TITLE 13. CALIFORNIA AIR RESOURCES BOARD

NOTICE OF PUBLIC HEARING TO CONSIDER THE ADOPTION OF A CONTROL MEASURE FOR DIESEL PARTICULATE MATTER FROM ON-ROAD HEAVY-DUTY RESIDENTIAL AND COMMERCIAL SOLID WASTE COLLECTION VEHICLES

The Air Resources Board (the Board or ARB) will conduct a public hearing at the time and place noted below to consider adoption of a control measure for diesel particulate matter from on-road heavy-duty residential and commercial solid waste collection vehicles. The control measure mandates the reduction of diesel particulate matter emissions through the application of best available control measures to in-use solid waste collection vehicles. Both owners of these vehicles and municipalities that contract for solid waste removal services have responsibilities under the proposal. This notice summarizes the proposed control measure. The staff report presents the control measure in greater detail.

DATE:	July 24, 2003
TIME:	9:00 a.m.
PLACE:	California Environmental Protection Agency Air Resources Board Central Valley Auditorium, Second Floor 1001 I Street Sacramento, California 95814

This item will be considered at a two-day meeting of the Board, which will commence at 9:00 a.m., July 24, 2003, and may continue at 8:30 a.m., July 25, 2003. This item may not be considered until July 25, 2003. Please consult the agenda for the meeting, which will be available at least ten days before July 24, 2003, to determine the day on which this item will be considered.

If you have special accommodation or language needs, please contact the ARB's Clerk of the Board at (916) 322-4011, or amalik@arb.ca.gov as soon as possible. TTY/TTD/Speech-to-Speech users may dial 7-1-1 for the California Relay Service.

INFORMATIVE DIGEST OF PROPOSED ACTION AND POLICY STATEMENT OVERVIEW

Sections Affected: Proposed adoption of new sections 2020, 2021, 2021.1 and 2021.2, of article 4 within chapter 3, division 3, title 13, California Code of Regulations (CCR).

Background: In 1998 the Board identified diesel particulate matter emissions from diesel-fueled engines as a toxic air contaminant. Two years later, the Board adopted the Risk Reduction Plan to Reduce Particulate Matter Emissions from

Diesel-Fueled Engines and Vehicles (Plan) in September 2000, which established a goal of reducing emissions and the resultant health risk from virtually all diesel-fueled engines and vehicles within the State of California by the year 2020. This Plan envisions that particulate matter emissions from diesel-fueled engines and vehicles should be reduced by 75 percent in 2010 and 85 percent in 2020. The Plan identified various methods for achieving the goals including new, more stringent standards for all new diesel-fueled engines and vehicles, the use of diesel emission control strategies on in-use engines, and the use of low-sulfur diesel fuel.

The major sources of diesel particulate matter (diesel PM) are the approximately 1,250,000 diesel-fueled engines in vehicles and equipment used in California. The health impacts of diesel PM include increased incidence of lung cancer, chronic respiratory problems (such as asthma and bronchitis), cardiovascular disease, and increased hospital admissions and mortality. In California, diesel PM emissions are estimated to comprise 70 percent of the total potential cancer risk from all identified toxic air contaminants.

On May 16, 2002, the Board approved the Diesel Emission Control Strategy Verification Procedure, Warranty and in-use Compliance Requirements for On-Road, Off-Road, and Stationary Diesel-Fueled Vehicles and Equipment. This rule establishes procedures for the verification of emission control strategies by ARB that can be applied on various diesel-fueled engines and vehicles to significantly reduce diesel PM emissions.

Proposed Actions: Diesel-fueled solid waste collection vehicles are of utmost concern because they operate in residential communities on a regular basis, in turn increasing the communities' risk of exposure to these toxic emissions. ARB proposes to mandate solid waste collection vehicles owners and municipalities that authorize owners through a contract, franchise agreement, permit, license or similar approval for residential and commercial solid waste collection service to reduce diesel PM emissions from these vehicles. The solid waste collection vehicle control measure is the second in a series of rules that target almost all diesel-fueled heavy-duty vehicles in California for diesel PM reduction. The fleet rule for transit agencies, which requires transit agencies to reduce diesel PM emissions from urban buses, was adopted by the Board in February 2000 and amended in October 2002.

Section 2020 of this proposal identifies the purpose and defines terminology used in this and other diesel particulate control measures. Sections 2021, 2021.1, and 2021.2 comprise the control measure for solid waste collection vehicles.

1. Scope and Applicability

The proposed regulation applies to solid waste collection vehicle owners, whether private or government entities, and to municipalities that authorize owners through a contract, franchise agreement, permit, license or similar approval for residential and commercial solid waste collection service. The proposed regulation also mandates the reduction of diesel PM emissions from 1960 to 2006 engine model year on-road diesel-fueled heavy-duty residential and commercial solid waste collection vehicles with a manufacturer's gross vehicle weight rating greater than 14,000 pounds.

2. Compliance Requirement for Municipalities

As of December 31, 2004, a municipality that contracts for solid waste collection service must ensure that each contractor, for which it regulates the rates that may be charged to those who receive solid waste collection services, is in compliance with title 13, CCR, section 2021.2.

Municipalities that contract for service are required, under this proposal, to submit reports to the ARB's Executive Officer annually, beginning in 2004 through 2013, which identify all contractors and certify compliance by those contractors with this rule. In addition, the municipality is required to notify the ARB's Executive Officer if it becomes aware of non-compliance by its contractors within 30 days of the determination.

3. Compliance for Owners of Solid Waste Collection Vehicles and Municipalities

Compliance with the proposed rule requires use of best available control technology, as defined, implementation according to the specified schedule, and record keeping. In addition, there are provisions for compliance extensions and special circumstances.

Best Available Control Technology

Three different options are offered to meet the requirement to use best available control technology. The first option is to use a diesel engine or power system alone or in combination with a verified diesel emission control strategy (DECS) that is certified to the 0.01 g/bhp-hr particulate emission standard. The second option is to use an alternative fuel engine, or a heavy-duty pilot ignition engine. The third option is to apply the highest level diesel emission control strategy or system verified by ARB for a specific engine, and which the manufacturer or authorized dealer agrees can be successful on the specific engine and vehicle combination.

Implementation Schedule

The implementation schedule phases-in compliance by the model year of the engine. There are three different groups for the specified percentage of vehicles by each applicable compliance deadline: Group 1 includes 1988-2002 model year engines, and the phase-in period is from December 31, 2004 through December 31, 2007. Group 2 includes 1960 through 1987 model year engines, and the phase-in period is from December 31, 2007, through December 31, 2010. Group 3 encompasses 2003 through 2006 model year engines, and the phase-in period begins December 31, 2009, and is complete by December 31, 2010. The proposed regulation describes the required equations needed to calculate the active fleet size.

Compliance Extensions

Staff believes owners may experience conditions that would justify a compliance extension. Three main categories of compliance extensions proposed in the rule are: an extension granted for early implementation of a specified portion of an owner's fleet, an extension granted because there is no verified diesel emission control strategy, and an extension for 100 percent compliance for small business owners with fewer than four vehicles.

Special Circumstances

Owners would be required to maintain best available control technology on each vehicle once that vehicle is in compliance, and would not be required to upgrade to a higher level of best available control technology. Certain specified special circumstances, however, are described. First, failure or damage of the diesel emission control strategy within or outside of the warranty period of the device. Second, discontinuance of a fuel verified as a diesel emission control strategy. Third, the use of a diesel emission control strategy verified to Level 1 (25 to 49 percent particulate matter reduction) is limited in time and use. Fourth, engine retirement within one year of the required compliance deadline. Fifth, the use of an experimental diesel emission control strategy.

Record Keeping Requirement for Owners

Staff proposes that specific records pertaining to compliance be kept at the terminal and in the vehicle. Each owner must keep these records for the life of the vehicle while it operates in California. If a vehicle is sold, the records should be transferred with that vehicle.

Non-Compliance

Staff proposes a specific reference to civil penalties for violations of the compliance provisions.

AVAILABILITY OF DOCUMENTS AND AGENCY CONTACT PERSONS

The Board staff has prepared a Staff Report, which includes the initial statement of reasons for the proposed action and a summary of the economical and environmental impacts of the proposal. The staff has also prepared a technical support document that summarizes technology available and feasible per rule compliance.

Copies of the Staff Report, Technical Support Document, and the full text of the proposed regulatory language may be accessed on the Board's web site listed below, or may be obtained from the Board's Public Information Office, Air Resources Board, Visitors and Environmental Services Center, 1001 I Street, 1st Floor, Sacramento, CA 95814, (916) 322-2990 at least 45 days prior to the scheduled hearing.

Upon its completion, the Final Statement of Reasons (FSOR) will also be available and copies may be requested from the agency contact persons in this notice, or may be accessed on the web site listed below.

