Garfield County Emissions Inventory

Prepared for Garfield County

Prepared by the Colorado Department of Public Health and Environment

Air Pollution Control Division

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Executive Summary

The air we breathe in many U.S. cities is being polluted by activities such as driving cars and trucks, burning coal, oil, and other fossil fuels, and manufacturing chemicals. Air pollution can also come from smaller, everyday activities such as dry cleaning, filling your car with gas, and degreasing and painting operations. All of these activities add gases and particles to the air we breathe. When these gases and particles accumulate in the air in high enough concentrations, they can harm both our environment and us. There is a direct correlation between population and air pollution. Higher populations in cities and surrounding counties means more cars, trucks, industrial and commercial operations, and generally means more air pollution.

This emissions inventory report describes both the natural and man-made emissions that contribute to the air quality in Garfield County. For a number of reasons, air pollutants that are transported into the county are not considered in this report.

The air pollutant inventory data in this report is based on 2010 Colorado Air Pollution Control Division data. This data is compiled using a variety of different methods, including required Air Pollutant Emission Notices (APENs), computer models, emission factors, and other reporting mechanisms (such as Hazardous Air Pollutant Addendum forms).

The pollutants that were inventoried and are as follows:

- NO_x (nitrogen oxides)
- PM_{10} (particulate matter less than 10 microns in diameter)
- SO_2 (sulfur dioxide)
- VOC (volatile organic compounds)
- CO (carbon monoxide)
- Benzene

The report describes the largest sources of pollution by pollutant. In some cases the largest sources of emissions are natural or biogenic (e.g., decomposition, vegetation, biomass) which are not controllable sources of air pollution. This is particularly valid for volatile organic compounds. In many cases, man-made, or anthropogenic, emissions are the largest sources. Major man-made categories include:

- *Point* – Specific location, releases pollutants above certain threshold to require a permit (e.g., power plants, industrial facilities)
- *Area* – Numerous facilities or activities that individually release small amounts of given pollutant(s), but collectively can release significant amounts of pollution (e.g., woodburning)
- *Oil and Gas* – Can be both point and area sources (point – compressor stations, gas plants; Area – wellheads, vents)
- *Mobile* – Wide variety of vehicles, engines, and equipment that move, or can be moved, from place to place (vehicles, construction, ATVs)

For nitrogen oxides, oil and gas activities are the primary contributors of emissions in Garfield County followed by highway vehicle emissions. Nitrogen oxide emissions, excluding fires, have increased 72% from 1996 to 2010. For PM_{10}, construction and oil and gas activities are the largest sources. PM_{10} emissions, excluding fires, have increased 28% from 1996 to 2010. For sulfur dioxide, oil and gas activities are the largest contributors. Sulfur dioxide emissions, excluding fires, have increased 29% from 1996 to 2010. For VOCs, oil and gas activities and biogenic sources are the primary contributors. VOC emissions, excluding fires, have increased 50% from 1996 to 2010. For carbon monoxide, highway vehicles and oil and gas activities are the largest source in Garfield County. Carbon monoxide emissions, excluding fires, have decreased 18% from 1996 to 2010.

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1.0 Introduction

The purpose of this report is to present basic emission information to county officials and the public about the specific nature of air quality in Garfield County. This report will present the various contributions of air pollution that add to the air quality in the area and attempt to quantify the levels of pollution for each source. This report does not look at any monitored concentrations of pollutants in the ambient air. In order to provide a general understanding of emission inventories, the following sections provide a general description of the purpose of emission inventories, how they are prepared, and common methodologies used in preparing them.

1.1 What is an emissions inventory?

An emissions inventory is an estimation of the amount of pollutants emitted from pollution sources in a given area over a specific amount of time. Pollutants may be emitted naturally, such as from plants, or from anthropogenic (man-made) sources. Inventories are developed using geographic information system (GIS) techniques to determine the known sources of air pollution that exist in an area. These sources are typically broken into three categories: point, area, and mobile sources. More detailed information on subcategories may be found in Appendix C.

Point Sources:
Point sources are individual stationary facilities that emit pollutants. These include such industries as power plants, asphalt plants, refineries, compressor stations and quarries.

Mobile Sources:
Mobile sources are typically broken into two major subcategories: highway vehicles emissions (on-road), and non-road. On-road mobile sources include light-duty vehicles, light-duty trucks, heavy-duty vehicles, and motorcycles, used for transportation on the road. On-road vehicles may be fueled with gasoline, diesel fuel, or alternative fuels such as alcohol or natural gas. Non-road mobile sources include non-road gasoline equipment and vehicles, non-road diesel equipment and vehicles, aircraft, marine vessels, locomotives, and assorted other engines and vehicles.

Area Sources:
Area sources collectively represent individual sources that are small and numerous, and that have not been inventoried as specific point, mobile, or biogenic sources. They include such sources as residential and commercial fuel combustion, gas wells, biogenic emissions, structural fires, wild fires and prescribed burning. Biogenic emissions are pollutants from natural sources such as plants, animals, marshes, and the earth itself. Vegetation for example, emits large amounts of isoprene, terpenes, and other organic compounds that are potential precursors of ozone. Biogenic sources are not controllable sources of air pollution.

The process for preparing the emission inventory involves several steps. First, the boundary of the study area is defined, which in this case is Garfield County. Then the sources of data for each category must be identified. The Air Pollution Control Division (APCD) of the Colorado Department of Public Health and Environment (CDPHE) has developed a statewide emission inventorying system and uses a number of standardized methodologies to make emission estimates for various source categories. These methodologies are discussed in more detail for

each category in section 1.4 of this report. Finally, once the source calculations are made, a summary emissions inventory report is prepared along with supporting tables, graphs and charts.

It needs to be kept in mind that an emissions inventory is constantly evolving. As industries start up, shut down or modify, emissions in an area change. Additionally, there are minimum reporting limits, so an emissions inventory probably underestimates the true total emissions in an area. These minimum reporting limits have been reduced over time, so older inventories may not be comparable to newer inventories for certain industrial sectors. Finally, emissions inventory values are based on permitted emissions limits, (not on monitoring), which are the maximum "potential to emit" amounts that a facility is allowed to release in a year. Thus, actual emissions may be less for the year and potentially could happen all on one day in an extreme case. In addition, the application of new pollution controls will change emissions at a source and should be accounted for when comparing emissions from different years.

An emissions inventory is a resource that utilizes data to evaluate emission trends, and is not the sole tool that is used for air dispersion modeling, air quality rule development, and air toxics risk assessment. Tracking emission trends over time may alert the APCD to potential air quality issues, which gives support to future planning.

1.2 How can this emissions report be used?

Emissions reports can be used for a variety of planning areas. These include:

1. Identify sources and general emission levels;
2. Inputs for certain air quality models and to compare to results of other air quality models;
3. Evaluate trends and meeting of air quality goals;
4. Evaluate potential exposure risks; and
5. Provide reports to the public and to agencies.

The U.S. Environmental Protection Agency (EPA) has set national ambient air quality standards (NAAQS) for six common pollutants (also referred to as "criteria" pollutants) and uses these as indicators of air quality. These criteria pollutants are carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide, particulates and lead. These pollutants are monitored to determine if an area has "clean" air or "dirty" air. Monitors are set up around the state to measure the concentrations of pollutants in the ambient air. If an air shed is determined to have dirty air, the regulating agency must implement stricter air pollution regulations. The air shed above Garfield County is considered "clean" because the monitored air pollutants (and expected levels of non-monitored air pollutants) have not exceeded the national standards.

In general, the ultimate goal of the planning process is to identify and achieve a level of emissions that does not result in violation of national and state ambient air quality standards and/or help identify methods to reduce or eliminate current and future violations.

1.3 What air pollutants are included in an emissions inventory?

An emissions inventory includes most of the criteria pollutants because they are often used for regional air quality planning and modeling. However, ozone is not included as it is a secondary formation pollutant and is not directly emitted from sources. In addition, lead is not included in

the emissions inventory but nationally it is included as a "hazardous air pollutant" (HAP) in certain inventories rather than as an individual pollutant. Additional pollutants may also be included in an emissions inventory.

Below is a brief discussion of each air pollutant that is included in this emission inventory report and some of the potential health effects from each pollutant. Health and risk information on these and other pollutants is available from the Agency for Toxic Substances and Disease Registry (ATSDR).

Nitrogen Oxides (NO_x):
Nitrogen dioxide (NO_2) is a brownish, highly reactive gas that is present in all urban atmospheres. NO_2 can irritate the lungs, cause bronchitis and pneumonia, and lower resistance to respiratory infections. Nitrogen oxides (NO_x), which include nitric oxide (NO) and NO_2, are an important precursor both to ozone (O_3) and acid rain, and may affect both terrestrial and aquatic ecosystems. The major mechanism for the formation of NO_2 in the atmosphere is the oxidation of the primary air pollutant NO. NO_x plays a major role, together with VOCs, in the atmospheric reactions that produce O_3. NO_x forms when fuel is burned at high temperatures. The two major emissions sources are transportation and stationary fuel combustion sources such as electric utility and industrial boilers.

Particulate Matter (PM_{10} and $PM_{2.5}$):
Air pollutants called particulate matter include dust, dirt, soot, smoke and liquid droplets directly emitted into the air by sources such as factories, power plants, cars, construction activity, fires and natural windblown dust. Particles formed in the atmosphere by condensation or the transformation of emitted gases such as SO_2 and VOCs are also considered particulate matter. Some of the health concerns include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, damage to lung tissue, carcinogenesis and premature death. The major subgroups of the population that appear to be most sensitive to the effects of particulate matter include individuals with chronic obstructive pulmonary or cardiovascular disease or influenza, asthmatics, the elderly and children. Particulate matter also soils and damages materials, and is a major cause of visibility impairment in the United States. This report includes particulate matter with a diameter of 10 microns or less. However, smaller particulate matter with a diameter of 2.5 microns or less are likely responsible for most of the adverse health effects of particulate matter because of their ability to reach the thoracic or lower regions of the respiratory tract.

Sulfur Dioxide (SO_2):
High concentrations of sulfur dioxide (SO_2) affect breathing and may aggravate existing respiratory and cardiovascular disease. Sensitive populations include asthmatics, individuals with bronchitis or emphysema, children and the elderly. SO_2 is also a primary contributor to acid deposition, or acid rain, which causes acidification of lakes and streams and can damage trees, crops, historic buildings and statues. In addition, sulfur compounds in the air contribute to visibility impairment in large parts of the country.

