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EVALUATION OF THE COLORADO AUTOMOBILE INSPECTION AND READJUSTMENT (AIR) PROGRAM

COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

September 2009

Prepared for:

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September 4, 2009

Members of the Legislative Audit Committee:

This report contains the results of an evaluation of the Department of Public Health and Environment's Automobile Inspection and Readjustment (AIR) Program. The evaluation was conducted pursuant to Section 42-4-316, Colorado Revised Statutes, which requires the Legislative Audit Committee to review the performance of the AIR Program every three years to determine the ongoing public need for the Program. The Colorado Office of the State Auditor contracted with *dKC* de la Torre Klausmeier Consulting, Inc., for this evaluation. This report presents our findings, conclusions, and recommendations, and the responses of the Department of Public Health and Environment.

Carol de la Torre

Carol de la Torre
President

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Glossary of Terms and Abbreviations

AIR Program - Automobile Inspection and Readjustment Program. The Program operated by the State of Colorado to control pollutants emitted by automobiles.

Air Quality Control Commission - A citizen board in Colorado state government with authority to develop air pollution control policies, regulate pollution sources, and conduct hearings involving violations of the State's air pollution laws.

Carbon monoxide - A pollutant generated primarily by incomplete combustion of gasoline in motor vehicles. It is one of three precursors in the formation of ozone.

Criteria pollutant - Pollutants for which the federal Environmental Protection Agency has established National Standards.

Cost per ton - The measurement unit for assessing the cost effectiveness of air pollution control strategies.

Denver Metropolitan Area - Geographic area covered by the AIR Program. It includes all or portions of the following counties: Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson.

Department - Department of Public Health and Environment. A principal department in Colorado state government whose mission is to protect and preserve the health and environment of the people of Colorado and which is responsible for administering the AIR Program.

Early Action Compact - An agreement entered into between EPA and Colorado in which Colorado pledged to meet the ozone standard earlier than required.

EGU - Electrical Generation Units. Electricity producing plants, usually coal or natural gas fired.

EPA - Environmental Protection Agency. A federal agency with authority to promulgate air pollution standards.

ESP - Environmental Systems Products. A private company under contract with the Department that conducts emissions tests on all 1982 and newer vehicles registered in the Denver Metropolitan Area.

Ethanol waiver - An approval from the EPA that allows the sale of gasoline-ethanol blends with higher volatility levels than non-blended gasoline.

Evaporative emissions - Vehicle emissions that are caused by evaporation of gasoline as opposed to exhaust emissions that are caused by combustion of fuel in the engine.

Hydrocarbons - A pollutant generated by, among other sources, vehicle exhaust. It is one of three precursors in the formation of ozone.

IM240 test - A component part of the traditional emissions test in which model year 1982 and newer vehicles are placed on a treadmill-like device that simulates a driving cycle typical of urban driving.

LEI - Low Emitter Index. This is a standardized index that is used as an indicator of the probability that a particular vehicle would pass the traditional emissions test based on historical information with respect to its make, model, and year.

MOBILE6.2 - A model developed by EPA for use in air quality modeling and control strategy development. States must use MOBILE6.2 to estimate benefits from inspection and maintenance programs (such as the AIR Program).

MOVES - The EPA's new model for estimating benefits from inspection and maintenance programs (such as the AIR Program). States will be required to use MOVES by the end of Calendar Year 2009.

Nitrogen oxides - A pollutant generated by, among other sources, vehicle exhaust. It is one of three precursors in the formation of ozone.

Ozone - A type of air pollutant, of particular concern in Colorado, which at ground level causes health and environmental problems. Vehicle exhaust contributes to the formation of ozone.

OAP - Ozone Action Plan. A plan, adopted by the Air Quality Control Commission, with strategies for reducing ozone levels in the Denver Metropolitan Area to attain compliance with federal ozone standards.

Parts per billion - The measurement unit for national standards for ozone. The current standard is 85 parts per billion averaged over 8 hours. In Calendar Year 2010 states must comply with a new standard of 75 parts per billion.

SIP - State Implementation Plan. The SIP is a planning document required of each state by the EPA that indicates how states will attain compliance with national standards.

VMR - Vehicle Mailer Request. A document that the Department sends to vehicle owners saying they qualify for Rapid Screen clean screen tests.

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Evaluation of the
Colorado Automobile Inspection and Readjustment (AIR) Program
Department of Public Health and Environment

September 2009

Purpose and Scope

Pursuant to statute (Section 42-4-316, C.R.S.), the purpose of this evaluation was to review the following issues with respect to the Colorado Automobile Inspection and Readjustment (AIR) Program: the effect of the Program on air quality; the cost and relative cost effectiveness of the Program; the need to continue the Program in the future; the application of the Program to assure compliance with warranties on air pollution control equipment; the effectiveness of the Rapid Screen Program; and alternatives for improving the existing AIR Program. The Colorado Office of the State Auditor contracted with *dKC* de la Torre Klausmeier Consulting, Inc., to conduct this performance evaluation which occurred between April and September 2009. We acknowledge the assistance and cooperation of the Department of Public Health and Environment (Department) and the Air Quality Control Commission in completing this report.

Overview

The Colorado General Assembly established the AIR Program in 1980 to reduce vehicle emissions and to meet federal air quality standards. The AIR Program focuses on reducing ozone and carbon monoxide, which are the primary air quality concerns in the Denver Metropolitan Area. Carbon monoxide is emitted directly from manmade sources, such as motor vehicles, while ozone is formed secondarily when carbon monoxide, hydrocarbons, and nitrogen oxides (ozone precursors) mix together in the presence of sunlight. On-road mobile sources contribute about 13 percent of the ozone precursors emitted in the Denver Metropolitan Area.

Under the AIR Program, which measures emissions from cars and gasoline-powered trucks, a vehicle must pass an emissions test to be registered in the Denver Metropolitan Area. Vehicles that fail the test due to excessive emissions are required to be repaired. Emissions tests are conducted either at fixed inspection stations (the traditional emissions test) or through the use of mobile vans utilizing remote sensing technology (Rapid Screen). During Calendar Year 2008 the AIR Program tested about 716,000 vehicles through the traditional emissions test. Of these, about 660,000 (92 percent) passed their inspection the first time. Of the 56,000 vehicles (8 percent) that initially failed the inspection, about 49,000 were subsequently repaired and, when retested, passed the emissions test. Also during Calendar Year 2008, an additional 200,000 vehicles satisfied AIR Program requirements by way of the Rapid Screen Clean Screen test.

AIR Program Emissions Reductions and Costs

We found that the AIR Program's traditional emissions test has reduced hydrocarbon emissions by 19 tons per day, or by 15 percent; carbon monoxide emissions by 160 tons per day, or by 14 percent; and nitrogen oxides emissions by 9.5 tons per day, or by 6 percent. We also found that the AIR Program improves the fuel economy for repaired vehicles. We estimate that fuel consumption for the 49,000 vehicles that failed the traditional emissions test, were repaired, and then passed the test was reduced by 1.9 million gallons per year, saving vehicle owners $4.8 million annually. Finally, we found that although the cost of the AIR Program increased from $42.5 million in Calendar Year 2005 to $43.7 million in Calendar Year 2008, the cost per ton of removing ozone precursors has fallen 21 percent during this period, from $9,800 per ton in Calendar Year 2005 to $7,700 per ton in Calendar Year 2008. The primary reason for the lower cost per ton is that the new emissions standards implemented by the Air Quality Control Commission in May 2008 significantly increased the effectiveness of the Program in reducing emissions of hydrocarbons and nitrogen oxides.

Key Findings

We evaluated the effectiveness of and need for the current AIR Program to help reduce air pollution and comply with federal air quality standards for ozone in the short- and long-term, the effectiveness of Rapid Screen in identifying both "clean" and "high-emitting" vehicles, and potential enhancements or alternatives to the current AIR Program. We found:

- **Need for the AIR Program.** The AIR Program reduces ozone precursors, and thus the amount of ozone in the Denver Metropolitan Area. As a result, the AIR Program is needed in the short-term for the Denver Metropolitan Area to attain compliance with current ozone standards. We estimate that the AIR Program produces a decrease in ozone levels of 0.6 parts per billion. Using Calendar Year 2006 data, we project that without the AIR Program, ozone levels will exceed the federal ozone standard of 85 parts per billion in Calendar Year 2010. However, the ozone reductions provided by the AIR Program are relatively small compared with total ozone concentrations in the Denver Metropolitan Area and may be more expensive than those provided by other air pollution control strategies. Therefore, other controls unrelated to vehicle emissions may be more cost effective in helping the Denver Metropolitan Area attain and maintain compliance with stricter ozone standards in the future.

- **Effectiveness of Rapid Screen**. The State will not be able to rely solely on Rapid Screen to identify vehicles that meet emissions standards or high-emitting vehicles. If Rapid Screen were to replace the traditional emissions test it would reduce the benefits of the AIR Program by 90 percent. Although the percentage of vehicles screened by Rapid Screen has increased significantly since the 2006 review, Rapid Screen is still not reaching about half of the vehicle fleet in the Denver Metropolitan Area and it is unlikely that the Department could increase coverage to the amounts needed to eliminate the traditional emissions test. In addition, when Rapid Screen is used to identify "clean" vehicles that should be exempted from the traditional emissions inspection, Rapid Screen passes some vehicles that should fail the traditional emissions test, which reduces the benefits of the AIR Program by 7 percent for hydrocarbons and carbon monoxide and 14 percent for nitrogen oxides. Further, Rapid Screen is not as effective as the traditional emissions test in identifying high emitting vehicles because it identified as high emitters only 290 (10 percent) of the 2,842 vehicles in our sample that failed the traditional emissions test.

- **On-Board Diagnostic System Testing.** Using on-board diagnostic system testing in addition to the current AIR Program would increase the emissions benefits obtained through the Program by at least 35 percent and would lower the cost per ton of emissions reduced. Specifically, using on-board diagnostic system testing in conjunction with the current AIR Program would reduce ozone levels in the Denver Metropolitan Area by an additional 0.2 parts per billion, for a total reduction of 0.8 parts per billion, compared with the 0.6 parts per billion reduction obtained currently through the Program. Although total repair costs would increase if on-board diagnostic system testing were used, the cost per ton of emissions reductions would decrease from about $7,700 per ton under the current Program to about $7,100 per ton.

- **Other Air Pollution Control Strategies.** Ozone reductions provided by the AIR Program are relatively small when compared with total ozone concentrations in the Denver Metropolitan Area, and current strategies may be more expensive than those provided by other air pollution control strategies. There may be other air pollution control strategies that the Department could adopt which, if implemented, would likely provide more significant ozone reductions than the 0.6 parts per billion resulting from the AIR Program. These strategies could include implementing controls over non-road vehicles and electrical generating units, eliminating the ethanol waiver, and identifying vehicles with excessive evaporative emissions. In total, these strategies could potentially reduce ozone levels in the Denver Metropolitan Area between 2 to 5 parts per billion, based on preliminary analysis, which is 3 to 8 times the reductions achieved by the current AIR Program. Additional work is needed to determine how each of these strategies can be applied to specific sources, how each strategy will impact emissions, how much each strategy will cost, and how each strategy would be implemented.

Our recommendations and the responses from the Department of Public Health and Environment can be found in the Recommendation Locator and in the body of this report.

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RECOMMENDATION LOCATOR
Agency Addressed: Department of Public Health and Environment

Rec. No.	Page No.	Recommendation Summary	Agency Response	Implementation Date
1	31	(a) Maintain the current AIR Program through Calendar Year 2010 and consider implementing enhancements to the Program during this time, and (b) continue to analyze data on the cost effectiveness of the AIR Program compared with other air pollution control strategies to identify the most cost effective set of control strategies in the longer term. If the Department determines that the AIR Program as currently designed is no longer needed, work with the Air Quality Control Commission to evaluate whether the Program should be eliminated or modified and whether other strategies should be adopted. If the Department determines that the AIR Program provides meaningful ozone reductions, consider what changes or enhancements could be made to the Program to improve its effectiveness.	Agree	Ongoing
2	36	Seek to improve the Rapid Screen clean screen program by requesting that the Air Quality Control Commission add nitrogen oxides to the program's qualification criteria and updating the Low Emitter Index to include vehicles with a low probability of failing nitrogen oxides cutpoints. With this enhancement, continue to use Rapid Screen as a clean screen component of the AIR Program.	Agree	April 2010
3	39	Discontinue the Rapid Screen high emitter pilot study when the study is scheduled to terminate in early Calendar Year 2010 and seek any appropriate and necessary amendments to House Bill 06-1302 to reflect the limitations of remote sensing technology.	Agree	January 2011
4	44	Consider incorporating on-board diagnostic system testing, utilizing emissions-related diagnostic trouble codes, into the current AIR Program as an enhancement to the traditional emissions test.	Agree	June 2010

RECOMMENDATION LOCATOR
Agency Addressed: Department of Public Health and Environment

Rec. No.	Page No.	Recommendation Summary	Agency Response	Implementation Date
5	46	Continue to analyze other air pollution control strategies as alternatives to the current AIR Program to help further reduce ozone levels in the Program area. Continue to work with stakeholders and the Air Quality Control Commission to develop a cost effective package of control measures to achieve attainment of the ozone standard.	Agree	Ongoing

Overview of Air Pollution and the AIR Program

Chapter 1

Title 42, Article 4 of the Colorado Revised Statutes provides authority for the Department of Public Health and Environment (Department) to administer the Automobile Inspection and Readjustment (AIR) Program. The Colorado General Assembly established the AIR Program in 1980 to reduce vehicle emissions and to meet federal air quality standards. The federal Environmental Protection Agency (EPA) requires that a vehicle inspection and maintenance program, such as the AIR Program, be established in populated areas that fail to meet National Ambient Air Quality Standards for ozone or carbon monoxide.

The statutes (Section 42-4-316, C.R.S.) require the Legislative Audit Committee to review the performance of the AIR Program, every three years, beginning January 1, 2000. The review is to determine the ongoing public need for the Program and to consider the following factors:

- The demonstrable effect of the AIR Program on ambient air quality ("ambient" is the term used to describe the air we breathe).
- The cost to the public of the AIR Program.
- The cost-effectiveness of the AIR Program relative to other air pollution control programs.
- The need, if any, for further reduction of air pollution caused by mobile sources to attain or maintain compliance with the National Ambient Air Quality Standards.
- The application of the AIR Program to ensure compliance with legally required warranties covering air pollution control equipment.

The Colorado Office of the State Auditor contracted with *dKC* de la Torre Klausmeier Consulting, Inc., to conduct this review. In addition to evaluating the requirements set forth in the statutes (listed above), the review also analyzed data to determine:

- The effectiveness of the Rapid Screen Program.
- Alternatives for improving the existing AIR Program.

The primary purpose of the AIR Program is to reduce air pollution from motor vehicles. In the first half of this chapter, we provide a general discussion of air pollution in the Denver Metropolitan Area (which includes all or portions of the following counties: Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson) and discuss federal standards for maintaining air quality. In the second half of this chapter, we provide a detailed description of the AIR Program, including a history of the Program and changes made to the Program since our last review in 2006. We also present our analysis of the emissions reductions obtained by the AIR Program, the cost of the AIR Program, and the overall cost-effectiveness of the AIR Program, as required by the statutes. Our findings and recommendations related to the overall continued need for the AIR Program, the effectiveness of Rapid Screen, and possible alternatives for improving the AIR Program are contained in Chapter 2.

Air Pollution

Air pollution has many causes, manmade as well as natural. Naturally caused pollution can come from sources such as plants, fires, and geothermal events. Also, pollution can be generated from sources within a geographic area or it can be "blown-in" from outside sources. Manmade pollution comes from both stationary and mobile sources. Stationary sources include, for example, oil refineries and electrical generating plants. Mobile sources include both on-road and off-road vehicles. On-road vehicles are gasoline- or diesel-powered and include passenger cars, light trucks (which include most sport utility vehicles and vans), and heavy-duty vehicles (heavy-duty trucks and buses). Off-road vehicles are primarily diesel-powered and include construction equipment, locomotives, marine vessels, and recreational vehicles such as all-terrain vehicles and snowmobiles.

Air pollution can endanger human health, damage crops and forests, damage building materials, and impair visibility. Health effects from pollution can occur at a range of levels. While many inhaled pollutants have direct respiratory consequences, others affect the heart or nervous system. Additionally, some studies suggest that air pollution can cause DNA damage through the addition of polluting chemicals to the DNA structure. Since motor vehicles contribute to air pollution, they also contribute to adverse health effects. Prolonged exposure to high levels of vehicle emissions can result in a significant increase in mortality and morbidity. Studies have shown that uncontrolled vehicle emissions can have adverse effects on the respiratory and immune systems of individuals in direct contact, and can cause cancer in human beings.

The State has in place comprehensive mechanisms to control pollution from both stationary and mobile sources. With respect to stationary sources, the EPA requires states to mandate "reasonably available control technologies" for new sources. There are mechanisms in place, for example, to control nitrogen oxides burners in oil refineries. The AIR Program, which is the subject of this review, is a mechanism in place to reduce emissions from on-road motor vehicles. It is one of many strategies utilized in the State to control air pollution from all sources.

Ozone

In recent years, ozone, a type of air pollutant, has been of particular concern in Colorado. Although ozone occurs naturally in the stratosphere to provide a protective layer high above the earth, at ground level ozone is a public health nuisance. When inhaled, even at very low levels, ozone can cause health problems, including acute respiratory problems, aggravated asthma, a temporary decrease in lung capacity for some healthy adults, inflamed lung tissue, and impaired immune system defenses. These health problems make people more susceptible to respiratory illness, including bronchitis and pneumonia, and can result in significant increases in emergency room visits and hospital admissions. Children are most at-risk from exposure to ozone, particularly those with symptoms of asthma.

In addition to causing health problems in humans, ground-level ozone harms the environment. Ground-level ozone reduces crop and forest yields and interferes with the ability of plants to produce and store food, which makes them more susceptible to disease, insects, other pollutants, and harsh weather. Ozone also damages the leaves of trees and other plants, affecting the appearance of cities, national parks, and recreation areas.

Ground-level ozone is not emitted directly from manmade sources. It is formed secondarily when the following three pollutants mix together in the presence of sunlight:

- Carbon monoxide
- Nitrogen oxides
- Hydrocarbons

These three pollutants can be caused by natural emissions sources such as trees and wildfires, or they can come from manmade sources, such as automobile exhaust, solvent fumes, and many other manmade emissions sources. Within the Denver Metropolitan Area (Area) approximately 67 percent of the pollutants that make up ozone are from natural sources or are blown in from other geographic areas. Another 20 percent are from stationary and non-road mobile sources. On-road mobile sources contribute about 13 percent of the ozone precursors (the elements that form ozone in the presence of sunlight) emitted in the Denver Metropolitan Area, with about 9 percent coming from cars and light trucks. At the time of the 2006 review, hydrocarbons had been the primary contributor to the creation of ozone in the Denver Metropolitan Area. Extensive air quality modeling has shown, however, that ozone concentrations in the Denver Metropolitan Area are now more sensitive to nitrogen oxides emissions than hydrocarbon emissions.

Air Quality Standards

Under the federal Clean Air Act, the EPA is directed to establish standards for air quality that reduce pollutants to levels that do not impair health. To that end, the EPA has adopted National Ambient Air Quality Standards (National Standards) to protect the public health, allowing for an adequate margin of safety. The EPA has established National Standards for six pollutants: ozone, carbon monoxide, nitrogen dioxide, particulate matter, sulfur dioxide, and lead. Pollutants for which the EPA has established National Standards are referred to as "criteria pollutants." Initially, reducing carbon monoxide was the primary concern in the Denver Metropolitan Area. However, over the past several years ozone has become a greater concern in the Area and is therefore the focus of this report.

National Standards for ozone are measured in parts per billion concentrations in ambient air (i.e., the air that we breathe), and the current standard is 85 parts per billion, averaged over an eight-hour period. The test for compliance with the eight-hour ozone standard is the three-year rolling average of the fourth highest reading, which must be less than 85 parts per billion. The EPA enacted the 85 parts per billion standard in Calendar Year 2004 after extensively studying the impact on health of exposure to elevated ozone levels.

The Clean Air Act requires the EPA to periodically review air quality standards and revise them if necessary. As a result, in May 2008 the EPA lowered the ozone standard to 75 parts per billion based on more recent information available on the health effects of ozone. Although the EPA has not yet established the date for requiring attainment of the new standard, the EPA will determine the Denver Metropolitan Area's attainment status of the new standard during Calendar Year 2010. As discussed later in the report, Colorado has already been designated in non-attainment for the 85 parts per billion standard, and the State will need to come up with more aggressive control strategies in order to be in attainment of the 75 parts per billion standard.

There are other pollutants, besides the six pollutants for which the EPA has set standards (criteria pollutants), which are also harmful to health.

Mobile sources account for half or more of these pollutants, and programs such as the AIR Program directly reduce these emissions.

Manufacturer Standards for Motor Vehicle Emissions

Manufacturer standards for motor vehicle emissions have contributed toward much of the progress made towards attainment of the National Standards for ozone and carbon monoxide. Since the first manufacturer standards for motor vehicle emissions were established by the EPA, the standards have become progressively more stringent. Newer vehicles (i.e., those 1996 and newer), which are equipped with emissions control systems, emit 95 percent less hydrocarbons, carbon monoxide, and nitrogen oxides than older vehicles without emission controls. In the Denver Metropolitan Area, manufacturer standards for motor vehicle emissions have had the greatest impact on reducing carbon monoxide levels since most carbon monoxide comes from motor vehicles.

Colorado's History of EPA Compliance with Ozone Standards

During Calendar Years 2001 through 2003, the Denver Metropolitan Area was not in compliance with ozone standards. As a result, in December 2002, Colorado, along with a number of other states, submitted an *Early Action Compact* to the EPA pledging to meet ozone standards earlier than required. These states had to meet a number of criteria and agreed to meet certain milestones, such as:

- Developing and implementing air pollution control strategies,
- Accounting for emissions growth, and
- Achieving and maintaining the national eight-hour ozone standard.

Under the *Early Action Compact*, if the Denver Metropolitan Area had been in compliance with the ozone standard through 2007, the State would have had until 2011 to submit a plan to the EPA showing how it would maintain compliance with the National Standards in the future. The State would have had the option of eliminating the AIR Program if, through its technical analyses, it could have shown that the Program was no longer needed to maintain compliance with the National Standards. However, the Denver Metropolitan Area violated the 85 parts per billion ozone standard by approximately one part per billion during Calendar Years 2005 through 2007. As a result, the EPA designated the Area as being in non-attainment, which required Colorado to develop a new State Implementation Plan that must demonstrate attainment of the ozone standard by 2010.

In December 2008 the Colorado Air Quality Control Commission approved an *Ozone Action Plan (OAP)*, which was prepared by the Regional Air Quality Council. The goal of the *OAP* is to reduce ozone levels in the Denver Metropolitan Area and attain compliance with the current ozone standard of 85 parts per billion by 2010. A majority of the proposals included in the *OAP* address stationary sources of ozone such as oil and gas production, which is one of the largest sources of hydrocarbon emissions in the Area. Strategies for these sources include controls on condensate tanks, which collect liquid hydrocarbons during oil and gas production. The primary mobile source strategy in the *OAP* is to revise the AIR Program to further control hydrocarbon and nitrogen oxides emissions from motor vehicles. Although the control measures in the *OAP* are enforceable, most are not included in the State Implementation Plan, which was submitted to the EPA in June 2009.

AIR Program

As mentioned, the AIR Program was established by the General Assembly in 1980 to reduce vehicle emissions and to meet the National Standards. Under the AIR Program, which measures emissions from cars and gasoline-powered trucks, a vehicle must pass an emissions test and inspection to be registered in the Denver Metropolitan Area. Vehicles that fail the test due to excessive emissions must be repaired. The frequency of inspection depends on the age of the vehicle. All new vehicles are exempt from regular inspection, including a change of ownership inspection, during their first four model-years. Model-year 1981 and older cars and trucks are required to be tested every year, while 1982 and newer cars and trucks are subject to a biennial inspection. In addition to the regular annual or biennial inspection, every vehicle that is four years old or older must also be inspected prior to its sale, or upon initial registration in the Denver Metropolitan Area.

In Calendar Year 2008 there were about two million vehicles registered in the Denver Metropolitan Area. The AIR Program inspected approximately 716,000 of these vehicles. Of these, about 660,000 (92 percent) vehicles passed their inspections the first time. Of the 56,000 (8 percent) vehicles that failed the test when they took it the first time, about 49,000 returned and subsequently passed the test or received a waiver[1]. The remaining 7,000 vehicles that failed the emissions test and were never retested are assumed to have been removed from service, relocated outside of the Denver Metropolitan Area, or operated with expired plates. As discussed later in this section, an additional 200,000 vehicles satisfied AIR

[1] Motorists can receive a waiver (i.e., are not required to pass the emissions test) if they spend $715 or more on emissions-related repairs. Fewer than 239 vehicles received waivers in Calendar Year 2008.

Program requirements in 2008 by way of the Rapid Screen Clean Screen test.

Appendix A describes the current AIR Program in more detail.

History of the AIR Program

The AIR Program has changed significantly since it first began in 1980. When the Program was first initiated, the Denver Metropolitan Area often exceeded the National Standards for carbon monoxide and, at times, ozone. At the time, a major cause of excessive carbon monoxide emissions was carburetors that had idle air and fuel mixtures adjusted to provide more fuel than needed for proper combustion. The original AIR Program focused on identifying vehicles that emitted high concentrations of carbon monoxide, and thus needed to have their idle mixtures adjusted for Colorado's high altitude. An emissions analyzer was used to identify vehicles with high carbon monoxide emissions while they were idling.

Over time, emissions control systems in vehicles have improved dramatically. Vehicles equipped with complex computer-controlled fuel injection systems have gradually replaced those with traditional manually adjusted carburetors. Although motor vehicles are still responsible for most of the carbon monoxide emissions in the Denver Metropolitan Area, improved emissions control systems have greatly reduced ambient carbon monoxide levels in the Area. Along with improvements to vehicles, the EPA required states to make changes to their emissions test procedures. The EPA believed that the idle test could not identify many of the vehicles with emissions-related problems, leading it to require polluted areas to implement more stringent emissions tests.

Beginning in 1990, the EPA instituted a series of new requirements for states to implement enhanced inspection and maintenance programs in areas that did not meet the National Standards for ozone and carbon monoxide. In 1995 the AIR Program underwent many changes in response to these requirements. Colorado initiated centralized emissions inspections, using inspection stations set up and staffed by a private company, Environmental Systems Products (ESP). The Department contracts with ESP to conduct emissions tests on all 1982 and newer vehicles registered in the Denver Metropolitan Area. Private garages or ESP may inspect vehicles that are 1981 and older. ESP conducts emissions tests through centralized stations in 14 locations: Arvada, Broomfield, Boulder, Castle Rock, Central Denver, County Line Road, Golden, Ken Caryl, Longmont, Northglenn, Parker, Sheridan, Southeast Denver, and Stapleton.

Up until January 1, 2007, the AIR Program operated in El Paso, Larimer, and Weld counties, in addition to the Denver Metropolitan Area. The Program was discontinued in these three counties, effective January 1, 2007 because they were found to meet all of the National Standards. However, effective January 1, 2010, Larimer and Weld counties will again be part of the Program area to assist in attaining the ozone standard and to assure equitable treatment of all the major pollutant sources.[2]

Inspection Procedures

Under the AIR Program an emissions inspection typically includes three components:

- **IM240 test**. Model year 1982 or newer vehicles are subjected to a dynamometer test where they are placed on a treadmill-like device that simulates a driving cycle typical of urban driving. The driving cycle is called IM240 and corresponds to 240 seconds of the Federal Test Procedure, the test that is used on all new cars to determine if the vehicles meet new car certification standards. The IM240 test evaluates emissions of hydrocarbon, carbon monoxide, and nitrogen oxides. Colorado's emissions standards (or cutpoints, as they are commonly called) are set to identify vehicles with high hydrocarbon, carbon monoxide and nitrogen oxides levels, since these are the primary concerns in the formation of ozone. Similar to other states, Colorado's emissions standards for hydrocarbon, carbon monoxide, and nitrogen oxides emissions are set much higher (i.e., tolerate higher levels of hydrocarbons, carbon monoxide, and nitrogen oxides emissions) than the federal certification standards for new vehicles. This helps ensure that the emissions test fails only those vehicles that clearly emit hydrocarbon, carbon monoxide, and nitrogen oxides at substantially higher rates than the federal standards for new vehicles. It also helps to minimize the likelihood that the emissions test would mistakenly fail a vehicle. Vehicles that are 1981 or older, or heavy-duty vehicles that weigh more than 8,500 pounds, receive a two-speed idle test. The two-speed idle test measures emissions at idle and at raised idle (i.e., the gas pedal is depressed to increase the engine revolutions to 2,500 revolutions per minute). The two-speed idle test evaluates only hydrocarbon and carbon monoxide emissions and does not evaluate nitrogen oxides emissions.

[2] Throughout this report we use the term Denver Metropolitan Area to refer to the geographic jurisdiction of the AIR Program. As applicable, such term is also deemed to refer to those counties that were part of the AIR Program prior to January 1, 2007 and on or after January 1, 2010.

- **Gas cap test.** When a gas cap is missing or cannot hold pressure, a significant amount of hydrocarbon can evaporate into the air, contributing to the formation of ozone. Gas gap pressure checks are completed as part of the inspection to lower evaporative hydrocarbon emissions.

- **Anti-tampering inspection.** This is a visual inspection to make sure that the vehicle has all key emissions devices, that the devices appear to be working, and that no tampering has occurred. A catalytic converter is an example of a key emissions device.

The IM240 test, gas cap test, and anti-tampering inspection make up the typical vehicle emissions test currently conducted at Colorado's 14 centralized stations. For purposes of this report, we will refer to this as the "traditional emissions test."

Rapid Screen

The AIR Program also includes the Rapid Screen Program, which serves as an alternative to the traditional emissions test. The General Assembly authorized the Department to develop a clean screen program (i.e., a program that uses remote sensing technology to identify vehicles that should pass the emissions test) through legislation enacted in 2001 and 2002. The Department implemented the Rapid Screen Program in October 2004, which is intended to reduce the number of vehicles that must undergo the traditional emissions test, and thus decrease motorist inconvenience. The Rapid Screen Program uses remote sensing devices to measure emissions as vehicles drive past roadside monitors. The Rapid Screen monitors measure vehicle emissions and record license plate numbers. If a vehicle passes the Rapid Screen test, the vehicle owner is notified that he or she can substitute the Rapid Screen results for the traditional emissions test. If the owner chooses to substitute the Rapid Screen emissions test, he or she can pay the emissions fee along with the registration renewal fee and will not have to take the vehicle to a testing facility for an emissions inspection. According to the Department, the number of vehicles inspected through Rapid Screen has been increasing as the program develops and the number of remote sensing vans increases. For example, in Calendar Year 2007 ESP increased the number of vans screening vehicles from 9 to 18. In Calendar Year 2008, about 200,000 of the approximately 920,000 (22 percent) vehicles in the Denver Metropolitan Area requiring an inspection complied with AIR Program requirements via Rapid Screen. We discuss Rapid Screen in more detail in Chapter 2.

Program Administration

The administration of the AIR Program is divided between two departments. In accordance with the statutes (Section 42-4-307, C.R.S.), the Department is responsible for the technical aspects of the AIR Program. This includes maintaining and analyzing emissions inspection data, reporting emissions data to the Air Quality Control Commission, and administering the licensing tests for emissions inspectors and mechanics. The Commission is responsible for evaluating the AIR Program to ensure compliance with the State Implementation Plan (the State's plan for complying with the National Standards, submitted to and approved by the EPA) and federal law. In Fiscal Year 2008 AIR Program expenditures at the Department were $1.9 million and the Program had 15.9 FTE.

The statutes (Section 42-4-305, C.R.S.) also assign certain AIR Program responsibilities to the Department of Revenue. Specifically, the Department of Revenue is responsible for (1) issuing all inspection station, facility, mechanic, and inspector licenses; (2) providing program oversight of all licensed stations, facilities, mechanics, and inspectors; and (3) performing announced and unannounced audits of inspection stations and facilities to ensure compliance with statutes, rules, and regulations. The scope of this review did not include activities performed by the Department of Revenue.

Changes Made to the AIR Program Since the 2006 Review

Following is a summary of the major changes that have been made to the AIR Program since the previous review conducted in 2006.

More stringent standards. In response to a recommendation in our 2006 review, in May 2008 the Department and the Air Quality Control Commission made the Program's standards (or "cutpoints") for hydrocarbon and nitrogen oxides emissions more stringent. Prior to May 2008, the standard for nitrogen oxides was so high that the AIR Program had no impact on emissions of this ozone precursor. With the new standard, allowable emission levels for nitrogen oxides were reduced by more than 50 percent for most vehicles. As a result of this change, the AIR Program now appears to significantly reduce emissions of nitrogen oxides, as well as hydrocarbons and carbon monoxide.

Rapid Screen vans. Colorado received additional Rapid Screen vans, increasing the number of vans from 9 to 18 in 2007. About 50 percent of the vehicle fleet was observed at least once by Rapid Screen during Calendar Year 2008.

Low Emitter Index. In response to a recommendation in our 2006 review, during the latter part of Calendar Year 2007 the Department implemented a Low Emitter Index (LEI) element as part of the Rapid Screen Program. The LEI is an indicator of the probability that a particular vehicle would pass the traditional emissions test based on historical information with respect to its make, model, and year. The LEI is updated by the Department when changes are made to the traditional emissions test standards. Vehicles included on the LEI can pass the Rapid Screen test with just one observation below the clean screen standard instead of two.

Anti-tampering inspection. Test procedures have been changed so that now the anti-tampering inspection on 1996 and newer vehicles can be skipped if the malfunction indicator lamp is off and all monitors are set to ready.

AIR Program Emissions Reductions and Costs

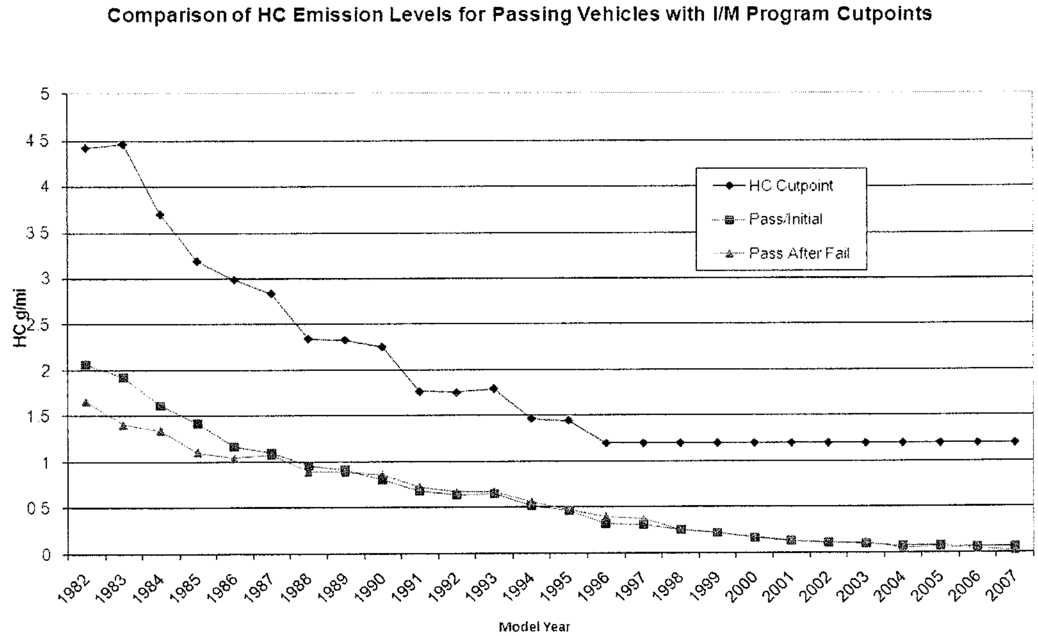
The statutes (Section 42-4-316, C.R.S.) require this review to evaluate the AIR Program's demonstrable effect on ambient air quality, cost to the public, and cost-effectiveness relative to other air pollution control programs. We address these issues, as they relate to the AIR Program's traditional emissions test component and Rapid Screen, in the next few sections.

We reviewed AIR Program data obtained from the Department to evaluate the impact of Colorado's traditional emissions test program on emissions reductions. We found that the traditional emissions test has reduced hydrocarbon, carbon monoxide, and nitrogen oxides emissions from motor vehicles. On the basis of data collected for Calendar Year 2008**,** we estimate that the traditional emissions test reduced hydrocarbon emissions from motor vehicles by 19 tons per day, or by 15 percent (approximately one-third of the reduction in hydrocarbon emissions is attributable to the gas cap inspection). Similarly, the traditional emissions test reduced carbon monoxide emissions from motor vehicles by 160 tons per day, or by 14 percent. Finally, the traditional emissions test reduced nitrogen oxides emissions from motor vehicles by 9.5 tons per day, or by 6 percent. These reductions have contributed to improving the air quality in the Denver Metropolitan Area. Over time, older vehicles in the fleet will be replaced with newer vehicles that are designed to emit lower levels of pollutants. As vehicles become cleaner due to manufacturing standards, there will be less opportunity for the AIR Program to affect reductions in the levels of pollution caused by motor vehicles.

