal land designation, and SCC.

Data gap filling will be performed to ensure that the planning year inventory is as complete as feasible with respect to pollutants and source categories. In order to fill data gaps, the following steps will be taken.

- CO₂ and CH₄ emissions are not included in Parikh et al. (2017). CO₂ and CH₄ emissions will be added based on emission factor ratios by source category. To the extent feasible, emission factors ratios will be basin specific.
- PM_{2.5} emissions are not included in Grant et al. (2018) and Parikh et al. (2017). PM_{2.5} emissions will be added based on source category specific PM_{2.5} to PM₁₀ ratios.
- Mud degassing emissions are not included in Grant et al. (2018) and Parikh et al. (2017). Mud degassing emission will be added based on EPA (2018).

Deliverables: Base year 2014 WRAP region O&G emission inventory in spreadsheet or database format.

3.1.2 Task 1b: 2014 O&G Activity

In order to prepare O&G activity inputs for spatial surrogates and to better understand base year O&G activity, IHS Enerdeq will be used to compile 2014 O&G activity. To the extent feasible, activity will be distinguished by well bore type (i.e., vertical, horizontal/directional). Base year O&G activity data is expected to provide background information that will facilitate decision making for data collection in Task 1c.

Deliverables: Base year 2014 WRAP region O&G activity in spreadsheet or database format.

3.1.3 Task 1c: Identify Emission Factors and Speciation Profiles for Oil and Gas Sources

In order to enhance base year emission inventory accuracy and to ensure the use of the best available gas composition profiles in emission calculations and emission processing speciation profiles, Ramboll will identify emission factors and speciation profile updates.

Ramboll will identify 5 to 10 potential survey source categories and select emission inventory inputs for the identified source categories for additional data gathering. The 5 to 10 source categories and corresponding inputs will be selected based on high uncertainty and/or potential for substantial impact on emissions magnitude. In order to identify 5 to 10 source

categories, Ramboll will develop base year 2014 emission inventory contributions by source category and perform literature review.

It is expected that identified source categories will include (1) source categories which have been identified in literature review as highly uncertain and/or with a high likelihood of being high emitters and (2) source categories that may be misrepresented in current inventories because of changes in nonpoint source equipment configurations resulting from changes in basin-wide O&G production from vertical to horizontal wells. Updates to control information by source category for parameters such as control capture efficiency and/or rule effectiveness or other factors identified as critical to emission inventory accuracy such as venting and loss source gas compositions will be considered.

Ramboll will review reference sources of O&G venting and loss speciation profiles available in EPA's latest modeling platform and emission inventory calculations for the Intermountain West to inform gas composition data collection efforts.

5 to 10 source categories along with source category specific inputs identified for update will be submitted to the OGWG for review and will be refined as needed based on OGWG comments. A simple web-based survey will be developed for S/L/T agencies to provide basin specific input factor updates. Basin specific input factors from existing inventories will be included in the survey, to the extent feasible. Existing factors will remain unchanged in the event that an S/L/T agency does not respond to the survey.

Deliverables: The literature review will be documented in a PowerPoint presentation. A simple, web-based survey will be developed to collect data from S/L/T agencies. The results of the survey will be documented in a memorandum which will include a description of the methodology by which the WRAP region emission inventory will be updated to incorporate survey data-based inputs.

3.1.4 Task 1d: Technical Improvements

In this task Ramboll will implement technical improvements identified in Task 1c to update the WRAP region O&G emission inventory compiled in Task 1a.

Deliverables: Updated WRAP region base year 2014 O&G emission inventory in spreadsheet or database format.

3.1.5 Task 1e: Reporting

Ramboll will document the methods used to develop the WRAP region O&G emission inventory in Task 1 and summarize emission inventory results.

Deliverables: Draft and final reports documenting Task 1 activities.

3.1.6 Task 1f: SMOKE-ready Inventory Files

Ramboll will develop SMOKE-ready input files in Flat File 2010 (FF10) format for the WRAP region nonpoint and point O&G inventory. The 2014 O&G activity data, compiled in Task 1b, will be used to develop spatial surrogates needed for SMOKE processing. The gas composition data collected in Task 1c will be used to develop basin-specific venting and loss speciation profiles by well type.