This is especially noticeable in national parks. Ambient SO_2 is largely from stationary sources such as coal and oil combustion, steel mills, refineries, pulp and paper mills, nonferrous smelters and forest fires.

Volatile Organic Compounds (VOCs):
VOCs are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects. VOCs are emitted by a wide array of products numbering in the thousands. Examples include: paints and lacquers, gasoline, cleaning supplies, pesticides, building materials and furnishings, and office equipment such as copiers and printers. VOCs are also released from oil and gas development sources. VOCs are not considered one of the six "criteria" pollutants for which EPA has set a national standard. However, VOCs can act as precursors to the formation of ground level ozone (O_3). In this report, VOCs do not include benzene, which is listed separately.

Carbon Monoxide (CO):
CO is a colorless, odorless and poisonous gas produced by incomplete burning of carbon in fuels. When CO enters the bloodstream, it reduces the delivery of oxygen to the body's organs and tissues. Health threats are most serious for those who suffer from cardiovascular disease, particularly those with angina or peripheral vascular disease. Exposure to elevated CO levels can cause impairment of visual perception, manual dexterity, learning ability and performance of complex tasks.

Benzene:
Benzene is found in the air from emissions from burning coal and oil, oil and gas development, gasoline service stations, and motor vehicle exhaust. Acute (short-term) inhalation exposure of humans to benzene may cause drowsiness, dizziness, headaches, as well as eye, skin, and respiratory tract irritation, and, at high levels, unconsciousness. Chronic (long-term) inhalation exposure has caused various disorders in the blood, including reduced numbers of red blood cells and aplastic anemia, in occupational settings. Reproductive effects have been reported for women exposed by inhalation to high levels, and adverse effects on the developing fetus have been observed in animal tests. Increased incidence of leukemia (cancer of the tissues that form white blood cells) has been observed in humans occupationally exposed to benzene. EPA has classified benzene as a "Group A" human carcinogen. Benzene is one of the VOC compounds, but is broken out and discussed independently as it is typically associated with oil and gas production as well as mobile sources.

1.4 What methods were used in developing this emission inventory?

As discussed above, emission sources are divided into three major categories: stationary point sources, mobile sources, and area sources. Generally, emission estimates for each category are made using established emission factors multiplied by an activity rate. An emission factor is a representative value that attempts to relate the "potential to emit" quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. The general equation for emissions estimation is:

$E = A \times EF$

Where:
E = emissions;
A = activity rate;
EF = emission factor

Stationary/Point Source Methods:
Point sources are also referred to as stationary sources. The APCD currently requires any source that emits two tons per year or greater of the above listed pollutants (excluding benzene) to submit an Air Pollutant Emission Notice (APEN). This means that sources that emit less than two tons per year are not necessarily accounted for in an emissions inventory. The point source emissions for Garfield County were obtained from this tracking system. The emission estimates are made using a variety of methodologies. Data from source-specific emission tests, or continuous emission monitors are preferable, but not always available. The EPA has developed a variety of emission factors to estimate emissions as well. Emission factors are frequently the best or only method available for estimating emissions. Appendix C provides more specific detail on methodologies for estimating emissions from point sources.

Mobile Source Methods:
Mobile sources are classified in two major subcategories: highway vehicle emissions (called on-road), and non-road.

Highway Vehicles Methods:
The EPA model (Motor Vehicle Emission Simulator) MOVES is an emission factor model for predicting grams per mile of emissions for Hydrocarbons (HC), Carbon Monoxide (CO), Nitrogen Oxides (NO_x), Sulfur Dioxide (SO_2), Carbon Dioxide (CO_2), Particulate Matter (PM), and toxics from cars, trucks, and motorcycles, based on analysis of millions of emission test results and considerable advances in EPA's understanding of vehicle emissions. Starting in 2009, the MOVES model replaces the previously used MOBILE6 model.

Non-Road Methods:
Emissions from non-road mobile sources were calculated using the EPA Non-road Emission Factor Model. The model provides emission estimates at the county level.

Area Sources Methods:
Area sources were based on the EPA National Emission Trends (NET) inventory. This is a county-by-county inventory that utilizes population apportionment methods and is corrected to minimize double counting with the point source inventory. Appendix C provides a more detailed explanation of the methods for each type of area source.

1.5 How is the statewide emission inventory broken down?

The statewide inventory is broken down into various regions of Colorado, depending on a number of factors, including population, emission sources and types, and regional characteristics. Garfield County is included in the West Slope Region. This Region consists of the counties depicted below in Figure 1.

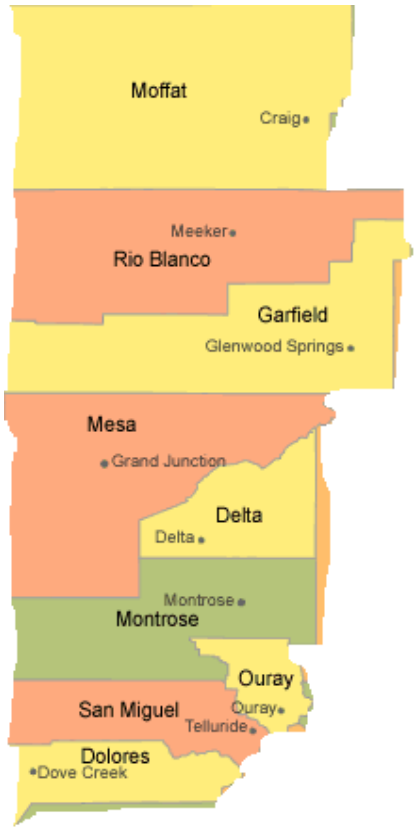

Figure 1: West Slope Counties

2.0 Garfield County Emissions Inventory

Table 1 provides a summary of the 2010 Garfield County emissions inventory for all sources. The values shown are in tons per year. This table was also used to produce Figures 2 through 8, which provide a pollutant percentage distribution as well as a percentage breakout of the sources of emissions for each pollutant in the inventory.

Table 1: Summary of 2010 Garfield County Emissions Inventory

Category	NO_x (tons/year)	PM_{10} (tons/year)	SO_2 (tons/year)	VOCs[1] (tons/year)	CO (tons/year)	Benzene (tons/year)
Agriculture	[3]	81				0[2]
Aircraft	1	2	0	10	113	0
Biogenic	471	0	0	27,966	3,730	0
Commercial Cooking	0	16	0	15	6	0
Construction	0	1,920	0	0	0	0
Forest and Prescribed Fire	17	88	6	149	713	0
Fuel Combustion	70	1	2	5	53	0
Highway Vehicles	1,402	62	5	1,123	12,888	32
Non-Road	350	33	1	333	2,787	11
O&G area	6,288	604	168	19,837	8,370	0
O&G point	5,424	138	48	14,807	3,147	198
Other Point Sources	122	252	24	503	233	4
Pesticide Application	0	0	0	55	0	0
Portable Fuel Containers	0	0	0	33	0	0
Railroads	584	14	33	22	58	0
Refueling	0	0	0	93	0	0
Road Dust	0	527	0	0	0	0
Solvent Utilization	0	0	0	232	0	0
Structure Fires	0	1	0	1	4	0
Surface Coating	0	0	0	170	0	0
Tank Trucks In Transit	0	0	0	1	0	0
Woodburning	57	581	9	812	4,197	34
TOTAL	14,786	4,322	297	66,163	36,297	281

[1]VOCs do not include Benzene, which is listed separately.
[2]Zero values are for data that have been reported as zero or estimated to be zero.
[3]Blank values are those for which no data has been reported or estimated.

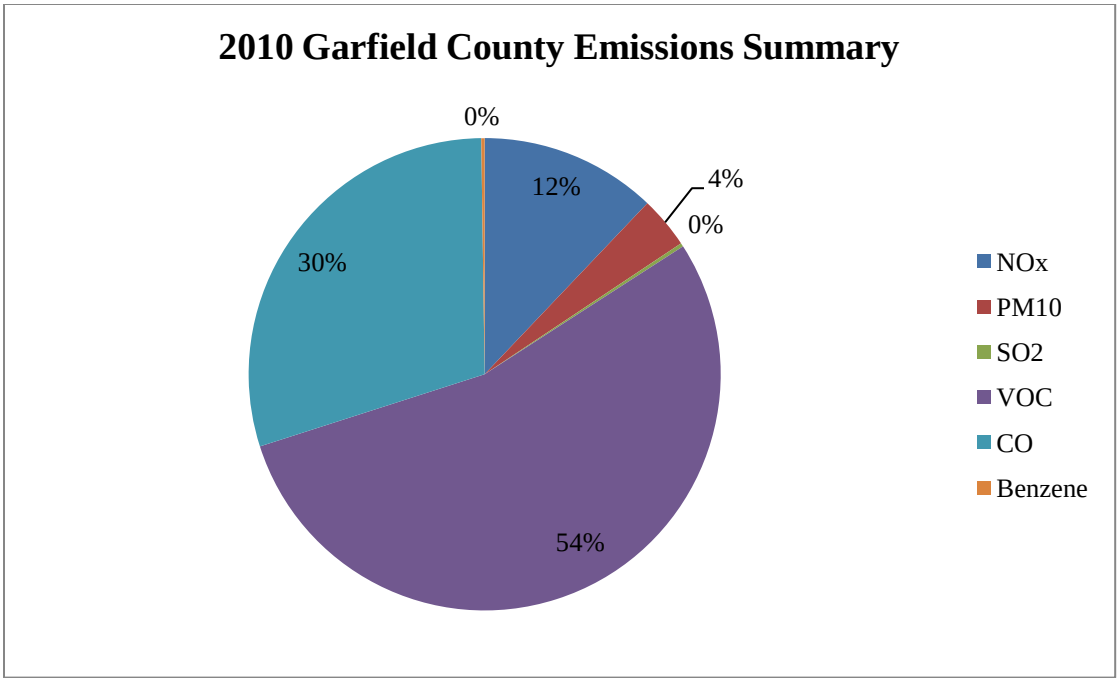

Figure 2: Garfield County Emissions Inventory Summary

As can be seen in both Table 1 and Figure 2, VOCs are the largest percentage of emissions followed by carbon monoxide (CO). It can also be seen that these two pollutants are emitted in significantly higher quantities than the other pollutants in Garfield County.

VOCs are the largest pollutant emitted in Garfield County and are dominated by oil and gas activity emissions. This is not typical for most areas; usually the biogenic category is the main source of VOC pollution. Biogenic emissions make up the bulk of the rest of the VOC emissions. CO is the second largest pollutant emitted in Garfield County and is mostly attributed to mobile sources and also oil and gas activities.