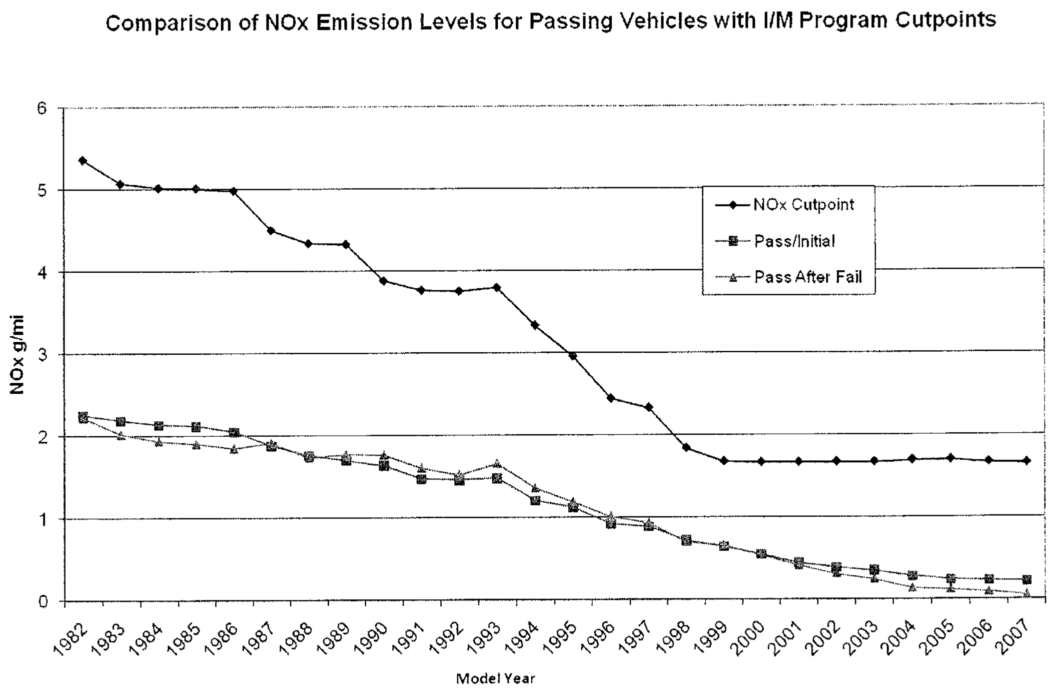
One of the reasons the traditional emissions test has achieved these emissions reductions is that the test does a relatively good job of identifying vehicles with high emissions (i.e., emissions that exceed Colorado's emissions standards or "cutpoints"). When the traditional emissions test identifies these high-emitting vehicles and the owners repair them, the vehicles, when retested, have emissions levels that are almost identical to the emissions levels of vehicles that pass the emissions test the first time. During Calendar Year 2008 the AIR Program tested about 716,000 vehicles through the traditional emissions test. Using either the IM240 or the two-speed idle test (used on 1981 and older, or heavy duty vehicles) the AIR Program identified about 35,000 vehicles (5 percent of all vehicles tested) with high hydrocarbon, carbon monoxide, or nitrogen oxides emissions that failed the test. (The 35,000 does not include approximately 21,000 vehicles that failed the AIR Program traditional emissions test due only to problems with their gas caps or tampering with emission control systems.) About 29,000 of the vehicles with high emissions were subsequently repaired and, when retested, passed the emissions test. The remaining 7,000 vehicles that failed the emissions test and were never retested are assumed to have been removed from service, relocated outside of the Denver Metropolitan Area, or operated with expired plates.

The following graphs compare the hydrocarbon and nitrogen oxides emissions of vehicles, by model year, that (1) failed the traditional emissions test, (2) were repaired and retested, and (3) subsequently passed the emissions test with the emissions of vehicles that initially passed the traditional emissions test and with the AIR Program's emissions standards for each precursor. After repair, emission levels for vehicles initially failing the traditional emissions test were very close to emission levels for vehicles that passed their initial test. On average, vehicles that pass their initial tests (or pass after failing their initial tests and then are repaired) have emission levels much lower than Colorado's emissions standards or "cutpoints," as illustrated in the graphs.

Colorado Automobile Inspection and Readjustment (AIR) Program
Comparison of Hydrocarbon (HC) Emission Levels for Vehicles That Pass the Colorado Emissions Standards (or Cutpoints)



Colorado Automobile Inspection and Readjustment (AIR) Program
Comparison of Nitrogen Oxides (NOx) Emission Levels for Vehicles That Pass the Colorado Emissions Standards (or Cutpoints)



Source: *AIR Program data.*
Note: See Appendix D for an explanation on how emissions benefits in grams per mile are estimated for the AIR Program.

It is important to note that the actual emissions reductions of hydrocarbon and nitrogen oxides, calculated using AIR Program data collected in Calendar Year 2008, generally were greater than the emissions reductions estimated by the EPA's emissions model, MOBILE6.2. This model was developed by the EPA for use in air quality modeling and control strategy development as it estimates the emissions reductions that will be gained from a traditional emissions test program. States must use MOBILE6.2 to estimate benefits from inspection and maintenance programs. The emissions reductions assumed in the *Ozone Action Plan* adopted by the Air Quality Control Commission are based on MOBILE6.2. MOBILE6.2 predicted that the traditional emissions test in Colorado's AIR Program would reduce hydrocarbon (exhaust and evaporative emissions) and nitrogen oxides emissions by 11 and 8.2 tons per day, respectively. However, our analysis of actual AIR Program data shows that the traditional emissions test reduced hydrocarbon emissions by 19 tons per day and nitrogen oxides emissions by 9.5 tons per day, significantly more than estimated by EPA's modeling tool.

By the end of Calendar Year 2009, the EPA will require states to use its new mobile source emissions factor model, MOVES, for State Implementation Plan planning, instead of MOBILE6.2. Based on our review of the data, we estimate that the MOVES model will project the AIR Program benefits for all pollutants to be about 25 percent lower than would be projected by MOBILE6.2. The discrepancy between the EPA's models and AIR Program data occurs because the models are based on assumptions of how vehicle emissions increase as a vehicle ages and how repairs reduce emissions. However, actual data from the AIR program show that vehicle emissions increase more than the models assume as vehicles age, and that repairs generally are more effective in reducing emissions than the models assume. It is not clear if the EPA will allow alternative estimates of AIR Program benefits once states must use MOVES for State Implementation Plan planning. If Colorado is required to use the MOVES model to demonstrate that its proposed air pollution control strategies, if implemented, will ensure attainment of the ozone standard, it appears that Colorado will be required to implement even more stringent strategies to demonstrate compliance with MOVES' estimates. It is not clear whether the EPA will allow flexibility in the application of the MOVES model. Appendix E contains comparisons of vehicle emission factors predicted by MOBILE6.2 and MOVES.

Fuel Economy Benefits

In addition to achieving significant reductions in hydrocarbon and carbon monoxide emissions, the AIR Program's traditional emissions test achieves other benefits. One benefit of the traditional emissions test is improved fuel economy for repaired vehicles. We identified a sample of about 15,000 vehicles that failed the traditional emissions test, were repaired, and retested. These 15,000 vehicles received a full-length, 240-second emissions test during both their initial test and their retest after repair, allowing us to make a meaningful comparison of fuel economy. We found that fuel economy for these 15,000 vehicles improved from an average of 20.6 miles per gallon to 22.5 miles per gallon after repair, for an overall increase in fuel economy of 9 percent. We applied the observed fuel economy improvements, by model-year category, to the 49,000 vehicles that failed the AIR Program test, were repaired, and then passed when they were retested. When projected, fuel consumption for the 49,000 vehicles was reduced by about 1.9 million gallons per year, saving vehicle owners about $4.8 million per year.

Colorado Automobile Inspection and Readjustment (AIR) Program
Impact of Repairs to Failed Vehicles on Fuel Economy

Year of Vehicle	Test Sequence	Miles per Gallon (MPG)
1982-1995	**Before Repair**	20.56
	After Repair	22.65
1996 and newer	**Before Repair**	20.69
	After Repair	22.19
Average of MPG Before Repair		20.61
Average of MPG After Repair		22.46
Fuel Savings (gallons/yr)		1.9 million

Source: *AIR Program data: Calendar Year 2008.*
Note: *Changes in the miles per gallon before and after repair were projected to the total number of vehicles failed and repaired, based on the results of our sample of 15,000. Average annual mileage for failed vehicles is 8,230.*

Cost-Effectiveness of the AIR Program

Finally, we found that while the total cost of the AIR Program has increased slightly since our last review, the cost per ton of eliminating ozone precursors has decreased dramatically. This has made the AIR Program more cost effective. From Calendar Year 2005 through Calendar Year 2008 total costs of the Program have risen from $42.5 million to $43.7 million, as set forth in the following table. We found that the cost per ton of removing ozone precursors, however, has fallen 21 percent during this period, from $9,800 per ton at the time of our 2006 review to $7,700 per ton in Calendar Year 2008, thus making the AIR Program much more cost effective. The primary reason for the lower cost per ton is that the new emission standards ("cutpoints") implemented in May 2008 significantly increased the effectiveness of the Program in reducing emissions of hydrocarbons and nitrogen oxides. California has been a national leader in establishing cost-effectiveness guidelines for the purpose of funding mobile source control measures. Based on California's guidelines, a control is considered to be cost-effective if it reduces emissions for a cost of less than $16,000 per ton of ozone precursors[3]. The AIR Program is considerably below that guideline.

Colorado Automobile Inspection and Readjustment (AIR) Program Calendar Year 2005 and 2008 Estimated Costs		
Item	**2005**	**2008**
Inspection Revenue -- ESP, Private Garages, State	$23,700,000	$19,700,000
Repair Costs	9,200,000	12,400,000
Fuel Savings Credit	(3,000,000)	(4,800,000)
Motorist Inconvenience – Travel	8,400,000	8,200,000
Motorist Inconvenience -- Wait Time	3,800,000	3,100,000
Rapid Screen (RSD) Revenue	400,000	5,100,000
Total	**$42,500,000**	**$43,700,000**
Cost per Vehicle Registered in the Denver Metropolitan Area	***$21***	***$22***
Source: *dKC analysis of AIR Program costs; see Appendix C.*		

Other Pollution Controls

There are sources of hydrocarbon and nitrogen oxides emissions, other than motor vehicles, that can potentially be reduced at a lower cost per ton. It is important to note that a number of factors contribute to ozone formation, and reducing emissions of hydrocarbons or nitrogen oxides from one type of source may not necessarily affect ozone formation to the same extent as reducing emissions of these pollutants from another type of source.

To date, most controls for stationary sources in the Denver Metropolitan Area have focused on hydrocarbon emission reductions from oil and gas operations and large reciprocating engines. In Calendar Year 2008 the Air Quality Control Commission adopted additional controls in its *Ozone Action Plan* for several sources of hydrocarbon emissions, including flash emissions (i.e., evaporative emissions resulting from pressure changes that occur when processing petroleum products), oil and gas production, and large reciprocating internal combustion engines (e.g., an engine used to run a pipeline gas compressor). As of Calendar Year 2007, controls on flash emissions were expected to reduce hydrocarbon emissions by 55 tons

[3] Bay Area Air Quality Management District – Carl Moyer Program Fact Sheet – May 2009. The Carl Moyer Program funds alternative control measures in California.

per day at a cost of about $250 per ton. The new controls on oil and gas operations were expected to reduce hydrocarbon emissions by an additional 23 tons per day at a cost of between $400 and $2,700 per ton, and industrial engine controls were expected to reduce hydrocarbon emissions by 4 tons per day at a cost of about $1,400 per ton.

The 2008 *Ozone Action Plan* also identified other sources of emissions that could be controlled such as automotive aftermarket products (e.g., automotive refinishing or painting), architectural coatings, household and personal products, adhesives and sealants, pesticide application, and lawn and garden products, among others. Currently the State relies upon federal guidelines to control emissions from these sources.

As discussed previously, new analyses of ozone in the Denver Metropolitan Area find that controls on emissions of nitrogen oxides generally yield greater ozone reductions than controls on hydrocarbon emissions. There appear to be many opportunities for other cost-effective controls for nitrogen oxides emissions, in addition to the AIR Program. This includes controls on electrical generating units and non-road vehicles, which are discussed in more detail in Chapter 2. We estimate the emissions reductions and cost per ton for applying air pollution controls to sources other than motor vehicles in Appendix C.

The statutes also require the review to consider whether the AIR Program ensures vehicle manufacturers comply with legally required warranties covering air pollution control equipment. Vehicle manufacturers are required to repair emissions system failures detected by the on-board diagnostic system while vehicles are still under warranty. Although manufacturers are not required to repair emissions systems problems that are not identified by the on-board diagnostic system, most will make the repairs as long as the vehicle is under warranty.

Evaluation Scope

Our review evaluated the continued need for the AIR Program and the effectiveness of the Rapid Screen Program. We also evaluated a number of alternatives the Department could consider for reducing air pollution in the Denver Metropolitan Area and for improving the effectiveness of the AIR Program, while reducing costs. We discuss our findings and recommendations related to these issues in Chapter 2. Details of our data analysis and methodology are presented in the Appendices.

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AIR Program
Chapter 2

As discussed in Chapter 1, air quality in the Denver Metropolitan Area has generally improved over the last two decades. Improvements are due, in large part, to new vehicle emissions certification standards, more rigorous emissions testing procedures, and enhancements to stationary source emissions controls. As we discuss throughout this report, however, stricter national standards related to ozone make air pollution a continuing concern for Colorado. A comprehensive strategy is needed to achieve sufficient ozone reductions to ensure the State's compliance with federal requirements and to protect public health.

In this chapter, we discuss the need for the AIR Program to help reduce air pollution and comply with the National Standard for ozone in the short- and long-term. Additionally, we discuss the effectiveness of the Rapid Screen Program in identifying both "clean vehicles" (vehicles that should pass the traditional emissions test) and "high-emitting vehicles" (vehicles that should fail the traditional emissions test). Finally, we discuss enhancements to the current AIR Program, such as on-board diagnostic system testing, as well as other air pollution control strategies.

Need for the AIR Program

The statutes (Section 42-4-316, C.R.S.) require this performance evaluation to assess the continued need for the AIR Program, taking into consideration factors such as the Program's effect on air quality, the cost-effectiveness of the Program relative to other air pollution control strategies, and the need to further reduce air pollution caused by mobile sources to attain or maintain compliance with National Standards. As discussed in Chapter 1, due to stricter National Standards, the primary focus of the AIR Program in recent years has been on reducing emissions that lead to the formation of ozone. Ozone precursors include carbon monoxide, hydrocarbons, and nitrogen oxides. As carbon monoxide levels are no longer an issue for the Denver Metropolitan Area, the AIR Program focuses on reducing emissions of hydrocarbons and nitrogen oxides.

We reviewed emissions data provided by the Department of Public Health and Environment (Department) to evaluate the effectiveness of the AIR Program in reducing ozone precursors in the Denver Metropolitan Area and to determine the extent to which the Program contributes to the Area's attainment of National Standards. Overall, we found that the AIR Program reduces ozone precursors, and thus the amount of ozone in the Denver Metropolitan Area. As a result, we concluded that the AIR Program is needed in the short-term for the Denver

Metropolitan Area to attain compliance with current ozone standards. However, we also found that the ozone reductions provided by the AIR Program are relatively small in relation to the total levels of ozone concentration in the Area and may be more expensive than some other air pollution control strategies. Therefore, we concluded that there may be other controls, unrelated to vehicle emissions, that could be more cost-effective in helping the Denver Metropolitan Area attain and maintain compliance with stricter ozone standards in the future.

Current Ozone Standards

The current National Standard for ozone is 85 parts per billion, which is measured using a rolling three-year average of the fourth highest reading. In Calendar Year 2007 the Denver Metropolitan Area exceeded this standard when ozone levels reached 90 parts per billion and the EPA designated the Area to be in non-attainment for ozone. In December 2008 the Air Quality Control Commission approved an *Ozone Action Plan*, the goal of which was to reduce ozone levels in the Denver Metropolitan Area and attain compliance with the 85 parts per billion standard by Calendar Year 2010. This Plan included the AIR Program as one control that would be used to help the Area attain compliance with the standard.

We reviewed emissions data provided by the Department for Calendar Years 2006 through 2008 to determine the amount of ozone reductions attributable to the AIR Program during this period. We found that, overall, the AIR Program is responsible for reducing ozone levels by 0.6 parts per billion. This includes a reduction of 19 tons per day in hydrocarbon emissions and 9.5 tons per day in nitrogen oxides emissions. Although the amount of ozone reductions attributable to the AIR Program is small compared with total ozone concentrations, the 0.6 parts per billion reduction will be key to the Denver Metropolitan Area's attainment of the 85 parts per billion standard. Using Calendar Year 2006 data and assuming consistent weather patterns, we project that without the AIR Program, ozone levels would reach 85.5 parts per billion in Calendar Year 2010, and thus exceed the ozone standard. However, the 0.6 parts per billion reduction, provided by the AIR Program would reduce ozone levels to 84.9 parts per billion and bring the Denver Metropolitan Area into attainment with the current ozone standard. Therefore, we conclude that the AIR Program is needed for the next several years to help the Denver Metropolitan Area attain and maintain compliance with ozone standards.

Future Ozone Standards

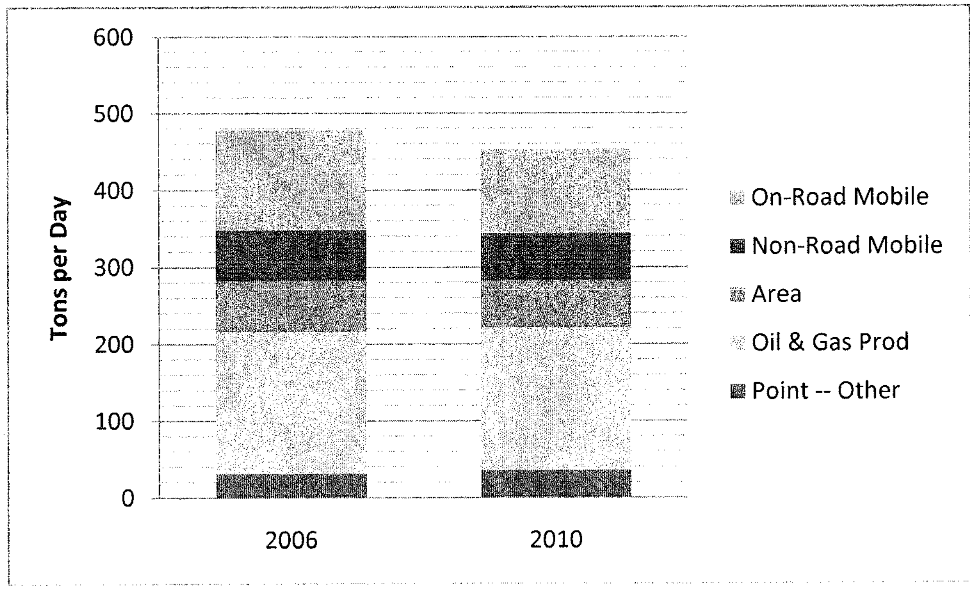
As discussed previously, due to concerns with the health effects of ozone, in May 2008 the EPA lowered the National Standards for ozone from 85 parts per billion to 75 parts per billion. Although the EPA has not yet established the attainment date for the new standard, it is expected that the EPA will determine the Denver Metropolitan Area's attainment status during Calendar Year 2010, based on monitoring data from Calendar Years 2006 through 2008. If the Denver

Metropolitan Area does not attain compliance with the new standard, the Air Quality Control Commission will be required to submit a revised State Implementation Plan to the EPA in March 2013. Until the Denver Metropolitan Area is declared by the EPA to be in non-attainment for the new standard, the Denver Metropolitan Area will continue to be required to meet the 85 parts per billion standard discussed above. If the Air Quality Control Commission has to submit a revised State Implementation Plan for the new standard, the Denver Metropolitan Area will have between 3 and 20 years to attain the standard, depending on the severity the Area's non-attainment status.

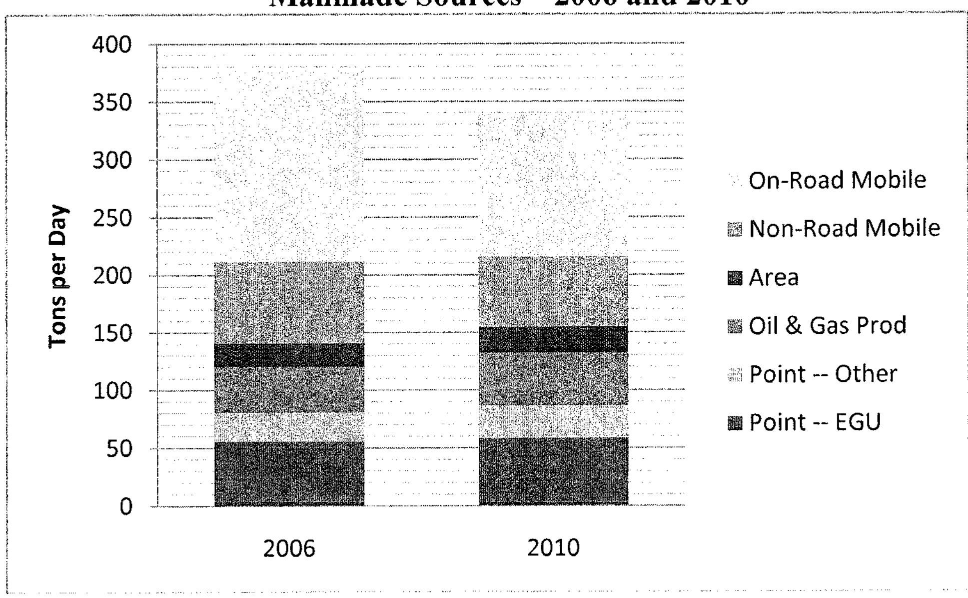
We reviewed the extent to which the AIR Program will contribute to the Denver Metropolitan Area's attainment of the 75 parts per billion ozone standard and compared the cost-effectiveness of the Program with other control measures. Overall, we found that the ozone reductions provided by the AIR Program are relatively small in relation to total ozone concentrations and more expensive than those provided by some other control measures. Specifically, we found that emissions from vehicles subject to the AIR Program account for a small percentage of the pollutants that make up ozone. As mentioned in Chapter 1, only about one-third of the pollutants (e.g., hydrocarbons and nitrogen oxides) that make up ozone in the Denver Metropolitan Area are from manmade sources, such as on-road mobile, non-road mobile, and point (e.g., factories, refineries, and electricity generation units) sources. The other two-thirds of the pollutants are from natural sources or are manmade and blown in from other geographic areas. This means that when implementing air pollution control measures to help the Denver Metropolitan Area attain compliance with EPA standards, the Air Quality Control Commission has the ability to control only about 33 percent of all pollutants that lead to the formation of ozone. Within this 33 percent, about 9 percent are attributable to the automobiles and gasoline-powered trucks under the purview of the AIR Program.

The following exhibits compare hydrocarbon and nitrogen oxides emissions in the Denver Metropolitan Area from all manmade sources during Calendar Year 2006 with projections for Calendar Year 2010. As the exhibits show, on-road mobile sources make up about a quarter of the manmade hydrocarbon and nitrogen oxides emissions in the Denver Metropolitan Area that can be controlled.

Hydrocarbon Emissions in the Denver Metropolitan Area
Manmade Sources – 2006 and 2010



Nitrogen Oxides Emissions in the Denver Metropolitan Area
Manmade Sources – 2006 and 2010



Source: The *Ozone Action Plan*, including revisions to the State Implementation Plan, approved by the Air Quality Control Commission, December 12, 2008.
On-Road Mobile: Cars, gasoline-powered trucks, and diesel-powered trucks and buses.
Non-Road Mobile: Construction equipment, locomotives, and marine.
Area: Architectural coatings, lawn and garden, consumer products, and automotive aftermarket.
Oil & Gas Production: Venting gases during production.
Point -- Other: Factories, refineries, and other stationary sources.
Point-- Electricity Generation Units (EGU): EGU does not contribute to hydrocarbon emissions.

The above exhibits also show that emissions from on-road mobile sources are expected to decrease over the next few years. Specifically, the mobile source portion of hydrocarbon emissions is expected to decrease from 27 percent of total manmade hydrocarbon emissions in Calendar Year 2006 to 24 percent in Calendar Year 2010. The mobile source portion of nitrogen oxides emissions is expected to decrease from 44 percent of total manmade nitrogen oxides emissions in Calendar Year 2006 to 36 percent in Calendar Year 2010. The majority of these decreases, however, will not be due to the AIR Program, but will instead be due to the turnover and replacement of older vehicles with newer "cleaner" vehicles. As federal requirements related to emissions for newly manufactured vehicles continue to become more stringent, and as these newer vehicles replace older, higher emitting vehicles, the Denver Metropolitan Area will experience a decrease in hydrocarbon and nitrogen oxides emissions.

We also found that some other air pollution control strategies have the potential to provide greater ozone reductions than the AIR Program, at a lower cost. As discussed previously, the AIR Program is responsible for reducing ozone levels in the Denver Metropolitan Area by 0.6 parts per billion at a cost of $7,700 per ton. This includes a 19 ton per day reduction in hydrocarbon emissions and a 9.5 ton per day reduction in nitrogen oxides emissions. With hydrocarbon emissions from all sources (including naturally occurring and manmade emissions) expected to total almost 1,200 tons per day by Calendar Year 2010, a 19 ton per day reduction from the AIR Program would represent an overall reduction in hydrocarbon emissions of only 1.6 percent. Similarly, with nitrogen oxides emissions from all sources expected to total almost 400 tons per day by Calendar Year 2010, a 9.5 ton per day reduction from the AIR Program would represent an overall reduction in nitrogen oxides emissions of only 2.4 percent.

Comparatively, a study commissioned by the Department in 2008 concluded that implementing catalytic controls for nitrogen oxides on electrical generating units could potentially reduce nitrogen oxides emissions by 30 to 40 tons per day at a cost of about $2,000 per ton. This is estimated to equate to a reduction of ozone levels in the Denver Metropolitan Area of 1 to 2 parts per billion, based on ozone source apportionment studies. These controls have the potential to provide approximately three times the benefits of the AIR Program for about 25 percent of the cost per ton. Similarly, we estimate that retrofitting controls on non-road mobile sources could potentially reduce ozone levels by 1 to 3 parts per billion at a cost of $2,000 to $19,000 per ton, depending on the control. This would include a reduction in hydrocarbon emissions of about 30 tons per day and a reduction in nitrogen oxides emissions of 30 to 40 tons per day. As the exhibits above show, electrical generating units are responsible for a large percentage of the manmade nitrogen oxides emissions in the Denver Metropolitan Area and off-road mobile sources are responsible for a large percentage of hydrocarbon and nitrogen oxides emissions. Additional analysis is needed, however, to fully assess the costs, benefits, and implementation issues associated with these strategies, which are discussed in more detail in Recommendation No. 5.

By lowering the National Standards related to ozone, the EPA has emphasized the importance of having sufficient air pollution controls in place to reduce ozone to an acceptable level. If Colorado fails to comply with these standards, it could be subject to federal sanctions, including the withholding of federal highway dollars. The future need for the AIR Program will depend on the Program's ability to have a sufficient impact on the Denver Metropolitan Area's attainment of these standards. As discussed above, mobile sources account for a small percentage of hydrocarbon and nitrogen oxides emissions which lead to the formation of ozone. In addition, the contribution to these emissions by mobile sources is expected to decrease over the next several years as older vehicles in the fleet are replaced with newer vehicles that are designed to emit lower levels of pollutants. As vehicles become cleaner due to manufacturing standards, the potential impact of the AIR Program on the Denver Metropolitan Area's ozone levels in the future may be limited.

The Department needs to develop a comprehensive strategy for addressing air pollution in the Denver Metropolitan Area to ensure compliance with current and future ozone standards. This strategy should include both a short- and long-term approach to reducing emissions leading to the formation of ozone. In the short-term, the Department should continue the AIR Program at least through Calendar Year 2010, as laid out in the State's *Ozone Action Plan*, when attainment with the 85 parts per billion standard will be determined by the EPA. The Department should also consider implementing enhancements to the AIR Program, as discussed later in this chapter, to further reduce emissions and improve the effectiveness of the Program.

In the long-term, after Calendar Year 2010, the Department should determine the need for the AIR Program when the Denver Metropolitan Area must attain compliance with the 75 parts per billion standard. To help make this determination, the Department should continue to collect and analyze data on air pollution from all sources, including motor vehicles, and on other types of air pollution control strategies to identify the controls that will provide the most reductions in ozone levels at the lowest cost. If the Department determines that the AIR Program as currently designed is no longer needed as a control strategy, the Department should work with the Air Quality Control Commission to evaluate whether the Program should be eliminated or modified and whether other strategies should be adopted instead. If the Department determines that the AIR Program is able to provide meaningful reductions in ozone levels, the Department should consider what additional changes or enhancements could be made to the Program to further improve its effectiveness and, if possible, reduce costs.

Recommendation No. 1:

The Department of Public Health and Environment should:

a. Maintain the current AIR Program as laid out in the State's *Ozone Action Plan*, at least until Calendar Year 2010 when the Environmental Protection Agency makes a determination of whether the Program area is in compliance with the 85 parts per billion standard. The Department should also consider implementing enhancements to the AIR Program during this time to further reduce emissions and improve the effectiveness of the Program.

b. Continue to analyze data on the cost-effectiveness of the AIR Program compared with other air pollution control strategies to identify the most cost effective set of control strategies in the longer term for the Program area to attain compliance with the 75 parts per billion ozone standard. If the Department determines that the AIR Program as currently designed is no longer needed as a control strategy, the Department should work with the Air Quality Control Commission to evaluate whether the Program should be eliminated or modified and whether other strategies should be adopted. If the Department determines that the AIR Program is able to provide meaningful reductions in ozone levels, the Department should not only consider what other strategies could be adopted, but also what additional changes or enhancements could be made to the Program to further improve its effectiveness and, if possible, reduce costs.

Department of Public Health and Environment Response:

a. Agree. Implementation date: Ongoing.

b. Agree. Implementation date: Ongoing. In its efforts to reduce ambient levels of ozone and meet federal air quality standards, the Department will continue to identify, evaluate, select, and implement the most cost-effective means of reducing ozone pre-cursor emissions. The Department recognizes, however, that achieving the 75 parts per billion standard presents a very significant challenge, requiring deep cuts in ozone precursor emissions, and therefore, the State may not have very much flexibility in choosing among cost-effective emission reduction strategies.

Rapid Screen

The Rapid Screen Program uses remote sensing devices to measure emissions as vehicles drive past roadside monitors. The Rapid Screen test is conducted using sensing devices that measure vehicle emissions remotely by passing an infrared or ultraviolet light beam across a highway to a source detector on the other side. When a vehicle passes through the light beam, the changes in the intensity of the transmitted light indicate the concentrations of the exhaust gases being monitored. It reports hydrocarbon and nitrogen oxides emissions concentrations in the exhaust as parts per million and carbon monoxide concentrations as a percentage of total exhaust.

Currently Rapid Screen is used primarily to identify vehicles that should pass the traditional emissions test, and thus can be certified without needing to take the traditional emissions test. There are two alternative ways in which a vehicle can pass the Rapid Screen test:

- If a vehicle is observed by remote sensors twice within the 10-month window before the owner's registration is due and is found both times to pass the clean screen standard; or

- If a vehicle has just one observation below the clean screen standard within the 10-month window and the vehicle, according to the Low Emitter Index (LEI), has a high probability of passing the traditional emissions test. The LEI, which is updated by the Department, indicates which vehicles have a high probability of passing because historical data on the specific vehicle year and model indicate that the vehicle's emissions levels are unlikely to be above AIR Program cutpoints.

If a vehicle passes the Rapid Screen test, the vehicle owner is notified by mail. The owner can return the notification, along with the $25 fee to pay for the Rapid Screen test, and forego the traditional emissions test.

In 2006 the General Assembly enacted House Bill 06-1302 for the purpose of increasing the State's reliance on the Rapid Screen Program. House Bill 06-1302 requires the Department to develop, and the Air Quality Control Commission to approve, a plan to expand the use of Rapid Screen both to identify vehicles that should pass the traditional emissions test and to identify vehicles that are "high-emitters" of pollution and that, therefore, require repair. The goal of House Bill 06-1302 is to eventually replace the current traditional emissions test with a program that identifies "high-emitters" through Rapid Screen's remote sensors. Only high emitting vehicles would then be required to receive a traditional emissions test. House Bill 06-1302, if implemented as intended, would substantially improve motorist convenience and reduce costs to motorists.

In 2009, the General Assembly enacted Senate Bill 09-003, which requires the Department to delay deployment of remote sensing equipment beyond the Denver Metropolitan Area until the completion of the Legislative Audit Committee's audit of the remote sensing program. Senate Bill 09-003 states that deployment of remote sensing equipment "shall not occur unless the Air Pollution Control Division, in conjunction with the Department of Revenue Emissions program, determines the validity and viability of the remote sensing program."

We reviewed the effectiveness of the Rapid Screen Program, including the Department's efforts to implement the requirements of House Bill 06-1302. Overall, we found that the State will not be able to rely solely on Rapid Screen to identify vehicles that meet the emissions standards or to identify high-emitters, as envisioned by House Bill 06-1302. Although the percentage of vehicles screened by Rapid Screen has increased significantly since our 2006 review, Rapid Screen is still not reaching about half of the vehicle fleet in the Denver Metropolitan Area. However, as we discuss in more detail below, Rapid Screen coverage is currently at optimal levels; it is unlikely that the Department will be able to increase Rapid Screen's coverage in amounts needed to eliminate the traditional emissions test.

We also found that when used to identify "clean" vehicles, or vehicles that should be exempted from the traditional emissions inspection, Rapid Screen is not as effective as the traditional emissions test and reduces the benefits of the AIR Program by 7 percent for hydrocarbons and carbon monoxide and 14 percent for nitrogen oxides. Additionally, we found that when used to identify "high-emitters," or vehicles that should fail the traditional emissions inspection, Rapid Screen is ineffective and would reduce the benefits of the AIR Program by 90 percent if it were to completely replace the traditional emissions test. Further, technology does not currently exist that will allow the State to use remote sensing alone to identify and repair high emitters, as anticipated by House Bill 06-1302. We discuss each of these issues, along with our recommendations for improving Rapid Screen, in the next sections.

Rapid Screen Coverage

To meet the objectives of House Bill 06-1302 with respect to either (1) identifying vehicles that are clean, and therefore can be exempted from the traditional emissions test or (2) identifying vehicles that are high-emitters, and therefore are in need of repair, it is critical that any remote sensing program screen a sufficient percentage of vehicles. If a large percentage of vehicles are not screened, benefits from remote sensing will be reduced. Under the current AIR Program, all vehicles in the Denver Metropolitan Area must either pass a rapid screen test or the traditional emissions test to be registered by the Motor Vehicle Division.

We reviewed Department data from Calendar Years 2006 through 2008 to evaluate the adequacy of Rapid Screen coverage. We found that Rapid Screen's coverage rates have improved since our 2006 review. Specifically, during Calendar Year 2008 at least 49 percent of the vehicle fleet was observed at least once by Rapid Screen. In contrast, during Calendar Year 2005 only 25 percent of the vehicle fleet received one Rapid Screen observation. Additionally we found that of the approximately 920,000 Denver Metropolitan Area vehicles that were required to have an emissions test during 2008, about 240,000 vehicles (26 percent) passed Rapid Screen tests within 10 months of their registration renewals (passing either two observations or one observation along with an LEI). All of these vehicle owners were notified that their vehicle had passed the Rapid Screen test. Of these, 200,000 vehicle owners (22 percent of the 920,000 vehicles) took advantage of passing the Rapid Screen emissions tests by mailing in their notification along with the $25 fee. In contrast, in 2005 only 27,000 of the 890,000 (3 percent) vehicles required to have an emissions test passed Rapid Screen and of these, only 16,000 vehicle owners (just under 2 percent of the 890,000 vehicles) mailed their notification along with the $25 fee.

There are several reasons why Rapid Screen coverage has improved since our last review. First, the Department doubled the number of Rapid Screen vans on the road—from nine vans to eighteen—and conducts Rapid Screen testing at 150 different sites. Second, the Department adopted the one observation with an LEI approach as recommended in our 2006 review. Using the one observation with the LEI increased coverage by about 50 percent, based on the percentage of vehicles that received only one Rapid Screen test versus the percentage of vehicles that received two or more observations in a year.

Although Rapid Screen coverage has increased substantially since our last review, coverage rates are still below the maximum allowed by the State Implementation Plan. As stated above, under its improved coverage rates, the Department still is not able to obtain at least one Rapid Screen observation on about 50 percent of the vehicles in the Denver Metropolitan Area. Further, the Department's ability to increase Rapid Screen coverage is limited for several reasons. One of the Department's agreements with the EPA allows only up to 50 percent of the vehicles in the Denver Metropolitan Area to pass an emissions test through Rapid Screen. However, even without the limitation in this agreement, studies have found that it is difficult for remote sensing technology to exceed a 50 percent coverage rate. This is because remote sensing technology must be located properly and have suitable conditions to operate effectively. Typically, sensors are located where traffic moves in only one direction and vehicles are accelerating. Many vehicles only operate on surface streets which are not suitable remote sensing sites.

Impact of Using Rapid Screen to Identify "Clean" Vehicles

Even though Rapid Screen's coverage rate is not adequate to allow the State to use remote sensing as its sole method for controlling vehicle emissions, Rapid Screen, used as one component of the AIR Program, provides a highly desirable benefit—customer convenience. Therefore, we evaluated the effectiveness of Rapid Screen in identifying clean vehicles and compared it with the effectiveness of the traditional emissions test. We found that Rapid Screen is not as effective as the traditional emissions test and that Rapid Screen reduces the benefits of the Air Program. This is because Rapid Screen passes some vehicles that would ultimately fail the traditional emissions test.

To determine the impact of the Rapid Screen Program on emissions reduction, we analyzed data on vehicles whose owners were sent a Vehicle Mailer Request (VMR) saying they qualified for Rapid Screen Clean Screen tests[1] but instead decided to undergo the traditional emissions test. Based on test results for these vehicles, we projected the impact of the Rapid Screen Program on AIR Program benefits. Benefits of the AIR Program for each of the three precursor pollutants that create ozone are estimated to decrease as a result of the Rapid Screen Program. Specifically, we estimate hydrocarbon and carbon monoxide benefits are each reduced by 7 percent, and nitrogen oxides benefits are reduced by 14 percent.

Previously in this report, we estimated the AIR Program is responsible for reducing ozone levels in the Denver Metropolitan Area by 0.6 parts per billion. The negative impact of Rapid Screen is estimated to be around 0.1 parts per billion, assuming a linear relationship between hydrocarbons and nitrogen oxides emission reductions and apportioned ozone. In other words, without the Rapid Screen Program, the AIR Program would reduce ozone levels in the Area by an estimated 0.7 parts per billion.