Inquiries concerning the substance of the proposed regulation may be directed to Ms. Crystal Reul Chen, Air Resources Engineer, by email at creul@arb.ca.gov or by phone at (626) 350-6543, or to Dr. Nancy L.C. Steele, Manager, by email at nsteele@arb.ca.gov or by phone at (626) 350-6598.

If you are a person with a disability and desire to obtain this document in an alternative format, please contact the Air Resources Board Americans with Disability Act Coordinator at (916) 232-4916, or TDD (916) 324-9531, or (800) 700-8326 for TDD calls from outside the Sacramento area.

Further, the agency representative and designated back-up contact persons to whom nonsubstantive inquiries concerning the proposed administrative action may be directed are Artavia Edwards, Manager, Board Administration & Regulatory Coordination Unit, (916) 322-6070, or Alexa Malik, Regulations Coordinator, (916) 322-4011. The Board staff has compiled a record that includes all information upon which the proposal is based. This material is available for inspection upon request to the contact persons.

This notice, the ISOR and all subsequent regulatory documents, including the FSOR when completed, will be available on the ARB Internet site for this rulemaking at http://www.arb.ca.gov/regact/dieselswcv/dieselswcv.htm.

COSTS TO PUBLIC AGENCIES AND TO BUSINESSES AND PERSONS AFFECTED

The determinations of the Board's Executive Officer concerning the costs or savings necessarily incurred in reasonable compliance with the proposed regulations are presented below.

The Executive Officer has determined that the proposed regulatory action will create costs or savings, as defined in Government Code section 1146.5(a)(5) and 11346.5(a)(6), to a state agency or in federal funding to the state, costs or mandate to any local agency or school district whether or not reimbursable by the state pursuant to Part 7 (commencing with section 17500), Division 4, Title 2 of the Government Code, or other non discretionary savings to local agencies, except as discussed below.

Fiscal Effect On State Government

No increased cost is expected in the current fiscal year, July 2003 to June 2004. Up to three additional staff will be required to implement and enforce the regulation beginning in 2004.

Fiscal Effect on Local Government

The majority of local governments have contracts with private solid waste collection companies to provide refuse collection services. Approximately 1,200 vehicles, however, are directly owned and operated by local governments. These vehicles are owned by cities such as Los Angeles and Fresno that have fleets of solid waste collection vehicles and bill residents for the service. There is no cost associated with implementation during the current fiscal year 2003-2004. The average costs to local government for fiscal years 2004-2005 and 2005-2006 are about $59,000 and $228,000, respectively.

For local governments that contract with private solid waste collection companies, an increase in the contract cost may occur within the terms of the contract or at the renewal of the contract. This is an indirect cost that is passed on to customers and, therefore, is not included in the cost to local government agencies.

These local government agencies are required to submit an initial report and annual reports to the Air Resources Board. The time to complete the reports will vary depending on the number of contracts let, but would not be considered an additional cost as the additional paperwork is within the scope of normal paperwork for contracting.

Any costs to local government are fully reimbursable from collection fees charged to customers for residential and commercial solid waste collection as authorized by Resources Code sections 40059 and 47109.

Fiscal Impact of Businesses

The Executive Officer has made an initial determination that adoption of the proposed regulatory action may have a significant, statewide adverse economic impact directly affecting business, specifically on some solid waste collection

businesses, if those businesses are unable to increase their rate for collection solid waste. Other solid waste collection vehicle businesses may experience no adverse economic impacts because they have the ability to recover costs through rate increases. Adoption of the proposed rule will not affect the ability of California businesses to compete with businesses in other states.

Businesses that provide technology or services mandated under this proposal, such as engines, diesel emission control systems, or installation services, may experience significant economic benefit from this rule. Some, but not all, of those businesses are located in California.

In accordance with Government Code section 11346.3, the Executive Officer has determined that the proposed regulatory action may affect the creation or elimination of jobs within the State of California, the creation of new businesses or elimination of existing businesses within California, or the expansion of businesses currently doing business within California. An assessment of the economic impacts of the proposed regulatory action can be found in the Staff Report.

In developing this regulatory proposal, the ARB staff evaluated the potential economic impacts on representative private persons or businesses. The ARB has determined that there will be no, or an insignificant, potential cost impact, as defined in Government Code section 11346.5(a)(9) on representative private persons or businesses in reasonable compliance with the proposed action.

Finally, the Executive Officer has also determined, pursuant to title 1, CCR, section 4, that the proposed regulation may affect small businesses.

Costs to the Public

Costs are expected to be passed along to customers who receive solid waste collection services. The cost per household would be about $5.90 in total, or $0.85 annually from 2004 through 2010.

Consideration of Alternatives

The Executive Officer has considered proposed alternatives that would lessen any adverse economic impact on businesses and invites you to submit proposals. Submissions may include the following considerations:

(i) The establishment of differing compliance or reporting requirements or timetables which take into account the resources available to businesses.
(ii) Consolidation or simplification of compliance and reporting requirements for businesses.
(iii) The use of performance standards rather than prescriptive standards.
(iv) Exemption or partial exemption from the regulatory requirements for businesses.

Before taking final action on the proposed regulatory action, the Board must determine that no reasonable alternative considered by the agency or that has otherwise been identified and brought to the attention of the agency would be more effective in carrying out the purpose for which the action is proposed or would be as effective and less burdensome to affected private persons than the proposed action.

Pursuant to Government Code section 11346.3(c), the Board finds that it is necessary for the health, safety, and welfare of the people of this state that this regulation which requires a report apply to businesses.

SUBMITTAL OF COMMENTS

The public may present comments relating to this matter orally or in writing at the hearing, and in writing or by e-mail before the hearing. To be considered by the Board, written submissions must be received by **no later than 12:00 noon, July 23, 2003** and addressed to the following:

Postal Mail is to be sent to:

Clerk of the Board
Air Resources Board
1001 "I" Street, 23rd Floor
Sacramento, California 95814

Electronic mail is to be sent to: dieselswcv@listserv.arb.ca.gov and received at the ARB **no later than 12:00 noon, July 23, 2003**.

Facsimile submissions are to be transmitted to the Clerk of the Board at (916) 322-3928 and received at the ARB **no later than 12:00 noon, July 23, 2003**.

The Board requests, but does not require, that 30 copies of any written statement be submitted at least 10 days prior to the hearing so that ARB staff and Board Members have time to fully consider each comment. The ARB encourages

members of the public to bring to the attention of the staff in advance of the hearing any suggestions for modification of the proposed regulatory action.

STATUTORY AUTHORITY AND REFERENCES

This regulatory action is proposed under that authority granted in sections 39600, 39601, and 39658 of the Health and Safety Code. This action is proposed to implement, interpret and make specific sections 39002, 39003, 39658, 43000, 43013, 43018, 43101, 43102, 43104, 43105 and 43700 of the Health and Safety Code.

HEARING PROCEDURES

The public hearing will be conducted in accordance with the California Administrative Procedure Act, title 2, division 3, part 1, chapter 3.5 (commencing with section 11340) of the Government Code.

Following the public hearing, the Board may adopt the regulatory language as originally proposed, or with nonsubstantive or grammatical modifications. The Board may also adopt the proposed regulatory language with other modifications if the text as modified is sufficiently related to the originally proposed text that the public was adequately placed on notice that the regulatory language as modified could result from the proposed regulatory action; in such event the full regulatory text, with the modifications clearly indicated, will be made available to the public, for written comment, at least 15 days before it is adopted.

The public may request a copy of the modified regulatory text from the ARB's Public Information Office, Air Resources Board, 1001 I Street, Visitors and Environmental Services Center, 1st Floor, Sacramento, CA 95814, (916) 322-2990.

CALIFORNIA AIR RESOURCES BOARD

Catherine Witherspoon
Executive Officer

Date: May 27, 2003

State of California
California Environmental Protection Agency
AIR RESOURCES BOARD

PROPOSED DIESEL PARTICULATE MATTER CONTROL MEASURE FOR ON-ROAD HEAVY-DUTY RESIDENTIAL AND COMMERCIAL SOLID WASTE COLLECTION VEHICLES

Staff Report

June 6, 2003

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\$/lb	Dollars per pound
AB	Assembly bill
ARB, or the Board	Air Resources Board
ATCM	Air toxic control measure
BACT	Best available control technology
CCR	California Code of Regulations
CO	Carbon monoxide
CRRC	California Refuse Removal Council
DECS	Diesel Emission Control System or Strategy
DOC	Diesel Oxidation Catalyst
DRRP, or Diesel Risk Reduction Plan	Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles Risk Reduction Plan
DTSC	Department of Toxic Substances Control
g/bhp-hr	Grams per brake horsepower-hour
GVWR	Gross vehicle weight rating
HC	Hydrocarbon
H&SC	Health and Safety Code
Low sulfur diesel fuel	Diesel fuel with less than 15 ppmw sulfur content
$\mu g/m^3$	Microgram per cubic meter
MY	Model year
Moyer Program	Carl Moyer Memorial Air Quality Standards Attainment Program
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NOV	Notice of violation
NYGTC	New York garbage truck cycle
OEHHA	Office of Environmental Health Hazard Assessment
O & M	Operation and maintenance
PM	Particulate matter
ppmw	Parts per million by weight
SWCV, or collection vehicle	Solid waste collection vehicle
SCAQMD	South Coast Air Quality Management District
SJVAPCD	San Joaquin Air Pollution Control District
TAC	Toxic air contaminant
tpd	Tons per day
U. S. EPA	United States Environmental Protection Agency
VIN	Vehicle identification number
VOC	Volatile organic carbon

EXECUTIVE SUMMARY

The Air Resources Board, in addition to maintaining long-standing efforts to reduce emissions of ozone precursors, is now challenged to reduce emissions of diesel particulate matter. In 1998, the Air Resources Board identified diesel particulate matter as a toxic air contaminant. Because of the amount of emissions to California's air and its potency, diesel particulate matter is by far the number one contributor to the adverse health impacts of toxic air contaminants.