2.1 Nitrogen Oxides (NO_x)

Statewide, the majority of NO_x is attributed to fossil fuel combustion, with motor vehicles contributing 40%, power plants and other industrial facilities contributing 24%. Biogenic activity (biological decay, lightning) adds approximately 14%.

- The West Slope Region emits about 17% of total NO_x in Colorado.
- Garfield County contributes 29% of West Slope NO_x.
- Garfield County contributes 5% of NO_x statewide.

Figure 3 depicts the breakdown of NO_x in Garfield County. It is clear that oil and gas activities dominate NO_x emissions in the county, contributing 79% of emissions. A combination of mobile (16%) and biogenic emissions (3%) make up the rest of the NO_x emissions in the county.

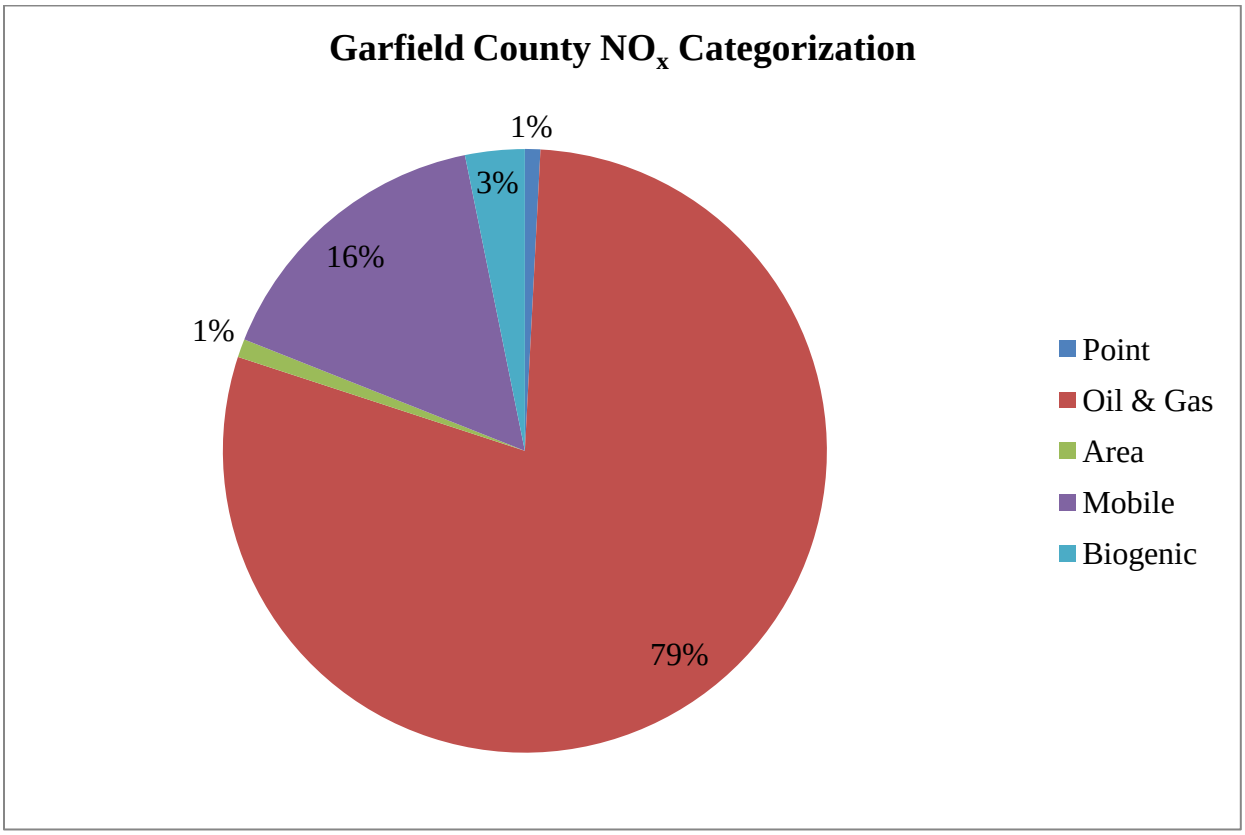

Figure 3: Garfield County NO_x Summary

2.2 Particulate Matter (PM_{10})

Particulate matter includes dust, dirt, soot, smoke, and liquid droplets. Statewide, mobile vehicles emit 34%, agriculture 30%, construction 23%, and industrial facilities and woodburning lesser amounts.

- The West Slope region contributes around 10% of total PM_{10} in Colorado.
- Garfield County contributes 15% of West Slope PM_{10}.
- Garfield County contributes 1% of PM_{10} statewide.

Figure 4 shows PM_{10} emissions in Garfield County. A combination of area sources (62%), oil and gas activities (17%), and mobile sources (15%) account for most of the PM_{10} emissions in the county.

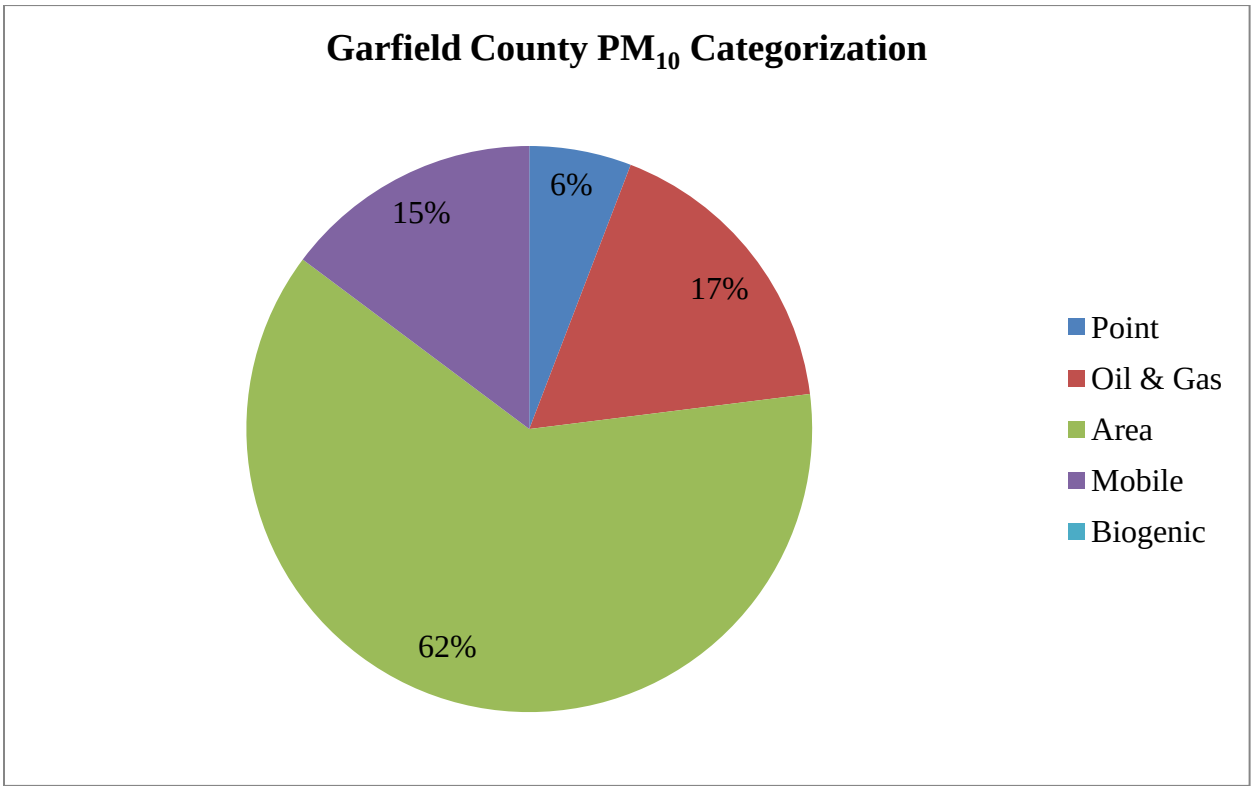

Figure 4: Garfield County PM_{10} Summary

2.3 Sulfur Dioxide (SO_2)

The major source of sulfur dioxide is from power plants and industrial facilities that derive product from raw materials such as metallic ore, coal, and crude oil (refineries, cement manufacturing), with 95% of SO_2 emissions in Colorado originating from these sources. Less than 5% is emitted from mobile source that burn diesel (aircraft, locomotives).

- The West Slope region contributes 15% of statewide SO_2.
- Garfield County contributes 4% of West Slope SO_2.
- Garfield County contributes 1% of SO_2 statewide.

Figure 5 illustrates SO_2 emissions for Garfield County. It is clear that oil and gas activities dominate SO_2 emissions in the county, contributing 73% of emissions. A combination of mobile (13%), point (8%), and area sources (6%) make up the rest of the SO_2 of emissions in the county.

