Final Report

DEVELOPMENT OF 2012 OIL AND GAS EMISSIONS PROJECTIONS FOR THE SOUTH SAN JUAN BASIN

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INTRODUCTION

This document outlines the projection methodologies used in generating the 2012 emissions projections from oil and gas sources in the South San Juan Basin. These methodologies will use as a starting point the 2006 baseline South San Juan Basin oil and gas emissions inventory, described in the baseline emissions report entitled "Development of Baseline 2006 Emissions from Oil and Gas Activity in the South San Juan Basin".

This methodology description is broken down into subsections which describe:

- Geographic grouping of data – regional differences in production or activity are factored into the projection methodology by geographic region
- Projected parameters – seven basic parameters are projected forward to 2012 for purposes of developing scaling factors: total well counts, conventional gas well counts, CBM well counts, spud counts, total gas production, oil production and condensate production
- Scaling factors and developing uncontrolled emissions projections – the projected parameters are used to develop scaling factors (incorporating geographic groupings), and these scaling factors are applied to the 2006 baseline emissions
- Application of "on-the-books" regulations and control measures – existing regulations are summarized for their impacts on the future year emissions and applied to adjust the uncontrolled 2012 inventory.

Projections for years beyond 2012 (not addressed in this methodology) will likely include additional parameters and will be based on these 2012 projections as the start year. The methodology for developing far future year projections will be detailed in a separate analysis.

Following the discussion of the methodology, the results of the 2012 emissions projections for the South San Juan Basin are presented in graphical and tabular formats.

GEOGRAPHIC GROUPING

The projections for 2012 have been conducted for the complete South San Juan Basin, with no separate projections conducted for individual counties in the Basin.

The reason for grouping all counties together is that the South San Juan Basin has essentially two major production types: conventional gas and CBM gas. Oil production is relatively minor in this basin as compared to other Phase III basins (Bar-Ilan, et al., 2009a; Bar-Ilan, et al., 2009b; Bar-Ilan, et al., 2009c; Bar-Ilan, et al., 2008). This production is essentially grouped in San Juan and Rio Arriba counties, and major formations straddle these county lines. Efforts were made to investigate gas production properties of individual formations and counties, but these were not successful in determining a set of production data for each county that could be used to accurately back-cast the production data (for purposes of verifying its use in the forward projections). However it should be noted that gas production has been flat or in decline in general in the South San Juan Basin since 2000, and it was expected that this trend would continue in all production counties in the basin.

PARAMETERS PROJECTED

The 2012 projections for oil and gas emissions in the South San Juan Basin rely on scaling 7 parameters:

- Total well counts
- Conventional gas well counts
- CBM well counts
- Spud counts
- Total gas production
- Oil production
- Condensate production

These seven parameters are considered because each parameter applies to the emissions projections of one or more source categories. Note that the analysis uses data from the IHS database, which defines condensate production as liquid hydrocarbon production from wells which are classified as gas wells. Similarly, oil production is defined as liquid hydrocarbon production from wells which are classified as oil wells. The classification of gas vs. oil wells in the IHS database is based on the gas-oil ratio (GOR) of the well, using a cutoff GOR defined by the New Mexico Oil and Gas Conservation Division (NMOCD) (NMT, 2009). This is the only distinction made between condensate and oil production. Similarly, for New Mexico the IHS database distinguishes CBM wells from conventional gas wells based on a threshold water production for the well, since the NMOCD database does not classify wells as CBM or non-CBM.

The mapping of source category to projection parameter is shown below in Table 1.

Table 1. Scaling parameter for each oil and gas source category considered in this inventory.

Source	SCC	Description	Projection Parameter
Unpermitted	2310000100	Heaters	Total Well Counts
Unpermitted	2310000220	Drill rigs	Spud Countss
Unpermitted	2310000230	Workover rigs	Total Well Counts
Unpermitted	2310000300	Pneumatic devices	Total Well Counts
Unpermitted	2310000700	Unpermitted Fugitives	Total Well Counts
Unpermitted	2310000801	Truck Loading of Gas Wells	Gas Well Condensate Production
Unpermitted	2310000802	Truck Loading of Oil Wells	Oil Production
Unpermitted	2310000820	Gas Plant Truck Loading	Gas Well Condensate Production
Unpermitted	2310001610	Venting - initial completions	Spud Counts
Unpermitted	2310001611	Initial completion Flaring	Spud Counts
Unpermitted	2310001620	Venting - recompletions	Spud Counts
Unpermitted	2310001630	Venting - blowdowns	Total Gas Production
Unpermitted	2310001640	Venting - Compressor Startup	Total Gas Production
Unpermitted	2310001650	Venting - Compressor Shutdown	Total Gas Production
Unpermitted	2310002230	Condensate tank	Gas Well Condensate Production
Unpermitted	2310002240	Oil Tank	Oil Production
Unpermitted	2310002231	Condensate tank flaring	Gas Well Condensate Production
Unpermitted	2310003100	Miscellaneous engines	Total Well Counts
Unpermitted	2310003200	Pneumatic pumps	Conv. Gas Well Count
Unpermitted	2310020600	Compressor engines	Based on Producer Provided Horsepower

Source	SCC	Description	Projection Parameter
			Growth Estimates*
Unpermitted	2310021410	Dehydrator	Total Gas Production
Unpermitted	2310021411	Dehydrator Flaring	Total Gas Production
Unpermitted	2310000330	Artificial Lift	Oil Production
Unpermitted	2310023000	CBM pump engines	CBM Well Count
Unpermitted	2310000440	Saltwater Disposal Engines	CBM Well Count
Permitted Sources	10200602	Heater/Boiler (10-100 Million Btu/hr)	Total Gas Production
Permitted Sources	20100102	Reciprocating Engines	Total Gas Production
Permitted Sources	20100202	Reciprocating Engines	Total Gas Production
Permitted Sources	20200102	Reciprocating Engines	Total Gas Production
Permitted Sources	20200201	Compressor Engines	Total Gas Production
Permitted Sources	20200202	Compressor Engines	Total Gas Production
Permitted Sources	20200252	Compressor Engines	Total Gas Production
Permitted Sources	20200253	Compressor Engines	Total Gas Production
Permitted Sources	20200254	Compressor Engines	Total Gas Production
Permitted Sources	20200256	Compressor Engines	Total Gas Production
Permitted Sources	20200305	Reciprocating Engine: Crankcase Blowby	Total Gas Production
Permitted Sources	30600508	Oil/Water Separator	Total Gas Production
Permitted Sources	30600903	Natural Gas Flares	Total Gas Production
Permitted Sources	30990013	Natural Gas: Incinerators	Total Gas Production
Permitted Sources	30990023	Natural Gas: Flares	Total Gas Production
Permitted Sources	31000201	Natural Gas Production, Gas Sweetening: Amine Process	Total Gas Production
Permitted Sources	31000203	Compressor Engines	Total Gas Production
Permitted Sources	31000205	Natural Gas Production, Flares	Total Gas Production
Permitted Sources	31000207	Permitted Fugitives	Total Gas Production
Permitted Sources	31000209	Natural Gas Production, Incinerators Burning Waste Gas or Augmented Waste Gas	Total Gas Production
Permitted Sources	31000215	Natural Gas Production, Flares Combusting Gases >1000 BTU/scf	Total Gas Production
Permitted Sources	31000227	Glycol Dehydrator	Total Gas Production
Permitted Sources	31000228	Glycol Dehydrator	Total Gas Production
Permitted Sources	31000299	Natural Gas Production, Other Not Classified	Total Gas Production
Permitted Sources	31000301	Glycol Dehydrator	Total Gas Production
Permitted Sources	31000302	Glycol Dehydrator	Total Gas Production
Permitted Sources	31000303	Glycol Dehydrator	Total Gas Production
Permitted Sources	31000304	Glycol Dehydrator	Total Gas Production
Permitted Sources	31000305	Natural Gas Processing Facilities, Gas Sweeting: Amine Process	Total Gas Production
Permitted Sources	31000306	Natural Gas Processing Facilities, Process Valves	Total Gas Production
Permitted Sources	31000404	Process Heaters	Total Gas Production
Permitted Sources	31000414	Natural Gas: Steam Generators	Total Gas Production
Permitted Sources	31000506	Oil-Water Separation Wastewater Holding Tanks	Total Gas Production
Permitted Sources	31088811	Permitted Fugitives	Total Gas Production
Permitted Sources	38500101	Mechanical Draft	Total Gas Production
Permitted Sources	40301011	Crude Oil RVP 5: Breathing Loss (250000 Bbl. Tank Size)	Total Gas Production
Permitted Sources	40400250	Loading Racks	Total Gas Production
Permitted Sources	40400301	Permitted Tank Losses	Total Gas Production
Permitted Sources	40400302	Permitted Tank Losses	Total Gas Production
Permitted Sources	40400311	Permitted Tank Losses	Total Gas Production
Permitted Sources	40400312	Permitted Tank Losses	Total Gas Production
Permitted Sources	40400313	Fixed Roof Tank, Lube Oil, working+breathing+flashing losses	Total Gas Production
Permitted Sources	40400314	Fixed Roof Tank, Specialty Chem- working+breathing+flashing	Total Gas Production
Permitted Sources	40400315	Permitted Tank Losses	Total Gas Production
Permitted Sources	40400340	Pressure Tanks (pressure relief from pop-off valves)	Total Gas Production
Permitted Sources	31000220	Natural Gas Production, All Equipt Leak Fugitives	Total Gas Production

**Further details on the projection methodology for unpermitted compressors are provided below.*

PROJECTION METHODOLOGIES FOR THE SOUTH SAN JUAN BASIN

For the South San Juan Basin, the methodology for obtaining the 2012 value of each projection parameter (total well counts, conventional gas well counts, CBM well counts, spud counts, total gas production, oil production, and condensate production) is described below. In general, spud count projections were developed by obtaining the historical spud count data for the geographic grouping using the IHS database, and reconciling this data with planned drilling activities of the participating companies in the survey process for the basin. Well count projections for the basin were developed by deriving an average ratio of annual spud counts to well counts for a number of historical years, and then applying this ratio to the projected spud counts to estimate the annual number of new wells added for each future year of the projection. These new wells were divided among conventional gas and CBM (assuming no new oil wells). Gas and oil production projections were assumed to remain flat throughout the 6-year period of the projections from 2006-2012. Condensate production projections were assumed to follow the trends for gas production.

