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WRAP Oil & Gas:

2002/2005 and 2018 Area Source Emissions Inventory Improvements

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WRAP Oil and Gas Project Overview

- Project is focused on developing an improved emissions inventory of oil and gas exploration and production area sources in the WRAP region
- Area source categories include compressor engines, drilling rigs, heaters and other wellhead equipment
- Previous emission inventory (EI) efforts:
  - WRAP Phase I analysis, 2002 and 2018 (completed 2005)
  - NMED EI for San Juan and Rio Arriba counties (completed 2006)
- Specific objectives of the Phase II project:
  - Emissions inventory improvements for 2002
  - Current base year updates for 2005
  - 2018 growth factor projections improvements
  - Control technology evaluations and control strategies scenarios
  - 2018 point source SO_2 emissions improvements

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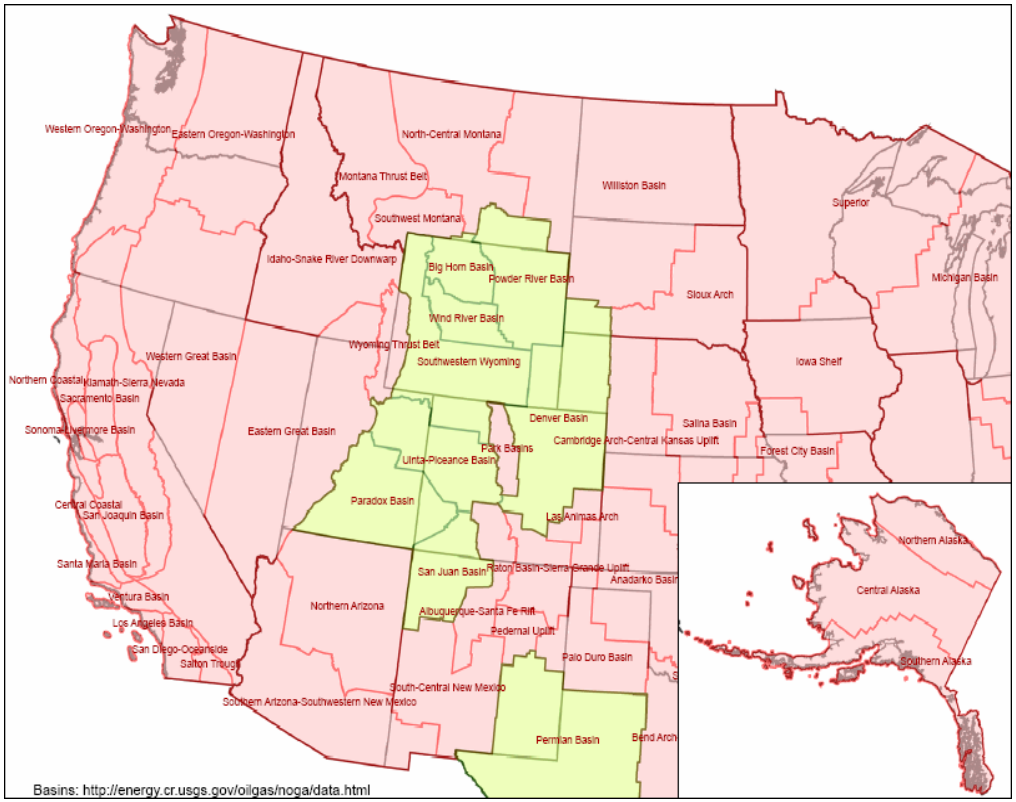
Western States Oil & Gas Regions of Interest



Major basins of O&G activity in Phase II analysis:

- Permian Basin (NM)
- San Juan Basin North (CO)
- Denver-Julesburg Basin (CO)
- Green River Basin (WY)
- Big Horn Basin (WY and MT)
- San Juan Basin South (NM)
- Uinta-Piceance Basin (CO and UT)
- Paradox Basin (UT)
- Wind River Basin (WY)
- Powder River Basin (WY and MT)

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Western States Oil & Gas Recent Activity

- Why examine oil and gas emissions?
  - Major growth in natural gas exploration and production in WRAP region between 2000 – present
  - State SIP compliance issues – Wyoming
- Why area source emissions?
  - Previous inventories did not include these important sources
  - Over 100,000 wells in New Mexico & Wyoming alone