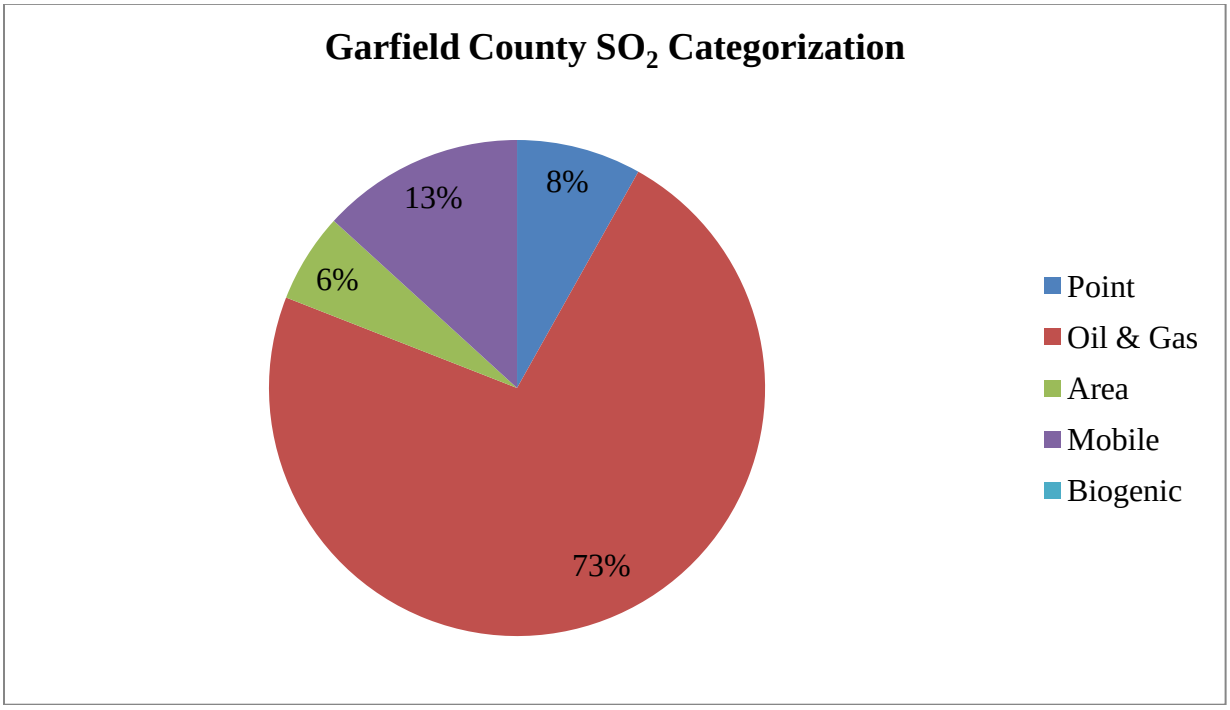

Figure 5: Garfield County SO_2 Summary

2.4 Volatile Organic Compounds (VOCs)

VOCs are chemicals containing hydrogen, carbon, and other elements that evaporate easily. Hundreds of these compounds are present in the atmosphere. In the presence of sunlight and NOx, VOCs react to form ground-level ozone, a component of smog. In Colorado, biogenic sources (organic compounds from vegetation) are also a major source of emissions, comprising over 70% of total VOCs. Statewide, anthropogenic sources are oil and gas (14%), mobile sources (9%), paints and solvents (3%), and woodburning (1%).

For the purposes of understanding which man-made source categories contribute VOCs, oftentimes inventories are examined with and without biogenic emissions.

For the purposes of understanding which man-made source categories contribute VOCs, oftentimes inventories for these compounds are examined with and without biogenic emissions, as shown in Table 2.

Table 2: Garfield County VOC Emissions with and without Biogenic Emissions

With Biogenic VOC Emissions	Without Biogenic VOC Emissions
The West Slope region contributes approximately 20% of total VOCs in Colorado.	The West Slope region contributes approximately 18% of total VOCs in Colorado when not accounting for biogenic sources.
Garfield County contributes 26% of West Slope VOCs.	Garfield County contributes 58% West Slope VOCs when not accounting for biogenic sources.
Garfield County contributes 5% of VOCs statewide.	Garfield County contributes 11% of VOCs statewide when not accounting for biogenic sources.

Figure 6 depicts VOC emissions without biogenic sources included in Garfield County. Most of Garfield County's man-made VOC emissions are from oil and gas activities (91%).

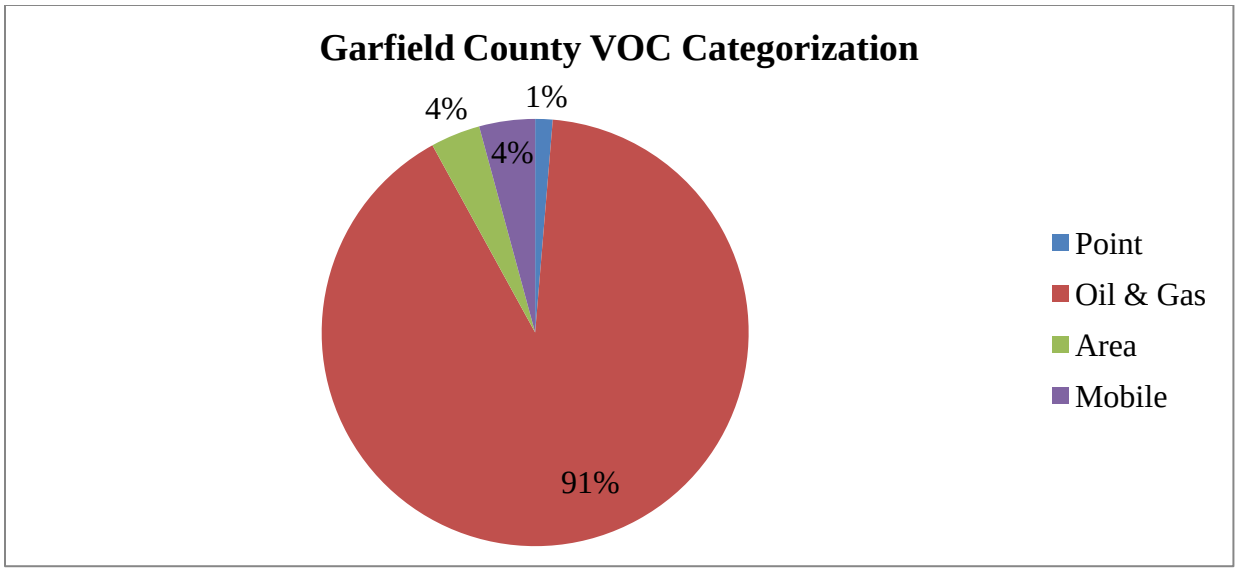

Figure 6: Garfield County VOC Summary (without biogenic sources)

2.5 Carbon Monoxide (CO)

Carbon monoxide is primarily emitted from mobile sources, such aircraft, trucks, automobile, non-road mobile (construction and farm equipment), and railroads. Mobile source contribute around 75% of total CO emissions in Colorado. Wildfires (considered biogenic) are about 10%, woodburning 7%, oil and gas fuel combustion 3%, and other fuel combustion sources less than 5%.

- The West Slope region contributes approximately 11% to total CO emissions in Colorado.
- Garfield County contributes 24% of CO emissions in the West Slope region.
- Garfield County contributes 3% of CO statewide.

Figure 7 shows CO emissions in Garfield County. The most significant source categories for Garfield County's CO emissions are mobile sources (44%) and oil and gas activities (32%).

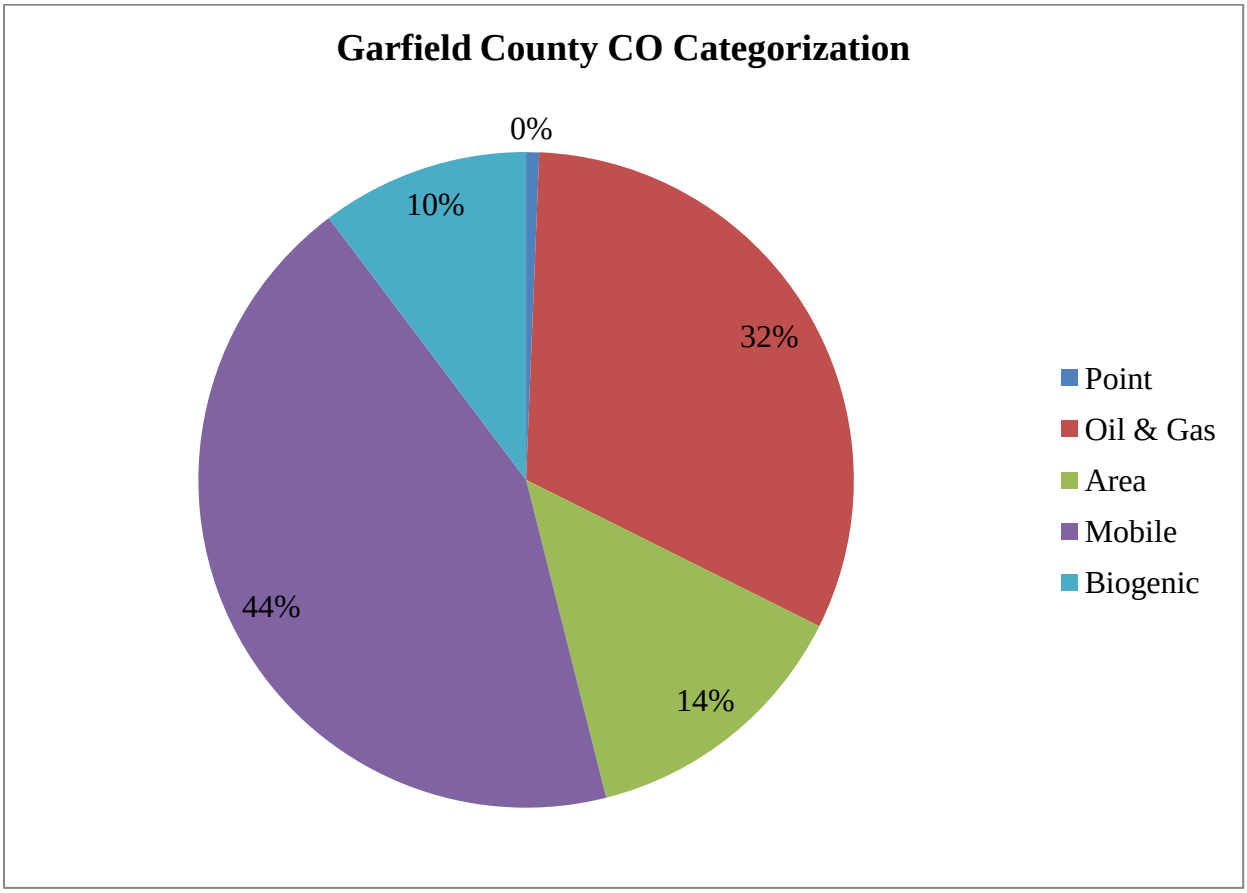

Figure 7: Garfield County CO Summary

2.6 Benzene (C_6H_6)

Benzene is not considered a criteria pollutant. However, benzene is a considered a Hazardous Air Pollutant (HAP) and facilities submit Addendum Forms noting when benzene is emitted. Benzene is a "trigger" pollutant in Colorado for HAPs and is also important as one of the main components of gasoline. Mobile sources contribute about 66% of total benzene in Colorado, area sources (such as woodburning) contribute 17%, and oil and gas activities contribute 14%.

- The West Slope region contributes 18% of total benzene emissions in Colorado.
- Garfield County contributes 35% of benzene emissions in the West Slope region.
- Garfield County contributes 6% of benzene statewide.

Figure 8 demonstrates benzene emissions in Garfield County. The benzene emissions in Garfield County can be mostly attributed to oil and gas activities (71%) and mobile sources (16%).