Improving the Effectiveness of Rapid Screen as a Clean Screen Tool

We examined ways the Rapid Screen test could be improved to better identify only those vehicles that should pass their traditional emissions tests (clean vehicles), and thus improve program benefits. We found that Rapid Screen's effectiveness could be improved by adding criteria for screening vehicles for nitrogen oxides. Rapid Screen does not currently screen for nitrogen oxides. This is important because ozone in the Denver Metropolitan Area now appears to be more sensitive to mobile source nitrogen oxides emissions than mobile source hydrocarbon emissions. Adding a 1,000 parts per million limit for nitrogen oxides to the Rapid Screen Program, in addition to the existing limits on hydrocarbons (200 parts per million) and carbon monoxide (0.5 percent), will cause the percent of AIR Program benefits lost due to Rapid Screen to drop from 6.6 percent to 3.6 percent for hydrocarbons, from 6.6 percent to 3.8 percent for carbon monoxide, and from 14.4 percent to 4.2 percent for nitrogen oxides. This would provide benefits from the Rapid Screen Program that are almost equal to the benefits from

[1] 85 percent of the owners of vehicles receiving a vehicle mail request (VMR) informing owners that they can skip their regular inspection opted to pay the test fee by mail.

the traditional emissions test. In other words, with the addition of a nitrogen oxides limit for Rapid Screen, the overall benefit of the AIR Program in reducing ozone would be 0.7 parts per billion.

The Department should seek to improve the Rapid Screen Program by requesting that the AIR Quality Control Commission add criteria to screen vehicles for nitrogen oxides emissions. With this enhancement, Rapid Screen should continue as a clean screen component of the AIR Program. Continuing Rapid Screen, if improvements are made, improves customer convenience, which in turn lowers motorist inconvenience costs, and furthers the priorities of the General Assembly. In addition, the Department should ensure that it updates the LEI on an ongoing basis and that the LEI includes vehicles that have low probabilities of failing nitrogen oxides cutpoints as well as hydrocarbon and carbon monoxide cutpoints.

Recommendation No. 2:

The Department of Public Health and Environment should seek to improve the Rapid Screen Clean Screen program by requesting that the Air Quality Control Commission add nitrogen oxides to the program's qualification criteria and updating the Low Emitter Index to include vehicles with a low probability of failing nitrogen oxides cutpoints. With this enhancement, the Department should continue to use Rapid Screen as a component of its AIR Program for identifying vehicles that meet emissions standards, and thus should be exempted from the traditional emissions test.

Department of Public Health and Environment Response:

Agree. Implementation date: April 2010.

Using Rapid Screen to Identify "High-Emitting" Vehicles

House Bill 06-1302 required the Department to develop, and the Air Quality Control Commission to approve, a plan for substantially increasing the use of remote sensing for identifying high-emitting vehicles, or vehicles that should fail the traditional emissions test. The Department's plan established a pilot program for using Rapid Screen to identify and repair high-emitting vehicles. The plan was approved by the Commission in December 2006.

We evaluated the Department's pilot program and also conducted our own analysis of Department data to determine Rapid Screen's effectiveness in identifying high-emitting vehicles. Both the results of the pilot program and our own analysis concluded that Rapid Screen is not an effective tool for identifying vehicles with high emissions. We came to this same conclusion in our 2006 review. If the State relied solely on a Rapid Screen high-emitter program, as envisioned by House Bill 06-1302, the benefits of the AIR Program would be substantially reduced.

The Department initiated its high-emitter pilot program in 2007 and it is expected to conclude early in Calendar Year 2010. The pilot program attempts to provide a real-world assessment of the effectiveness of remote sensing in identifying high-emitting vehicles. The Department applied a "most stringent" emissions standard and a "least stringent" emissions standard at different times during the pilot to gain a better understanding of the number of vehicles identified as "high-emitters" under the different standards. In the pilot program, owners of vehicles that were observed at least twice to have emissions levels exceeding the standards were sent notices that they needed to get a "confirmatory" traditional emissions test. Vehicles that fail the confirmatory test must be repaired to meet standards or be removed from the fleet.

We reviewed the data generated from the Department's high-emitter pilot program and found that 14 percent of the vehicles identified as high-emitters were repaired and subsequently passed confirmatory test standards, while 5 percent never passed. The data also show that 46 percent of the vehicles identified by Rapid Screen as high-emitters subsequently passed their confirmatory tests and were not in need of repair. Vehicles that fail Rapid Screen but subsequently pass their confirmatory test are considered "false fails." Finally, the data show that the owners of 35 percent of the vehicles identified as high-emitters never responded to the notice.

Our review of Rapid Screen data produced similar results as our review of pilot program data. To conduct our analysis, we identified 45,000 vehicles that had a traditional emissions test within one year after being observed through Rapid Screen. We applied the same "most stringent" and "least stringent" standards used by the Department in its pilot to our analysis. If Rapid Screen operates as expected, the tool should identify the greatest number of high-emitting vehicles under the most stringent standards and the least number of high-emitting vehicles under the least stringent standards. Using the most stringent standards, we identified 749 vehicles that failed the Rapid Screen emissions test. Of the 749 vehicles, 432 (58 percent) were false fails. That is, these 432 vehicles failed Rapid Screen even though they passed their traditional emissions tests. Using the least stringent criteria, we identified 390 vehicles in our data set that failed the Rapid Screen emissions test. Of these 390 vehicles, 192 (49 percent) were false fails, that is, these 192 vehicles passed their traditional emissions tests.

In addition to confirming the problems with false fails identified through the Department's pilot, we conducted additional analysis to evaluate the effectiveness of Rapid Screen in identifying high-emitters. From the 45,000 vehicles that had traditional emissions tests within one year after being observed through Rapid Screen, we identified a sample of 2,842 vehicles that failed their traditional emissions test. We found that Rapid Screen identified a low percentage of these vehicles as high emitters. Specifically, when we applied the most stringent standards, Rapid Screen identified as high-emitters only 290 (10 percent) of the 2,842 vehicles in our sample that failed the traditional emissions test. Using the least stringent standards, Rapid Screen identified only 182 (6 percent) of the 2,842 vehicles that failed the traditional emissions test. Our analysis demonstrates that Rapid Screen is ineffective at accurately identifying high-emitters. This is significant because the Air Program obtains all of its emissions reduction benefits by identifying high-emitting vehicles causing owners to either repair the vehicles or remove them from the fleet.

Problems with Identifying High-Emitters

One reason that Rapid Screen has problems correctly identifying high-emitting vehicles is that the Rapid Screen technology, by design, has limitations. Rapid Screen is designed to test emissions over a very short period of time (instantaneous) under one type of driving condition (moderate acceleration). However, vehicles operate under a wide variety of driving conditions (e.g., cold start, bumper-to-bumper traffic, high-speed cruising) and, depending upon the driving conditions, emit different levels of exhaust pollutants. In contrast, the traditional emissions test includes the IM240 test, which measures emissions over a 240-second test cycle under a much wider range of loads (acceleration) than can be observed in an instant Rapid Screen test. The traditional emissions test will therefore provide a better measure of emission levels than Rapid Screen. The traditional emissions test also does a better job of replicating the results of the Federal Test Procedure, the test required to certify the emissions for new vehicles.

Impact of a High-Emitters Program on AIR Program Benefits

Since Rapid Screen would, at best, identify only about 10 percent of the high-emitters among the vehicles from which it obtains valid readings, the State cannot rely solely on Rapid Screen to identify and remove high-emitting vehicles from the fleet. Reliance on Rapid Screen alone to identify high-emitters would reduce the benefits of the AIR Program by more than 90 percent. Additionally, since Rapid Screen cannot test gas cap pressure through remote sensing technology, Rapid Screen loses the emissions benefits achieved from the gas cap pressure test currently performed as part of the traditional emissions test. When all these factors are considered, if Rapid Screen replaced the traditional emissions test as the exclusive means to identify high-emitters, the AIR Program would get only 0.9 tons per day hydrocarbon emissions reductions and 0.5 tons per day nitrogen oxides emissions reductions. This compares to the 19 tons per day in hydrocarbon emissions reductions and 9.5 tons per day nitrogen oxides emissions reductions for the current AIR Program. When applied against the EPA ozone standard, this means that if the State were to rely exclusively on remote sensing technology to detect high-emitters instead of the traditional emissions test, there would be less than 0.1 parts per billion reduction in ozone, compared with the 0.6 parts per billion reduction under the current AIR Program.

The Department cannot use a Rapid Screen high-emitter program to replace the current traditional emissions test and Rapid Screen Clean Screen components of the AIR Program, as intended by House Bill 06-1302. Further, technology does not currently exist that would reach the ultimate goal of House Bill 06-1302. As discussed previously, Colorado will realize significant reductions from motor vehicle emissions over time due to the enhanced vehicle emissions standards required of all new vehicles. As the vehicle fleet turns over and older vehicles are replaced with newer vehicles, pollutants from vehicle emissions are substantially reduced. Turnover of the fleet, not a Rapid Screen high-emitter program, will help the State make progress in reaching the goals of House Bill 06-1302.

House Bill 06-1302 requires the Department to develop a plan that will lead to the ultimate goal of reliance on Rapid Screen as the exclusive method of the AIR Program to reduce pollution. Since it is not feasible for the Department to develop a realistic plan to achieve the ultimate goal of House Bill 06-1302, upon completion of the pilot study, the Department should seek any appropriate and necessary statutory revisions to reflect the limitations of remote sensing technology for the foreseeable future. Additionally, the Department should discontinue the pilot program in early Calendar Year 2010, as scheduled. Extending the pilot for further study would only require the expenditure of more time and resources without reaching different results.

Recommendation No. 3:

The Department of Public Health and Environment should discontinue the high-emitter pilot study when the study is scheduled to terminate in early Calendar Year 2010. After completing the pilot study and as informed by the final analysis of that study, the Department should seek any appropriate and necessary amendments to House Bill 06-1302 to reflect the limitations of remote sensing technology.

Department of Public Health and Environment Response:

Agree. Implementation date: January 2011.

Based on the Air Pollution Control Division pilot study to date, and in light of the Denver Metropolitan Area's and North Front Range Area's ozone non-attainment status, replacement of the current AIR Program with a stand-alone remote sensing-based high-emitter program does not appear to be a viable option. It appears that the emission reduction benefits from a stand-alone remote sensing-based high-emitter program would be an order of magnitude less than the emission reduction benefits of the current AIR Program. The Department believes, however, that use of remote sensing devices to identify high-emitting vehicles should be further evaluated as a potential supplement to the current program as a way to increase the emission reduction benefits and the cost effectiveness of the program at little or no additional testing cost. The Department anticipates completing the pilot program in early 2010 and then assessing what role, if any, remote sensing-based high-emitter identification could play in the AIR Program no later than August, 2010. As informed by this assessment, the Department will work with stakeholders involved in the implementation and assessment of House Bill 06-1302, including the Air Quality Control Commission and the Transportation and Legislative Review Committee, to identify appropriate changes, as may be necessary, that reflect the limitations on the use of remote sensing technology for effective high-emitter identification and move forward to propose any needed amendments to House Bill 06-1302.

On-Board Diagnostic System Testing

Most 1996 and newer model-year vehicles sold in the United States are equipped with engine/emissions on-board diagnostic systems. Model-year 1995 and older vehicles are not equipped with these systems. On-board diagnostic systems monitor virtually all components that make up the engine management and emissions control systems. These systems can detect malfunctions or deterioration of these components often well before the motorist becomes aware of any performance problems. When a potential emissions-related problem occurs, the malfunction indicator lamp (e.g., "check engine" or "service engine soon" light) on the vehicle instrument panel comes on. Technicians can then diagnose the problem by utilizing diagnostic trouble codes within the on-board computers. These codes describe the problem that caused the light to go on and are standardized for all vehicle manufacturers.

Prior to 2003 the AIR Program used information from on-board diagnostic systems during the traditional emissions test to fail vehicles if the malfunction indicator lamp was illuminated. In 2003 the Air Quality Control Commission decided to discontinue this practice because the on-board diagnostic standards for emissions-related problems that cause the light to come on were more stringent than AIR Program standards. The Commission recommended that the traditional emissions test contractor continue to download information from the on-board diagnostic system as part of the traditional emissions test, but not to pass or fail a vehicle based on that information.

We evaluated three different models for using on-board diagnostic system testing as either an enhancement or alternative to the current AIR Program. These models included (1) using on-board diagnostic system testing in addition to the current AIR Program, (2) only using on-board diagnostic system testing for 1996 and newer vehicles and continuing to use the traditional emissions test for all 1995 and older vehicles, and (3) using on-board diagnostic system testing for all 1996 and newer vehicles and eliminating all other tests for 1995 and older vehicles.

Overall, we found that using on-board diagnostic system testing in addition to the current AIR Program would increase the emissions benefits obtained through the Program by at least 35 percent and would also lower the cost per ton of emissions reduced. However, we found that although only using on-board diagnostic system testing for 1996 and newer vehicles and maintaining the traditional emissions test for all other vehicles would produce similar increases in emissions benefits as the first model, these increases would come at a higher cost than under the first model or the current AIR Program. Finally, we found that relying solely on on-board diagnostic system testing for 1996 and newer vehicles and eliminating all tests for 1995 and older vehicles would provide significantly lower emissions benefits than is currently obtained through the AIR Program.

Using On-Board Diagnostic System Testing in Addition to the Current AIR Program

First, we reviewed Department data to determine if using on-board diagnostic system testing in addition to the current AIR Program would improve the emissions benefits obtained through the Program. Under this approach, all vehicles in the Denver Metropolitan Area would continue to receive the traditional emissions test and fail if they exceed the standards of that test. In addition, 1996 and newer vehicles would be inspected to determine if the malfunction indicator lamp is illuminated. Vehicles with the malfunction indictor lamp illuminated would fail the on-board diagnostic system test if specific diagnostic trouble codes are triggered, indicating that significant hydrocarbon and nitrogen oxides emissions are occurring. Additional information on this approach is provided in Appendix D.

We found that using on-board diagnostic system testing in conjunction with the AIR Program would reduce ozone levels in the Denver Metropolitan Area by an additional 0.2 parts per billion, for a total reduction of 0.8 parts per billion, compared with the 0.6 parts per billion reduction obtained currently through the Program. This would include an increase in the amount of hydrocarbon emissions reductions obtained through the AIR Program from 19 tons per day to 22 tons per day and increase nitrogen oxides emissions reductions from 9.5 tons per day to 13 tons per day. This approach would also increase the evaporative emissions benefits obtained through the AIR Program, although we lack the data needed to quantify these benefits. On-board diagnostic systems monitor evaporative emission control systems and identify problems, in addition to leaky gas caps, that increase evaporative hydrocarbon emissions from motor vehicles.

We also found that although total repair costs would increase if on-board diagnostic system testing were used, the cost per ton of emissions reductions would decrease. Specifically, we found that total repair costs using on-board diagnostic system testing would increase from about $6.7 million under the current Program to about $11.9 million. This increase is because on-board diagnostic system testing would identify more vehicles with emissions problems than the traditional emissions test and, therefore, more vehicles would need to be repaired. Failure rates for 1996 and newer vehicles would increase from 5.1 percent to 9.9 percent if on-board diagnostic system testing were used. However, the amount of emissions reductions obtained by using on-board diagnostic system testing would offset the higher repair costs, to yield a lower cost per ton than under the current AIR Program. The cost of reducing ozone precursors under the current Program is about $7,700 per ton, compared with $7,100 per ton if on-board diagnostic system testing is also used.

Given the significant challenges facing Colorado with respect to meeting current and future ozone standards, it is important that the Department consider all opportunities for increasing the benefits obtained from the AIR Program, and thus decreasing ozone levels in the Denver Metropolitan Area. The Department should consider incorporating on-board diagnostic system testing, utilizing specific emissions-related diagnostic trouble codes, into the current AIR Program as an enhancement to the traditional emissions test.

Using Only On-Board Diagnostic System Testing for 1996 and Newer Vehicles and Continuing the Current AIR Program for 1995 and Older Vehicles

Second, we reviewed Department data to determine the feasibility of using only on-board diagnostic system testing for all 1996 and newer vehicles and continuing the current AIR Program for all 1995 and older vehicles. Similar to the first model, we found that under this approach, ozone levels in the Denver Metropolitan Area would also decrease by an additional 0.2 parts per billion, for a total reduction of 0.8 parts per billion compared with the 0.6 parts per billion reduction obtained under the current AIR Program. This would include a reduction of 22 tons per day in hydrocarbon emissions and a reduction of 13 tons per day in nitrogen oxides emissions.

However, we also found that total repair costs would increase significantly under this approach, which would increase the cost per ton of emissions reductions obtained. Specifically, we found that total repair costs using on-board diagnostic system testing for 1996 and newer vehicles and the traditional emissions test for 1995 and older vehicles would increase from about $6.7 million under the current Program to about $20.1 million. This increase is because all 1996 and newer vehicles with a malfunction indicator lamp on would fail the on-board diagnostic system test, regardless of which diagnostic trouble codes were triggered, and have to be repaired. Failure rates for 1996 and newer vehicles would increase from 5.1 percent under the current AIR Program to 13 percent. The increase in repair costs would also increase the cost of reducing ozone precursors from about $7,700 under the current Program to about $8,200 per ton. Although this model would help to further reduce ozone levels in the Denver Metropolitan Area, the increased costs associated with this model make it a less cost-effective option than using on-board diagnostic system testing in addition to the current AIR Program, as described above.

Using On-Board Diagnostic System Testing Only

Finally, we reviewed the feasibility of using on-board diagnostic system testing as an alternative to the current AIR Program. Colorado is currently the only state that relies exclusively on the traditional emissions test. All other states with inspection programs use either a combination of tail pipe inspections and on-board diagnostic system testing or they rely exclusively on the on-board diagnostics. Although the current trend is for more states to rely exclusively on on-board diagnostic system testing, we found that if the AIR Program were to rely solely on this testing, the benefits obtained from the Program would decrease significantly. Specifically, we found that:

- Hydrocarbon benefits would decrease 42 percent, from 19 tons per day under the current Program to 11 tons per day with on-board diagnostic system testing only.

- Nitrogen oxides benefits would decrease 26 percent, from 9.5 tons per day under the current Program to 7 tons per day with on-board diagnostic system testing only.

- Carbon monoxide benefits would decrease 52 percent, from 160 tons per day under the current Program to 77 tons per day with on-board diagnostic system testing only.

This decrease in benefits means that the AIR Program would reduce ozone levels in the Denver Metropolitan Area by 0.4 parts per billion, rather than the 0.6 parts per billion reduction obtained through the current Program. This amounts to a 33 percent reduction in benefits. This reduction is due to the number of 1995 and older vehicles still in the Denver Metropolitan Area fleet. As mentioned previously, on-board diagnostic systems are only included on 1996 and newer vehicles. As a result, none of the 1995 and older vehicles, which are often higher emitters than newer vehicles, would be tested and repaired under a program that relies exclusively on on-board diagnostic system testing. Currently about 23 percent of the Denver Metropolitan Area fleet is made up of 1995 and older vehicles. Therefore, relying exclusively on on-board diagnostic system testing is not a viable option for the AIR Program at this time. However, the Department may wish to re-visit this option at a later time when there are fewer 1995 and older models in the fleet.

Recommendation No. 4:

The Department of Public Health and Environment should consider incorporating on-board diagnostic system testing, utilizing specific emissions-related diagnostic trouble codes, into the current AIR Program as an enhancement to the traditional emissions test.

Department of Public Health and Environment Response:

Agree. Implementation date: June 2010.

Other Air Pollution Control Strategies

As discussed in Recommendation No. 1, we found the ozone reductions provided by the AIR Program are relatively small when compared with the total level of ozone concentrations in the Denver Metropolitan Area, and may be more expensive than those provided by some other air pollution control strategies. Overall, the AIR Program is responsible for reducing ozone levels in the Denver Metropolitan Area by 0.6 parts per billion, which includes a 19 ton per day reduction in hydrocarbon emissions and a 9.5 ton per day reduction in nitrogen oxides emissions. There may be other air pollution control strategies, however, that the Department could adopt which, if implemented, would likely provide more significant ozone reductions. In total, these strategies could potentially reduce ozone levels in the Denver Metropolitan Area between 2 to 5 parts per billion, based on our preliminary analysis, which is 3 to 8 times the reductions achieved by the current AIR Program. The Department has already begun to analyze some of these strategies but additional work is needed to determine how each of these strategies can be applied to specific sources, how each strategy will impact emissions, how much each strategy will cost, and how each strategy would be implemented. We discuss each of these strategies below.

Electrical Generation Units (EGUs) – Electric utilities are major sources of nitrogen oxides emissions, which now appear to be the greatest contributor to the formation of ozone. A 2008 study commissioned by the Department indicated that it might be possible to reduce nitrogen oxides emissions from EGUs by 30 to

40 tons per day at a cost of $1,600 per ton[2]. We estimate that this could yield a reduction in ozone of 1 to 2 parts per billion, assuming a linear relationship between nitrogen oxides emission reductions and apportioned ozone. These controls could potentially provide three times the benefits of the AIR Program for about 25 percent of the cost. The Department is gathering additional data to determine the actual costs of control strategies for specific units and to evaluate the practicability of assessing such costs.

Non-Road Vehicles – Non-road vehicles are also a major source of nitrogen oxides emissions. Non-road vehicles include locomotives, portable generators, agricultural equipment, construction equipment, and lawn and garden equipment. Based on research conducted by the EPA, we estimate that retrofitting controls on non-road vehicles could reduce nitrogen oxides emissions by 30 to 40 tons per day and hydrocarbon emissions by up to 30 tons per day at a cost of $2,000 to $19,000 per ton. We project that this could yield a reduction in ozone of 1 to 3 parts per billion[3], assuming a linear relationship between hydrocarbons and nitrogen oxides emission reductions and apportioned ozone, and recognizing there may be practical implementation issues that will need to be addressed with respect to controls on non-road vehicles. There may also be limits on the Department's authority to implement some controls on non-road vehicles because they are under the purview of the EPA. The EPA has established some new standards for non-road vehicles, but it will be more than 10 years before these controls impact emissions.

Ethanol Waiver – When ethanol is blended with gasoline, the volatility of the blend increases, which increases the amount of hydrocarbons emitted. Many states, including Colorado, request and receive approval from the EPA to allow the sale of gasoline-ethanol blends with higher volatility levels than gasoline only. Although ethanol has some positive environmental benefits, the ethanol waiver results in significantly increased hydrocarbon emissions because of the increased use of higher volatility fuel. Eliminating the ethanol waiver, and requiring manufacturers to take additional steps in the refining process to reduce the volatility of gasoline-ethanol blends could reduce hydrocarbon emissions by as much as 8.4 tons per day at an estimated cost of $7,200 per ton, or $0.02 per gallon. This would yield a reduction in ozone of 0.1 parts per billion, assuming a linear relationship between hydrocarbons emission reductions and apportioned ozone.

Excessive evaporative emissions – Currently the only evaporative emission problems identified by the AIR Program are leaky gas caps. However, there are other possible problems that could lead to excessive evaporative emissions

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[2] Summary of Research on Potential Control Options, Emission Reductions and Costs for Reducing SO2 and NOx from Existing Major Colorado Point Sources, BBC Research & Consulting, June 27, 2008.

[3] EPA420-R-07-005 -- An Analysis of the Cost-Effectiveness of Reducing Particulate Matter and Nitrogen Oxides Emissions from Heavy-Duty Nonroad Diesel Engines Through Retrofits, May 2007.

problems, including liquid gasoline leaks and broken or disconnected evaporative emission canisters. These canisters contain activated carbon that absorbs vapors generated from the fuel tank while the engine is off; the vapors are then routed to the engine while the engine is on. As we discussed in Recommendation No. 4, on-board diagnostic system testing can also be used to identify evaporative emissions. Based on studies by the EPA and the State of California, vehicles with liquid fuel leaks emit large amounts of hydrocarbons. Identifying vehicles with excessive evaporative emissions could reduce hydrocarbon emissions by as much as 1 to 2 tons per day. The estimated cost of these reductions is not ascertainable because of current uncertainties as to how vehicles would be identified and repaired.

The Department should continue its analysis of these other strategies as alternatives to the current AIR Program to determine which strategies will be the most cost effective in further reducing ozone levels in the Program area. The Department should also continue to work with stakeholders and the Air Quality Control Commission to develop a cost effective package of control measures to achieve the 75 parts per billion ozone standard.

Recommendation No. 5:

The Department of Public Health and Environment should continue to analyze other air pollution control strategies as alternatives to the current AIR Program to help further reduce ozone levels in the Program area. These strategies could include implementing controls on non-road vehicles and electrical generating units, eliminating the ethanol waiver, and identifying vehicles with excessive evaporative emissions. The Department should also continue to work with stakeholders and the Air Quality Control Commission to develop a cost effective package of control measures to achieve attainment of the 75 parts per billion ozone standard.

Department of Public Health and Environment Response:

Agree. Implementation date: Ongoing.

Reducing ambient levels of ozone in the Denver Metropolitan Area has been and continues to be one of the Department's most important air quality goals. Since the early 2000's the Department has actively considered a myriad of air pollution control strategies designed to reduce ozone concentrations. As part of these efforts, the Department has proposed, and the Air Quality Control Commission has adopted, regulatory programs that have reduced ozone precursor emissions by hundreds of tons per day. While the Department and the Air Quality Control Commission have achieved great success in lowering ozone precursor emissions over the past several years, during this time period EPA has lowered the national ozone standard to 75 parts per billion, and is currently considering lowering the standard even further. In response to these additional challenges, the Department is actively evaluating the additional emission reduction strategies identified by the auditor, and is working to further develop and refine its understanding of the associated costs, benefits, and implementation issues associated with these strategies. As part of this analysis, the Department will consider any legal barriers to enacting any of these strategies, such as federal preemption requirements that might bar State action, notwithstanding the fact that the strategy may be a cost-effective method to reduce ozone. The Department is also considering other potential strategies including several alternative methods to reduce gasoline volatility and thereby reduce volatile organic compound (VOC) emissions from vehicles and reduce nitrogen oxide (NO_x) emission from large industrial sources, more stringent controls on VOC and NO_x sources at oil and gas exploration and production facilities, VOC controls at gas stations, and vehicle miles traveled (VMT) reduction strategies. Achieving the 75 parts per billion ozone standard presents a very significant challenge requiring significant reductions in ozone precursor emissions. If EPA further lowers the ozone standard, additional dramatic emission reductions will be required. Accordingly, while the Department will strive to adopt the most cost-effective package of emission control strategies possible, given the significance of the challenge in meeting a 75 parts per billion or even lower standard, the State may not have very much flexibility in choosing among cost-effective emission reduction strategies.

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Disposition of Recommendations Made in the 2006 Review

Recommendation	Contractor's Disposition
1. The Department of Public Health and Environment (the Department) should: a. Maintain the current AIR Program until April 15, 2008, the ozone demonstration date under the *Early Action Compact*. b. Analyze data evaluating the extent to which the AIR Program will be needed beyond 2007. If the Department determines the AIR Program is no longer needed, work with the Air Quality Control Commission to evaluate eliminating the Program, and depending on the Commission's actions, with the federal Environmental Protection Agency to eliminate the Program from the State Implementation Plan.	*Implemented. Based on air quality data collected since the last review, the Department determined that the AIR Program is needed to demonstrate attainment of national air quality standards. (The Denver Metropolitan Area exceeded the 8 hour ozone standard in 2007 and 2008.) The continued need for the AIR Program is discussed in Recommendation No. 1 of this report.*
2. The Department of Public Health and Environment should conduct its own evaluation of the effectiveness of using Rapid Screen to identify high-emitting vehicles. If based on this evaluation the Department determines that Rapid Screen does not effectively identify high-emitting vehicles, the Department should work with the General Assembly to determine the appropriate policy direction to take with respect to the Program, and if necessary, seek statutory change to eliminate the requirement that Rapid Screen be used for this purpose.	*In Progress. The Department is in the process of conducting a "high-emitter" pilot program to evaluate the effectiveness of using Rapid Screen to identify high-emitting vehicles. The pilot began in Calendar Year 2007 and is scheduled to be completed early in Calendar Year 2010. The Department reports that it will use the results of the pilot program to determine whether or not a high-emitter program can replace the traditional emissions test, and pursue any necessary changes at that time. Rapid Screen's effectiveness at identifying high-emitting vehicles is discussed in Recommendation No. 3 of this report.*

Recommendation	Contractor's Disposition
3. The Department of Public Health and Environment should consider retaining the Rapid Screen clean screen component of the AIR Program if the Front Range Area does not meet National Standards for ozone in 2007, or the Department's analysis indicates that emissions reductions are needed in the future. If Rapid Screen is retained, the Department should consider requiring only one valid observation in conjunction with using a high-emitter index.	*Implemented. The Department has continued the Rapid Screen clean screen program. Beginning in 2007, the Department started requiring only one valid observation in conjunction with using a low-emitter index. The Rapid Screen clean screen program is discussed in Recommendation No. 2 of this report.*
4. The Department of Public Health and Environment should work with the Air Quality Control Commission to fully evaluate the impact of increasing the model-year exemptions for the AIR Program greater than the current four model-years. The current four model-year exemption should be maintained until the Commission considers and acts upon the results of the Department's evaluation.	*Implemented. The Department reports that it decided to keep the current four-model-year exemption after determining that expanding model year exemptions was not compatible with Rapid Screen and that the Rapid Screen Program would have to be reduced significantly if model year exemptions were expanded. According to the Department, increasing model year exemptions reduces the revenue base for Rapid Screen, which would force ESP, the testing contractor, to cut back on the number of Rapid Screen tests.*
5. The Department of Public Health and Environment should evaluate options for integrating on-board diagnostic system testing into the AIR Program if the decision is made to continue the Program to further reduce emissions.	*Partially Implemented. The Department implemented a minor change in test procedures that allows ESP, the testing contractor, to skip the anti-tampering inspection if the malfunction indicator lamp is off and all monitors are ready. The Department has not implemented broader uses of on-board diagnostics in the AIR Program. On-board diagnostic system testing is discussed in Recommendation No. 4 of this report.*
6. If the Department of Public Health and Environment determines that the AIR Program is needed in the future to further reduce vehicle emissions, the Department should consider using the idle test for 1995 and older vehicles in conjunction with onboard diagnostic system testing for 1996 and newer vehicles.	*Not Implemented. The Department reports that it decided to maintain current inspection procedures. According to the Department, changing to an idle test is no longer advisable since the Denver Metropolitan Area needs reductions in nitrogen oxides as well as hydrocarbons to demonstrate attainment of the ozone standard. Idle tests do not identify vehicles with excessive emissions of nitrogen oxides.*

Recommendation	Contractor's Disposition
7. The Department of Public Health and Environment should consider alternatives to strengthen the AIR Program if it is needed in the future. Alternatives include inspecting vehicles for liquid fuel leaks, increasing the stringency of AIR Program standards, and annually inspecting 1995 and older vehicles that fail an inspection.	*Partially Implemented. The Department implemented the most significant of the suggested alternatives – more stringent hydrocarbon and nitrogen oxides standards. These standards have significantly increased benefits for the AIR Program, particularly for nitrogen oxides. The Department reports that it is also evaluating alternative ways to identify vehicles with excessive evaporative emissions, including liquid leaks. Additional alternatives to the AIR Program are discussed in Recommendation No. 5 of this report.*
8. The Department of Public Health and Environment should recommend to the Regional Air Quality Council that the Council evaluate whether to include vehicles in which the malfunction indicator lamp has been turned on due to emissions-related problems in the Repair Your Air Campaign.	*Not Implemented. The Repair Your Air Campaign has been de-emphasized and the Department reports that it has concentrated on the high-emitter pilot program.*
9. The Department of Public Health and Environment should ensure that it has sufficient, accurate information related to the AIR Program and emissions in the Front Range Area to support decision-making by: a. Working with the Environmental Protection Agency to ensure its new mobile source emissions model (MOVES) accurately reflects vehicle deterioration in high-altitude areas. b. Using all available data and resources to evaluate the various components of the AIR Program and to support recommendations for Program enhancements and modifications.	*a. Not Implemented. The Department did not act on this recommendation. The Department reports that it plans to work with EPA on resolving concerns over MOVES, but nothing official has been done since the last review. Concerns about MOVES, particularly with respect to the amount of benefit a state can claim for its inspection and maintenance program, is discussed further in Chapter 1 and Appendix E of this report.* *b. Ongoing. The Department makes use of available data to evaluate the various components of the AIR Program and to support recommendations for Program enhancements and modifications.*

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APPENDIX A

BACKGROUND ON AIR PROGRAM[1]

This Appendix A contains specific information about the AIR Program and provides details on both the traditional emissions test and the Rapid Screen Program, including a description of the tests required for vehicle types and at what frequency, an identification of fees and waiver amounts, a discussion of the AIR Program's enforcement provisions, and technical information on Rapid Screen.

1) **Types of tests administered**

   a. Light-duty gasoline-powered vehicles (LDGV – Passenger cars)*, Light-duty gasoline-powered trucks (LDGT)
      i. 1982 and newer LDGV and LDGT receive an IM240 inspection
      ii. 1981 LDGV and LDGT receive a Two Speed Idle (TSI) inspection with pass/fail at 2500 RPM
      iii. 1980 and older vehicles receive a TSI with pass/fail at idle only
      iv. Vehicles that cannot be tested by IM240 receive TSI inspection with pass/fail at 2500 rpm
      v. All 1975 and newer vehicles receive a pass/fail anti-tampering inspection for:
         1. Catalytic Converter(s)
         2. Oxygen (O2) sensor(s)
         3. Air Injection System(s)
         4. Gas cap presence
      vi. All 1975 and newer vehicles (if applicable) receive an advisory only inspection of the "check engine" light illumination
      vii. 1975 and newer LDGV/LDGT receive pass/fail gas cap pressure test
      viii. 1996 and newer LDGV and LDGT receive an advisory only OBDII interrogation
      ix. All vehicles receive a pass/fail visible smoke inspection

   b. Heavy-duty gasoline-powered vehicles (HDGV)*
      i. 1981 and newer receive TSI inspection with pass/fail at 2500 rpm
      ii. 1980 and older receive TSI with pass/fail at idle only
      iii. 1975 and newer receive a pass/fail anti-tampering inspection for:
         1. Catalytic Converter(s)
         2. Oxygen (O2) sensor(s)
         3. Air Injection System(s)
         4. Gas cap presence
      iv. All 1975 and newer vehicles (if applicable) receive an advisory only inspection of the "check engine" light illumination
      v. All vehicles receive a pass/fail visible smoke inspection

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[1] Prepared by *dKC* de la Torre Klausmeier Consulting, Inc.

* The 1982 and newer fleet can only be inspected by Environmental Systems Products (ESP) as part of the centralized inspection network. Either ESP or an independent inspection only station can inspect vehicles 1981 and older.

NOTE: All vehicles receive a free retest if the vehicle fails and is reinspected within the first 10 days following the failure. If an independent station inspects the vehicle, the vehicle must also be returned to that station that performed the initial inspection in order to receive a free retest.

2) Network:

a. 1981 and older: ESP stations (#'s 1-15); private facilities: (#s>19)

3) Program coverage areas

a. Denver Metropolitan Area, which includes the following counties:
   i. Adams (Partial county)
   ii. Arapahoe (Partial county)
   iii. Boulder
   iv. Broomfield
   v. Denver
   vi. Douglas
   vii. Jefferson

b. Northern Front Range Area, which includes the following counties: (effective January 1, 2010)
   i. Larimer
   ii. Weld

4) Test Frequencies

a. All 1982 and newer vehicles inspected on a biennial basis.
b. All 1981 and older vehicles inspected on a annual basis.
c. Vehicle model years 1960 and newer and at a minimum 25 years old AND registered as Collector Series vehicles are required to be inspected at the time of their original application for collector series designation, the inspection is valid until the vehicle is sold or transferred.
d. Vehicle model years older than 1960 AND registered as Collectors Series vehicles are not required to be inspected.
e. Vehicles plated as Street Rods, Farm Vehicles, and Horseless Carriage are also not required to be inspected.

5) Model Years

a. All vehicles are required to be inspected with the following exemption:
   1. Vehicles four-model-years-old and newer are exempted (required to be inspected at age five)

6) Test On Resale

a. Vehicles that are NOT in their first three years of their four-year exemption period are required to be inspected at the time of sale or transfer.

7) **Program Waiver Requirements**

a. All vehicles must pass the anti-tampering and visible smoke requirement to be eligible for a waiver.
b. A one time economic hardship (as determined by the Department of Revenue) waiver is available for vehicles where the owner cannot afford repairs up to the required minimum waiver repair limit.
c. As determined by the Department of Revenue, all repairs must be applicable to the emissions failure.

8) **Waiver Repair Cost Limit**

a. Model years 1968 and newer must spend a minimum of $715 to qualify for a waiver.
b. Model years 1967 and older must spend a minimum of $75 to qualify for a waiver.

9) **Vehicle Non-Compliance Information**

a. Vehicles operating within the Program area for a minimum of 90 days within a 12-month period must comply with the Program area requirements.
b. Results from an evaluation regarding vehicles that never passed their I/M inspection in 2007 were included in the Department of Public Health and Environment's 2007 Annual Report (page 9).

10) **Program Enforcement**

a. The AIR Program is a registration denial program.

11) **Internal Program Enforcement**

a. AIR and Rapid Screen Program oversight is divided between the Colorado Department of Public Health and Environment (CDPHE) and the Department of Revenue (DOR).
b. CDPHE's duties include the majority of the technical elements of the Program with DOR's duties being contractor audit and enforcement.
c. DOR performs overt audits on each I/M240 lane quarterly and covert audits biannually for each lane. Overt audits consist of both equipment and inspector performance.
d. The DOR no longer performs drive-by audits on the Remote Sensing Device (RSD) units. The new version of equipment allows the DOR to perform "puff" audits within the van (i.e. an internal calibration cell). These audits are performed approximately every two days by DOR.

RULES AND REGULATIONS

1) Regulation 11 describes requirements for motor vehicle emissions inspections. It can be accessed at:
http://www.cdphe.state.co.us/regulations/airregs/100113aqccmotorvehicleinspections.pdf

COLORADO AIR PROGRAM FEES

1) Inspection fee for all 1982 and newer non-fleet vehicles - $25 ($24.75 to the contractor, $0.25 to State)

2) Inspection fee for all 1981 and older vehicles - $15(max) ($14.75 to inspection shop, $0.25 to State)

3) Fee collected by the County Clerk for registration-based Program enforcement - $ 0.70 (Annual on all vehicles in Program area)

4) Fee collected by the County Clerk to implement pay-upon-registration- $ 0.83 - (clean-screened vehicles only)

5) Registration fee collected by the County Clerk for State oversight funding for CDPHE & DOR – $ 1.50, (annual on all vehicles in Program area)

SIGNIFICANT CHANGES TO THE AIR PROGRAM SINCE 2006

1) Elimination of the Program in El Paso, Larimer, and Weld counties as of January 1, 2007.
2) More stringent HC and NOx standards were implemented May 2008.
3) The Emissions Control System Inspection (visual) was modified in Oct. 2008. Vehicles are no longer failed for missing or tampered fuel inlet restrictor. Also, for OBDII vehicles, the contractor is allowed to bypass the visual inspection if the MIL is off (and commanded off) and ALL readiness monitors are set.