To address this health concern, the Air Resources Board adopted the "Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles" in October 2000. The projected emission benefits associated with the full implementation of this plan, including proposed federal measures, are reductions in diesel particulate matter emissions and associated cancer risks of 75 percent by 2010 and 85 percent by 2020. To achieve these goals, the Air Resources Board directed staff to develop specific control measures designed to reduce diesel particulate matter emissions. The objective of each regulation is to reduce diesel particulate matter to the greatest extent possible through technologically feasible measures.

This report describes the proposed "Diesel Particulate Matter Control Measure for On-Road Heavy-Duty Residential and Commercial Solid Waste Collection Vehicle Diesel Engines." The control measure is directed toward the reduction of diesel particulate matter emissions from 1960 to 2006 model years diesel-fueled engines in residential and commercial solid waste collection vehicles. The owners of these collection vehicles must use best available control technology for their engines, which is defined as either an engine alone or in conjunction with a verified diesel emission control strategy that meets a 0.01 gram per brake horsepower-hour particulate matter standard; an alternative-fuel engine or heavy-duty pilot-ignition engine; or application of an Air Resources Board-verified diesel emission control strategy to the engine, which reduces diesel particulate matter emissions by the greatest amount possible for that engine and application. The requirement to install best available control technology will be phased-in between December 31, 2004 and December 31, 2010, by engine model year group.

Municipalities contract, license, and permit many of the solid waste collection vehicle owners covered by this regulation in California. The rates that can be charged by solid waste collection vehicle owners for solid waste collection are regulated in some form by these municipalities. The proposed regulation requires municipalities to bear joint responsibility with vehicle owners for compliance and enforcement of the application of best available control technology to vehicles that operate under contract, license, or permit for solid waste collection. Municipalities also have reporting responsibilities.

In the development of this control measure, staff relied on public involvement and dialogue through public workshops and meetings with groups and individuals.

This measure will reduce diesel particulate matter emissions by 1.03 to 1.15 tons per day (tpd) of particulate matter in 2010. This translates to as high as 81 percent reduction expected in 2010 and up to 85 percent reduction in 2015 of diesel particulate matter from the solid waste collection vehicle fleet. The best available control technologies associated with the proposed regulation are expected to reduce other pollutant emissions, including ozone precursors, as well. Between 3.45 and 3.69 tpd of hydrocarbons, 8.86 and 9.44 tpd of carbon monoxide and 13.0 and 18.08 tpd of oxides of nitrogen may be reduced as a result of this regulation in 2010. Furthermore, cancer risk as a result of exposure to diesel particulate matter will be reduced by a factor of ten from a high of about 31 cancer cases per million to about three in a million in the highest exposure areas.

The costs associated with carrying out this proposed control measure will be on the order of the costs associated with other major Air Resources Board programs to reduce air toxic emissions. The approximate cost effectiveness is $28 per pound of particulate matter reduced, if all of the costs of compliance are allocated to diesel particulate matter reduction. Since this rule will also result in significant reductions in hydrocarbons and oxides of nitrogen emissions, staff allocated half of the costs of compliance against these benefits, resulting in cost-effectiveness values of $13 per pound of diesel particulate matter and $ 0.71 per pound of hydrocarbon plus oxides of nitrogen reduced. Since the proposed regulation impacts solid waste collection vehicles, costs are expected to be passed on to the solid waste collection customers. The cost per household would be about $5.90 per household in total or $0.85 per household annually from 2004 to 2010.

The proposed control measure, as described herein, is consistent with the risk management phase of the "Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles." The Air Resources Board staff, therefore, recommends that the Board adopt new sections 2020, 2021.1 and 2021.2, title 13, California Code of Regulations (CCR), set forth in the proposed Regulation Order in Appendix A.

I. INTRODUCTION

The Air Resources Board (ARB, or "the Board"), in addition to maintaining long-standing efforts to reduce emissions of ozone precursors, is now challenged to reduce emissions of diesel particulate matter (PM). In 1998, the ARB identified diesel PM as a toxic air contaminant (TAC). Because of the amount of emissions in California's air, and the magnitude of the cancer potency, diesel PM is by far the number one contributor to the adverse health impacts of toxic air contaminants.

The public's exposure to TACs is a significant public health issue in California. In 1983, the California Legislature adopted Assembly Bill (AB) 1807 to enact a program to identify the health effects of TACs and reduce exposure to these contaminants in order to protect public health (Health and Safety Code (H&SC) sections 39650 - 39674). The Legislature established a two-step process to address the potential health effects from TACs. The first step is the risk assessment or identification phase while the second is the risk management or emission reduction phase.

A. Overview and Purpose

After ten years of extensive research and public outreach, the Board identified diesel PM as a TAC in August 1998 (CalEPA 1998). As part of the identification process, the Office of Environmental Health Hazard Assessment (OEHHA) evaluated the potential for diesel exhaust to affect human health. OEHHA found exposure to diesel PM exhaust resulted in an increased risk of cancer and an increase in chronic non-cancer health effects, including a greater incidence of coughing, labored breathing, chest tightness, wheezing, and bronchitis (OEHHA 1998).

Following the identification process, the next step mandated by law is the risk management, or emission reduction phase of the process. ARB staff spent two years working with stakeholders in determining the best control measures for diesel PM. The result was the "Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles" (Diesel Risk Reduction Plan, or DRRP), which was approved by the Board in September 2000. This plan directs staff to develop measures to reduce diesel PM emissions from all diesel-fueled engines and vehicles by developing "new retrofit requirements for existing on-road, off-road, and stationary diesel-fueled engines and vehicles where determined technically feasible and cost-effective."

The proposed diesel PM control measure herein represents the second regulation in a series to implement the Diesel Risk Reduction Plan. It is an important step toward achieving the goal of reducing diesel PM emissions to at or near zero by the year 2020. This rule will be followed by similar regulations to reduce diesel PM emissions from other sources, such as public fleets, emergency stand-by generators, trucks that transport fuel, transportation refrigeration units, and other on- and off-road vehicles. By 2005, ARB plans to have adopted diesel PM control measures for most mobile and stationary diesel engines, including off-road and portable equipment.

B. Regulatory Authority

The Federal Clean Air Act grants California the authority to control emissions from mobile sources. The California Clean Air Act (H&SC sections 39002, 43013, and 43018) establishes the ARB as the state agency that sets standards for mobile sources. Most important to this regulation, the California Legislature also granted ARB the authority to identify TACs and establish airborne toxic control measures (ATCMs) to reduce risk.

In controlling TACs, the Board is directed to address specific issues pursuant to the need for regulation (H&SC section 39665). These requirements were addressed in detail in the Diesel Risk Reduction Plan, including the extent of present and anticipated future emissions, the estimated levels of human exposure, and the risks associated with those levels. The DRRP (ARB 2000b) describes the physical and chemical characteristics of diesel PM and the contribution to emissions by present sources, as well as the costs, availability, technological feasibility of control measures, and the potential adverse health or environmental impacts. Each of these issues is considered in the development of diesel PM regulations and will be discussed in this report specifically as each relates to this control measure.

C. Current Regulations and Voluntary Programs

Both the Federal government and the State of California have adopted rules that reduce diesel PM from on-and off-road vehicles. The following sections briefly describe the existing federal, state, local and voluntary programs that currently apply to diesel-fueled engines and vehicles operating in California.

1. Federal Regulations

Standards for smoke emissions from on-road heavy-duty diesel vehicles were set by the United States Environmental Protection Agency (U.S. EPA) in 1970. New engines were subject to PM exhaust emission standards with model year (MY) 1988. Over the years, more stringent emission standards have paralleled improvements in control technology. Recent amendments to the on-road standards regulate the heavy-duty vehicle and its fuel as a single system, including diesel-fuel sulfur-content requirements. The particulate standard for new heavy-duty diesel engines is 0.01 grams per brake-horsepower hour (g/bhp-hr), which is a 90 percent reduction from the existing standard, and will take effect with MY 2007. That standard is based on the use of high-efficiency exhaust emission control devices or comparably effective advanced technologies. Because these devices are less efficient when used with the current formulation of diesel fuel, reducing the level of sulfur in highway diesel fuel by 97 percent to 15 parts per million by weight (ppmw) by mid-2006 is also required.

