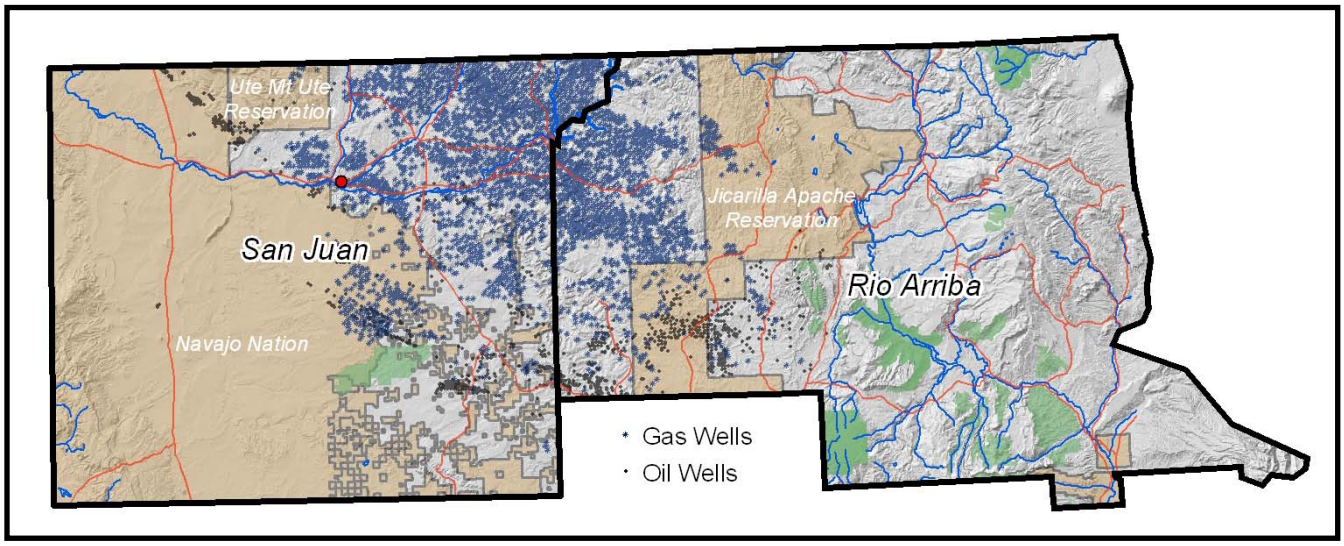
Final Report

OZONE PRECURSORS EMISSION INVENTORY FOR SAN JUAN AND RIO ARRIBA COUNTIES, NEW MEXICO



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1. INTRODUCTION

STUDY BACKGROUND

San Juan and Rio Arriba Counties are located in the northwestern part of New Mexico in the Four Corners area. The New Mexico Environmental Department (NMED) operates three continuous ozone monitors in San Juan County: Substation, Bloomfield and Navajo Lake. Monitored ozone data is collected by NMED, submitted to the EPA, and used to determine the air quality status in northwestern New Mexico with respect to the ozone NAAQS.

In the past several years, the 8-hour average ozone concentrations have approached the standard of 0.08 ppm in San Juan County. The air quality status of a region is determined by the 8-hour ozone design value, defined as the average of the fourth highest 8-hour average ozone concentration from the most recent three years. The Substation monitor's design value is currently 0.0747 ppm (based on data from 2001, 2002 and 2003), while Bloomfield's current design value is 0.0743 ppm. San Juan County has never exceeded the 8-hour standard and is currently in attainment for the 8-hour NAAQS.

In December 2002, the New Mexico Environmental Department, US EPA, the Cities of Aztec, Bloomfield and Farmington, and San Juan County, NM entered into a voluntary agreement, known as the Early Action Compact (EAC) for ozone, to evaluate and analyze ozone air quality in northwestern New Mexico with respect EPA's 8-hour standard for ground-level ozone. The EAC sets forth a schedule for the development of technical information concerning ozone formation in the region and the adoption and implementation of any necessary emissions control measures. The EAC process requires a state-of-science photochemical grid modeling demonstration to show attainment of the 8-hour ozone standard by December 2007. Any emission controls found through modeling to be necessary for attainment of the NAAQS must be implemented by 2005.

San Juan County qualified for consideration of an EAC because the region currently is in attainment of the 1-hour ozone standard. Since there was a possibility that the region's 8-hour ozone could conceivably approach the 8-hour ozone standard, the NMED elected to opt-in to the EAC in lieu of the possibility of being declared an 8-hour nonattainment area in 2004. Significant impacts from being declared an ozone nonattainment area include the requirement for transportation conformity budgets to be met or highway funds may be cut off, the need to offset emissions from major new or modified construction in the nonattainment area, and potential restrictions in economic growth in the area.

The development of a credible photochemical dispersion modeling study, an essential component of the EAC process, was performed by a project team comprised of ENVIRON and Alpine Geophysics under the direction of the NMED Air Quality Bureau staff (Tesche, et al., 2004). Key elements of the EAC include:

- Early emission reductions to attain the 8-hour ozone standard;
- Local control of the EAC process, with broad-based public input;
- State support to ensure technical integrity of the early action plan;
- Early action plan incorporated into the SIP;

- Effective date of nonattainment designation and/or designation requirements is deferred (as long as all EAC terms and milestones are met); and
- Safeguards to return to a traditional SIP requirements if EAC terms and/or milestones are not met.

The base and future year photochemical modeling required by the EAC was completed in February of 2004 and included components to address emissions growth at least five years beyond 2007, with efforts to ensure that the area remain in attainment for the 8-hour ozone standard. Additional emissions control scenarios were considered to evaluate various economic growth scenarios. A discussion of these modeling analyses can be found in Tesche, et al. (2004).

INVENTORY SCOPE

The scope of the area sources emission inventory that was developed is as follows:

Geographical extent: The emission inventory was developed for San Juan and Rio Arriba Counties. As shown in the map of these two counties on the cover, there are tribal lands within these counties. The emission inventories developed cover both full counties (estimated separately), including emissions sources on tribal lands.

Source categories: The purpose of this project was to develop improved estimates of San Juan and Rio Arriba area source emissions. By far the dominant area source emissions category considered in this work is oil and gas production, and the majority of the effort was focused on generating oil and gas area source emissions estimates. ENVIRON has prepared the first region-wide inventory of area source oil and gas emissions for the western states (Russell and Pollack, 2005), but that initial effort used broad regional assumptions as resources were not available to obtain local data. For this project we met with the local producers, developed a survey with them for providing detailed data, and obtained detailed information from a majority of the producers to generate more refined local oil and gas emissions estimates. Section 2 of this report describes the data obtained, assumptions made, and the methods used to estimate the emissions. The resulting oil and gas emissions are provided at the end of the section.

Emissions for other area source categories were developed using EPA and Emission Inventory Improvement Program (EIIP) guidance methods. Full details of the other area source emissions estimates and results are provided in Section 3 of this report.

Biogenic and fire (wildland, prescribed, and agricultural burning) emissions are not included in this inventory. Emissions for those sources are day-specific, and are typically generated when an air quality episode has been identified for modeling. At the time this work was done the NMED had not yet identified episode(s) for further modeling, and NMED opted to devote more resources to developing the oil and gas emissions estimates.

Temporal extent: The emission inventory was developed for 2002, for both the full year and also for an average day during the May through October ozone season.

Pollutants: The emission inventory includes the ozone precursor pollutants nitrogen oxides (NOx), volatile organic compounds (VOC), and carbon monoxide (CO).

2. OIL AND GAS EMISSIONS

In March 2006, NMED and ENVIRON invited the major production companies in the San Juan Basin to attend a meeting to discuss the inventory project. The twelve companies invited collectively represented over 80 percent of well ownership in the inventory year, 2002. Nearly all the companies sent a representative to the March 14th meeting in Farmington. In all, just less than 80 percent of 2002 well ownership was represented at that meeting.

At the meeting the strategy was presented for an inventory that would refine the existing oil and gas emission inventories for San Juan and Rio Arriba Counties by gathering more detailed information from the producers. We proposed to refine emissions estimates using two methods:

1. To improve emissions estimates for engines we would conduct a survey of the producers to gather detailed information about the types of engines used in the oil and gas fields and the typical operating parameters of those engines. This information would be used to develop revised emissions estimates for drill rigs, compressors, salt water disposal pumps and artificial lift devices.

2. To refine the emissions estimates for the remaining source categories, we would revise the assumptions and inputs to previous emission estimates in order to tailor the emissions estimates more specifically to the San Juan Basin. This process would once again rely on information gathered from producers, but a more general approach would be used by gathering information through discussion with key industry representatives.

At the meeting many concerns were voiced about the level of detail being requested, the difficulty of obtaining data for operations in the year 2002, and the aggressive timeline defined for the project. Based on that discussion we made adjustments to the survey to the degree possible to allay the producers' concerns without compromising the emissions estimates that would ultimately be made from the survey data. Those adjustments included modifications to the type of data requested as well as changing the project timeline in order to give the survey participants more time to respond to the more challenging data requests.

For the detailed survey, the response received ranged from representing 67 – 72 percent (depending on the equipment type) of 2002 well ownership. As one of the conditions of the survey, we have guaranteed confidentiality of the data provided by the participating companies. We agreed to present the survey data in aggregate, without making distinction as to the data or operations of the individual producers and without assigning emissions to individual producers. Therefore, when referencing data obtained from the survey we will simply reference the New Mexico Oil and Gas Association (NMOGA) 2006. Individual companies have made exceptions allowing us to disclose some portions of the data they provided. In such cases, it will be explicitly stated that such permission was given.

The remainder of the discussion of the oil and gas emissions estimates is divided into two parts. In the first part, the methods used to arrive at emissions estimates for the engines included in the detailed survey are addressed. Here the data obtained, assumptions and methods used, and emission estimates for drill rig, compressor, artificial lift, and salt water disposal engines are

provided. In the second part we describe the procedures used to estimate emissions for the other equipment.

DRILL RIG, COMPRESSOR, SALT WATER DISPOSAL AND ARTIFICIAL LIFT ENGINE EMISSION ESTIMATES DERIVED FROM SURVEY DATA

After revising the proposed information requests based on the discussion at the March 14, 2006 meeting, we distributed those requests to the producers. The actual information requests are included as Appendix A. The timeline for responses was requested to allow the most time to obtain the information that the producers had indicated would be most difficult.

Not surprisingly, there was some deviation from the schedule in order to obtain as much data as possible. Also, the exact information that survey participants were able to obtain differed somewhat from what was initially expected. In some cases, the level of detail desired was not available. In other cases a greater level of information was available than had been expected. The data obtained for each of the engine categories and the procedures used to estimate emissions based on that data are described below.

Drill Rigs

The only existing emissions estimate for the activity of drill rigs operating in San Juan and Rio Arriba Counties was made in an inventory of oil and gas emissions for the Western states prepared for the Western Regional Air Partnership (WRAP). That emission estimate was based on basic information about the number of wells drilled, the depth of the wells and an approximation of the time required to drill wells (Russell and Pollack, 2005). In this project we sought to improve that estimate by obtaining data on the actual equipment used and the activity of that equipment in drilling new wells and servicing existing wells.

The information request for drill rigs prioritized the gathering of rig-specific project data. In other words, for each rig that was employed by the producer in 2002, we sought to obtain the characteristics of the rig itself and aggregate data on the projects carried out by that rig. The key characteristics requested for the rig were the make and model of the engines used by the rig, the total horsepower of those engines, and emission rates for those engines. The project data were the number of new wells drilled by the rig, the number of workover projects performed by the rig and the gallons of diesel fuel consumed by the rig. Additional project-specific data were requested if available. The criteria agreed upon were for data elements where the data were of key importance for emissions estimates and data that producers expected they could obtain in collaboration with their drilling contractors.

Participation in the survey of drilling activity equated to 72 percent of total 2002 well ownership. The actual data that were obtained were somewhat different from what was requested. The principal difference was that fuel consumption for all rigs employed by the survey respondents was simply not available. Some drilling contractors were able to provide such information to the producers, and in other cases it could be extracted from billing records. However, in many cases the drilling contractor simply billed a day rate and did not itemize fuel consumption. Contacting drilling companies directly confirmed that fuel consumption for many of the rigs was not on record (Roundtree, 2006).

Producers responded to the lack of rig fuel consumption in a variety of ways. Some extrapolated the rig fuel consumption data that they were able to obtain from a subset of their drilling contractors to fill in the gaps. Others used internal estimates of fuel consumption based on past billing and project experience to estimate project-specific fuel consumption. Others simply provided descriptions of the projects performed without attempting to quantify fuel consumption. The minimum obtained from each producer was a description of the drilling projects completed. We compiled the drilling project data based on the general type of project (new well/workover) and the estimated fuel consumed. If a fuel estimate was not provided by the producer for the project, the average reported fuel consumption for the project type was assigned. This yielded an estimate of diesel fuel consumption for each drilling project completed by a survey participant in 2002. A summary of this drilling activity is provided in Table 2-1.

Table 2-1. Drilling activity reported by survey participants.

	Rio Arriba		San Juan	
	Projects	**Diesel (gal)**	**Projects**	**Diesel (gal)**
New Well	127	709,875	209	948,742
Workover	735	379,725	1248	580,461

In addition to the project activity data, the producers provided information about the engines installed on a number of the rigs that were used. Additional rig engine information was obtained by contacted drilling contractors (Peterson, 2006). Though engine data were not provided for all rigs, enough data were obtained to establish typical characteristics for the rigs used for workovers and the rigs used for new well drilling. Emission rates for the engines on the rigs were not obtained from the survey. We were, however, able to obtain tested emission rates for the most common engines by contacting an engine retailer. This retailer provided NOx and HC emissions rates for the engines that were reported to have been used in 2002. However, the retailer also noted that many engines have since been swapped out for cleaner, more efficient Detroit Diesel Series 60 engines (Countryman, 2006). For SO2 emission rates, the method used by the NONROAD model for calculating emissions based on fuel consumption and fuel sulfur content was used to derive the appropriate emission rate. The necessary county diesel fuel sulfur contents were obtained from on-road emissions inventory were performed for the WRAP (Pollack et al., 2006). A summary of the typical engines on the rigs used for workover and new well projects and the emission rates for the rigs is given in Table 2-2.

Table 2-2. Typical engines used for workovers and new wells.

Project Type	Rig Engines	NOx (g/gal)*	VOC (g/gal)*	SO2 (g/gal)*	
				Onroad Fuel	Nonroad Fuel
New Well	Equal mix of Detroit Diesel 12V71T and 16V71T.	256.33	7.07	2.20	15.08
Workover	Detroit Diesel 8V71T	292.89	5.29	2.20	15.09

*Emission rates with units of g/hp-hr obtained from the engine retailer were converted to units of g/gal using fuel consumption data from the test and an assumed diesel fuel density of 7.1 lb/gal. The rates also incorporate a deterioration factor adopted from the NONROAD model to account for a decline in engine performance with age, as well as sub-optimal field operating conditions (EPA, 2004).

Emissions were estimated for each reported project as the estimated fuel consumption for that project and the emission rates for the appropriate project type. Nonroad diesel fuel was assumed to have been used in all projects, except where the producer had specifically indicated that onroad fuel was used, following the protocol established at the March 14 meeting. For nearly all the drilling projects sufficient information had been provided by the producers to assign to the project to a specific well. The location of the well was therefore used to assign the emissions to the appropriate county. Therefore, by summing the emissions from each project for San Juan and Rio Arriba, we arrived at emissions estimates for the drilling activity of the survey participants within each county.

To complete the emission estimate for drill rigs it was necessary to scale up the emissions for the survey participants to estimate emissions for all drilling in the county. Different scaling methods were used for new well projects and workover projects. New well drilling was scaled up based on the ratio of the number of new wells represented in the survey data to the total number of new wells drilled in the county in 2002. Workover projects were scaled up based on the well ownership represented in the survey response. The total number of new wells drilled in 2002 and well ownership has been determined from a database maintained by the New Mexico Oil Conservation Division (NMOCD, 2003). The derivation of the scaling factors is shown in Table 2-3.

Table 2-3a. Derivation of well drilling scaling factor.

	Rio Arriba	San Juan
Wells reported in survey	75	128
Total new wells drilled in 2002	201	323
Scaling Factor	1.60	1.66

Table 2-3b. Derivation of workover project scaling factor.

	Rio Arriba	San Juan
Total Active Wells in 2002	7035	10125
Wells Active in 2002, Owned by Participating Producers	4884	7512
Scaling Factor	1.440	1.348

The resulting drill rig emissions estimates are shown in Table 2-4. They are significantly less than were previously estimated in the WRAP project. The primary reason for this is that in the WRAP project an approximation of drilling duration was part of the measure of well drilling activity. The approximation was based on drilling data from the NMOCD that appears to have resulted in a large overestimate of the amount of time required to drill a well. In fact, the time required to drill a well is perhaps ¼ of the time estimated to be required in the WRAP project.

Table 2-4. 2002 Estimated drill rig emissions (tons).

County		New Wells	Workovers	Total
Rio Arriba	NOx	320.0	176.6	496.6
	VOC	9.3	3.4	12.7
	SO2	18.8	8.8	27.6
San Juan	NOx	444.0	252.6	696.6
	VOC	12.2	4.6	16.8
	SO2	26.1	10.9	37.0

Compressor Engines

Previous emission inventories conducted both by NMOGA (2003) and WRAP (Russell and Pollack, 2005) identified natural gas fired compressor engines as the largest source of area source NOx emissions in San Juan and Rio Arriba Counties. Given the importance of this source category, a large share of project resources were dedicated to obtaining detailed engine specific information that would enhance both the accuracy and the confidence that could be ascribed to emissions estimates.

The preliminary data requests presented to the producers at the March 14th meeting included both information on the engines themselves and on the wells that were served by those engines. Many producers objected to this request because it was felt that the engine-well correlation for the year 2002 was impossible to reconstruct at this point. Therefore the survey was revised to prioritize the engine data – make, model, rated power, and emission rates – and to place the well data on a second tier, which though desired was not a necessary part of data submission.

