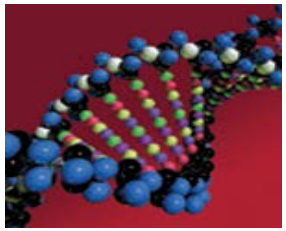
A Comprehensive Emissions Inventory of Upstream Oil and Gas Activities in the Rocky Mountain States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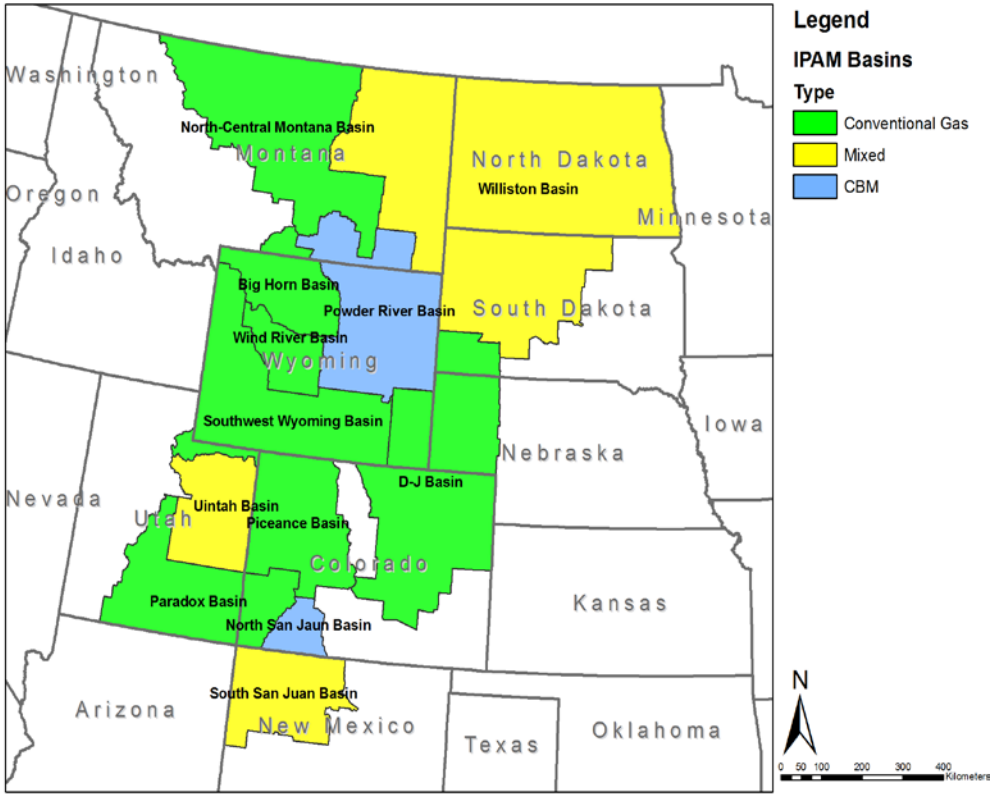
Presentation to WRAP
Western Meteorological, Emissions, and Air Quality Modeling Workshop

June 2011

Overview

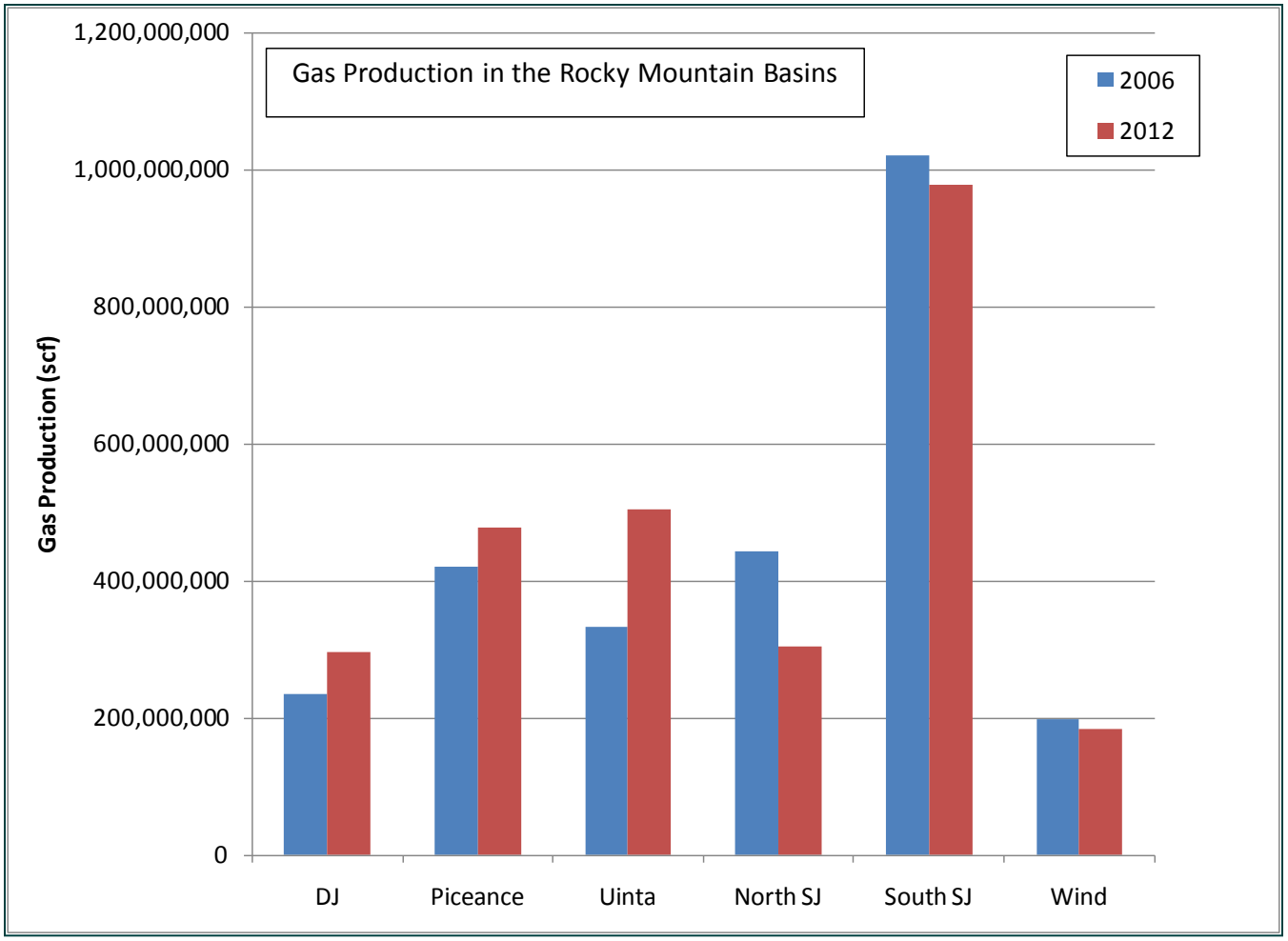
- History of oil and gas EI development
- Phase III – the latest and greatest oil and gas EIs
- Geographic scope
- Source categories
- Methodology
- Trends in oil and gas emissions
- Current and future work

Oil and Gas Production in the Rocky Mountains



- Boom in oil and gas production in this region over the last ten years driven by record prices for crude oil and natural gas
  - Colorado gas production in 1996: 0.57 trillion cubic feet
  - Colorado gas production in 2006: 1.2 trillion cubic feet
  - Colorado gas production in 2009: 1.51 trillion cubic feet
- Activity supported by large fleet of equipment at thousands of individual well sites
- Because of partial inventories in the past and wide variation from state-to-state in permitting requirements, three phases of inventory work were required to capture a complete inventory.