Ramboll will identify a list of nonpoint SCCs and develop a cross reference between SCC and spatial surrogates. We will provide recommendations for spatial surrogate assignments to the OGWG. Incorporating any feedback received from the OGWG, we will develop WRAP region-wide spatial surrogates and a cross reference file to assign surrogates to nonpoint SCCs for SMOKE processing. We anticipate developing no more than 12 unique spatial surrogate files for the WRAP region based on IHS Enerdeq O&G activity data. Spatial surrogate files developed for allocation of previous WRAP region O&G emissions have included the following

1. Active production well location (gas wells)
2. Active production well location (oil wells)
3. Active production well location (CBM wells)
4. Gas production by well location (gas wells)
5. Gas production by well location (CBM wells)
6. Associated gas production by well location (oil wells)
7. Condensate production by well location (gas wells)
8. Oil production by well location (oil wells)
9. Spuds locations (all wells)

Up to three additional spatial surrogate files would be developed to allow for distinction between vertical and horizontal well bore spatial surrogates. The suite of spatial surrogates to be developed would be informed by the findings of Task 1b and chosen based on input from the OGWG technical committee.

Development of additional spatial surrogate files, including development of spatial surrogates based on S/L/T agency specific datasets would require additional resources.

Ramboll will update speciation profiles based on data collected in Task 1c. The results of gas composition data collection will determine how many additional speciation profiles need to be developed. It is important to note that only detailed gas composition analyses are suitable for developing speciation profiles. The basin-specific speciation profiles for venting and loss source categories will be created for SMOKE processing in SMOKE format. We will also develop a speciation cross reference file. To develop a cost estimate for this task, we have assumed that 10 speciation profiles will be developed. The results of data collection in Task 1c will determine the actual number of speciation profiles that need to be developed.

Deliverables: Ramboll will develop point and nonpoint source emission inventory FF10 files, spatial surrogate and spatial surrogate cross reference files, and speciation and speciation cross reference files in SMOKE-ready file formats for the base year 2014 emission inventory.

3.2 Task 2: Forecast Year (OTB & OTW Controls) Oil & Gas Emissions Inventory

The major steps recommended for developing a comprehensive WRAP region forecast year O&G emission inventory with OTB and OTW controls are described below. The future year inventory will be estimated for a future year 2023. Given uncertainty in future estimates of O&G activity trends, the 2023 future year inventory will be used to represent emissions in future year 2028.

The future year inventory scope is described below.

- Temporal:
 - Year: Calendar year 2023¹⁰
 - Period: Annual emissions
- Geographical:
 - Area: All WRAP states
 - Granularity: By county and tribal/non-tribal land designation
- Source Categories:
 - Coverage: Well site and midstream
 - Granularity: EPA SCC
- Pollutants:
 - NO_x
 - SO_x
 - PM₁₀
 - PM_{2.5}
 - VOC
 - CO
 - CH₄
 - CO₂
- File Formats:
 - Excel or Database format emission inventory
 - SMOKE-ready format files
 - Emission inventory
 - Spatial surrogates (if updates to base year spatial surrogates are required)
 - Speciation (if updates to base year speciation are required)

3.2.1 Task 2a: Identify Historical Growth, Supply, Demand, and Production Decline

Ramboll will use IHS Enerdeq to develop basin-level historical O&G activity trends. The historical trends will be for oil production, gas production, active well count, and spuds and will be distinguished by well type (oil, gas, CBM). To the extent feasible O&G activity will also be

¹⁰ Given uncertainty in future estimates of O&G activity trends, the 2023 future year inventory will be used to represent emissions in future year 2028.

distinguished by well bore configuration (vertical, directional/horizontal). Historical price trends will be compiled from the latest available EIA AEO.