The response obtained in the compressor engine survey represents 68 percent of total well ownership in 2002. In general, the quality of the data provided was excellent showing that participants dedicated considerable effort to obtaining the data requested. In all, the survey response enabled us to determine the make, model and rated power of 2,523 engines; a total of 373,459 horsepower of installed power (rated). For 2,347 of those engines, a manufacturer's emissions rate was also provided in the survey response. For many of the remaining engines the emission rate of a similar engine produced by the same manufacturer was adopted. For the remaining engines – less than 5 percent – a weighted average emission rate was calculated from the other engines. Table 2-5 shows the top five most reported engines, the number of engines reported and the emission rates provided for the engine.

Table 2-5. Five most common compressor engines reported in the survey.

Make & Model	Number Reported	Fraction of total Engine Response	NOx (g/hp-hr)	CO (g/hp-hr)	VOC (g/hp-hr)	SO_2 (g/hp-hr)
ARROW VRG330	561	22%	11.6	14.6	0.2	0.0004
CAT 3304NA	500	25%	16.7	4.2	1.3	0.0004
WAUKESHA VRG330	375	26%	21.2	29.3	1.0	0.0004
CAT 3306NA	157	14%	17.7	2.7	0.4	0.0004
WAUKESHA VRG220	116	12%	21.2	32.4	1.5	0.0004

In addition to emission rate information, some producers provided fuel consumption estimates, generally based on manufacturer's specifications. These fuel consumption estimates were combined with the estimated sulfur content of the gas produced to derive an SO2 emission factor for compressor engines. The basin-wide average sulfur content of the gas that was derived is probably a conservative (high) estimate. The BLM has been compiling a database of wells where H2S has been measured (Hewitt, 2006). To expand these samples to a basin-wide estimate of annual average H2S concentration, we assigned the average H2S concentration found in the BLM data for each section (township-range-section) to all gas wells in that section. This yielded an average basin-wide H2S concentration of 0.6 ppmv. Based on anecdotal descriptions of the infrequent occurrence of detectable H2S, this probably overestimates the total amount of H2S produced.

In addition to the engine-specific data, each survey respondent provided an estimate of the average hours operated annually by their compressor engines and the typical loading of the engines. There was considerable variation in the estimates provided. The hours of use provided ranged from 5342 to 8760 hours per year, with a weighted average of 8072 hours; the load factors ranged from 0.4 to 1.0, with a weighted average of 0.71.

The estimates that put engine load near 100 percent or annual hours at 8760 are probably over estimated. On the other hand, the lower load and hours estimates may be too low; however, these did appear to be calculated from actual measurements rather than simple guesses. In previous projects where we have performed tests on similar gas compressor engines we have found loads in the range of 0.3 to 0.7 (Russell, Yarwood and Lindhjem, 2005). And certainly the overall averages of 8,072 hours and a load 0.71 are within the expectations. Therefore, for those engines where a load factor and/or hours estimate was provided by the producer, we used those values. Where load and/or hours were not provided, we used the weighted average values.

Emissions for each engine reported in the survey were estimated as follows:

$$E = P \times L \times H \times EF$$

where: E = engine emissions (g)
P = engine site-derated power (hp)
L = estimated engine load
H = estimated annual engine hours
EF = deteriorated engine emission factors (g/hp-hr)

Two adjustments indicated in this calculation were performed. First, Rio Arriba and San Juan Counties are well above sea level. In fact, we have estimated the average elevation for wells in the two counties to be approximately 6,331 ft. based on the well database (NMOCD, 2003). Nameplate engine horsepower is calculated with the assumption that the engine is at sea level. Based on a standard derating formula – a 3 percent power drop for each 1,000 ft increase beyond 1,500 ft – the site derated horsepower of engines in the two counties should be about 12 percent less than the nameplate horsepower. Some companies provided the engine's derated horsepower in the survey. For the remaining companies this adjustment was made using the 12 percent derating factor. The other adjustment made was to revise the manufactures' emission rates to account for deterioration due to engine wear and tear and also the sub-optimal field conditions under which the engines operate. To make this adjustment the deterioration factors from the EPA NONROAD model were applied (EPA, 2004). Those factors resulted in a 3 percent increase in NOx emission rates, a 35 percent increase in CO emission rates, and a 26 percent increase in VOC emission rates.

After estimating emissions as described for the surveyed engines, it was then necessary to scale the emissions estimates up to represent all engine activity in the counties. In the previous NMOGA inventory, similar scaling had been accomplished by a simple comparison of the wells owned by survey respondents as compared to the total number of wells in the basin. We have attempted to do something more precise by incorporating the correlation between engine activity and gas production.

As has been mentioned, information about the wells serviced by the compressor engines was request as a second tier response item on the compressor engine survey. Some companies did find the time to provide that information. In fact for 1,219 engines, almost half of the entire response, we obtained information that enabled us to link the engine to a specific well. Well specific production was obtained from the online database operated by New Mexico Tech (NMT, 2006). Figure 2-1 shows a plot of engine horsepower versus well production; the plot shows a strong correlation between the production of a well and the size of engine that services the well.

Rather than a continuous distribution of engines, there are instead large numbers of engines of distinct classes that can be defined by a range of engine power. Scaling factors for each of the engine classes were derived by comparing the number of wells of each class represented in the survey to the total number of wells in each class in the basin. Representative well classes were arrived at for each engine class first based on a technique that sought to minimize the error in making well-to-engine assignments. The results yielded by this procedure were then evaluated against the entire survey group to see if an appropriate number of engines was arrived at. Small adjustments were necessary to improve the number of engines predicted by several of the well classes. Emissions for the seven distinct engine classes were then scaled up from surveyed emissions to total basin emissions using the scaling factors shown in Table 2-6.

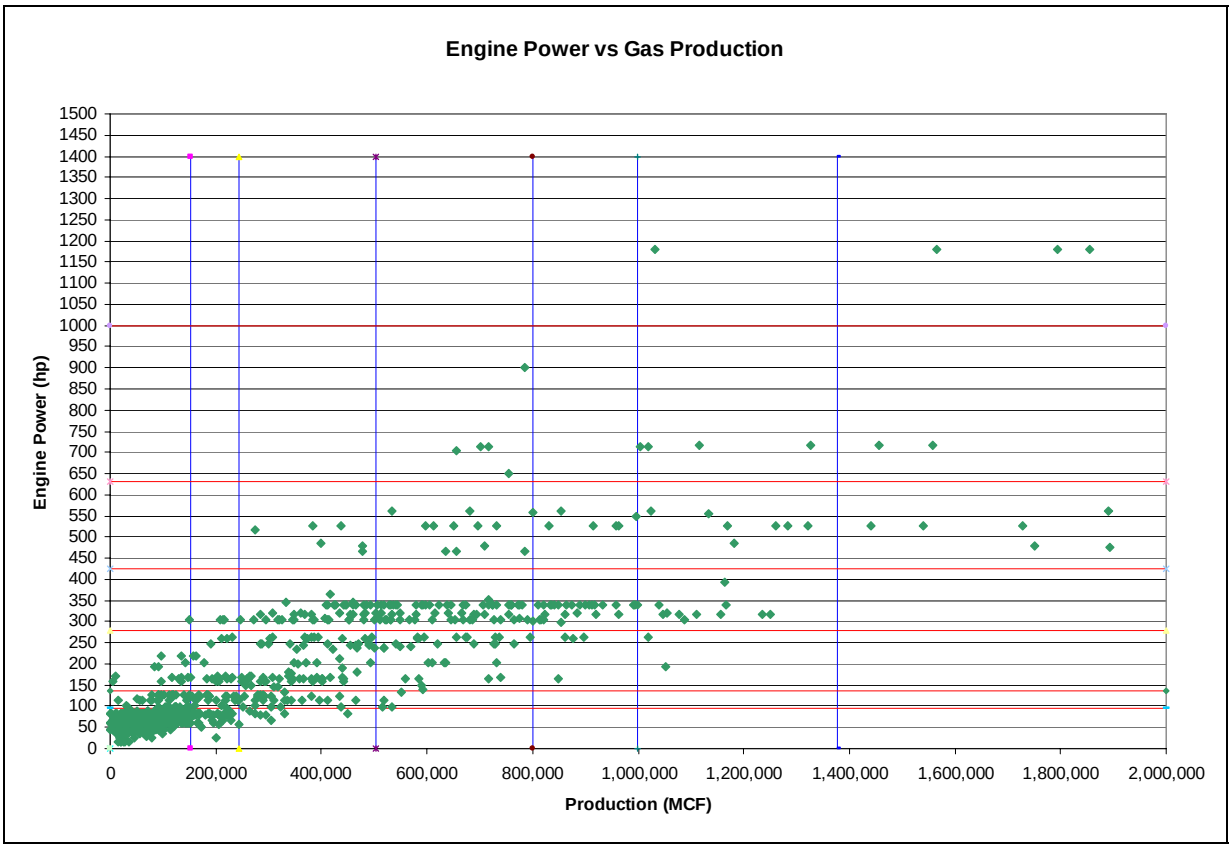

Figure 2-1. Compressor engine power versus well production.

Table 2-6. Compressor engine classes and scaling factors for estimating emissions.

Engine Class	Scaling Factor
0 – 95 hp	1.46
96 - 135 hp	1.32
136 - 280 hp	1.10
281 - 425 hp	1.02
426 - 630 hp	1.03
631 - 1000 hp	1.20
1001+ hp	1.23

To allocate the total basin compressor engine emissions to San Juan and Rio Arriba Counties, the same engine–well classifications were used. The number of wells of each class found in a county was divided by the basin total number of wells to obtain the appropriate allocation fraction. The seven allocation fractions that resulted for each county were applied to the emissions estimates for the seven engine classes to estimate the county emissions. The total county emissions estimated for compressor engines are shown in Table 2-7.

Table 2-7. 2002 Estimated compressor engine emissions (tons).

	Rio Arriba	San Juan	Total
NOx	11,279	16,042	27,321
CO	11,172	16,391	27,563
VOC	1,079	1,981	3,060
SO2	0.4	0.6	1.0

Artificial Lift Engines

The survey for artificial lift engines requested a count of the number of engines by type of lift device and the typical characteristics of those engines. Companies were additionally requested to indicate the number of lift devices operating in each of the major production pools.

The survey response for artificial lift engines represented 67 percent of total 2002 well ownership. In all, 783 small gas fired engines were reported. To estimate emissions from these engines we aggregated the engines reported in the survey into several classes. Several of those classes are specific engine types. The other classes represent many engines sharing similar characteristics. These classes are shown in Table 2-8.

Table 2-8. Artificial lift engine classes.

Engine Type/Category	Survey Count	Site Rated Power (hp)
Arrow, C46	154	8.8
Arrow, C66	156	11.5
Arrow, C96	56	16.4
AJAX, B	10	30
Waukesha, VRG330	3	40
Other Engine Group A	334	15.0
Other Engine Group B	31	15
Other Engine Group C	39	27

For the engine categories that represent one specific engine type, the manufacturers' emission rates provided by the survey respondents were used. For the remaining engine groups, average emission factors were calculated. As was done for compressor engines, the nameplate engine power has been derated for elevation. Also, the same NONROAD model deterioration factors have been applied to adjust for engine wear and field operating conditions. Once again, an effort was made to estimate the SO2 emissions from these engines. To do so, a fuel consumption estimate for natural gas fired engines was obtained from the NONROAD model and combined with the previously described estimated sulfur content of the gas produced to derive an SO2 emission factor. The emission rates for artificial lift engines thus estimates are shown in Table 2-9.

Table 2-9. Artificial lift engine emission rates (g/hp-hr).

	NOx	CO	NMHC	SO2
Arrow, C46	4.23	0.50	0.01	0.0005
Arrow, C66	3.81	0.87	0.00	0.0005
Arrow, C96	2.84	0.65	0.01	0.0005
AJAX, B	4.53	4.46	1.64	0.0005
Waukesha, VRG330	13.34	1.49	0.06	0.0005
Other Engine Group A	4.12			0.0005
Weighted Average	4.02	0.78	0.05	0.0005

These engines have been assumed to operate 8,760 hours per year. This is a conservative estimate because wells must occasionally be taken offline in order to perform maintenance. Nonetheless, that these engines function nearly without interruption year-round is an assumption supported by the survey respondents.

The final piece of information necessary to calculate emissions from the surveyed engines was an estimate of the average loading of the engines. This was somewhat challenging given the cyclical nature of the lift engine's power cycle. Most of the engine's power is delivered on the lifting stroke of the pump, so overall engine power fluctuates continuously as the pump operates. The approximate form of this power cycle was obtained from a report examining engine maintenance requirements with a pump-jack engine as the studied engine (McInroy and Legowski, 2001). Because this report did not relate the power delivered to the rated engine power, we assumed the maximum power delivered to be 100 percent of available engine power (i.e. a load of 100 percent) and the minimum power to be a 10 percent load representative of idling. With these bounds and the approximate form of the power curve, we estimated an average loading of 71 percent. For each of the engine classes emissions were then estimated as follows:

$$E = N \times H \times P \times L \times EF$$

where: E = Emissions
N = the number of engines surveyed in this group
H = the hours of operation per year
P = the site derated power of the engine group (hp)
L = the average load
EF = the emission rate (g/hp-hr)

The resulting emissions that resulted were then scaled up to estimate total basin emissions. As mentioned, the surveyed producers had been requested to provide the number of engines operating in each production pool. This information was requested in order to facilitate a pool-specific scale up. The preference for a pool-specific scale up is based on the assumption that wells serving the same pool will have similar artificial lift requirements. The survey respondents did not, in general, provide the number of lifts serving the major production pools. They did, however, provide summaries of the number of lifts serving the major formations. Thus, following an assumption that lift requirements are similar among wells serving the same formation, we created scaling factors for three distinct groups of wells: one for the Fruitland Coal formation, one for the Dakota and Mesa Verde formations, and one for all other wells.

The scaling factors for each of these well groups were calculated as the total number of wells in the formation divided by the number of wells operated in that formation by the survey respondents. The scaling up procedure then required two steps. First, the emissions estimated from the survey were assigned to the three well groups based on the fraction of lift devices reported to be operated in each group. Then, these well group specific emissions were scaled up using the three scaling factors. The fraction of lift devices reported to be in each of these well groups are shown in Table 2-10, along with the scaling factors derived for each group.

Table 2-10. Artificial lift scaling factors for estimating emissions.

Well Group	Fraction of Reported Engines	Scaling Factor
Fruitland Coal	0.45	0.67
Dakota/Mesa Verde	0.38	0.83
Other Formations	0.17	0.45

The total basin emissions were then allocated to San Juan and Rio Arriba Counties based on the fraction of wells in each formation occurring in the county. One final adjustment was made to zero out VOC emissions for the engines on the Fruitland formation. Because the coalbed methane gas produced in the Fruitland Coal formation contains no volatile constituents, the VOC emissions that result from gas that is not combusted was not considered to be volatile. The final estimated county emissions are shown in Table 2-11.

Table 2-11. 2002 Emissions estimates for artificial lift engines (tons).

	Rio Arriba	San Juan	Total
NOx (ton)	166.4	297.9	464.3
CO (ton)	35.1	62.8	97.9
VOC (ton)	2.12	2.72	4.84
SO2 (ton)	0.02	0.09	0.11

Salt Water Disposal Engines

Emissions for salt water disposal engines had not been estimated in the previous oil and gas emission inventories. This group of engines was therefore included in the survey to facilitate an emissions estimate for the heretofore uncharacterized source. However, this source category was not expected to be a major contributor of emissions, so the data request was relatively basic.

The total survey response for salt water disposal engines represented 67 percent of total 2002 well ownership. Each of the responding producers provided a list of the salt water disposal facilities that they operated, the make and model of engines at those facilities, and estimated operating hours and engine loading. One of the respondents indicated that the facility that they reported was permitted as a point source by the NMED. We therefore reviewed the 2002 New Mexico point source inventory and found that eight of the facilities for which producers provided data were already included in the point source inventory. We excluded those eight facilities from our emissions estimates in order to avoid double counting of emissions.

What remained were 32 engines serving ten distinct salt water disposal wells. Manufacturers' emission rates were provided by the respondents for some but not all engines. Engines were

divided into three classes, each of which could be served by one of the emission rates. Those engine groups, the number of engines in the group and the emission rates are shown in Table 2-12.

Table 2-12. Salt water disposal engines and emission rates (g/hp-hr).

	No. Engines	NOx	CO	VOC	SO_2
microturbine	3	0.2	0.5	0.1	0.0005
large engine (>= 100 hp)	13	15.5	2.0	0.6	0.0005
small engine (<100 hp)	16	11.3	2.7	2.3	0.0005

The emission rates presented in Table 2-12 have been adjusted from the manufacturers' emission rates using the NONROAD model's deterioration factors. Also obtained from the NONROAD model were fuel consumption estimates for this class of engines. These were then combined with the estimated sulfur content of the gas produced to derive the SO2 emission factor.

The survey respondents also provided estimates of the hours operated and loading of the engines. The hours estimates ranged from 25 hours for one of the smaller engines, up to 1,718 hours for the engines of one facility. The microturbines were conservatively estimated to run 8760 hours per year. The engines have been conservatively estimated to operate at 100 percent load. The microturbines are estimated to operate at 67 percent as suggested in the survey. With these assumed operating parameters, it was possible to estimate emissions for the surveyed engines as shown below. As for the other types of engines, the engine derating for elevation was either provided by the producer or the basin average 12 percent derating was applied.

$$E = P \times L \times H \times EF$$

where: E = Emissions (g)
P = the site derated engine power (hp)
L = the load
EF = the deteriorated emission rate for the appropriate engine group (g/hp-hr)

These emissions calculated for the non-permitted, surveyed SWD engines were summed for each county. These were then scaled up to estimate county total emissions using scaling factors calculated as follows:

- First a complete list of the salt water disposal wells was obtained from the NMOCD database
- Salt water disposal facilities that were inventoried in the 2002 New Mexico point source inventory were then removed that list
- Several survey respondents reported operating salt water disposal facilities using line power, rather than engines. Those facilities were therefore also removed from the list of wells.
- Scaling factors were then calculated as the number of non-permitted, engine-powered SWD wells in the county divided by the number of those facilities captured in the survey.