Oil and Gas Production in the Rocky Mountains



- Variation in production across basins
- Projected both growth and decline

History of Oil and Gas EIs in the Intermountain West

- Represented the first regional inventories for the western U.S. to address oil and gas area sources not previously inventoried
- Base year of 2002 with future year projection for 2018
- Focused primarily on NOx and SOx emissions for regional haze issues, with focus on compressor engines and drilling rigs
- Ozone precursors study for San Juan and Rio Arriba counties in northwest New Mexico
  - Direct survey data from oil and gas producers
  - Considered major NOx and VOC source categories
- WRAP Phase I and II, and regional studies limited in scope
  - Did not cover all source categories
  - Did not apply consistent methodology to a broad region (NMED, WY studies)

Current Phase III Effort

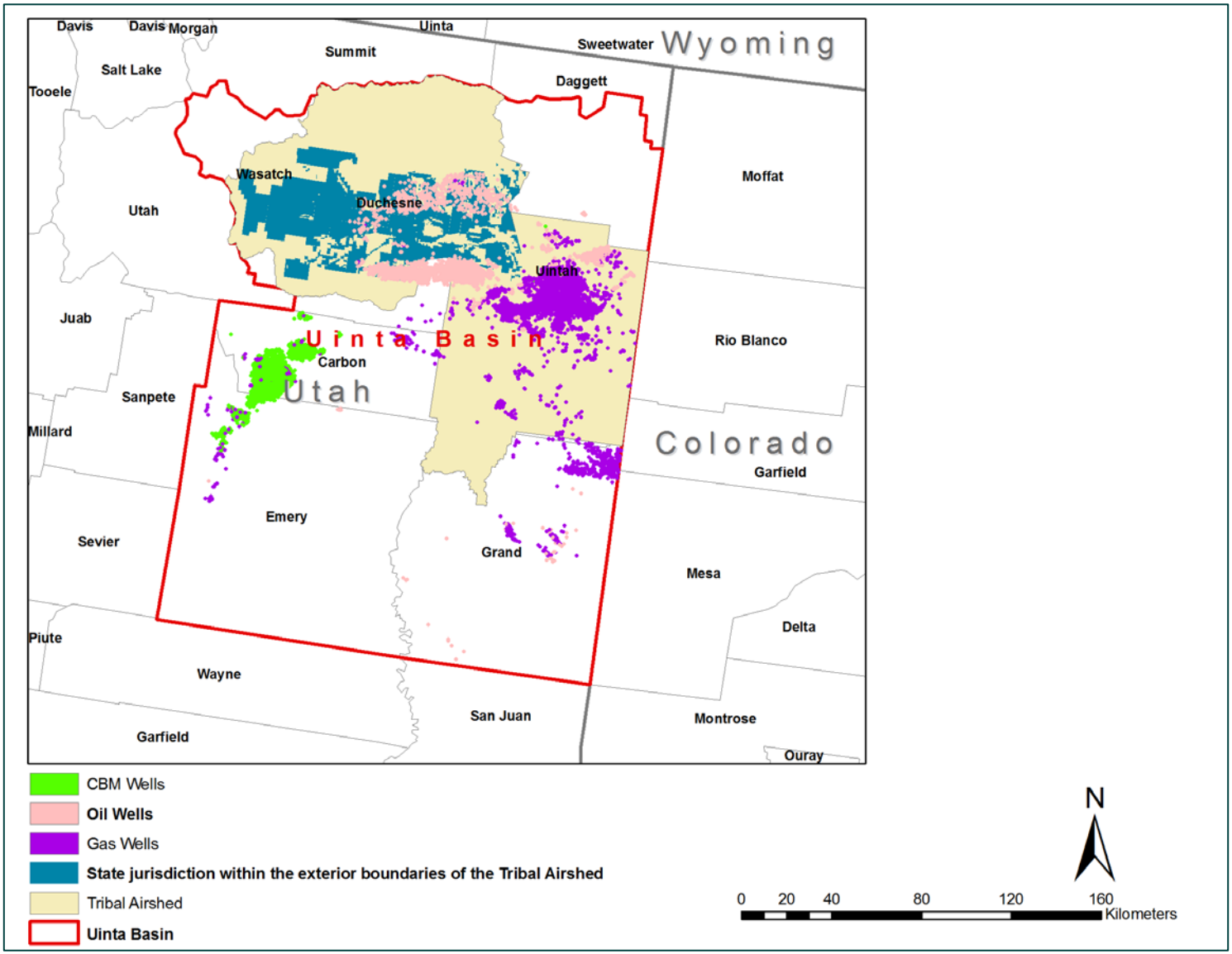
- Scope of study includes the South San Juan (NM), North San Juan (CO), Denver-Julesburg (CO), Piceance (CO), Uinta (UT), Southwest Wyoming (WY), Wind River (WY), Powder River (WY), Great Plains (MT) and Williston (MT & ND) Basins
- To date 7 basin inventories have been completed – remaining basins are the Williston, and Southwest Wyoming
- For all basins the boundaries of the basins have been aligned with county boundaries, and basins are analyzed for tribal and non-tribal inventories
- Baseline inventories developed for 2006 with midterm projections to 2012 (for D-J Basin projections to 2010)
    - Same methodology underway for 2009 data for Williston, Wind River, Powder River and Southwest Wyoming Basins
    - All basins inventories will be projected to 2008 for Westjump AQMS project

Phase III – Source Categories

- Large Point Sources

  (Gas plants, compressor stations)
- Drill Rigs
- Wellhead Compressor Engines
- CBM Pump Engines
- Heaters
- Pneumatic Devices
- Condensate and Oil Tanks
- Dehydrators
- Completion Venting
- Lateral compressor engines
- Workover Rigs
- Salt-Water Disposal Engines
- Artificial Lift Engines (Pumpjacks)
- Vapor Recovery Units (VRU's)
- Miscellaneous or Exempt Engines
- Flaring
- Fugitive Emissions
- Well Blowdowns
- Truck Loading
- Amine Units (acid gas removal)
- Water Tanks