Ramboll will develop basin-level historical O&G data for not more than 20 O&G basins. Each basin will be divided along county lines. Given the large number of basin and activity metric combinations, efficient processing and visualization of results is needed. Ramboll has already developed scripts to efficiently process IHS Enerdeq data. Ramboll expects to use a web-based application such as Dash¹¹ to display O&G activity trends for OGWG review.

Deliverables: Charts of basin-level historical O&G activity trends and O&G prices.

3.2.2 Task 2b: Identify a Range of Forecast Year Oil and Gas Scenarios

Upon provision of historical O&G activity data charts described in Task 2a to the OGWG, Ramboll will also document a range of possible options for developing emission forecasts in a one-page concept paper. In collaboration with the WRAP OGWG, the general methodology for developing the three forecast scenarios will be chosen and the one-page document will be updated to describe chosen forecast scenarios. It is expected that O&G activity and price trends will be used as a basis to develop a range of O&G activity forecast scenarios for 2023. Trends are expected to be basin specific. Example potential bases for scenarios are: (1) Forecast year O&G activity estimates assuming high O&G prices based on historical high development rates by basin, (2) Forecast year O&G activity estimates assuming low O&G prices based on historical low development rates by basin; and (3) a mid-range scenario based on the average of (1) and (2). EIA AEO cases (e.g., reference, high oil and gas resource and technology, low oil and gas resource and technology, high oil price, and low oil price) may be used to inform scenario development. Ramboll will leverage forecasts developed in other studies (e.g., Grant et al. [2018]) to the extent feasible.

Deliverables: Draft and final one-page forecast scenarios documents. Growth factors by basin and O&G activity metric for three scenarios.

3.2.3 Task 2c: Identify Rule Penetration and Effectiveness for Oil and Gas Sources: National, State, Local, Tribal

As discussed above in Section 2.3, OTB controls have been identified in collaboration with Federal and S/L/T agencies. The OTB controls will be updated to the extent necessary in collaboration with OGWG members to reflect any recent changes to OTB control status and to include any OTW controls not included in the OTB controls.

Base year controls information used to develop 2014 emission inventories is needed to accurately develop future year emission control estimates. Base year controls assumptions will be compiled by Ramboll from existing emission inventories, where available, for the control

¹¹ <https://plot.ly/products/dash/>

parameters listed below for applicable source categories. Estimates for italicized items may not be available for all areas.

- Applicable rule(s)
- Control efficiency
- Applicability to new/modified/existing sources
- *Control capture efficiency*
- *Control effectiveness*
- *Rule penetration*
- *Rule effectiveness*
- *Fleet turnover rate*

Future year OTB and OTW controls information is needed to estimate associated emission reductions. Ramboll will compile estimates of the same parameters as above for future year 2023.

The resulting base year and future year controls matrices will be reviewed by the WRAP OGWG. Ramboll will update the control matrices as needed to address WRAP OGWG comments.

Deliverables: Draft and final OTB and OTW controls matrices by basin.

3.2.4 Task 2d: Implement Regionally-Consistent 2023 Forecast (OTB & OTW Controls) Emissions Inventory

The future year emission inventory will be based on (1) the base year emission inventory compiled in Task 1d, (2) O&G activity scaling factors compiled in Task 2b, and (3) detailed controls information compiled in Task 2c. Ramboll will summarize forecast emission inventory assumptions and methodology in a PowerPoint presentation. OGWG comments will be incorporated into the future year emission inventory development methodology. Ramboll will compile three future year 2023 emission inventories (one each for low, medium, and high O&G activity development scenarios).

To efficiently and transparently compile the emission inventory over the entire WRAP region, emission inventory calculations will be performed in a database. The relational database will include the following input tables: (1) base year emissions, (2) O&G activity growth factors, and (3) controls. The equations implemented in the database to calculate future year emissions will be documented in Task 2e reporting and implemented database query scripts will be available to OGWG members, if requested.

Deliverables: Forecast inventory assumptions PowerPoint presentation. WRAP region O&G 2023 future year emission inventory in spreadsheet or database format.

3.2.5 Task 2e: Reporting

Ramboll will document the methods used to develop the WRAP region O&G emission inventory in Task 2 and will summarize emission inventory results.