Note that these scaling factors have been calculated without including the microturbine-powered facility. Under the assumption that no other salt water disposal facilities are powered by microturbines, only emissions from the engine-powered facilities are scaled up to the total

county facilities. The scaling factors derived were 1.25 for Rio Arriba County and 6.4 for San Juan County. However, the microturbine facility's emissions are included in the final county emissions estimates; they have simply been excluded from the scaling calculations. Table 2-13 shows the total estimated county emissions for salt water disposal engines that resulted from application of the procedures described above.

Table 2-13. 2002 Estimated emissions from salt water disposal engines (tons).

	Rio Arriba	San Juan	Total
NOx	62.35	43.38	105.73
CO	9.20	6.03	15.23
VOC	3.67	2.28	5.95
SO2	0.00	0.00	0.00

ADDITIONAL EMISSIONS ESTIMATES

Emissions have been estimated for a number of other NOx and VOC sources associated with oil and gas production. In contrast to the engine emissions estimates, these are not based on detailed survey data. The number of these minor sources makes a survey prohibitively resource intensive. Instead, emissions estimates for these sources were based on methods developed in the previous WRAP and NMOGA inventories that combine available well data with information about typical well setup and production practices to arrive at emissions estimates. Below the procedures and assumptions used to estimate emissions for the minor NOx and VOC emissions sources at oil and gas wellheads are described.

For these analyses, wells were divided into gas wells and oil wells following the criteria in the rules of the New Mexico Oil Conservation Division (NMOCD, 2006). Coal Bed Methane (CBM) wells are those that produce from the Fruitland Coal formation. Emissions from CBM wells are estimated along with emissions from conventional gas wells.

Gas Wells

Completions

The flaring and venting emissions occurring during completion of a well were estimated following a procedure initially developed by the Wyoming Department of Environmental Quality (Madison, 2004). In this method the typical duration of completion activities is combined with the gas flow rates measured during the completion to estimate the total volume of gas vented during well completion. As was done by WYDEQ, we have examined several well completion logs to estimate typical duration of completion activities and gas flow rates. Ultimately, we have adopted the values for a well that was drilled in 2003 and completed on the Dakota and Mesa Verde formations (NMOCD, 2003b). This and other sample logs were obtained from the NMOCD (2006) online imaging system. Table 2-14 shows the assumptions used in these estimates.

Table 2-14. Assumptions used to estimates gas well completion emissions.

Assumption	Source
Gas is venting during 8 days of completion activities	Sample well completion log (NMOCD, 2003b)
Gas is vented at an average rate of 887 MCFD	Average of tested values from multiple completion logs (NMOCD, 2006). This is representative of the maximum flow rate during completion activities (obtained when testing the well), so this is a conservative assumption.
50 percent of gas is vented, and 50 percent of gas is flared with a destruction efficiency of 50 percent	Madison, 2004
AP-42 NOx and CO emission rates for flares	Madison, 2004
Gas heating value of 1000 btu/scf	Typical value for natural gas
Formation gas compositions	NMOGA, 2003
Basin average sulfur content of 0.6 ppmv	Calculated as described in previous discussions of engine emission rates

By combining these assumptions with emission factors for flares and the formation specific gas compositions, we derived an estimate of typical emissions per well completion. To then estimate emissions from completions in 2002, we identified all wells with a 2002 completion date in the NMOCD (2005)[1] database. For each well with a 2002 completion, the typical completion emissions were ascribed.

Fugitives

Emissions from fugitives were estimated by defining a typical well setup for oil, conventional gas and CBM gas wells. These setups were defined by preparing diagrams of the equipment likely to be found at a well site and submitting those diagrams to survey participants for review and comment. Through this collaboration we arrived at the well diagrams contained in Appendix B. The diagrams are not intended to accurately depict the details of any single well; rather, they are a tool for estimating equipment counts to be used for emissions estimates. The counts of fugitive emission sources that were arrived at for conventional gas wells are shown in Table 2-15, along with the emission rates and sources for those emission rates. Note that fugitives have not been estimated for CBM wells because CBM gas does not contain a significant volatile component.

[1] This is the second version of the well database that we have used. Two versions have been used because well ownership has changed since 2002, and the owners listed in the 2005 database are no longer accurate for the year 2002. Therefore, when accurate well ownership was required, the early 2003 database (NMOCD, 2003) was used. When well ownership was not used, the 2005 database (NMOCD, 2005) was used because it is more likely to contain any revisions or late entries for the year 2002.

Table 2-15. Equipment counts and emission factors (kg gas/hr) for a typical gas well.

Equipment	Count	Emission Factor	EF Source
Polished rod	1	8.8x10-3	EPA, 1995
Pressure gauge	2	8.8x10-3	EPA, 1995
Master valve	1	4.5x10-3	EPA, 1995
Tubing flow valve	1	4.5x10-3	EPA, 1995
Casing flow valve	1	4.5x10-3	EPA, 1995
Connector	2	2.0x10-4	EPA, 1995
Sample Connection	2	2.0x10-3	NMOGA, 2003
Flange – gas	4	3.9x10-4	EPA, 1995
Compressor	1	8.8x10-3	EPA, 1995
Relief valve	1	8.8x10-3	EPA, 1995
Meter	1	8.8x10-3	EPA, 1995
Flange – light oil	1	1.1x10-4	EPA, 1995
Separator dump valve	3	244,550 SCF/year	NMOGA, 2006

* Except where otherwise specified

We combined these equipment counts and emission rates into a single aggregate annual natural gas emission rate for a conventional gas well. Then, by combining that rate with the gas composition we created a VOC emission rate with units of ton VOC per conventional gas well. Emissions were estimated for each gas well using this emission rate.

Heaters

Emissions from heaters were determined using a method similar to that used for fugitives. The well diagrams were used as a tool to estimate the typical number of heaters for each well type. Through this process it was established that at CBM gas wells, heaters would serve the separator and, in addition, serve the water storage tanks in the winter. At conventional gas wells, a heater would serve the separator, but no tank heaters would be used. That tank heaters are necessary at a CBM well and not at a conventional gas well because of the composition of the fluids produced. Water produced from the conventional well formations is typically quite saline and there is little risk that it will freeze in the winter (NMOGA, 2006). The heaters that have therefore been assumed for gas wells are shown in Table 2-16.

Table 2-16. Heaters at conventional and CBM gas wells.

CBM Well	Conventional Gas
1 Separator Heater (0.5 MMBtu/hr), operated year-round	1 Separator Heater (0.5 MMBtu/hr), operated year-round
2 Tank Heaters (0.5 MMBtu/hr each), operated winter only.	

Using these assumptions we estimated the annual fuel consumption (MMBtu) of heaters at a CBM and a conventional gas well. Using AP-42 emission factors for fuel combustion we then calculated NOx and CO emissions for heaters at each well type. SO2 emissions were estimated as well using the estimated basin average H2S concentration and the conversion of 1000 Btu/scf for natural gas.

Pneumatic Pumps

Emissions from pneumatic devices were estimated based on the volume of methanol reported to have been injected by one of the producers and information about the vent rate of one of the more typical pump types found in the basin. The reported use of methanol was compared with the gas production of the same producer to arrive at an estimate of the amount of methanol consumed per unit of production. The resulting value was 0.145 gallons of methanol injected for every MMCF of natural gas produced (NMOGA, 2006). Although methanol is not the only chemical injected using pneumatic pumps, its volume use is believed to be much greater than any other chemical. Thus although this may not capture all emissions from pneumatic pumps, it gives a good approximation.

One of the more common pumps used in the San Juan Basin is a 1/4 " Williams pump. When pumping at 100 psi (a typical pressure in the basin), the pump uses and emits 64.29 SCF of gas per gallon of fluid injected (Langford, 2006). The pneumatic pump emission rates shown in Table 2-17 were derived combining the methanol injection estimate with this pump emission rate and the gas composition of the major formations.

Table 2-17. Pneumatic pump emission rates (lb VOC/MCF produced) by formation.

Formation	Emission Rate
Mesa Verde	8.39
Dakota	13.92
Pictured Cliffs	6.27
Fruitland	
Gallup	14.65
Other	10.82

Tanks

Flashing emissions were estimated using the Vazquez-Beggs equation following the approach of NMOGA (2003). Some concern was voiced about the appropriateness of using this for calculation of condensate emissions, given that the API gravity of the condensate produced is near the suggested boundaries for use of this method (EPA, 1999). However, this method was most readily adaptable to the data available and the consensus of the survey group was that it would produce a reasonably accurate estimate of flashing emissions. Using the methodology described in the EPA (1999) guidance documents, with the inputs defined by NMOGA (2003), we arrived at the emission rates for flash losses shown in Table 2-18.

Table 2-18. Gas well flashing emission rates (ton/1000 BBL condensate) by formation.

Formation	VOC Emissions
Mesa Verde	0.13
Dakota	0.24
Pictured Cliffs	0.09
Gallup	0.08
Other	0.17

Working and breathing emissions were calculated using the TANKS (Version 4.0) model. The inputs to this model were as follows:

Height = 16 ft
Diameter = 10.6 ft
Fluid Composition = 7.0 RVP (NMOGA, 2003)
Max Liquid Height = 15 ft
Avg Liquid Height = 7.5 ft
Light Gray Coating
Good Condition

These inputs were run with an annual throughput of 4,200 gallons per year (100 BBL) and with a throughput of 420,000 gallons per year (10,000 BBL). The breathing losses in both cases are the same, but the working losses change dramatically. These results were used to derive the emission rates shown in Table 2-19, which for breathing losses have units of emission per well (assuming one condensate tank per condensate producing well), but for working losses have units of emissions per unit of production.

Table 2-19. Gas well breathing and working loss emission rates.

	Working	**Breathing**
Throughput = 4,200 gal	26.2 lb/yr	1459.67 lb/yr
Throughput = 420,000 gal	2287.9 lb/yr	1459.67 lb/yr
Emission Rates	0.11 ton / 1000 BBL	0.73 ton / well

Venting

Venting of wells is routinely done to unload fluids that may after time reduce the amount of gas produced. Venting a well may be done by simply opening the well to atmospheric pressure and allowing the pressure of the formation to directly lift fluids to the surface, or by using a plunger lift that also lifts fluids using the natural pressure of the formation. In either case, the well is open to the atmosphere, which allows for relatively large volumes of gas to escape. Where that natural gas contains volatile components, this is a significant source of VOC emissions.

Only one of the producers in the San Juan Basin reported having made attempts to quantify these emissions. That producer, BP, has provided their estimates of venting flowrates for use in this project without restriction. However, they are based only on data collected from BP's wells. That sample was selected with attention to obtaining an appropriate mix of well types. Nonetheless, the venting practices of other producers may differ from those of BP and therefore these rates may not be appropriate for non-BP wells. However, in the absence of any other estimates of venting rates, the rates provided by BP, as shown in Table 2-20, have been assumed for all gas wells.

Table 2-20. Gas well estimated venting flowrates (MCF/minute) by formation. Source: Smith, 2006.

Formation	Flowrate
Mesa Verde	0.40
Dakota	0.26
Pictured Cliffs	0.18
Fruitland	0.26
Calculated average*	0.28

* Calculated value not provided by BP

The flowrates provided by BP have units of MCF per minute that the well is vented. In addition, BP provided data on the total minutes that BP wells in each of the formations were vented over the past several years. By converting these minutes to gas vented using the flowrates above, then comparing the result with BP's gas production for the same formations in the same years, we estimated the volume of gas vented per volume of gas produced. As BP has done considerable work to reduce these emissions over the past several years, only the first three years (1998 – 2000) of BP data were used to establish amount of venting per unit of production in the baseline condition. This vent rate was applied to most wells in the basin. To incorporate BP's success in reducing emissions by the year 2002, we used BP's 2002 minutes vented in order to calculate distinct venting factors that were then applied just to BP's wells. The venting rates thus developed are shown in Table 2-21.

Table 2-21. Gas well venting emission rates (natural gas, MCF vented/MMCF produced).

Formation	Venting Emission Rates	
	Non-BP wells	BP wells
Mesa Verde	11	8
Dakota	33	22
Pictured Cliffs	3	2
Fruitland*		
Other formations	16	11

* not estimated because there is no volatile component

These were then combined with the gas composition of each formation to arrive at the VOC emission rates for venting shown in Table 2-22.

Table 2-22. Gas well VOC venting emission rates (ton VOC/MMCF produced).

Formation	Venting Emission Rates	
	Non-BP wells	BP wells
Mesa Verde	0.45	0.035
Dakota	0.23	0.156
Pictured Cliffs	0.009	0.007
Fruitland*		
Other formations	0.085	0.060

*not estimated

Truck Loading

Emissions have been estimated using the emission rates obtained from NMOGA (2003). No information was obtained that would enable improvement of these factors. The factor used for loading condensate to tank trucks was 0.20 ton VOC per 1000 barrels.

Dehydrators

Emissions were not estimated for glycol dehydrators. Field dehydration is not practicable given the low field pressures in the San Juan Basin (NMOGA, 2006). Any dehydration would be performed in gas plants and should therefore be accounted for in the point source inventory.

A summary of the gas well emissions for each category is shown in Table 2-23.

Table 2-23. Estimated 2002 gas well emissions (tons).

	Rio Arriba			San Juan		
Category	**NOx**	**SO_2**	**VOC**	**NOx**	**SO_2**	**VOC**
Tanks			2,872			3,686
Completions	33	0.02	6,833	51	0.04	8,577
Heaters	2,379	2		3,740	3	
Pneumatics			11			13
Venting			20,698			24,594
Fugitives			16,799			20,504
Truck Loading			202			196
Total	**2,412**	**2**	**47,415**	**3,790**	**3**	**57,570**

Oil Wells

For fugitives, heaters and pneumatics, the same methods were used for estimating emissions as were used for gas wells.

Tanks

Flashing emissions were estimated following the approach of NMOGA (2003), which uses the Vazquez-Beggs equation. However, parameters and emission rates differed. Again, some concern was voiced about the appropriateness of using this for calculation of condensate emissions, given that the API gravity of the condensate produced is near the suggested boundaries for use of this method (EPA, 1999). However, this method was most readily adaptable to the data available and the consensus of the survey group was that it would produce a reasonably accurate estimate of flashing emissions. Following the methodology described in the EPA (1999) guidance documents, with the inputs defined by NMOGA (2003), we arrived at the emission rates for flash losses shown in Table 2-24.

Table 2-24. Oil well flashing emission rates (ton/1000 BBL oil) by formation.

Formation	VOC Emissions
Mesa Verde	0.06
Dakota	0.11
Pictured Cliffs	0.04
Gallup	0.04
Other	0.08

Working and breathing emissions were calculated using the TANKS (Version 4.0) model. The inputs to this model were as follows.

Height = 16 ft
Diameter = 10.6 ft
Fluid Composition = 5.0 RVP (NMOGA, 2003)
Max Liquid Height = 15 ft
Avg Liquid Height = 7.5 ft
Light Gray Coating
Good Condition

These inputs were run with an annual throughput of 4,200 gallons per year (100 BBL) and with a throughput of 420,000 gallons per year (10,000 BBL). The breathing losses in either cases are the same, but the working losses change dramatically. These results were used to derive the emission rates shown in Table 2-25, which for breathing have units of emission per well (assuming two oil tank per oil producing well) but for working have units of emissions per unit of production.

Table 2-25. Oil well breathing and working loss emission rates.

	Working	Breathing
Throughput = 4,200 gal	11.88 lb/yr	808.6 lb/yr
Throughput = 420,000 gal	1038.28 lb/yr	808.6 lb/yr
Emission Rates	0.05 ton / 1000 BBL	0.8 ton / well

Truck Loading

Emissions have been estimated using the emission rates obtained from NMOGA (2003). No information was obtained that would enable improvement of these factors. The factor used for loading oil to tank trucks was 0.11 ton VOC per 1000 barrels.

A summary of oil well emissions for each category is shown in Table 2-26.

Table 2-26. Estimated 2002 gas well emissions (tons).

Category	Rio Arriba		San Juan	
	NOx	VOC	NOx	VOC
Tanks		210		430
Completions				
Heaters	63		146	
Pneumatics		0.07		0.04
Venting				
Fugitives		133		129
Truck Loading		38		43
Total	**63**	**381**	**146**	**601**

COMPARISON OF EMISSIONS WITH PREVIOUS WRAP INVENTORY

Table 2-27 shows a comparison of the estimated 2002 oil and gas wellhead emissions estimated in this work with the previous WRAP emission inventory estimates. SO_2 emissions are not included in the table since SO_2 emissions were only estimated for drill rigs in the previous WRAP inventory. Also, for comparison purposes, VOC emissions from dehydration units (estimated for gas wells in the WRAP inventory) are not included in the table. The previous WRAP estimates for dehydration units (6,727 tons/yr for Rio Arriba County and 14,020 tons/yr for San Juan County) were based on region-wide assumptions that are not appropriate in the San Juan Basin. As noted above, field dehydration is not practicable given the low field pressures in the San Juan Basin (NMOGA, 2006), and any dehydration would be performed in gas plants and should therefore be accounted for in the point source inventory. Fugitive VOC emissions, however, estimated in this work but not estimated in the previous WRAP inventory, are included in the table.

Table 2-27. Comparison of 2002 emissions estimates (tons) with previous WRAP inventory.

Category	WRAP[1]				This Work			
	Rio Arriba		San Juan		Rio Arriba		San Juan	
	NOx	VOC	NOx	VOC	NOx	VOC	NOx	VOC
Tanks		1,896		1,238		3,082		4,116
Completions		10,922		17,372	33	6,833	51	8,577
Heaters	2,185		2686		2,442		3,886	
Pneumatics		566		669		11		13
Venting						20,698		24,594
Fugitives [2]						16,931		20,632
Truck Loading						240		239
Total	**2,185**	**13,384**	**2,686**	**19,280**	**2,475**	**47,796**	**3,936**	**58,171**

[1] Dehydration was not included in this comparison because emissions were considered to be included in point source inventory.
[1] Fugitive emissions were not estimated in the WRAP inventory.