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2002 Emissions Inventory Improvements

- New methodology estimated 2002 emissions on a basin-wide average basis for all basins in the WRAP region, focusing on those basins where major O&G activities are occurring and detailed producer information is available

- In basins where significant activity was not occurring, or producer information was unavailable, used Phase I estimates

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Data Collection from O&G Producers

- Data were collected from all major and some medium-sized and independent oil and gas companies operating in the WRAP region
- Data collection was in the form of a questionnaire sent to each producer
- Information was provided on:
  - Overall activity (i.e. number of wells, gas production, etc.)
  - Equipment used and equipment counts
  - Emissions controls in use or planned
  - Projections of future activity, demand, and production in the region

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Brief Overview of Methods

- Basin-specific emissions estimates were made using activity and equipment information provided directly by the producers
  - Previous Phase I work used available data from limited areas and generalized to WRAP region
- For Phase II EI improvements, focus is on well-head compressors and drilling rigs as area sources
- Focused basin list only – these are the areas where major oil and gas activity is occurring or expected to occur
- Updated baseline emissions year from 2002 to 2005
- Revised 2018 projections using most recent planning information available and producer data where available

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2002 Emissions Inventory
Drilling Rig Emissions

- Improved estimate of actual drilling time by formation and basin from producer information on drilling times (rather than spud date and well completion date)
- Improved estimate of average drilling rig engine load by formation and basin
- Determined average horsepower requirements by formation and basin and identified most often used or representative makes/models of drilling rig engines
- Incorporated manufacturer's rated emissions factors for makes/models identified, or producers' emissions tests where available
- Incorporated SO_2 emissions factors (based on sulfur content of fuel)

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2002 Emissions Inventory
Drill Rig Emissions - TPY

	NOx	SOx	VOC
	2002	2002	2002
Alaska	877	66	0
Arizona	0	0	0
Colorado	2,803	118	101
Montana	1,046	225	0
Nevada	24	1	0
New Mexico	5,476	244	68
North Dakota	1,536	358	0
Oregon	0	0	0
South Dakota	29	6	0
Utah	334	17	12
Wyoming	4,997	150	228
WRAP Total	17,123	1,185	410

Note: Emissions estimates include data from previous work for the NMED in the San Juan Basin and the Southern Ute inventory in Colorado

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2002 Emissions Inventory
Compressor Engine Emissions

- Determined for each basin the average percentage of wells with wellhead, lateral and central compression
- Did not include central and lateral compressors that have been counted in a point source inventory for each state
- Determined for each basin a representative or most often used make/model of compressor, including HP and rated or tested emissions factors
- Determined for each basin an average load factor for wellhead/lateral compressors
- Basin-wide emissions estimate on the basis of total well count

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2002 Emissions Inventory

Compressor Engine Emissions - TPY

	NOx	SOx	VOC
	2002	2002	2002
Alaska	0	0	0
Arizona	8	0	0
Colorado	3,271	0	1,204
Montana	1,791	0	4
Nevada	33	0	0
New Mexico	35,140	1	3,541
North Dakota	2,920	0	0
Oregon	73	0	0
South Dakota	284	0	0
Utah	843	0	53
Wyoming	1,791	0	231
WRAP Total	46,154	1	5,034

Note: Emissions estimates include data from previous work for the NMED in the San Juan Basin and the Southern Ute inventory in Colorado

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2002 Emissions Inventory
Exploration & Production

- Previous Work included:
  - Tanks - flashing, working and breathing losses (VOC)
  - Glycol dehydration units (VOC)
  - Heaters (VOC and NOx)
  - Pneumatic Devices (VOC)
  - Completion-venting and flaring (VOC, NOx, CO)
- This work also investigated:
  - Coal Bed Methane (CBM) wells
  - Fugitive dust (resources did not allow this task to be completed)

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Updated 2002 → 2005 Emissions

- Objective was to update base year for projections from 2002 to 2005 using newly available state OGC data for 2005
- 2005 represents a more current base year for projections and can be used as a second “data point” to verify projections methodology
- Methodology was to first update 2002 emissions using the Phase II tasks described here, then to scale up 2002 data using 2005 OGC well count or production
- In areas with no production or wells in 2002, but with production or wells in 2005 emissions were scaled based on state average emissions per well (or per production unit)