Deliverables: Draft and final reports documenting Task 2 activities.

3.2.6 Task 2f: SMOKE-ready Inventory Files

Ramboll will develop SMOKE-ready input files based on the WRAP region-wide future year O&G emission inventory for three O&G activity development scenarios (low, medium, and high). The extent of future year spatial surrogate and speciation profile updates for the future year emission inventory will be known only after the future year emission inventory methods have been fully developed; therefore, resources needed for development of updated future year spatial surrogates and speciation profiles are not included in the cost estimate for this task.

Ramboll will develop SMOKE-ready emission inventory files in FF10 format for the WRAP region nonpoint and point source future year O&G emission inventory for low, medium, and high scenarios.

Deliverables: Point and nonpoint source SMOKE-ready emission inventory flat files for three future year 2023 emission inventory scenarios.

3.2.7 Optional Task 2o: Compile WRAP Region BLM RFD Estimates

In certain areas of the WRAP, federal mineral estate constitutes a substantial percentage of O&G activity. In these areas, federal mineral development is a critical driver of O&G development. BLM RFD analyses document estimates of future year O&G development. At the discretion of the OGWG, Ramboll will compile RFD estimates for 10 BLM Planning Areas, including a brief memorandum summarizing the RFD forecasts and potential methods for incorporation of the RFD forecasts into Task 2b forecast scenarios.

Deliverables: Memorandum summarizing RFD forecasts and potential methods for incorporation of RFD forecasts into Task 2b forecast scenarios.

3.3 Forecast Year (Additional Reasonable Controls) Oil & Gas Emissions Inventory

The major steps recommended for developing a comprehensive WRAP region forecast year annual future year O&G emission inventory with additional reasonable controls are described below.

The future year inventory scope will be as follows:

- Temporal:
 - Year: Calendar year 2023¹⁰
 - Period: Annual emissions

- Geographical:
 - Area: All WRAP states
 - Granularity: By county and tribal/non-tribal land designation
- Source Categories:
 - Coverage: Wellsite and midstream
 - Granularity: EPA SCC
- Pollutants:
 - NO_x
 - SO_x
 - PM₁₀
 - PM_{2.5}
 - VOC
 - CO
 - CH₄
 - CO₂
- File Formats:
 - Excel or Database format emission inventory
 - SMOKE-ready format files
 - Emission inventory

3.3.1 Task 3a: Identify Additional Reasonable Controls for Oil and Gas Sources

The OGWG will provide general direction on potential additional reasonable controls, including applicable source categories, control technology, and enforcement. Ramboll will compile a draft memorandum documenting controls assumptions to be applied in the additional reasonable controls scenario which are above and beyond OTB and OTW controls (Task 2c). Based on the OGWG review of and comments on the draft memorandum, final additional reasonable controls assumptions will be documented in the final memorandum.

Deliverables: Draft and final memoranda documenting assumptions for additional reasonable controls.

3.3.2 Task 3b: Identify Rule Penetration and Effectiveness for Oil and Gas Sources: National, State, Local, Tribal

As discussed above, a controls matrix will be developed to quantify reductions resulting from OTB and OTW controls in Task 2c. Ramboll will update the OTB and OTW controls matrix to include additional reasonable controls as determined in Task 3a.

The resulting control matrix applicable to the additional reasonable control scenario will be submitted for review by the WRAP OGWG. Ramboll will update the control matrix as needed to address WRAP OGWG comments.

Deliverables: Draft and final additional reasonable controls matrix.

3.3.3 Task 3c: Implement Regionally-Consistent Forecast Year (Additional Reasonable Controls) Emissions Inventory

The future year additional reasonable controls emission inventory will be based on (1) the base year emission inventory compiled in Task 1d, (2) low, medium, or high O&G activity scaling factors compiled in Task 2b, and (3) detailed controls information compiled in Task 3b. Ramboll will summarize additional reasonable control emission inventory assumptions and methodology in a PowerPoint presentation for the OGWG. OGWG comments will be incorporated into the future year emission inventory development methodology. Ramboll will compile a single future year 2023 emission inventory with additional reasonable controls, leveraging the relational database developed in Task 2d.