The IHS database is a tool to query oil and gas statistical well and production data, and uses as its reference data the databases maintained by various state OGCC's (or equivalent).

Spud Counts

Spud counts in the San Juan Basin have been plotted for the years 1970 – 2006 below in Figure 1, including projections to 2012.

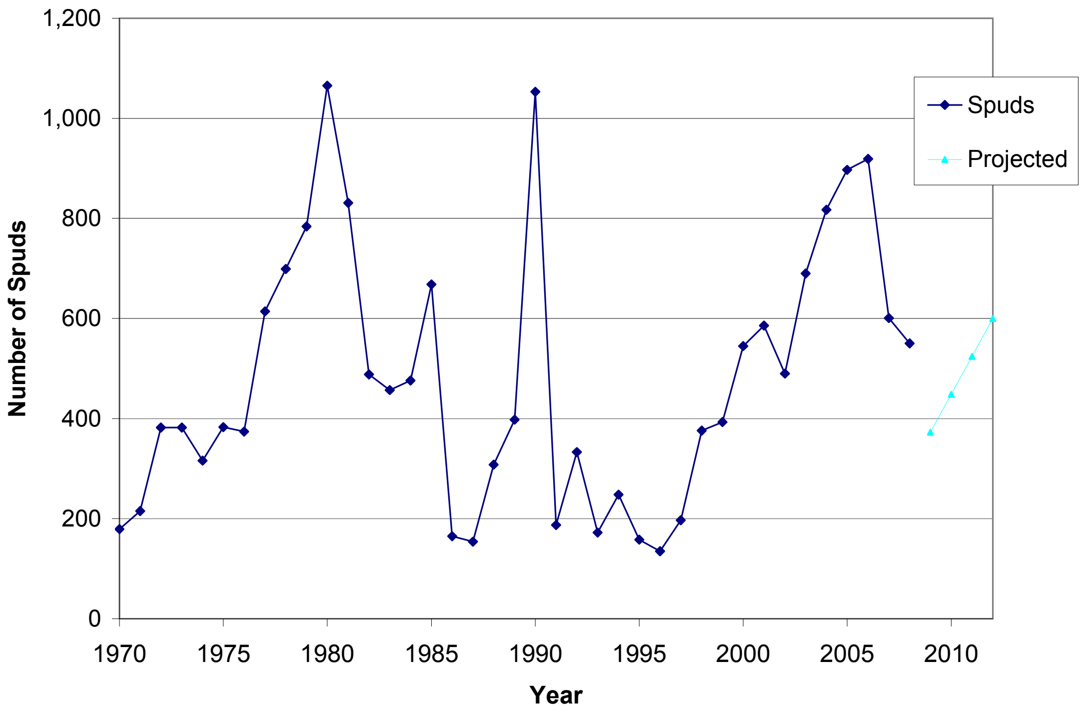

Figure 1. Spud count historical data (from the IHS database) for the San Juan Basin and projections to 2012.[1]

Historic spud counts in the basin, as obtained from the IHS database for the period 1970-2006 are erratic, making an extrapolation from historical data infeasible. Given the recent downturn in economic activity driving a downturn in drilling activity in the basin, the IHS database was queried for two additional years of spud data – 2007 and 2008. The period 2006-2008 shows a sharp decline in the total number of spuds in the basin. For 2009, the participating companies were queried for their specific drilling plans in the basin, and the resulting total planned spuds from these companies' responses were scaled by spud ownership to a basin-wide total. The results of the query to companies indicated that a total of approximately 375 spuds were planned for 2009. These same companies were queried about plans for future drilling beyond 2009, and the best available data indicated that drilling levels were expected to rise again to reach the 2007 historic levels by 2012. A linear curve fit was conducted between the 2009 spud count and the expected spud count of 600 in 2012 (roughly equivalent to the 2007 total).

[1] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2009) all rights reserved).

Conventional Gas Well Counts

Conventional gas well counts in the South San Juan Basin have been plotted for the years 1970 – 2006 below in Figure 2, including projections to 2012.

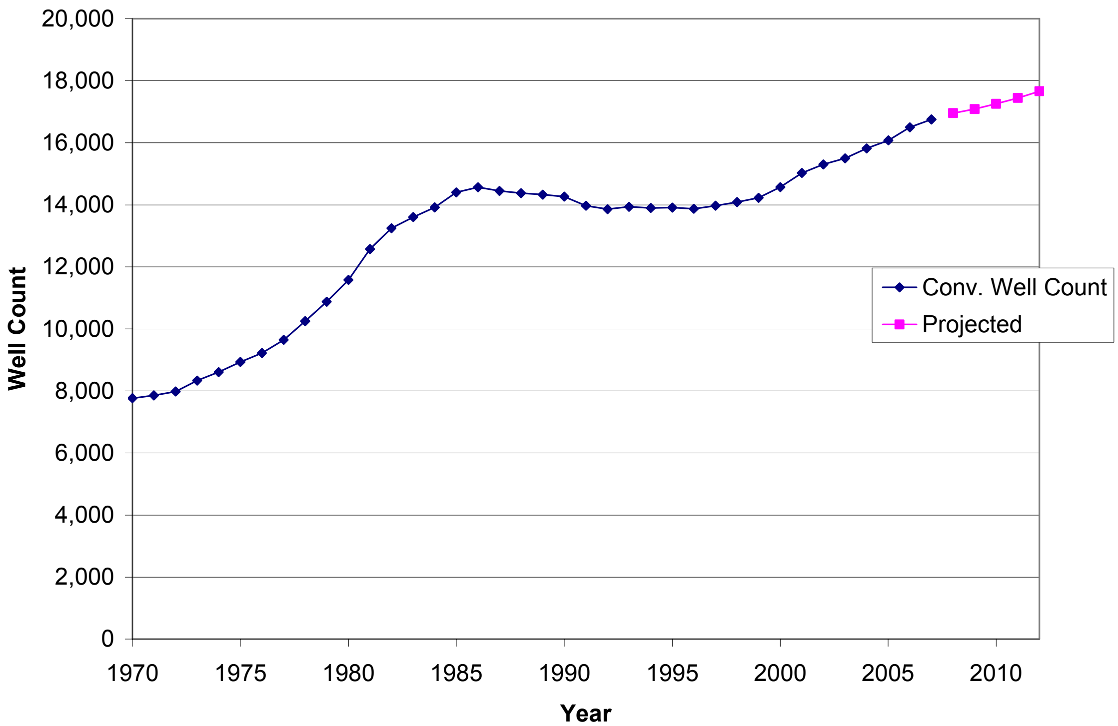

Figure 2. Conventional gas well count historical data (from the IHS database) for the South San Juan Basin and projections to 2012. [2]

Conventional gas well count projections were developed for the period 2007 – 2012 by first developing a ratio of the number of spuds in each year from 2003 – 2007 to the number of new wells (conventional gas and CBM) added in each of those years. This represented the historic rate of drilling as compared to the rate of new well addition, accounting for factors such as unsuccessful drilling and wells which were plugged and abandoned. Note that this average historic drilling-to-well ratio does not distinguish between conventional gas and CBM wells. This data for the years 2003 – 2007 was averaged to develop a single historical drilling rate estimate of 1.179. This drilling rate estimate was then applied to the number of spuds as predicted by the spud count projection (see Figure 1) in order to determine the number of new wells added in each year from 2007 – 2012.

The conventional gas well counts for the basin in each year from 2006-2012 were developed by determining the fraction of the total number of new wells added that were conventional gas and the fraction that were CBM. The conventional gas well fraction was determined according to Equation 1:

[2] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2009) all rights reserved).

Equation (1) $$N_{CONV,added,i} = N_{TOT,added,i} \times \left(\frac{N_{CONV,2007} - N_{CONV,2002}}{N_{TOT,2007} - N_{TOT,2002}} \right)$$

where:

$N_{CONV,added,i}$ is the estimated basin-wide number of new conventional gas wells added in year *i*

$N_{TOT,added,i}$ is the estimated basin-wide total number of new gas wells added in year *i* (conventional gas and CBM)

$N_{CONV,2007}$ is the basin-wide total number of conventional gas wells in 2007

$N_{CONV,2002}$ is the basin-wide total number of conventional gas wells in 2002

$N_{TOT,2007}$ is the basin-wide total number of gas wells in 2007

$N_{TOT,2002}$ is the basin-wide total number of gas wells in 2002

Equation 1 essentially scales the estimated total number of new gas wells added (as described above) by a fraction representing the percentage of new wells added in the period 2002-2007 that were conventional gas. 2002-2007 represented a recent period in which there was significant growth in both conventional gas and CBM gas wells and was considered representative of future development plans for the basin.

CBM Well Counts

CBM well counts in the South San Juan Basin have been plotted for the years 1970 – 2006 below in Figure 3, including projections to 2012.