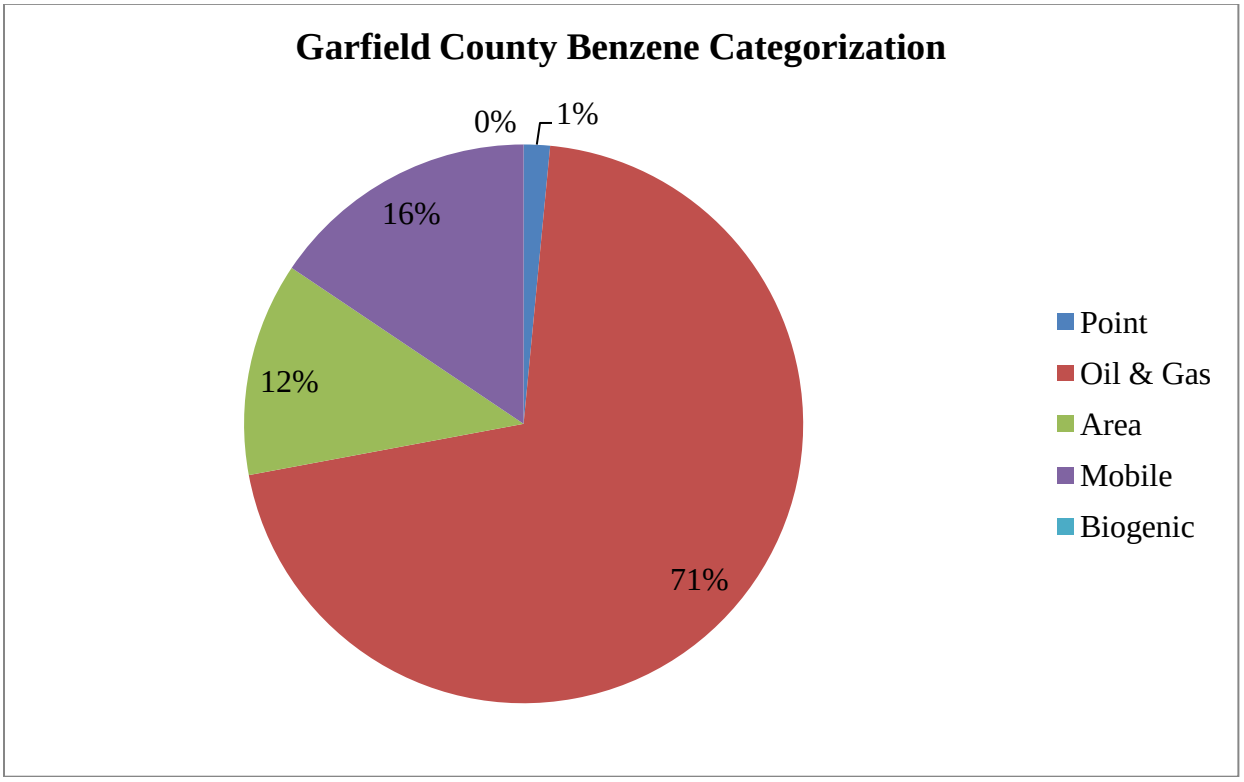

Figure 8: Garfield County Benzene Summary

3.0 Emission Trends in Garfield County

Emission inventory reports are often used to evaluate trends for planning purposes and meeting air quality goals for a region. In this section, emission trends in Garfield County are demonstrated. The emission totals are figured both with and without fire emissions. Fire emissions are more unpredictable than the other categories of emissions, so removing the fire totals, give a more stable look at the emission trends through time. Biogenic emissions remain constant over the years as the forested area of the county has remained essentially the same over the period.

As emissions inventories have been refined over time and as new information becomes available, more detailed break-outs of source types is possible. The "Stationary Sources" category is an example of this, where it can be broken out into what are oil and gas-related sources and what are not. Table 3 through Table 8 show emissions inventory data for the years 1996, 2000, 2005, 2007 and 2010. It should be noted that minimum reporting levels and calculation methodologies for pollutants and source categories have changed over time. Thus, older inventories are not necessarily comparable to more recent inventories and comparisons should not be seen as definitive for trends.

3.1 Nitrogen Oxides Emission Trends

Nitrogen dioxide emissions (Table 3), excluding fire, have increased over the 1996 to 2010 period, particularly from 2005 to 2010. As can be seen in Figure 9, this increase is mostly from the recent increase in oil and gas activities. Highway vehicle emissions have decreased from 1996 to 2010. A combination of fleet turnover, tightened fuel standards, and methodology changes are the causes for this reduction. The large increases in stationary source emissions of nitrogen dioxide are mostly due to increased oil and gas activities. It is quite possible that some of this is also an artifact in the inventory due to better reporting, accounting and/or estimation techniques. Excluding fires, which can be variable from year to year, overall nitrogen dioxide emissions increased approximately 72% from 1996 to 2010.

Table 3: NO_x Emission Trends in Garfield County

Nitrogen Oxides (tons/year)						
Year		1996	2000	2005	2007	2010
Agriculture		[3]			0[2]	
Aircraft		0	0	0	0	1
Biogenic		471	471	471	471	471
Commercial Cooking					0	0
Construction					0	0
Forest and Prescribed Fire		234	100	20	60	17
Fuel Combustion		64	64	63	66	70
Highway Vehicles		3,179	2,852	1,919	2,010	1,402
Non-Road		211	478	400	324	350
Stationary Sources[1]	O&G area	1,558	1,748	4,404	4,639	6,288
	O&G point				4,281	5,424
	Other Point Sources				113	122
Pesticide Application						0
Portable Fuel Containers						0
Railroads		511	543	467	508	584
Refueling					0	0
Road Dust					0	0
Solvent Utilization					0	0
Structure Fires					0	0
Surface Coating						0
Tank Trucks In Transit						0
Woodburning		26	39	36	39	57
TOTAL		6,254	6,296	7,782	12,512	14,786
Total without Fire		6,020	6,196	7,762	12,452	14,769

[1]For "Stationary Sources", improvements in the emissions inventory over time now allow for more detailed break-outs of source types.

1996 and 2000: "Stationary Sources" = all area + all point sources
2005: "Stationary Sources" = all point sources + all non-oil & gas area sources
2007: "Stationary Sources" split out into 3 sub categories

[2]Zero values are for data that have been reported as zero or estimated to be zero.
[3]Blank values are those for which no data has been reported or estimated.

Figure 9, below shows how the NO_x emissions have changed over time for the top significant pollutant categories. "Stationary Sources" represents the sum of oil and gas point and area sources as well as the other point sources category. Oil and gas area and point sources represent almost 99% of the stationary source NO_x emissions in Garfield County in 2010. Oil and gas area and point sources are the top two source categories for NO_x emissions and contribute 79% of all NOx emissions in Garfield County. Although highway vehicles are third highest source category for NOx emissions in Garfield County, only 9% of NO_x emissions are from highway vehicles.

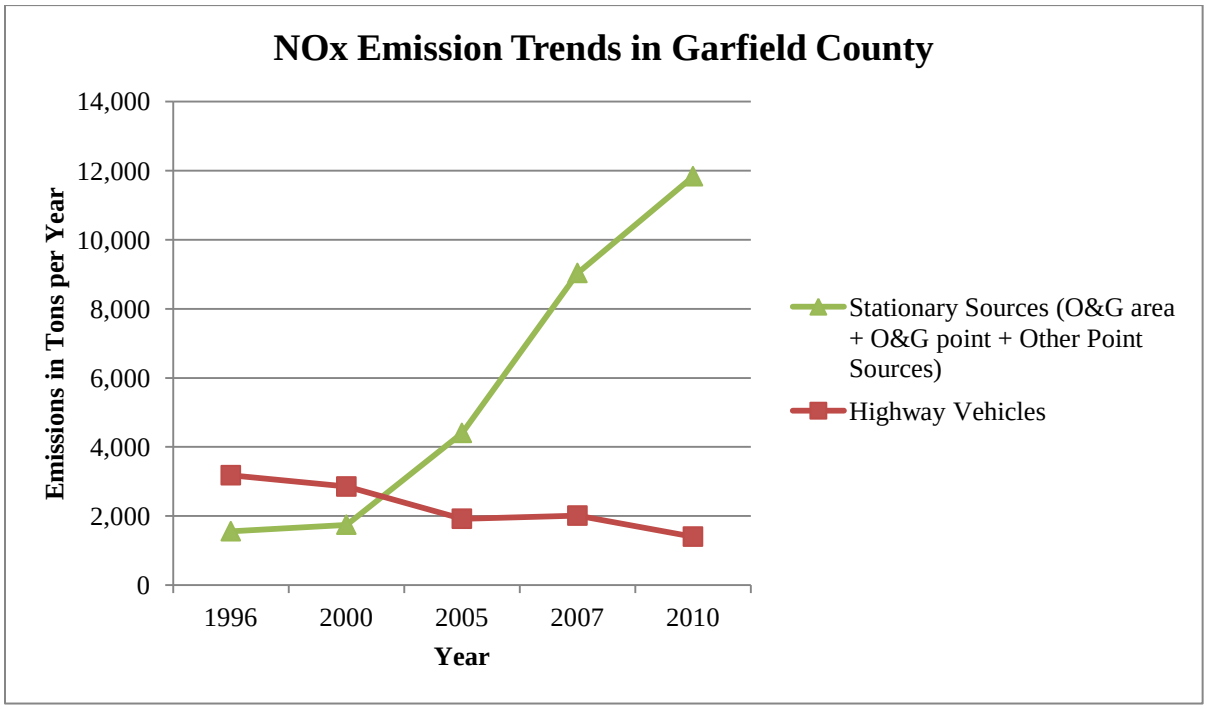

Figure 9:NO_x Emission Trends in Garfield County for the Top Significant Pollutant Categories

3.2 Particulate Matter Emission Trends

Particulate emissions (Table 4) have increased for a number of significant sources from 1996 to 2010. Figure 10 illustrates that stationary sources have increased from 2005 due to oil and gas development activities. It is quite possible that some of this is an artifact in the inventory due to better reporting, accounting and/or estimation techniques. Road dust is one category that has decreased significantly from 2007 to 2010, due to a reduction in vehicles mile traveled on unpaved roads. Excluding fires, which can be variable from year to year, overall PM_{10} increased approximately 28% from 1996 to 2010.