RAPID SCREEN BACKGROUND

Structure of the Rapid Screen Program

The Clean Screen program in Colorado is called the Rapid Screen Program. This Program utilizes Remote Sensing Devices (RSD) to collect emissions measurements on vehicles that drive by the testing units. These measurements are used to screen vehicles with low emissions and exempt them from their traditional emissions test. Currently only light duty gas vehicles, 1982 and newer, are entitled to participate in Colorado's Rapid Screen Program. These vehicles are eligible to participate if their two most recent consecutive emissions readings observed during the 12-month time period prior to their registration renewal date and the most recent passing emissions reading occurred on a different day or at a different site from the prior observation. The measurements from these systems are kept in a database that is queried each month for vehicles due for an emissions test. This query is conducted approximately two months before the vehicle's registration month to allow for data processing and notification time. Therefore, the data available for a Rapid Screen Program qualification is based on a rolling ten months.

Rapid Screen is a voluntary program in that owners of qualified vehicles can chose to have a traditional emissions test done. County Clerks notify vehicle owners that have qualified for Rapid Screen by printing a "Passed Roadside Emissions" statement on their registration renewal cards. The vehicle owner can send in the testing fee with their registration renewal to utilize the RSD test or they can go to an emissions station and have a traditional inspection.

During the latter part of 2007 Colorado implemented a Low Emitter Index element as part of the Clean Screen program. If the last RSD observation is below the clean screen standard AND the vehicle has a high probability of passing the IM240 (based on historical information), the vehicle is eligible to participate in the Rapid Screen Program.

Chronology of Significant Changes to Rapid Screen Since 2006

Program Area:

1) The Division requested that ESP collect RSD data in Colorado Springs in 2007 to help in evaluating the fleet after the I/M program was eliminated in that area (e.g. will the fleet become older, dirtier etc.). As a result, ESP starting collecting RSD data in May 2007 in the Colorado Springs area.

RSD Units:

1) During 2007 Colorado received additional RSD vans bringing the total to 18.

RSD Technology:

1) The RSD 4000 was upgraded to the 4600 which is an enclosed unit.

Sites:

1) In 2005, there were about 60 permitted and licensed sites in the Denver Metropolitan Area.

2) Currently, there are about 150 permitted and licensed sites in the Denver Metropolitan Area.

Fleet Coverage:

The percentage of vehicles observed within a 10-month window in 2007 and 2008 were 19.09 percent and 38.86 percent respectively.

Rapid Screen Criteria

The following steps are used on a monthly basis to determine vehicle clean screen eligibility.

1. ESP specifies month and year corresponding to registration expiration date (esp_month_year).

2. Vehicle registration must expire in month and year specified by ESP. The date that the next emissions test is due must be less than or equal to ESP-specified month and year plus 1 year.

(next_insp_dt) <= ((esp_month_year) +1)).

3. Fuel type must be 'g' (gas).

4. Vehicle model year must be 1982 and newer and the vehicle must be registered in counties 1, 7, 10, 11, 12, 47, or 64.

5. Last three digits of 'License Type' cannot = 'CNY', 'CTY', or 'SOC.'

6. Emission_flag (emission required) must be Yes.

7. Number of years between vehicle registration expiration year and vehicle model year must be greater than or equal to 4 years.

   ((Registration_expiration_year) – (vehicle_model_year)) >= 4 years

8. If one or more vehicle test records from centralized testing exist, the most recent test result must be a 'pass.'

9. Use the two most recent remote sensing roadside test records, ignoring duplicates for the same site on the same date. If multiple tests on the same date at the same site exist, only the first test of that day will be used. The second test would have to occur at a different site or on a different date. For each of the two most recent remote sensing roadside test records, the test dates must be greater than or equal to the registration_expiration_date - one year, i.e. the test records cannot be greater than one year old based on the registration expiration date.

10. For each of the two most recent remote sensing roadside test records, both HC and CO must be equal to or less then 200 ppm and 0.5 percent respectively.

11. For the two most recent remote sensing roadside test records, the ESP image QA reviewer must confirm the following by visual review:

    - The two images match each other
    - Each image matches the registration data

12. Using Polk PCVIS (or equivalent) VIN decoding software

    If model year < 1979, then GVW <= 6000 lb

    If model year => 1979 then GVW <= 10,000 lb

    If GVW cannot be determined then set criteria to eligible

13. Ambient temperature must be between 20° and 120° F.

14. Acceleration must >= 0mph/second.

15. Alignment alarm flag must not be set.

16. During the latter part of 2007 Colorado implemented a Low Emitter Index (LEI) element as part of the Rapid Clean Screen Program. If the last RSD observation is below the clean screen standard AND the vehicle has a high probability of passing the IM240 (based on historical information), the vehicle is eligible to participate in the Rapid Screen Program.

Appendix B

CONTRIBUTION OF THE COLORADO AUTOMOBILE INSPECTION AND READJUSTMENT (AIR) PROGRAM TO REDUCING OZONE IN THE DENVER METROPOLITAN AREA[1]

Introduction

Based on ambient air monitoring data for the three-year period, 2005 to 2007, the Denver Metropolitan Area violated the 8-hour National Ambient Air Quality Standard (National Standard) for ozone (O_3). As a result, the EPA re-designated the Area to nonattainment, requiring Colorado to develop and submit a State Implementation Plan (SIP) which must demonstrate compliance with the National Standard by 2010. This Appendix B presents detailed information with respect to the present impact of Colorado's AIR Program on reducing O_3 concentrations and need for the Program in the future.

Recent O_3 Concentrations in the Denver Metropolitan Area

Air Improvement Resources, Inc. (AIRInc) prepared time series plots of the 8-hour O_3 design value concentrations[2] for each site in the Denver Metropolitan Area (DMA), which are shown in the attached figures. Based on a visual inspection of the time series, it is obvious that there is no significant trend. The trend of the averages is slightly positive. The Rocky Flats North monitor (#080590006), which is the design value site, and the Fort Collins West (#08590011) monitor are the two highest sites. They have been fluctuating above and below the current National Standard and display opposite trends. (The National Standard is achieved when the concentration is below 85 parts per billion (ppb)).

These results are consistent with analyses performed by the Department of Public Health and Environment (Department) and others as part of the SIP development[3] which also show flat time series. In addition, these analyses examined meteorologically-adjusted O_3 trends that exhibit slight upward trends.

The lack of a downward trend clearly suggests that additional emissions control measures need to be adopted in order to comply with the National Standard by 2010. It also means that any control programs already in place, for example, the AIR Program, will likely need to remain in place if the program is effective.

SIP Attainment Demonstration

As noted above, the State of Colorado had to develop a SIP that would include the control strategies needed to achieve compliance with the current O_3 standard by 2010. To develop this

[1] Prepared by Air Improvement Resources, Inc. and *dKC* de la Torre Klausmeier Consulting, Inc.
[2] A design values is the 4^{th} highest annual 8-hour O_3 value averaged over 3 consecutive years.
[3] Alpine Geophysics, Regional Air Quality Council, Colorado Department of Public Health and Environment, and Environ, "Denver Metropolitan Area and North Front Range 8-Hour Ozone State Implementation Plan Weight of Evidence to Support the Modeled Attainment Demonstration," October, 29, 2008.

SIP, the State retained the services of Environ International Corporation and Alpine Geophysics, LLC. The emissions control strategy that they identified is detailed in Morris et al. (2009).[4] The final SIP includes some additional stationary source controls but no additional mobile source controls beyond the existing Federal Tier 2 requirement and the AIR Program.

Emissions inventories by source developed for the air quality modeling to support the SIP are shown in Table B-1. "Base" means without additional controls, and "Final" means with additional controls needed to attain the 85 ppb standard. The emissions reductions are shown in Table B-2. Some emissions increased (for VOC[5] from point and oil and gas sources; and for NOx from point, oil and gas, and area sources). There are reductions in VOC and NOx for non-road mobile and on-road mobile sources, and also for area sources for VOC.

Table B-1. VOC and NOx emission inventories in tons per average episode day

	VOC			NOx		
Source Type	**2006**	**2010 Base**	**2010 Final**	**2006**	**2010 Base**	**2010 Final**
Point	32.1	37.0	37.0	81.0	86.4	86.4
Oil & Gas Prod	185.2	203.3	186.2	39.7	46.2	46.2
Area	66.3	61.0	61.0	20.2	22.1	22.1
Non-Road Mobile	65.3	61.3	61.3	70.5	61.0	61.0
On-Road Mobile	129.7	109.2	109.2	165.5	122.9	122.9
Total Anthropogenic	478.6	471.8	454.8	376.8	338.5	338.5
Biogenic	694.0	694.0	694.0	53.0	53.0	53.0
Total	1172.6	1165.8	1148.8	429.8	391.5	391.5

Table B-2. VOC and NOx Emission Reductions by Source (Base minus Final)
(a negative number indicates an emissions increase)

Source	VOC	NOx
Point	-4.9	-5.4
Oil and gas	-1	-6.5
Area	5.3	-1.9
Non-Road Mobile	4	9.5
On-Road Mobile	20.5	42.6
Biogenic	0	0
Total	23.9	38.3

The percent of emissions for each source is shown in Table B-3. On-road mobile sources, which include passenger cars and light duty trucks subject to I/M, represent 9.5 percent of VOC and 31.4 percent of NOx. Of course, heavy-duty diesel vehicles are included in this as well.

[4] Morris, R., Sakulyanonvittaya, T., Tai, E., McNally, D. and Loomis, C., "Final 2010 Ozone Attainment Demonstration Modeling for the Denver 8-hour Ozone State Implementation Plan," January 12, 2009.

[5] Volatile organic compounds, also referred to throughout these appendices as hydrocarbons or HC.

Table B-3. Percent Emissions Due to Each Source						
	VOC			NOx		
	2006	**2010 Base**	**2010 Final**	**2006**	**2010 Base**	**2010 Final**
Point	2.7%	3.2%	3.2%	18.8%	22.1%	22.1%
Oil and gas	15.8%	17.4%	16.2%	9.2%	11.8%	11.8%
Area	5.7%	5.2%	5.3%	4.7%	5.6%	5.6%
Non-Road Mobile	5.6%	5.3%	5.3%	16.4%	15.6%	15.6%
On-Road Mobile	**11.1%**	**9.4%**	**9.5%**	**38.5%**	**31.4%**	**31.4%**
Biogenic	59.2%	59.5%	60.4%	12.3%	13.5%	13.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Using the Comprehensive Air-Quality Model with extensions (CAMx), Environ and Alpine predict that this control strategy will bring all monitors within the Denver Metropolitan Area into compliance with the 85 parts per billion ozone standard by 2010. The modeled design values for the 2006 base case and the 2010 control strategy case are shown in Table B-4 for the two highest sites.

Table B-4. 2005-2007 Design Values and 2010 Targets From Modeling		
Monitoring Site	**2005-2007 DV**	**2010 Target**
Rocky Flats North	85.0	84.9
Fort Collins West	86.0	84.8

As stated above, the National Standard is achieved when the concentration is below 85 parts per billion. Consequently, these two sites are predicted to barely meet the standard by 2010 with little or no margin for error.

Apportionment of Motor Vehicle Contributions to Ozone in Denver

A unique and important feature of the CAMx modeling system is its ability to determine the contribution of different source categories and different geographical regions to the ozone observed in any grid cell in the modeling domain. Such information is contained in McNally et al. (2008)[6] for every day for a June-July, 2006 ozone episode. The most relevant information is that for July 29, which had the highest ozone concentration (76.1 parts per billion) of the episode at the Rocky Flats North site. On that day, approximately 24 parts per billion was attributed to anthropogenic sources. Of the 24 parts per billion from anthropogenic sources, 20 parts per billion were from sources in the DMA; 4 parts per billion were from sources outside the DMA. Of the sources in the DMA, approximately 10 parts per billion is attributed to on-road motor vehicle emissions. Of that, only 1 parts per billion is attributed to vehicle VOC emissions and the remainder (9 parts per billion) to vehicle NOx emissions. It should be noted that any contribution by CO to O_3 formation will be lumped into the VOC contribution. Note that these results are specific for the Rocky Flats monitor. Other areas in the DMA have shown to be more sensitive to VOC than NOx emissions reductions.

[6]McNally, D., Loomos, C., Morris, R., Sakulyanontvittaya, T. and Tai, E., "2010 Ozone Projections for the 2010 Base Case and 2010 Sensitivity Tests and the 2010 Ozone Source Apportionment Modeling for the Denver 8-hour Ozone State Implementation Plan," September 8, 2008.

We found that the AIR Program is responsible for a 15 percent reduction in VOCs from mobile sources. It is reasonable to assume that this reduction produces a proportional reduction in ozone. Therefore, the impact of mobile source VOC reductions from the AIR Program is estimated to be: (15 percent) x 1 parts per billion or about 0.15 parts per billion.

This suggests that the VOC reductions due to AIR have resulted in a 0.1 parts per billion reduction in ambient O_3 at the site with the highest observed concentrations. As a check on this estimated reduction, the results of a sensitivity modeling run conducted by McNally et al. (2008) can be used. They examined the impact on ozone of reducing vehicle VOC emissions by 20 percent from their 2010 base case. This corresponds to a VOC reduction of 21.8 tons/day compared to the 19 ton/day attributed to AIR. This 21.8 tons/day reduction decreased the modeled O_3 concentrations at Rocky Flats North and Fort Collins West by 0.2 and 0.1 parts per billion, respectively. Thus, this sensitivity run provides confidence in the above estimate.

We found that the AIR Program is responsible for a 6 percent reduction in NOx emissions from mobile sources. Since 9 parts per billion of the O_3 was attributed to on-road mobile NOx emissions, the O_3 reduction would be on the order of 0.06 x 9 parts per billion = 0.5 parts per billion.

Consequently, the total O_3 benefit that can be attributed to the AIR Program is about 0.6 parts per billion. This number is 6 times larger than the difference between the projected 2010 design value at Rocky Flats North (84.9 parts per billion) after all control measures are applied and the 85 parts per billion National Standard. In other words, without the AIR Program, the predicted O_3 level would be 0.6 parts per billion higher at 85.5 parts per billion, instead of at 84.9 parts per billion. Without the AIR Program as part of the State's overall control program, attainment would probably not be demonstrated in 2010.

Beyond 2010

In March, 2008, EPA lowered the 8-hour O_3 National Standard to 75 parts per billion.[7] Designations for this new standard will be made in June of 2010 and compliance must be achieved in the 2013-2020 time frame. Assuming Colorado meets the current National Standard by 2010, the State is going to need an additional 10 ppb O_3 reduction to meet the new standard. Consequently, the State will need emissions reductions significantly larger than that produced by the current AIR Program, or even produced by an improved AIR Program. And, according to the analysis above, it should mostly be NOx. Based on data collected from 2005 to 2008, several air monitoring sites in the Denver Metropolitan Area have exceeded the 75 parts per billion standard.

[7] US EPA (2008), Final Ozone Rule, http://www.epa.gov/fedrgstr/EPA-AIR/2008/March/Day-27/a5645.pdf

Denver Metro - North Front Range

(continued)

Ozone Data From Monitors Operated Year-Round in NAA

4th Maximum 8-Hour Ozone Values and 3-Year Averages

Site Name	AQS#	2005 [ppm]	2006 [ppm]	2007 [ppm]	2008* [ppm]	3-Year Average 2005-2007 [ppm]	3-Year Average 2006-2008* [ppm]	2009 Highest Allowable 4th Max. [ppm]
CDPHE-APCD Sites								
Welby	08-001-3001	0.073	0.069	0.070	0.076	0.070	0.071	0.081
Highland	08-005-0002	0.080	0.081	0.075	n/a	**0.078**	n/a	n/a
S. Boulder Ck.	08-013-0011	0.076	0.082	0.085	0.076	**0.081**	**0.081**	0.066
CAMP	08-031-0002	0.051	0.062	0.057	n/a	0.056	n/a	n/a
Carriage	08-031-0014	0.074	0.072	0.078	0.072	0.074	0.073	0.079
Denver Animal	08-031-0025	n/a	n/a	n/a	0.070	n/a	n/a	n/a
Chatfield Park	08-035-0004	0.084	0.086	0.082	0.080	**0.084**	**0.082**	0.065
Arvada	08-059-0002	0.078	0.082	0.079	0.074	**0.079**	**0.078**	0.074
Welch	08-059-0005	0.064	0.081	0.080	0.073	0.075	**0.078**	0.074
Rocky Flats - N	08-059-0006	0.077	0.090	0.090	0.079	**0.085**	**0.086**	0.058
NREL	08-059-0011	0.079	0.083	0.085	0.076	**0.082**	**0.081**	0.066
Ft. Collins - West	08-069-0011	n/a	0.087	0.085	0.076	n/a	**0.082**	0.066
Ft. Collins - CSU	08-069-1004	0.076	0.078	0.069	0.066	0.074	0.071	0.092
Weld Co. Twr.	08-123-0009	0.078	0.082	0.074	0.073	**0.078**	**0.076**	0.080
Other Agency Sites								
Rocky Mtn. NP	08-069-0007	0.075	0.076	0.078	0.076	**0.076**	**0.076**	0.073

Notes:
- 3-year averages above the 0.075 ppm Ozone NAAQS
- Ozone monitors located in the existing 9-County Ozone Non-Attainment Area
- * Data values through October 2008

Source: *Air Quality Around the State*: Colorado Air Pollution Control Division, May 21, 2009.

Impact of Using MOVES in Place of MOBILE6.2 on O_3 Predictions

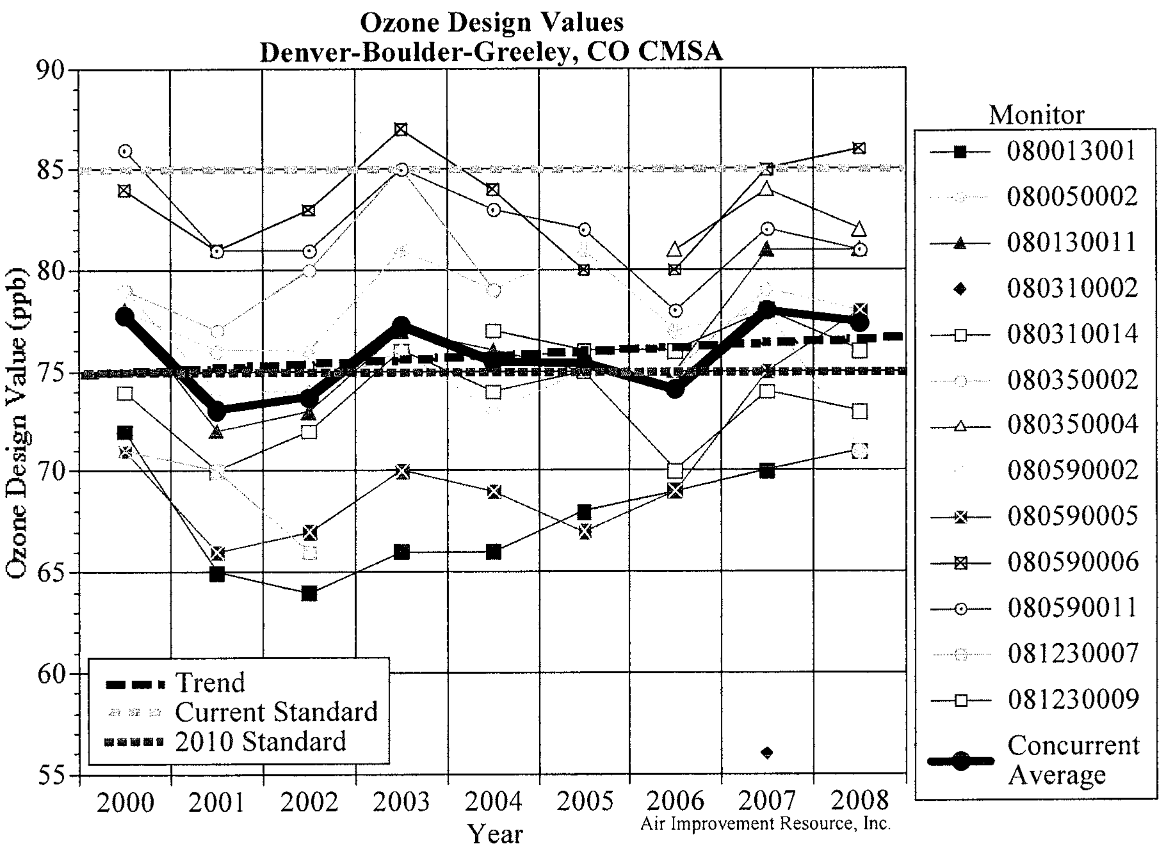
Using the 2010 VMT projections and the MOBILE6.2 and MOVES emission factors, we calculate that MOVES predicts mobile-source emissions 3 percent higher for VOCs and 44 percent higher for NOx than would be estimated by MOBILE6.2. Because of these differences, there will be some increases to the overall emissions inventory for both the 2006 base case and the 2010 control case if MOVES is employed. This will more than likely produce slightly different O_3 estimates and different spatial patterns for both scenarios as well. In addition, the site specific Relative Response Factors (RRFs) derived from the base case and used to project 2010 8-hour Design Values are likely to change as well. However, neither the magnitude nor the direction of the changes is obvious because of the non-linear chemical reactions that are involved. This is demonstrated by some of the analyses conducted in the Weight of Evidence document[8] developed as part of the SIP process. In the section entitled, "Trends in the Weekend-Weekday Effect," it was noted that most of the monitoring sites in the Denver Metropolitan Area experienced on average higher O_3 concentrations on weekends than on weekdays despite lower emissions on weekend days for the period 2005-2007. They also noted that the trend appeared to

[8] Alpine Geophysics, Regional Air Quality Council, Colorado Department of Public Health and Environment, and Environ, "Denver Metropolitan Area and North Front Range 8-Hour Ozone State Implementation Plan Weight of Evidence to Support the Modeled Attainment Demonstration," October, 29, 2008.

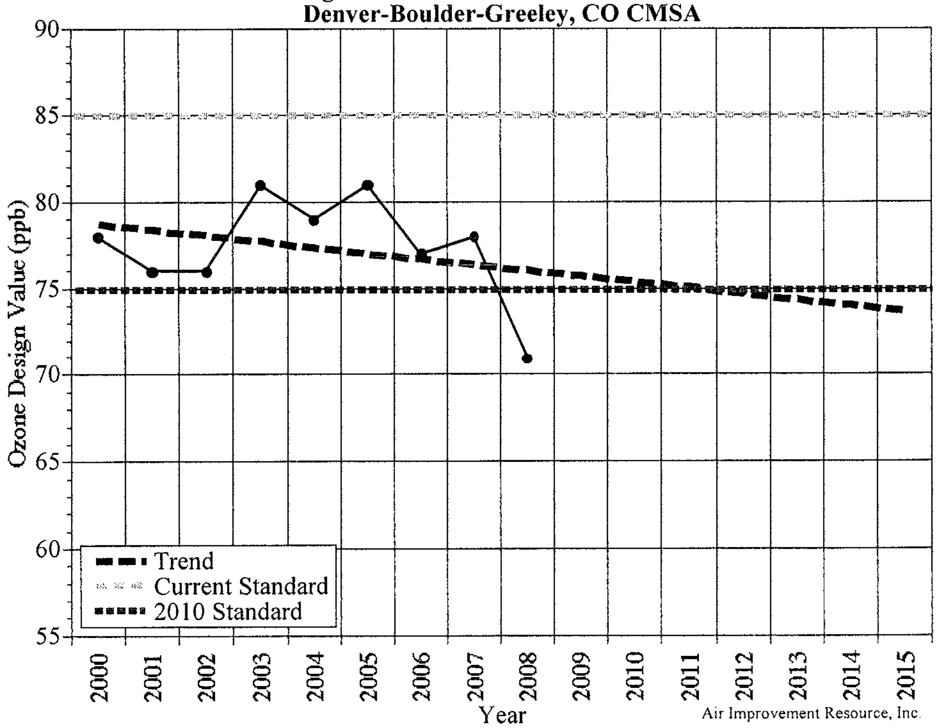
becoming more pronounced over time during the 3-year period. They also presented a map indicating areas of the basin that were VOC-limited and those that were NOx-limited. They caution, however, that the map should not be used to define areas that would benefit from reducing NOx emissions or VOC emissions. Nevertheless, collectively, this information demonstrates the complexity of the Denver situation and underscores the need to conduct addition photochemical modeling runs to quantitatively determine the impact of using different emission factors derived from MOVES. Consequently, we recommend that CAMx be run using the MOVES-derived emissions inventory in the 2006 base case and for the 2010 control strategy case.

Attachment 1

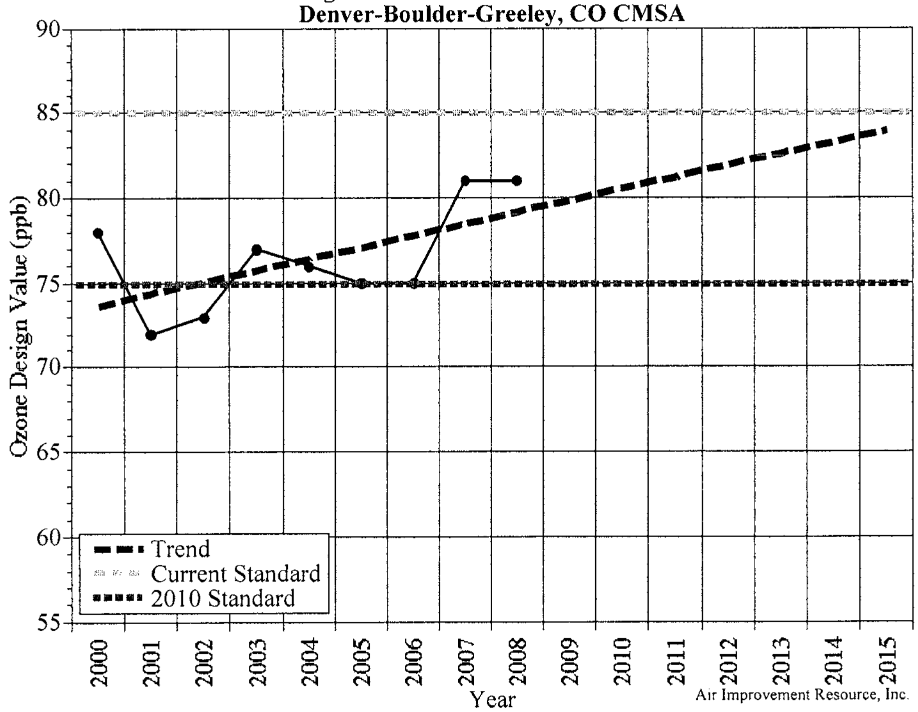
Trends in Ozone at Specific Monitors in Denver Metropolitan Area

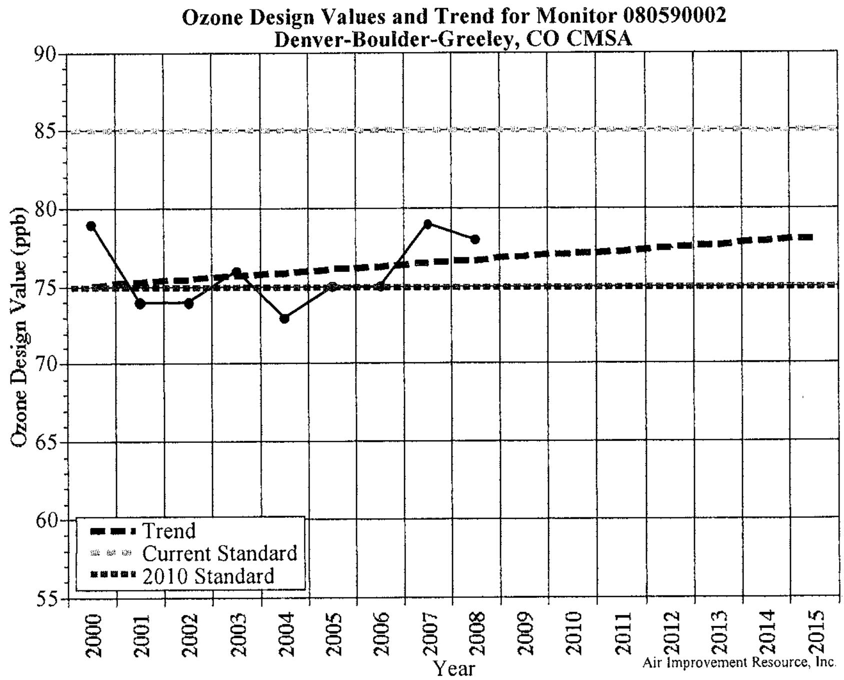


Ozone Design Values and Trend for Monitor 080050002
Denver-Boulder-Greeley, CO CMSA



Ozone Design Values and Trend for Monitor 08013011
Denver-Boulder-Greeley, CO CMSA





Ozone Design Values and Trend for Monitor 080590002
Denver-Boulder-Greeley, CO CMSA
Ozone Design Value (ppb)
90
85
80
75
70
65
60
55
Trend
Current Standard
2010 Standard
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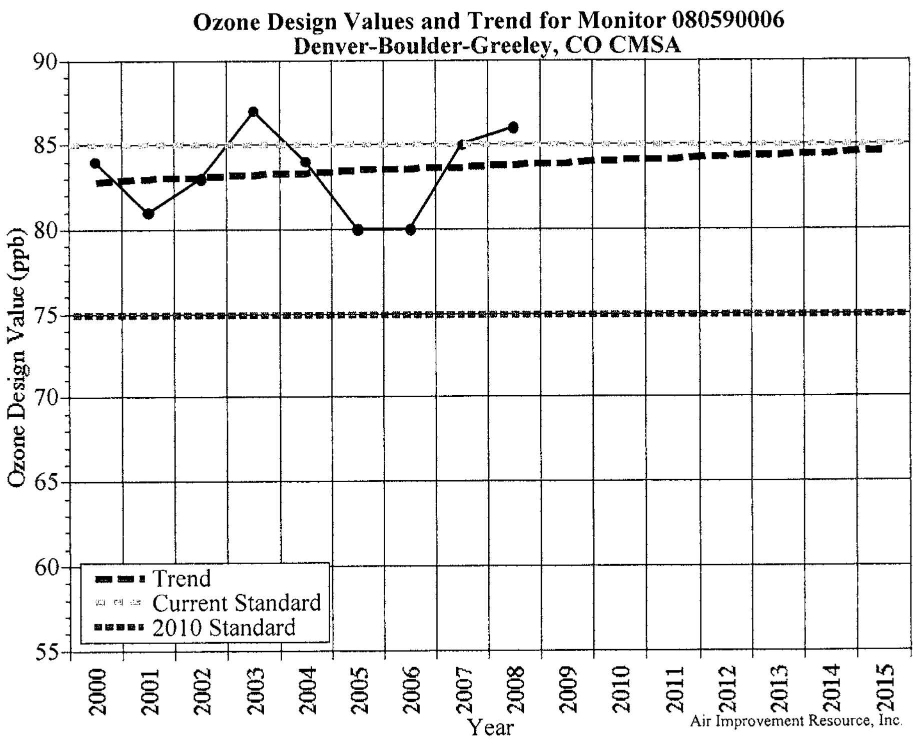
2013
2014
2015
Year
Air Improvement Resource, Inc.



Ozone Design Values and Trend for Monitor 080590006
Denver-Boulder-Greeley, CO CMSA
Ozone Design Value (ppb)
90
85
80
75
70
65
60
55
Trend
Current Standard
2010 Standard
2000
2001
2002
2003
2004
2005
2006
2007
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2009
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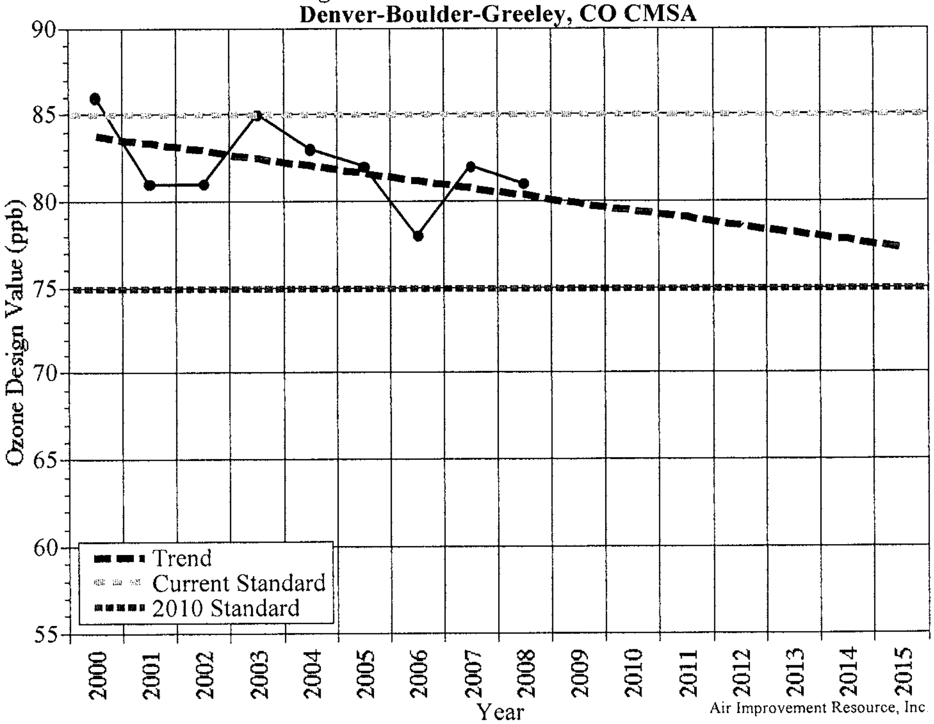
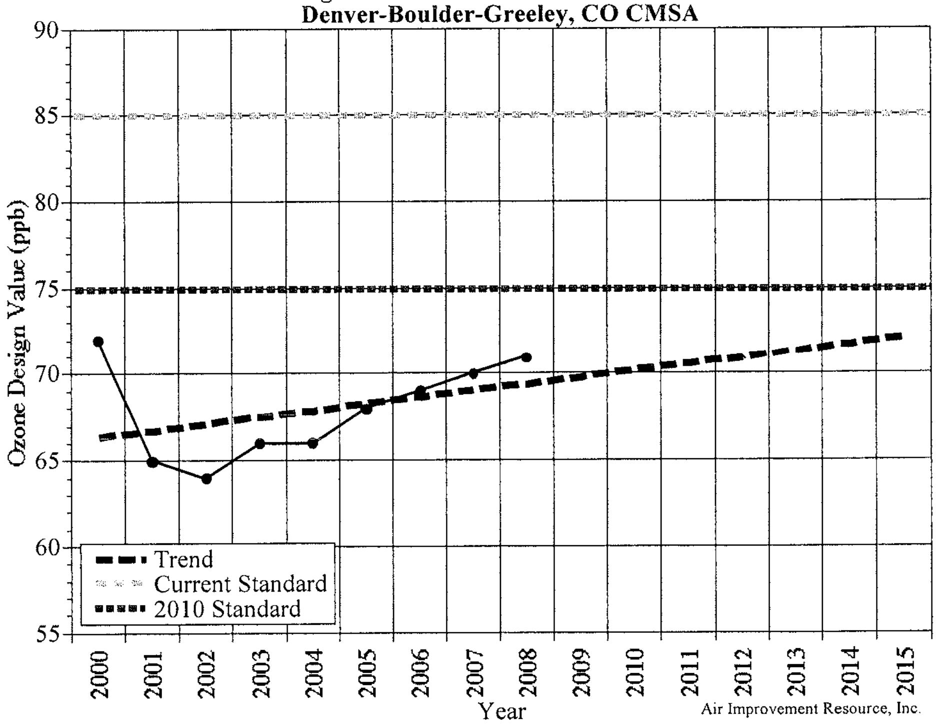
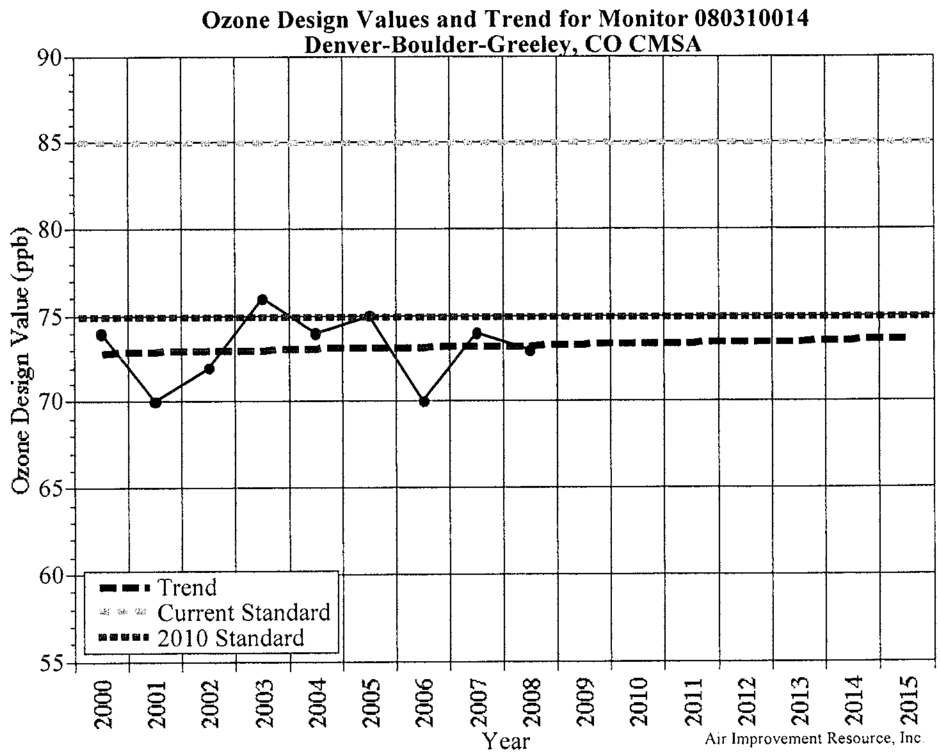
Year
Air Improvement Resource, Inc.