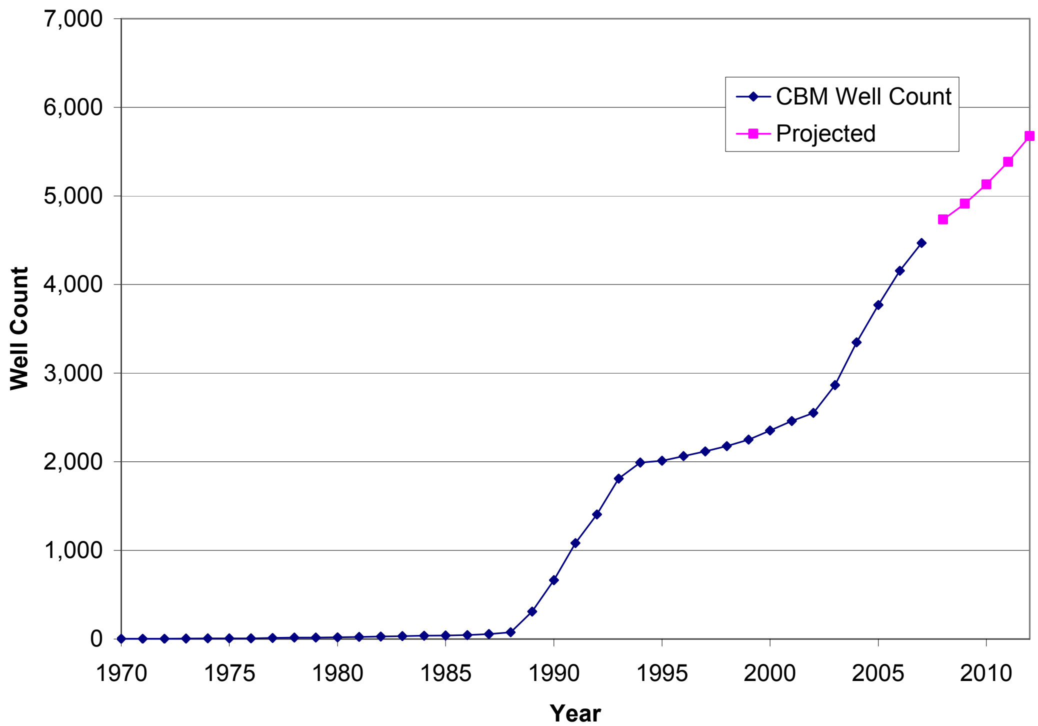

Figure 3. CBM well count historical data (from the IHS database) for the South San Juan Basin and projections to 2012.[3]

CBM well count projections were developed for the period 2007 – 2012 similarly to conventional gas well counts as described above. Similar to conventional gas well counts the starting point was the development of total gas well count projections for the basin, followed by an estimation of the fraction of these new wells which are expected to be CBM.

The CBM well counts for the basin in each year from 2006-2012 were developed by determining the fraction of the total number of new wells added that were CBM. The CBM well fraction was determined according to Equation 2:

Equation (2) $$N_{CBM,added,i} = N_{TOT,added,i} \times \left(\frac{N_{CBM,2007} - N_{CBM,2002}}{N_{TOT,2007} - N_{TOT,2002}} \right)$$

where:

$N_{CBM,added,i}$ is the estimated basin-wide number of new CBM wells added in year *i*

$N_{TOT,added,i}$ is the estimated basin-wide total number of new gas wells added in year *i* (conventional gas and CBM)

$N_{CBM,2007}$ is the basin-wide total number of CBM wells in 2007

[3] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2009) all rights reserved).

$N_{CBM,2002}$ is the basin-wide total number of CBM wells in 2002
$N_{TOT,2007}$ is the basin-wide total number of gas wells in 2007
$N_{TOT,2002}$ is the basin-wide total number of gas wells in 2002

As with conventional gas wells, the 2002-2007 period was selected because it represented a recent period of activity which included growth in both CBM and conventional gas well counts. Prior to this period there were two past periods of growth in CBM well counts in the basin but these were not considered representative of the recent rate of development of CBM wells.

Total Well Counts

Total gas well counts in the South San Juan Basin have been plotted for the years 1970 – 2006 below in Figure 4, including projections to 2012.

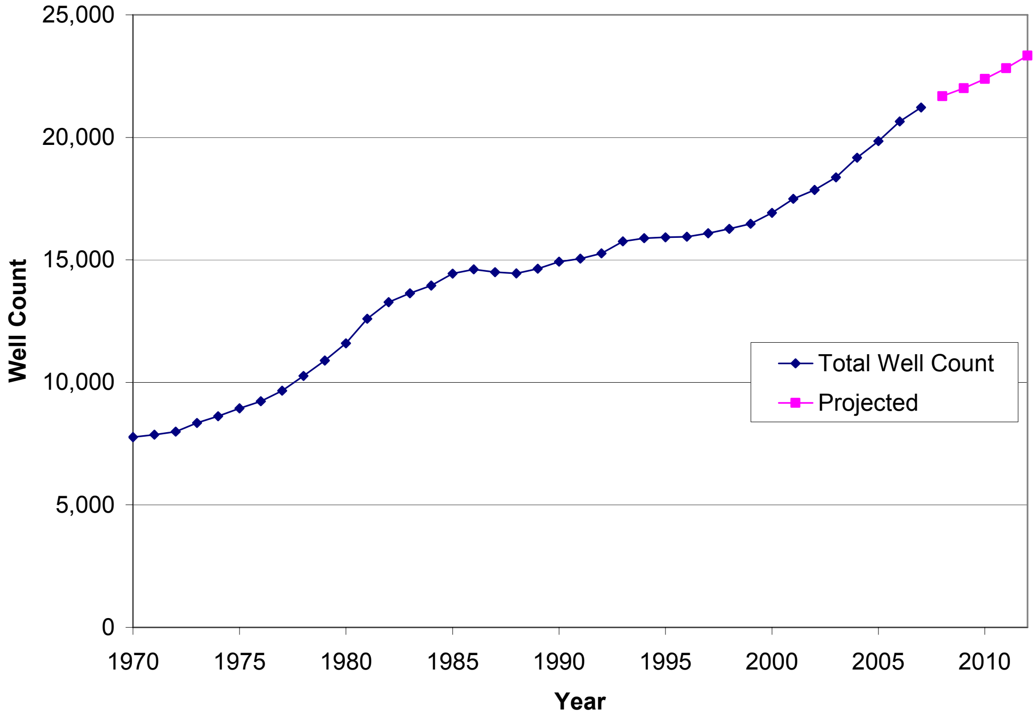

Figure 4. Total gas well count historical data (from the IHS database) for the South San Juan Basin and projections to 2012. [4]

As described above, total gas well counts were developed for the period 2007 – 2012 by first developing a ratio of the number of spuds in each year from 2003 – 2007 to the number of new wells (conventional gas and CBM) added in each of those years. This data for the years 2003–2007 was averaged to develop a single historical drilling rate estimate of 1.179. This drilling rate estimate was then applied to the number of spuds as predicted by the spud count projection in order to determine the number of new wells added in each year from 2007 – 2012.

[4] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2009) all rights reserved).

Total Gas Production

Gas production in the San Juan Basin has been plotted for the years 1970 – 2006 below in Figure 5, including projections to 2012.

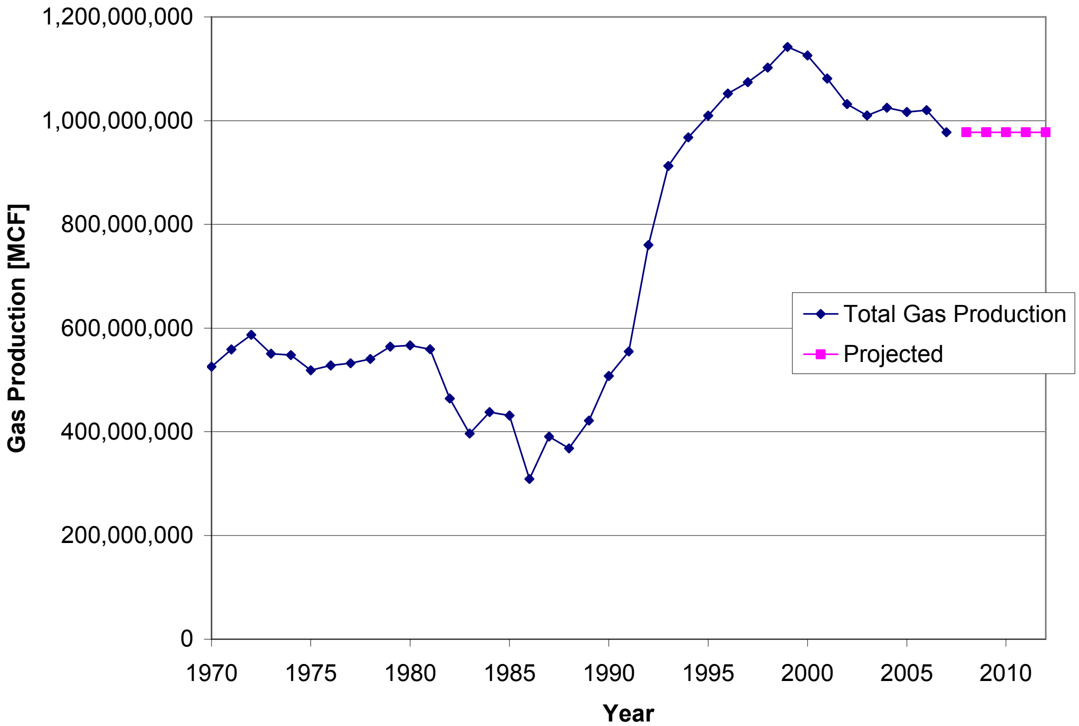

Figure 5. Total gas production historical data (from the IHS database) for the San Juan Basin and projections to 2012. [5]

Gas production in the San Juan Basin has generally been in decline since 1999. Efforts were made in this analysis to develop representative conventional and CBM gas well decline curves, and to construct projections for total gas production using these decline curves combined with the projected well counts. As with midterm projections for other basins in the Phase III work, efforts were made to validate draft well decline curves by verifying their ability to accurately back-cast production in the basin for past years. No reasonable correlation between representative well decline curves and historic gas production data could be found for either conventional gas wells or CBM wells, and therefore this approach was not used.