Whereas the current PM engine emission standard for on-road heavy-duty diesel trucks is 0.1 g/bhp-hr, the current federal PM emission standard for new urban transit bus engines is 0.05 g/bhp-hr. On April 23, 1993, the U.S. EPA finalized the Urban Bus Retrofit/Rebuild Program to reduce the ambient levels of diesel PM in urban areas. The program is limited to 1993 and earlier model year urban buses operating in metropolitan areas with 1980 populations of 750,000 or more, whose engines are rebuilt or replaced after January 1, 1995. Approximately 40 urban areas are affected. Operators of the affected buses are required to choose between two compliance options: Program 1 sets PM emissions requirements for each urban bus engine in an operator's fleet which is rebuilt or replaced; Program 2 is a fleet averaging program that establishes specific annual target levels for average PM emissions from urban buses in an operator's fleet.

Other than the Urban Bus Retrofit/Rebuild Program, no other federal regulations exist mandating reducing emissions from in-use heavy-duty engines.

2. California Regulations

California is the only state granted the authority in the Federal Clean Air Act to set standards for mobile engines. While its passenger car standards are more stringent than federal standards, in the area of new heavy-duty diesel engines California has generally harmonized with federal rules. However, California has also adopted regulations to ensure compliance with smoke standards. California's Heavy Duty Vehicle Inspection and Periodic Smoke Inspection Programs reduce excessive smoke emissions and tampering with diesel-fueled vehicles over 6,000 pounds gross vehicle weight rating (GVWR) and apply to all trucks traveling within California. The regulations impose limits on the opacity of smoke from diesel engines when measured in accordance with a snap-acceleration test procedure, and have been in effect since 1991, with amendments adopted in 1997.

Another source for which California has adopted more stringent regulations than the U.S. EPA is urban transit buses. The Fleet Rule for Transit Agencies, adopted in February 2000 and amended in October 2002, is designed to achieve significant reductions in diesel PM and oxides of nitrogen (NOx) emissions from 2001 to 2015 through the implementation of a fleet rule and increasingly stringent engine standards. Emission reductions are achieved as transit agencies purchase new lower-emission buses or repower older, higher-emitting buses to lower-emitting configurations. Reductions in diesel PM are also mandated beginning January 1, 2004, and the use of diesel fuel with less than 15 ppmw sulfur content (low sulfur diesel fuel) is required, beginning July 1, 2002. For new engines, long-term emission reductions are achieved through establishing increasingly more stringent new engine standards. The particulate standard for new engines sold in California is 0.01 g/bhp-hr for engines produced as of October 1, 2002. Over time, ultra-low, near-zero, and zero emissions buses will replace older higher emitting engines.

3. Local Regulations

The South Coast Air Quality Management District Rule 1193, "Clean On-Road Residential and Commercial Refuse Collection Vehicles," was adopted June 16, 2000 (SCAQMD 2000). This rule dictates that solid waste collection fleets operating in the SCAQMD may only purchase alternative-fuel vehicles, and applies to government agencies and private companies with fleets of 15 or more. Compliance deadlines are July 1, 2001, for fleet operators of 50 or more collection vehicles; and July 1, 2002, for fleet operators of 15 or more collection vehicles. Prior to July 1, 2003, operators may purchase dual-fuel vehicles in lieu of dedicated alternative-fuel vehicles. Amendments proposed in April 2003 would extend the date allowing purchase of dual-fuel vehicles to July 1, 2004.

4. Voluntary and Incentive Programs

Voluntary efforts play a key role in helping to achieve air quality goals. Incentives or early implementation credits can induce vehicle owners to reduce vehicle emissions prior to compliance deadlines or in excess of regulatory requirements.

The California Legislature established the Carl Moyer Memorial Air Quality Standards Attainment Program (Moyer Program) in 1998 to reduce NOx emissions from existing vehicles. The Moyer Program funds the incremental cost of repower, retrofit, or purchase of new, cleaner engines that meet a specified cost-effectiveness level for NOx reduction. In addition, the Moyer Program has a statewide 25 percent PM emission reduction target and a 25 percent PM emission reduction requirement for districts in serious nonattainment for federal PM_{10} standards. Total Moyer Program funding since fiscal year 1998/1999 has been approximately $114 million.

In 2000, the Legislature approved new funds to reduce emissions from school buses. The ARB, in coordination with the California Energy Commission and the local air pollution control districts, established guidelines for the Lower-Emissions School Bus program. The goal of this incentive program is to reduce the exposure of school children to both cancer-causing and smog-forming compounds. This program utilizes two strategies to attain these goals: pre-1987 model year school bus replacement and in-use controls for later model year diesel-fueled school buses. Over fiscal years 2000/2001 and 2001/2002, program funding was $66 million total.

Voters approved Proposition 40, the California Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act of 2000, which granted additional funding to reduce diesel emissions. The measure provides about $50 million over two years to ARB, 20 percent of which is to be spent for the acquisition of "clean, safe, school buses for use in California's public schools." The remainder is allocated to the Moyer Program.

On the federal level, the U.S. EPA established a Voluntary Diesel Retrofit Program in 2000 to address pollution from diesel construction equipment and heavy-duty on-highway vehicles. This program allows fleet operators to choose appropriate, U.S. EPA-verified technologies that will reduce the emissions of the vehicles and engines in their fleets and identify potential funding sources to assist air quality planners and fleet operators as they create and implement retrofit programs. The program assists air quality planners in determining the number of State Implementation Plan credits produced by their retrofit projects. The U.S. EPA has also established a program to fund school bus retrofits and replacements from penalty revenues.

II. PUBLIC OUTREACH

The ARB is committed to ensuring that all California communities have clean, healthful air by addressing not only the regional smog that hangs over our cities but also the nearby toxic pollution that is generated within our communities. The ARB works to ensure that all individuals in California, especially the children and elderly, can live, work and play in a healthful environment that is free from harmful exposure to air pollution.

A. Environmental Justice

The ARB is committed to integrating environmental justice in all its activities. On December 13, 2001 (ARB 2001d), the Board approved Environmental Justice Policies and Actions,[1] which formally established a framework for incorporating environmental justice into the ARB's programs, consistent with the directives of State law. Environmental justice is defined as the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies. These policies apply to all communities in California, but recognize that environmental justice issues have been raised more in the context of low-income and minority communities.

To achieve this ambitious goal, the ARB has established a Community Health Program and placed new emphasis on community health issues in our existing programs. The Neighborhood Assessment Program is a key component in the Community Health Program. The Neighborhood Assessment Program Work

[1] Complete information for these programs can be found at http://www.arb.ca.gov/ch/ej.htm.

Plan presents a plan that the ARB staff proposes to use to develop guidelines for evaluating and reducing air pollution impacts at the neighborhood-scale (ARB 2000a).

The Environmental Justice Policies are intended to promote the fair treatment of all Californians and cover the full spectrum of ARB activities. Underlying these Policies is a recognition that we need to engage community members in a meaningful way as we carry out our activities. People should have the best possible information about the air they breathe and what is being done to reduce unhealthful air pollution in their communities. The ARB recognizes its obligation to work closely with all stakeholders; communities, environmental and public health organizations, industry, business owners, other agencies, and all other interested parties to successfully implement these Policies.

This control measure is in direct response to the environmental justice policy to reduce health risks from toxic air pollutants in all communities, especially low-income and minority communities. This control measure, when adopted, will provide immediate air-quality benefits by reducing diesel PM emissions from collection vehicles, which operate in neighborhoods. The actions we have taken in applying these policies in our rulemaking reflect the Board's commitment to the fair treatment of all people throughout California.

In addressing the environmental justice policy to support research and data collection needed to reduce cumulative emissions and health risks in all communities, ARB has initiated various studies to better understand issues such as the physical and chemical characteristics of diesel PM and demonstrations of emission control technologies. Staff has conducted a focused risk assessment to characterize near-source dispersion patterns of diesel PM as they relate to collection vehicles. The results of this study are discussed in Section III.F.

B. Outreach Efforts

As part of the environmental justice policy to strengthen our outreach and education efforts in all communities, staff conducted extensive workshops and meetings in the development of this rule from December 2000 through May 2003. The meetings were held at times and locations that encouraged public participation, including late afternoon and evening sessions. Attendees included representatives from environmental organizations, waste management companies and service providers, associations, and other parties interested in residential waste removal (Appendix B). These individuals participated both by providing data and reviewing draft regulations and by participating in open forum workshops, in which staff directly addressed their concerns.