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Updated 2002 → 2005 Emissions

Drill Rig Emissions - TPY

	NOx		SOx		VOC	
	2002	2005	2002	2005	2002	2005
Alaska	877	835	66	62	0	0
Arizona	0	0	0	0	0	0
Colorado	2,803	8,000	118	350	101	308
Montana	1,046	3,007	225	640	0	3
Nevada	24	37	1	1	0	0
New Mexico	5,476	8,640	244	362	68	111
North Dakota	1,536	3,055	358	688	0	0
Oregon	0	0	0	0	0	0
South Dakota	29	203	6	43	0	0
Utah	334	2,888	17	149	12	106
Wyoming	4,997	15,783	150	541	228	714
WRAP Total	17,123	42,448	1,185	2,835	410	1,242

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Updated 2002 → 2005 Emissions

2005 Compressor Engine Emissions - TPY

	NOx		SOx		VOC	
	2002	2005	2002	2005	2002	2005
Alaska	0	0	0	0	0	0
Arizona	8	6	0	0	0	0
Colorado	3,271	3,302	0	0	1,204	1,225
Montana	1,791	2,267	0	0	4	10
Nevada	33	33	0	0	0	0
New Mexico	35,140	35,345	1	1	3,541	3,542
North Dakota	2,920	2,799	0	0	0	0
Oregon	73	51	0	0	0	0
South Dakota	284	305	0	0	0	0
Utah	843	996	0	0	53	64
Wyoming	1,791	3,288	0	0	231	459
WRAP Total	46,154	48,393	1	1	5,034	5,300

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2018 Emissions

- Emissions estimated for county-level emissions in WRAP region for:

  NOx, SO_2, VOC, CO

- Emissions included updated growth projections from Resource Management Plans, Alaska Oil & Gas Report, and National Energy Forecast released by the Energy Information Administration (EIA)
- Projected emissions to 2018 using 2005 base case and growth factors
- State controls evaluated:
  - Wyoming BACT requirements for permitted sources
  - Colorado controls requirements for point sources (ERG)
  - Utah BACT requirements for compressors
- Federal controls evaluated:
  - Federal nonroad engine standards
  - EPA nonroad diesel fuel sulfur content standards

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2018 Emissions Projections
Drilling Rigs - TPY

	NOx		SOx		VOC	
	2005	2018	2005	2018	2005	2018
Alaska	835	452	62	1	0	0
Arizona	0	0	0	0	0	0
Colorado	8,000	4,413	350	11	308	155
Montana	3,007	2,821	640	6	3	10
Nevada	37	21	1	0	0	0
New Mexico	8,640	5,343	362	3	111	68
North Dakota	3,055	1,655	688	4	0	0
Oregon	0	0	0	0	0	0
South Dakota	203	118	43	0	0	0
Utah	2,888	944	149	1	106	31
Wyoming	15,783	9,883	541	3	714	407
WRAP Total	42,448	25,652	2,835	29	1,242	671