One potential reason for the lack of correlation between well decline curves and historic gas production is the frequent workover of wells in the South San Juan Basin, which alters the production curves for these wells. Another is the non-optimal allocation of compression resources in the basin, such that the maximum feasible or target production from a well may not have been achieved during some portion of the lifetime of the well.

Given this lack of correlation, and the decline in basin-wide gas production from 1999-2006, it was conservatively estimated that gas production would remain constant at 2007 production levels in the period through 2012.

[5] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2009) all rights reserved).

Oil Production

Oil production in the South San Juan Basin has been plotted for the years 1970 – 2006 below in Figure 6, including projections to 2012.

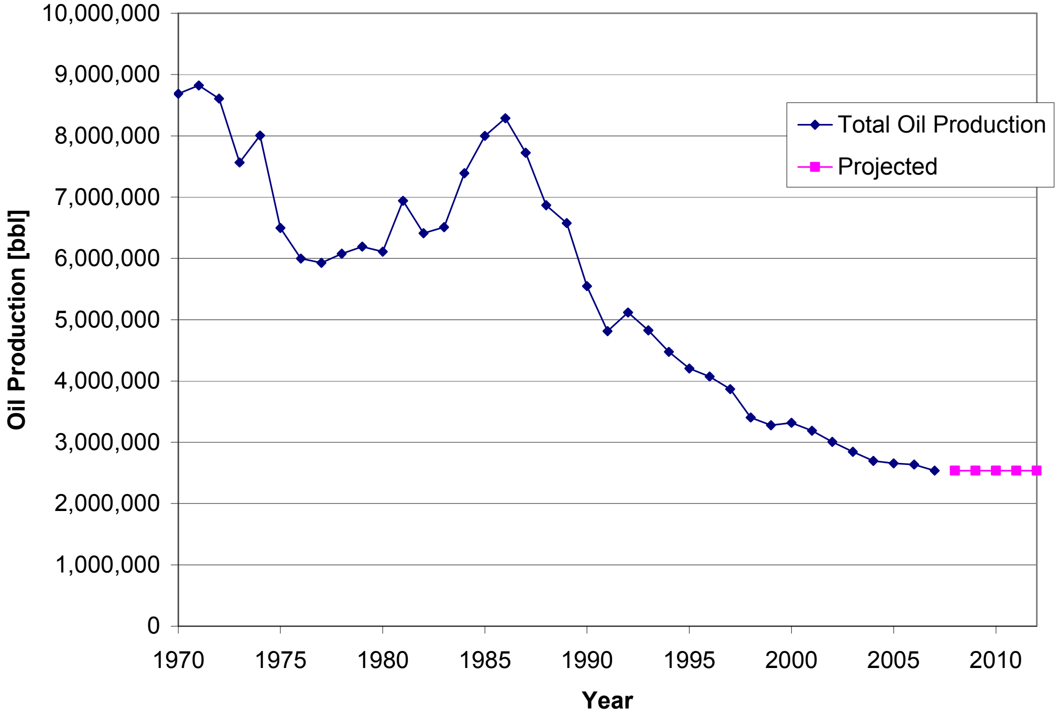

Figure 6. Oil production historical data (from the IHS database) for the South San Juan Basin and projections to 2012.[6]

Similar to gas production, oil production has been in significant decline in the South San Juan Basin since the mid-1980's and is expected to continue to decline. This analysis projects no new oil wells as part of development activities in the South San Juan Basin in the period 2006-2012. Given this historic decline, it was conservatively projected that oil production would remain at 2007 levels in the period through 2012.

[6] (Includes data supplied by IHS Inc., its subsidiary and affiliated companies; Copyright (2009) all rights reserved).

Condensate Production

Condensate production in the South San Juan Basin has been plotted for the years 1970 – 2006 below in Figure 7, including projections to 2012.

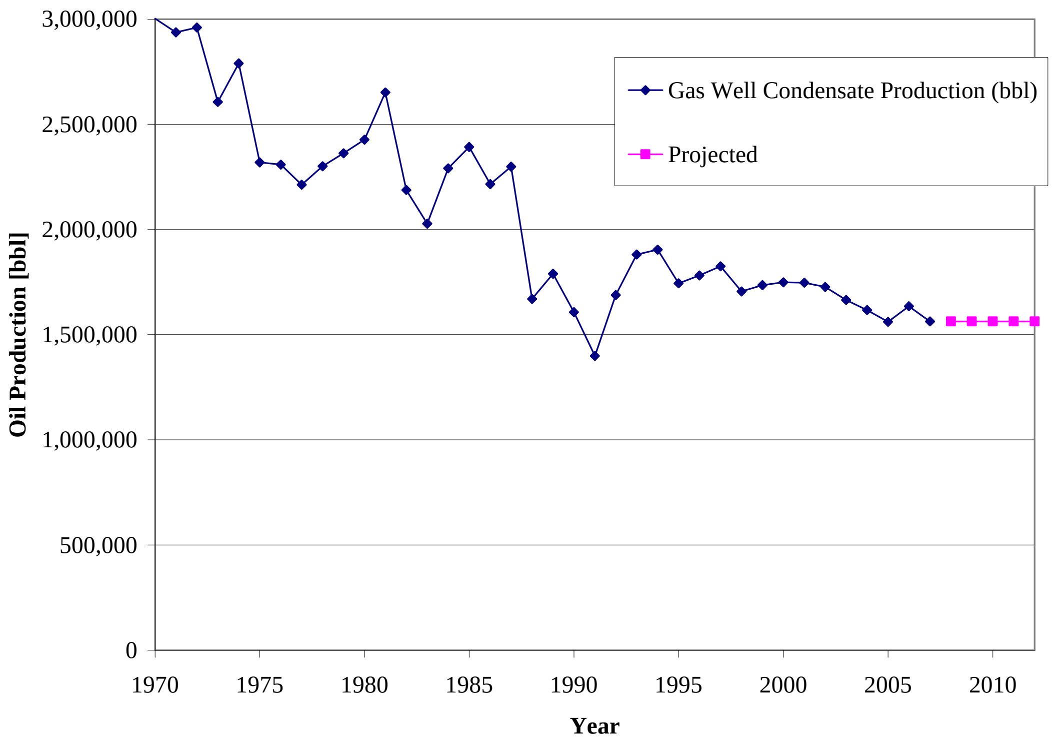

Figure 7. Condensate production historical data (from the IHS database) for the South San Juan Basin and projections to 2012.

Condensate production in the South San Juan Basin is projected to directly track gas production, as the condensate is a by-product of the gas production. Similar to basin-wide gas production, condensate production in the South San Juan Basin has generally been in decline since the mid-1990's. It was conservatively projected that condensate production would remain at 2007 levels in the period through 2012.

SCALING FACTOR DEVELOPMENT AND UNCONTROLLED 2012 EMISSIONS

Scaling factors were generated for the South San Juan Basin as a whole, for each parameter considered here: total well counts, conventional gas well counts, CBM well counts, spud count, total gas production, condensate production and oil production. These are presented for each county below, but note that they are identical for each county since it was not possible to conducted county-specific activity projections for this basin, as described above. The ratio of the value of each of these parameters in 2012 to their values in 2006 is the scaling factor for that parameter for purposes of this projection. This is shown in Equation 3 below:

Equation (3) $$f_i = {W_{2012}}/{W_{2006}}$$

where:

f_i is the scaling factor for the South San Juan Basin for parameter *i* (total well count, conventional gas well count, CBM well count, spud count, total gas production, condensate production, or oil production)

W_{2006} is the value of parameter *i* in 2006

W_{2012} is the projected value of parameter *i* in 2012

The scaling factor based on the appropriate parameter is selected for each source category as described in Table 1. The scaling factors for the seven parameters used in this analysis for each county in the South San Juan Basin are presented in Table 2 below.

Table 2. Scaling factors for the seven parameters used in the projection analysis for the four counties in the South San Juan Basin.

Geographic Grouping	Total Well Count	Conv. Gas Well Count	CBM Well Count	Spud Count	Total Gas Production	Condensate Production	Oil Production
McKinley County	1.12	1.07	1.34	0.65	0.96	0.96	0.96
Rio Arriba County	1.12	1.07	1.34	0.65	0.96	0.96	0.96
Sandoval County	1.12	1.07	1.34	0.65	0.96	0.96	0.96
San Juan County	1.12	1.07	1.34	0.65	0.96	0.96	0.96

CONTROLLED 2012 EMISSIONS

This methodology considered any "on-the-books" federal or state regulations that would affect the uncontrolled 2012 emissions projections described above.

Table 6 below lists the "on-the-books" federal and state regulations that affect emissions source categories in the oil and gas industry, and the action taken to adjust the 2012 emissions inventory appropriately. A more detailed description follows of the methodology used to address each of these regulations as they affected the uncontrolled 2012 South San Juan Basin emissions projections.

The uncontrolled 2012 emissions were adjusted based on the proposed actions or control factors developed for each regulation described in Table 3 to account for how these regulations may affect any oil and gas source category considered in this inventory.

Table 3. Summary of federal and state "on-the-books" regulations affecting the oil and gas source categories considered in this inventory.