Ozone Design Values and Trend for Monitor 080590011
Denver-Boulder-Greeley, CO CMSA



Ozone Design Values and Trend for Monitor 080013001
Denver-Boulder-Greeley, CO CMSA




Ozone Design Values and Trend for Monitor 080310014
Denver-Boulder-Greeley, CO CMSA
90
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Ozone Design Value (ppb)
Trend
Current Standard
2010 Standard
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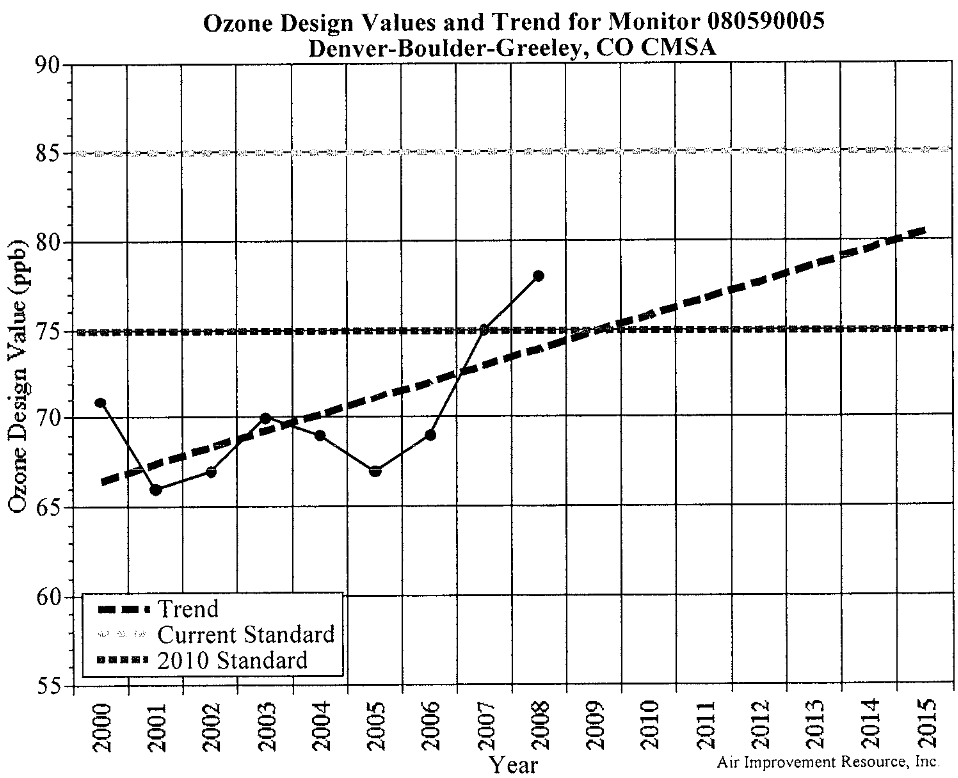
Air Improvement Resource, Inc


Ozone Design Values and Trend for Monitor 080590005
Denver-Boulder-Greeley, CO CMSA
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Ozone Design Value (ppb)
Trend
Current Standard
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Year
Air Improvement Resource, Inc.

APPENDIX C

COST AND COST-EFFECTIVENESS OF THE AIR PROGRAM[1]

dKC updated the 2006 estimates on the cost of the AIR Program. Testing and Rapid Screen counts were revised as were repair costs and motorist inconvenience costs. The new estimates are based on 2008 test data. The following cost components were considered:

- Inspection Revenue:
    - Cost for inspections at centralized facilities;
    - Cost for inspections at decentralized facilities;
    - State oversight fee;
- Rapid Screen;
- Repair costs;
- Fuel Savings; and
- Motorist inconvenience costs.

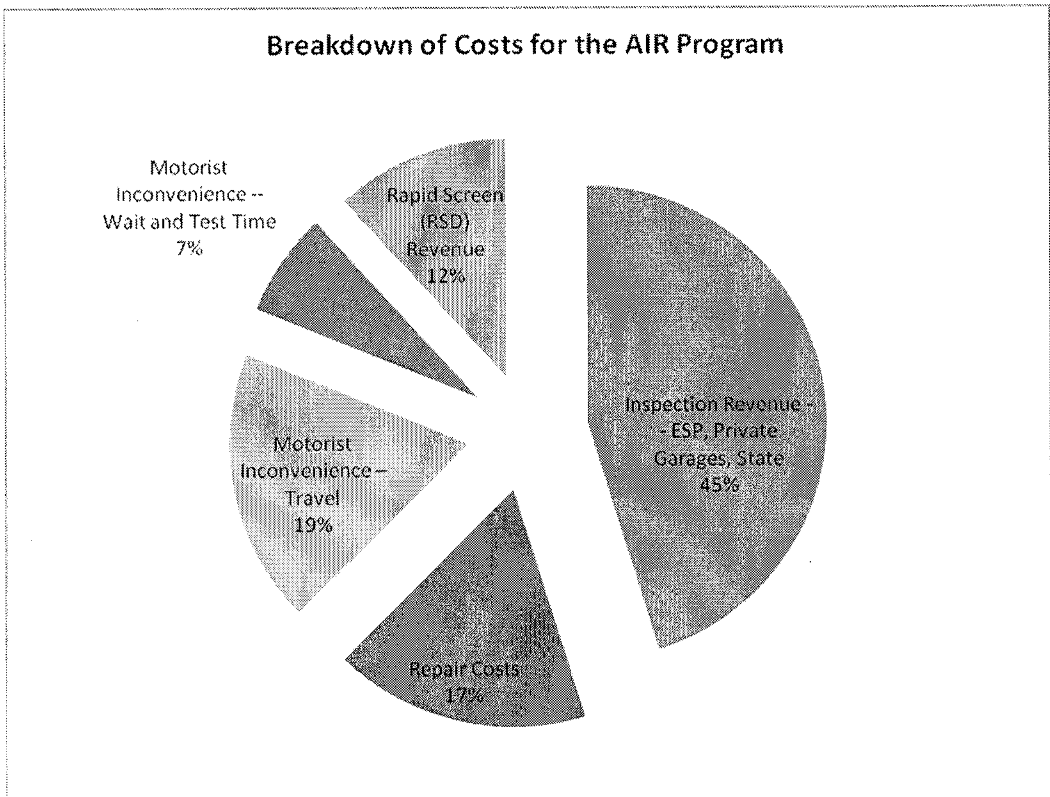
Costs are summarized in Table C-1 and Figure C-1. Total estimated costs are $43,700,000 vs. $42,500,000 for the estimated costs in Calendar Year 2005. The primary reason for the higher cost in this audit is that repair costs have increased due to more stringent IM240 standards.

Table C-1 – Estimated Cost of AIR Program -- 2008

ITEM	Estimated Cost
Inspection Revenue -- ESP, Private Garages, State	$19,700,000
Repair Costs	$12,400,000
Fuel Savings Credit	-$4,800,000
Motorist Inconvenience – Travel	$8,200,000
Motorist Inconvenience -- Wait and Test Time	$3,100,000
Rapid Screen (RSD) Revenue	$5,100,000
Total	**$43,700,000**

[1] Prepared by *dKC* de la Torre Klausmeier Consulting, Inc.

Figure C-1 – Cost Breakdown



Inspection Costs

Inspection revenues are based on the number of vehicles receiving paid emission tests times the estimated inspection fees, including the State and county fees. Table C-2 compares Colorado's fee for 1982 and newer vehicles with inspection fees in other states and provinces with similar emission tests. Colorado's fee is lower than fees in most other programs with similar emissions tests.

Table C-2 -- Inspection Fees in Current I/M Programs

State/Province	Test Procedure	Test Fee ($)	Comments
AZ (Phoenix)	Loaded-mode + OBD	$27.75	
BC	Loaded-mode + OBD	$40.00	$47 Cdn
CA	Loaded-mode + OBD	$49.00	Average inspection fee
CO	Loaded-mode + OBD	$25.00	
CT	Loaded-mode + OBD	$20.00	
GA	Loaded-mode + OBD	$25.00	Cap on fee
NY (Downstate)	Loaded-mode + OBD	$27.00	
Ontario	Loaded-mode + OBD	$30.00	Capped at $35 Cdn
PA	Loaded-mode + OBD	~$50.00	Fee is market driven
RI	Loaded-mode + OBD	$47.00	
TX DFW/Houston	Loaded-mode + OBD	$35.00	
UT (Salt Lake County)	Loaded-mode + OBD	$25.00	Average inspection fee
VA	Loaded-mode + OBD	$28.00	Cap on fee
WA	Loaded-mode + OBD	$15.00	No NOx measurement
Washington DC	Loaded-mode + OBD	$24.00	Cap on fee

Repair Costs

Repair costs are based reported repair costs in the vehicle test record (VTR) multiplied by the number of vehicles that were repaired. The average cost to repair IM240 failures was $290; the average cost to repair Two-Speed Idle (TSI) failures was $120.

Fuel Saving Generated from Repairs

Fuel savings are based on the fuel economy improvement between failing tests and passing tests. *dKC* developed a dataset of pairs of vehicles that failed in 2008 after (May 4) and passed by the end of the year. *dKC* then identified pairs where full length IM240 tests were done on the failing initial tests and passing retests. A total of 14,387 pairs were identified. Results are shown in Table C-3. Note that fixing gas cap failures did not improve fuel economy (miles per gallon - MPG) as determined by the IM240 test. This makes sense, since IM240 MPG estimates are based on exhaust emissions, which are not affected by replacing faulty gas caps. The IM240 test does not measure fuel savings from capturing vapors that would have escaped due to faulty gas caps.

Table C-3 – Impact of Repairs to Failed Vehicles on Fuel Economy (Miles per Gallon -- MPG)

Yr Category	MPG	Emissions Result: Fail	Pass (Failed Gas Cap Test)	All Fails
91-95	Before	20.55	22.31	20.56
	After	22.64	23.17	22.65
96+	Before	20.94	19.55	20.69
	After	22.66	20.00	22.19
Average of MPG-Before Repair		20.02	19.68	20.61
Average of MPG-After repair		22.51	20.15	22.46
	Confidence Levels for Emission Fails			
	Parameter	**95% Confidence Level**	**Low Benefit**	**High Benefit**
	95% Conf Before	0.09	20.71	20.52
	95% Conf After	0.12	22.34	22.57
		% Increase in MPG	7.30%	9.09%

Public Cost of Time and Travel

The cost for motorist inconvenience was estimated based on analysis of average travel costs and time to and from the I/M station, time spent in line at the station, and testing time. The hourly cost is assumed to equal one half the average hourly wage in Colorado ($26/hr). Other assumptions are shown on Table C-4.

Table C-4

Assumptions Used to Estimate Customer Inconvenience for getting inspections at AIR Stations	
Parameter	**Assumed Value**
Distance to station	5 miles
Average speed	20 mph
Average cost to operate vehicle	$0.50/mile
Consumer wage rate	$26.44/hour
Average wait time	10 minutes
Average test time	10 minutes

The distance to the station of 5 miles is based upon the contract requirement that 80 percent of the population be within 5 miles of a contractor station. The average speed of 20 mph is based upon the average speed value used in the MOBILE model for urban modeling scenarios. The $0.50 per mile is a value selected based on IRS reimbursable travel costs. The consumer wage rate is from Colorado statistics for 2008.

A wait time estimate of 10 minutes is based on the contractor's requirement that the wait time not exceed 10 minutes for any 120 minute basis.

The time a consumer waits for their vehicle to finish testing after waiting in the queue is included in the total costs associated with the program as well. For this analysis it was assumed that the average time for a vehicle to complete the testing was 10 minutes.

Cost-Effectiveness of the AIR Program

Cost effectiveness of the AIR Program is based on total program costs for one year divided by estimates of program benefits for one year.

Tons per day reductions from inspecting vehicles in 2008 – *dKC* estimated the benefits of the AIR Program. The total benefit from identifying and repairing high emitting vehicles during one year of the AIR Program was calculated as follows:

- **Exhaust Emissions --** Observed grams per mile readings before and after repairing IM240 failures were multiplied by the number of tailpipe failures that ultimately passed and assumed annual mileage accumulation. Results were calculated by model year and then were summed to determine total exhaust emission benefits.

- **Evaporative Emissions --** The number of gas cap failures were multiplied times the assumed benefit from replacing faulty gas caps and assumed annual mileage accumulation.

Benefits also factor in repair longevity, (i.e., how long the repair reduces emissions). Repair longevity is based upon the number of vehicles that pass in 2008 after failing in 2006. Tons per year benefits estimated for repairing vehicles that fail during one year of the AIR Program are shown below.

- Hydrocarbons: 3,500 tons per year,
- Carbon Monoxide: 29,000 tons per year, and
- Nitrogen Oxides: 1,740 tons per year.

Annual Cost and Cost-Effectiveness – Annual costs for the AIR Program are based on the estimate presented above. They are estimated to be $43.7 million per year.

Cost-effectiveness is expressed in terms of $ per ton of HC+CO/60+NOx removed from the atmosphere. The CO reductions are divided by 60 to reflect their reduced importance in terms of reducing ozone levels in the DMA. The cost-effectiveness of the AIR Program is calculated to $7,700 per ton of HC+CO/60+NOx removed from the atmosphere.

Cost-Effectiveness of Alternative Control Measures

Analysis of ozone in the Denver Metropolitan Area finds that controls on emissions of nitrogen oxides (NOx) and hydrocarbons (HC) are needed to attain the ozone standard. There appear to be many opportunities for cost-effective controls for nitrogen oxides emissions, in addition to the AIR Program. Table C-5 summarizes controls for the major sources. A 2008 study commissioned by the Department concluded that emissions of nitrogen oxides from Electricity Generating Units (EGUs) could be reduced by 82-84 percent at a cost of $1,600 per ton[2]. EGUs are estimated to account for 17 percent of the manmade nitrogen oxides emissions in 2010.

Another source of nitrogen oxides are non-road vehicles. Non-road includes locomotives, portable generators, agricultural equipment, construction equipment and lawn and garden equipment. The non-road category is estimated to account for 15 percent of the manmade nitrogen oxides emissions in 2010. Controls for non-road sources were not mentioned in Colorado's most recent SIP. EPA has established new standards for these sources but it will take a long time (>10 years) before these standards have an impact on emissions. Based on research by the EPA, retrofitting controls on non-road sources reduces NOx by 40-70 percent for a cost of $2,000 - $19,000/ton[3].

Table C-5 – Additional Controls for Nitrogen Oxides

Source Category	2010 Base (tons/day)	Cost Effectiveness ($/ton NOx)	Control Strategy
Electrical Generation Units	58.5	~2000	82-84% reduction through Selective Catalytic Reduction systems
Non-Road Vehicles	81	$2,000-$19,000	Need further study

Table C-6 shows emission reductions and cost-effectiveness of hydrocarbon controls listed in the *Ozone Action Plan (OAP)*. The State committed to establishing air pollution controls for evaporative HC emissions from condensate tanks, oil and gas production, large reciprocating internal combustion engines and on-road mobile sources in its *Early Action Compact (EAC)* with the EPA. On the basis of the Department's supporting documentation submitted with the Early Action Compact, air pollution controls applied to flash emissions, oil and gas production, and large reciprocating internal combustion engines reduce hydrocarbon emissions at a cost that is less than $3,000 per ton. The cost per ton for these air pollution controls is less than the cost per ton for the AIR Program ($7,700 per ton). Since air pollution controls for these sources (flash emissions, oil and gas production, and large reciprocating internal combustion engines) are so cost effective, the Department is proposing to apply these air pollution controls outside of the Denver Metropolitan Area. The Department believes that air pollution controls for these sources will help with Denver's attainment of the ozone standard since, as discussed previously, much of the ozone in the Denver Metropolitan Area is transported in from outside the Area.

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[2] Summary of Research on Potential Control Options, Emission Reductions and Costs for Reducing SO2 and NOx from Existing Major Colorado Point Sources, BBC Research & Consulting, June 27, 2008.

[3] EPA420-R-07-005 -- An Analysis of the Cost-Effectiveness of Reducing Particulate Matter and Nitrogen Oxides Emissions from Heavy-Duty Nonroad Diesel Engines Through Retrofits, May 2007.

Table C-6 – Existing Stationary Source Controls for Volatile Organic Compounds

Source Category	2010 Base (tons/day)	Cost-Effectiveness of Additional Controls ($/ton HC)
Flash	130	Controls already applied in EAC: $250/ton
Oil and Gas Production	7	Controls already applied in EAC: $400/ton to $2,700/ton
Reciprocating Internal Combustion Engines	8.7 (2007)	Controls already applied in EAC: $1,400/ton

Table C-7 shows emission reductions and cost-effectiveness of controls for sources listed in the EAC and OAP that are currently uncontrolled. Colorado has not committed to further air pollution controls for the remaining sources for hydrocarbon emissions (other stationary sources, automotive after market products, architectural coatings, household and personal products, other area sources, lawn and garden, and other off-road sources) in its EAC. Where possible, we estimated the amount of reduction the State could achieve, and the estimated cost per ton for achieving that reduction.

Table C-7 – Additional Controls for Volatile Organic Compounds

Source Category	2010 Base (tons/day)	Cost-Effectiveness ($/ton HC)	Control Strategy
Other Stationary Sources	35	Unknown	Cannot define without details on sources
Area: Automotive After Market Products	13	$1,500	Require CA rules
Area: Architectural Coatings	17	$6,400	Require CA rules
Area: Household and Personal Products	18	$800	Require CA rules
Other Area Sources	10	Unknown	Cannot define without details on sources
Lawn & Garden	31	$2,000 to $1,000,000	Range of controls possible
Other Off-road	28	$12,000 to $1,000,000	Range of controls possible
On-Road: Evaporative Emissions	~80	$7,200	8 tons per day reduction by eliminating Ethanol Waiver

By adopting regulations requiring that area sources such as automotive after market products, architectural coatings, and household and personal products meet California specifications, it may be possible to achieve the same reductions as the AIR Program for lower costs. Note, however, that the State cannot just substitute controls that get the same reductions as the AIR Program and stay in compliance with the SIP. The attainment demonstration in the SIP was based on ozone modeling studies in the DMA. Ozone is sensitive to the spatial and temporal distribution of emissions, as well as the reactivity of the specific HCs emitted by different sources. For example, a 10 ton per day reduction through revised specifications on area sources may not reduce ozone as much as a 10 ton per day from mobile sources.

APPENDIX D

ANALYSIS OF BENEFITS FOR THE AIR PROGRAM, REMOTE SENSING, AND ALTERNATIVE OPTIONS FOR MOBILE SOURCES[1]

I. ANALYSIS OF DATA ON VEHICLE TEST RESULTS (VTR) AND REMOTE SENSING DEVICE (RSD) READINGS IN THE AIR PROGRAM

The key results of the 2009 evaluation are based primarily on an analysis of data collected in the AIR Program. These data can be grouped into three categories:

- **Vehicle Test Results (VTR) – I/M test results from AIR stations;**
- **Rapid Screen or Remote Sensing Device (RSD) results; and**
- **Results of OBD tests during AIR inspections.**

Table D-1 lists the datasets that were analyzed for the 2009 evaluation. Following is a summary of all the analysis results.

Table D-1 – Datasets Analyzed for Audit

Date	Provider Org	Description
4/09	CDPHE	2006 I/M data (VTR)
4/09	CDPHE	2007 I/M data (VTR)
4/09	CDPHE	2008 I/M data (VTR)
4/09	CDPHE	2006 OBD data (VTR)
4/09	CDPHE	2007 OBD data (VTR)
4/09	CDPHE	2008 OBD data (VTR)
4/09	CDPHE	2006 Rapid Screen data (VDR)
4/09	CDPHE	2007 Rapid Screen data (VDR)
4/09	CDPHE	2008 Rapid Screen data (VRR)
5/09	CDPHE	2008 Vehicle Registration Data for AIR Program area

[1] Prepared by *dKC* de la Torre Klausmeier Consulting, Inc.

DERIVING AIR PROGRAM BENEFITS FROM VEHICLE TEST RESULTS (VTR)

The following procedure was used to derive estimates of the impact of the AIR Program on emissions.

- *dKC* developed spreadsheets showing average grams per mile emissions by model year broken down by AIR Program results for initial tests and re-tests. Results were limited to data recorded after May 4, 2008, when the Colorado Department of Public Health and Environment (CDPHE) changed the IM240 cutpoints.

- Using VTR data after May 4, 2008, *dKC* calculated the failure rate by model year.

- Using data on VTR results for the first two months of 2008, *dKC* calculated the percent of vehicles failing in 2008 that ultimately passed.

    - Data from remote sensing devices (RSD) were used to determine the fraction of the vehicles that never pass and continue to operate in the Program area. This analysis indicated that about 60 percent of the vehicles that failed and never passed are no longer being driven in the program area.

- *dKC* calculated the emission reductions from repairing failed vehicles to obtain a passing result.

    - *dKC* calculated the change in vehicle emissions by model year considering the emission reductions for failed vehicles, the percent of vehicles failing, and the percent of failed vehicles that ultimately pass.

    - *dKC* weighted as received (initial test results) and after repair composite levels by the number of vehicles tested by model year and their assumed mileage accumulation rate.

    - Based upon the weighted emission levels for as-received and after-I/M cases, *dKC* calculated the percent reduction in vehicle emissions from identifying and repairing high emitting vehicles. This percent reduction is defined as the ***single cycle emission reduction.***

    - Tons per day reductions were determined by multiplying the reduction for failed vehicle in grams per mile by the number of failed vehicles and assumed annual vehicle miles traveled by model year. *dKC* used MOBILE6.2 default values for annual VMT by model year and vehicle type.

- Total emissions reductions were calculated by adjusting the tons per day reductions for expected repair life based upon the percent of vehicles that fail and then pass in one cycle that pass again at the next cycle. Based upon data on vehicles tested in 2006 and 2008, 77 percent of the vehicles that are repaired pass their next inspection two years later.

- *dKC* calculated the benefits from the gas cap pressure test by first calculating the number of vehicles that failed the gas cap pressure test. *dKC* multiplied the number of gas cap failures by the assumed benefit from replacing faulty gas caps. These benefits were based upon studies by the California Bureau of Automotive Repair. Again, the benefits by model year were adjusted by the number of failures by model year, assumed accumulated mileage by model year, and expected repair life.

Table D-2 shows the mileage accumulation assumptions that were used in calculating total benefits.

Table D-2 -- Assumed Mileage Accumulation Rates
LDGV -- Light-Duty Gasoline Vehicles (Passenger Cars)
LDGT -- Light-Duty Gasoline-Powered Trucks

Yr	LDGV	LDGT	Weighted
1982	4208	2979	3757
1983	4427	2829	3935
1984	4656	3017	4105
1985	4898	3312	4442
1986	5152	3685	4748
1987	5420	4055	5012
1988	5701	4468	5353
1989	5997	4931	5702
1990	6308	5435	6082
1991	6636	6000	6485
1992	6980	6565	6897
1993	7342	7147	7356
1994	8124	8496	8295
1995	7723	7815	7810
1996	8546	9253	8838
1997	8989	10010	9407
1998	9456	10617	9869
1999	9947	10897	10401
2000	10463	12616	11353
2001	10006	13562	11524
2002	10577	14576	12350
2003	12810	16912	14686
2004	12178	15568	13606

Yr	LDGV	LDGT	Weighted
2005	13475	18054	15424
2006	14174	19258	16158
2007	14910	20251	17156
2008	14910	20251	17156
Source: MOBILE6.2 Users Guide			

Vehicle Emissions in Grams per Mile

Estimates of emissions and emission reductions in grams per mile were derived directly from IM240 test results provided in the VTR. *dKC* assumed that IM240 values in grams per mile can be used to project emissions and emission changes for vehicles receiving two-speed idle (TSI) tests.

Impact of Repairs on Vehicle Emissions

dKC analyzed vehicle test results and estimated the impact of the AIR Program on vehicle emissions. Our focus was on HC and NOx reductions, as these are the primary ozone precursors of concern. The AIR Program identifies high-emitting vehicles and subsequent repairs significantly reduce their emissions:

- One test and repair cycle of the AIR Program reduces HC exhaust emissions from the tested population by 23 percent, CO emissions by 24 percent, and NOx emissions by 6.5 percent. These reductions are based on IM240 tests on passenger cars and light trucks[2]. They do not account for vehicles being clean screened in the Rapid Screen Program. As shown on Figure D-1, significant HC, CO and NOx reductions are evident across the range of model years included in the Program. These reductions do not include the long-term effects of multiple inspection cycles. Based on data on vehicles tested over two inspection cycles, 77 percent of the vehicles that failed and were repaired passed their next inspection two years later, which indicates that most repairs were durable.

- Repairs to vehicles failing their AIR inspection reduced HC and CO emissions as measured by the IM240 test by over 60 percent for most model years. NOx emission reductions for failed vehicles varied from about 10 percent for the oldest models to over 90 percent for the newest models (Figure D-2). In terms of grams per mile (g/mi), all model years show significant HC, CO and NOx emissions benefits (Figure D-3).

    - After repair emissions were very close to the emissions levels for vehicles that passed their initial test, which is considered to be the ideal target (Figures D-4 and D-5). Note on Figure 4 the large reductions in NOx emission levels. This indicates that repair technicians are able to repair NOx failures as well as HC and CO failures.

[2] These results are for the period after the IM240 standards were changed in May 2008.

- Overall, 73 percent of the IM240 fails had an indication from the OBDII system that something was wrong with the vehicle. The repair success rate on vehicles with OBDII systems that failed IM240 tests was over 93 percent, which indicates that technicians were able to find and correct some problems that were not identified by the OBD system. And as indicated by the large HC and NOx emission reductions on OBDII equipped vehicles (1996 and newer models), these repairs were effective in reducing emissions.

- Emission levels for vehicles that pass their initial tests or pass after failing their initial test are less than half the I/M program cutpoints (Figures D-6 and D-7).

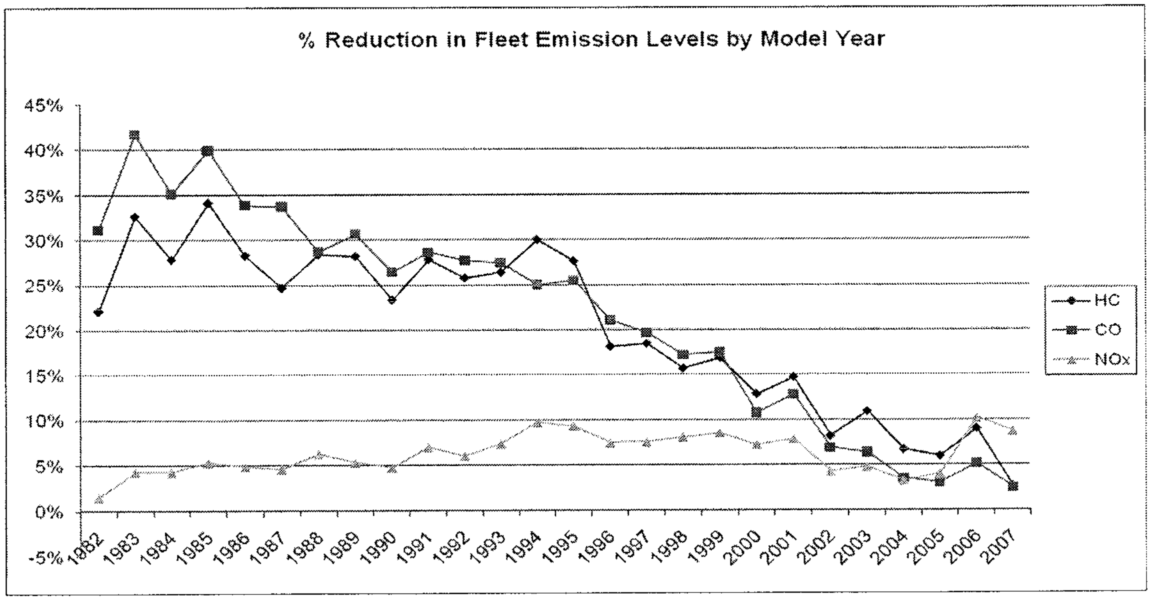
- In 2008, 23,760 vehicles (or 3 percent of the tested population) failed gas cap pressure tests.

- 87 percent of the vehicles failing AIR inspections ultimately pass. This is a higher pass rate than many other I/M programs. (Reference AZ, CT and BC) (Figure D-8)

    - Based on analysis of remote sensing observations for vehicles that failed and never passed, about 60 percent of these vehicles are no longer being driven in the Program area. If these vehicles were to be tracked for another year, it is likely that more of them would be sold, scrapped, move out of the area, or would otherwise stop operating on the roadway.

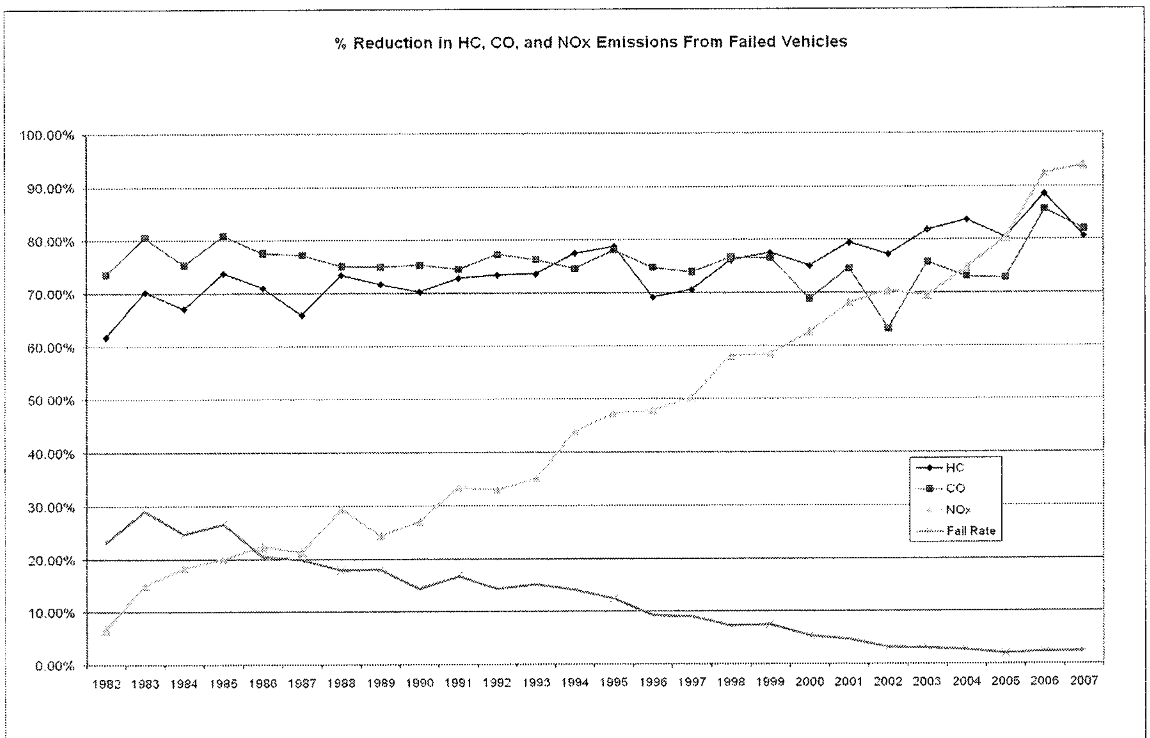
    - Based on vehicles tested in 2006 and 2008, 77 percent of the vehicles that failed and were repaired to pass their previous inspection pass their next inspection.

Figure D-1



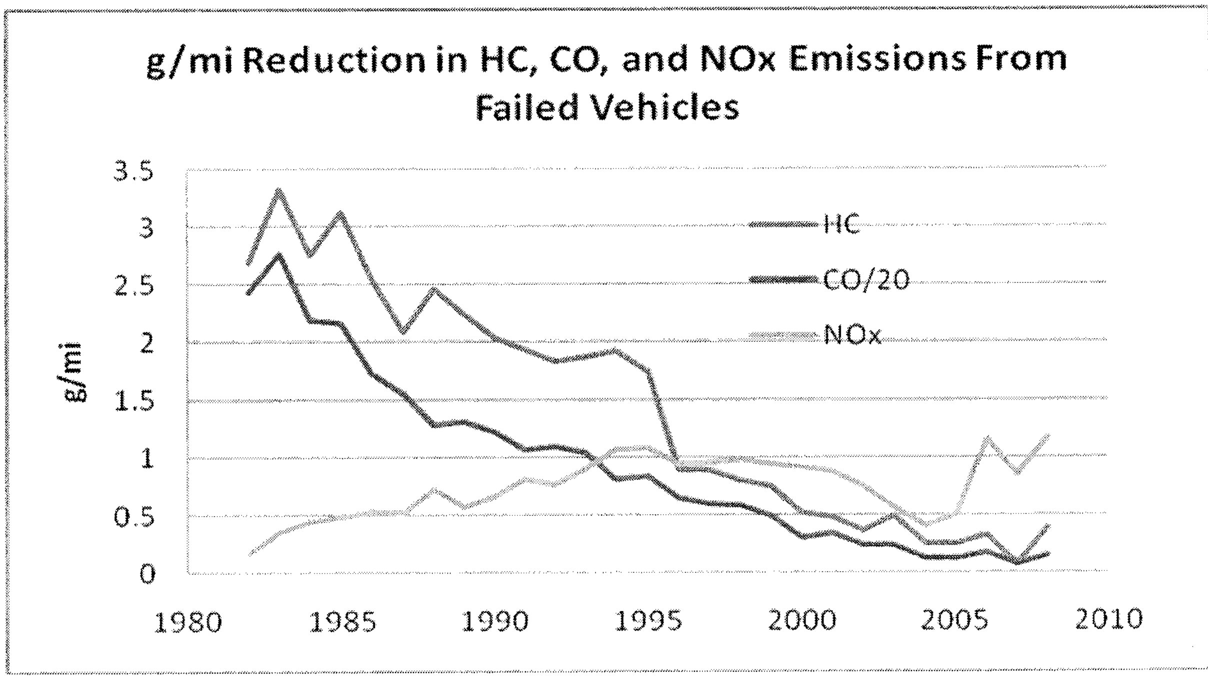
Comment: All model years show significant benefits from repairs. On a percentage basis, older models show the greatest HC and CO benefits from the AIR Program, while 1990 and newer models show the greatest NOx benefits.

Figure D-2



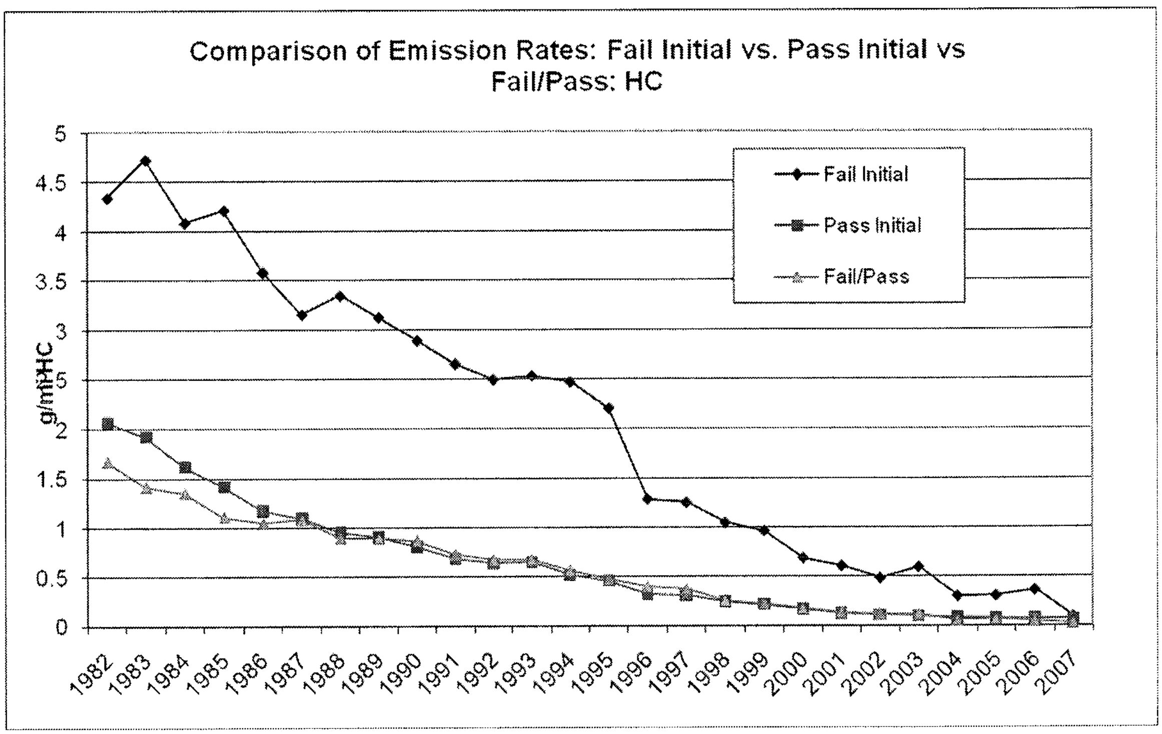
Comment: Most vehicles that fail and are repaired show large HC and CO emissions reductions. The newest vehicles that fail the test show the largest NOx reductions in terms of percent reductions. Note that older vehicles have much greater fail rates than new vehicles.