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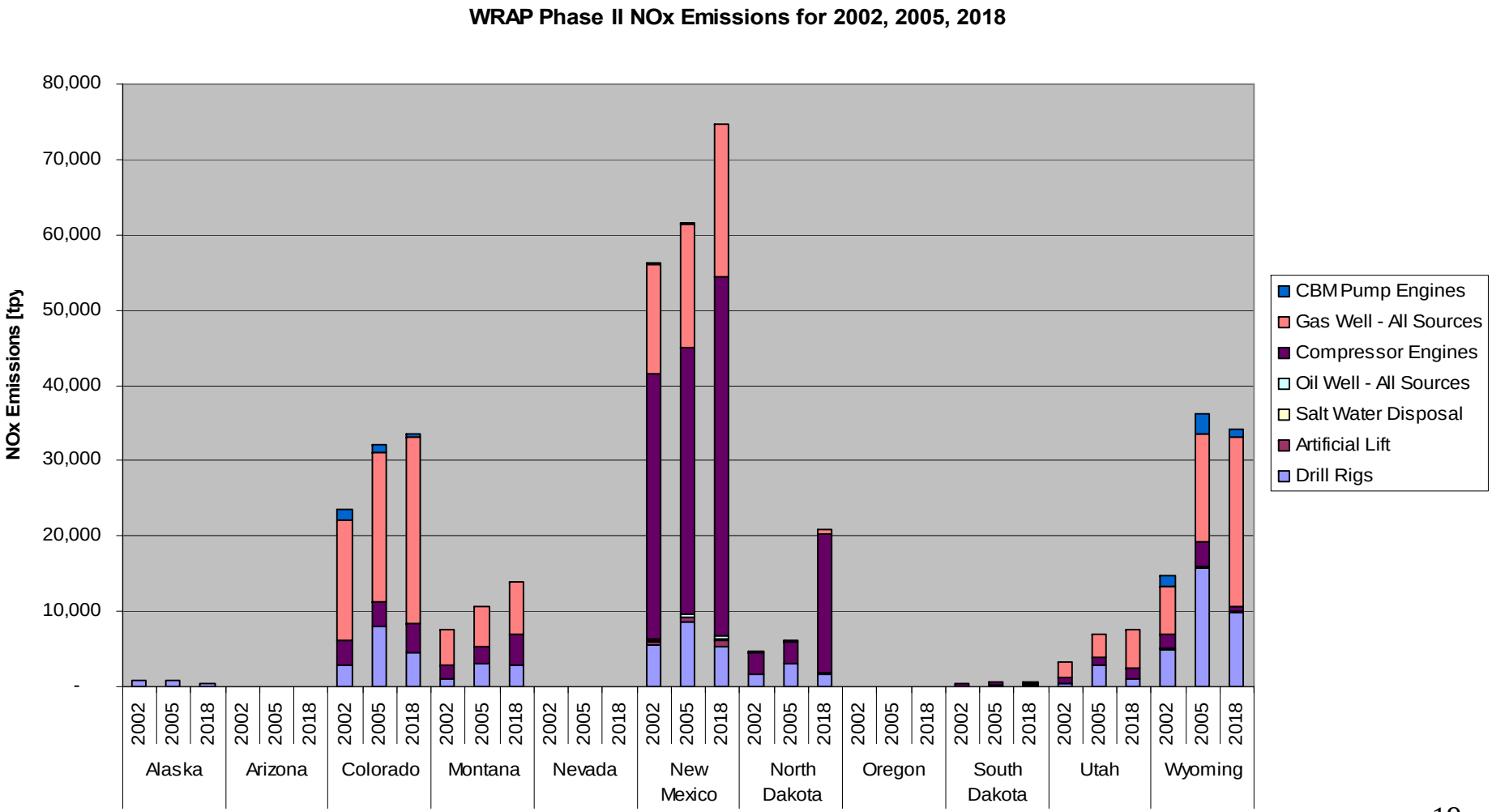
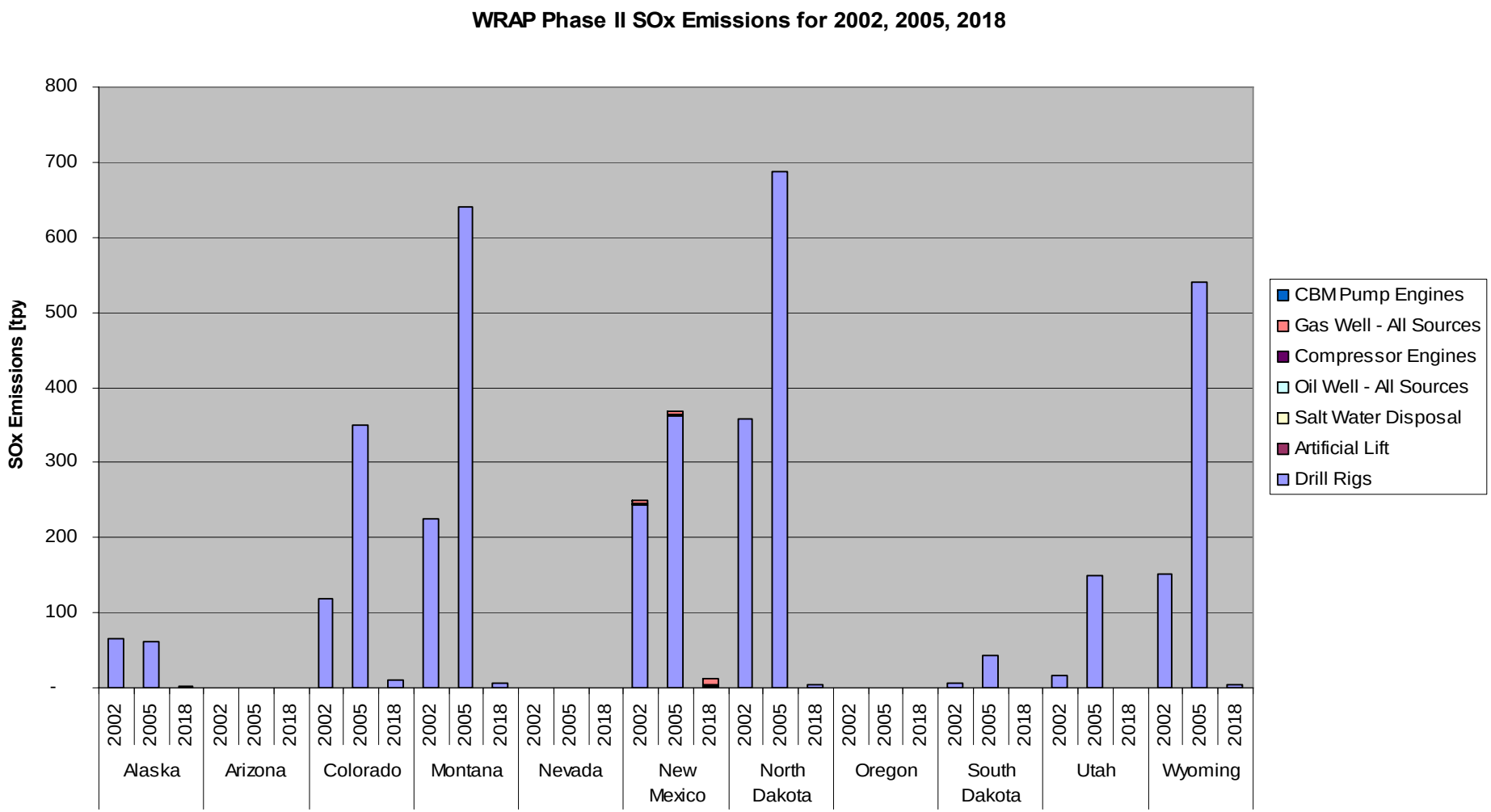
2018 Emissions Projections
Compressor Engines - TPY