Deliverables: Additional reasonable controls PowerPoint presentation. WRAP region O&G 2023 future year additional reasonable controls emission inventory in spreadsheet or database format.

3.3.4 Task 3d: Reporting

Ramboll will document the methods used to develop the future year 2023 WRAP region O&G emission inventory in Task 3 and summarize emission inventory results.

Deliverables: Draft and final reports documenting Task 3 activities.

3.3.5 Task 3e: SMOKE-ready Inventory Files

Ramboll will develop SMOKE-ready input files based on WRAP region-wide 2023 future year O&G emission inventory with additional reasonable controls. The extent of future year spatial surrogate and speciation profile updates for the future year emission inventory will be known only after the additional reasonable controls emission inventory methods have been fully developed; therefore, resources needed for development of updated additional reasonable controls spatial surrogates and speciation profiles are not included in the cost estimate for this task.

Ramboll will develop SMOKE-ready emission inventory files in FF10 format for the WRAP region nonpoint and point source future year O&G additional reasonable controls emission inventory.

Deliverables: Point and nonpoint source SMOKE-ready emission inventory FF10 files for a single future year 2023 additional reasonable controls emission inventory.

3.4 Identification and Review of Member Agency Oil & Gas Programs and Emissions Management

3.4.1 Task 4a: Identification and Review of Member Agency Oil & Gas Programs

In collaboration with the OGWG, Ramboll will compile regulatory drivers and associated requirements that are expected to be common across O&G programs:

- Permitting and registration requirements
- Emissions management requirements
- Emissions inventory requirements
- Modeling requirements
- Monitoring requirements

Additionally, Ramboll will develop a survey to compile information from OGWG members on key features and elements of existing WRAP region O&G programs to inform development of the sample O&G program. The survey will be a simple web-based survey with queries to identify strengths, areas for improvement, gaps, requirement overlap and authority concerns, and lessons learned by individual agencies.

Ramboll will develop a PowerPoint presentation on O&G program drivers, program requirements, and survey results. The PowerPoint presentation will include explicit discussion of the needs of agencies without O&G programs and outline the required components of a basic example O&G program.

Deliverables: Web-based survey and PowerPoint presentation.

3.4.2 Task 4b: Reporting

Ramboll will document the findings of Task 4a in draft and final technical memoranda.

Deliverables: Draft and final technical memoranda documenting Task 4 activities.

3.5 Administration and Meetings

To facilitate communication with the OGWG, Ramboll will participate in monthly meetings with the OGWG and/or OGWG technical committee. At the monthly meetings, Ramboll will report on project status and present on key topics needed to ensure that the project schedule is met. Prior to meetings, Ramboll will provide materials to the OGWG committee chair for distribution.

Monthly progress reports with progress description by project task will be provided to the project manager.

Deliverables: Participation in monthly OGWG and/or OGWG technical committee monthly meetings and monthly progress reports.

3.6 Summary

Table 3-1 shows tasks, deliverables, deliverable due dates, OGWG involvement, and budget for this study.

Table 3-1. Task deliverables, schedule, budget and OGWG involvement.