Figure D-3



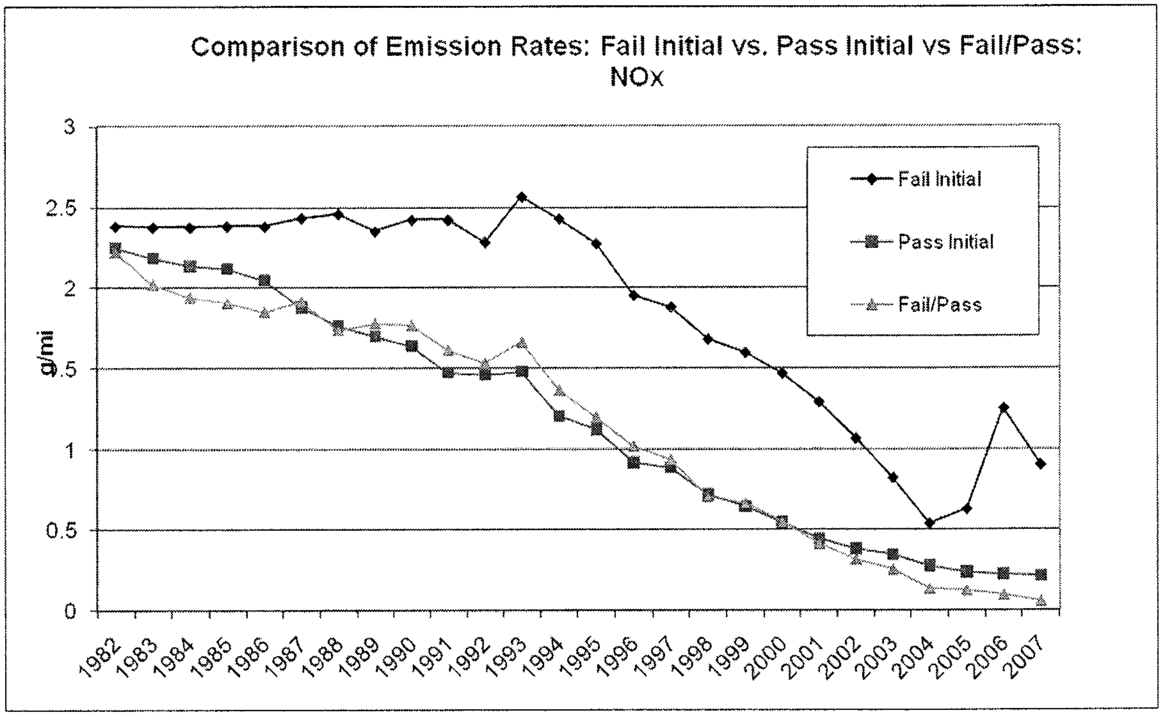
Comment: On average, vehicles that fail and are repaired show large HC, CO and NOx emissions reductions in terms of grams per mile (g/mi).

Figure D-4



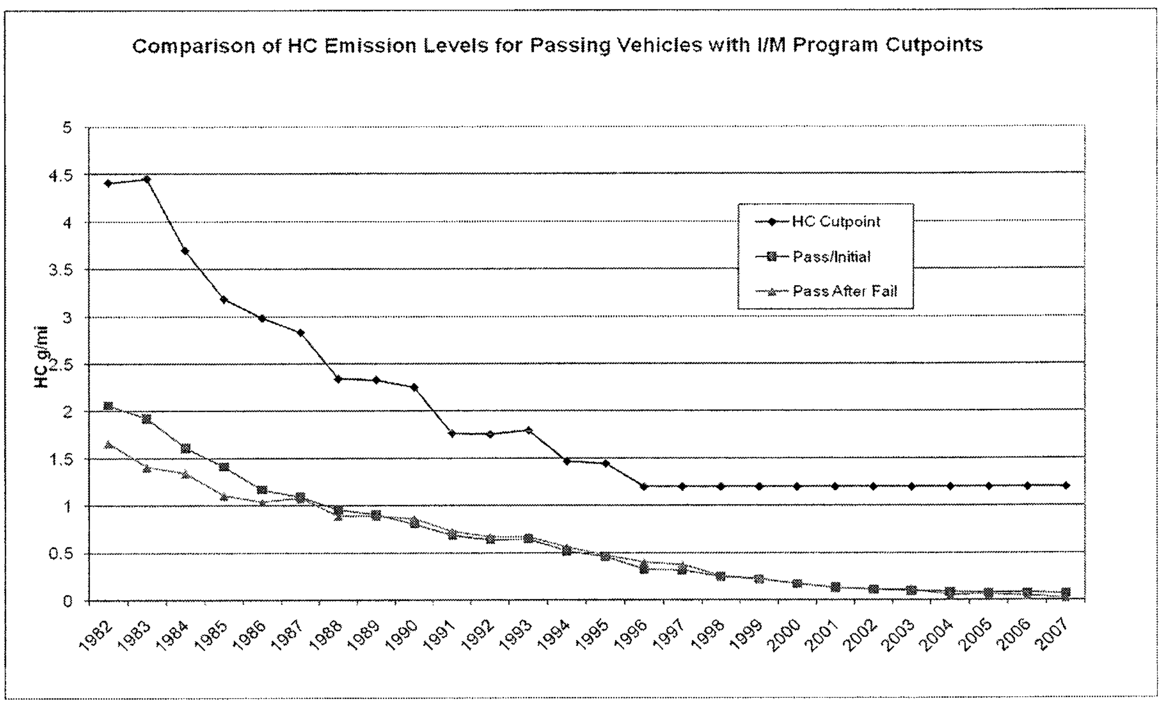
Comment: HC emission levels after repair (Fail/Pass) are very close to levels for vehicles that pass their initial test, which is considered to be the target.

Figure D-5



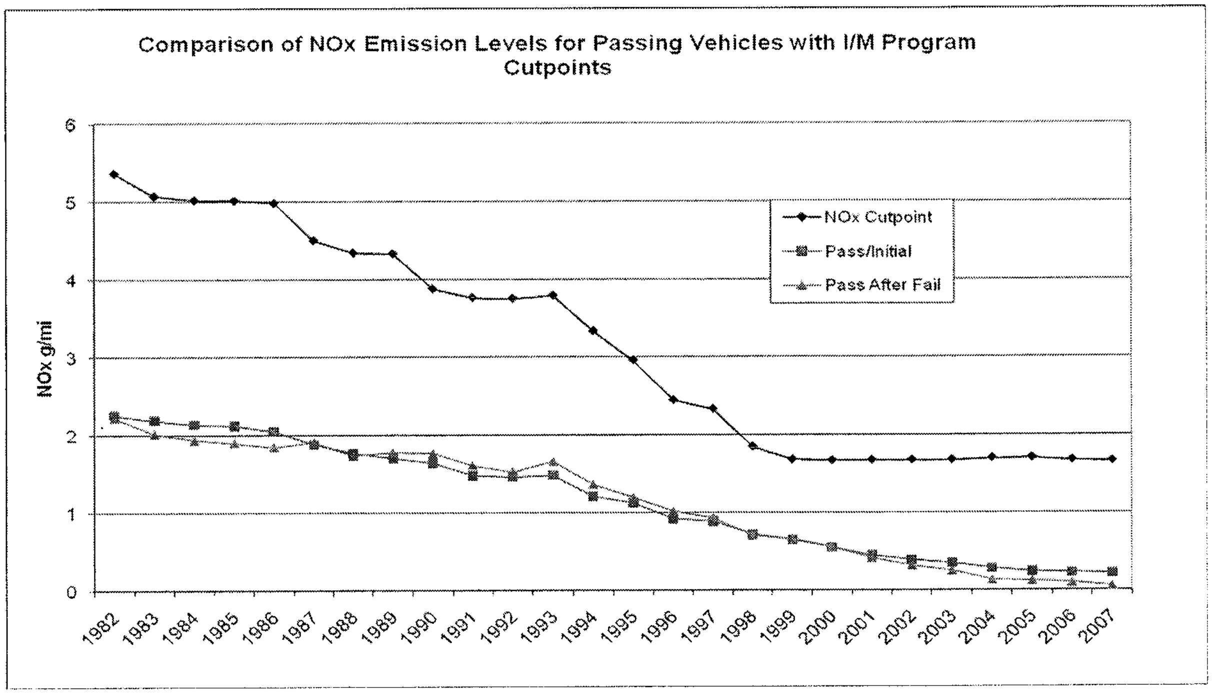
Comment: NOx emission levels after repair are very close to levels for vehicles that pass their initial test, which is considered to be the target. This indicates that repair technicians are able to repair NOx failures as well as HC and CO failures.

Figure D-6



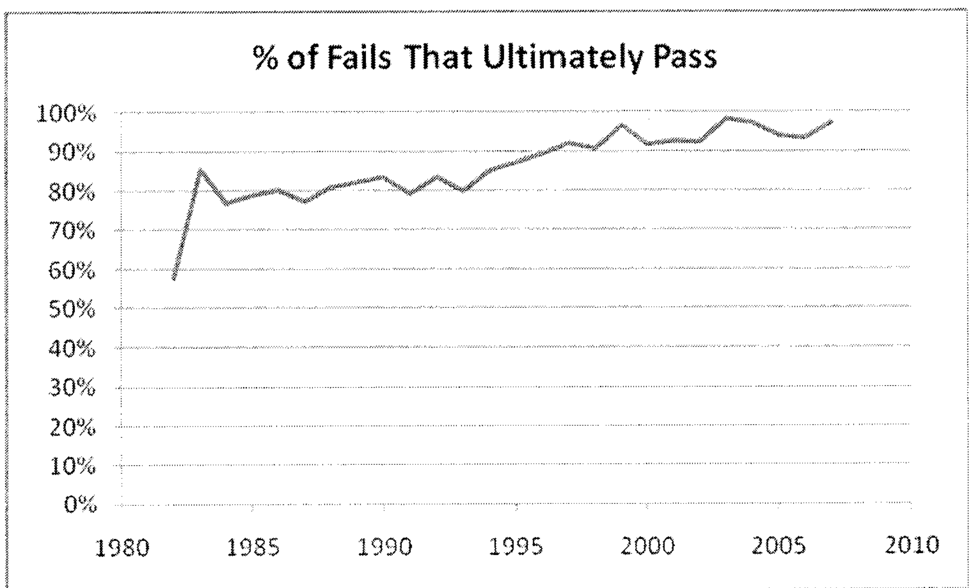
Comment: This chart compares average HC cutpoint with after repair emission levels. Technicians are not just repairing vehicles to meet the cutpoint.

Figure D-7



Comment: This chart compares average NOx cutpoint with after repair emission levels. Technicians are not just repairing vehicles to meet the cutpoint.

Figure D-8



Comment: 80 to 90 percent of the failed vehicles ultimately comply with AIR Program standards. The overall average is 87 percent.

Overall Tons Reduction from the AIR Program

The overall benefits in tons per day for the AIR Program adjusted for expected repair life are as follows:

- Total HC: 19.1 tons per day
    - HC Exhaust: 12.8 tons per day
    - HC Evap: 6.3 tons per day
- CO: 158 tons per day
- NOx: 9.5 tons per day

Benefits based on MOBILE6.2 are lower for HC and NOx but higher for CO:

- Total HC: 10.7 tons per day
- CO: 165 tons per day
- NOx: 8.2 tons per day

ANALYSIS OF DATA FROM RAPID SCREEN TESTS IN THE DENVER METROPOLITAN AREA (DMA)

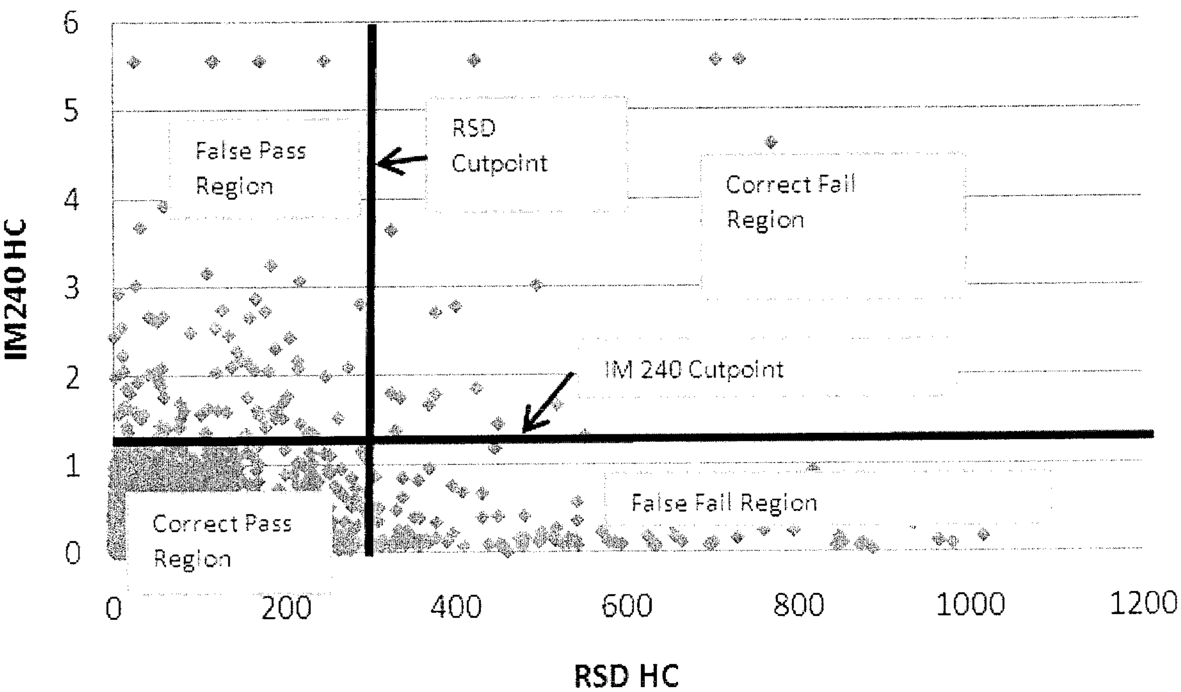
Since 2004, Environmental Systems Products (ESP) has been conducting on-road emissions tests using RSD. These tests are termed Rapid Screen. Rapid Screen measurements provide an instantaneous snapshot of vehicle emissions under moderate acceleration. Currently Rapid Screen is used primarily to identify vehicles that should pass the traditional emissions test, and thus, can be certified without needing to take the traditional emissions test. In 2006, the Legislature enacted House Bill 06-1302 for the purpose of increasing the State's reliance on the Rapid Screen Program. Specifically, the bill intended for Rapid Screen to replace the traditional emissions test as the primary means to identify high-emitting vehicles.

Correlation Between RSD and IM240 Emission Rates

dKC investigated the correlation between Rapid Screen and IM240 emissions test results from our 2008 data set for all 1998 model-year vehicles. We selected this model-year for our analysis because it was a year with substantial emissions reductions from the AIR Program, and the data set had a high number of Rapid Screen observations. We matched the results of the most recent Rapid Screen test taken before the same vehicle's IM240 test. Figure D-9 shows a scatter plot of IM240 results vs. Rapid Screen results. As shown, there is essentially no correlation between the two ways to measure vehicle emissions. The distribution of false passes and false fails for the 5,268 vehicles in our sample is shown the chart. A hypothetical Rapid Screen cutpoint of 300 ppm is shown as the vertical line. Vehicles with Rapid Screen levels greater than the cutpoint would fail this hypothetical test. The IM240 cutpoint is shown as the horizontal line. Vehicles to the left of the Rapid Screen cutpoint are the clean screen candidates while those to the right are high emitter candidates.

Vehicles that are above the IM240 cutpoint and to the right of the Rapid Screen cutpoint are correctly identified as high emitters. Those below the IM240 cutpoint and to the right of the Rapid Screen cutpoint are incorrectly identified as high-emitters (or false failures). Similarly, those vehicles that are above the IM240 cutpoint and to the left of the Rapid Screen cutpoint are false passes, while those below the IM240 cutpoint and to the left of the Rapid Screen cutpoint are correct passes. Note that there are a lot more observations in the lower left-hand corner than in the upper left-hand corner. On the other hand, there are a lot more observations in the lower right-hand corner than in the upper right hand corner. These data graphically illustrate that Rapid Screen is better as a tool to identify clean vehicles (clean screen) than as a tool to identify high emitting vehicles (dirty screen).

Figure D-9
Colorado Automobile Inspection and Readjustment (AIR) Program
Correlation Between IM240 Test Results and Rapid Screen Results
for 1998 Model-Year Passenger Vehicles

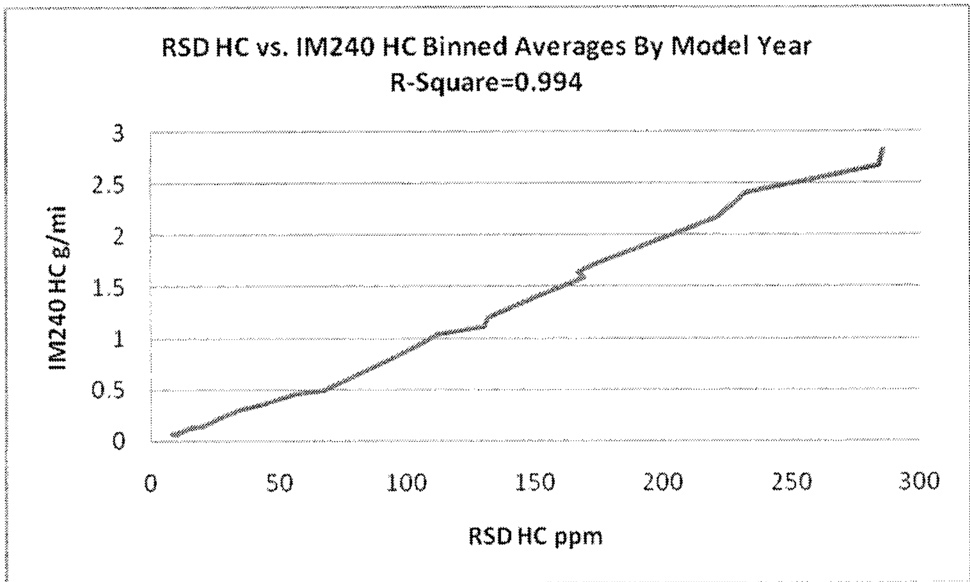


Source: *Colorado Department of Public Health and Environment Rapid Screen and IM240 data.*
Correct Pass: Below the established cutpoint for both the Rapid Screen and IM240 tests.
False Pass: Below the established cutpoint for Rapid Screen but above IM240 cutpoint.
False Fail: Below the established cutpoint for the IM240 test but above the Rapid Screen cutpoint.
Correct Fail: Above the established cutpoint for both the Rapid Screen and IM240 tests.

Although individual Rapid Screen results do not correlate well with individual IM240 results, Rapid Screen results do provide an accurate measure of vehicle emissions trends.

This is shown on Figure D-10, which correlates average Rapid Screen results by model year with average IM240 results. Looking at averages is termed binning. Binned Rapid Screen results for HC correlate well with binned IM240 results. R-square equals 0.994; a perfect correlation has an R-square of 1.0. From this analysis, we conclude that average RSD levels provide an accurate measure of fleet emissions trends.

Figure D-10



AIR Program benefits based on data from remote sensing devices (RSD)

Data from RSD as measured in the Rapid Screen Program also confirm that the AIR program significantly reduces vehicle emissions. Following are the key results based on an analysis of RSD data:

- Observed reductions in HC emissions:
    - **Before and After IM240 tests:** Average RSD HC emissions levels for the one year period after vehicles received IM240 inspections were 19.5 percent lower than RSD emissions levels for the one year period before inspection. This is almost identical to the observed reduction based on AIR Program data.
    - **Before and After Two-Speed Idle (TSI) tests:** Average RSD HC emissions levels for the one year period after vehicles received TSI inspections were 12.7 percent lower than RSD emissions levels for the one year period before inspection. We do not have adequate data from the AIR Program to compare with this estimate.

- Observed reductions in NOx emissions:

    - **Before and After IM240 tests:** Average RSD NOx emissions levels for the period after vehicles received IM240 inspections were 6.0 percent lower than RSD emissions levels for the one year period before inspection[3]. Like the HC results, NOx reductions based on RSD are almost identical to results based on AIR Program data.

    - **Before and After Two-Speed Idle (TSI) tests:** Average RSD NOx emissions levels for the one year period after vehicles received TSI inspections were the same as RSD emissions levels for the one year period before inspection. This makes sense since the TSI test does not enforce NOx emission limits.

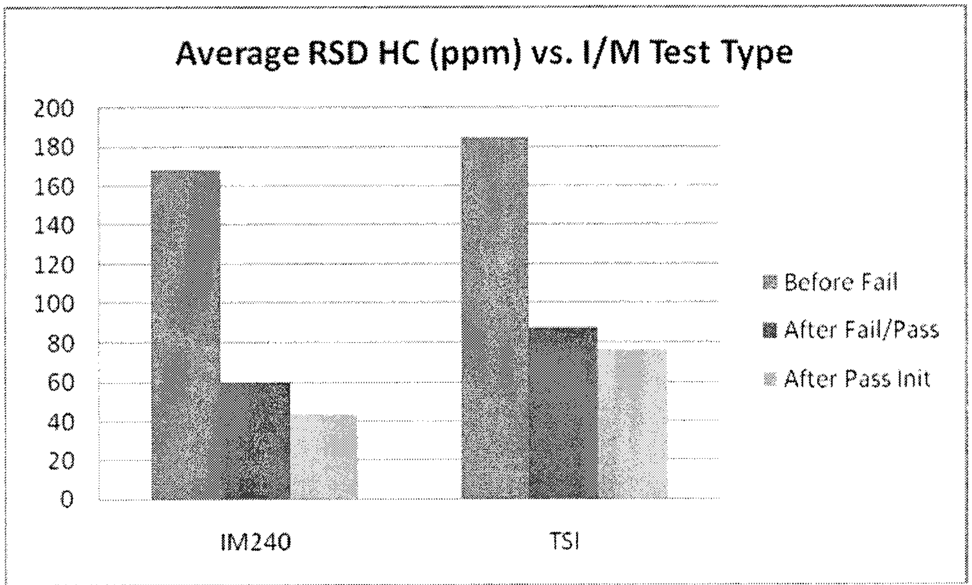
- RSD emission levels for vehicles that failed and were repaired to pass generally were much lower than RSD emission levels for vehicles prior to failing their initial test.

    - For HC, both IM240 and TSI failures saw large emission reductions (Figure D-11). After repair levels are almost as low as HC levels for vehicles that passed their initial test.

    - For NOx, vehicles failing IM240 tests saw large emission reductions, while TSI failures showed low emission reductions, which is expected (Figure D-12). Vehicles failing IM240 tests have after repair levels that are almost as low as NOx levels for vehicles that passed their initial test.

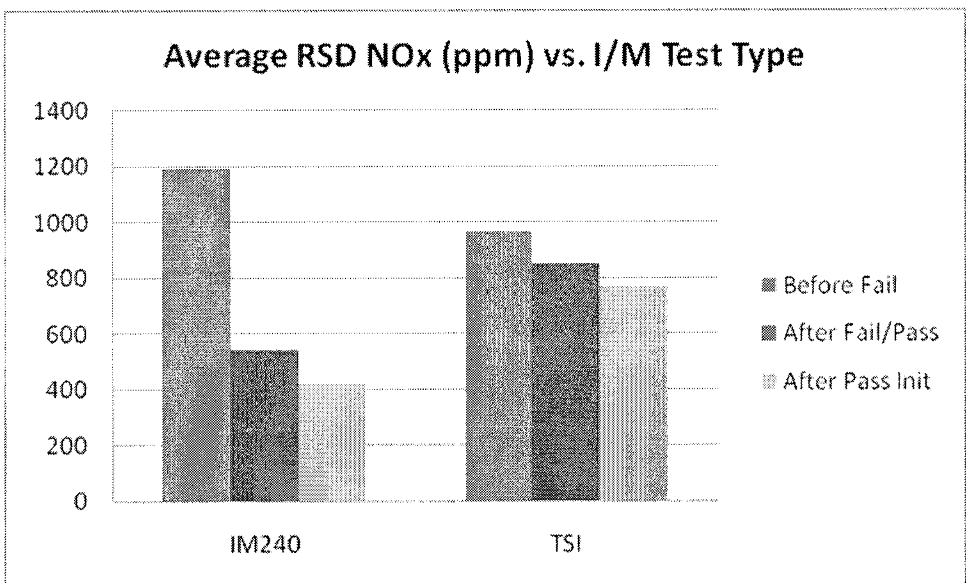
[3] These results are for the period after the IM240 standards were changed in May 2008.

Figure D-11



Comment: Data from remote sensing devices indicate that repairs to vehicles failing AIR inspections significantly lower their HC emission rates.

Figure D-12



Comment: Data from remote sensing devices indicate that repairs to vehicles failing IM240 inspections significantly lower their NOx emission rates. Because the TSI test does not evaluate NOx emissions, significant NOx emissions reductions are not expected. These results are for the period after the IM240 standards were changed in May 2008.

Analysis of the Effectiveness of the Rapid Screen Program as an Alternative to the AIR Program

As discussed above, Rapid Screen is currently being used to identify vehicles that could be exempted from their traditional emissions test, and it is being proposed as the primary means to identify high-emitters. The process of using Rapid Screen to identify vehicles that are likely to pass the traditional emissions test is termed "Clean Screen." The process of using Rapid Screen to identify vehicles that are likely to fail the traditional emissions test is termed "Dirty Screen."

Emissions Impact of Rapid Screen as a Clean Screen Tool

The effectiveness of Rapid Screen in identifying low emitting vehicles was evaluated two ways:

- Data on vehicles that qualified for Rapid Screen clean screen tests[4] but instead received IM240 tests were analyzed to project the impact of the Rapid Screen Program.
- Data were analyzed on Rapid Screen tests that were matched with the most recent AIR Program test after the Rapid Screen test. Two scenarios were evaluated:
    - Two Rapid Screen observations (termed hits) prior to AIR.
    - One Rapid Screen hit prior to AIR.

Rapid Screen Coverage

In 2008, ESP conducted 7,490,645 Rapid Screen tests that could be matched with vehicle registration records. *dKC* calculated the number and percent of vehicles that were registered in the AIR Program area and were tested in the Rapid Screen Program. Table D-3 presents the results of this analysis: 49 percent of the vehicles subject to the AIR Program were seen by Rapid Screen at least once; 33 percent of the vehicles were seen two or more times.

Table D-3 – Percent of Vehicles Subject to the AIR Program that Get Valid Rapid Screen Tests

Year	Rapid Screen Observations			
	1+	2+	% 1+	% 2+
1981	5,994	2,477	9%	4%
1982	595	293	19%	10%

[4] Most of these vehicles received vehicle mail request (VMR) informing owners that they can skip their regular inspection, if they pay the test fee. Some of the vehicles qualifying for Rapid Screen tests did not receive a VMR, so that they could be part of a random sample to evaluate Rapid Screen.

	Rapid Screen Observations			
Year	**1+**	**2+**	**% 1+**	**% 2+**
1983	860	396	20%	9%
1984	1,686	884	22%	12%
1985	2,227	1,173	23%	12%
1986	3,279	1,781	27%	14%
1987	4,116	2,294	28%	16%
1988	5,865	3,307	30%	17%
1989	7,770	4,434	32%	18%
1990	10,862	6,392	35%	21%
1991	13,474	7,971	36%	21%
1992	16,203	9,843	39%	24%
1993	20,578	12,698	40%	25%
1994	25,817	15,904	42%	26%
1995	33,732	21,334	44%	28%
1996	35,756	22,997	46%	30%
1997	46,180	30,020	48%	31%
1998	53,681	35,584	51%	34%
1999	64,705	43,716	53%	36%
2000	74,501	51,436	56%	38%
2001	75,138	52,370	56%	39%
2002	80,537	56,983	59%	42%
2003	74,208	52,984	59%	42%
2004	78,104	56,883	61%	44%
2005	75,726	55,329	62%	45%
ALL	**811,594**	**549,483**	**49%**	**33%**

Effectiveness of Rapid Screen Based on Vehicles that Were Issued VMRs but Were Tested by the IM240 test

dKC matched Vehicle Mailer Requests (VMRs) issued in 2008 with IM240 test results. Overall, about 85 percent of the motorists opt for clean screen. Based on test results for vehicles that qualified for clean screen but received IM240 tests, *dKC* projected the impact of the Rapid Screen Program on I/M program benefits. These projections are shown on Table D-4. The clean screen program impacts NOx emissions much more than HC and CO emissions. Assuming that ozone reductions are proportional to apportioned emission reductions, the Rapid Screen Program reduced the ozone benefits of the AIR Program from 0.7 parts per billion to 0.6 parts per billion.

Table D-4 – Projected Impact of Rapid Screen on AIR Program Benefits – Results Based on Vehicles that Qualified for Rapid Screen but Were Tested by the IM240 Test

Scenario	Percent Reduction in Emissions from Fleet Subject to AIR Program		
	HC	CO	NOx
Without Rapid Screen	22.59%	23.64%	6.53%
With Rapid Screen	21.10%	22.09%	5.59%
% of Benefits Lost with Rapid Screen	6.6%	6.6%	14.4%
% of AIR Program Vehicles Opting for Rapid Screen	22%		

Effectiveness based on Rapid Screen results matched with IM240 results

dKC matched IM240 results with the two most recent Rapid Screen results prior to the IM240 test. *dKC* also matched IM240 results with the most recent Rapid Screen result prior to the IM240 test. We developed the following spreadsheet models to estimate the effectiveness of one-hit and two hit Rapid Screen scenarios:

- Impact of One-Hit Clean and Dirty Screen on AIR Program Effectiveness.
- Impact of Two-Hit Clean and Dirty Screen on AIR Program Effectiveness.

The above models have been provided to CDPHE.

Table D-5 presents the projected impact of the Rapid Screen Program on a fleet where we have two valid hits on every vehicle. If 50 percent of the fleet received two valid Rapid Screen tests[5] using the current criteria, Rapid Screen would reduce AIR Program benefits by the following percentages, based on the percent of excess emissions in the clean screen candidates:

- HC: 9 percent
- CO: 8 percent
- NOx: 15 percent

In addition, 67 percent of the vehicles which fail for other reasons, primarily gas cap pressure test fails, qualify for clean screen. In 2008, about 33 percent of the fleet was seen by Rapid Screen two or more times. Multiplying the percent of excess emissions lost due to clean screen by 33 percent results in impacts varying from 6 percent for HC and

[5] 50 percent is the maximum percentage of vehicles that could be clean screened according Colorado Rules.

CO to 10 percent for NOx, which are slightly lower than the impacts based on analysis of VMR/IM240 matches.

Table D-5 – Projected Impact of Rapid Screen on the Percent of Vehicles that Should Fail AIR Program Tests – 2 Hits: Both Hits less than 0.5% CO and 200 ppm HC

Parameter	Value[6]
% Valids that are clean screen (CS)	71.25%
% of IM Fails that are CS	41.22%
% of Emissions Fails that are CS	28.04%
% Excess CO Pass CS	17.95%
% Excess HC Pass CS	16.28%
% Excess NOx Pass CS	30.23%
% of Other fails that are CS	66.90%

In 2007, clean screen criteria was modified to also allow vehicles that had one RSD hit to be clean screened provided the last observation is less than 0.5 percent CO and 200 ppm HC, and the vehicle has a high probability of passing the IM240 test (based on historical information). The probability of passing an IM240 test is termed Low Emission Index (LEI). Table D-6 shows the projected impact of a clean screen program using these criteria. If 50 percent of the fleet received a valid Rapid Screen test using the current criteria, Rapid Screen would reduce AIR Program benefits by the following percentages, based on the percent of excess emissions in the clean screen candidates:

- HC: 2.5 percent
- CO: 2 percent
- NOx: 6 percent

Note that these impacts are much less than those for the two hit scenario without an LEI. The LEI for this analysis was based on IM240 failure rates in 2008, which included the period after NOx cutpoints were reduced (made more stringent) [7]. This could explain the greatly improved performance with respect to excess NOx emissions.

[6] These percentages apply to the population that received valid Rapid Screen observations.

[7] In May 2008, hydrocarbon (HC) and oxides of nitrogen (NOx) standards were made more stringent (lower numerically). Allowable NOx emission levels were reduced by more than 50 percent for most vehicles.

Table D-6 – Projected Impact of Rapid Screen on the Percent of Vehicles that Should Fail AIR Program Tests – 1 Hit: Most recent hit less than 0.5% CO and 200 ppm HC and Low Emitter Index (LEI) Less than 50 percent (Cleanest 50 percent)

Parameter	Value[5]
% Valids that are clean screen (CS)	55.39%
% of IM Fails that are CS	22.88%
% of Emissions Fails that are CS	9.25%
% Excess CO Pass CS	5.05%
% Excess HC Pass CS	4.29%
% Excess NOx Pass CS	11.98%
% of Other fails that are CS	48.03%

Possible Enhancements to the Rapid Screen Clean Screen Program

dKC evaluated the following enhancements to the Rapid Screen clean screen program:

- Add NOx criteria to the Rapid Screen clean screen criteria.
- Continue to update the Low Emitter Index to use data from IM240 tests conducted after May 4, 2008 when HC and NOx cutpoints were significantly reduced.

Currently, the effectiveness of the AIR Program in reducing NOx is compromised because there are no clean screen criteria on NOx emission levels recorded by Rapid Screen. This is important since ozone in the DMA now appears to be more sensitive to mobile source NOx emissions than mobile source HC emissions. Table D-7 shows the impact for the two-hit scenario of adding a 1000 parts per million NOx limit to the current HC limit of 200 parts per million and CO limit of 0.5 percent. The percent of excess NOx drops from 30 percent to 9 percent when a 1000 parts per million NOx limit is added. The percent of vehicles that are clean screen candidates only drops from 71 percent to 60 percent when a NOx limit is added. Table D-8 shows the impact of adding NOx criteria to the one-hit plus LEI scenario. The percent of excess NOx in the clean screen group drops from 12 percent to 6 percent while the percent of vehicles qualifying for clean screen only drops from 55 percent to 53 percent.

Table D-7 – Projected Impact of Rapid Screen on the Percent of Vehicles that Should Fail AIR Program Tests – 2 Hits: Both Hits less than 0.5% CO, 200 ppm HC, and 1000 ppm NOx

Parameter	No NOx Limit[5]	1000 ppm NOx Limit[5]
% Valids that are clean screen (CS)	71.25%	60.20%
% of IM Fails that are CS	41.22%	26.06%
% of Emissions Fails that are CS	28.04%	11.29%
% Excess CO Pass CS	17.95%	10.26%
% Excess HC Pass CS	16.28%	8.86%
% Excess NOx Pass CS	30.23%	8.72%
% of Other fails that are CS	66.90%	54.83%

Table D-8 – Projected Impact of Rapid Screen on the Percent of Vehicles that Should Fail AIR Program Tests – 1 Hit: Most recent hit less than 0.5% CO, 200 ppm HC and 1000 ppm NOx Low Emitter Index (LEI) Less than 50% (Cleanest 50%)

Parameter	No NOx Limit[5]	1000 ppm NOx Limit[5]
% Valids that are clean screen (CS)	55.39%	52.59%
% of IM Fails that are CS	22.88%	19.71%
% of Emissions Fails that are CS	9.25%	5.81%
% Excess CO Pass CS	5.05%	4.46%
% Excess HC Pass CS	4.29%	3.48%
% Excess NOx Pass CS	11.98%	6.06%
% of Other fails that are CS	48.03%	45.36%

In addition to adding an NOx limit to the emissions criteria, CDPHE should assure that the LEI used in the one-hit clean screen scenarios is updated to include vehicles that have low probabilities of failing NOx cutpoints as well as HC and CO cutpoints. As noted above, the LEI used for this analysis was based on IM240 failure rates in 2008, which included the period after NOx cutpoints were reduced. Using this model, we predict that the one-hit plus LEI scenario has a relatively low impact on AIR Program benefits for NOx, as well as HC and CO. Based on discussions with CDPHE, the LEI was updated in January 2009.

Model-Year Exemptions as an Alternative to Rapid Screen Clean Screen Tests

Currently the AIR Program exempts the newest four model-years from traditional emissions tests. The AIR Program requires the remainder of the gasoline-powered fleet to be inspected. As part of the 2006 review, we evaluated data on emissions by model-year to determine whether the current four-year exemption is appropriate and whether the number of exemption years could be expanded to decrease motorist inconvenience without significantly affecting emissions reductions. We recommended that CDPHE evaluate expanded model year exemptions as a supplement to the Rapid Screen clean screen program. CDPHE determined that expanding model year exemptions was not compatible with Rapid Screen and that the Rapid Screen Program would have to be reduced significantly if model year exemptions were expanded. Increasing model year exemptions reduces the revenue base for Rapid Screen, which would force the testing contractor to cut back on Rapid Screen tests.

We have revisited model year exemptions. We compared the impact of expanding model year exemptions to six years with the impact of using Rapid Screen to clean screen the same number of vehicles. Exempting the newest six model years would reduce inspection volume by about 22 percent, which is the current percentage of vehicles that meet Air Program requirements via Rapid Screen. Exempting the newest six model years (instead of the first 4 model years) eliminates 6.4 percent of the reductions in ozone precursor emissions (hydrocarbon plus nitrogen oxides). Clean screening 22 percent of the fleet via Rapid Screen causes the program to lose only 3.8 percent of the ozone precursor benefits, assuming that CDPHE implements the Rapid Screen improvements discussed above. If CDPHE does not implement the recommended changes, the program will lose 10 percent of the benefits, which is greater than the benefits that would be lost if model year exemptions were expanded to six years.

Assessment of CDPHE's Pilot Program for "Dirty Screen"

CDPHE's pilot program for high-emitting vehicles was reviewed to determine if it provided useful information to address the direction established by HB06-1302. The pilot program provides an effective, real-world assessment of the effectiveness of remote sensing in identifying high-emitting vehicles. The primary area for improvement in the pilot program is in high-emitter selection criteria. The high-emitter selection criteria should attempt to identify vehicles with excessive NOx emissions, as well as HC and CO emissions. Currently, selection criteria primarily identify vehicles with excessive HC or CO emissions. Another area that must be addressed is collecting data to assess the fleet impact of a high-emitter program, if the State intends for it to replace the conventional emission test.

Data from CDPHE's high-emitter pilot program were reviewed to determine the effectiveness of the remote sensing as a means to identify high-emitting vehicles. Table D-9 lists the following statistics from the pilot program:

- # notified that they had to get a confirmatory test (CT)
- # and percent responding to notification
- # and percent that passed CT
- # and percent that failed CT
- # and percent that were repaired and passed.

The results are broken out by the criteria used to select the vehicle. The most stringent criteria is Criteria X (HC>550 ppm or CO>3%). The least stringent criteria is Criteria Z

(HC>2000 ppm or CO>4%). The percent of vehicles that passed their CT after being selected by Criteria X is much higher than the percent of vehicles that passed their CT after being selected by Criteria Z (80 percent vs. 57 percent). Later in this Appendix we apply the same criteria to a dataset of the two most recent RSD observations matched with IM240 results. The pass rate (which is sometimes termed error of commission rate) was lower than the rates shown on Table D-9, which suggests that many owners repaired their vehicles before the confirmatory test (CT). This hypothesis is supported by Rapid Screen data on vehicles that were observed after they passed their CT. As shown on Figure D-13, Rapid Screen values for HC and CO after a vehicle passed their CT were much lower than values that were the basis for receiving a high-emitter notification[8]. Overall, 14 percent of the vehicles being notified were repaired to pass CT standards[9]. We do not have data on vehicles that were scrapped instead of being repaired.