	NOx		SOx		VOC	
	2005	2018	2005	2018	2005	2018
Alaska	0	0	0	0	0	0
Arizona	6	8	0	0	0	0
Colorado	3,302	4,006	0	0	1,225	1,485
Montana	2,267	3,946	0	0	10	421
Nevada	33	40	0	0	0	0
New Mexico	35,345	47,599	1	1	3,542	4,879
North Dakota	2,799	18,399	0	0	0	0
Oregon	51	37	0	0	0	0
South Dakota	305	368	0	0	0	0
Utah	996	164	0	0	64	91
Wyoming	3,288	655	0	0	459	464
WRAP Total	48,393	76,399	1	1	5,300	7,340

WRAP Phase II NOx Emissions for 2002, 2005 and 2018



WRAP Phase II SOx Emissions for 2002, 2005 and 2018



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Discussion of Results of 2018 Projections

- NOx emissions jump in North Dakota - due to Dakota Prairie Grasslands Resource Management Plan (RMP).
- Wyoming NOx emissions decrease from 2005 to 2018 – due to wellhead compressor emissions reduction, implementation of the BACT controls requirement by 2018
- Oil vs. gas wells – corrected the assumption of emissions based on all gas production, no gas equipment on oil wells.
- SO_2 emissions in both 2002 and 2018 have been reduced from Phase I due to improved estimates of actual drilling times based on producer feedback
- General trend in this analysis is for SOx emissions to decrease substantially by 2018 due to the phase-in of ultra-low sulfur diesel fuel

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Future Work

- Expand updated methodology to other source categories
  - Dehydrators
  - Heaters
  - Wellhead sources (i.e. venting, flaring, breathing losses)
  - Pneumatic devices
- Analyze and apply potential control measures and look at basin-wide and state-wide controls scenarios