Table 4: PM_{10} Emission Trends in Garfield County

PM_{10} (tons/year)						
Year		1996	2000	2005	2007	2010
Agriculture		436	86	81	81	81
Aircraft		0[2]	1	1	1	2
Biogenic		0	0	0	0	0
Commercial Cooking		22	27	31	33	16
Construction		599	973	973	1,017	1,920
Forest and Prescribed Fire		796	331	62	307	88
Fuel Combustion		3	3	0	0	1
Highway Vehicles		111	71	53	46	62
Non-Road		33	50	41	33	33
Stationary Sources[1]	O&G area	591	195	290	664	604
	O&G point				109	138
	Other Point Sources				237	252
Pesticide Application		[3]				0
Portable Fuel Containers						0
Railroads		13	13	12	13	14
Refueling						0
Road Dust		903	1,091	950	1,083	527
Solvent Utilization					0	0
Structure Fires					1	1
Surface Coating					0	0
Tank Trucks In Transit						0
Woodburning		336	387	467	507	581
TOTAL		3,842	3,227	2,962	4,132	4,322
Total without Fire		3,046	2,896	2,899	3,825	4,234

[1]For "Stationary Sources", improvements in the emissions inventory over time now allow for more detailed break-outs of source types.

1996 and 2000: "Stationary Sources" = all area + all point sources
2005: "Stationary Sources" = all point sources + all non-oil & gas area sources
2007: "Stationary Sources" split out into 3 sub categories

[2]Zero values are for data that have been reported as zero or estimated to be zero.
[3]Blank values are those for which no data has been reported or estimated.

Figure 10 below shows how the PM_{10} emissions have changed through time for the top pollutant categories. "Stationary Sources" represents the sum of oil and gas point and area sources as well as the other point source category. It should be noted that oil and gas area sources are the largest stationary source contributor, at about 61% of total emissions from stationary sources in 2010.

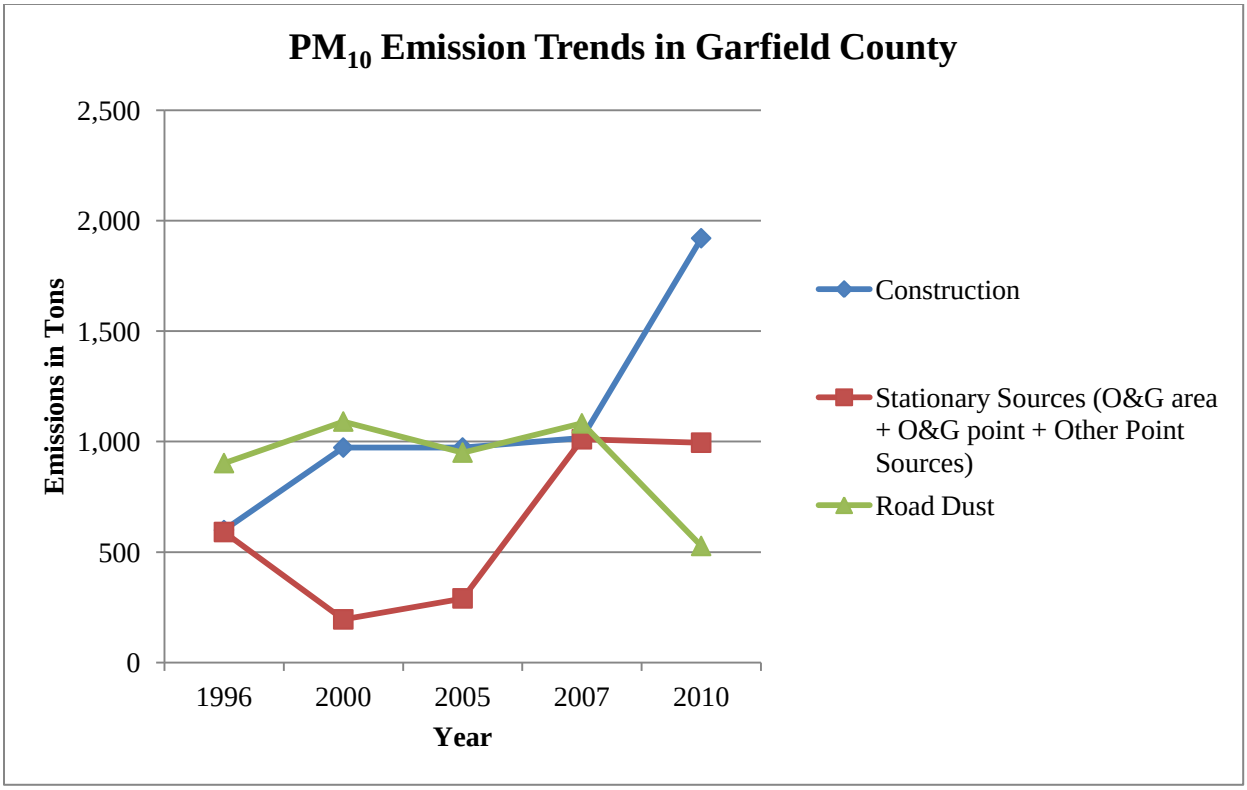

Figure 10: PM_{10} Emission Trends in Garfield County for the Top Pollutant Categories

3.3 Sulfur Dioxide Emission Trends

Sulfur dioxide emissions (Table 5) in Garfield County are minimal as there are no major sources such as coal burning power plants. As can be seen in Figure 11, emissions from highway vehicles have decreased significantly from 1996 to 2010, likely due to ultra-low sulfur diesel fuel standards that began phase-in requirements in 2006. Emissions of sulfur dioxide from non-road sources have also decreased significantly since 2000 due to similar low-sulfur diesel fuel standards that began phase-in requirements in 2007, and ultra-low sulfur standards with requirements starting in 2010. Stationary sources, particularly for oil and gas, have increased dramatically since 2005 as can be seen in Figure 11. It is quite possible that this is an artifact in the inventory due to better reporting, accounting and/or estimation techniques. Excluding fires, which can be variable from year to year, overall sulfur dioxide emissions increased approximately 29% from 1996 to 2010.

Table 5: SO_2 Emission Trends in Garfield County

Sulfur Dioxide (tons/year)						
Year		1996	2000	2005	2007	2010
Agriculture		[3]			0[2]	
Aircraft		0	0	0	0	0
Biogenic		0	0	0	0	0
Commercial Cooking					0	0
Construction					0	0
Forest and Prescribed Fire		9	4	4	19	6
Fuel Combustion		14	13	2	2	2
Highway Vehicles		102	101	57	16	5
Non-Road		23	112	47	10	1
Stationary Sources[1]	O&G area	29	11	19	185	168
	O&G point				11	48
	Other Point Sources				20	24
Pesticide Application						0
Portable Fuel Containers						0
Railroads		32	25	27	29	33
Refueling						0
Road Dust					0	0
Solvent Utilization					0	0
Structure Fires					0	0
Surface Coating					0	0
Tank Trucks In Transit						0
Woodburning		5	6	7	8	9

TOTAL	214	271	162	300	297
Total without Fire	206	267	159	281	291

[1]For "Stationary Sources", improvements in the emissions inventory over time now allow for more detailed break-outs of source types.

1996 and 2000: "Stationary Sources" = all area + all point sources
2005: "Stationary Sources" = all point sources + all non-oil & gas area sources
2007: "Stationary Sources" split out into 3 sub categories

[2]Zero values are for data that have been reported as zero or estimated to be zero.
[3]Blank values are those for which no data has been reported or estimated.

Figure 11 below shows how SO_2 emissions have changed over time for the top pollutant categories. "Stationary Sources" represents the sum of oil and gas point and area sources as well as the other point source category. Oil and gas area sources are the main contributor to stationary source emissions, contributing 70% in 2010.

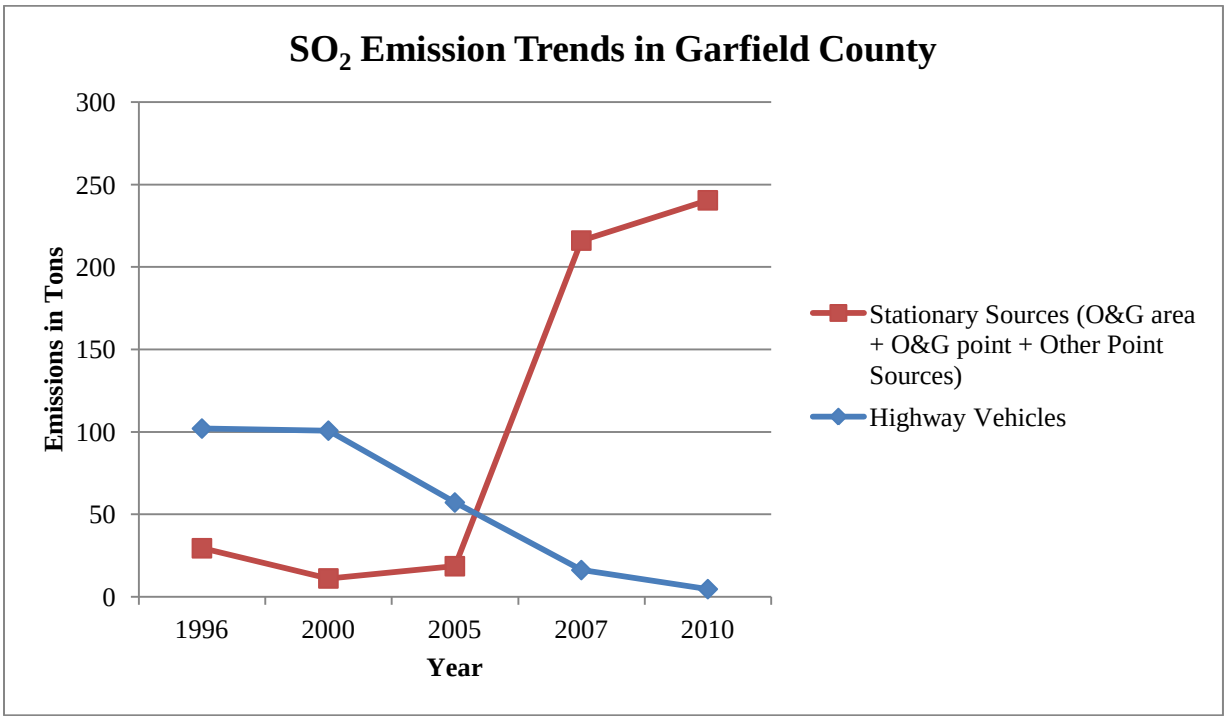

Figure 11: SO_2 Emission Trends in Garfield County for the Top Pollutant Categories

3.4 Volatile Organic Compounds Emission Trends

Volatile organic compound emissions (Table 6) from highway vehicles decreased from 1996 through 2005, likely due to fleet turnover, but increased slightly in 2007, due to population growth. Woodburning emissions of VOCs have also increased over time, due to population growth. The large increases in stationary source emissions of VOCs as seen in Figure 12 are mostly due to oil and gas sources. Once again, it is quite possible that some of this is an artifact in the inventory due to better reporting, accounting and/or estimation techniques. Excluding fires, which can be variable from year to year, overall VOC emissions increased approximately 50% from 1996 to 2010.