Staff met with a number of stakeholders' groups throughout the rulemaking process. Representatives of the California Refuse Removal Council (CRRC) assisted us in gathering data from their members and also provided input in developing our data survey forms. These initial meetings led to the formation of an industry workgroup. This workgroup met six times over the course of a year, during which staff worked closely with a group of collection vehicle fleet owners, their CRRC representatives, and representatives of non-CRRC member companies to review preliminary draft regulations thoroughly and work together to resolve outstanding issues. Alternatives were suggested to the proposed regulation and explored by staff.

The staff held two meetings with municipalities that contract for solid waste collection or provide direct waste removal service, in addition to individual contacts. These meetings were influential in helping determine specific feasibility and implementation of the financial and enforcement sections of the proposed regulation. Staff also met with the Californians for a Sound Fuel Strategy, a coalition led by the California Chamber of Commerce, to discuss specific issues.

Staff also conducted outreach through telephone calls and site visits with approximately 65 collection vehicle owners during the data collection phase of feasibility studies to determine the engine exhaust temperatures and fleet maintenance. A wide demographic of fleet types was covered by this outreach, including both public and private fleets, and small and large fleets.

In 2001 and 2002, ARB held ten workshops in preparing this rule, with both afternoon and evening sessions, in four different locations to accommodate as many people as possible (**Table 1**). Over 2,500 individuals and/or companies were notified through a series of mailings and a large number of people participated (Appendix B). In addition, notices were posted to the diesel risk reduction and collection vehicle rule web sites and e-mailed to subscribers of ARB's electronic list server.

Table 1. Workshop Locations and Times.

Date	Location	Time
June 26, 2001	Sacramento	2:30 – 4:30 PM
June 26, 2001	Sacramento	6:30 – 8:30 PM
June 28, 2001	El Monte	2:30 – 4:30 PM
June 28, 2001	El Monte	6:30 – 8:30 PM
September 4, 2001	Sacramento	1:30 – 3:30 PM
September 5, 2001	Los Angeles	1:30 – 3:30 PM
February 26, 2002	Oakland	2:00 – 4:00 PM
February 28, 2002	El Monte	4:00 – 6:00 PM
December 9, 2002	Sacramento	2:00 – 5:00 PM
December 10, 2002	El Monte	2:00 – 5:00 PM

To generate additional public participation and to enhance the information flow between ARB and interested persons, staff made all documents, including workshop presentations, available via the ARB's Internet web sites on diesel risk reduction and the collection vehicle rule.[2] The web sites provide background information on diesel PM, including fact sheets, workshop dates and locations, and other diesel related information and serves as a portal to other web sites with related information.

Staff will continue outreach and education efforts following the adoption of the regulation to both municipalities and collection vehicle owners. Outreach plans include development of a guidance document to describe compliance mechanisms and technologies; training classes targeting mechanics and maintenance personnel; and an enhanced web site. Staff will also develop optional reporting forms for use by municipalities.

III. NEED FOR REDUCTION OF DIESEL PARTICULATE MATTER EMISSIONS

Diesel PM is a complex mixture that consists of dry solid fragments, solid cores with liquid coatings and small droplets of liquid. These tiny particles vary greatly in shape, size and chemical composition and can be divided into several size fractions. Coarse particles are between 2.5 and ten microns in diameter, and arise primarily from natural processes, such as wind-blown dust or soil. Fine particles are less than 2.5 microns in diameter and are produced mostly from combustion, or burning activities and are termed $PM_{2.5}$. Particles with an aerodynamic diameter less than or equal to a nominal ten microns (about 1/7 the diameter of a single human hair) are termed PM_{10}; PM_{10} is a criteria air pollutant for which federal and state ambient air quality standards have been set. Diesel PM is a subset of PM_{10}.

A. Ambient Air Quality Standards for Particulate Matter

Both the California and the U.S. EPA have established standards for the amount of PM_{10} in the ambient air. These standards define the maximum amount of particles that can be present in outdoor air without threatening the public's health and welfare. California's current PM_{10} standard is more protective of human health than the corresponding national standard. Standards for $PM_{2.5}$ have also been established to further protect public health (**Table 2**).

[2] Located at http://www.arb.ca.gov/diesel/dieselrrp.htm and http://www.arb.ca.gov/msprog/SWCV/SWCV.htm.

Table 2. State and National Particulate Matter Standards.

California Standard		National Standard	
		PM_{10}	
Annual Arithmetic Mean	20 μg/m^3	Annual Arithmetic Mean	50 μg/m^3
24 Hour Average	50 μg/m^3	24 Hour Average	150 μg/m^3
		$PM_{2.5}$	
Annual Arithmetic Mean	12 μg/m^3	Annual Arithmetic Mean	15 μg/m^3
24 Hour Average	No separate State standard	24 Hour Average	65 μg/m^3

When the ARB sets California's ambient air quality standards, it designs them to protect the most sensitive subpopulations, whether that is children, the elderly, or people with pre-existing disease, such as cardiac patients or asthmatics.

B. Identification of Diesel Particulate Matter as a Toxic Air Contaminant

After ten years of extensive research and public outreach, ARB identified diesel PM as a TAC in August 1998 (CalEPA 1998). As part of the identification process, OEHHA evaluated the potential for diesel exhaust to affect human health. OEHHA found that exposures to diesel PM resulted in an increased risk of cancer and an increase in chronic non-cancer health effects, including a greater incidence of cough, labored breathing, chest tightness, wheezing, and bronchitis (OEHHA 1998). OEHHA estimated, based on available studies, that the potential cancer risk for exposure to diesel PM in concentrations of one microgram per cubic meter (μg/m^3) ranged from 130 to 2400 excess cancers per million. The ARB's Scientific Review Panel approved OEHHA's determinations concerning health effects and approved the range of risk for PM from diesel-fueled engines, concluding that a value of 300 excess cancers per million people, per μg/m^3 of diesel PM, was appropriate as a point estimate of unit risk for diesel PM.

OEHHA also concluded that exposure to diesel PM in concentrations exceeding five μg/m^3 can result in a number of long-term chronic health effects. The five μg/m^3 value is referred to as the chronic reference exposure value for diesel PM. The SRP supported OEHHA's conclusion and noted that the reference exposure value may need to be lowered further as more data emerge on potential adverse chronic effects of diesel PM.

C. Physical and Chemical Characteristics of Diesel Particulate Matter

Diesel PM is the non-gaseous portion of the exhaust from a diesel-fueled compression ignition engine. PM emissions result from incomplete combustion of fuel in the cylinder and lubrication oil that has entered the cylinder incidentally.

Diesel PM consists of several constituents, including an elemental carbon fraction, a soluble organic fraction, and a sulfate fraction. The majority of diesel PM, approximately 98 percent, is smaller than ten microns in diameter. Diesel PM is a mixture of materials containing over 450 different components, including vapors and fine particles coated with organic substances. Over 40 chemicals in diesel exhaust are considered TACs by the State of California (**Table 3**).

Table 3. Substances in Diesel Exhaust Listed by California as Toxic Air Contaminants.

Acetaldehyde	Manganese compounds
Acrolein	Mercury compounds
Aniline	Methanol
Antimony compounds	Methyl Ethyl Ketone
Arsenic	Naphthalene
Benzene	Nickel
Beryllium compounds	4-Nitrobiphenyl
Biphenyl	Phenol
Bis[2-ethylhexyl]phthalate	Phosphorus
1,3-Butadiene	Polycyclic organic matter, including polycyclic aromatic hydrocarbons (PAHs) and their derivatives
Cadmium	
Chlorine	
Chlorobenzene	
Chromium compounds	
Cobalt compounds	Propionaldehyde
Creosol isomers	Selenium compounds
Cyanide compounds	Styrene
Dibutylphthalate	Toluene
Dioxins and dibenzofurans	Xylene isomers and mixtures
Ethyl benzene	o-Xylenes
Formaldehyde	m-Xylenes
Inorganic lead	p-Xylenes

Note: California H&SC section 39655 defines a TAC as "an air pollutant which may cause or contribute to an increase in mortality or in serious illness, or which may pose a present or potential hazard to human health."

D. Sources and Ambient Concentrations Of Diesel Particulate Matter

PM emissions from diesel-fueled vehicles and engines totaled about 28,000 tons per year in California as of 2000 (ARB 2000b). These emissions come from a wide variety of sources including over one million on-road and off-road vehicles, about 16,000 stationary engines, and close to 50,000 portable engines. On-road engines account for about 27 percent of the emissions, off-road engines and portable engines about 71 percent, and the remaining two percent from stationary engines. With full implementation of the current vehicle standards and vehicle turnover, but not considering this control measure, diesel PM emissions will still total about 22,000 tons per year in 2010 and about 19,000 tons per year in 2020.

In the year 2000, outdoor diesel PM concentrations were 1.8 μg/m^3 and projected to be 1.5 μg/m^3 in 2010 after accounting for current regulations. After including indoor concentrations of diesel PM, total exposure was 1.26 μg/m^3 in 2000 and projected to be 1.05 μg/m^3 in 2010 (**Table 4**).