The VOC and NOx wellhead emissions in this work were expected to be different, as much more detailed local data were obtained to generate the Rio Arriba and San Juan inventories in this work than in the regionwide WRAP inventory, which was the first broad inventory of oil and gas area source emissions. Emissions for the original WRAP work were primarily based on emission factors developed by the Wyoming DEQ and applying these factors, with some

adjustments, to the well specific production data from the State oil and gas commissions. In the current effort, much more detailed specific local information was provided by the producers and allowed a more accurate estimate of emissions. Furthermore, fugitive emissions were found to be significant while the original WRAP inventory did not include an estimate of fugitive emissions.

Table 2-28 includes a summary of the estimated emissions for all categories from this work, including fugitives. The emissions estimated for the previous WRAP estimates for all categories of emissions are shown in Table 2-29; in this table again the dehydrator emissions are excluded for comparative purposes. Note that in the WRAP work CBM wellhead emissions were estimated separately; in this work CBM well emissions were included in the gas well emissions.

Table 2-28. Estimated 2002 emissions for all categories (tons).

Category	NOx		SO_2		VOC	
	Rio Arriba	San Juan	Rio Arriba	San Juan	Rio Arriba	San Juan
Compressor Engines	11,279	16,042	0	1	1,079	1,981
Drill Rig Emissions	497	697	28	37	12	17
Artificial Lift emissions	166	298	0	0	3	6
SWD Engines	62	43	0	0	4	2
Gas Wells	2,412	3,790	2	3	47,415	57,570
Oil Wells	63	146	0	0	381	601

Table 2-29. Estimated emissions by category in the previous WRAP inventory (tons).

Category	NOx		SO_2		VOC	
	Rio Arriba	San Juan	Rio Arriba	San Juan	Rio Arriba	San Juan
Compressor Engines	9,136	14,907				
Drill Rig Emissions	1,331	1,671	289	363		
CBM Emissions	48	94				
Gas Wells	2,406	3,039			19,925	33,154
Oil Wells	1	1			186	145

A comparison of the two total oil and gas area source emissions inventories is shown in Table 2-30. Table 2-30 also provides the absolute and relative differences between the two estimates inventories.

Table 2-30. Comparison of 2002 total estimated 2002 emissions in this work use previous WRAP inventory.

Emissions Inventory	Rio Arriba			San Juan		
	NOx	VOC	SO2	NOx	VOC	SO2
NMED tons	14,528	48,894	30	21,016	60,177	41
WRAP tons	10,515	20,111	289	16,672	33,299	363
Difference	4,013	28,783	-259	4,344	26,878	-323
Percent change	+38%	+143%	-90%	+26%	+81%	-89%

The most significant change in NOx emission estimates was the difference in drill rig emission estimates. As described earlier, drill rig emissions estimated in this work are significantly less than were previously estimated in the WRAP project. The reason for this is that in the WRAP inventory an approximation of drilling duration was part of the measure of well drilling activity, as the oil and gas commissions do not provide the actual drilling times for any States. The approximation was based on drilling data from the NMOCD that appears to have resulted in a large overestimate of the amount of time required to drill a well, because of an outlier in the underlying data. Therefore, we expect that drilling times will decrease for all states. Depending on other factors such as the use of air assist, the drilling emissions may decrease for other states as well.

While NOx emissions from compressors differed significantly from the previous WRAP inventory, the current estimates are based on more accurate information on compressor engines from the producers. The difference in SO_2 emissions is also based on more accurate local information on estimating sulfur concentrations and estimating emissions based on fuel consumption and fuel sulfur content. Previous estimates were based on proportioning SO_2 emissions based on production.

3. OTHER AREA SOURCES

This section describes the methods, data, and assumptions used to estimate NO_x, VOC, and CO emissions for other area sources (i.e., excluding oil & gas), by source category, within Rio Arriba and San Juan Counties, and provides the resulting emissions estimates.

FUEL COMBUSTION

The fuel combustion category includes all industrial, commercial/institutional, and residential sector fuel combustion; residential wood combustion (RWC) is treated as a separate category. The fuel types in the fuel combustion category include distillate fuel oil, residual fuel oil (industrial only), liquefied petroleum gas (LPG), natural gas (NG), and coal.

Ideally, a fuel survey of local fuel dealers would provide accurate local fuel consumption data. In fact, a preliminary phone survey of 12 local fuel dealers was conducted as part of this project. Unfortunately, zero responses were obtained from this preliminary survey. In addition, the fuel distribution network in San Juan and Rio Arriba Counties is complicated by the existence of a significant number of fuel dealers located outside of the two counties that distribute fuel within the two counties.

In lieu of a local survey, an alternative source of fuel consumption data was used. State-level fuel consumption data for the industrial, commercial/institutional, and residential sectors were obtained from the Energy Information Administration (EIA, 2006). The 2002 state-level fuel consumption data were disaggregated to the county-level as described in the EIIP area source method abstracts (EIIP, 1999a; EIIP, 1999b).

Residential fuel use was disaggregated to the county-level based upon the number of households heating with a particular fuel and the number of heating degree days (HDD). Household heating information was obtained from the 2000 census (U.S. Census, 2000). Heating degree day was obtained from the national 2000 RWC inventory (Goehl et al., 2001).

Commercial and institutional fuel use was disaggregated to the county-level based upon the number of employees for Standard Industrial Classifications (SIC) 50-99 (now North American Industry Classification System [NAICS] 42, 44, 51-56, 61-62, 71-72, 81, 95, and 99) (U.S. Census, 2002) and the number of HDD (Goehl et al., 2001).

Industrial fuel use was disaggregated to the county-level based upon the number of employees for SIC 20-39 (now NAICS 31) (U.S. Census, 2002). It should be noted that the industrial fuel combustion area source categories were not reconciled with any point source fuel combustion estimates.

Emission factors for fuel oil, LPG, natural gas, and coal were obtained from *AP-42* (Sections 1.5, 1.3, 1.4, and 1.1, respectively) (U.S. EPA, 1995).

Emissions for the fuel combustion category were calculated using the following equation:

$E_{f,p} = U_f \times EF_{f,p} \times (1\ ton/2000\ lbs)$

where: $E_{f,p}$ = Emissions for fuel f and pollutant p (tons/year)
UF_f = Fuel usage for fuel f (10^3 gal, 10^6 ft^3, or tons)
$EF_{f,p}$ = Emission factor for fuel f and pollutant p (lb/10^3 gal, lb/10^6 ft^3, or lb/ton)

A sample calculation for estimating annual NO_x emissions from residential natural gas combustion in Rio Arriba County is as follows:

UF_{ng} = 810,165,444 ft^3
$EF_{ng,NOx}$ = 94 lb/10^6 ft^3
$E_{ng,NOx}$ = 810,165,444 ft^3 × 94 lb/10^6 ft^3 × (1 ton/2,000 lbs) = 38.1 tons NO_x/year

Ozone season daily emission estimates for industrial fuel combustion were calculated by dividing annual emissions by 365 days. Ozone season daily emissions for residential and commercial/institutional fuel combustion were estimated based upon the fraction of annual HDD occurring during the ozone season (i.e., May through October). For Rio Arriba county (i.e., El Vado Dam meteorological station), there were 1,446 ozone season HDD compared to 7,387 annual HDD. For San Juan county (i.e., Farmington Agricultural Science Center meteorological station), there were 657 ozone season HDD compared to 5,508 annual HDD (NCDC, 2002). Annual emissions were multiplied by this fraction and then divided by the number of ozone season days (i.e., 184 days) to estimate the ozone season daily emissions.

The ozone season daily NO_x emissions from residential natural gas combustion in Rio Arriba County were calculated using the following equation:

$E_{oz} = E_a \times (HDD_{oz}/HDD_a) \times (2{,}000\ lbs/1\ ton) \times (1/184\ days)$

where: E_{oz} = Ozone season daily emissions (lbs/day)
E_a = Annual emissions (tons/year)
HDD_{oz} = Ozone season HDD
HDD_a = Annual HDD

E_{oz} = 38.1 tons NO_x/year × (1,446/7,387) × (2,000 lbs/1 ton) × (1/184 days) = 81.0 lbs NO_x/day

It should be noted that residential fuel combustion occurs in both space heating and cooking/ water heating. Space heating will vary based upon HDD, while cooking/water heating will be more constant throughout the year. Due to data limitations, space heating and cooking/water heating were not disaggregated out of the total residential fuel combustion category; therefore, both were temporally allocated based upon HDD.

RESIDENTIAL WOOD COMBUSTION

Annual emissions data for the RWC category were directly obtained from the 2002 National Emission Inventory (NEI) (U.S. EPA, 2006). These data were available at the county level.

Ozone season daily emissions were estimated in the same manner as the residential sector emissions for the other fuel combustion category, as described above, using HDD.

OPEN BURNING

Residential open burning typically includes both burning of municipal solid waste (MSW) (i.e., trash/garbage) and yard waste (i.e., leaves and yard trimmings). Current open burning regulations, which took effect in 2004, limit open burning to yard waste and prohibit the burning of MSW (NMED, 2004). Information about residential open burning in 2002 was extremely limited. Farmington Fire Emergency Services staff indicated that 274 burn permits were issued in 2002, but the type and quantity of materials burned was not available (Veazzy, 2006). Also, a mass balance approach was considered which would subtract the total quantity of landfilled and recycled waste from the total quantity of generated waste to obtain the amount of waste disposed of by open burning. However, this approach was not used due to the unavailability of landfill statistics and considerable uncertainty regarding the quantity of illegal dumping.

The amount of MSW open burning was estimated based upon conversations with the three residential waste contractors that serve Rio Arriba and San Juan Counties (i.e., Waste Management, Inc.; Waste Corporation of America – Transit Waste, and North Central Solid Waste). These residential waste contractors were unable to provide information regarding open burning of yard waste; therefore, the open burning category was limited to MSW.

Waste Management, Inc. staff indicated that nearly 48 percent of households in Farmington have curbside residential waste pickup (Kleins, 2006); this pickup ratio was applied to the entire population of Rio Arriba and San Juan Counties to determine the population which does and does not have curbside pickup. Interviews with staff at the three residential waste contractors indicated that most of the population that does not have curbside pickup transports their waste either directly to the landfill or to waste receiving stations; they also believe that open burning of waste rarely occurs (i.e., estimated at less than 1 percent of the population) (Kleins, 2006; Goldsmith, 2006; Hammer, 2006). It was conservatively assumed that 1 percent of the population without curbside pickup burns their MSW and yard waste.

Per capita daily MSW generation rates were obtained from the EIIP guidance and applied to the percentage of the population that burns; emission factors were also obtained from the EIIP guidance (EIIP, 2001a). It should be noted that the CO and NOx emission factors were applied to the entire quantity of waste generated by the percentage of the population that burns, while the VOC emission factor was only applied to the quantity of waste actually burned.

Annual emissions for open burning of MSW were calculated using the following equation:

$$E_p = W \times EF_p \times (1\ ton/2000\ lbs)$$

where: E_p = Emissions for pollutant p (tons/year)
W = MSW generated or burned (tons)
EF_p = Emission factor for pollutant p (lb/ton waste)

A sample calculation for estimating CO emissions from open burning of MSW in Rio Arriba County is as follows:

W (generated) = 172.52 tons
EF_{CO} = 85 lbs/ton
E_{CO} = 172.52 tons × 85 lbs/ton × (1 ton/2000 lbs) = 7.3 tons CO/year

The EIIP guidance for open burning indicates that emissions can be seasonal or influence by weather conditions; however, because this information is not known for Rio Arriba and San Juan Counties, it was assumed that open burning occurs throughout the year. Ozone season daily emission estimates were calculated by dividing annual emissions by 365 days.

The ozone season daily CO emissions from open burning of MSW in Rio Arriba County were calculated using the following equation:

E = 7.3 tons CO ÷ 365 days × (2000 lbs/ton) = 40.2 lbs CO/day

STRUCTURE FIRES

Structure fire information for Farmington were obtained from Fire Emergency Services (Veazzy, 2006); no other structure fire information was identified. As a result, the Farmington structure fire statistics were extrapolated to Rio Arriba and San Juan Counties based upon county-wide population (U.S. Census, 2006). Based on the EIIP guidance document (EIIP, 2001b), the following assumptions were made: average structure size of 1,732 square feet, combustible structural mass loading of 16.3 lbs/ft^2, combustible building contents loading of 7.91 lbs/ft^2, and average loss of 7.3 percent per fire. Appropriate emission factors were also obtained from the EIIP guidance document.

The equation for estimating emissions from structure fires is:

$$E_p = F \times S \times (SM + BC) \times L \times EF_p \times (1\ ton/2000\ lbs)$$

where: E_p = Emissions for pollutant p (tons/year)
F = Number of structure fires
S = Average size of structure (ft^2)
SM = Combustible structural mass loading (lbs/ft^2)
BC = Combustible building contents loading (lbs/ft^2)
L = Building loss (i.e., fraction of building consumed)
EF_p = Emission factor for pollutant p (lbs/ton burned)

A sample calculation for Rio Arriba County CO is as follows:

E_{CO} = 73 fires × 1,732 ft^2/structure × (16.3 lbs/ft^2 + 7.91 lbs/ft^2) × (1 ton/2000 lbs) × 0.073 × 60 lbs CO/ton × (1 ton/2000 lbs) = 3.3 tons CO/year

The EIIP guidance indicates an increased incidence of structural fires during cold weather in some areas due to careless open burning, Christmas lights, or space heater or fireplace use. However, detailed seasonal fire information was not available. It was assumed that there was no seasonal variation associated with structural fires. Therefore, average ozone season daily emissions were calculated by dividing annual emissions by 365 days.

E = 3.3 tons CO ÷ 365 days × (2000 lbs/ton) = 18.3 lbs CO/day

VEHICLE FIRES

Vehicle fires for Farmington were obtained from Fire Emergency Services (Veazzy, 2006); no other vehicle fire information was identified. As a result, the Farmington vehicle fire statistics were extrapolated to Rio Arriba and San Juan Counties based upon county-wide population (U.S. Census, 2006). Based on the EIIP guidance document (EIIP, 2000a), a total of 500 pounds of vehicle components were consumed in each vehicle fire. Appropriate emission factors were also obtained from the EIIP guidance document.

The equation for estimating emissions from vehicle fires is:

$$E_p = F \times B \times EF_p \times (1\ ton/2000\ lbs)$$

where: E_p = Emissions for pollutant p (tons/year)
F = Number of vehicle fires
B = Quantity of vehicle components burned (tons)
EF_p = Emission factor for pollutant p (lbs/ton of vehicle components burned)

A sample calculation for Rio Arriba County CO is as follows:

E_{CO} = 43 fires × 0.25 tons × 125 lbs CO/ton × (1 ton/2000 lbs) = 0.7 tons CO/year

It was assumed that there is no seasonal variation associated with vehicle fires. Therefore, average ozone season daily emissions were calculated by dividing annual emissions by 365 days.

E = 0.7 tons CO ÷ 365 days × (2000 lbs/ton) = 3.7 lbs CO/day

ON-SITE INCINERATION

The on-site incineration source category includes cremation (human and animal) and hospital hazardous waste incinerators. Emissions were only estimated for human cremation; relevant activity data for animal cremations and hospital hazardous waste incinerators in hospitals.

The number of crematories in Rio Arriba and San Juan Counties were identified from U.S. Census Bureau statistics (U.S. Census, 2002); the data indicated two crematories in San Juan County and none in Rio Arriba County. The average number of annual cremations per crematory in New Mexico was estimated by dividing the total number of cremations by the number of crematories in the state (CANA, 2006). Emission factors were obtained from an evaluation test by the California Air Resources Board (ARB, 1992).

ARCHITECTURAL SURFACE COATINGS

Emissions from architectural surface coatings were estimated using per capita emission factors developed using steps found in the EIIP guidance (EIIP, 1995). National-level paint and population statistics were obtained from the U.S. Census Bureau (U.S. Census, 2003; U.S. Census, 2005a). A 20 percent reduction due to the promulgation of national VOC rules was applied to the consumer and commercial solvent use category (i.e., the national VOC rule was promulgated after the date that the per capita emission factors were developed) (Federal Register, 1998a). The per capita emission factors were developed for the second and third quarters (i.e., April through September) and were assumed to roughly approximate the ozone season (i.e., May through October).

The equation for estimating VOC emissions from architectural surface coatings using per capita emission factors is:

$$E = EF \times P \times (1\ ton/2000\ lbs) \times (1 - R)$$

where: E = VOC emissions (tons/season)
EF = VOC per capita emission factor (tons/person-season)
P = Population (people)
R = Reduction due to national VOC rules (0.2)

A sample calculation for Rio Arriba County (including both solvent- and water-based coatings) is as follows:

E = 1.771 lbs/person-season × 41,010 people × (1 ton/2000 lbs) × (1 – 0.2) = 29.0 tons VOC/season

The average ozone season daily emissions were calculated by dividing the ozone season emissions by the number of days in the ozone season (i.e., 184 days).

E = 29.0 tons VOC ÷ 184 days × (2000 lbs/ton) = 315.7 lbs/day

AUTOBODY REFINISHING

National-level autobody refinishing emissions were extrapolated down to Rio Arriba and San Juan Counties based upon the employee population in the “Automotive body, paint, and interior repair and maintenance” sector (NAICS – 811121) (EIIP, 2000b).

The national-level autobody refinishing emissions were obtained from the 2002 National Emissions Inventory (NEI) (U.S. EPA, 2006), while the national and county employee population statistics were obtained from the U.S. Census (U.S. Census, 2002).

The equation for estimating VOC emissions from autobody refinishing using extrapolation is:

$$E_c = E_n \times (Emp_c/Emp_n)$$

where: E_c = County-level VOC emissions (tons/year)
E_n = National-level VOC emissions (tons/year)
Emp_c = County-level employees (people)
Emp_n = National-level employees (people)
E_c = 107,157.47 tons/year × (8 employees/219,876 employees) = 3.9 tons VOC/year

Based upon information from the EIIP guidance, there are not any significant seasonal production variations in the autobody refinishing category. Average ozone season daily emissions were calculated by dividing annual emissions by 365 days.