Task Description		Deliverable Description	Deliverable Type ¹	Due Date (Months from Project Start)	OGWG Involvement ³	Budget ²
Task 1 2014 (Planning) Base Year Emission Inventory						\$72,500
1a	Inventory Compilation, Reconciliation, Data Gaps	Emission Inventory File	SS/Db	1	not applicable	\$4,300
1b	2014 O&G Activity	2014 O&G Activity File	SS/Db	1.5	not applicable	\$7,200
1c	Identify Emission Factors and Speciation Profiles for Oil and Gas Sources	Literature Review PowerPoint	Ppt	2.5	Comment on PPT	\$15,000
		Draft and Final O&G Survey	Ggl	3.5	Review Draft, Complete Survey	\$5,400
		O&G Survey Results Memorandum	Doc	5.5	Comment on Memo	\$10,000
1d	Technical Improvements	Draft and Final Emission Inventory	SS/Db	7	Review Draft	\$12,200
1e	Reporting	Draft and Final Report	Doc	7	Review Draft	\$6,700
1f	SMOKE-ready Emission Inventory Files	SMOKE-ready Emission Inventory Files	SMK	8.5	not applicable	\$11,700
Task 2 Forecast Year (OTB & OTW Controls) Oil & Gas Emissions Inventory						\$74,100
2a	Identify historical growth, supply, demand, and production decline	Graphs of Historical O&G Activity Trends with O&G Price History	Gph	3	Comment on Graphs	\$11,400
2b	Identify a Range of Forecast Year Oil and Gas Scenarios	Draft and Final One-page Forecast Scenario Description, 2023 O&G Activity Growth Factors for Three Scenarios	Doc, SS/Db	5.5	Comment on One-pager , Comment on Graphs	\$21,600
2c	Identify Rule Penetration and Effectiveness for Oil and Gas Sources: National, State, Local, Tribal	OTB & OTW Emission Controls Matrix	SS/Db	7	Collaborate to fill-in matrix	\$13,000
2d	Implement Regionally-Consistent 2023 Forecast (OTB & OTW controls) Emissions Inventory	Methodology Presentation, Draft and Final Emission Inventory	Ppt, SS/Db	9.5	Comment on Presentation, Review Draft Inventory	\$16,800
2e	Reporting	Draft and Final Report	Doc	9.5	Review Draft	\$9,200
2f	SMOKE-ready Emission Inventory Files	SMOKE-ready Emission Inventory Files	SMK	10.5	not applicable	\$2,100
2o	<i>Optional: Compile WRAP Region BLM RFD Estimates</i>	<i>Memorandum</i>	<i>SS/Db</i>	<i>3.5</i>	<i>Comment on Memo</i>	<i>\$6,400</i>

Task Description		Deliverable Description	Deliverable Type ¹	Due Date (Months from Project Start)	OGWG Involvement ³	Budget ²
Task 3 Forecast Year (Additional Reasonable Controls) Oil & Gas Emissions Inventory						\$29,100
3a	Identify Additional Reasonable Controls for Oil and Gas Sources	Additional Controls Emission Scenario Memorandum	Doc	11	Comment on Memo	\$5,800
3b	Identify Rule Penetration and Effectiveness for Oil and Gas Sources: National, State, Local, Tribal	Additional Reasonable Emission Controls Matrix	SS/Db	14	Comment on Controls Matrix	\$6,100
3c	Implement Regionally-consistent 2023 Forecast (Additional Reasonable Controls) Emissions Inventory	Methodology Presentation, Draft and Final Emission Inventory	Ppt, SS/Db	16	Review Draft	\$7,000
3d	Reporting	Draft and Final Report	Doc	16	Review Draft	\$9,200
3e	SMOKE-ready Emission Inventory Files	SMOKE-ready Emission Inventory Files	SMK	17	not applicable	\$1,000
Task 4 O&G Programs and Emission Management						\$19,700
4a	Identification and Review of Member Agency Oil & Gas Programs	Survey of Existing O&G Programs. Survey Results Presentation.	Ggl, Ppt	13	Collaborate on Survey Development, Fill-out Survey , Comment on Presentation.	\$11,900
4b	Reporting	Draft and Final Memoranda	Doc	15	Review Draft	\$7,800
Task 5 Administration & Meetings						\$18,600
5a	Administration & Meetings	Monthly OGWG Teleconferences, Bi-monthly Progress Reports, Three Regional Planning Work Group Meeting Presentations	Mtg	TBD	not applicable	\$18,600
Total (without optional Task 2o)						\$214,000

¹ Abbreviations: WORD and/or PDF document (Doc); spreadsheet or database (SS/Db), PowerPoint Presentation (Ppt), Google document/spreadsheet (Ggl), SMOKE-ready input file format (SMK), graphs and charts (Gph).