Geographic Scope



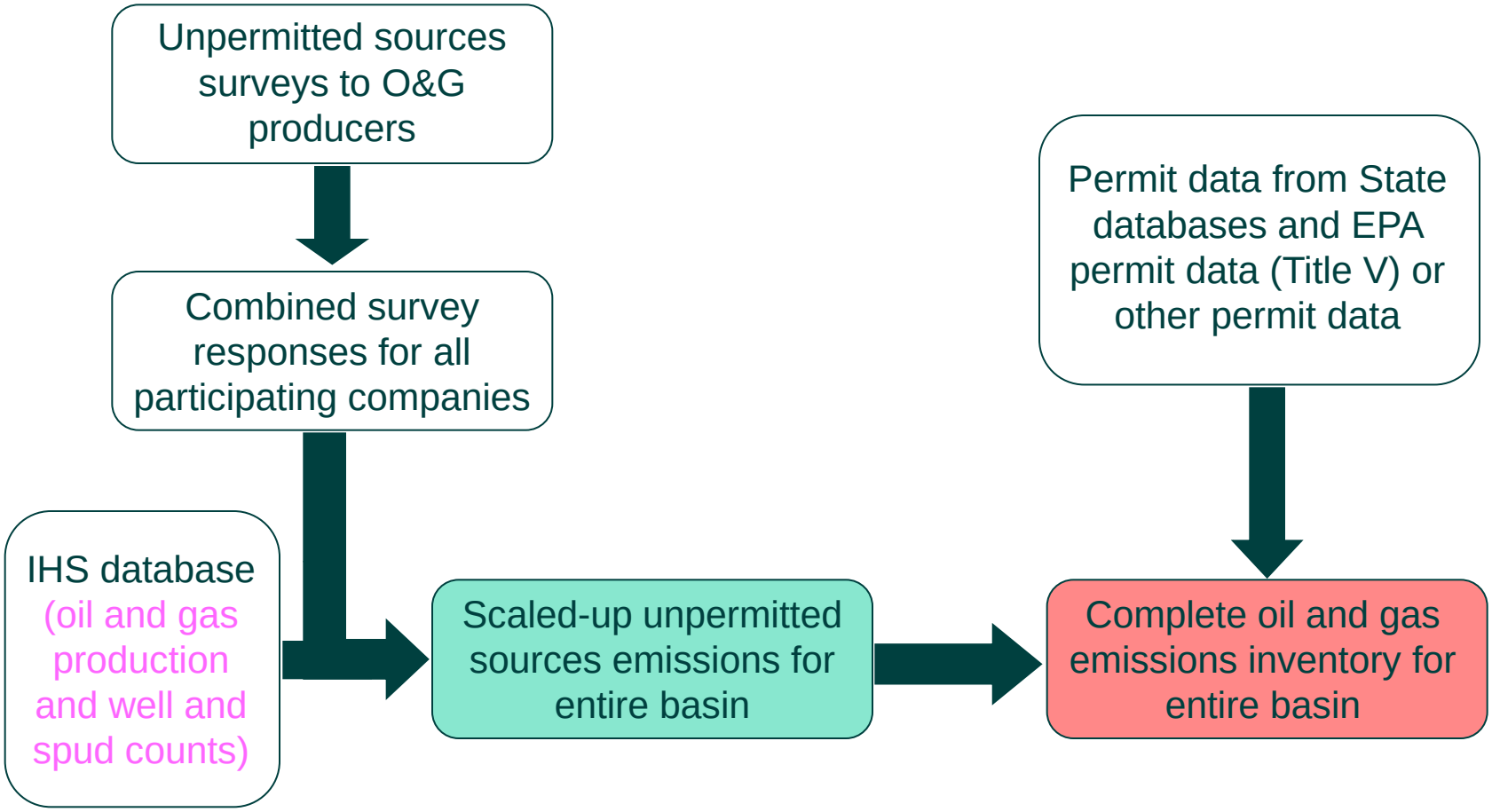
Basin Oil and Gas Statistics

Basin	Well Count			Oil Production (bbl)			Gas Production (MCF)			Spud Counts
	total	CONV	CBM	Total	Oil Well Oil	Gas Well Condensate	Total	CONV	CBM	Total
D-J Basin	16,774	16,774	0	14,242,088	0	14,242,088	234,630,779	234,630,779	0	1500
Uinta Basin	6,881	6,018	863	11,528,121	9,758,247	1,769,874	331,844,336	254,219,432	77,624,904	1069
Piceance Basin	6,315	6,255	60	7,158,305	5,755,076	1,403,229	421,358,666	420,165,237	1,193,429	1186
North San Juan Basin	2,676	1,009	1,667	32,529	27,962	4,567	443,828,500	28,642,418	415,186,082	127
South San Juan Basin	20,649	16,486	4,163	2,636,811	1,002,060	1,634,751	1,020,014,851	520,060,869	499,953,982	919
Wind River Basin	1,350	1,330	20	3,043,459	2,563,912	479,547	198,190,024	197,166,868	1,023,156	98

Red figures are greatest value in each column, showing spatial variation in O&G E&P operations

- Wide variation in total production of gas and oil/condensate among basins
- Gas production activity is more significant than oil production activity in all basins – oil production is in historic decline
- Spud counts are surrogates for where greatest exploration and production activity was occurring in 2006

Phase III Methodology Diagram



Results – 2006 Criteria Pollutant Emissions

- Oil and gas production a significant source of NOx, VOC, CO emissions, particularly in rural counties
- NOx emissions primarily result from wellhead and centralized compression
- VOC emissions contributions from many different processes including tank flashing, dehydration and pneumatics
- SOx and PM emissions minor in most basins and primarily driven by drill/workover rigs (sour gas production in some basins)

Basin	Emissions (tons/yr)				
	NOx	VOC	CO	SOx	PM
D-J Basin	20,783	81,758	12,941	226	636
Uinta Basin	13,093	71,546	8,727	396	623
Piceance Basin	12,390	27,464	7,921	314	992
North San Juan Basin	5,700	2,147	6,450	15	52
South San Juan Basin	42,075	60,697	23,471	305	574
Wind River Basin	1,814	11,981	2,840	1,792	37

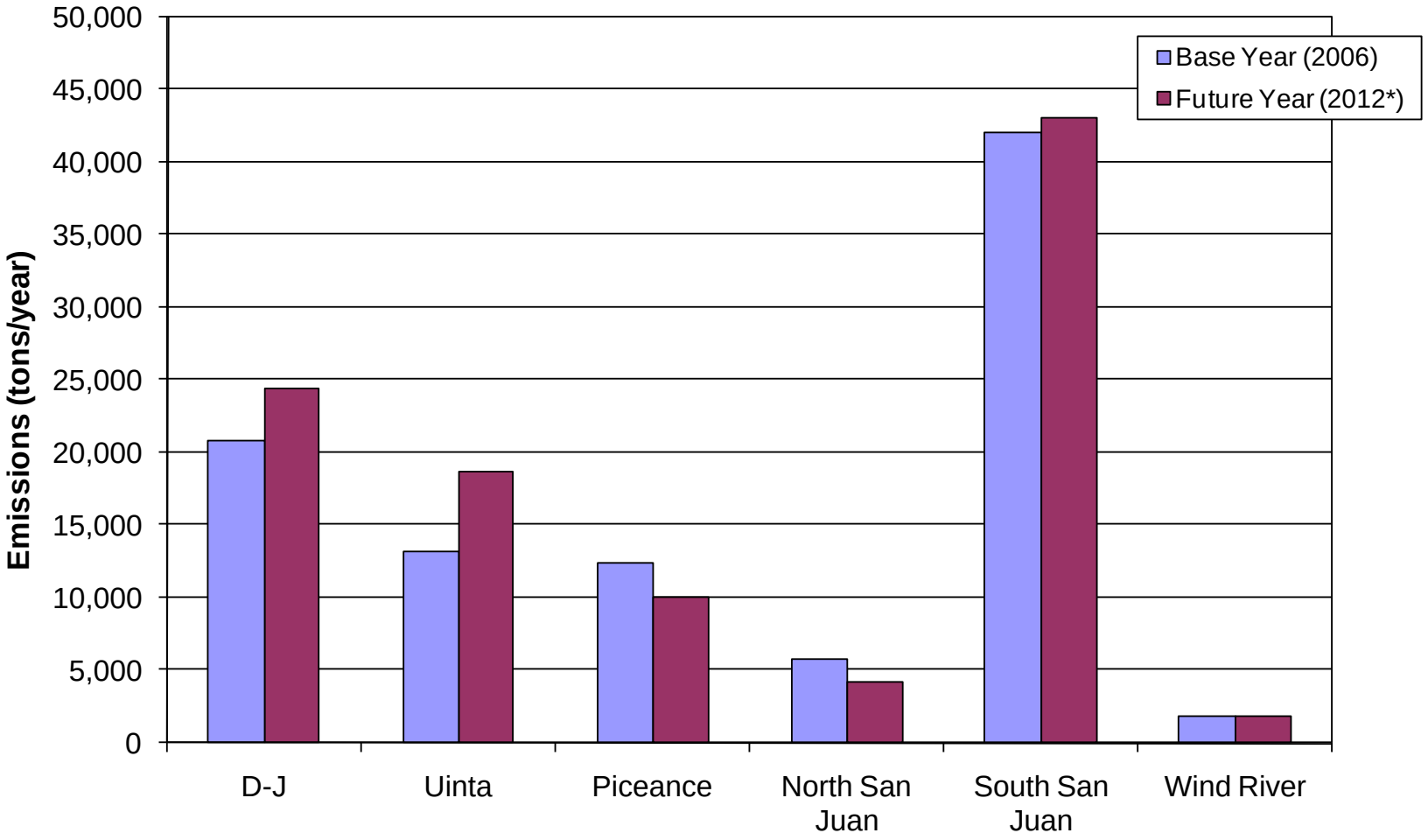
Red figures are greatest value, showing spatial variation in O&G E&P emissions