Table D-9 – High Emitter Pilot Program Statistics (CT=Confirmatory Test)

Selection Criteria	# Notified	# Responded	Percent Responded	# Pass CT	% Pass CT	# Fail CT	% Fail CT	#Pass Retest	% of Notified Vehicles Repaired to Pass Retest
X: HC > 550 ppm CO>3%	727	479	66%	384	80%	95	20%	67	9%
Y: HC > 550 ppm or CO>3%, and HEI>10%	863	568	66%	411	72%	157	28%	119	14%
Z: HC>2000 ppm or CO>4%	339	213	63%	121	57%	92	43%	68	20%
XZ: HC>2000 ppm or CO>4%	236	140	59%	82	59%	58	41%	46	19%
ALL	2165	1400	65%	998	71%	402	29%	300	14%

[8] The increase in NOx is further evidence that repairs were done, since repairing a vehicle that has excessive HC or CO emissions often increases NOx emissions.

[9] CT test standards were the same as the IM240 standards for the AIR program standards

Figure D-13

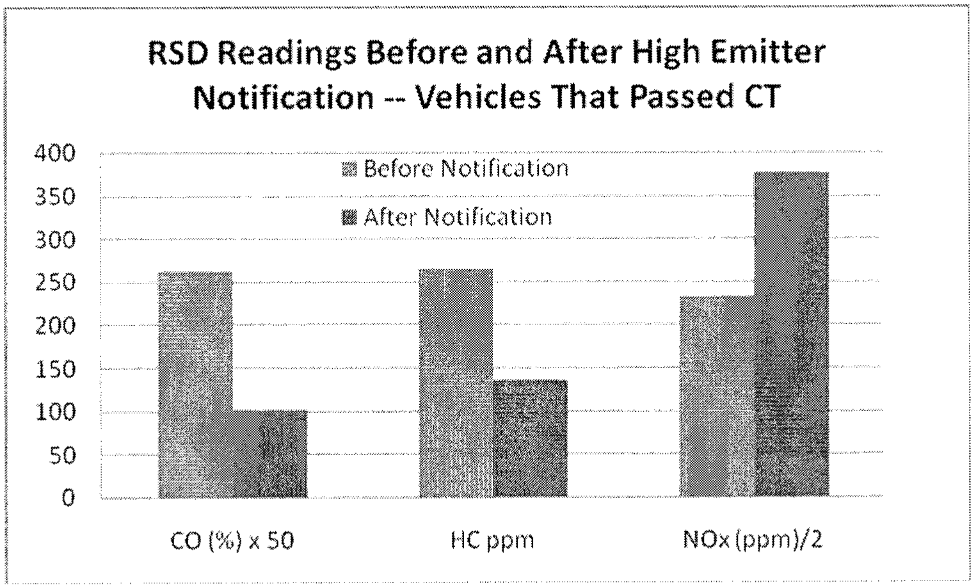


Table D-10 shows the estimated emission reductions for a high emitter program based on the pilot program. Emission reductions are based the observed reduction in IM240 emission levels for vehicles that failed their CT and were repaired to pass. Benefits from scrapping high emitters are not included in the estimates. Vehicles failing the least stringent standards (e.g., Standard Z) show the greatest benefits per repair, which makes sense since they have much higher remote sensing emission levels. The program did not generate data for us to project the impact of replacing the conventional emission test with a high emitter program. On a per vehicle tested basis, the pilot program generated large HC and CO reductions, but resulted in a small increase in NOx emissions.

Table D-10 – Projected Emission Reductions for High-Emitter Pilot Program (CT=Confirmatory Test)

Selection Criteria	Average Emission Reduction (g/mi) Per Vehicle Repaired			Tons per Day (per 10,000 notifications)		
	HC	CO	NOx	HC	CO	NOx
X: HC > 550 ppm CO>3%	3.54	46.89	-0.04	0.10	1.30	0.00
Y: HC > 550 ppm or CO>3%, and HEI>10%[10]	2.33	36.25	0.24	0.10	1.51	0.01
Z: HC>2000 ppm or CO>4%	3.59	66.68	-0.47	0.22	4.04	-0.03
XZ: HC>2000 ppm or CO>4%	2.92	87.02	-0.46	0.17	5.12	-0.03
Average	2.98	53.89	-0.10	0.12	2.25	0.00

Analysis of the Effectiveness of a Remote Sensing High Emitter Identification Program Based on Remote Sensing Results Matched with IM240 Results

dKC matched IM240 results with the two most recent Rapid Screen results prior to the IM240 test and calculated the potential effectiveness of a large scale high-emitter identification program using Rapid Screen results. *dKC* first looked at three different sets of pollution "cutpoints" at which a vehicle would fail a dirty screen exam. Two of the cutpoints were used in the high-emitter pilot program discussed above. One was a hybrid, combining the most stringent high-emitter cutpoint (550 ppm HC and 3% CO) with a 2000 parts per million NOx cutpoint. For each of these sets, *dKC* estimated:

- Percent of vehicles identified as high-emitters by Rapid Screen (percent Fail Rapid Screen). This percentage only applies to the vehicles that receive Rapid Screen tests.

- The percent of vehicles failing the IM240 test that would fail the Rapid Screen test (percent of IM240 failures identified). This percentage only applies to the vehicles that receive Rapid Screen tests. The overall percentage of IM240 fails identified equals the percent of vehicles that receive Rapid Screen tests times this percentage. For example, if 30 percent of the fleet receives Rapid Screen tests and the test identifies 40 percent of the IM240 failures, then 12 percent of the IM240 failures are identified.

[10] HEI – High-Emitter Index: Essentially the opposite of a LEI. HEI denotes the ranking of that particular year, make, model combination in failing an IM240 test.

- The percent of vehicles failing the Rapid Screen test that would pass a subsequent IM240 test (percent false failures).

- The percent of excess HC, CO, and NOx emissions[11] in the fraction that fails the Rapid Screen test.

As shown on Table D-11, *dKC* found that cutpoints of 3 percent CO, 550 parts per million HC and 2000 parts per million NOx identified around 40 percent of the excess emissions while failing only 4.1 percent of the vehicles. The false rate was 53 percent (53 percent of the vehicles selected passed their IM240 inspection). CDPHE should investigate these alternative cutpoints in the high emitter pilot program. Note that the false fail rate on Table D-11 for cutpoints of 3 percent CO and 550 ppm HC is much lower than the false fail rate observed in the high emitter pilot program for the same cutpoints (58 percent vs. 80 percent). This suggests that many vehicles in the high-emitter pilot were repaired prior to their confirmatory test.

Table D-11 -- Effectiveness of RSD Tests in Identifying High-Emitters: Two RSD Observations, Both Observations Must Exceed Cutpoints

	RSD Cutpoints (Percent CO/ppmHC/ppmNOx)		
Evaluation Criteria	**3/550/9999**	**3/550/2000**	**4/2000/9999**
Percent Fail Rapid Screen	1.65%	4.09%	0.86%
Percent of IM240 Fails Identified	10.20%	28.36%	6.40%
Percent False Failures	57.68%	53.12%	49.23%
Percent Excess HC Identified	33.17%	38.71%	24.87%
Percent Excess CO Identified	30.64%	41.20%	20.03%
Percent Excess NOx Identified	1.89%	39.19%	0.98%

dKC also looked at using a low emitter index (LEI). As previously noted, an LEI was helpful in accurately identifying clean vehicles. As shown on Table D-12, at cutpoints of 3 percent CO, 550ppm HC and 2000ppm NOx, adding an LEI reduces the percentages of false failures from 53 percent to 48 percent. The impact on the percent of excess emissions identified varies from a 40 percent reduction (from 39 percent to 24 percent) for HC to a 12 percent reduction (from 39 percent to 34 percent) for NOx.

[11] Excess emissions are the positive differences between IM240 cutpoints and IM240 levels for failing vehicles.

Table D-12 -- Effectiveness of RSD Tests in Identifying High-Emitters: Two RSD Observations, With and Without LEI

Evaluation Criteria	RSD Cutpoints (3%CO or 550ppm HC or 2000ppm NOx)	
	No LEI	LEI > 50% (Dirtiest 50%)
Percent Fail Rapid Screen	4.09%	2.79%
Percent of IM240 Fails Identified	28.36%	21.43%
Percent False failures	53.12%	47.91%
Percent Excess HC Identified	38.71%	23.94%
Percent Excess CO Identified	41.20%	31.41%
Percent Excess NOx Identified	39.19%	34.26%

dKC evaluated the use of an LEI in conjunction with one Rapid Screen observation. Table D-13 presents an analysis of Rapid Screen effectiveness in identifying high emitters based on one RSD observation. Cutpoints of 3 percent CO, 550 parts per million HC, and 2000 parts per million NOx were used with and without an LEI. The one-hit scenarios identify much more of the excess emissions, but, as expected, the false failure rate is higher than the two-hit scenarios.

Table D-13 -- Effectiveness of RSD Tests in Identifying High-Emitters: One RSD Observations, With and Without LEI

Evaluation Criteria	RSD Cutpoints (3%CO or 550ppm HC or 2000ppm NOx)	
	No LEI	LEI > 50% (Dirtiest 50%)
Percent Fail Rapid Screen	9.37%	7.27%
Percent of IM240 Fails Identified	44.73%	39.84%
Percent False failures	67.33%	62.79%
Percent Excess HC Identified	54.40%	48.72%
Percent Excess CO Identified	56.54%	52.21%
Percent Excess NOx Identified	55.35%	47.87%

As noted above, in 2008 there was at least one Rapid Screen observation on 49 percent of the vehicles subject to AIR Program requirements. However, the percentage of AIR Program failures that were observed by Rapid Screen is lower -- 42 percent. This occurs despite the fact that 7.5 million valid Rapid Screen tests were conducted in the DMA in 2008.

Alternative Method to Identify High-Emitting Vehicles

dKC evaluated an alternative method to meet the intent of House Bill 06-1302. This method uses information from Rapid Screen tests if they are available on the vehicle. Otherwise, the determination of whether or not the vehicle is a high-emitter is based strictly on the Low Emission Index (LEI). In addition, vehicles with high LEI values (highest fail rates) get selected regardless of their Rapid Screen results. This alternative has the advantage of being able to cover 100 percent of the fleet. Still this option reduces HC exhaust benefits by 27 percent and NOx benefits by 42 percent. Also, evaporative HC benefits would be reduced by approximately 80 percent. For these reasons, this alternative was not recommended.

Table D-14 presents the estimated effectiveness of this approach assuming there is at least one Rapid Screen observation on 50 percent of the fleet. RSD cutpoints of 3 percent CO, 550 parts per million HC and 2000 parts per million NOx are used for the vehicles seen by Rapid Screen. This method identifies 73 percent of the excess HC and 58 percent of the excess NOx by selecting 15 percent of the vehicles for confirmatory tests.

Table D-14 -- Effectiveness of Alternative Method to Identify High-Emitters – Select Vehicles with High LEI (High Expected Fail Rates) Regardless of Rapid Screen Results. Select Vehicles with High Rapid Screen Emission Levels if They Have Low LEIs.

Parameter	RSD or HEI	HEI Alone	Fleet
Percent Selected	14.82%	16.72%	15.77%
Percent False failures	70.44%	67.20%	68.82%
Percent Excess HC Identified	72.71%	72.40%	72.56%
Percent Excess NOx Identified	67.54%	48.12%	57.83%

II. ALTERNATIVE OPTIONS FOR MOBILE SOURCES

Alternative mobile source strategies that were evaluated include the following:

1. Alternative Strategy One. Utilize information from the OBDII system when inspecting 1996 and newer vehicles.
2. Alternative Strategy Two. Two-Speed Idle (TSI) tests Instead of IM240 tests.
3. Alternative Strategy Three. Eliminate 1 PSI RVP Waiver for Ethanol.
4. Alternative Strategy Four. Inspect vehicles for liquid fuel leaks.
5. Alternative Strategy Five. Early Vehicle Retiremen.t

Each of these strategies is discussed below.

1. Alternative Strategy One. Utilize information from the OBDII system when inspecting 1996 and newer vehicles.

In 2002, Colorado stopped enforcing compliance with the OBD MIL check, but its inspection contractor (ESP) continues to perform OBDII tests on 1996 and newer vehicles. CDPHE had several concerns over OBD tests including lack of correlation between OBD test results and IM240 results, excessive failure rates, and excessive repair costs. This evaluation revisited the issue of performing OBDII inspections in the AIR Program. *dKC* analyzed vehicle test result (VTR) data on vehicles that received OBD and IM240 tests. *dKC* also analyzed data on vehicles that received AIR tests, OBD tests, and RSD tests. *dKC* compared the effectiveness of OBD inspections to current AIR Program tests. *dKC* specifically evaluated two alternatives for using OBDII information in making pass/fail decisions in the AIR Program:

- Fail according to current pass/fail criteria plus fail vehicles that have MILs on and specific diagnostic trouble codes (DTCs)
- Fail according to EPA's OBDII pass/fail criteria

These options are described below. Then their impact on emissions and costs are discussed.

OBDII Alternative 1: Fail vehicles that have Malfunction Indicator Lights (MILs) on and specific diagnostic trouble codes (DTCs), in addition to failing vehicles that exceed IM240 levels.

A key feature of an OBDII system is the ability to identify why the vehicle's MIL is illuminated. Whenever the Malfunction Indicator Lamp (MIL[12]) is illuminated, a Diagnostic Trouble Code (DTC) should be stored in the vehicle's computer. DTCs describe the problem that caused the MIL to go on. Before OBDII, each manufacturer had their own specific trouble code list and code definitions. Under the OBDII requirements, all manufacturers must comply with a standardized convention for DTCs. The universal DTC format consists of a 5-character alphanumeric code, consisting of a single letter character followed by four numbers.

dKC reviewed the list of generic DTCs and selected specific DTCs that directly affect HC, CO , or NOx Emissions. These DTCs are shown on Table D-15. They are a small subset of the total list of DTCs. Appendix E contains the complete list DTCs that would be cause for failure under this scenario.

Table D-15 – Diagnostic Trouble Codes (DTCs) Selected for Pass/Fail Determination

DTCs	Description
P0130-P0175	Fuel and Air Metering
P0300-P0312	Ignition System or Misfire
P0400-P0460	Auxiliary Emissions Controls

[12] MIL is a term used for the light on the instrument panel, which notifies the vehicle operator of an emission related problem. The MIL is required to display the phrase "check engine" or "service engine soon" or the ISO engine symbol. The MIL is required to illuminate when a problem has been identified that could cause emissions to exceed a specific multiple of the standards the vehicle was certified to meet.

OBDII Alternative 2: Stop performing IM240 tests on 1996 and newer vehicles and enforce EPA's recommended pass/fail criteria for OBDII inspections.

Most US inspection and maintenance (I/M) programs inspect 1996 and newer light-duty vehicles by looking for emission related problems identified by the OBDII system[13]. The emissions test system is plugged into the OBDII connector and information on the status of the vehicle's OBDII system is automatically downloaded and recorded. Vehicles fail the OBDII inspection if they have the following problems:

- MIL is commanded-on – This is the primary reason for failure
- MIL not working (Termed Key-On Engine-Off, KOEO, failure[14]), and
- OBDII diagnostic link connector damaged
- If the vehicle has too many monitors that are not ready[15]

Correlation Between IM240 Results and OBDII Results

Although Colorado stopped enforcing compliance with the OBD malfunction indicator light (MIL) check, its inspection contractor (ESP) continued to perform OBDII tests on 1996 and newer vehicles. Using data on IM240 tests matched with OBD results, we calculated the percent of IM240 failures and excess IM240 emissions[16] that are identified by the EPA OBD tests. We also calculated the percent of IM240 failures that had any indication that a problem had been identified by the OBD system. We defined a vehicle with an OBD identified problem as one with either a MIL illuminated or an unset readiness monitor. An unset readiness monitor could indicate that MIL had been extinguished by clearing the memory of the on-board computer[17].

The results of our evaluations are set forth in Table D-16. As shown, 59 percent of the IM240 fails will also fail the EPA OBDII test. Note that this 58 percent figure jumps to 73 percent when the "Any OBD Fault" criteria is used. In other words, 73 percent of the IM240 fails have some indicator that the OBD system identified a problem, as indicated by one or more monitors being not ready or the MIL being illuminated.

[13] Title 40, Code of Federal Regulations (CFR), Parts 51 and 85, and the Final Implementation Guidance: "Performing On-Board Diagnostic System Checks as Part of a Vehicle Inspection and Maintenance Program" (EPA420-R-01-015, June 2001) set forth criteria for OBDII-only inspections.

[14] The Key-On Engine-Off (KOEO) determines if the MIL bulb is working. The bulb should illuminate when the vehicle is turned on but not started.

[15] OBDII systems have up to 11 diagnostic monitors, which run periodic tests on specific systems and components to ensure that they are performing within their prescribed range. OBDII systems must indicate whether or not the onboard diagnostic system has monitored each component. Components that have been diagnosed are termed "ready", meaning they were tested by the OBDII system. For 1996-2000 models, two non-continuous monitors can be not ready; for 2001 and newer models, one non-continuous monitor can be not ready.

[16] Excess emissions are emissions in excess of the IM240 cutpoint.

[17] Readiness status for all monitors is set to "not ready" when fault codes are cleared and the MIL is extinguished by a technician with a scan tool.

Table D-16 – Relationship Between OBDII Test Results and AIR Program Results Based on Matched AIR Test and OBDII Test Data: Sample Size = 120,253

Parameter	Fail EPA OBDII	Fault Identified by OBD[18]
Percent of Sample	13%	20%
Percent of AIR Emissions Fails Identified	59%	73%

Source: *dKC* de la Torre Klausmeier Consulting, Inc analysis of AIR Program data.

Emission Reductions for OBDII Alternatives

dKC reviewed data from the AIR and Rapid Screen Programs to determine the emissions impact and costs of alternatives compared to the current program. *dKC* first matched OBDII test results with IM240 test results. *dKC* then matched this matched dataset with the most recent Rapid Screen (remote sensing device or RSD) observation after the IM240 and OBDII test. The potential emission reductions were calculated two ways:

- Assuming that IM240 emission levels for passing vehicles equal the after repair emission levels.
- Assuming that Rapid Screen emission levels for passing vehicles equal the after repair emission levels.

The second calculation method independently evaluates the OBDII alternative vs. the current inspection scenario. The first method is biased towards the IM240 test, since IM240 emission levels are used to evaluate IM240 tests and alternative tests that includes an OBDII test component. Table D-17 present the estimated percent emission reductions for the two alternatives compared with the current pass/fail criteria.

Based on Rapid Screen data, adding specific DTCs to the current pass fail requirements has the following benefits for 1996 and newer vehicles:

- HC reductions increase from 11 percent to 18 percent.
- NOx reductions increase from 11 percent to 17 percent.

Switching to an OBDII inspection with EPA's pass/fail criteria has the following benefits for 1996 and newer vehicles:

- HC reductions increase from 11 percent to 19 percent.
- NOx reductions increase from 11 percent to 16 percent.

[18] MIL-on or any monitor not ready.

Table D-17 – Estimated Emission Reductions for Current Test and Alternative Test for 1996 and Newer Vehicles

Pass/Fail Scenario	% Fail	% Emission Reductions			
		Based on IM240		Based on Rapid Screen	
		HC	NOx	HC	NOx
Current Pass/Fail Scenario	5.1%	17%	9%	11%	11%
Current scenario + Fail for Specific DTCs	9.9%	20%	13%	18%	17%
Drop IM240 test and Enforce EPA's OBDII Test	13.0%	16%	10%	19%	16%

A concern with switching from an IM240 test to an EPA OBDII test is that many vehicles that currently fail back-to-back IM240 tests[19] pass according to EPA's OBDII criteria. Based on an analysis of vehicle test records (VTR) matched with OBDII test results, 41 percent of the IM240 failures pass an EPA OBDII inspection. The EPA OBDII test fails a lot more vehicles (13 percent vs. 5 percent), so the net effect is equal or greater emission reductions.

Cost and Cost-Effectiveness of Alternative OBDII Options

The primary impact of the two OBDII options on costs is increased failure rates, and, accordingly, repair costs[20]. Based upon data on matched OBDII and IM240 tests, failure rates for 1996 and newer vehicles will increase from 5.1 percent to 9.9 percent if vehicles with specific DTCs also failed inspection. Failure rates will increase to 13 percent if vehicles were failed according to EPA's OBDII pass/fail criteria. Data from Connecticut's I/M program is a reliable source of costs to repair OBDII failures. The average repair costs for vehicles with the selected DTCs for the first scenario is \$249[21]. The average repair cost for all OBDII failures is \$352. These costs compare with \$298 which is the average cost to repair 1996 and newer vehicles that fail the IM240 test, based on data collected in the program. The expected repair costs times the expected number of additional failures translates to an increased cost as follows:

- Add failing for specific DTCs to current pass/fail scenario: \$5,255,000
- Fail according to EPA's pass/fail criteria: \$13,436,000

[19] If a vehicle fails its 1st full-length IM240 test, it receives a 2nd chance test. It must fail this test before it is classified as a failure.

[20] 1996 and newer models receive an advisory OBDII test so additional inspection costs would not be incurred for the two OBDII options.

[21] In 2006, the Connecticut Department of Motor Vehicles (CT DMV) conducted a comprehensive survey of the cost to repair vehicles failing Connecticut's I/M test.

Table D-18 compares the cost and cost effectiveness of the current test procedure with the two OBDII alternatives. Adding specific DTCs reduces the cost per ton[22] of the AIR Program, while switching to an EPA OBD inspection increases the cost per ton.

Table D-18 – Costs and Cost-Effectiveness of Alternative Inspection Options for 1996 and Newer Vehicles

Pass/Fail Scenario	% Fail	Total Costs	Cost per Ton (HC+CO/60+NOx)
Current Pass/Fail Scenario	5.1%	$43,672,000	$7,659
Current scenario + Fail for Specific DTCs	9.9%	$48,927,000	$7,066
Drop IM240 test and Enforce EPA's OBDII Test	13.0%	$57,108,000	$8,248

Impact of Dropping IM240 Tests on 1995 and Older Models and Performing EPA's Recommended OBDII Test on 1996 and Newer Models

Several states have dropped or made plans to drop tailpipe emission and gas cap tests on 1995 and older model vehicles. These states plan to only perform OBDII tests on 1996 and newer models. Based on the emission reductions observed in 2008 for the conventional emission test and the projected benefits of OBDII inspections, dropping the conventional emission test for 1995 and older models and only performing OBDII inspections would reduce program benefits as follows:

- HC benefits would be reduced by 44 percent
- CO benefits would be reduced by 51 percent
- NOx benefits would be reduced by 26 percent

Based on the analysis of AIR Program costs, inspecting pre-1996 vehicles costs less per ton of emission reductions than inspecting 1996 and newer models, so it does not make sense at this time to drop 1995 and older vehicles from the AIR Program. CDPHE may want to revisit this option in the future when there are fewer 1995 and older models in the fleet.

[22] Cost-effectiveness is expressed in terms of $ per ton of HC+CO/60+NOx removed from the atmosphere. The CO reductions are divided by 60 to reflect their reduced importance in terms of reducing ozone levels in the DMA.

2. Alternative Strategy Two. Two-Speed Idle (TSI) tests Instead of IM240 tests

The 2006 audit recommended that CDPHE evaluate switching to a two-speed idle (TSI) test from the IM240 test. This recommendation was based on two factors:

- An analysis of Rapid Screen data that showed that the TSI test had similar effectiveness to the IM240 test in reducing HC emissions.

- Ozone modeling at that time predicted that the DMA was "VOC limited" meaning that reductions in NOx emissions were not expected to reduce ozone levels.

Since 2006, two major factors emerged that made switching to a TSI test less desirable. First, more recent ozone modeling now indicates that mobile source NOx reductions are more important than mobile source HC (VOC) reductions in reducing ambient ozone levels in the DMA. Second, the IM240 cutpoint change that was enacted in May 2008 significantly increased HC and NOx reductions. The TSI test does not reduce NOx emissions, and TSI cutpoints are at the lowest level recommended by EPA, so additional HC reductions are not possible from the TSI test. For these reasons, we recommend that the AIR Program continue to enforce compliance with the IM240 test.

3. Alternative Strategy Three. Eliminate 1 PSI RVP Waiver for Ethanol

When ethanol is blended with gasoline, the volatility of the blend is higher than the base gasoline. Volatility as measured by Reid Vapor Pressure (RVP) typically is increased by one (1) psi when 10 percent ethanol is splash blended with gasoline. Many areas have allowed gasoline/ethanol blends to meet a one psi higher RVP limit. This is termed the ethanol waiver. Although ethanol has positive environmental benefits, evaporative HC emissions are significantly increased if the area has an ethanol waiver.

The impact of the eliminating the one (1.0) psi RVP waiver for gasoline/ethanol blends was estimated by modifying MOBILE6.2 input files. CDPHE provided input files for 2008, 2009, and 2010. For this analysis we modified the 2008 file, so that the benefits could be compared to those for the AIR Program. The results of this analysis are shown in Table D-19. According to MOBILE6.2, eliminating the ethanol waiver has a significant impact on HC emissions and a slight impact on CO emissions; no impact is projected for NOx emissions. Total tons per day impact was estimated by applying the benefits to all gasoline powered vehicles registered in the AIR Program area. This likely underestimates the total impact, because it is likely that reduced RVP gasoline would be distributed outside the AIR Program area, if CDPHE requested to eliminate the ethanol waiver in the area.

Table D-19 – Estimated Impact of Ethanol Waiver

Pollutant	No Waiver (g/mi)	Waiver (g/mi)	Delta g/mi	Tons/Day
VOC	1.336	1.459	0.123	8.372
CO	10.189	10.434	0.245	16.675
NOx	1.364	1.364	0	0

The cost of eliminating the one psi RVP waiver for ethanol was estimated to be $0.01 to $0.02 per gallon[23]. A cost of $0.02 per gallon translates into $7,200 per ton of ozone precursors removed from the atmosphere ((HC+CO/60+NOx).

4. Alternative Strategy Four. Inspect vehicles for liquid fuel leaks

Based on studies by EPA and the State of California, vehicles with liquid fuel leaks emit large amounts of HC. MOBILE6.2 does not estimate benefits for inspections for liquid leaks. These benefits were estimated using results of a study by the California Bureau of Automotive Repair (BAR). BAR's study found that 1.68 percent of the vehicles have liquid leaks, and that the average emissions impact of these leaks was 4.26 g/mi. Table D-20 presents estimated credits for a liquid leak test assuming that such a test will identify and effect proper repairs on 50 percent of the vehicles with leaks. We also assume that these benefits only apply to vehicles older than 10 years old. Total benefits are estimated to be about 1 ton/day. The costs for performing checks for liquid leaks and repairing high emitters are not well defined. To some degree, this option is already being performed, since vehicles with water or fuel leaks are currently rejected from testing.

Table D-20 – Estimated I/M Credit from Liquid Leak Inspections
Source: California Bureau of Automotive Repair, September 11, 2000, Evaporative Emissions Impact of Smog Check.

VOC Impact (g/mi)	**4.26**
% of Fleet with leaks	**1.68%**
g/mi impact	**0.072**
Inspection and Repair effectiveness	**50%**
I/M Credit (g/mi)	**0.036**
Estimated Fleet Impact Over One Cycle (tons/day)	**0.90**

[23] Personal communication with Dave Hirshfeld, MathPro Inc., June 8, 2009.

5. Alternative Strategy Five. Early Vehicle Retirement

In June 2009, Congress passed a plan to provide consumers with rebates of up to $4,500 to turn in their gas-guzzling cars and trucks for more fuel-efficient vehicles. The almost $3 billion program was authorized from July through August, 2009. The program began in July 2009. The primary elements of this plan are shown below:

- Passenger car owners could receive a voucher worth $3,500 if they traded in a passenger car getting 18 miles per gallon or less for a new car getting at least 22 mpg.
- Owners of SUVs, pickups or minivans that get 18 mpg or less could receive a voucher for $3,500 if their new SUV, truck or minivan gets at least 2 miles per gallon more than their old vehicle.
- Passenger car owners could get a voucher for $4,500 if they traded in a passenger car getting 18 mpg or less for a new car that is 10 mpg higher than the old car.
- SUV, pickup or minivan owners who get 18 mpg or less could receive a voucher for $4,500 if the mileage of the new truck or SUV is at least 5 mpg higher than the older vehicle.
- Large trucks (pickups and vans weighing 6,000-8,500 pounds) with mileage of at least 15 mpg would be eligible for vouchers of $3,500 to $4,500.
- Dealers are directed to ensure that older vehicles are crushed or shredded to get the clunkers off the road.
- Older trade-in vehicles must be in drivable condition, be manufactured in model year 1984 or later, and be continuously insured and registered to the same owner for at least one year immediately prior to trade-in.

If Colorado were to implement a program to provide similar incentives beyond November 2009, the emission benefits and costs for such a vehicle scrappage program were estimated based on the following assumptions:

- Under this program, a 15 year old vehicle will be replaced by a new vehicle. Based on MOBILE6.2 a 15 year old vehicle emits 1.7 g/mi more ozone precursors (HC+CO/60+NOx) than a new vehicle. This estimate is for calendar year 2010.
- An incentive of $4,000 results in the vehicle being removed from the fleet five (5) years before it would have normally been removed.
- The average replacement vehicle is driven 10,000 miles per year.
- The fuel economy improves from 18 miles per gallon to 25 miles per gallon.

Based on these assumptions, an early vehicle retirement program costs $22,000 per ton of ozone precursors removed from the atmosphere ((HC+CO/60+NOx).

ATTACHMENT 1

Diagnostic Trouble Codes (DTCs) that would Result in a Vehicle Failing the AIR Program Inspection under the Hybrid OBD Option

DTC	Description
DTC Codes - P0130-P0175 – Fuel and Air Metering	
P0130	02 Sensor Circuit Malfunction (Bank I Sensor 1)
P0131	02 Sensor Circuit Low Voltage (Bank I Sensor I)
P0132	02 Sensor Circuit High Voltage (Bank I Sensor 1)
P0133	02 Sensor Circuit Slow Response (Bank 1 Sensor 1)
P0134	02 Sensor Circuit No Activity Detected (Bank I Sensor 1)
P0135	02 Sensor Heater Circuit Malfunction (Bank 1 Sensor 1)
P0136	02 Sensor Circuit Malfunction (Bank I Sensor 2)
P0137	02 Sensor Circuit Low Voltage (Bank I Sensor 2)
P0138	02 Sensor Circuit High Voltage (Bank I Sensor 2)
P0139	02 Sensor Circuit Slow Response (Bank 1 Sensor 2)
P0140	02 Sensor Circuit No Activity Detected (Bank 1 Sensor 2)
P0141	02 Sensor Heater Circuit Malfunction (Bank 1 Sensor 2)
P0142	02 Sensor Circuit Malfunction (Bank I Sensor 3)
P0143	02 Sensor Circuit Low Voltage (Bank I Sensor 3)
P0144	02 Sensor Circuit High Voltage (Bank I Sensor 3)
P0145	02 Sensor Circuit Slow Response (Bank 1 Sensor 3)
P0146	02 Sensor Circuit No Activity Detected (Bank I Sensor 3)
P0147	02 Sensor Heater Circuit Malfunction (Bank I Sensor 3)
P0150	02 Sensor Circuit Malfunction (Bank 2 Sensor I)
P0151	02 Sensor Circuit Low Voltage (Bank 2 Sensor I)
P0152	02 Sensor Circuit High Voltage (Bank 2 Sensor 1)
P0153	02 Sensor Circuit Slow Response (Bank 2 Sensor 1)
P0154	02 Sensor Circuit No Activity Detected (Bank 2 Sensor 1)
P0155	02 Sensor Heater Circuit Malfunction (Bank 2 Sensor 1)
P0156	02 Sensor Circuit Malfunction (Bank 2 Sensor 2)
P0157	02 Sensor Circuit Low Voltage (Bank 2 Sensor 2)
P0158	02 Sensor Circuit High Voltage (Bank 2 Sensor 2)
P0159	02 Sensor Circuit Slow Response (Bank 2 Sensor 2)
P0160	02 Sensor Circuit No Activity Detected (Bank 2 Sensor 2)
P0161	02 Sensor Heater Circuit Malfunction (Bank 2 Sensor 2)
P0162	02 Sensor Circuit Malfunction (Bank 2 Sensor 3)
P0163	02 Sensor Circuit Low Voltage (Bank 2 Sensor 3)

DTC	Description
P0164	02 Sensor Circuit High Voltage (Bank 2 Sensor 3)
P0165	02 Sensor Circuit Slow Response (Bank 2 Sensor 3)
P0166	02 Sensor Circuit No Activity Detected (Bank 2 Sensor 3)
P0167	02 Sensor Heater Circuit Malfunction (Bank 2 Sensor 3)
P0170	Fuel Trim Malfunction (Bank 1)
P0171	System too Lean (Bank 1)
P0172	System too Rich (Bank 1)
P0173	Fuel Trim Malfunction (Bank 2)
P0174	System too Lean (Bank 2)
P0175	System too Rich (Bank 2)
DTC Codes - P0300-P0312 – Ignition System or Misfire	
P0300	Random/Multiple Cylinder Misfire Detected
P0301	Cylinder 1 Misfire Detected
P0302	Cylinder 2 Misfire Detected
P0303	Cylinder 3 Misfire Detected
P0304	Cylinder 4 Misfire Detected
P0305	Cylinder 5 Misfire Detected
P0306	Cylinder 6 Misfire Detected
P0307	Cylinder 7 Misfire Detected
P0308	Cylinder 8 Misfire Detected
P0309	Cylinder 9 Misfire Detected
P0311	Cylinder 11 Misfire Detected
P0312	Cylinder 12 Misfire Detected
DTC Codes - P0400-P0460 – Auxiliary Emissions Controls	
P0400	Exhaust Gas Recirculation Flow Malfunction
P0401	Exhaust Gas Recirculation Flow Insufficient Detected
P0402	Exhaust Gas Recirculation Flow Excessive Detected
P0403	Exhaust Gas Recirculation Circuit Malfunction
P0404	Exhaust Gas Recirculation Circuit Range/Performance
P0405	Exhaust Gas Recirculation Sensor A Circuit Low
P0406	Exhaust Gas Recirculation Sensor A Circuit High
P0407	Exhaust Gas Recirculation Sensor B Circuit Low
P0408	Exhaust Gas Recirculation Sensor B Circuit High
P0410	Secondary Air Injection System Malfunction
P0411	Secondary Air Injection System Incorrect Flow Detected
P0412	Secondary Air Injection System Switching Valve A Circuit Malfunction
P0413	Secondary Air Injection System Switching Valve A Circuit Open
P0414	Secondary Air Injection System Switching Valve A Circuit Shorted
P0415	Secondary Air Injection System Switching Valve B Circuit Malfunction
P0416	Secondary Air Injection System Switching Valve B Circuit Open
P0417	Secondary Air Injection System Switching Valve B Circuit Shorted

DTC	Description
P0418	Secondary Air Injection System Relay 'A" Circuit Malfunction
P0419	Secondary Air Injection System Relay "B' Circuit Malfunction
P0420	Catalyst System Efficiency Below Threshold (Bank 1)
P0421	Warm Up Catalyst Efficiency Below Threshold (Bank 1)
P0422	Main Catalyst Efficiency Below Threshold (Bank 1)
P0423	Heated Catalyst Efficiency Below Threshold (Bank 1)
P0424	Heated Catalyst Temperature Below Threshold (Bank 1)
P0430	Catalyst System Efficiency Below Threshold (Bank 2)
P0431	Warm Up Catalyst Efficiency Below Threshold (Bank 2)
P0432	Main Catalyst Efficiency Below Threshold (Bank 2)
P0433	Heated Catalyst Efficiency Below Threshold (Bank 2)
P0434	Heated Catalyst Temperature Below Threshold (Bank 2)
P0440	Evaporative Emission Control System Malfunction
P0441	Evaporative Emission Control System Incorrect Purge Flow
P0442	Evaporative Emission Control System Leak Detected (small leak)
P0443	Evaporative Emission Control System Purge Control Valve Circuit
P0444	Evaporative Emission Control System Purge Control Valve Circuit
P0445	Evaporative Emission Control System Purge Control Valve Circuit Shorted
P0446	Evaporative Emission Control System Vent Control Circuit Malfunction
P0447	Evaporative Emission Control System Vent Control Circuit Open
P0448	Evaporative Emission Control System Vent Control Circuit Shorted
P0449	Evaporative Emission Control System Vent Valve/Solenoid Circuit Malfunction
P0450	Evaporative Emission Control System Pressure Sensor Malfunction
P0451	Evaporative Emission Control System Pressure Sensor Range/Performance
P0452	Evaporative Emission Control System Pressure Sensor Low Input
P0453	Evaporative Emission Control System Pressure Sensor High Input
P0454	Evaporative Emission Control System Pressure Sensor Intermittent
P0455	Evaporative Emission Control System Leak Detected (gross leak)

Appendix E

PROJECTIONS OF MOBILE6.2 EMISSIONS TO 2020 AND IMPACT OF MOVES[1]

MOVES vs. MOBILE6.2 Emission Factors for Different Vehicle Types

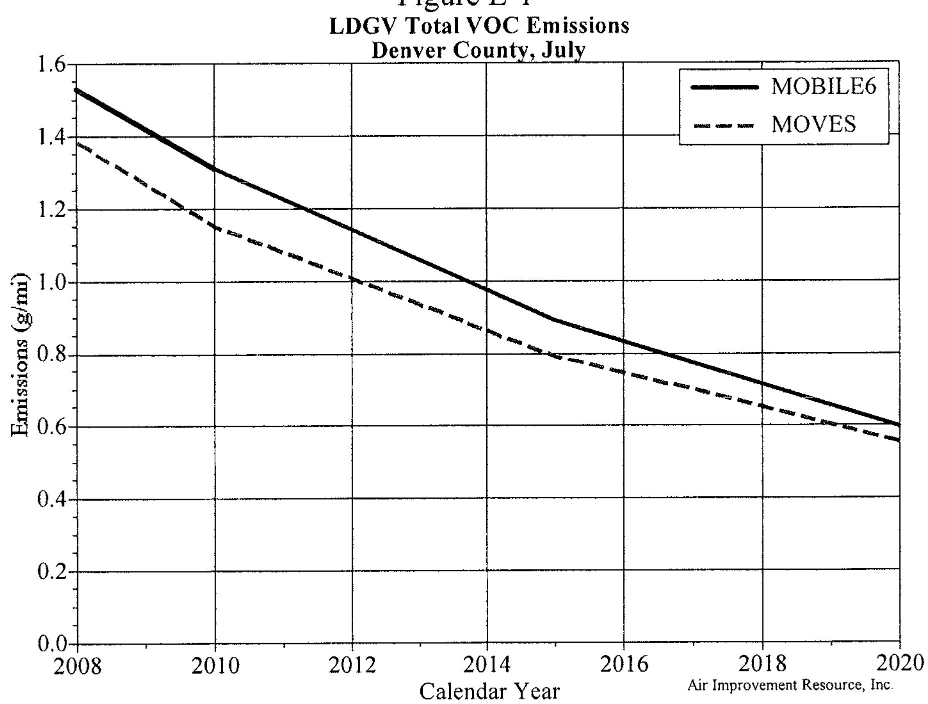
By the end of 2009, the EPA will require states to use its new mobile source emissions factor model, MOVES, for SIP planning instead of MOBILE6.2. MOVES stands for Motor Vehicle Emissions Simulator. Trends in VOC, CO, and NOx from 2008 to 2020 for cars and trucks for the Denver Metropolitan Area, for both MOBILE6.2 and the draft MOVES model, are shown in Figures E-1 to E-9. The draft MOVES model is being offered to states to allow them to become familiar with how to run the model, as well as how MOVES estimates differ from MOBILE6.2.