Table 4. Estimated Exposure of Californians to Diesel Particulate Matter for 2000, 2010 and 2020 (ARB 2000b).

Exposure Location	Estimated Average Air Exposure Concentration – 1990 (μg/m^3)	Estimated Average Air Exposure Concentration (μg/m^3) and Potential Risk (excess cancers/million)					
		2000		2010		2020	
		Conc.	Risk	Conc.	Risk	Conc.	Risk
Outdoor Ambient	3.0	1.8	540	1.5	450	1.2	360
Indoor	2.0	1.2	360	1.0	300	0.8	240
Total	2.1	1.26	380	1.05	315	0.84	252

E. Health Effects of Diesel Particulate Matter

Diesel PM has been linked to a wide range of serious health problems. Particles that are deposited deep in the lungs can result in lung cancer, increased hospital admissions; increased respiratory symptoms and disease; decreased lung function, particularly in children and individuals with asthma; alterations in lung tissue and respiratory tract defense mechanisms; and premature death. Increased PM exposure causes increased cardiopulmonary mortality risk as demonstrated in a validity and causality analysis of 57 epidemiological studies. (Dab et al. 2001). Significant positive associations exist between lung cancer incidence and the number of days per year that respirable particulates (PM_{10}) exceeded several thresholds (Beeson et al. 1998).

Long-term ambient concentrations of PM_{10} are associated with increased risks of all natural cause mortality in males, mortality with any mention of nonmalignant respiratory causes in both sexes, and lung cancer mortality in males (Abbey 2000; McDonnell *et al.* 2000). Initial findings indicate a clear correlation between lower lung function and more intense air pollution and high levels of nitrogen dioxide (NO_2), PM_{10}, $PM_{2.5}$, and acid vapor appear to be associated with slower lung growth (Peters 1991).

F. Risk Assessment

This section presents a brief summary of the potential cancer health risk associated with exposures to diesel PM emissions from all diesel-fueled engines in California. We also examine the potential cancer health risks associated with exposure to solid waste collection activities and the reduction in risk that will occur upon implementation of the proposed control measure.

1. Statewide Risk Reduction Goal of Diesel Risk Reduction Plan

Diesel PM is emitted from a variety of sources, including on- and off-road diesel-fueled vehicles and stationary engines. On a statewide basis, the average potential cancer risk associated with diesel PM emissions is 540 potential cases per million statewide, with the potential risk in the South Coast Air Basin estimated to be 1,000 per million people. Compared to other air toxics the Board has identified and controlled, diesel PM emissions are estimated to be responsible for about 70 percent of the total ambient air toxics risk. In addition to these general risks, diesel PM can also present elevated localized or near-source exposures. Depending on the activity and nearness to receptors, these potential risks can range from small to 1,500 per million or more.

The goal of the Diesel Risk Reduction Plan is to reduce diesel PM emissions and the associated cancer risk by 75 percent in 2010 and 85 percent in 2020 (**Figure 1**). This regulation is one of a group of regulations being developed to achieve the emission reduction goals of the Diesel Risk Reduction Plan of protecting the health of Californians by reducing the cancer risk from diesel PM and complying with legal requirements to control a TAC. Other benefits associated with reducing diesel PM emissions include increased visibility, less material damage from soiling of surfaces, and reduced incidence of non-cancer health effects, such as bronchitis, asthma, and allergy.

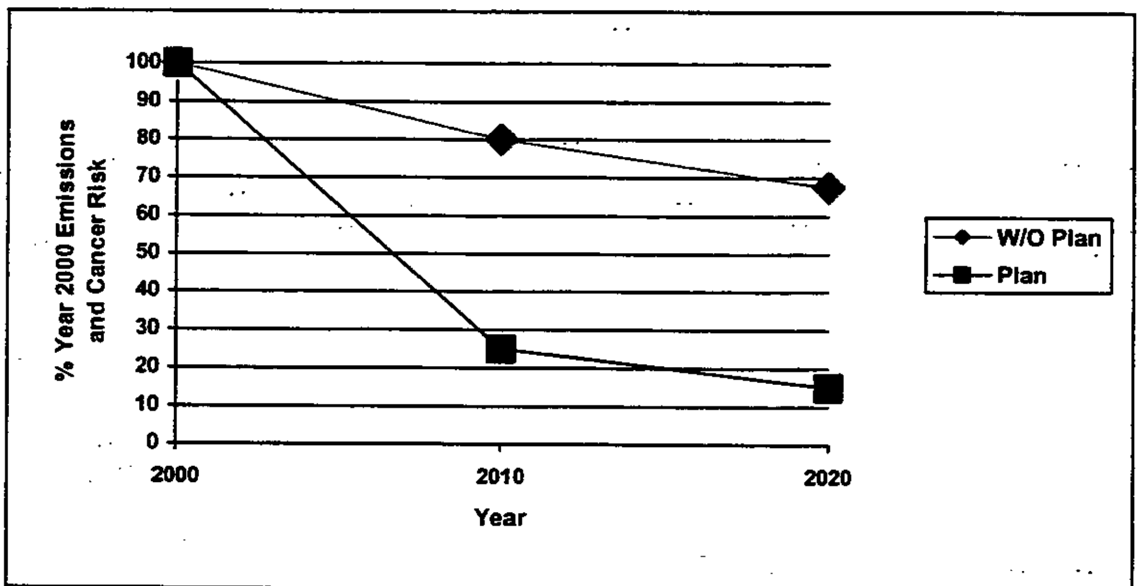

Figure 1. Statewide Reduction in Diesel PM Emissions and Risk to Californians With and Without the Diesel Risk Reduction Plan.

2. Collection Vehicle Health Risk Assessment

To examine the potential cancer health risks associated with exposure to PM emissions from collection vehicle activities, ARB staff identified several operating scenarios representing typical collection vehicle activities and determined the potential risk associated with these hypothetical scenarios. The detailed methodology used to estimate the potential cancer health risks is presented in Appendix D of this report. Noncancer chronic and acute health effects were not considered in this evaluation, although they are important. Cancer health impacts from inhalation exposure to diesel PM outweigh the noncancer multipathway health impacts to the speciated components of diesel PM.

Risk assessment is a complex process that requires the analysis of many variables to simulate real-world situations. Three key types of variables can impact the results of a health risk assessment for collection vehicle activities – the magnitude of the diesel PM emissions, the meteorological conditions, and the length of time someone is exposed to the emissions. The quantity of diesel PM emissions is a function of the age of the collection vehicle, how many collection vehicles are in a given area, and the operating schedules of these vehicles. Older vehicles tend to have greater emissions than newer vehicles and the more frequently a vehicle accesses a neighborhood, the greater the emissions in a neighborhood. Meteorological conditions can have a large impact on the resultant ambient concentration of diesel PM with higher concentrations found along the predominant wind direction and under calm wind conditions. A person's proximity to the emission plume and how long he or she breathes the emissions (exposure duration) are key factors in determining potential risk. The longer the exposure time, the greater the potential risk.

In order to examine the range of potential cancer health risks associated with exposure to diesel PM emissions from collection vehicle activities and the reduction in risk due to the implementation of this control measure, ARB staff evaluated three hypothetical exposure scenarios. In the first scenario, staff examined the potential cancer risk in a residential neighborhood due to solid waste collection. In the second scenario, staff determined the potential cancer risk in a mixed commercial/residential neighborhood with more frequent solid waste collection than in the first scenario. In the third scenario, staff calculated the potential cancer risk to residents living along a roadway leading to a solid waste disposal site.

The analyses were performed using the U.S. EPA's CAL3QHCR dispersion model to estimate the annual average diesel PM concentrations. Fleet weighted emission factors were developed based on EMFAC2000 emission factors and the New York Garbage Truck Cycle (NYGTC) testing conducted by West Virginia University. Meteorological data from Anaheim was selected to provide meteorological conditions representative of an urban area. The estimated annual average diesel PM concentrations were then adjusted to take into consideration how long a person might breathe these emissions. Consistent with the current risk assessment methodology recommended by the OEHHA and used by ARB in evaluating potential cancer risk from diesel PM emission sources, ARB staff assumed nearby residents would be exposed to the modeled diesel PM concentrations for 70 years. This exposure duration represented an "upper-bound" of the possible exposure duration. The potential cancer risk was estimated by multiplying the modeled annual average concentration of diesel PM by the unit risk factor for diesel PM (300 excess cancers per million people per $\mu g/m^3$ of diesel PM).