E = 3.9 tons VOC ÷ 365 days × (2000 lbs/ton) = 21.4 lbs/day

TRAFFIC MARKINGS

Annual traffic markings usage and roadway lengths for roadways under the jurisdiction of San Juan County were obtained from staff within the San Juan County Department of Public Works, Traffic Division (Cobb, 2006). Although repeated calls were made to the New Mexico Department of Transportation (DOT) and Rio Arriba County Public Works Department, no information was obtained from these agencies. As a result, the San Juan County jurisdiction roadway traffic markings usage was extrapolated to the total road lengths in Rio Arriba and San Juan Counties based upon a GIS road length data set (ESRI, 2003). A VOC emission factor for traffic markings was obtained from EIIP guidance (EIIP, 1997a); it was assumed that all traffic markings used in the two counties were water-based.

The equation for estimating VOC emissions from traffic markings is:

$$E = EF \times M \times (1\ ton/2000\ lbs)$$

where: E = VOC emissions (tons/year)
EF = VOC emission factor (lbs/gallon of traffic marking)
M = Quantity of traffic marking (gallons)

A sample calculation for Rio Arriba County is as follows:

E = 0.72 lbs/gal × 12,524 gallons × (1 ton/2000 lbs) = 4.5 tons VOC/year

Regarding the seasonality of emissions, the EIIP guidance indicates that water-based traffic paints have the best results when applied when the air temperature is 50 ºF or greater and there is low humidity. The EIIP guidance also indicates that, lacking survey information, that the seasonal activity factor for the ozone season is 33 percent (EIIP, 1997a). However, given a 6 month ozone season, that would result in 33 percent of the activity occurring during the ozone season and 67 percent of the activity occurring outside of the ozone season, which contradicts the application guidelines for best results. Therefore, it was assumed that season differences are negligible. Average ozone season daily emissions were calculated by dividing annual emissions by 365 days.

E = 4.5 tons VOC ÷ 365 days × (2000 lbs/ton) = 24.7 lbs/day

INDUSTRIAL SURFACE COATING

Emissions from industrial surface coating were estimated using per employee VOC emission factors from EIIP guidance (EIIP, 1997b). County-level employee statistics were obtained from the U.S. Census Bureau (U.S. Census, 2002).

The equation for estimating VOC emissions from industrial surface coating using per employee emission factors is:

$$E = EF \times Emp \times (1\ ton/2{,}000\ lbs)$$

where: E = VOC emissions (tons/year)
EF = VOC per employee emission factor (lbs/employee-year)
Emp = Employees (people)

A sample calculation for the wood furniture sector in Rio Arriba County is as follows:

E = 944 lbs/employee-yr × 31 employees × (1 ton/2,000 lbs) = 14.6 tons VOC/year

Based upon information from the EIIP guidance, there are no significant seasonal variations in industrial surface coating activities. Average ozone season daily emissions were calculated by dividing annual emissions by 365 days.

E = 14.6 tons VOC ÷ 365 days × (2000 lbs/ton) = 80.2 lbs VOC/day

DEGREASING

Emissions from degreasing were estimated using per employee emission factors from EIIP guidance (EIIP, 1997c). County-level employee statistics were obtained from the U.S. Census Bureau (U.S. Census, 2002).

The equation for estimating VOC emissions from degreasing activities using per employee emission factors is:

$$E = EF \times Emp$$

where: E = VOC emissions (tons/year)
EF = VOC per employee emission factor (lbs/employee-year)
Emp = Employees (people)

A sample calculation for Rio Arriba County is as follows:

E = 87 lbs/employee-yr × 402 employees × (1 ton/2,000 lbs) = 17.5 tons VOC/year

Based upon information from the EIIP guidance, there are not any significant seasonal variation in degreasing activities. Average ozone season daily emissions were calculated by dividing annual emissions by 365 days.

E = 17.5 tons VOC ÷ 365 days × (2000 lbs/ton) = 95.8 lbs VOC/day

DRY CLEANING

Emissions from dry cleaning were estimated using a per employee emission factor from EIIP guidance (EIIP, 1996a). County-level employee statistics were obtained from the U.S. Census Bureau (U.S. Census, 2002).

The equation for estimating VOC emissions from dry cleaning using per employee emission factors is:

$$E = EF \times Emp$$

where: E = VOC emissions (tons/year)
EF = VOC per employee emission factor (tons/employee-year)
Emp = Employees (people)

A sample calculation for Rio Arriba County is as follows:

E = 0.9 tons/employee-yr × 11 employees = 9.9 tons VOC/year

Based upon information from the EIIP guidance, there are not any significant seasonal production variations in the dry cleaning industry. Average ozone season daily emissions were calculated by dividing annual emissions by 365 days.

E = 9.9 tons VOC ÷ 365 days × (2000 lbs/ton) = 54.2 lbs VOC/day

GRAPHIC ARTS

Emissions from graphic arts were estimated using a per capita emission factor from EIIP guidance (EIIP, 1996b). County-level population statistics for July 1, 2002 were obtained from the U.S. Census Bureau (U.S. Census, 2006).

The equation for estimating VOC emissions from graphic arts using per capita emission factors is:

$$E = EF \times P$$

where: E = VOC emissions (tons/year)
EF = VOC per capita emission factor (tons/person-year)
P = Population (people)

A sample calculation for Rio Arriba County is as follows:

E = 0.00065 tons/person-yr × 41,010 people = 26.7 tons VOC/year

Based upon information from the EIIP guidance, there are no significant seasonal production variations in the graphic arts industry. Average ozone season daily emissions were calculated by dividing annual emissions by 365 days.

E = 26.7 tons VOC ÷ 365 days × (2000 lbs/ton) = 146.1 lbs VOC/day

CONSUMER AND COMMERCIAL SOLVENTS

Emissions from consumer and commercial solvents were estimated using a per capita emission factor from EIIP guidance (EIIP, 1996c). County-level population statistics for July 1, 2002 were obtained from the U.S. Census Bureau (U.S. Census, 2006). A 20 percent reduction due to the promulgation of national VOC rules was applied to the consumer and commercial solvent use category (i.e., the national VOC rule was promulgated after the date that the per capita emission factors were developed) (Federal Register, 1998b).

The equation for estimating VOC emissions from consumer and commercial solvents using per capita emission factors is:

$$E = EF \times P \times (1 \text{ ton}/2000 \text{ lbs}) \times (1 - R)$$

where: E = VOC emissions (tons/year)
EF = VOC per capita emission factor (tons/person-year)
P = Population (people)
R = Reduction due to national VOC rules (0.2)

A sample calculation for Rio Arriba County (for all seven solvent subcategories) is as follows:

E = 7.84 lbs/person-yr × 41,010 people × (1 ton/2000 lbs) × (1 – 0.2) = 128.6 tons VOC/year

Based upon information from the EIIP guidance, there are no significant seasonal production variations in the consumer and commercial solvents category. Average ozone season daily emissions were calculated by dividing annual emissions by 365 days.

E = 128.6 tons VOC ÷ 365 days × (2000 lbs/ton) = 704.7 lbs/day

ASPHALT APPLICATION

Annual asphalt usage and roadway lengths for roadways under the jurisdiction of San Juan County were obtained from staff within the San Juan County Department of Public Works, Traffic Division (Martinez, 2006; Cobb, 2006). Although repeated calls were made to the New Mexico Department of Transportation (DOT) and Rio Arriba County Public Works Department, no information was obtained from these agencies. As a result, the San Juan County jurisdiction roadway asphalt markings usage was extrapolated to the total road lengths in Rio Arriba and San Juan Counties based upon a GIS road length data set (ESRI, 2003). All asphalt used on the San Juan County jurisdiction roadways was hot-mix (Martinez, 2006); it was assumed that all asphalt used throughout Rio Arriba and San Juan Counties was hot-mix.

The EIIP guidance document indicates that hot-mix VOC emissions are low due to the high molecular weights and low vapor pressures of its components (EIIP, 2001c). As a result, the EIIP guidance does not provide a hot-mix asphalt emission factor. Instead, a VOC hot-mix asphalt emission factor was obtained from an ARB technical document (ARB, 2005).

The equation for estimating VOC emissions from traffic markings is:

$$E = EF \times M \times (1\ ton/2000\ lbs)$$

where: E = VOC emissions (tons/year)
EF = VOC emission factor (lbs/ton hot-mix asphalt)
M = Quantity of hot-mix asphalt (tons)

A sample calculation for Rio Arriba County is as follows:

$$E = 0.04\ lbs/ton \times 66{,}458\ tons \times (1\ ton/2000\ lbs) = 1.3\ tons\ VOC/year$$

Information could not be obtained regarding the seasonality of asphalt application. Therefore, average ozone season daily emissions were calculated by dividing annual emissions by 365 days.

$$E = 1.3\ tons\ VOC \div 365\ days \times (2000\ lbs/ton) = 7.3\ lbs/day$$

GASOLINE DISTRIBUTION

Emissions from gasoline distribution are divided into three segments: Stage I, Stage II and storage tank breathing. Stage I emissions are those associated with the delivery of gasoline to gas stations (i.e., from the tanker truck into the underground storage tank). Stage II emissions are those that occur at the pump when fuel is transferred to vehicles. Emissions from these processes are estimated as the product of activity level and emission factors. Emission factors are derived from EIIP, 2001 for Stage I and storage tank breathing and from EPA's MOBILE6 model for Stage II emissions. Activity for this category is gasoline throughput (EIA, 2006) and vehicle miles traveled (VMT) based on WRAP, 2006 data. Per communications with New Mexico Environment Department staff, no Stage I or Stage II controls are required in San Juan and Rio Arriba counties, therefore emissions estimations were made based on uncontrolled emission factors.

For Stage I and tank breathing emissions, ozone season emissions were estimated based on gasoline throughput from June to August. Annual Stage I and tank breathing emissions were estimated based on yearly gasoline throughput. For Stage II emissions, ozone season emissions were estimated based on MOBILE6 inputs for the months June to August. Annual Stage II emissions were estimated based on the average of ozone season emissions and winter season (months December to February) emissions.

The equations for estimating annual and ozone season VOC emissions from trucks in transit are:

Annual: $E_{VOC,T} = TAF \times (EF_{VOC,ET} + EF_{VOC,FT}) \times GS_{2002,A} / 2000 \times 365$
Ozone Season: $E_{VOC,T} = TAF \times (EF_{VOC,ET} + EF_{VOC,FT}) \times GS_{2002,O} / 2000$

where: $E_{VOC,T}$ = Emission from trucks in transit (tons VOC)
$GS_{2002,A}$ = 2002 San Juan annual gasoline sales (gal/day)
$GS_{2002,O}$ = 2002 San Juan ozone season gasoline sales (gal/day)
TAF = Transportation adjustment factor for fuel shipped more than once.
W = operational days per week
$EF_{VOC,ET}$ = Emission factor for empty trucks (lb VOC/1000 gal transported)
$EF_{VOC,FT}$ = Emission factor for full trucks (lb VOC/1000 gal transported)

Sample calculations using these equations for estimating VOC from trucks in transit in San Juan County are:

Annual: $E_{VOC,T} = 1.25 \times (0.055\ lb/gal + 0.005\ lb/gal) \times 187.8 \times 10^3 gal/day/2000 lb/ton \times 365$
$E_{VOC,T} = 2.57\ tons\ VOC/year$
Ozone Season: $E_{VOC,T} = 1.25 \times (0.055\ lb/gal + 0.005\ lb/gal) \times 197.8 \times 10^3 gal/day/2000 lb/ton$
$E_{VOC,T} = 7.42 \times 10^{-3}\ tons\ VOC/ozone\ season\ day$

The equations for estimating annual and ozone season VOC emissions from the delivery of fuel are:

Annual: $E_{VOC,D} = EF_{VOC,D} \times GS_{2002,A} / 2000\ lb/ton \times 365$
Ozone Season: $E_{VOC,D} = EF_{VOC,D} \times GS_{2002,O} / 2000\ lb/ton$

where: $E_{VOC,D}$ = Emission from delivery of fuel (tons VOC)
$EF_{VOC,D}$ = Emission factor for delivery (lb VOC/1000 gal delivered)

Sample calculations using these equations for estimating VOC from delivery of fuel in San Juan County are:

Annual: $E_{VOC,D} = 11.5\ lb/1000gal \times 187.8 \times 10^3 gal/day / 2000 lb/ton \times 365$
$E_{VOC,D} = 394$ tons VOC/year
Ozone Season: $E_{VOC,D} = 11.5\ lb/1000gal \times 197.8 \times 10^3 gal/day / 2000 lb/ton$
$E_{VOC,D} = 1.14$ tons VOC/ozone season day

The equations for estimating annual and ozone season VOC emissions from spillage and displacement are:

$E_{VOC} = (\sum E_{VOC,i})$

where: E_{VOC} = Emissions of VOC from spillage and displacement (tons VOC)
$E_{VOC,i}$ = Emissions of VOC from spillage and displacement from vehicle type i (tons VOC)

$E_{VOC,,i} = EF_{VOC,i} \times VMT_i / 907{,}185$

where: $EF_{VOC,i}$ = Stage II refueling losses ozone season emission factor for vehicle type *i* (g/mi)
VMT_i = Vehicle type i VMT (mi/day)

Sample calculation using these equations for estimating VOC from vehicle refueling in San Juan County are:

Annual: $E_{VOC,,LDGV}$ = 0.0935 g/mi × 606,450 mi/day / 907,185
$E_{VOC,,LDGV}$ = 0.0625 tons/day
E_{VOC} = (0.0625 tons/day + 0.0435 tons/day + 0.0214 tons/day +0.0120 tons/day) ×365
E_{VOC} = 50.9 tons VOC/year

Ozone Season: $E_{VOC,,LDGV}$ = 0.093 g/mi × 606,450 mi/day / 907,185
$E_{VOC,,LDGV}$ = 0.0622 tons/ozone season day
E_{VOC} = (0.0622 tons/day + 0.0434 tons/day + 0.0218 tons/day +0.0122 tons/day)
E_{VOC} = 0.140 tons VOC/ozone season day

The equations for estimating VOC emissions from tank breathing are:

Annual: $E_{VOC,TB} = EF_{VOC,TB} \times GS_{2002,A} / 2000 \times 365$
Ozone Season: $E_{VOC,TB} = EF_{VOC,TB} \times GS_{2002,0} / 2000$

where: $E_{VOC,TB}$ = Emission from tank breathing (tons VOC/yr)
$EF_{VOC,TB}$ = Emission factor for tank breathing (lb VOC/1000 gal delivered)

Sample calculations using these equations for estimating VOC from tank breathing in San Juan County are:

Annual: $E_{VOC,TB}$ = 1 lb/1000gal × 187.8×10^3 gal/day / 2000 lb/ton × 365
$E_{VOC,TB}$ = 34.3 tons/year

Ozone Season: $E_{VOC,TB}$ = 1 lb/1000gal × 197.8×10^3 gal/day / 2000 lb/ton
$E_{VOC,TB}$ = 9.89×10^{-2} tons VOC/ozone season day

WASTE WATER TREATMENT PLANTS (WWTP)

Emissions from waste water treatment plants (WWTPs) were based upon a survey conducted by the U.S. EPA in 1996 (U.S. EPA, 1996). Plant throughput (in million gallons per day [MGD]) for 1996, as well as served population, was obtained for wastewater treatment plants located in Rio Arriba and San Juan Counties. A total of nine facilities were identified in the two counties.

The 1996 treatment plant throughput for six facilities (i.e., Aztec, Bloomfield, Chama, Espanola, Farmington, and Shiprock) was extrapolated to 2002 using the ratio of 2002 population to 1996 population for each community served. The 1996 treatment plant throughput for the remaining three facilities (i.e., Abiquiu, Dulce, and Truchas) was extrapolated to 2002 using the ratio of 2002 population to 1996 population for each county (U.S. Census, 2005b).

The VOC emission factor was obtained a U.S. EPA guidance document (U.S. EPA, 1991).

The equation for estimating VOC emissions from waste water treatment plants is:

E = EF × T × 365 days × (1 ton/2,000 lbs)

where: E = VOC emissions (tons/year)
EF = Emission factor (lbs VOC/gallon treated water)
T = Treated throughput (MGD)

A sample calculation for Rio Arriba County is as follows:

E = 0.00011 lbs VOC/gal × 1.131 MGD × 365 days × (1 ton/2,000 lbs) = 22.7 tons VOC/year

It is likely that there are some seasonal variations due to temperature differences, but these were not estimated. Therefore, it was assumed that there were no significant seasonal emission variations from waste water treatment plants. Average ozone season daily emissions were calculated by dividing annual emissions by 365 days.

E = 22.7 tons VOC ÷ 365 days × (2000 lbs/ton) = 124.4 lbs/day

BIOPROCESSES – BAKERIES, BREWERIES, DISTILLERIES, AND WINERIES

The bioprocesses source category includes four different food and beverage sector sources: bakeries, breweries, distilleries, and wineries. Several references were searched to identify possible levels of activities for these sources. According to the U.S. Census County Business Patterns (U.S. Census, 2002), there is one bakery in San Juan County and one brewery and two wineries in Rio Arriba County. Two on-line Internet sources were found which identified six wineries and two breweries in the two counties (Wine, 2006; Beer, 2006). No distilleries were identified.

Because of limited activity data, emissions were only estimated for the wineries. Emissions were not estimated for bakeries, breweries, or distilleries. Emission factors were obtained from U.S. EPA's *AP-42* (U.S. EPA, 1995).