VOC from light-duty gasoline powered vehicles (LDGV – Passenger cars): VOC emissions will continue trending down through 2020 due to the Tier 2 and many other programs applied to these vehicles. The reductions are greater than 50 percent. MOBILE6.2 and the draft MOVES model are similar for total VOC for the Denver Metropolitan Area.

CO from LDGVs: CO emissions will also continue downward. The MOVES model has much lower CO emissions than MOBILE6.2.

NOx from LDGVs: NOx emissions will also trend down, with reductions of 50 percent and greater. The MOVES model is higher in 2008, but about equal to MOBILE6.2 in 2020.

Figure E-1



[1] Prepared by *dKC* de la Torre Klausmeier Consulting, Inc.

Figure E-2
LDGV CO Emissions
Denver County, July

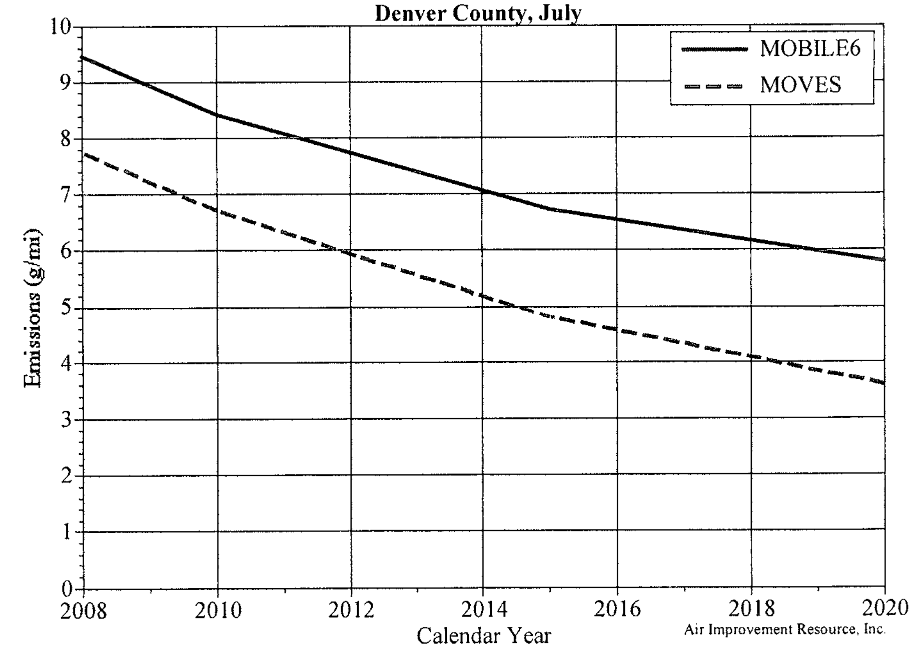
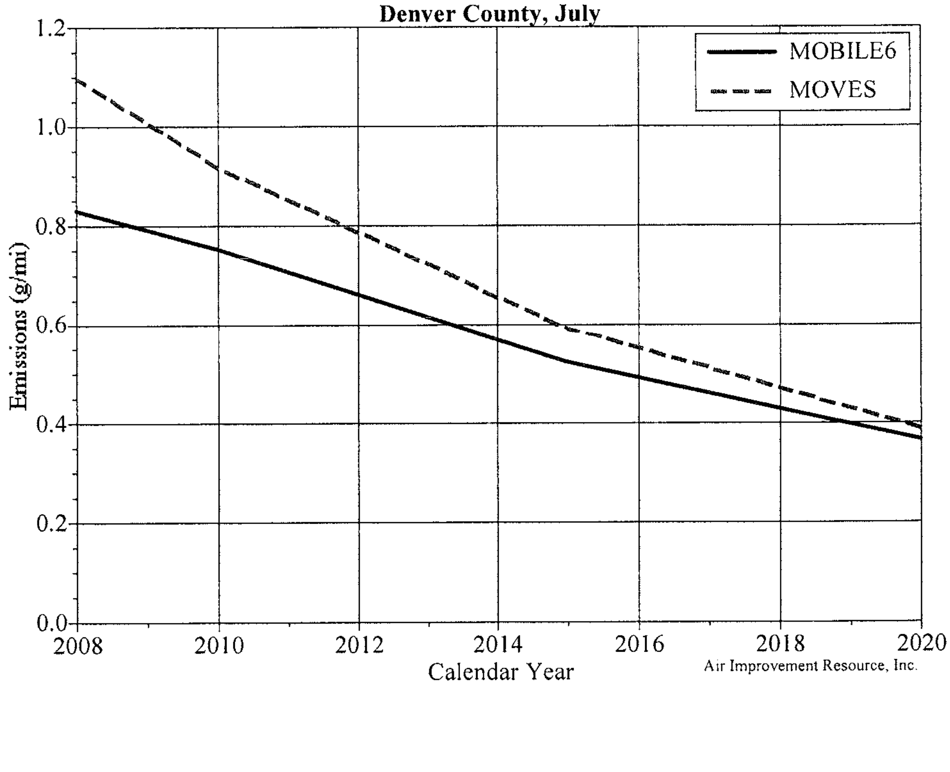


Figure E-3
LDGV NOx Emissions
Denver County, July



VOC from Light-duty gasoline-powered trucks (LDGT): VOC emissions from LDGTs will be reduced significantly between 2008 and 2020. For LDGTs, MOVES is somewhat higher than MOBILE6.2.

CO from LDGTs: CO emissions from LDGTs will continue trending down. MOVES CO for LDGT is somewhat higher than for MOBILE6.2.

NOx from LDGTs: NOx emissions from LDGTS will continue to decline. MOVES NOx is much higher for this class than MOBILE6.2, but it should be noted that this is a draft model, and much could change before the final model.

Figure E-4

LDGT Total VOC Emissions
Denver County, July

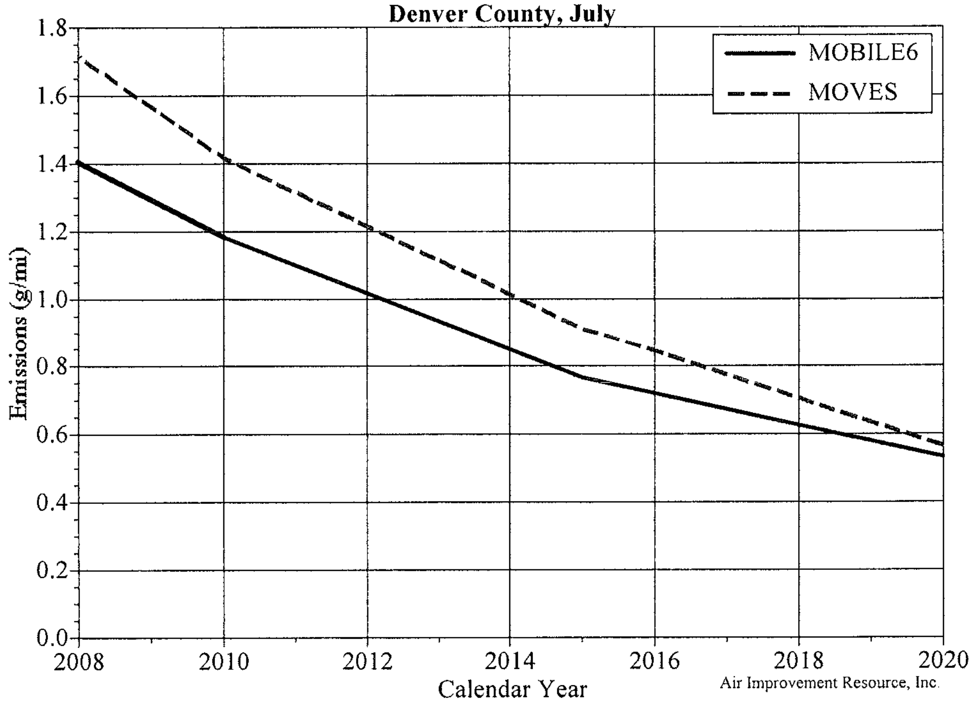


Figure E-5
LDGT CO Emissions
Denver County, July

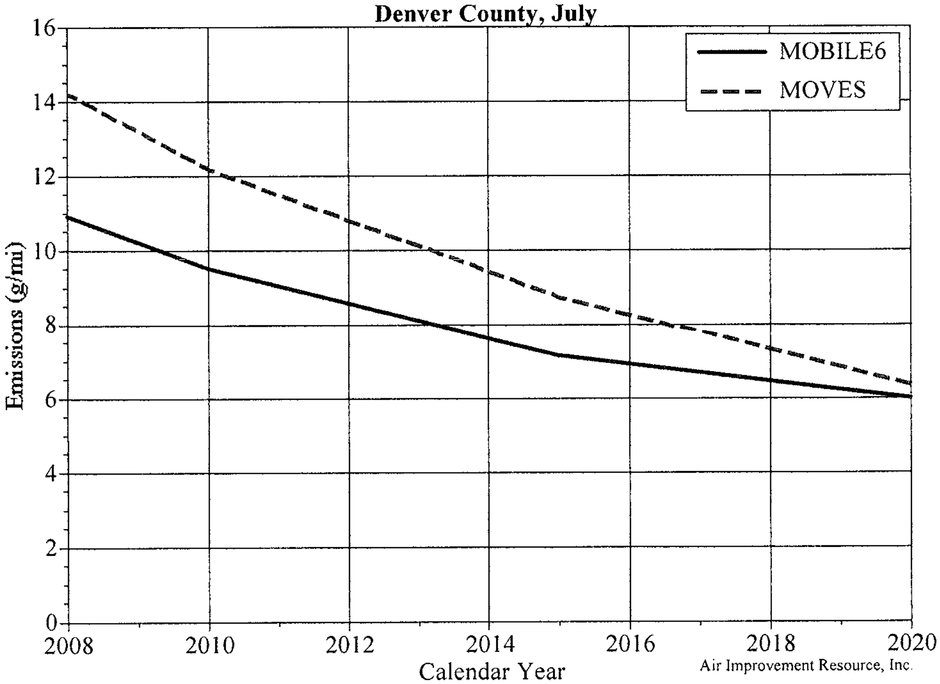
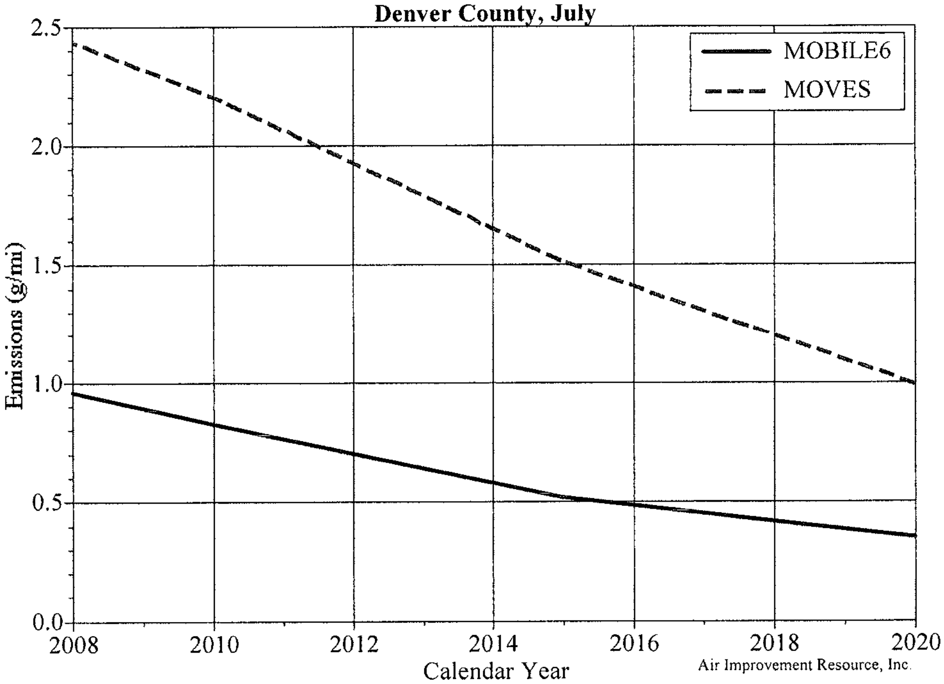


Figure E-6
LDGT NOx Emissions
Denver County, July



VOC from heavy-duty diesel vehicles (HDDVs): VOC emissions from HDDVs will be reduced significantly between 2008 and 2020. For HDDVs, MOVES is about the same as MOBILE6.2.

CO from HDDVs: CO emissions from HDDVs will continue trending down. MOVES CO for HDDV is much higher for this class than MOBILE6.2, but it should be noted that this is a draft model, and much could change before the final model.

NOx from HDDVs: NOx emissions from HDDVs will continue to decline. MOVES NOx is higher for this class than MOBILE6.2.

Figure E-7

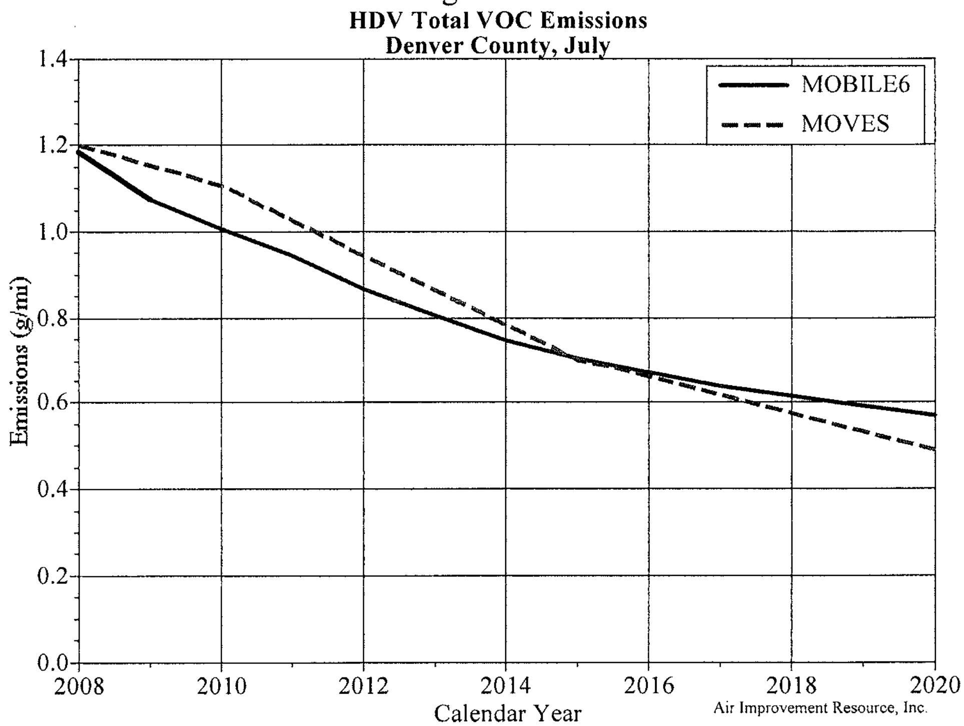


Figure E-8

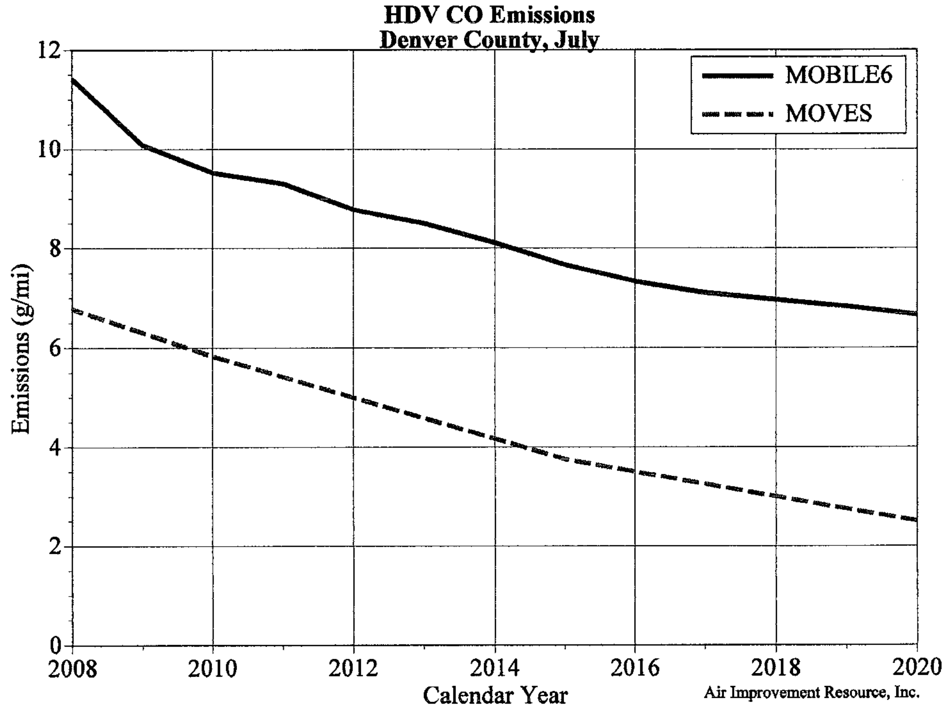
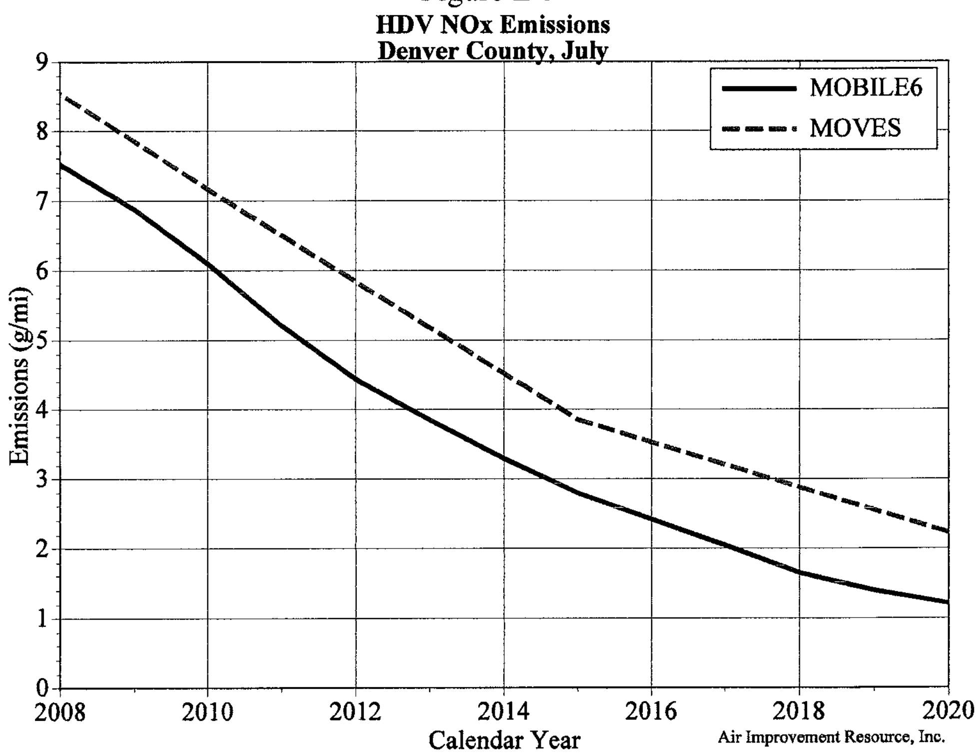


Figure E-9



MOVES vs. MOBILE6.2 I/M Program Benefits

As figures E-10 to E-15 show, MOVES projects less benefit for I/M programs. It is not clear what the EPA's policy will be for calculating credits for alternative I/M approaches. The I/M program modeled by MOVES will likely be different than the current or future AIR Program.

Figure E-10
"All Vehicle" Total VOC Emissions
Denver County, July

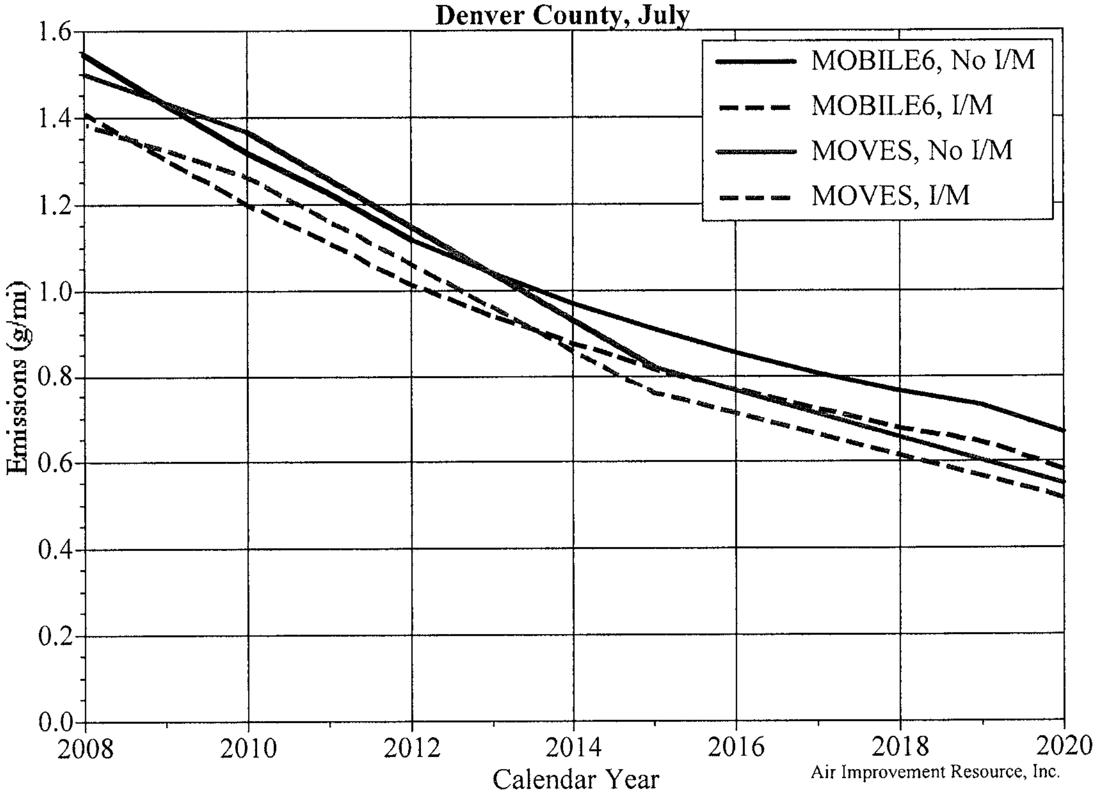


Figure E-11
"All Vehicle" CO Emissions
Denver County, July

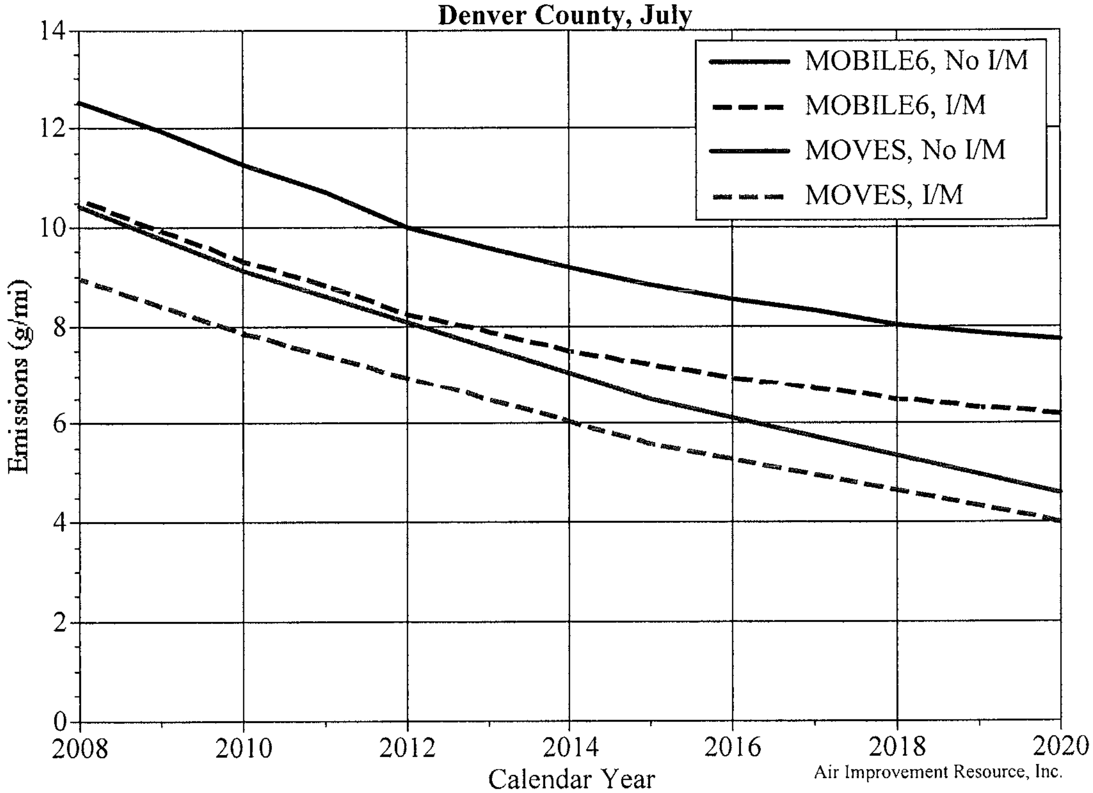


Figure E-12
"All Vehicle" NOx Emissions
Denver County, July

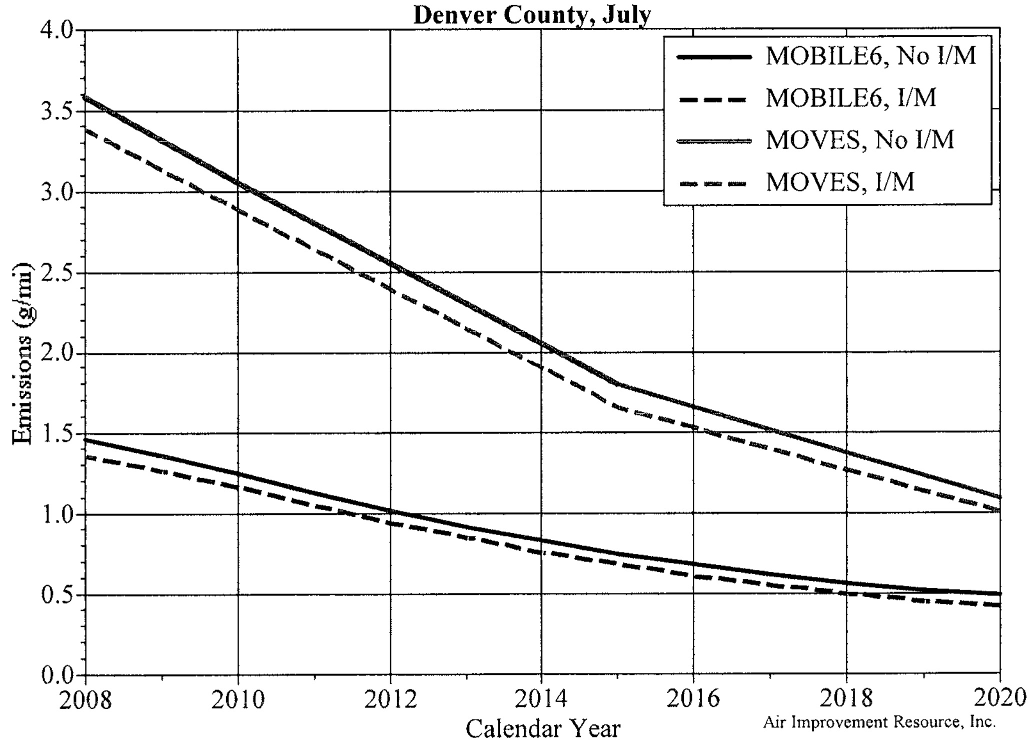


Figure E-13

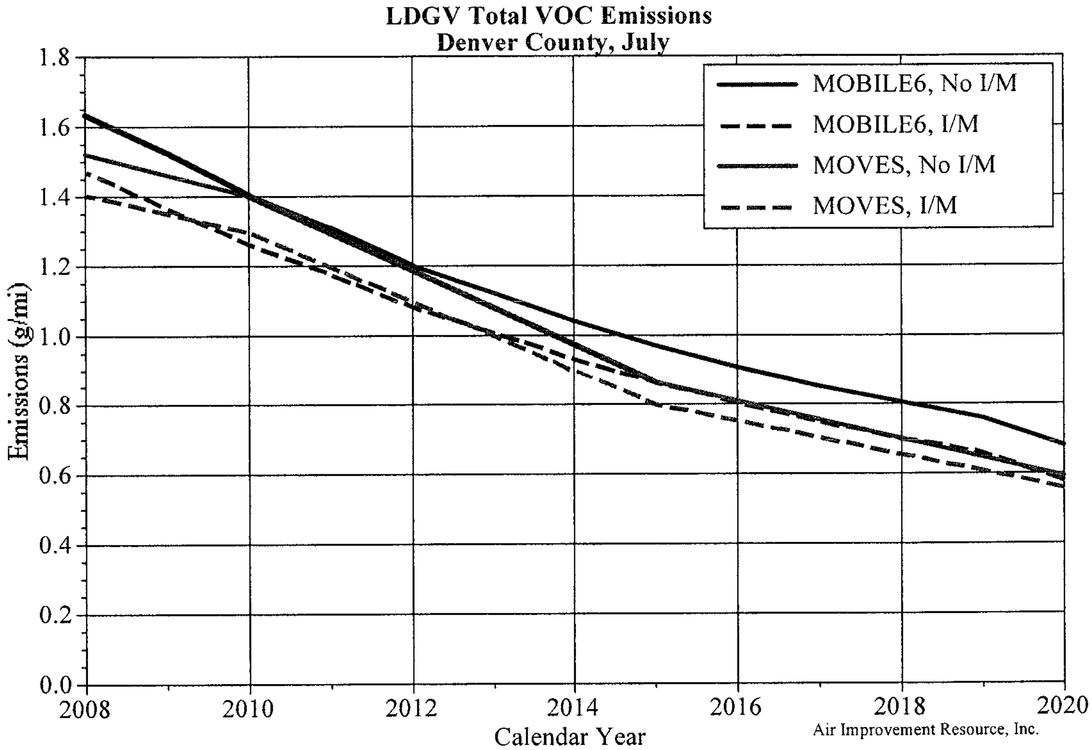


Figure E-14

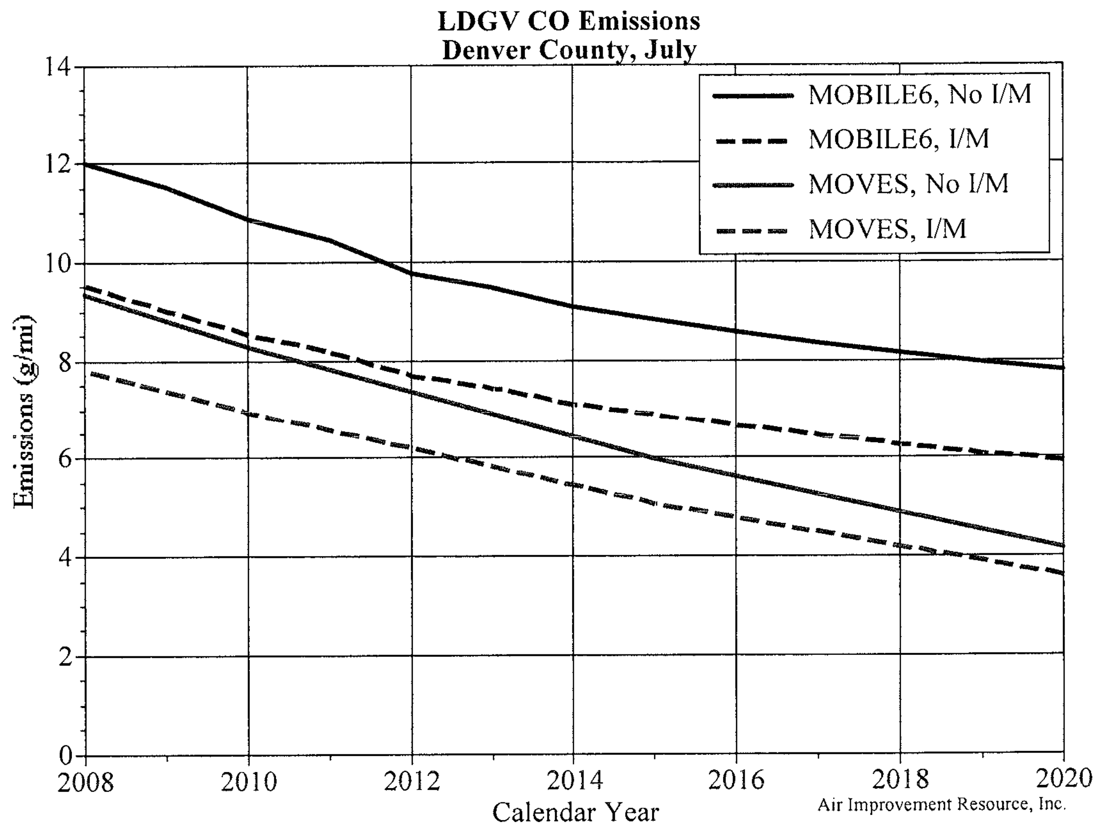
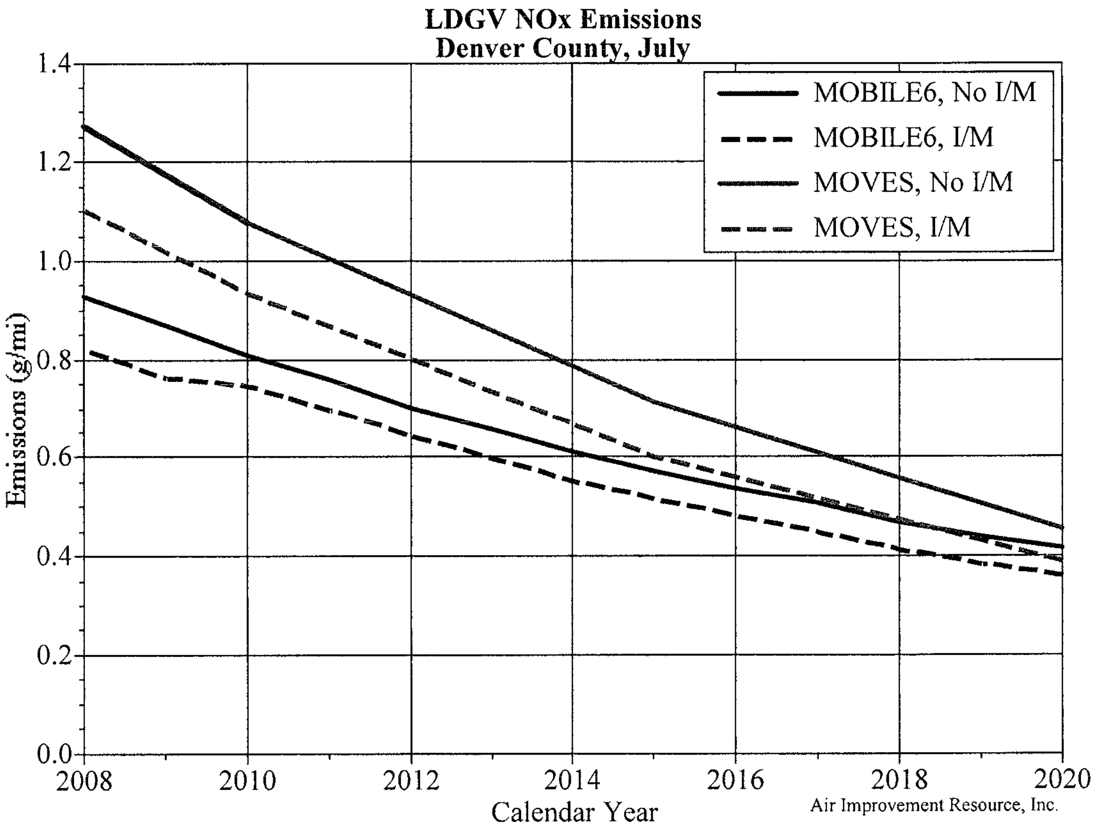


Figure E-15


LDGV NOx Emissions
Denver County, July
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Emissions (g/mi)
MOBILE6, No I/M
MOBILE6, I/M
MOVES, No I/M
MOVES, I/M
2008
2010
2012
2014
2016
2018
2020
Calendar Year
Air Improvement Resource, Inc.

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