Results – 2012 Projected Emissions

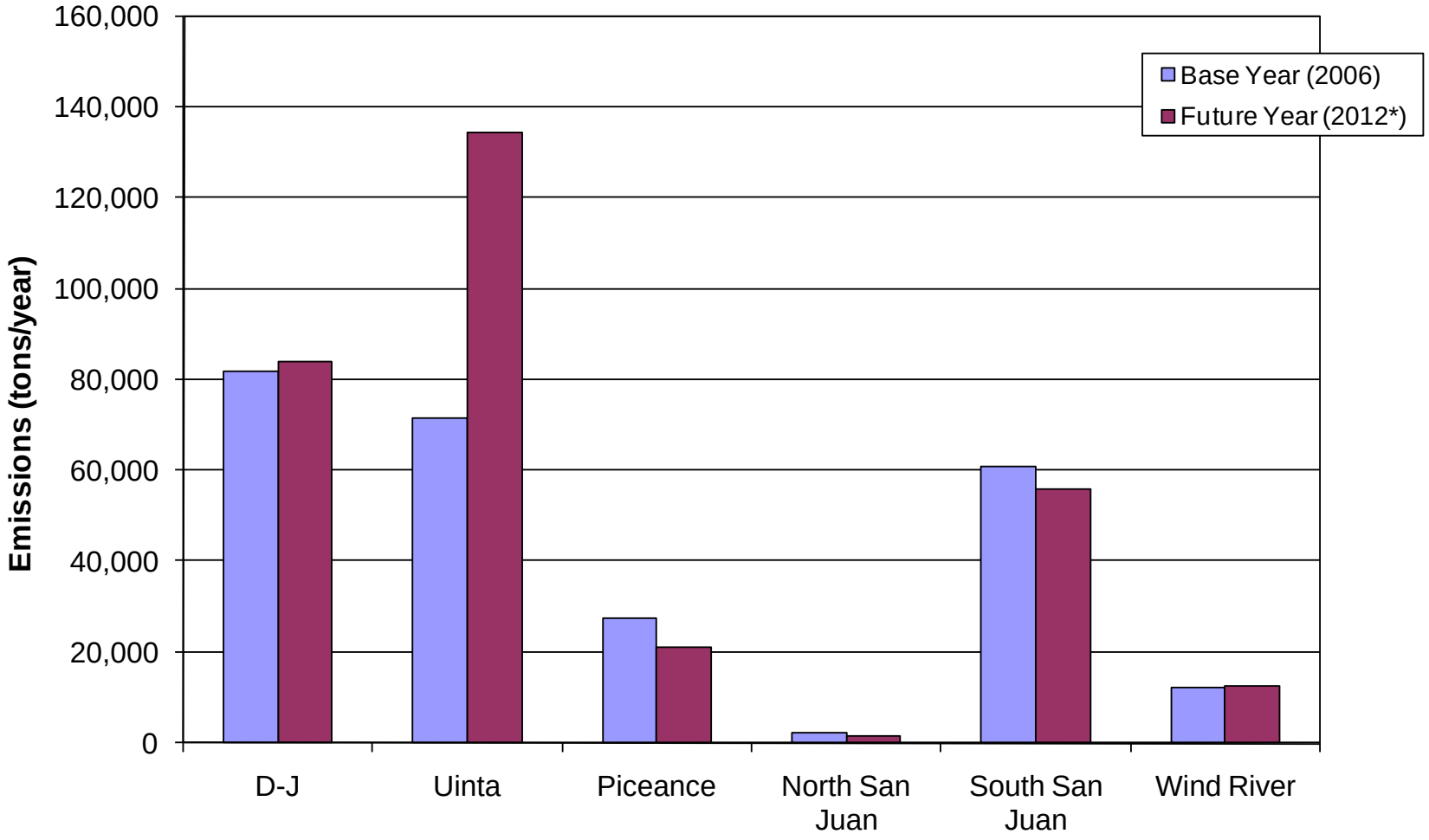
- Emissions projections include any growth or decline factors by oil and gas production surrogate type
- Control factors are applied to account for natural equipment turnover and state and federal rules and regulations which affect emission sources
- State regulations vary widely from state to state in emission source categories regulated and levels of control required

Basin	Emissions (tons/yr)				
	NOx	VOC	CO	SOx	PM
D-J Basin	24,408	84,050	15,412	131	771
Uinta Basin	18,652	134,543	47,075	26	721
Piceance Basin	9,951	20,962	7,668	77	374
North San Juan Basin	4,195	1,598	4,661	0	47
South San Juan Basin	43,050	55,705	25,421	132	523
Wind River Basin	1,758	12,480	2,738	1,618	39