² Task subtotals and grand totals do not include optional task

³ Bold items will be reviewed by the OGWG, items in regular font will be reviewed by the OGWG Technical Committee

3.7 Potential Future Task: Online Emission Inventory Platform

In addition to the tasks that have been scoped out in this work plan, Ramboll could also develop an online platform that allows for storage and download of planning and forecast year O&G emission inventory files. Emission inventory parameters such as scenario, state/county, inventory type (point or nonpoint source), SCC, and pollutant would be selected by the online user. The online platform would then create the requested file for the user to download. Additional input on desired online platform functionality would be needed to include the creation of such an online platform as an addendum to project work plan.

4.0 REFERENCES

- Allen, D.T, A. Pacsi, D. Sullivan, D. Zavala-Araiza, M. Harrison, K. Keen, M. Fraser, A. Hill, R. Sawyer, and J. Seinfeld. 2015. Methane Emissions from Process Equipment at Natural Gas Production Sites in the United States: Pneumatic Controllers, *Environmental Science & Technology* 2015 49 (1), 633-640. doi: 10.1021/es5040156
- Brandt, A.R., et al. 2014. Methane Leaks from North American Natural Gas Systems, *Science*, 343, 733-735.
- Brandt, A.R., et al. 2016. Methane Leaks from Natural Gas Systems Follow Extreme Distributions, *Environmental Science & Technology*, 2016, 50, 12512-12520, doi: 10.1021/acs.est.6b04303.
- EPA. 2016. "Technical Support Document (TSD): Preparation of Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform," US Environmental Protection Agency Office of Air and Radiation, Office of Air Quality Planning and Standards, Air Quality Assessment Division. August 2016.
- EPA. 2018. 2014 National Emissions Inventory, version 2. March 2018. US Environmental Protection Agency. February, 2018. <https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data>
- Grant, J., R. Parikh, A. Bar-Ilan, R. Morris. 2014a. "Development of Baseline 2011 and Future Year 2015 Emissions from Oil and Gas Activity in the Williston Basin, Final Report." August 2014. https://www.wrapair2.org/pdf/2011_2015_Williston_Basin_14Aug2014.pdf
- Grant, J., R. Parikh, A. Bar-Ilan, R. Morris. 2014b. "Development of Baseline 2011 and Future Year 2015 Emissions from Oil and Gas Activity in the Great Plains Basin, Final Report." August 2014. https://www.wrapair2.org/pdf/2011_2015_GreatPlains_Basin_14Aug2014.pdf
- Grant, J., Y. Alvarez, R. Parikh, L. Huang, A. Bar-Ilan, S. Kembball-Cook, G. Yarwood. 2015. "Final Report: Emissions from Oil and Gas Exploration and Production Activity in Northeast Texas". October 2015.
- Grant, J., R. Parikh, A. Bar-Ilan. 2017. "Memorandum: Analysis of the National Oil and Gas Emission Inventory," Ramboll Environ. Prepared for Tom Moore, WESTAR; Julie McDill, MARAMA; Theresa Pella, CenSARA; Mark Janssen, LADCO.
- Grant, J., R. Parikh, A. Bar-Ilan. 2018. "San Juan and Permian Basin 2014 Oil and Gas Emission Inventory," Ramboll. Prepared for Western Regional Air Partnership and Western States Air Resources Council. January 2018. https://www.wrapair2.org/pdf/2014_SanJuan_Permian_Baseyear_EI_Final_Report_10Nov2017.pdf