Table 6: VOC Emission Trends in Garfield County

Volatile Organic Compounds (tons/year)						
Year		1996	2000	2005	2007	2010
Agriculture		[3]			0[2]	
Aircraft		1	1	1	1	10
Biogenic		27,966	27,966	27,966	27,966	27,966
Commercial Cooking		3	4	4	4	15
Construction					0	0
Forest and Prescribed Fire		1,069	475	28	143	149
Fuel Combustion		2	3	4	4	5
Highway Vehicles		1,982	1,766	1,092	1,288	1,123
Non-Road		527	428	398	375	333
Stationary Sources[1]	O&G area	1,396	1,621	7,558	14,635	19,837
	O&G point				8,196	14,807
	Other Point Sources				1,920	503
Pesticide Application						55
Portable Fuel Containers						33
Railroads		19	21	17	19	22
Refueling						93
Road Dust					0	0
Solvent Utilization		504	339	118	124	232
Structure Fires					1	1
Surface Coating				183	191	170
Tank Trucks In Transit						1
Woodburning		649	795	901	979	812
TOTAL		34,117	33,418	38,271	55,845	66,163
Total without Fire		33,049	32,943	38,243	55,702	66,014

[1]For "Stationary Sources", improvements in the emissions inventory over time now allow formore detailed break-outs of source types.

1996 and 2000: "Stationary Sources" = all area + all point sources
2005: "Stationary Sources" = all point sources + all non-oil & gas area sources
2007: "Stationary Sources" split out into 3 sub categories

[2]Zero values are for data that have been reported as zero or estimated to be zero.
[3]Blank values are those for which no data has been reported or estimated.

Figure 12 below shows how VOC emissions have changed through time for the top three pollutant categories, except biogenic. "Stationary Sources" represents the sum of oil and gas point and area sources as well as the other point source category. Oil and gas area and point sources represent almost 99% of the stationary source VOC emissions in Garfield County in 2010. Although woodburning produces much lower emissions than stationary sources/oil and gas activities, it should not be discounted as a potential source category for further consideration.

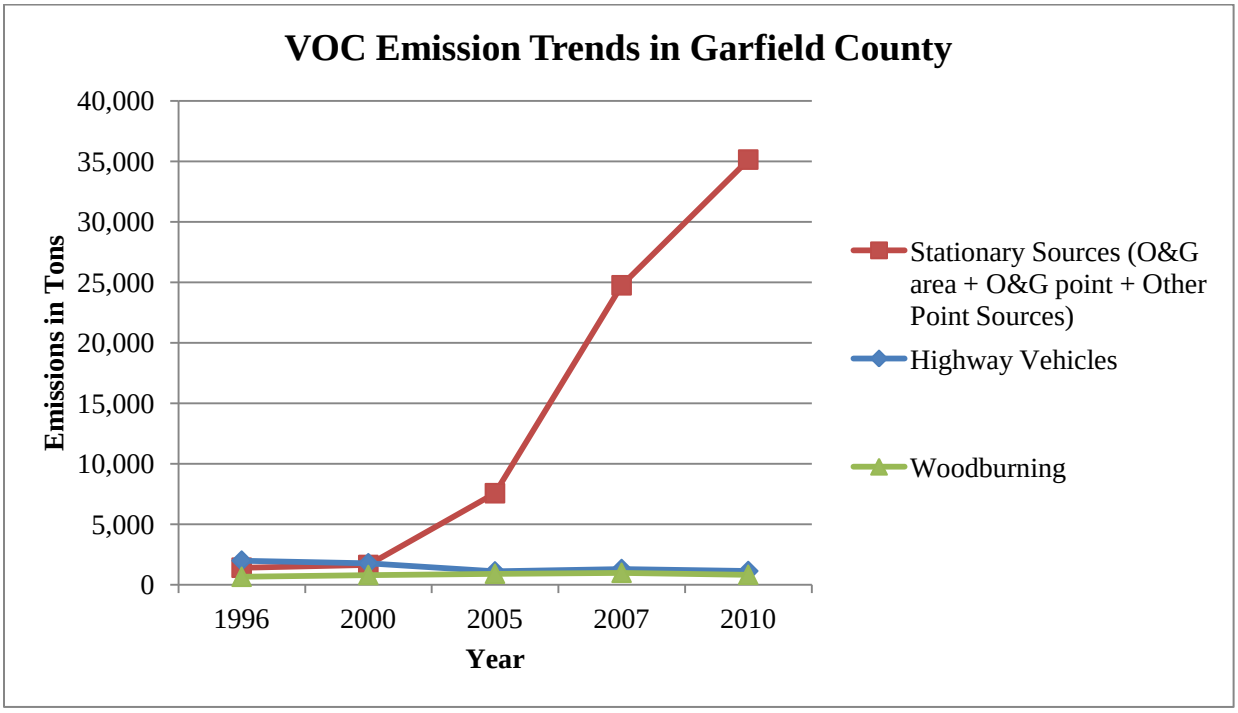

Figure 12: VOC Emission Trends in Garfield County for the Top Three Pollutant Categories, Except Biogenic

3.5 Carbon Monoxide Emission Trends

Carbon monoxide emissions (Table 7), excluding fire, decreased (13%) from 2007 to 2010, due to non-road mobile fuel standards. As can been seen in Table 7 and Figure 13, woodburning emissions of carbon monoxide have steadily increased over time, due to population growth. The large increase over time in stationary source emissions of carbon monoxide are mostly due to oil and gas activities, though it is quite possible that some of this is an artifact in the inventory due to better reporting, accounting and/or estimation techniques. Excluding fires, which can be variable from year to year, overall carbon monoxide emissions decreased approximately 18% from 1996 to 2010.

Table 7: Carbon Monoxide Emission Trends in Garfield County

Carbon Monoxide (tons/year)						
Year		1996	2000	2005	2007	2010
Agriculture		[3]			0[2]	
Aircraft		21	32	35	38	113
Biogenic		3,730	3,730	3,730	3,730	3,730
Commercial Cooking		8	10	12	12	6
Construction					0	0
Forest and Prescribed Fire		8,143	3,511	500	2,241	713
Fuel Combustion		30	33	27	28	53
Highway Vehicles		30,684	27,115	18,683	21,255	12,888
Non-Road		4,451	3,924	5,350	3,964	2,787
Stationary Sources[1]	O&G area				4,147	8,370
	O&G point				3,152	3,147
	Other Point Sources	627	1,273	2,558	125	233
Pesticide Application						0
Portable Fuel Containers						0
Railroads		52	52	46	50	58
Refueling						0
Road Dust					0	0
Solvent Utilization					0	0
Structure Fires					3	4
Surface Coating					0	0
Tank Trucks In Transit						0
Woodburning		2,409	2,788	3,348	3,636	4,197
TOTAL		50,155	42,468	34,289	42,383	36,297
Total without Fire		42,011	38,957	33,789	40,142	35,585

[1]For "Stationary Sources", improvements in the emissions inventory over time now allow for more detailed break-outs of source types.

1996 and 2000: "Stationary Sources" = all area + all point sources

2005: "Stationary Sources" = all point sources + all non-oil & gas area sources

2007: “Stationary Sources” split out into 3 sub categories

[2]Zero values are for data that have been reported as zero or estimated to be zero.

[3]Blank values are those for which no data has been reported or estimated.

Figure 13 below shows how the CO emissions have changed through time for the top significant pollutant categories except the biogenic category. “Stationary Sources” represents the oil and gas point and area sources as well as the other point source category all added together. Oil and gas area and point sources represent about 98% of the stationary source CO emissions in Garfield County in 2010.

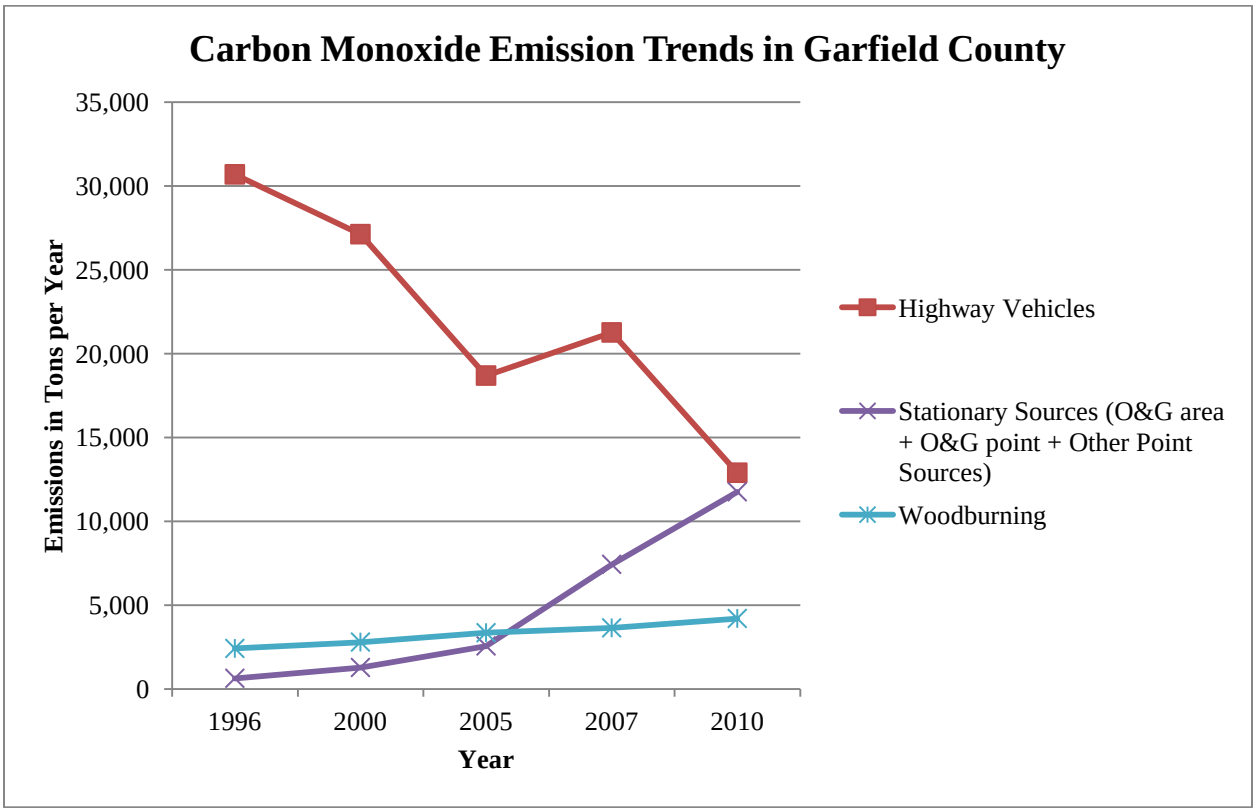

Figure 13: Carbon Monoxide Emission Trends in Garfield County for the Top Pollutant Categories

3.6 Benzene Emission Trends

Benzene emissions (Table 8) are a small portion of the total air emissions in Garfield County. As can be seen in Figure 14 below, highway vehicle emissions have decreased, but stationary source benzene emissions have increased. This increase in the stationary source area is in large part due to the increased oil and gas development in the County. Excluding fires, which can be variable from year to year, overall benzene emissions increased approximately 35% from 1996 to 2010.