The equation for estimating VOC emissions from wineries is:

E = EF × V × (1 ton/2000 lbs)

where: E = VOC emissions (tons/year)
EF = VOC emission factor (lbs/1,000 gallons)
V = Volume of wine produced (gallons)

A sample calculation for Rio Arriba County is as follows:

E = 3.22 lbs/1,000 gallons × 43,098 gallons tons × (1 ton/2,000 lbs) = 0.069 tons VOC/year

Information could not be obtained regarding the seasonality of wine production. Therefore, average ozone season daily emissions were calculated by dividing annual emissions by 365 days.

$$E = 0.69 \text{ tons VOC} \div 365 \text{ days} \times (2{,}000 \text{ lbs/ton}) = 0.38 \text{ lbs/day}$$

PESTICIDE APPLICATION

Staff from the San Juan and Rio Arriba County Extension Offices were contacted regarding pesticide application (Hathorn, 2006; Valdez, 2006). Pesticide application in San Juan County occurs on approximately 43,000 acres of cropland (including alfalfa, beans, corn, wheat, potatoes, and pumpkins). With the exception of a very limited amount of application in fruit orchards (including apples, pears, and cherries), pesticide application is basically zero in Rio Arriba County. Actual application rates were unavailable for either county. In addition, the cropland pesticide application in San Juan County is almost entirely pre-emergent with application primarily occurring during the month of March. Therefore, emissions from pesticide application were not estimated.

LANDFILLS

Although landfills were identified as an area source to be inventoried in the ENVIRON/ERG Scope of Work, it was decided not to include these in the area source inventory. The basis for this decision was that U.S. EPA has treated landfills as a point source category in the National Emissions Inventory (NEI) since 1999 (U.S. EPA, 2003; U.S. EPA, 2006).

LEAKING UNDERGROUND STORAGE TANKS

The New Mexico Environment Department's Petroleum Storage Tank Bureau (PSTB) was contacted regarding leaking underground storage tanks (USTs) and their associated remediation. A short survey form was sent to PSTB to gather relevant data regarding remediation actions; however, this survey form was never returned. An alternative methodology was employed to estimate emissions. A listing of past and current leak sites was obtained from PSTB (PSTB, 2006). A total of 62 leak sites were identified for Rio Arriba County and 169 leak sites were identified for San Juan County. However, not all of these leak sites were being remediated in 2002. Detailed site information was not available the PSTB listing to determine which sites were being remediated in 2002. However, the PSTB listing did include the date the release was reported to NMED, the last corrective action milestone achieved, and the date that milestone was achieved. This information was used to eliminate sites that were not likely remediated in 2002. For instance, sites with release report dates of 2003 or later were eliminated. Likewise, sites with milestone achievement dates of 2001 or earlier were eliminated. Also, sites with certain types of corrective action milestones (e.g., no further action required, monitoring, pre-investigation, referrals to other agencies, etc.) were also eliminated.

Emission factors were obtained from the EIIP area source method abstracts (EIIP, 1999a; EIIP, 1999b). It was assumed that the remediation event at each identified site occurred during the ozone season and lasted for a duration of 30 days.

The equation for estimating VOC emissions from leaking USTs is:

$E = EF \times RE \times D \times (1\ ton/2{,}000\ lbs)$

where: E = VOC emissions (tons/year)
EF = VOC emission factor (lbs-ozone season day/remediation event)
RE = Number of remediation events
D = Duration of remediation event (days)

A sample calculation for Rio Arriba County is as follows:

E = 28 lbs VOC-day/event × 9 events × 30 days × (1 ton/2,000 lbs) = 3.8 tons VOC/year

The EIIP guidance indicated that the emission factor used is applicable to the ozone season since it was developed using ambient temperature profiles occurring in the ozone season. It was assumed that all remediation events occurred during the ozone season. Average ozone season daily emissions were calculated by dividing annual emissions by 184 days.

E = 3.8 tons VOC ÷ 184 days × (2000 lbs/ton) = 41.1 lbs VOC/day

CATASTROPHIC/ACCIDENTAL RELEASES

Information regarding catastrophic or accidental releases was obtained from staff in the New Mexico Environment Department's Hazardous Waste Bureau (Harris, 2006). Most of the reported release incidents pertained to particulate matter. The information obtained was not complete enough to estimate emissions. Therefore, this category was not included in the final inventory.

RESULTS

Table 3-1 shows the estimated 2002 annual and ozone season daily emissions for all non-oil and gas area source emissions. Emissions are shown by source category for Rio Arriba County (Table 3-1a), San Juan County (Table 3-1b), and both counties combined (Table 3-1c). The relative contributions by emissions category for the annual and summer ozone season emissions are shown in Figures 3-1 through 3-6 (for both counties combined). VOC emissions are primarily from consumer products, gasoline distribution, architectural and industrial surface coatings, and residential wood combustion (in the winter). NOx emissions arise from small area sources fuel combustion. CO emissions are primarily from residential wood combustion and small area sources fuel combustion.

Table 3-1a. 2002 Annual and ozone season emissions for Rio Arriba County.

Source Category	Annual Emissions (tons)			Ozone Season Daily Emissions (lbs/day)		
	NOx	VOC	CO	NOx	VOC	CO
Architectural Surface Coating		53.00			315.73	
Asphalt Application		1.33			7.28	
Autobody Refinishing		3.90			21.36	
Bioprocess - Wineries		0.07			0.38	
Consumer Products		128.61			704.70	
Degreasing		17.49			95.82	
Dry Cleaning		9.90			54.25	
Fuel Combustion	156.01	7.89	99.06	503.21	26.37	338.67
Gasoline Distribution		145.51			816.36	
Graphic Arts		26.66			146.06	
Industrial Surface Coating		59.92			328.32	
Leaking Underground Storage Tanks		3.78			41.09	
On-Site Incineration (Crematories)	0.24	0.00	0.11	1.31	0.00	0.59
Open Burning	0.52	0.64	7.33	2.84	3.48	40.18
Residential Wood Combustion	9.61	226.25	795.05	20.45	481.39	1,691.64
Structure Fires	0.08	0.61	3.33	0.43	3.35	18.27
Traffic Markings		4.51			24.70	
Vehicle Fires	0.02	0.17	0.68	0.12	0.95	3.71
Waste Water Treatment		22.71			124.43	
Total	**166**	**713**	**906**	**528**	**3,196**	**2,093**

Table 3-1b. 2002 Annual and ozone season emissions for San Juan County.

Source Category	Annual Emissions (tons)			Ozone Season Daily Emissions (lbs/day)		
	NOx	VOC	CO	NOx	VOC	CO
Architectural Surface Coating		155.02			923.45	
Asphalt Application		1.05			5.78	
Autobody Refinishing		16.57			90.79	
Bioprocess - Wineries		0.01			0.08	
Consumer Products		376.15			2,061.12	
Degreasing		99.62			545.84	
Dry Cleaning		147.60			808.77	
Fuel Combustion	488.89	28.77	389.35	1,655.78	94.53	1,267.94
Gasoline Distribution		481.95			2,766.59	
Graphic Arts		77.97			427.21	
Industrial Surface Coating		183.96			1,008.02	
Leaking Underground Storage Tanks		2.94			31.96	
On-Site Incineration (Crematories)	-	-	-	-	-	-
Open Burning	1.51	1.86	21.44	8.29	10.19	117.51
Residential Wood Combustion	4.29	138.40	339.59	4.29	138.40	339.59
Structure Fires	0.23	1.79	9.75	1.25	9.79	53.43
Traffic Markings		3.58			19.59	
Vehicle Fires	0.06	0.51	1.98	0.35	2.78	10.85
Waste Water Treatment		77.22			423.15	
Total	**495**	**1,795**	**762**	**1,670**	**9,368**	**1,789**

Table 3-1c. 2002 Annual and ozone season emissions for Rio Arriba and San Juan Counties (combined).

Source Category	Annual Emissions (tons)			Ozone Season Daily Emissions (lbs/day)		
	NOx	VOC	CO	NOx	VOC	CO
Architectural Surface Coating		208.02			1,239.17	
Asphalt Application		2.38			13.06	
Autobody Refinishing		20.47			112.16	
Bioprocess - Wineries		0.08			0.46	
Consumer Products		504.76			2,765.81	
Degreasing		117.10			641.65	
Dry Cleaning		157.50			863.01	
Fuel Combustion	644.90	36.65	488.41	2,159.00	120.91	1,606.60
Gasoline Distribution		627.46			82.95	
Graphic Arts		104.62			573.27	
Industrial Surface Coating		243.88			1,336.34	
Leaking Underground Storage Tanks		6.72			73.04	
On-Site Incineration (Crematories)	0.24	0.00	0.11	1.31	0.00	0.59
Open Burning	2.03	2.50	28.78	11.13	13.68	157.68
Residential Wood Combustion	13.90	364.65	1,134.64	24.74	619.80	2,031.22
Structure Fires	0.31	2.40	13.08	1.67	13.14	71.69
Traffic Markings		8.08			44.30	
Vehicle Fires	0.09	0.68	2.66	0.47	3.73	14.57
Waste Water Treatment		99.93			547.57	
Total	**661**	**2,508**	**1,668**	**2,198**	**12,564**	**3,882**

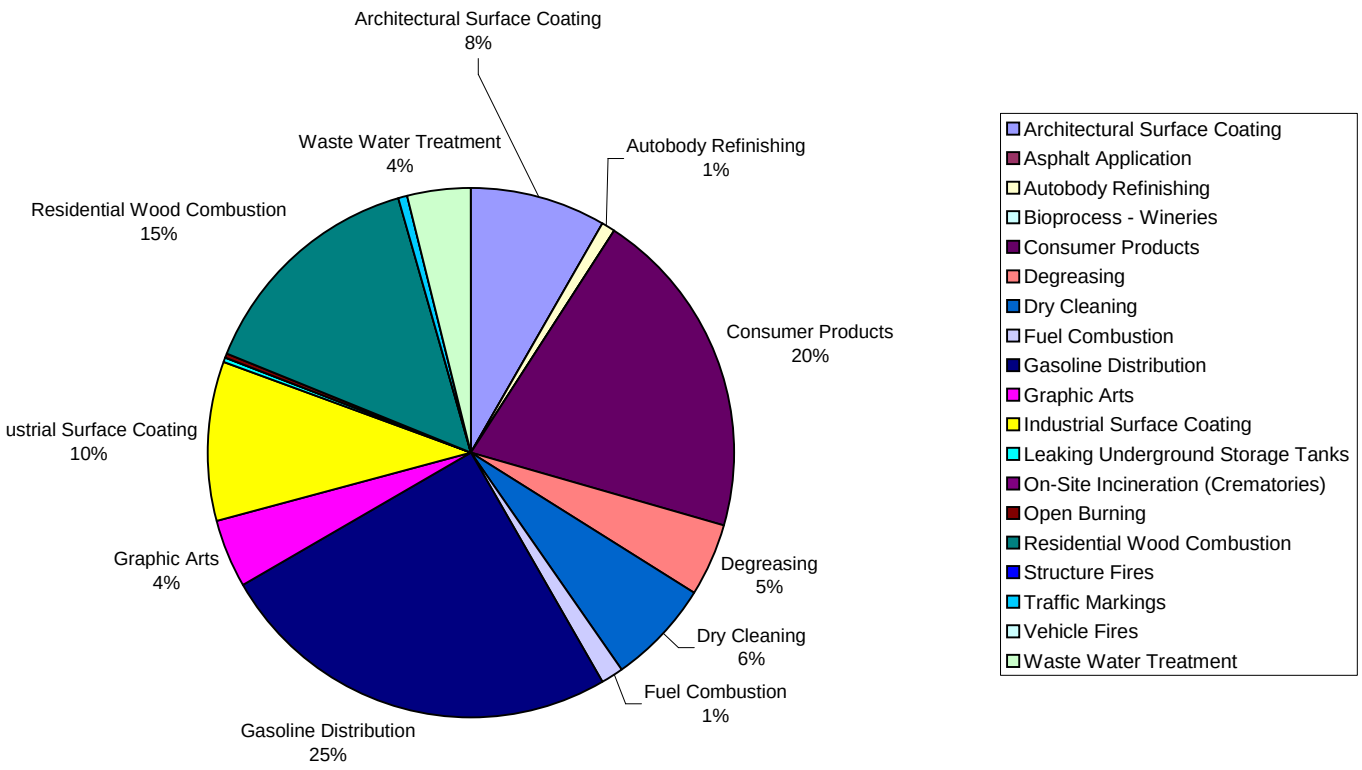

Figure 3-1. Other area sources annual VOC emissions contribution by source category.

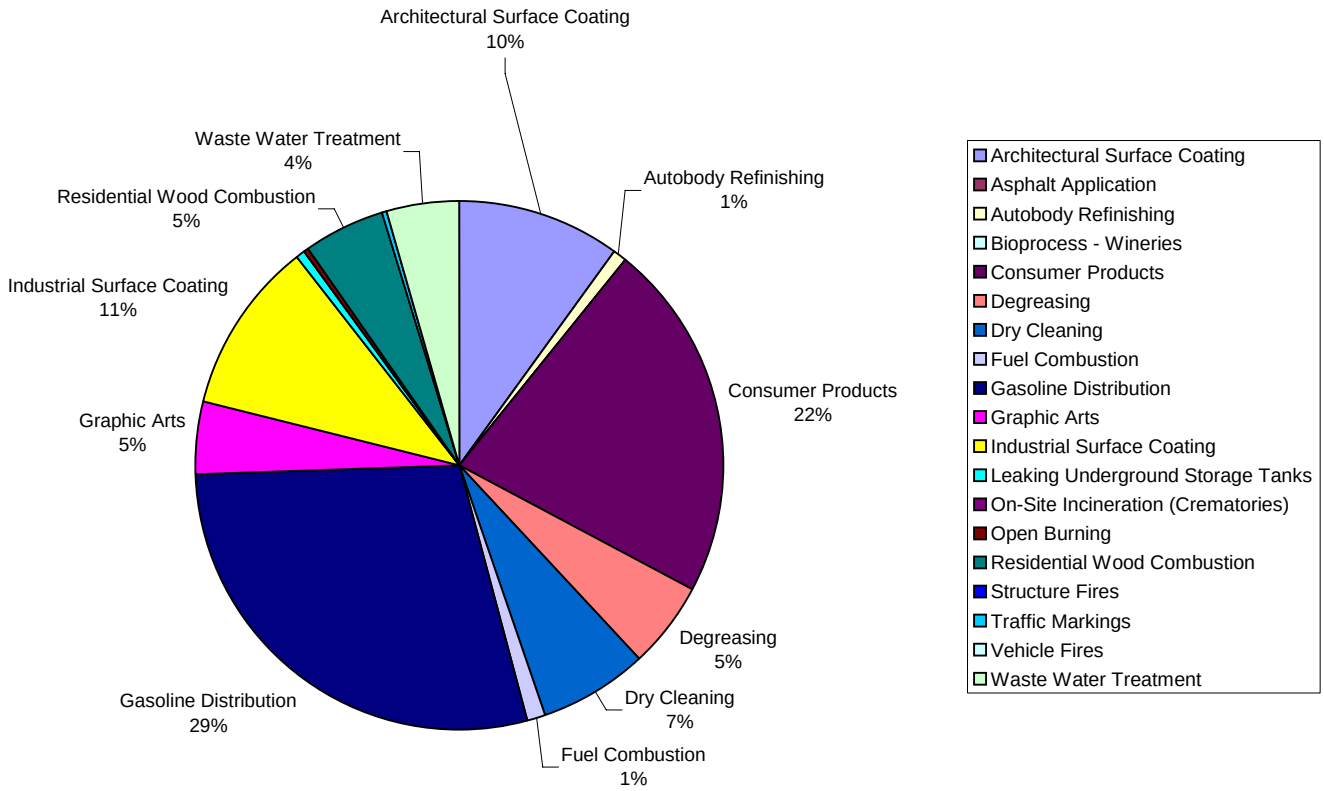

Figure 3-2. Other area sources ozone season VOC emissions contribution by source category.

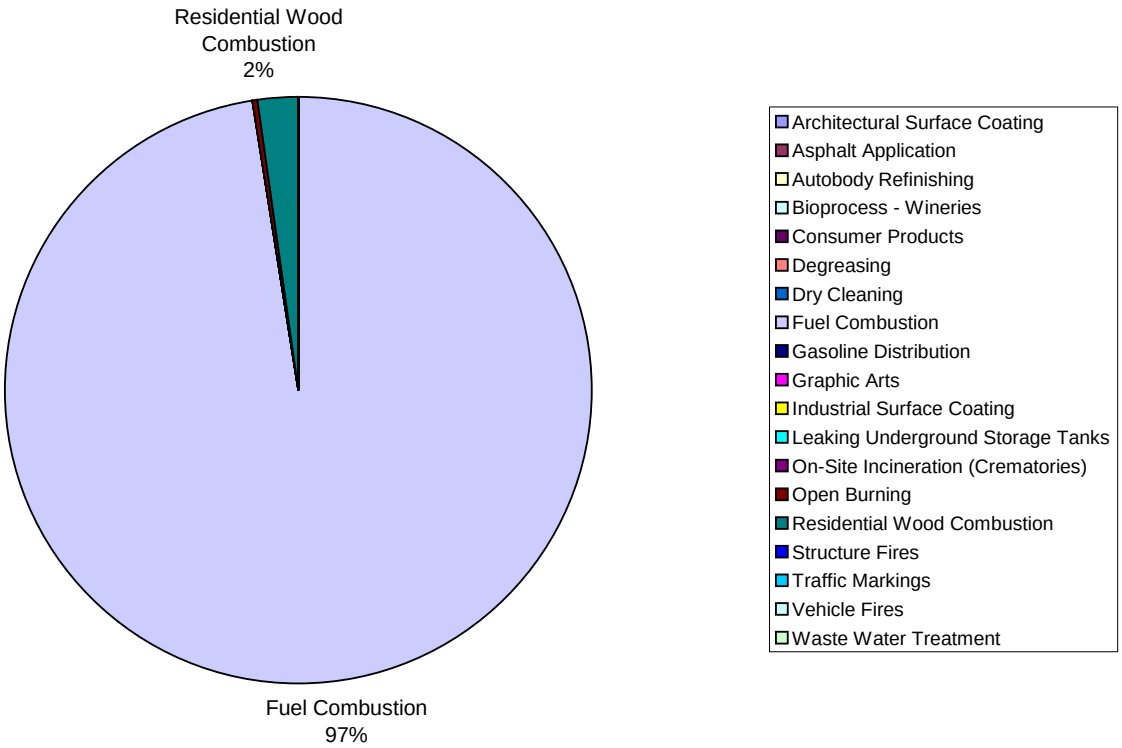

Figure 3-3. Other area sources annual NOx emissions contribution by source category.