Source Category	Regulation	Enforcing Agency	Effective Date	Implementation in the 2012 South San Juan Basin Emissions Projections
Federal				
Drill Rigs, Workover Rigs	Nonroad engine Tier standards (1-4) (EPA, 2005)	US EPA	Phase in from 1996 - 2014	EPA NONROAD model used to create county-level control factors for the drill rig SCC to account for fleet turnover.
Drill Rigs, Workover Rigs	Nonroad diesel fuel sulfur standards (EPA, 2006)	US EPA	Phase in beginning in 2010	Assume 15 ppm sulfur in nonroad diesel fuel throughout South San Juan Basin. Control factors derived from EPA NONROAD model (see above).
All New Spark-Ignited Stationary Engines	New Source Performance Stds. (NSPS) (EPA, 2008)	US EPA	Phase in from 2008 - 2011	Control factors developed considering the specific composition of engines in the inventory (described in more detail below).
New or Relocated Stationary Spark-Ignited Engines	Conditions of Approval for the Farmington Area Resource Management Plan (RMP) (NMED, 2009)	BLM	2005	Control factors developed considering the specific composition of engines in the inventory (described in more detail below).

Nonroad Diesel Engine Standards and Fuel Sulfur Standards

The EPA NONROAD2005 model was run with fuel inputs based on a 2002 study entitled "WRAP Mobile Sources Emission Inventory Update" (Pollack, et al., 2006). The model outputs were used to develop county-level emissions per unit population for "other oil field equipment" (SCC 2270010010) for the calendar year 2006, and then separately for the calendar year 2012. These emissions per unit population reflect the predicted fleet mix of engines – for various tier standards from baseline uncontrolled engines through Tier IV engines – and are used as a representation of fleet turnover for drilling rigs and workover rigs. The ratios of the per unit emissions in 2012 to those in 2006 for each county of interest were taken to be the control factors accounting for federal non-road tier standards.

In addition, the NONROAD model runs with the fuel inputs used for developing the tier standards control factors were also used to develop the control factors for SOx emissions factors for drilling rigs and workover rigs. The model is capable of tracking the expected reduction in fuel sulfur content from the baseline 2006 year – assumed to be the same as the WRAP 2002 inventory – and the 2012 future year. A similar approach was used as for the federal tier standards to develop control factors. The ratio of per unit SOx emissions in 2012 to those in 2006 were taken to be a control factor to apply to uncontrolled 2012 SOx emissions for drilling rigs and workover rigs to account for federal non-road diesel fuel standards.

New Source Performance Standards for Stationary Spark-Ignited Engines and Farmington RMP Conditions of Approval Standards for Gas Compressors

A combined analysis was undertaken to implement both the US EPA NSPS and the compressor engine standards requirement from the Farmington RMP COA, since both of these rules affect the same source category and had overlapping requirements in some cases. In previous basin analyses of NSPS application (Bar-Ilan, et al., 2009a; Bar-Ilan, et al., 2009b; Bar-Ilan, et al., 2009c; Bar-Ilan, et al., 2008), it was assumed that a flat or declining gas production projection would indicate no need for additional horsepower of compression. This was coupled with the assumption that there would be negligible turnover of engines during the period of the projections to conclude that NSPS did not need to be applied for purposes of developing the 2012 emissions inventory. Although gas production is not projected to change in the period 2006-2012, a special analysis was conducted for the South San Juan Basin compressors.

In the case of the South San Juan Basin, it is recognized that wellhead compressor engines represent a major source category, and that despite the flat gas production projections for 2012, declining field pressures in the basin still necessitate turnover and movement of compressors. Therefore data was requested from the major companies participating in the survey process on their planned compressor installations and switches, in order to estimate the change in total wellhead compression horsepower in the basin in the period 2006-2012. A subset of the companies that responded to the survey provided such data, indicating where a compressor was moved or replaced with another compressor, and the net change in horsepower resulting from the relocation or switch. These changes were summed to provide a net change in compression horsepower, which indicated an increase in compression horsepower. Similar to other producer-supplied data, the total increase in compression horsepower from the combined survey responses was scaled to a basin-wide total increase in compression horsepower using gas production as the surrogate, following Equation 4:

Equation (4) $$HP_{increase} = HP_{increase,survey} \frac{P_{TOT}}{P}$$

where:

$HP_{increase}$ is the total basin-wide increase in wellhead compression horsepower from 2006 to 2012 [hp]
$HP_{increase,survey}$ is the increase in wellhead compression horsepower from 2006 to 2012 for those companies providing survey data [hp]
P_{TOT} is the total basin-wide gas production in 2006 [mscf]
P is the gas production in 2006 owned by those companies providing survey data on compressor relocations and switches [mscf]

It was assumed that both the NSPS and Farmington RMP COA requirements applied only to the growth in compression horsepower – this analysis explicitly and conservatively assumes that engines which were not relocated or switched were not otherwise turned over and remained in operation in the period 2006-2012. These engines which were not changed would not be subject to NSPS or Farmington RMP COA requirements.

In general the analysis considered the growth in horsepower of engines, and assigned this additional horsepower to various "bins" of horsepower ranges according to the 2006 distribution of compressor horsepower. It was not possible to identify the exact horsepower range of each compressor that was relocated or switched from the data provided by the participating companies. For the various horsepower range bins, the analysis inside the boundaries of the Farmington RMP considered both the COA regulations and the NSPS for a given horsepower range and projection year (for each year in the period 2006-2012) and applied the more stringent of these two regulations. For the area outside the Farmington RMP, only the NSPS was applied.

NSPS Regulations

The EPA has promulgated a new regulation covering new stationary, spark-ignited engines of various horsepower classes. The regulation is assumed to apply to central compressor engines, wellhead and lateral compressor engines, and artificial lift engines as well as any other miscellaneous APEN exempt engines that are stationary, spark-ignited natural gas engines. The regulation requires new engines of various horsepower classes to meet increasingly stringent NOx and VOC emission standards over the phase-in period of the regulation.

For engines less than 25 horsepower, Table 4 shows the requirements of the NSPS regulation.

Table 4. Federal NSPS emissions standards for engines less than 25 horsepower.

HP Range[a]	Emissions Standards Requirement in (g/hp-hr)[b]		
	HC + NOx	NMHC + NOx[c]	CO
≤ 25 Hp			
Class I	16.1 (12.0)	14.8 (11.0)	610 (455)
Class I -A	50-37	-	-
Class I -B	40 (30)	37 (27.6)	
Class II	12.1 (9.0)	11.3 (8.4)	

[a] Class I-A: Engines with displacement less than 66 cubic centimeters (cc); Class 1-B: Engines with displacement greater than or equal to 66cc and less than 100cc; Class I: Engines with displacement greater than or equal to 100 cc and less than 225 cc
[b] Modified and reconstructed engines manufactured prior to July 1, 2008, must meet the standards applicable to engines manufactured after July 1, 2008
[c] NMHC+NOX standards are applicable only to natural gas fueled engines at the option of the manufacturer, in lieu of HC+NOX standards

For engines in the horsepower range 25 – 100 horsepower, Table 5 shows the requirements of the NSPS regulation.

Table 5. Federal NSPS emissions standards for engines greater than 25 horsepower but less than 100 horsepower.

HP Range	Manufacture Date	Emissions Standards Requirement (g/hp-hr)	
		HC + NOx	CO
25<HP<100	1-Jul-08	3.8	6.5
	1-Jul-08 (severe duty)	3.8	200

For engines in the horsepower range 100 – 1,350 horsepower, Table 6 shows the requirements of the NSPS regulation.

Table 6. Federal NSPS emissions standards for engines greater than 25 horsepower but less than 100 horsepower.

Engine Type and Fuel	HP Range	Manufacture Date	Emissions Standards Requirement (g/hp-hr)		
			NOx	CO	VOC
Non-Emergency SI Natural Gas and Non-Emergency SI Lean Burn LPG	100≤HP<500	1-Jul-08	2	4	1
		1-Jan-11	1	2	1
Non-Emergency SI Lean Burn Natural Gas and LPG	500≥HP<1350	1-Jan-08	2	4	1
		1-Jul-10	1	2	1
Non-Emergency SI Natural Gas and Non-Emergency SI Lean Burn LPG (except lean burn 500≥HP<1350)	HP≥500	1-Jul-07	2	4	1

A detailed analysis was carried forward to analyze the effects of this rule on the permitted and unpermitted engine fleet in the South San Juan Basin. Engines were sorted into bins representing horsepower ranges based on the detailed compressor engine data gathered as part of the baseline 2006 inventory development. For the area outside the Farmington RMP, it was assumed that only NSPS would apply to compressor engines. Because the NSPS requirements change over the phase-in period of the regulation, the growth of compression horsepower was tracked for each year in the period 2006-2012. For each year, the additional compression horsepower was sorted into the horsepower range bins, and NSPS was applied to these engines. In the case of the area within the boundaries of the Farmington RMP, consideration was made of whether the Farmington RMP COA or the NSPS was more stringent for a given year and horsepower range, and the more stringent of these two requirements was applied.

<u>Farmington RMP COA</u>

The Farmington RMP COA required that after 2005, new or relocated wellhead compressor engines meet the 2.0 g/bhp-hr NOx emissions standard. This was assumed to apply to all compressor engines regardless of the horsepower of the engine. There are no additional phase-in dates for the Farmington RMP COA, such that it was assumed this requirement applied equally in each year of the projections. A geographic information systems (GIS) analysis was conducted to intersect the boundaries of the Farmington RMP area with the basin-wide database of gas production in the South San Juan Basin, as shown in Figure 8 below. The gas production was used as a surrogate for determining the fraction of compression horsepower located within the Farmington RMP area, and the fraction outside of this area – consistent with the surrogate used to scale survey data on compression to basin-wide emissions. For those compressors located within the boundary of the Farmington RMP area, for each scenario year the requirements of the Farmington RMP COA and the NSPS were examined and the more stringent of these two was applied.