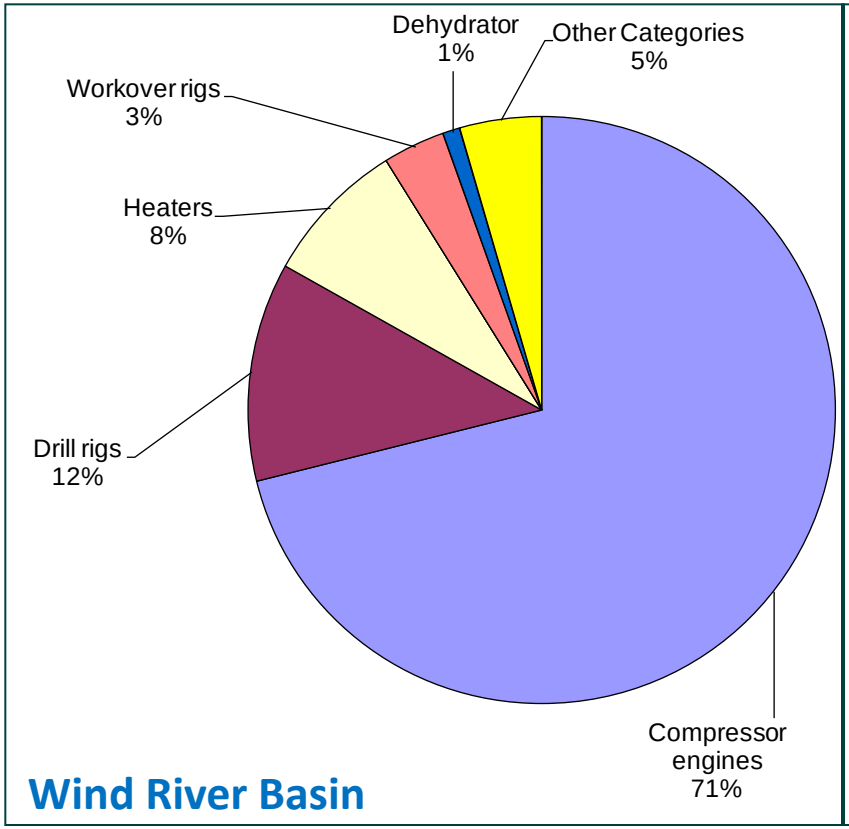
Results – NOx Emissions

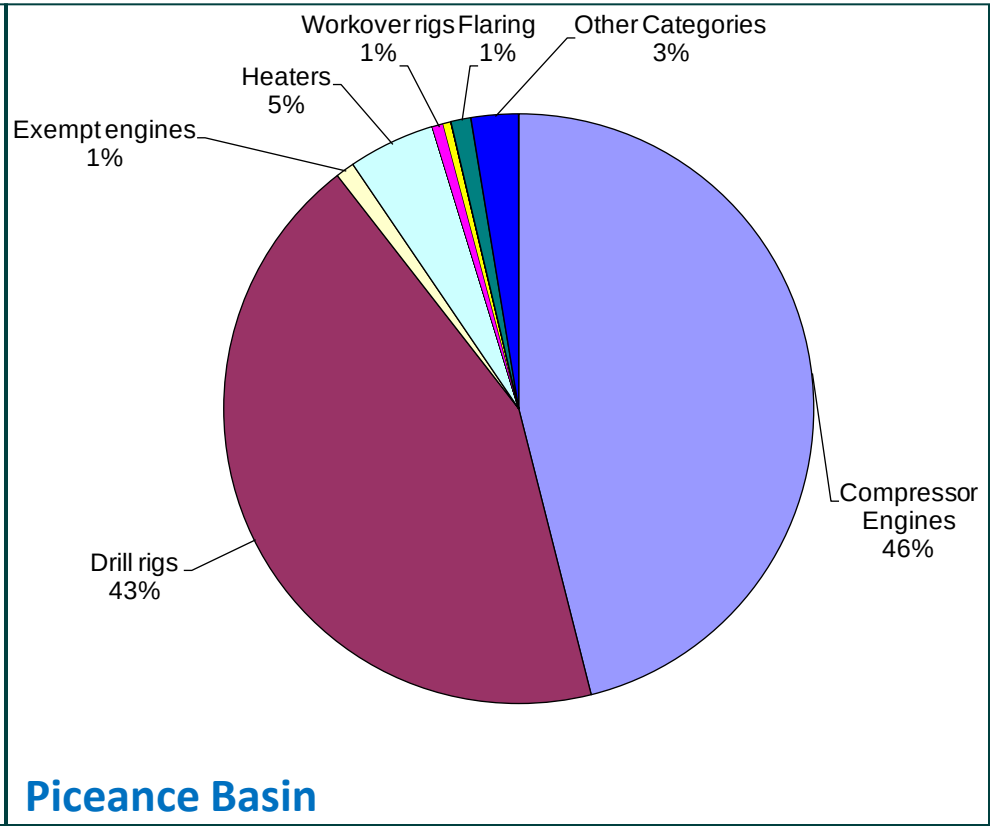


Results – VOC Emissions



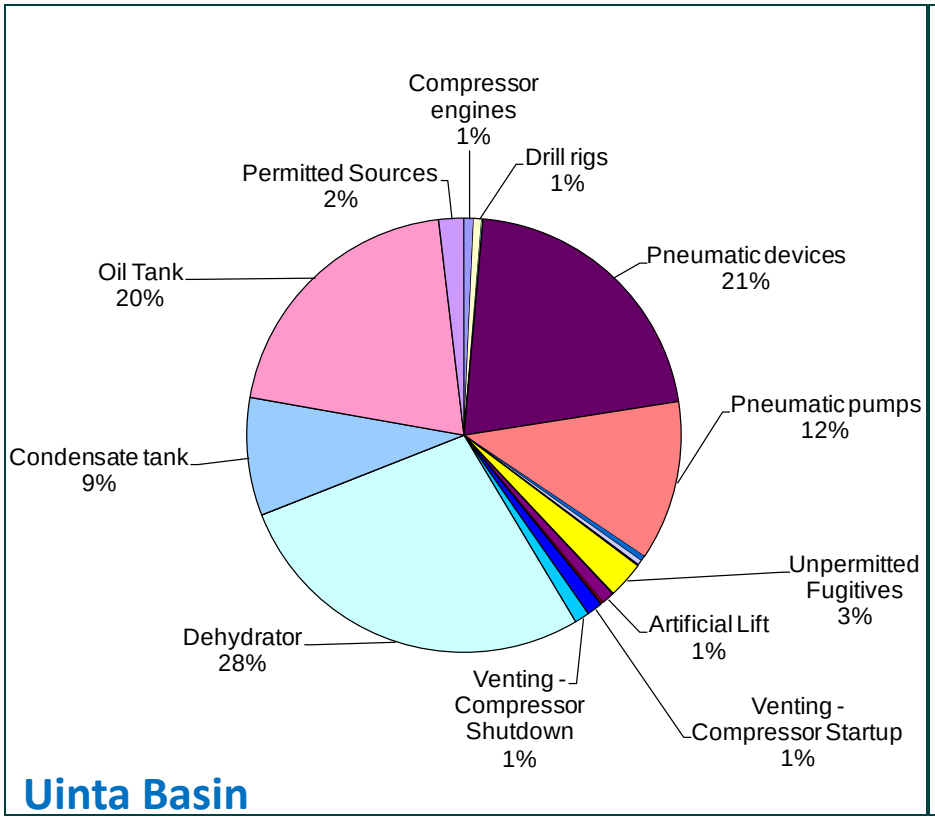
Results – Example NOx Emissions Breakdown By Source Category



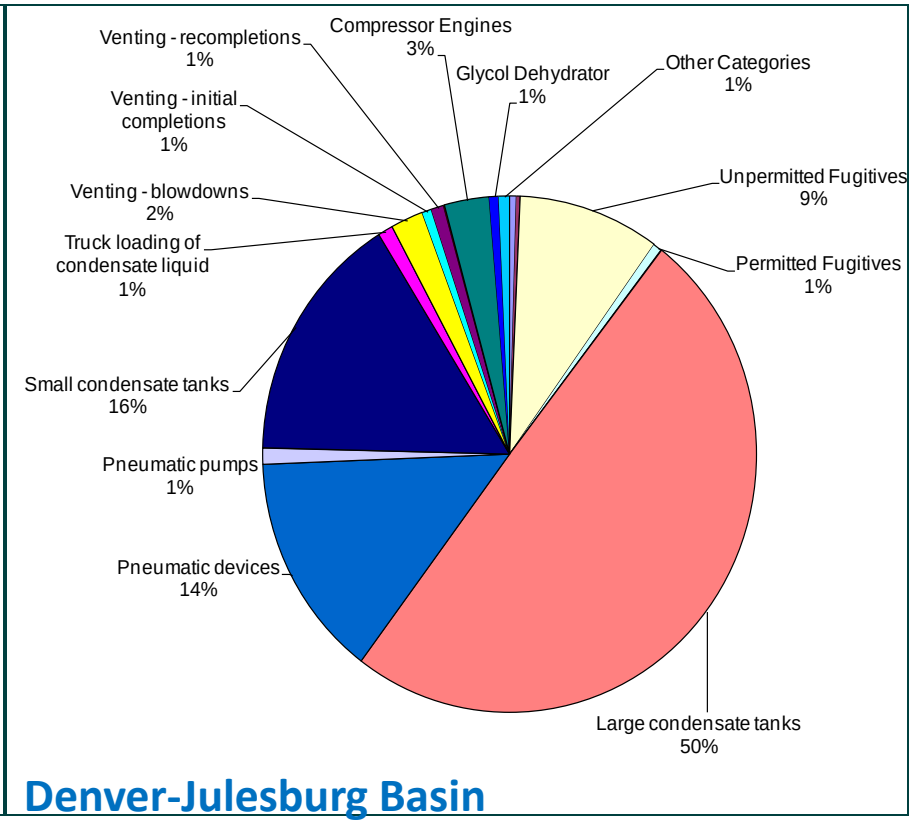


- NOx emissions primarily comprised of compressor engines (central and wellhead) and drill rigs for basins in which active drilling was occurring in 2006