Based on this evaluation, we found the estimated risk from collection vehicles operating in a residential or mixed used area varies depending on the age and number of collection vehicles operating in the neighborhood on a weekly basis. As expected, the maximum risk and the highest average risk would occur in neighborhoods serviced by older trucks and multiple trucks servicing the area (i.e., separate collection for trash and recyclables). In most cases, however, the potential cancer health risk in a neighborhood was less than ten potential cancer cases in a million. The potential cancer risk was greater along the road leading to a landfill due to the high frequency of vehicle trips. For this scenario the potential cancer health risk varied with the volume of vehicle traffic and the distance from the road. At 50 meters, the risk ranged from six to 18 potential cancer cases in a million.

Reducing diesel PM emission from the collection vehicles will result in a reduction of the potential cancer health risks. Based on the risk scenarios, staff concluded the reductions in diesel PM emissions that will result from implementation of the collection vehicle control measure will result in a reduction in the associated potential cancer risk. Our analyses show an 85 percent reduction in diesel PM emissions will reduce the potential health risk levels in most cases to less than one potential cancer case in a million.

These estimated risk levels provide a quantitative assessment of the potential risk levels in hypothetical neighborhoods. As mentioned previously, actual risk levels from collection vehicles at any individual site will vary with site specific parameters, including engine technologies, diesel emission control strategies (DECS), emission rates, fuel properties, operating schedules, meteorology, and the actual location of off-site receptors. In addition, although the overall magnitude of the diesel PM emissions and risk reductions from the collection vehicle control measure may appear modest, reducing these emissions are necessary if we are to achieve the ultimate goals outlined in the Diesel Risk Reduction Plan and to fulfill the requirements of H&SC section 39666. As described in the DRRP (ARB 2000b), it is necessary to reduce diesel PM emissions from essentially all diesel-fueled engines if we are to be successful in reducing the significant public health risk associated with diesel PM. Also, because diesel PM is a non-threshold carcinogen, California is required, under

H&SC section 39666, to reduce emissions to the lowest level achievable through the application of best available control technology (BACT).

IV. ENGINE AND EMISSION INVENTORY

An improved engine and emission inventory was developed for this rule proposal, including a new survey of collection vehicles in California (Appendix E of this document and Technical Support Document, Appendix C). California's emission inventory includes data on a vehicle level. Engine data are critical, however, to the understanding of how many vehicles will be able to apply what types of BACT. Thus, staff undertook a detailed survey to determine the engine make, model, model year, and vehicle type of the collection vehicles in California.

A. Engine Inventory

ARB has estimated the 2000 population of collection vehicles covered by this proposal to be approximately 11,800. The 2010 population is projected to be about 13,100 collection vehicles. ARB staff gathered engine and fleet data for approximately 70 percent of the California collection vehicles. Staff extrapolated these data to obtain a picture of the entire fleet of California collection vehicles (**Table 5**). Details regarding the methodology and results are presented in Appendix C of the Technical Support Document and the analysis and implications of the data for the use of BACT are discussed in the Technical Support Document.

Table 5. California's Collection Vehicles by Type and Model Year Group.

Engine Model Year Group	Collection Vehicle Type				Total By Engine MY Group
	Front Loaders	Rear Loaders	Roll Offs	Side Loaders	
1960-1987	5%	8%	3%	2%	18%
1988-1990	6%	9%	2%	4%	21%
1991-1993	5%	4%	1%	7%	17%
1994-2002	10%	6%	3%	25%	44%
Total by Vehicle Type	26%	27%	9%	38%	100%

B. Emission Inventory

Substantial improvements have been made to the emissions inventory for California on-road in-use collection vehicles. Updated population and turn over (useful life) data, and emission rates have been incorporated into the revised inventory (Appendix E). In 2000, the population of collection vehicles was 11,778, according to an ARB analysis of Department of Motor Vehicles data. The population is expected to increase slowly during the implementation of this regulation due to population increase in the State and a corresponding slow increase in solid waste collection needs to over 13,100 collection vehicles. Fleet turnover (the time a vehicle is retired from service) is expected to remain relatively slow.

Three possible implementation scenarios were used for the emissions benefits calculations (**Table 6**). The first is based on the implementation of currently verified in-use DECSs (Current). The second and third scenarios are based on no Level 2 DECSs verified (Potential 1) and Level 2 DECSs verified for all model years (Potential 2). The scenarios, which are detailed in Tables 15 – 17, are discussed in greater depth in the Technical Support Document. In short, the Current scenario, based on current DECS verifications, assumes that 30 percent of SWCVs will use Level 1 technology, 12 percent will use Level 3 technology, and 58 percent will either be repowered or replaced with engines meeting the 0.01 gpbhp-hr PM standard. Scenario Potential 1 assumes a greater percentage of vehicles will use Level 1 technology, 47 percent; the same number will use Level 3 technology, 12 percent; and 41 percent will repower or replace. Finally, Potential 2 scenario assumes a high number of vehicles will use Level 2 technology, 43 percent; and only 4 percent will use Level 1 technology. As with Potential 1, 12 percent are assumed to use Level 3 technology and 41 percent are assumed to be repowered or replaced.. The option of converting to alternative-fuel or heavy-duty pilot ignition engines exists for all engines either through vehicle replacement or conversion of the engine. This option is included in the scenarios as repower or replace.

Table 6. Three Possible Scenarios for Diesel Particulate Matter Emission Reductions Based on Diesel Emission Control Strategy Verification.

Calendar Year	Baseline Inventory[a] (tpd)	PM Emissions Reduction		
		Current	Potential 1	Potential 2
2005	1.57	3%	6%	10%
2010	1.42	81%	72%	79%
2015	1.36	85%	71%	78%
2020	1.12	82%	67%	75%

[a] PM emissions without the proposed rulemaking.

Under these three scenarios, the diesel PM emissions from collection vehicles are expected to be reduced from a baseline inventory of 1.57 tons per day (tpd) in 2005 by between 72 and 81 percent in 2010 and between 67 and 82 percent in 2020 (**Table 6**). The greatest diesel PM emission reductions would be achieved under the Current scenario, because the Current scenario is weighted toward engine repowers. Fewer repowers are predicted in the Potential 1 and Potential 2 scenarios, which assume greater use of DECS that reduce diesel PM by less than 85 percent (Level 3). The Potential 2 scenario predicts greater PM reductions than Potential 1 because Potential 2 assumes that almost half of the

SWCVs will use Level 2 technologies, which reduce diesel PM more than Level 1 technologies.

Emissions of HC, CO, and NO_x are also predicted to be reduced as a result of this regulation as discussed in Section IX.

V. SUMMARY OF PROPOSED CONTROL MEASURE

A. Scope and Applicability

The core of this proposal is a requirement that owners of collection vehicles apply BACT to their vehicles to reduce diesel PM emissions. The proposed regulation imposes duties on collection vehicle owners (owners) and cities, counties, and governmental agencies that contract for solid waste collection services (municipalities). The proposed rule applies to a collection vehicle that has a manufacturer's GVWR greater than 14,000 pounds and a MY 1960 to 2006 engine. A collection vehicle that operates in residential and commercial-mixed use neighborhoods directly impacts public exposure in the home and office. Municipalities have the ultimate responsibility for solid waste collection, thus they are jointly responsible with collection vehicle owners for implementing this regulation.

B. Determining Compliance of a Municipality with this Control Measure

A little over half of California's collection vehicles are under contract to a municipality to provide residential and commercial solid waste collection service (**Figure 2**). The municipalities, therefore, are critical stakeholders in the success of this proposed regulation. Staff proposes that municipalities require compliance with this regulation as a stipulation of any contract, license, or permit the collection vehicle owner has with the municipality and that a collection vehicle owner must comply with this regulation in order to maintain any contracts, permits, or licenses to operate for a municipality. Municipalities have told staff that contracts already require compliance with applicable regulations, thus this requirement is not burdensome. Some municipalities, however, may need to amend existing contracts so that the cost of complying with these regulations can be incorporated into the rate base of a contract.

Staff additionally proposes that municipalities be required to track compliance with the regulation through collecting signed statements from their contractors annually, which should ensure that municipalities and collection vehicle owners work together to comply with the regulation. The municipality is also required to submit a description of the total cost and funding source that will be used to bring a contractor into compliance with its initial report to ARB by August 1, 2004. The initial report will be used to ensure that rate-regulated contractors and the municipalities are discussing funding for compliance. Following the initial report, municipalities are required to submit annual statements of compliance to ARB by

January 31st of each year – either by submitting one statement signed by the municipality certifying compliance by its contractors or by submitting copies of the certification statements it received from its contractors.