- Lyon, D.R., et al. (2016), Aerial Surveys of Elevated Hydrocarbon Emissions from Oil and Gas Production Sites, *Environmental Science & Technology*, 2016, 50, 4877-4886, doi: 10.1021/acs.est.6b0070
- OIPA. 2014. "Pneumatic Controller Emissions from a Sample of 172 Production Facilities". Oklahoma Independent Petroleum Association. November 2014.
http://www.oipa.com/page_images/1418911081.pdf
- Parikh, R., J. Grant, A. Bar-Ilan. 2015. "Memorandum: Intermountain West Data Warehouse (IWDW) - Western Air Quality Study (WAQS) 2011b Modeling Platform O&G Emission Inventory Updates," Ramboll Environ. Prepared for Tom Moore, WESTAR; Zac Adelman, UNC. December 2015.
http://vibe.cira.colostate.edu/wiki/Attachments/Emissions/WSAQS_OG_2011b_memo_24Dec2015.pdf
- Parikh, R., J. Grant, A. Bar-Ilan. 2017. "Memorandum: 2014 Oil and Gas Intermountain West Criteria Pollutant Emission Inventories for Colorado, Montana, New Mexico, North Dakota, South Dakota, Utah, and Wyoming," Ramboll Environ. Prepared for Tom Moore, WESTAR-WRAP. June 2017.
http://vibe.cira.colostate.edu/wiki/Attachments/2014_OG/WESTAR_2014_OandG%20E_Memo_08Jun2017.pdf
- UDAQ. 2017. Uinta Basin: 2014 Air Agencies Oil and Gas Emissions Inventory. Utah Division of Environmental Quality. <https://deq.utah.gov/locations/U/uintahbasin/air-agencies-emissions-inventory/index.htm>
- University of North Carolina and ENVIRON. 2014. "Three-State Air Quality Modeling Study (3SAQS) Final Modeling Protocol 2011 Emissions & Air Quality Modeling Platform". July 2014.
vibe.cira.colostate.edu/wiki/Attachments/Modeling/3SAQS_2011_Modeling_Protocol_Finalv2.pdf
- Wells, D. 2017. "Consequences of the Evolution of Oil and Gas Control and Production Technology in the Denver Ozone Nonattainment Area," Colorado Department of Public Health and Environment, Air Pollution Control Division. August 2017.
http://vibe.cira.colostate.edu/ogec/docs/meetings/2017-09-14/EIC%202017%20Oil%20and%20Gas%20Session%20Papers%20and%20Presentations/1_EIC%202017%20OandG%208_915%20AM/Paper_Wells_Consequences%20of%20the%20Evolution%20of%20Control%20and%20Production%20Technology%20in%20the%20Denver%20Ozone%20NAA.pdf
- Vijayraghavan, K., Z. Liu, J. Grant, T. Shah, J. Jung, L. Huang, W. Hsieh, R. Morris, K. Meszaros, R. Erbes, D. Collins. (2017). "Colorado Air Resource Management Modeling Study (CARMMS) 2025 CAMx Modeling Results for the High, Low and Medium Oil and Gas Development Scenarios: CARMMS 2.0 Final Report". Ramboll Environ and Kleinfelder. August 2017.

WRAP. 2013. "Analysis of States' and EPA Oil & Gas Air Emissions Control Requirements for Selected Basins in the Western United States (2013 Update)," Lee Gribovicz. November 2013. [https://www.wrapair2.org/pdf/2013-11x_O&G%20Analysis%20\(master%20w%20State%20Changes%2011-08\).pdf](https://www.wrapair2.org/pdf/2013-11x_O&G%20Analysis%20(master%20w%20State%20Changes%2011-08).pdf)

WRAP OGWG. 2017. "WRAP OGWG Road Map Scope of Work Road Map," Western Regional Air Partnership Oil and Gas Work Group. November 2017.

APPENDIX A

On-the-books Regulation Tables

Available Electronically in *OGWG_WP_AppendixA.xlsx*

Appendix A On-the-books Regulation Tables

Table A1. State Control Regulations and Requirements as Compared to Federal Rules (VOC & Minor Source Permits; updated from WRAP [2013], Table 2).

Available electronically in *OGWG_WP_AppendixA.xlsx*, tab *A1*

Table A2. State Control Regulations and Requirements as Compared to Federal Rules (NOx Control Requirements); updated from WRAP [2013], Table 3).

Available electronically in *OGWG_WP_AppendixA.xlsx*, tab *A2*

Table A3. California Local Air Districts Requirements for VOC Emissions Control.

Available electronically in *OGWG_WP_AppendixA.xlsx*, tab *A3*

Table A4. California Local Air Districts Requirements for NOx Emissions Control.

Available electronically in *OGWG_WP_AppendixA.xlsx*, tab *A4*