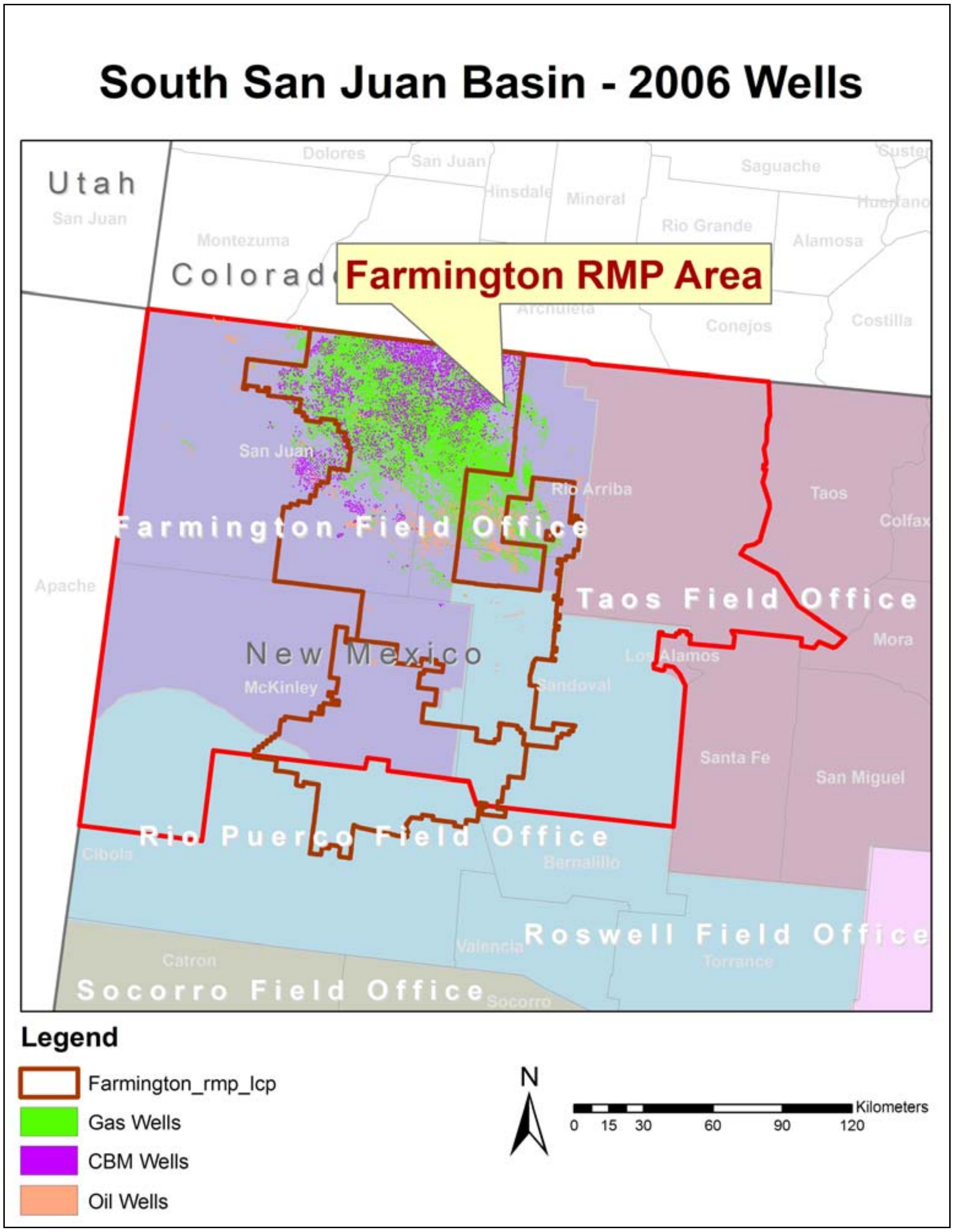

Figure 8. Boundaries of the Farmington RMP overlaid on the South San Juan Basin boundaries and 2006 well locations.

SUMMARY RESULTS

The scaling factors were applied to the baseline 2006 inventory, and “on-the-books” regulations were applied to the uncontrolled 2012 emissions projections to generate the final 2012 emissions projections and results are presented below.

Figures 9 and 10 show that NOx and VOC emissions, respectively, are primarily concentrated in Rio Arriba and San Juan Counties. NOx emissions in particular are concentrated in San Juan County, driven primarily by the gas production in this county and the standards for compressor engines phasing in during the period of the projections. VOC emissions are more evenly divided among these two counties. Only minor NOx and VOC emissions occur in McKinley and Sandoval Counties. The majority of these emissions occur on non-tribal land, as shown in Figures 11 and 12. This is consistent with the findings of the 2006 baseline emissions analysis.

Consistent with the 2006 baseline emissions analysis, compressor engines remain the dominant NOx source category in the South San Juan Basin. This includes the wellhead compressors and other lateral compressors operating in the basin. Despite some controls of NOx for the compressor source category through NSPS and the Farmington RMP COA, the drop-off in drilling activity leaves the NOx contribution of compressors essentially unchanged from the 2006 baseline. VOC emissions are divided among a number of source categories, similar to the 2006 baseline inventory for the basin. Venting from completions, recompletions and blowdowns, as well as dehydration venting collectively account for approximately 60% of VOC emissions in the basin.

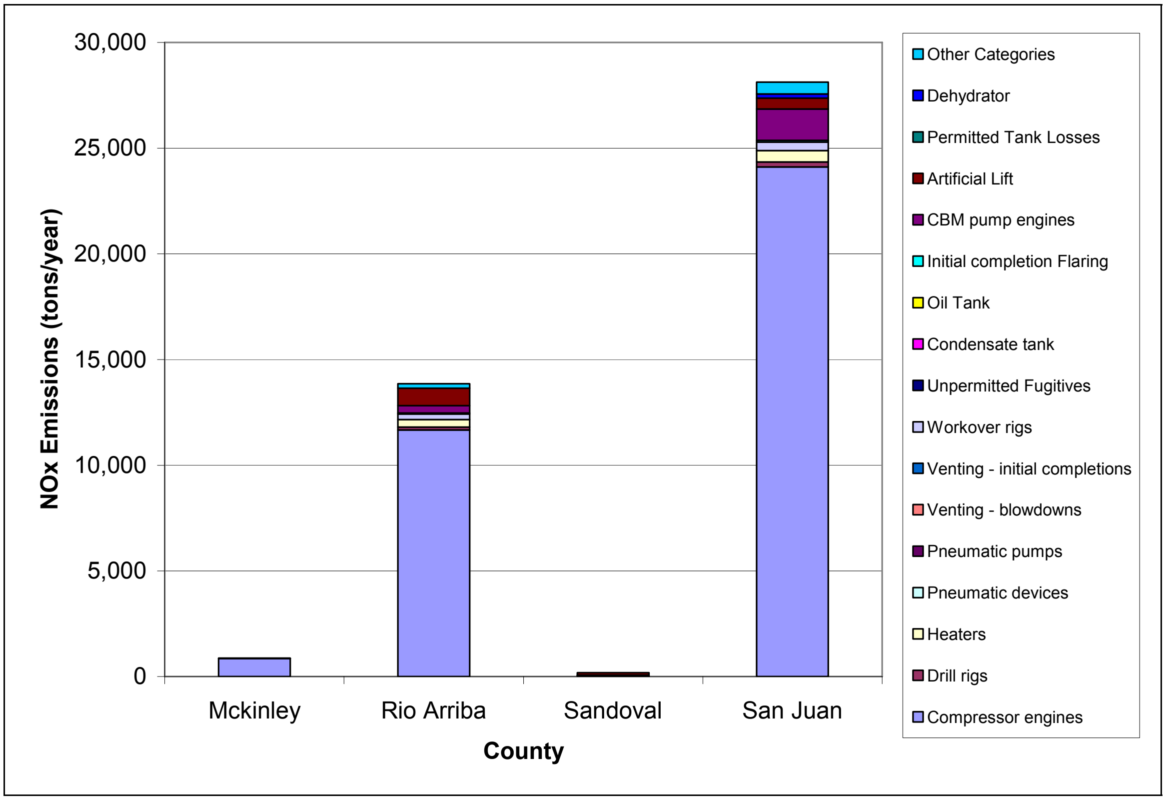

Figure 9. 2012 NOx emissions by source category and by county in the South San Juan Basin.