Results – Example VOC Emissions Breakdown By Source Category



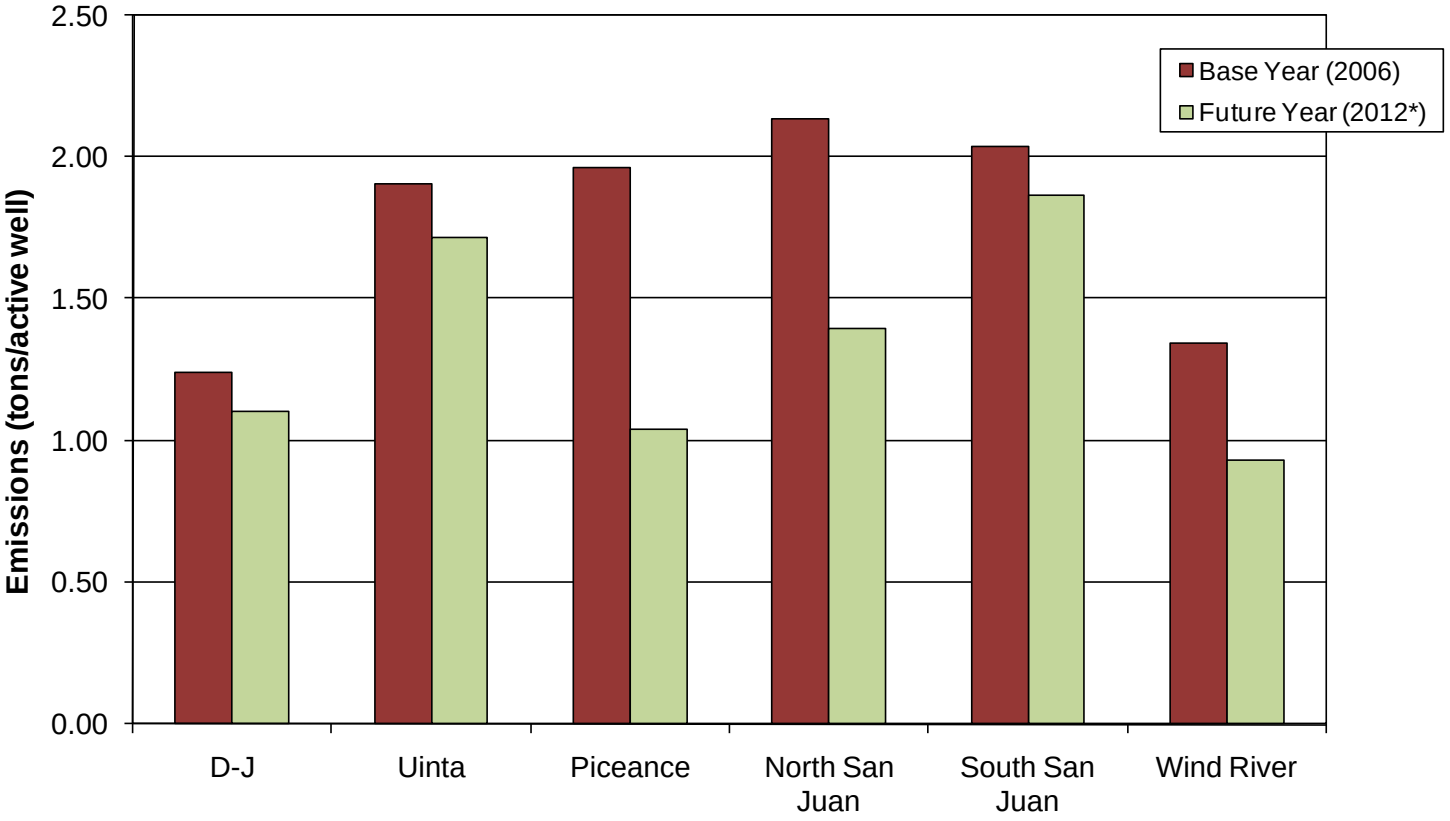
Uinta Basin



Denver-Julesburg Basin

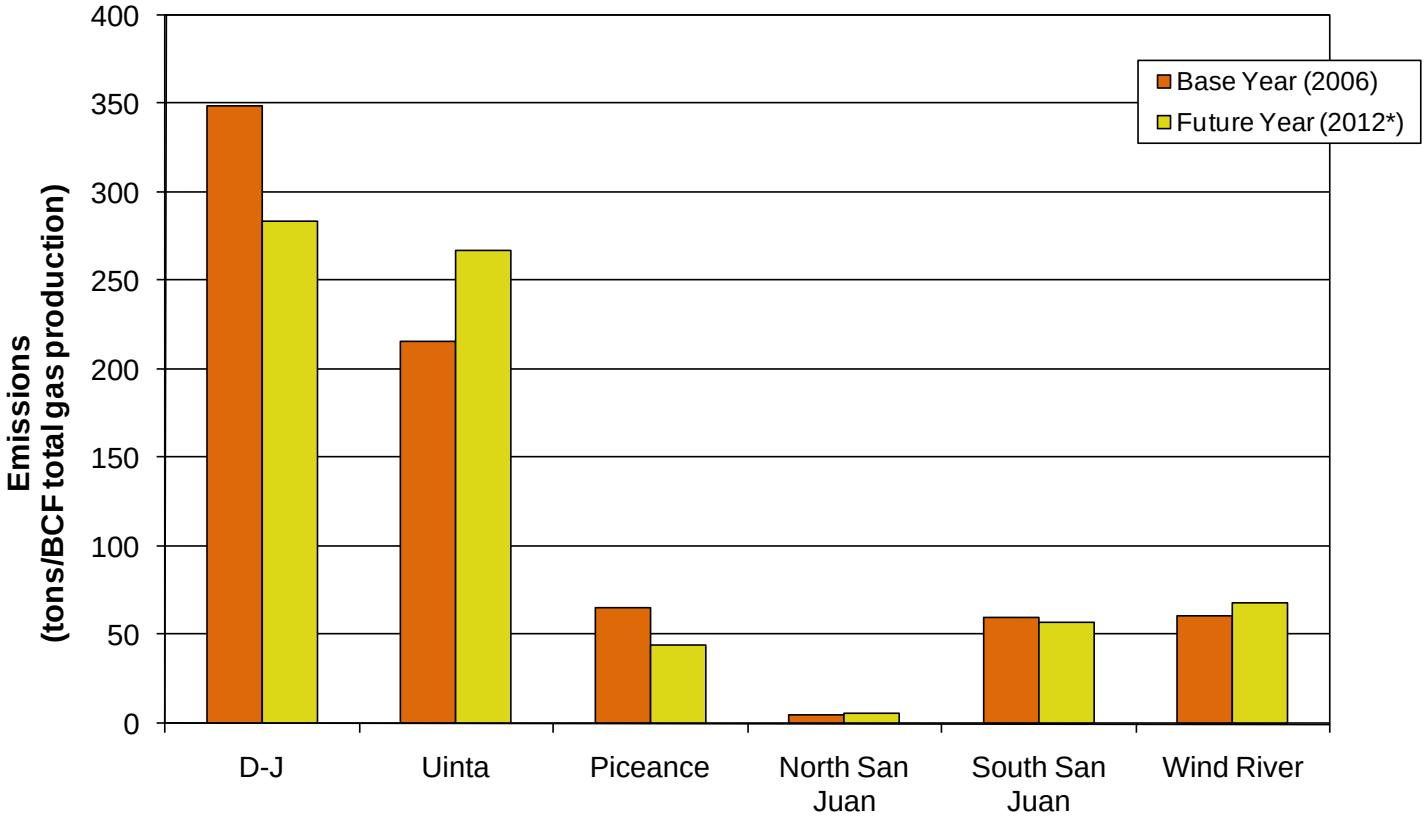
- VOC emissions sources vary significantly from basin to basin – tank flashing, dehydration and pneumatic devices are consistently large source categories in most basins