Table 8: Benzene Emission Trends in Garfield County

Benzene (tons/year)						
Year		1996	2000	2005	2007	2010
Agriculture		[3]			0[2]	0
Aircraft			0	0	0	0
Biogenic		0	0	0	0	0
Commercial Cooking		0	0	0	0	0
Construction					0	0
Forest and Prescribed Fire		78	34	2	11	0
Fuel Combustion		0	0	0	0	0
Highway Vehicles		74	66	41	37	32
Non-Road		14	11	11	12	11
Stationary Sources[1]	O&G area	79	102	202	0	0
	O&Gpoint				202	198
	Other Point Sources				12	4
Pesticide Application						0
Portable Fuel Containers						0
Railroads		0	0	0	0	0
Refueling						0
Road Dust					0	0
Solvent Utilization				5	5	0
Structure Fires					0	0
Surface Coating					0	0
Tank Trucks InTransit						0
Woodburning		16	20	20	25	34
TOTAL		262	234	281	304	281
Total without Fire		183	200	279	293	281

[1]For "Stationary Sources", improvements in the emissions inventory over time now allow for more detailed break-outs of source types.

1996 and 2000: "Stationary Sources" = all area + all point sources

2005: “Stationary Sources” = all point sources + all non-oil & gas area sources
2007: “Stationary Sources” split out into 3 sub categories

[2]Zero values are for data that have been reported as zero or estimated to be zero.
[3]Blank values are those for which no data has been reported or estimated.

Figure 14 below shows how benzene emissions have changed through time for the top three pollutant categories. “Stationary Sources” represents the sum of oil and gas point and area sources as well as the other point source category. Oil and gas point sources represent about 98% of the stationary source benzene emissions in Garfield County in 2010. Although woodburning produces much lower emissions than stationary sources/oil and gas activities, it should not be discounted as a potential source category for further consideration.

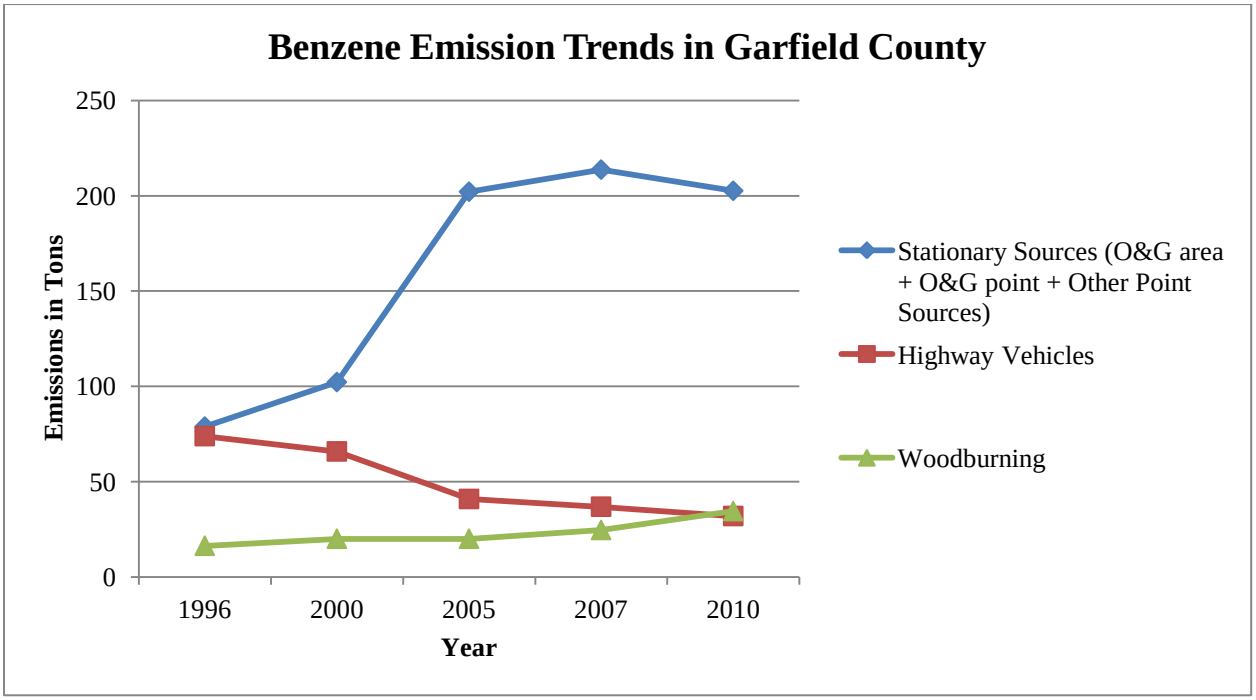

Figure 14: Benzene Emission Trends in Garfield County for the Top Pollutant Categories

4.0 Conclusions

This report provides a general context of what an emission inventory is, and what pollutants and sources are inventoried. Pollutants inventoried include some of the criteria or health-based pollutants (carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide and particulates) and volatile organic compounds. The county inventory presented in this report is for 2010, which is the most current complete inventory that is available.

This report describes the largest sources of air pollution for each pollutant. In some cases one of the largest source of emissions are natural or biogenic. This is particularly valid for volatile organic compounds. In many cases, anthropogenic (man-made) emissions are the largest sources. Major anthropogenic categories include mobile sources (cars and trucks), stationary point

sources (specific emission points large enough to require a permit) and area sources (small pollution sources located over a wide area, such as wood burning).

For nitrogen dioxide, oil and gas activities are the primary contributors of emissions in Garfield County followed by highway vehicle emissions. Nitrogen dioxide emissions, excluding fires, have increased 72% from 1996 to 2010. For PM_{10}, construction and oil and gas activities are the largest sources. PM_{10} emissions, excluding fires, have increased 28% from 1996 to 2010. For sulfur dioxide, oil and gas activities are the largest contributors. Sulfur dioxide emissions, excluding fires, have increased 29% from 1996 to 2010. For VOCs, oil and gas activities and biogenic sources are the primary contributors. VOC emissions, excluding fires, have increased 50% from 1996 to 2010. For carbon monoxide, highway vehicles and oil and gas activities are the largest source in Garfield County. Carbon monoxide emissions, excluding fires, have decreased 18% from 1996 to 2010.

5.0 Colorado Department of Public Health and Environment Contact Information

Please contact either Lisa Clarke, Air Quality Planner– Lisa.Clarke@state.co.us or 303-692-3117 or Kaitlin Stabrava, Community Outreach Planner – Kaitlin.Stabrava@state.co.us or 303-691-4086 at the Colorado Air Pollution Control Division if you have questions or would like to find out more information about this inventory.

Appendix A: References

U.S. Environmental Protection Agency
Clearinghouse for Inventories and Emission Factors
http://www.epa.gov/ttn/chief/

U.S. Environmental Protection Agency
Envirofacts Data Warehouse
http://www.epa.gov/enviro/

U.S. Environmental Protection Agency
Support Center for Regulatory Atmospheric Modeling
http://www.epa.gov/ttn/scram/

Colorado Department of Public Health and Environment
Emissions Inventory Viewer
http://www.colorado.gov/airquality/county_inventory.aspx

Agency for Toxic Substances and Disease Registry
ToxFAQs Fact Sheets of Toxic Compounds and Health Effects
http://www.atsdr.cdc.gov/toxfaq.html

Appendix B: Acronyms

APCD	Air Pollution Control Division
APEN	Air Pollution Emission Notice
ATSDR	Agency for Toxic Substances and Disease Registry
CDPHE	Colorado Department of Public Health and Environment
CO	Carbon monoxide
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information Systems
HAP	Hazardous air pollutant
NET	National Emission Trends
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
PM_{10}	Particulates 10 microns in diameter and smaller
SO_2	Sulfur dioxide
VOC	Volatile organic compound

Appendix C: Methods

More detailed methods for each emission category are provided in this appendix.

Agriculture:
These emissions include tilling activities based on crop types. The information comes from the agriculture census. Total acres of agricultural land are established for the area, and then an emission factor is applied to the acreage based on general assumptions about crop cover in the area.

Aircraft:
These emissions consist primarily of combustion emissions of fuel during take offs and landings. The number of take-offs and landings are estimated on an annual basis.

Biogenic:
Biogenic emissions are those produced by living organisms or biological processes. They are emissions are from plant life and soils, and are not a controllable source. Total acreage and plant cover is estimated and an emission factor is applied.

Commercial Cooking:
This category includes emissions from commercial restaurants. The emission factors come from EPA National Emission Inventory (NEI) data. The activity level or number of restaurants comes from a per capita number.

Construction:
These emissions include dirt-moving operations for residential and commercial construction.

Fuel Combustion:
These emissions include natural gas/propane used for space heating. The activity level is based on per capita numbers and utility company fuel usage numbers.

Highway Vehicles:
These emissions were calculated based on vehicle miles traveled (VMT) and the EPA Mobile emission factor model (MOVES). The VMT were obtained from the Federal Highway Performance Management System.

Non-road:
This category includes emissions from heavy equipment.

Railroads:
This category estimates emissions based on fuel usage of the trains. The activity level is apportioned by the miles of track in the area.

Solvent Utilization:
These emissions include commercial and residential products and are assigned an emission factor. The activity level is based on a per capita basis.

Surface Coating:
These emissions include small coating operations that would not be required to submit APENs, and are considered area sources. The activity level is based on per capita information.

Wild and Prescribed Fire:
These emissions are based on reports and aerial photography to determine the number of acres burned, the type of vegetation and the vegetation density.

Woodburning:
These emissions are based on per capita wood use.