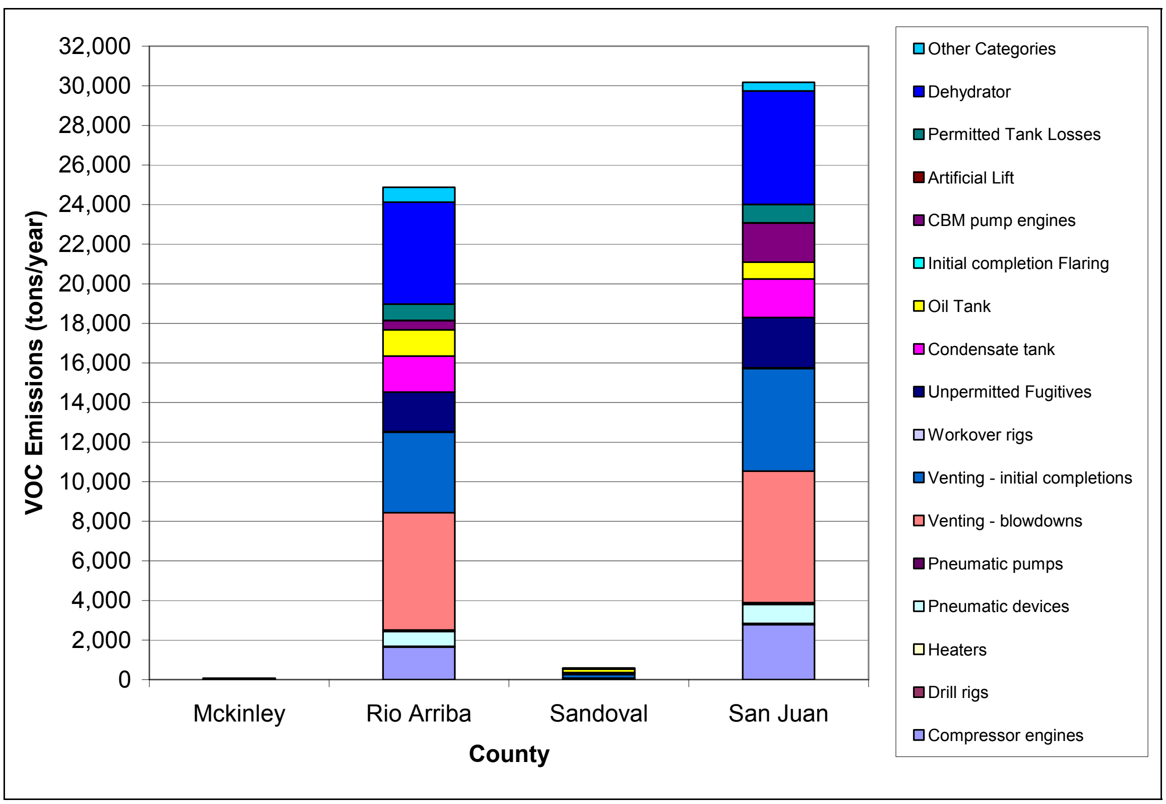

Figure 10. 2012 VOC emissions by source category and by county in the South San Juan Basin.

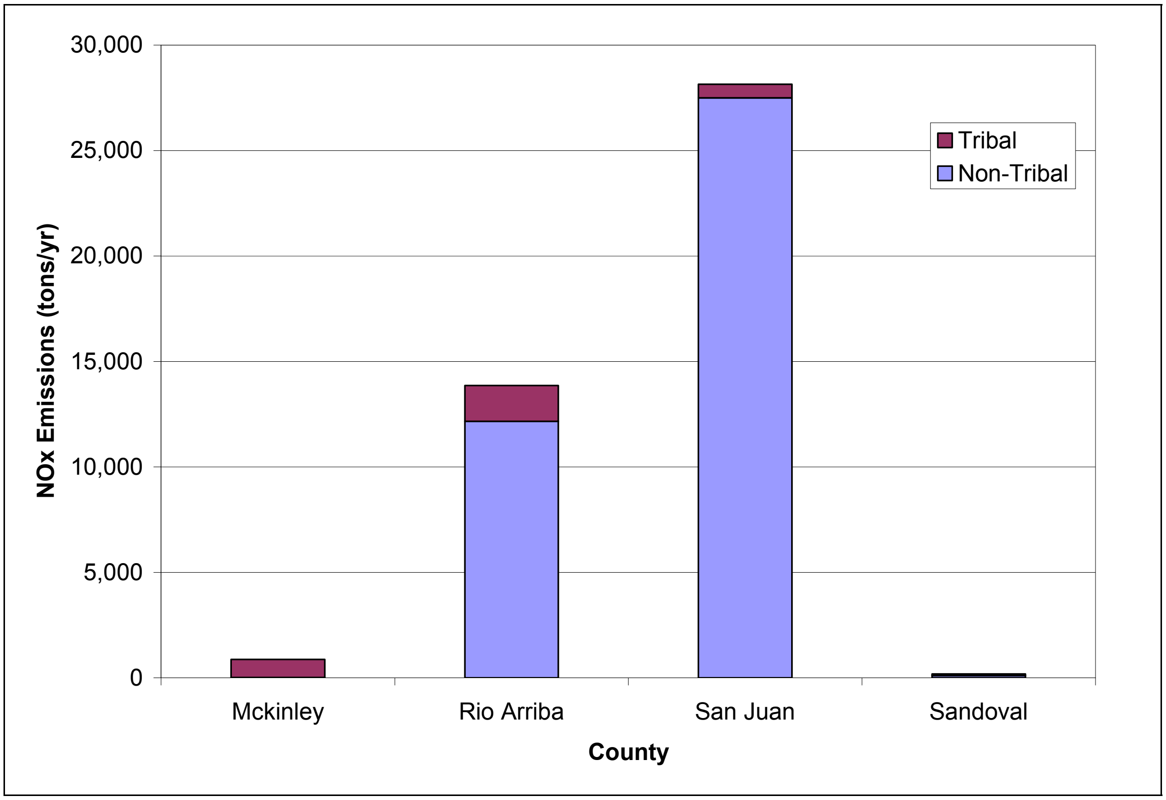

Figure 11. 2012 NOx emissions on tribal and non-tribal land by county in the South San Juan Basin**.**

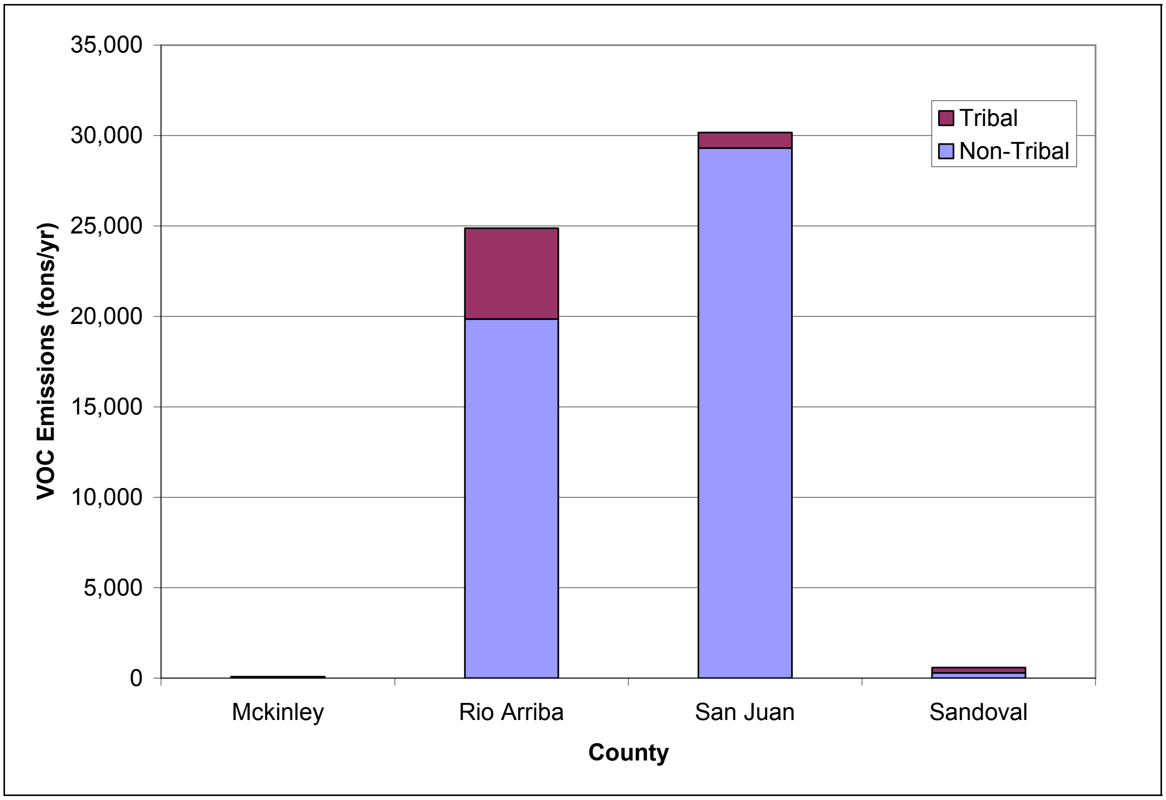

Figure 12. 2012 VOC emissions on tribal and non-tribal land by county in the South San Juan Basin.