Results – Per-Well NOx Emissions



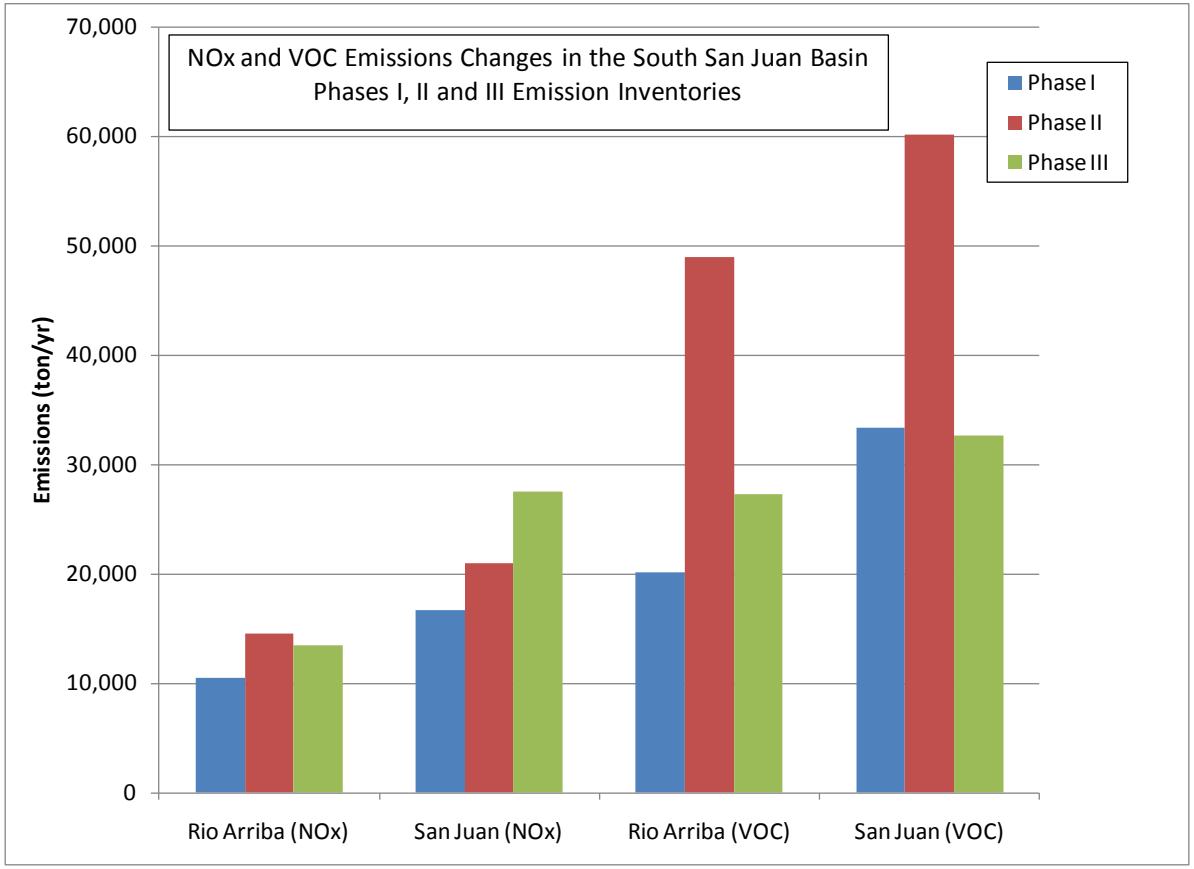
- **Per well NOx emissions relatively consistent across basins – differences mainly due to usage of compression and centralized vs. wellhead compression**
- **Projected NOx emissions vary across basins due to differences in projected activity levels and controls requirements by states**

Results – Per-Unit-Gas-Production VOC Emissions



- **Per unit gas production VOC emissions vary widely across basins – differences due to levels of liquid hydrocarbon production (oil and condensate) and VOC content of produced gas**
- **Projected VOC emissions also vary across basins due to differences in projected activity levels and controls requirements by states**

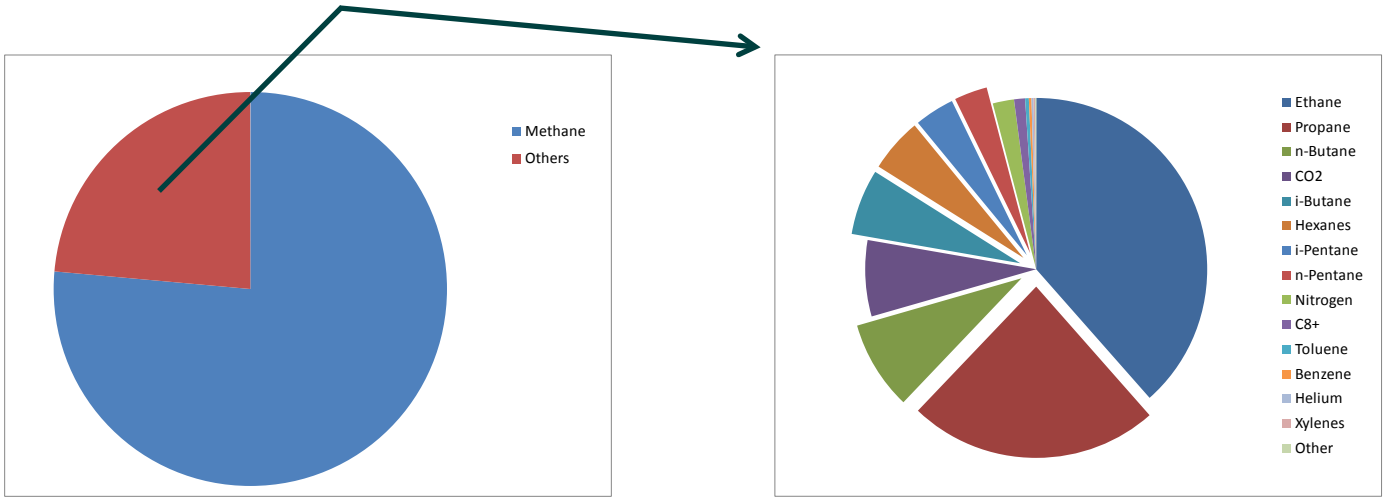
Oil and Gas Inventories and Use in Modeling Studies