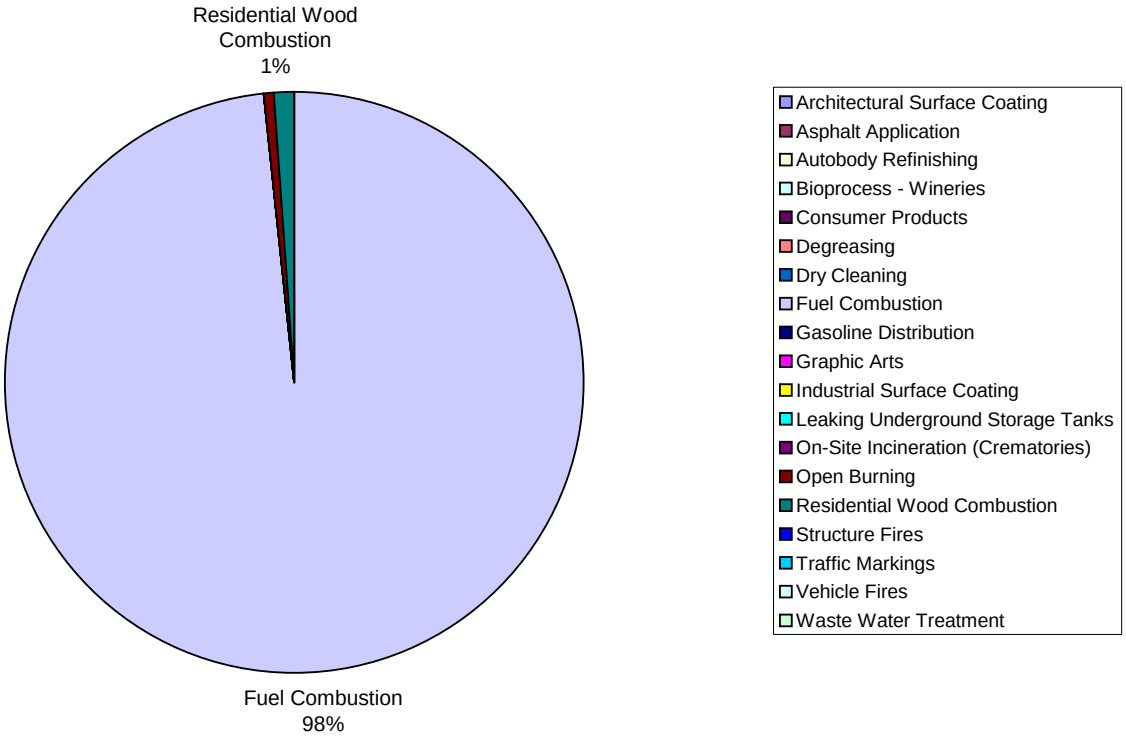

Figure 3-4. Other area sources ozone season NOx emissions contribution by source category.

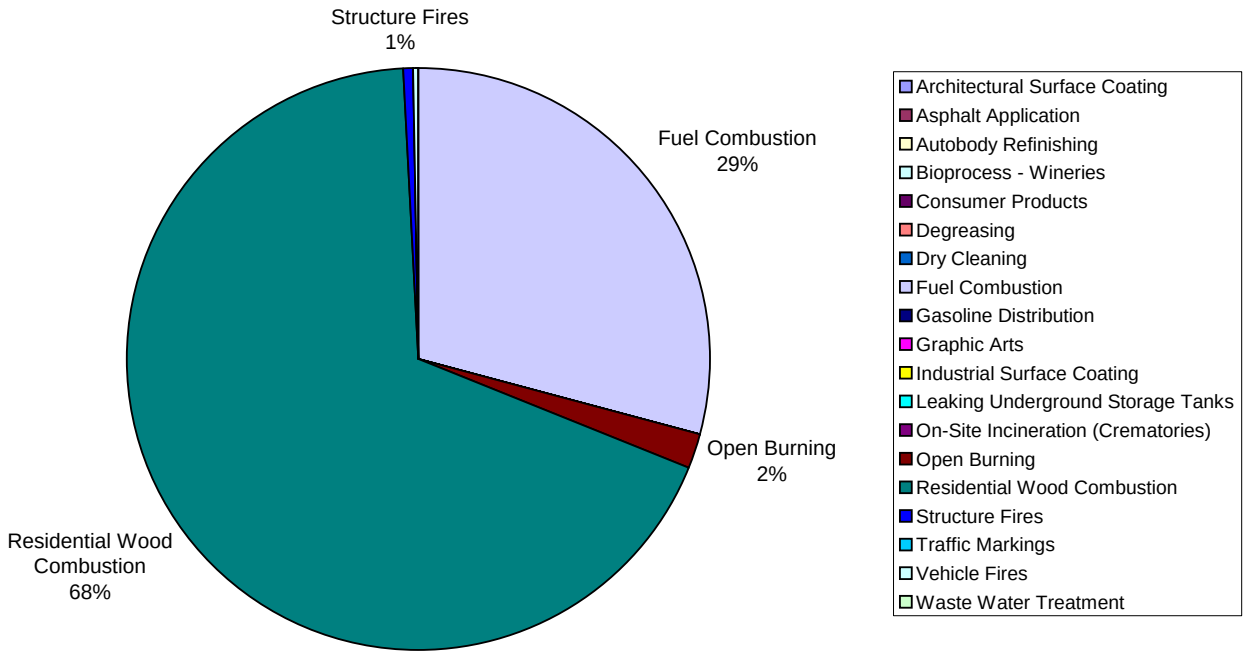

Figure 3-5. Other area sources annual CO emissions contribution by source category.

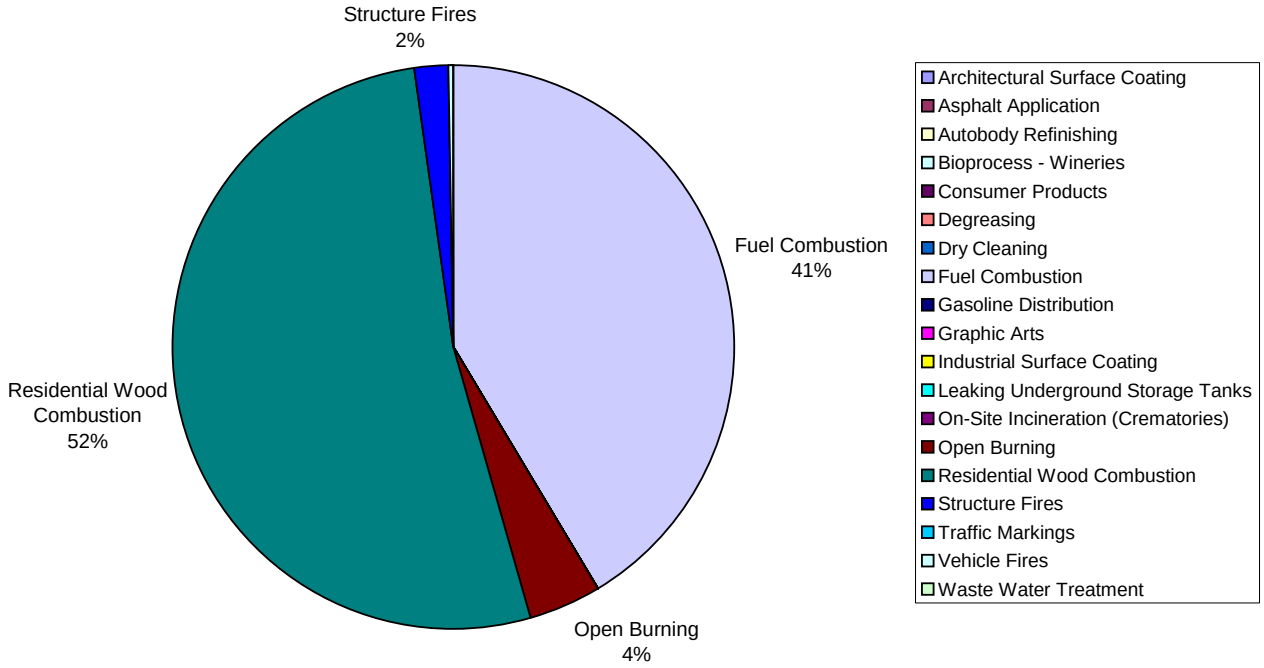

Figure 3-6. Other area sources ozone season CO emissions contribution by source category.

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APPENDIX A

Survey Forms for Oil and Gas Producers Engine Data Requests

-- Artificial Lift Engine Information Request --

ITEMS TO COMPLETE ON THIS FORM

1. Company information
2. General artificial lift information
3. Lift type detail
4. Production pool table
5. Engine detail (if available)

Introduction

Artificial lift engines refers to all engines providing power to the pumps used to lift fluids from wells. Examples of such engines would be a gas-fired pumpjack or a diesel generator powering one or more submersible pumps. Though individually small, in aggregate these engines represent a significant emissions source. We do not expect that most companies will be able to provide detailed information for each artificial lift engine. Therefore, we expect most companies will address items 1 - 4 on this form. However, if your company does maintain records of the data identified on the engine detail sheet, such data could be provided in place of the general information requested in items 2 - 4. The information provided by your company will be aggregated with that provided by other producers. From that compilation we will derive the engine activity estimates and emission factors necessary to make an accurate emissions estimate. *ENVIRON will hold as confidential all company-specific information provided; only aggregate information will be released.*

1. COMPANY INFORMATION

Company name	
Company contact name	
Contact phone	
Contact email	

Please continue to items 2 - 4

2. GENERAL ARTIFICIAL LIFT INFORMATION

In the table below, please provide the total number of lifts of each type that were operated by your company in 2002. If possible, provide subtotals for each of the fuel types.

	Total	Natural Gas	Diesel	Line Power	No Power	*Comments*
Pump-jacks						
Progressing Cavity Pump						
Electric Submersible Pump						
Plunger lift						
Other _____						
Other _____						
Other _____						

3. LIFT TYPE DETAIL

For each of the lift types operated by your company in 2002, please provide the average engine characteristics an operating parameters in the tables below.

Pump-jacks		**Value**	*Instruction*	**Comments**
Average rated power				
Average hours operated				
Maximum engine loading				
Average emission rates	NOx (g/hp-hr)		If available, please provide emission factors representative of this group of engines. If emission factors are not provided, default values will be applied.	
	CO (g/hp-hr)			
	VOC (g/hp-hr)			

Progressing Cavity Pumps		**Value**	*Instruction*	**Comments**
Average rated power				
Average hours operated				
Maximum engine loading				
Average emission rates	NOx (g/hp-hr)		If available, please provide emission factors representative of this group of engines. If emission factors are not provided, default values will be applied.	
	CO (g/hp-hr)			
	VOC (g/hp-hr)			

Electric Submersible Pump Generators		**Value**	*Instruction*	**Comments**
Average rated power				
Average hours operated				
Maximum engine loading				
Average emission rates	NOx (g/hp-hr)		If available, please provide emission factors representative of this group of engines. If emission factors are not provided, default values will be applied.	
	CO (g/hp-hr)			
	VOC (g/hp-hr)			

Other _____		Value	*Instruction*	Comments
Average rated power				
Average hours operated				
Maximum engine loading				
Average emission rates	NOx (g/hp-hr)		If available, please provide emission factors representative of this group of engines. If emission factors are not provided, default values will be applied.	
	CO (g/hp-hr)			
	VOC (g/hp-hr)			

Other _____		Value	*Instruction*	Comments
Average rated power				
Average hours operated				
Maximum engine loading				
Average emission rates	NOx (g/hp-hr)		If available, please provide emission factors representative of this group of engines. If emission factors are not provided, default values will be applied.	
	CO (g/hp-hr)			
	VOC (g/hp-hr)			

Other _____		Value	*Instruction*	Comments
Average rated power				
Average hours operated				
Maximum engine loading				
Average emission rates	NOx (g/hp-hr)		If available, please provide emission factors representative of this group of engines. If emission factors are not provided, default values will be applied.	
	CO (g/hp-hr)			
	VOC (g/hp-hr)			

4. PRODUCTION POOL DETAIL

Please indicate the number of lift devices of each type serving each of these production pools. Use the empty columns to add lift devices not already included. If more than 3 lifts are operated in a production pool other than those listed below, please add another line for that pool. If less than 3 lifts are operated in a pool not listed here, please count those in the "OTHER POOL" category.

Number of lifts by production pool served

	Pump-jack	Progressing Cavity Pump	Submersible Pump	Plunger lift		
BASIN FRUITLAND COAL (GAS)						
BLANCO-MESAVERDE (PRORATED GAS)						
BASIN DAKOTA (PRORATED GAS)						
BLANCO P. C. SOUTH (PRORATED GAS)						
BLANCO PICTURED CLIFFS (GAS)						
LINDRITH GALLUP-DAKOTA,WEST						
BISTI LOWER-GALLUP (O)						
PUERTO CHIQUITO MANCOS, WEST (F9)						
BISTI, S-GALLUP (O)						
LYBROOK GALLUP						
LINDRITH GALLUP DAKOTA, SOUTH						
CHA CHA GALLUP						
OTHER POOL						

5. ENGINE DETAIL

If available, please provide the following information for the artificial lift devices operated by your company in 2002. The priority data fields are indicated by red font. If emission factors are not provided, default values will be applied.

Engine description							Emission Factors			Well data			Additional Engine Operating parameters		
Engine ID	**Lift Type Served**	**Make**	**Model**	Age (yr)	**Rated Power (hp)**	Site Derated Power (hp)	**NOx (g/hp-hr)**	**CO (g/hp-hr)**	**VOC (g/hp-hr)**	Well APID	**Producing pool**	2002 well production (MCF)	fuel consumption	coordinates	coordinate description (latlon/utm/trs)

-- Compressor Engine Information Request --

ITEMS TO COMPLETE ON THIS FORM

1. Company information
2. Overall engine operating parameters
3. Engine detail

Introduction

This form requests data on the typical operations of your company's compressor engine fleet, as well as the characteristics of the individual engines. *Information is only requested for those engines not permitted by the New Mexico Environmental Department.* Previous inventory efforts have identified this subset of engines as an important contributor of ozone precursor emissions. However, the uncertainty in previous estimates is considerable considering the magnitude of this source and the importance of the oil and gas industry. The information that your company provides will contribute to a significant improvement in the degree of confidence associated with compressor engine emissions estimates. The information provided by your company will be aggregated with that provided by other producers. From that compilation we will derive the engine activity estimates and emission factors necessary to make an accurate emissions estimate. *ENVIRON will hold as confidential all company-specific information provided; only aggregate information will be released.*

1. COMPANY INFORMATION

Company name	
Company contact name	
Contact phone	
Contact email	

Please continue to item 2.

2. OVERALL ENGINE OPERATING PARAMETERS

In the table below, please provide the number of compressor engines operated by your company in 2002, as well as the typical operating parameters of those engines.

	Value	*Instruction*	**Comments**
Total number of engines operating in 2002		If total does not equal the count of engines on sheet 2, please indicate why in comments section	
Average annual hours operated		Please estimate the average annual hours of operation of engines in your fleet.	
Average engine loading		Report the average percent (or target percent) of rated engine power at which your fleet operates	
Average engine age		Report the average age of engines used by your company. Indicate in the comments if this is an estimate	
Typical number of compressor stages		If you can provide more detail as to the fraction of 1, 2 and 3 stage compressors, please do so in comments	

Please continue to item 3.

3. ENGINE DETAIL

For each engine operated by your company in 2002, please create a record in the table below. There are three levels of detail, as indicated by the color scheme. The fields with red text are the priority fields. For each engine operated in 2002, we request that you complete these priority fields. The fields with orange text are necessary for the emissions estimate. If this data is not provided, ENVIRON will use default values (to be determined in consultation with NMOGA) to make emissions estimates. Providing information for the remaining fields is also preferred, but it is understood that this level of detail will not be available in most cases. Two example records are provided for guidance.

Engine description						Emission Factors				Well data					Additional Engine Operating parameters					
Engine ID	Make	Model	Age (yr)	Rated Power (hp)	Site Derated Power (hp)	NOx (g/hp-hr)	CO (g/hp-hr)	VOC (g/hp-hr)	Source of emission factors	Number of wells served	Total 2002 production served (MCF)	Well APIDs	Producing pool(s)	2002 well production (MCF)	suction pressure (psi)	discharge pressure (psi)	Total 2002 Fuel Consumpion (MCF)	Location, Township-Range-Section	Location, coordinate (x; y)	coordinate description (LATLON/UTM/SP)
Ex. 1	CAT	3306 TA	6	220		13	7.4	1.3	manufacturer	3	128450	3004508556	Blanco Mesaverde	44097	60	600		29N 9W 10		
												3004522335	Blanco Mesaverde	58637						
												3004508453	Blanco Mesaverde	25716						
Ex. 2	CAT	342 NA		225	205	11.6	37.5	1.8	testing	2	156283		Basin Fruitland		50	600			250511; 4020820	UTM

-- Drill Rig Engine Information Request --

ITEMS TO COMPLETE ON THIS FORM

1. Company information
2. Drill rig utilization detail

Introduction

The prime movers of drill rigs are an important source of NOx and SO2 emissions in Rio Arriba and San Juan Counties. Though drill rigs have typically been exempted from permitting requirements, it is nonetheless important to account for this source in the emissions inventories that support air quality modeling and planning efforts. This form requests information about the drill rigs that were utilized by your company in 2002. The information that your company provides will contribute to a significant improvement in the area source emissions inventory. The information provided by your company will be aggregated with that provided by other producers. From that compilation we will derive the engine activity estimates and emission factors necessary to make an accurate emissions estimate. *ENVIRON will hold as confidential all company-specific information provided; only aggregate information will be released.*

1. COMPANY INFORMATION

Company name	
Company contact name	
Contact phone	
Contact email	

Please continue to item 2.