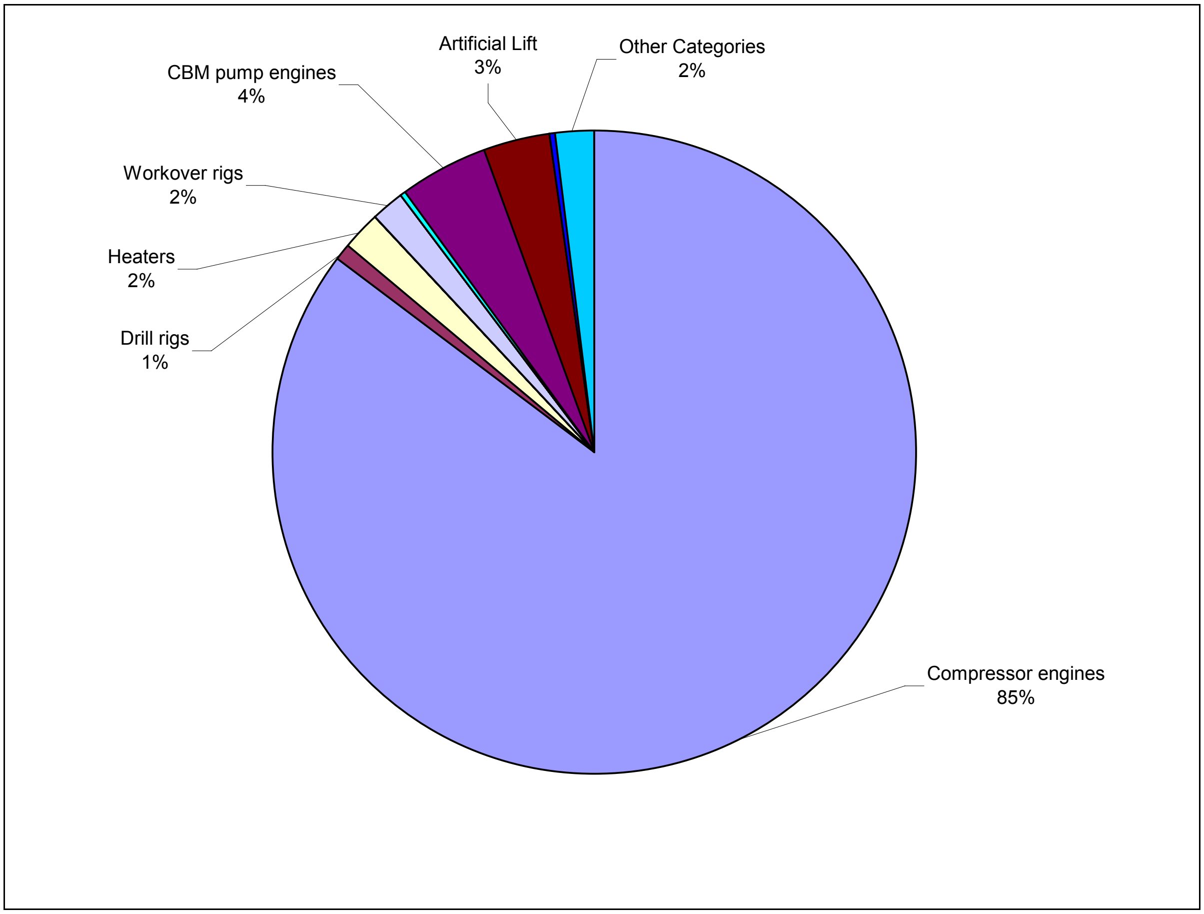

Figure 13. 2012 NOx emissions contributions by source category in the South San Juan Basin.

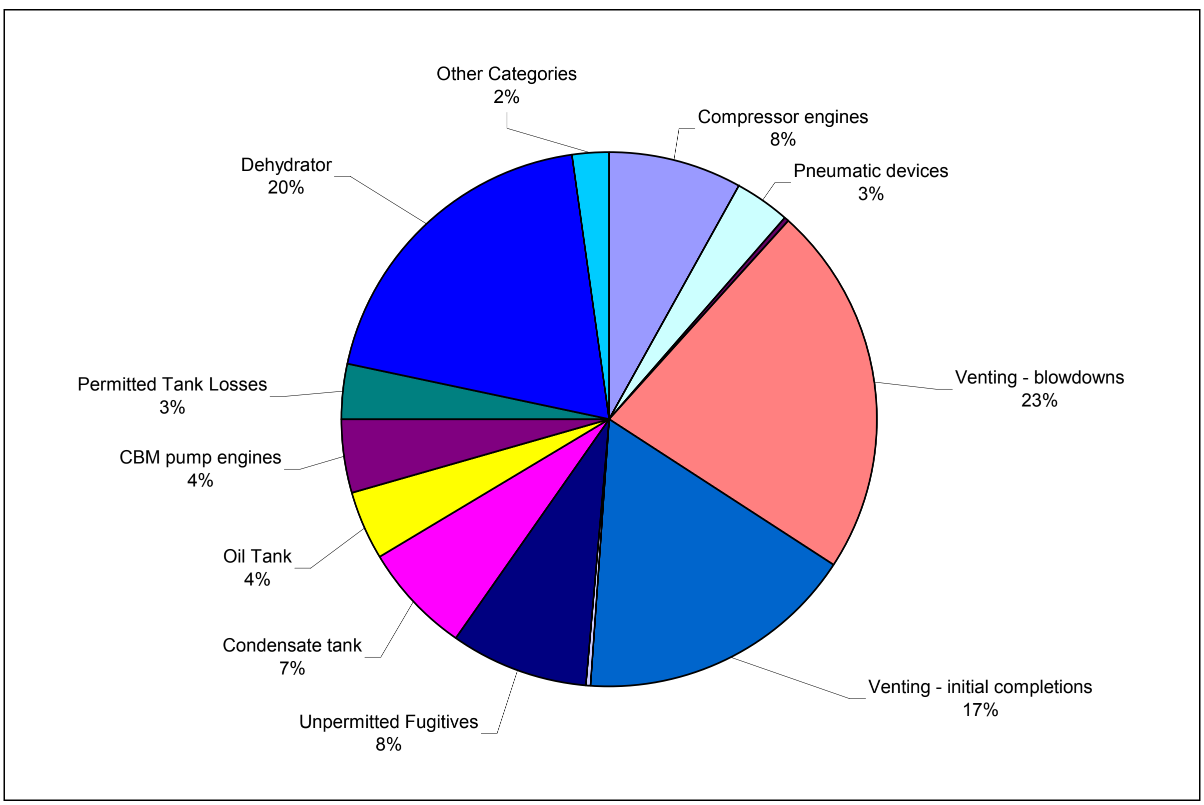

Figure 14. 2012 VOC emissions contributions by source category in the South San Juan Basin.

Table 7. 2012 emissions of all criteria pollutants by county for the South San Juan Basin.

County	NOx [tons/yr]	VOC [tons/yr]	CO [tons/yr]	SOx [tons/yr]	PM [tons/yr]
McKinley	873	73	171	1	6
Rio Arriba	13,858	24,875	9,378	7	141
San Juan	28,134	30,174	15,705	124	372
Sandoval	185	584	167	0	3
McKinley (Tribal)	857	4	156	1	6
Rio Arriba (Tribal)	1,695	5,022	1,367	3	23
San Juan (Tribal)	641	865	368	2	5
Sandoval (Tribal)	83	297	75	0	1
McKinley (Nontribal)	16	69	15	0	0
Rio Arriba (Nontribal)	12,163	19,852	8,011	4	118
San Juan (Nontribal)	27,493	29,309	15,337	122	367
Sandoval (Nontribal)	102	287	92	0	2
Totals	**43,050**	**55,705**	**25,421**	**132**	**523**
Total Tribal	**3,276**	**6,188**	**1,967**	**7**	**34**
Total Nontribal	**39,774**	**49,517**	**23,454**	**126**	**488**

Table 8. 2012 NOx emissions by county and by source category for the South San Juan Basin.

County	Compressor Engines	Drill Rigs	Heaters	Workover Rigs	Completion Flaring	CBM Pump Engines	Artificial Lift	Dehydrator	Other Categories	Total
McKinley	857	0	3	2	0	2	7	0	1	873
Rio Arriba	11,664	134	354	269	55	346	818	5	213	13,858
San Juan	24,106	245	531	403	82	1,482	520	195	569	28,134
Sandoval	32	7	14	11	2	5	110	0	6	185
McKinley (Tribal)	857	0	0	0	0	0	0	0	0	857
Rio Arriba (Tribal)	1,149	20	83	63	13	0	333	1	31	1,695
San Juan (Tribal)	423	3	14	11	2	89	82	0	17	641
Sandoval (Tribal)	18	0	7	6	1	0	48	0	3	83
McKinley (Nontribal)	1	0	3	2	0	2	7	0	1	16
Rio Arriba (Nontribal)	10,515	113	270	205	42	346	486	4	182	12,163
San Juan (Nontribal)	23,683	242	517	393	80	1,393	438	195	552	27,493
Sandoval (Nontribal)	13	7	7	5	1	5	62	0	3	102
Totals	**36,659**	**386**	**901**	**684**	**140**	**1,835**	**1,455**	**200**	**789**	**43,050**
Total Tribal	**2,447**	**24**	**105**	**80**	**16**	**90**	**463**	**1**	**50**	**3,276**
Total Nontribal	**34,212**	**363**	**796**	**605**	**123**	**1,746**	**992**	**199**	**739**	**39,774**

Table 9. 2012 VOC emissions by county and by source category for the South San Juan Basin.

County	Compressor Engines	Pneumatic Devices	Pneumatic Pumps	Venting – Blowdown	Venting - Initial Completion	Unpermitted Fugitives	Condensate Tanks	Oil Tanks	CBM Pump Engines	Permitted Tank Losses	Dehydrator	Other Categories	Totals
McKinley	4	6	1	0	32	15	0	11	3	0	0	1	**73**
Rio Arriba	1,645	761	65	5,922	4,069	1,992	1,824	1,327	463	817	5,152	837	**24,875**
San Juan	2,776	973	83	6,643	5,178	2,534	1,952	843	1,981	938	5,718	556	**30,174**
Sandoval	2	34	3	30	183	90	14	178	7	0	25	18	**584**
McKinley (Tribal)	4	0	0	0	0	0	0	0	0	0	0	0	**4**
Rio Arriba (Tribal)	195	203	17	941	1,090	533	344	540	0	213	852	94	**5,022**
San Juan (Tribal)	23	31	3	144	166	81	26	133	120	0	121	17	**865**
Sandoval (Tribal)	1	18	2	17	97	48	13	78	0	0	15	8	**297**
McKinley (Nontribal)	0	6	1	0	32	15	0	11	3	0	0	1	**69**
Rio Arriba (Nontribal)	1,450	558	48	4,981	2,979	1,458	1,480	788	462	605	4,300	744	**19,852**
San Juan (Nontribal)	2,753	942	80	6,500	5,011	2,453	1,925	710	1,862	938	5,597	540	**29,309**
Sandoval (Nontribal)	1	16	1	13	85	42	1	100	7	0	11	10	**287**
Totals	**4,427**	**1,774**	**151**	**12,595**	**9,462**	**4,631**	**3,790**	**2,359**	**2,453**	**1,755**	**10,896**	**1,413**	**55,705**
Total Tribal	**223**	**252**	**22**	**1,102**	**1,354**	**663**	**383**	**750**	**120**	**213**	**988**	**118**	**6,188**
Total Nontribal	**4,204**	**1,521**	**129**	**11,493**	**8,108**	**3,968**	**3,407**	**1,609**	**2,333**	**1,542**	**9,908**	**1,294**	**49,517**

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