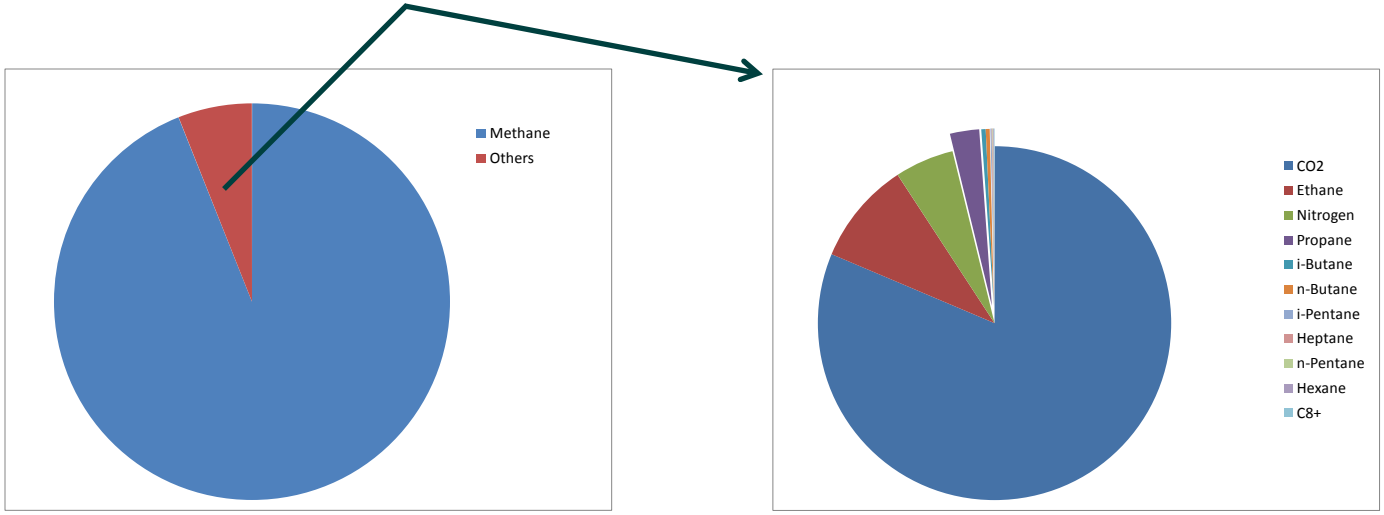
- **Phase 1 - used for WRAP 2002 Planning Case C and 2018 Base Case modeling scenarios**
- **Phase II - used for WRAP 2002 Planning Case D and (all 3) 2018 Preliminary Reasonable Progress modeling scenarios, (with improvement for Rio Arriba and San Juan Counties), for 4 Corners AQ Task Force modeling, and by EPA OAQPS in their recent 2005 platform-based modeling**
- **Phase III - used in UBAQS and 2 most recent rounds of Denver metro area Ozone SIP modeling, (with extrapolation to 2008 activity data), will be used in WestJumpAQMS modeling for all basins in NM, UT, CO, WY, ND, and MT; also Phase III EIs are the starting point for several NEPA EIS project analyses**

Results – Variability in Speciation Profiles by Source Type

Conventional Gas
(Vented/Fugitive Sources)

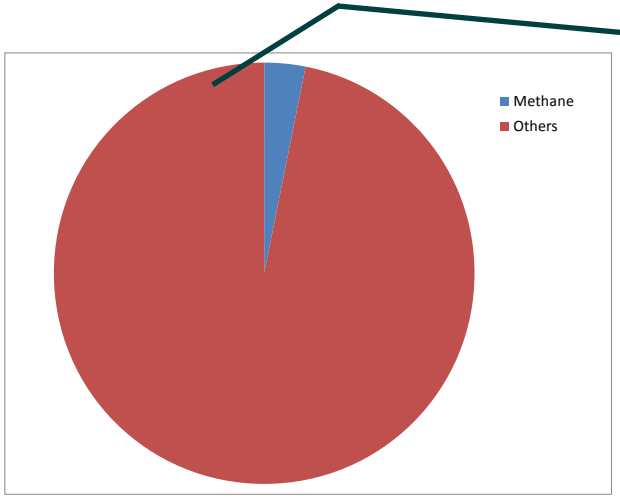


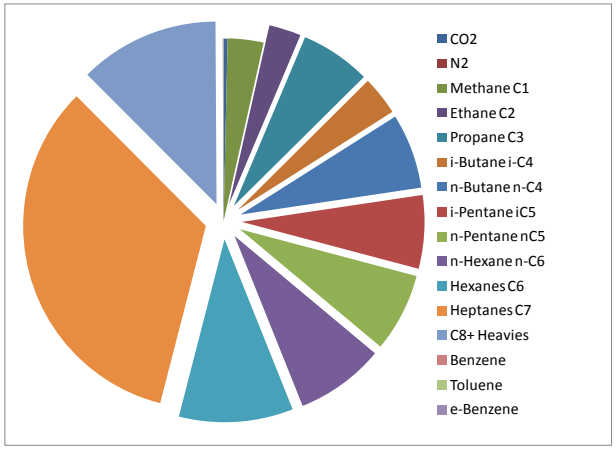
CBM Gas
(Vented/Fugitive Sources)



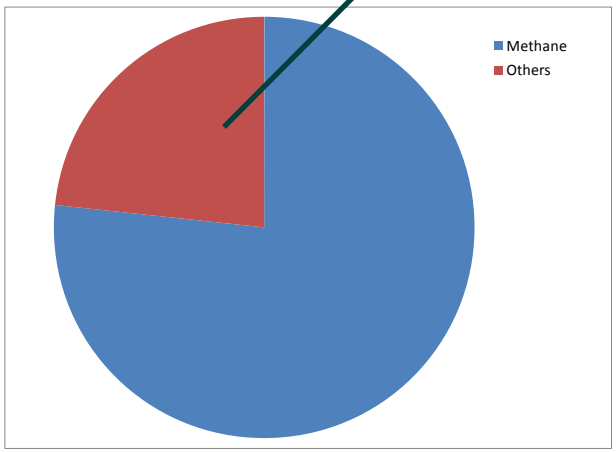
Results – Variability in Speciation Profiles by Source Type

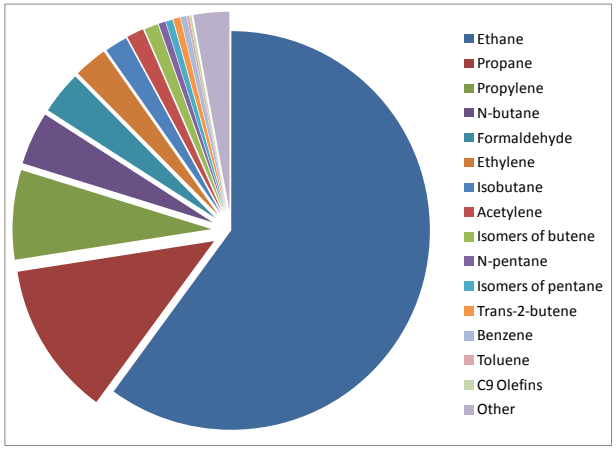
Flash Gas
(Condensate/Oil Tanks)





NG Combustion
(Compressor Engines)





Inventory Findings

- Wide range of NOx, VOC emissions between basins for the six basins completed thus far – indication that basin-level inventories are necessary to capture regional differences in activity and production levels
- NOx emissions per well are relatively consistent among basins, driven by the number of active wells and number/size of equipment – differences in some basins are due to a combination of regulatory requirements for compressor engines and the relative level of activity of drilling rigs
- VOC emissions per well vary widely across basins – highest values are for the D-J and Uinta Basins which have significant oil and condensate production, indicating that tank flashing emissions are significant for these basins
- Inventories are capable of capturing significant unpermitted and unreported emissions for both NOx and VOC – even in states where the permitting threshold is low
- Inventories are improving over time and significantly different from past inventory efforts

Related Ongoing and Future Work

- **Oil and gas mobile sources pilot project**

  http://www.wrapair2.org/Mobile.aspx

- **Update Phase III data from 2006 baseline to Phase IV 2009 baseline**

  http://www.wrapair2.org/PhaseIV.aspx

- **Use of Phase III Oil & Gas inventory in regional analysis of potential control strategies for states impacted by O&G operations**
  - States will need to comply with increasingly stringent ambient air quality standards for ozone, particulate and other pollutants

Acknowledgements

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Questions?