2. DRILL RIG UTILIZATION DATA

For each of the drill rigs employed by your company in 2002, please complete a record in the table below for the rig and, if possible, for the projects completed by that rig in 2002. There are three levels of detail, as indicated by the color scheme. The fields with red text are the priority fields. For each rig utilized in 2002, we request that you complete these priority fields. The fields with orange text refer to the projects completed by the rigs. If the project-specific information is not available, please provide the total fuel consumption and the total number of wells drilled and workovers performed by the rig in 2002. Example records for two rigs are provided for guidance. The first example shows fuel consumption reported by project, the second example presents only total fuel consumption for the rig. If the information is available, please complete any remaining fields as that additional data will help to refine the emissions estimates

	Rigs					Overall Emission Rates							Project					Fuel			
Internal ID	Owner	Owner ID	**Engine(s) make(s) & model(s)**	**Available horsepower**	Mechanical/Electric	**NOx (g/gal)**	**CO (g/gal)**	**VOC (g/gal)**	**PM10 (g/gal)**	**Source of emission factors**	**Total number of new wells drilled**	**Total number of workovers performed**	**Rig Project**	**Workover or New Well**	Well APID	**Pool**	Depth (ft)	**Diesel Consumed (gal)**	**Onroad / Nonroad Diesel**	Sulfur (lb S/10^6 lb diesel)	**Notes**
Ex. 1	Grey Wolf	97	CAT 398D, CAT 398D	2000	Diesel Electric SCR	148.5	54.5	5.0	17.8	manufacturer	2	0	1 of 2	New Well	3004520966	Basin Dakota (prorated gas)	7,290	11,300	Nonroad		
													2 of 2	New Well	3004520972	Basin Dakota (prorated gas)	6,840	10,800	Nonroad		
Ex. 2	Spradling	2	Detroit 8V92 TA	400	Mechanical	140.0	52.0	5.0	18.0	testing	0	2						3,200		2600	Project-specific fuel consumption not available

-- Salt Water Disposal Engine Information Request --

ITEMS TO COMPLETE ON THIS FORM

1. Company information
2. Overall engine operating parameters
3. Engine detail

Introduction

Salt water disposal engines refers to those engines powering pumps at salt water injection wells. This form requests data on the typical operations of your company's salt water disposal engines, as well as the characteristics of the individual engines. The size, number and frequent operation of this type of engine suggests that as a group these engines may represent a significant source of ozone precursor emissions. *Information is only requested for those engines not permitted by the New Mexico Environmental Department.* The information that your company provides will contribute to a significant improvement in the area source emissions inventory. The information provided by your company will be aggregated with that provided by other producers. From that compilation we will derive the engine activity estimates and emission factors necessary to make an accurate emissions estimate. *ENVIRON will hold as confidential all company-specific information provided; only aggregate information will be released.*

1. COMPANY INFORMATION

Company name	
Company contact name	
Contact phone	
Contact email	

Please continue to item 2.

2. OVERALL ENGINE OPERATING PARAMETERS

In the table below, please provide the number of salt water disposal engines operated by your company in 2002, as well as the typical operating parameters of those engines.

	Value	*Instruction*	**Comments**
Total number of engines operated in 2002		If total does not equal the count of engines on sheet 2, please indicate why in comments section	
Average hours operated		Please estimate the average annual hours of operation of engines in your fleet.	
Average engine loading		Report the average percent (or target percent) of rated engine power at which the engines operate	
Total number of electric pumps in 2002		Please report the number of pumps operated by line power	
Average engine age		Report the average age of engines used by your company. Indicate in the comments if this is an estimate	

Please continue to item 3.

3. ENGINE DETAIL

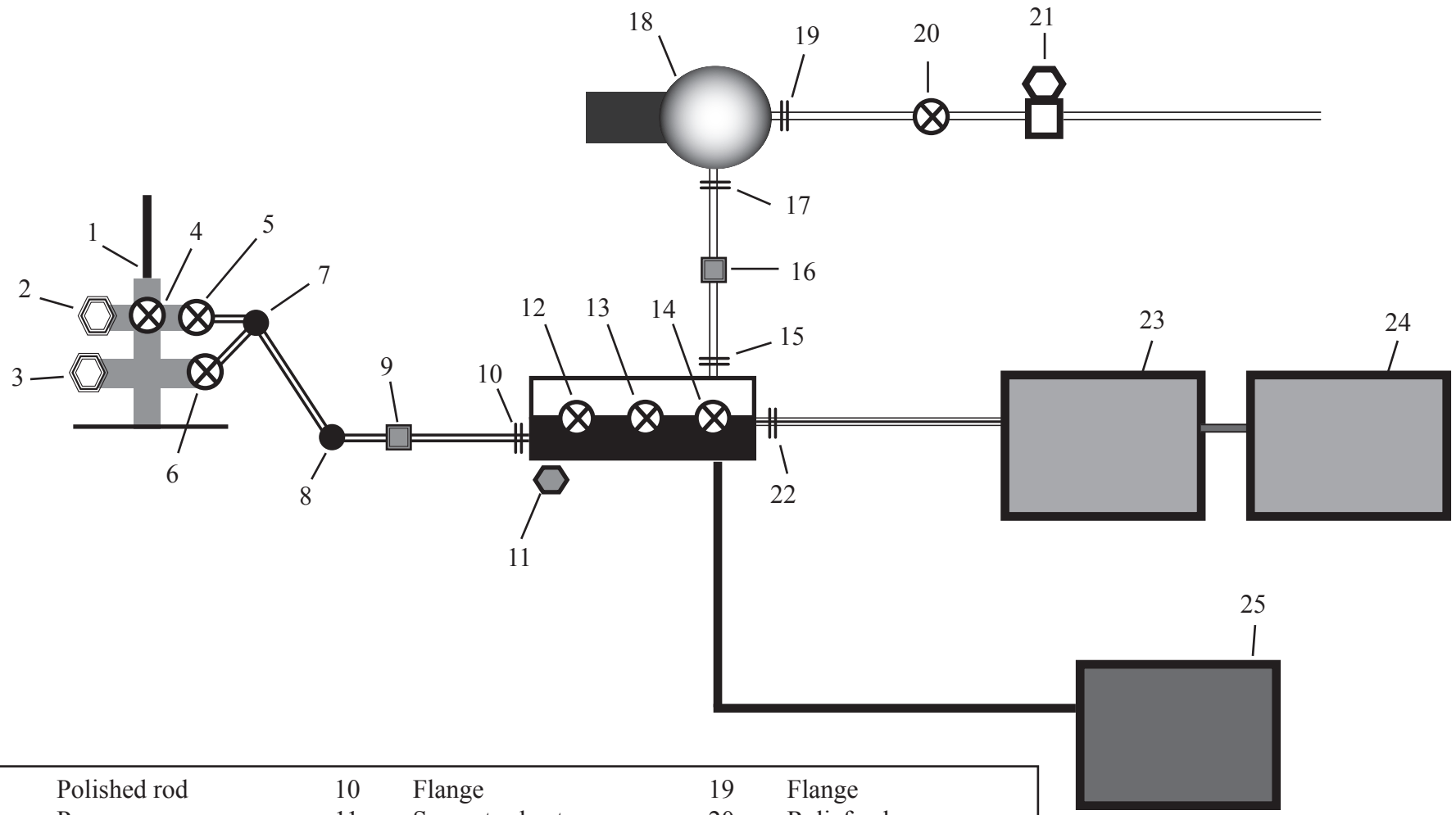
For each engine operated by your company in 2002, please create a record in the table below. There are three levels of detail, as indicated by the color scheme. The fields with red text are the priority fields. For each engine operated in 2002, we request that you complete these priority fields. The fields with orange text are necessary for the emissions estimate. If this data is not provided, ENVIRON will use default values (to be determined in consultation with NMOGA) to make emissions estimates. Providing information for the remaining fields is also preferred, but it is understood that this level of detail will not be available in most cases. Two example records are provided for guidance.

Engine description						Emission Factors				Injection Well Data			Additional Engine Operating Parameters			
Engine ID	**Make**	**Model**	Age (yr)	**Rated Power (hp)**	**Site Derated Power (hp)**	**NOx (g/hp-hr)**	**CO (g/hp-hr)**	**VOC (g/hp-hr)**	**Source of emission factors**	**Total Water Pumped (BBL)**	Well APID	Producing pool served	Total 2002 Fuel Consumpion (MCF)	Location, Township-Range-Section	Location, coordinate (x; y)	coordinate description (LATLON/UTM/SP)
Ex. 1	CAT	3306 TA	6	220		13	7.4	1.3	manufacturer			Blanco Mesaverde		29N 9W 10		
Ex. 2	CAT	342 NA		225	205	11.6	37.5	1.8	testing			Basin Fruitland			250511; 4020820	UTM

APPENDIX B

Typical Setup Diagrams for Oil, Gas, and Coalbed Methane Wells

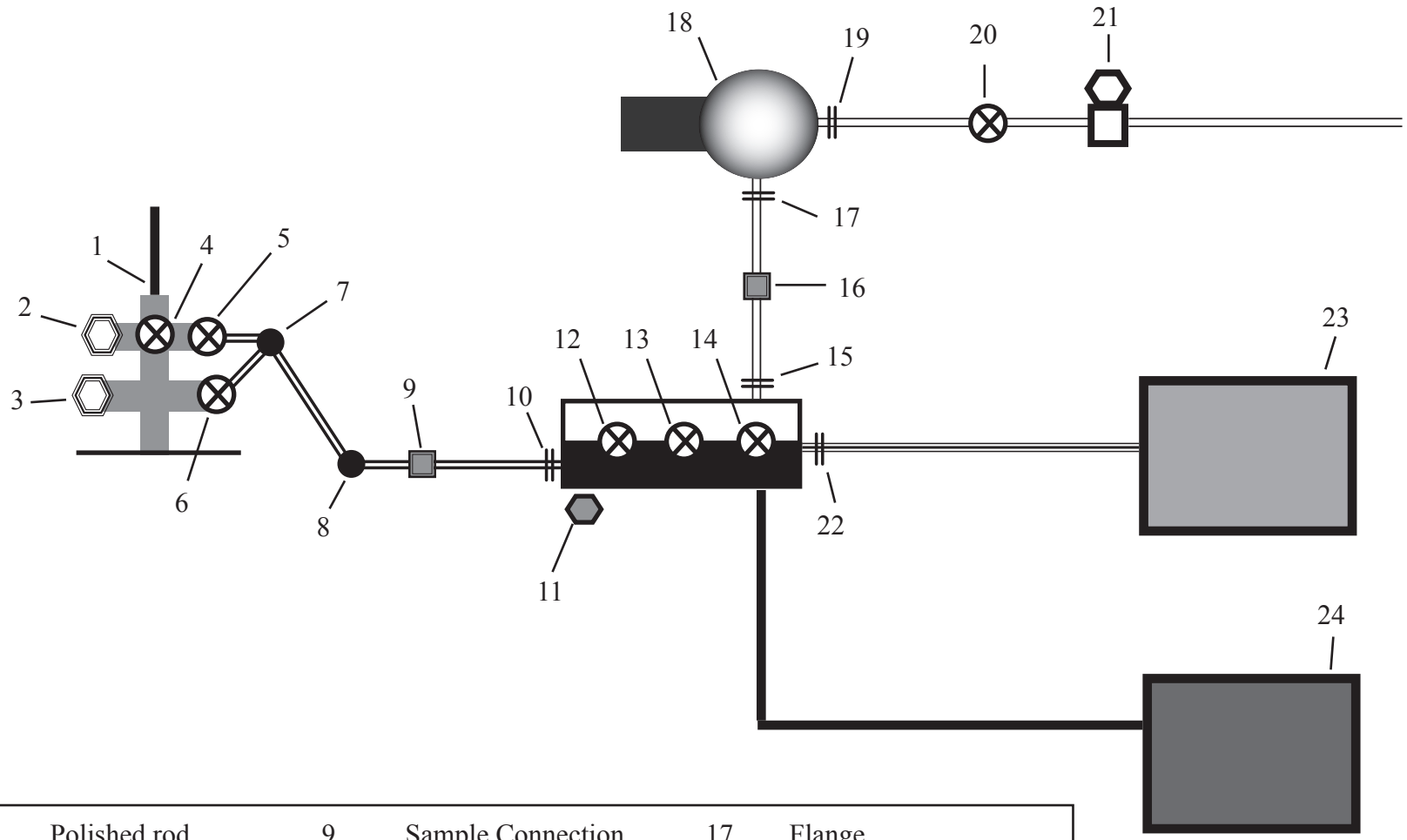
Oil Well - VOC and Minor NOx Sources



1	Polished rod	10	Flange	19	Flange
2	Pressure gauge	11	Separator heater	20	Relief valve
3	Pressure gauge	12	Separator dump valve	21	Meter
4	Master valve	13	Separator dump valve	22	Flange
5	Tubing flow valve	14	Separator dump valve	23	Oil Tank
6	Casing flow valve	15	Flange	24	Oil Tank
7	Connector	16	Sample Connection	25	Produced Water Tank
8	Connector	17	Flange		
9	Sample Connection	18	Compressor		

Note: Not drawn to scale.

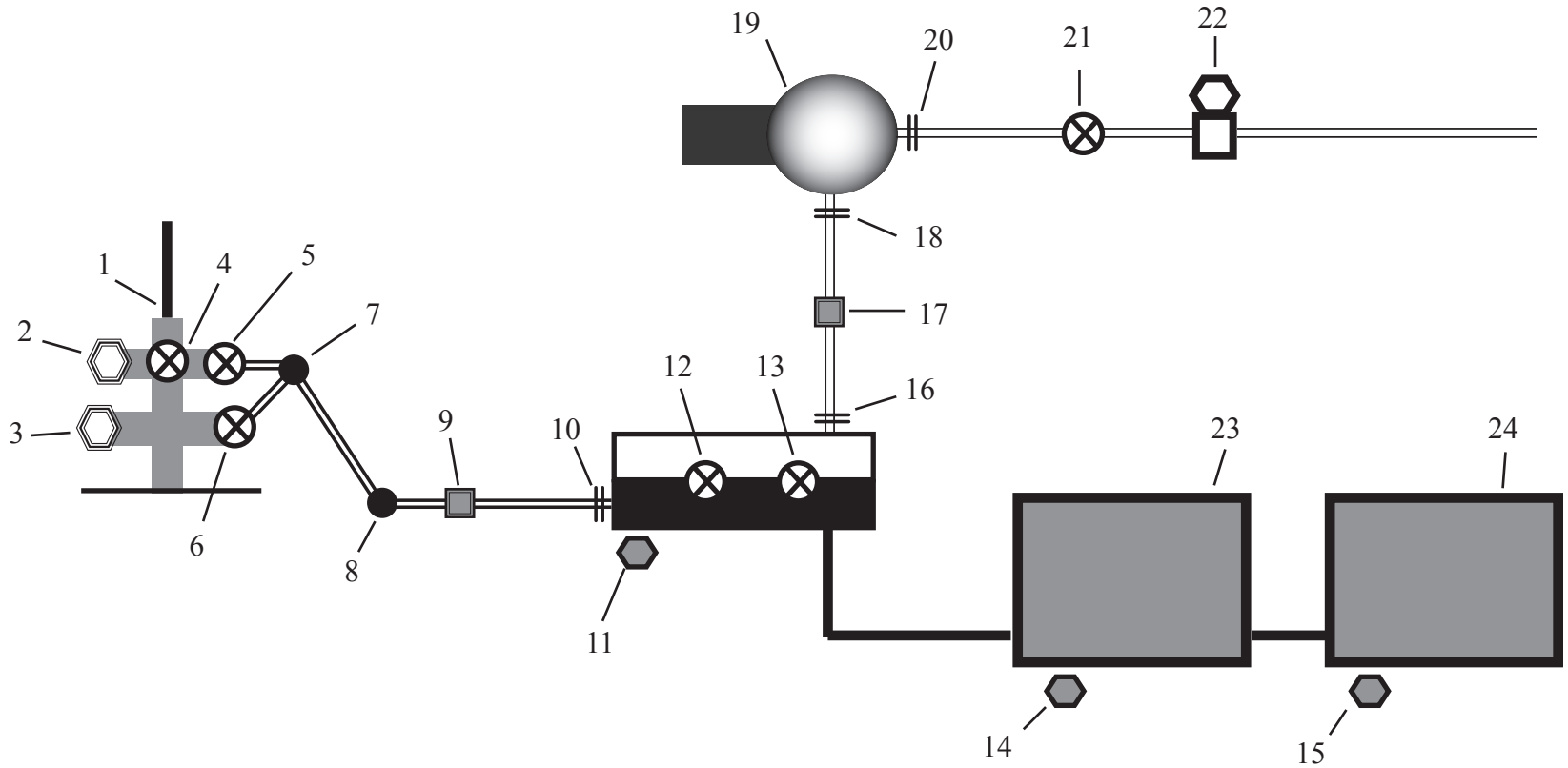
Gas & Condensate Well - VOC and Minor NOx Sources



1	Polished rod	9	Sample Connection	17	Flange
2	Pressure gauge	10	Flange	18	Compressor
3	Pressure gauge	11	Separator heater	19	Flange
4	Master valve	12	Separator dump valve	20	Relief valve
5	Tubing flow valve	13	Separator dump valve	21	Meter
6	Casing flow valve	14	Separator dump valve	22	Flange
7	Connector	15	Flange	23	Condensate Tank
8	Connector	16	Sample Connection	24	Produced Water Tank

Note: Not drawn to scale.

CBM Well - VOC and Minor NOx Sources



1	Polished rod	9	Sample Connection	17	Sample Connection
2	Pressure gauge	10	Flange	18	Flange
3	Pressure gauge	11	Separator heater	19	Compressor
4	Master valve	12	Separator dump valve	20	Flange
5	Tubing flow valve	13	Separator dump valve	21	Relief valve
6	Casing flow valve	14	Tank heater	22	Meter
7	Connector	15	Tank heater	23	Produced Water Tank
8	Connector	16	Flange	24	Produced Water Tank

Note: Not drawn to scale.