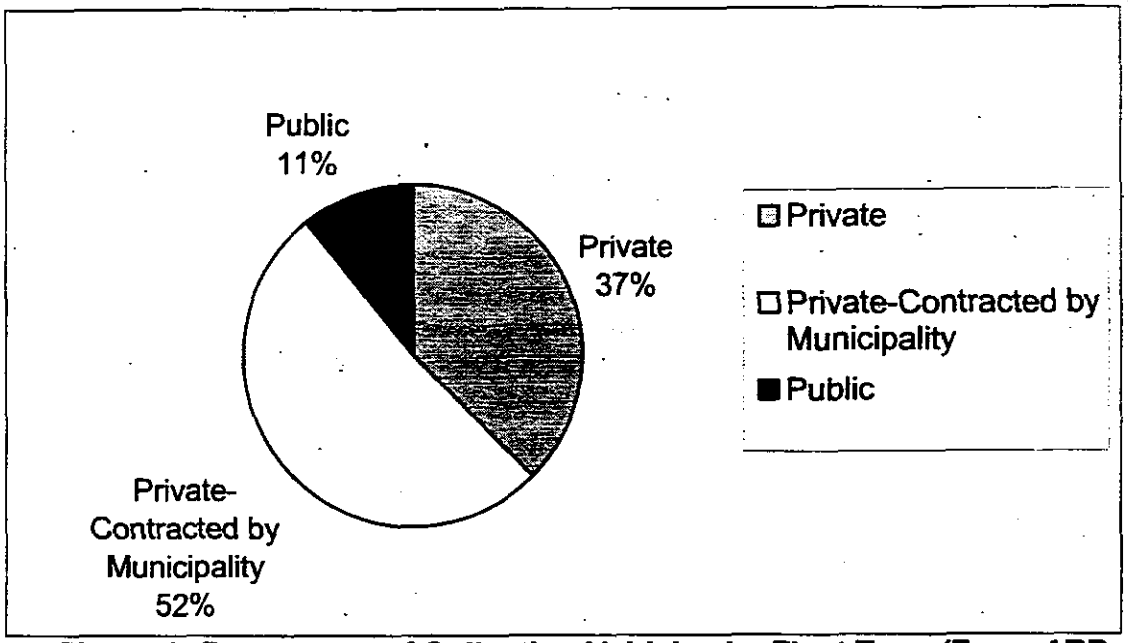

Figure 2. Percentage of Collection Vehicles by Fleet Type (From ARB Engine Survey).

When a municipality submits its annual report to ARB, staff will check to ensure all collection vehicle owners have stated they are in compliance with the regulation. If an owner has not submitted a signed compliance statement, ARB will investigate further. Staff may inspect the terminal and vehicles for compliance. If the owner is not in compliance, ARB may issue a notice of violation (NOV) or other document that requires the owner comply or face penalties. The contractor/owner is required to send the municipalities with whom they contract a copy of the non-compliance notification. ARB staff will also notify the municipality that one of its contractors is out of compliance with the regulation. ARB may also issue an NOV to the municipality for noncompliance by one of its contracted companies as non-compliance is a violation by both the vehicle owner and the municipality.

After January 31st of each year, if a municipality determines its contractor is out-of-compliance, the municipality must notify the Executive Officer of the determination within 30 days of discovery. Again, ARB will investigate and make a determination on issuance of an NOV. A municipality that knows its contractor is out of compliance and does not notify ARB within the required 30 days would be in violation of the proposed regulation.

The rule mandates all collection vehicle owners be in compliance by December 31, 2012, which includes any granted compliance extensions. Therefore, staff proposes municipalities submit their final reports on January 31, 2013. Following that date, municipalities are still required to notify ARB of non-compliance by contractors, and ARB will continue to notify municipalities of significant non-compliance by owners.

To assist with reporting, staff plans to develop an Internet-based automated reporting form, which would be offered to municipalities as a mechanism to streamline reporting. Municipalities may, of course, submit reports via the mail, fax, or electronic mail using any format containing all required information in section 2021.1 (b).

C. Best Available Control Technology Requirement

This rule proposes an owner be prohibited from operating a fleet of collection vehicles unless the owner complies with this diesel PM control measure as of the applicable implementation dates. Compliance with the proposed regulation is determined by choosing the BACT option for each collection vehicle over a phased-in implementation schedule, and keeping records at the maintenance facility and on-board the vehicle for inspection.

BACT refers to three main compliance options: (1) use of an engine certified either alone or in combination with a DECS to the 0.01 g/bhp-hr PM standard, (2) an alternative-fuel or heavy-duty pilot-ignition engine, or (3) a DECS that receives verification according to title 13, CCR, section 2702 for a specified engine, and which the DECS manufacturer or authorized dealer agrees can be used on a specified engine and vehicle combination. Owners are required to use the highest level DECS verified for their engine and application at the time of retrofit.

An owner who chooses to use an engine certified to the 0.01 g/bhp-hr PM standard would use an engine certified to either the optional 0.01 g/bhp-hr particulate emission standard as specified in title 13, CCR, section 1956.8(a)(2), or the 0.01 g/bhp-hr particulate emission standard as specified in title 13, CCR, section 1956.8(a), when it becomes effective in 2007. This option has a greater cost, as it entails either purchasing a replacement vehicle or engine (also called engine repowering), but may be preferred by an owner when his vehicle's engine is nearing the end of its useful life. An engine certified to 0.01 g/bhp-hr PM, however, may not be available for collection vehicles until the 2007 MY.

No additional controls are required to reduce diesel PM emissions from alternative-fueled vehicles because, by definition, alternative-fuel vehicles do not emit diesel PM. A dual-fuel collection vehicle, however, which uses both diesel fuel and an alternative-fuel, is covered by the proposed rule, and thus would be required to comply with the proposed regulation as a diesel-fueled vehicle. A dual-fuel collection vehicle with a verified diesel particulate filter installed, for example, would be in compliance with this regulation. A heavy-duty pilot-ignition engine is treated like an alternative-fuel engine in this rule. This engine uses diesel fuel in less than ten percent of its duty cycle for engine ignition and cannot operate or idle solely on diesel fuel at any time.

The third option is to install a verified DECS to meet the BACT requirement. This is a less expensive option that can be as effective in reducing diesel PM as installing an engine certified to the 0.01 g/bhp-hr PM standard if the technology used meets the Level 3 PM reduction requirements (**Table 7**). If an owner plans to comply using this option, he or she must install technology verified by ARB. Several DECS have received approval from ARB's Executive Officer under the Verification Procedure for In-Use Strategies to Control Emissions from Diesel Engines (title 13, CCR, sections 2700-2710). In this procedure diesel PM control devices can be verified to one of three levels of diesel PM reduction: Level 1, from 25 to 49 percent; Level 2, from 50 to 84 percent; and Level 3, 85 percent and greater. BACT is determined by Level, not by percent emission reduction. Thus a technology that reduces diesel PM by, for example, 45 percent is equivalent, under this rule, to one that reduces diesel PM by 25 percent. Both get the same credit as Level 1 DECSs.

Table 7. Potential Reductions from the Use of Diesel Emission Control Strategies.

Engine MYs	Particulate Standard (g/bhp-hr)	Maximum PM Emissions (gbhp-hr)		
		Level 3	Level 2	Level 1
1960 – 1987	None	85% reduction	50% reduction	25% reduction
1988 – 1990	0.6	0.09	0.30	0.45
1991 – 1993	0.25	0.04	0.13	0.19
1994 – 2006	0.1	0.02	0.05	0.08

The concept of BACT using a DECS can be further explained as follows. An owner must look for the highest level DECS that can be installed and operated successfully on each combination of an engine in a vehicle. If a Level 3 DECS is available for the engine, this option must be applied to the engine provided the DECS manufacturer or authorized dealer agrees that the DECS will work in that vehicle. If a Level 3 is not available or feasible, then a Level 2 option must be explored. A device verified to this level, for example, might be employed for those vehicles that do not have the appropriate PM to NOx ratio or exhaust temperature for a Level 3 DECS.

A Level 1 DECS is acceptable only if it is the only option available for the engine or application, with the exception that the oldest engines in Group 2 may not use Level 1 technology, unless the owner has fewer than 15 vehicles. If no DECS is verified and feasible, the owner may apply for an implementation delay, as discussed later, but will eventually have to repower or otherwise replace the engine with one meeting the 0.01 g/bhp-hr PM standard, an alternative fuel engine, or a heavy-duty pilot ignition engine. Technologies to meet the BACT option are discussed in more details in the Technical Support Document.

D. Implementation Schedule

Staff proposes an implementation schedule designed with the goals of phasing-in implementation by technical feasibility and cost (**Table 8**).

Table 8. Implementation Schedule for Engine Model Years 1960 to 2006.

Group	Engine MY	Percentage of Group to Use Best Available Control Technology	Implementation Date
1	1988 – 2002	10	December 31, 2004
		25	December 31, 2005
		50	December 31, 2006
		100	December 31, 2007
2[a]	1960 – 1987	25	December 31, 2007
		50	December 31, 2008
		75	December 31, 2009
		100	December 31, 2010
3	2003 – 2006	50	December 31, 2009
		100	December 31, 2010

[a]Group 2: An owner of an active fleet with 15 or more collection vehicles may not use Level 1 technology as BACT (see section f.3.b.).

The first implementation group includes vehicles with MY 1988 through 2002 engines. In this group, the engines most likely to be successfully retrofitted with Level 3 DECS are MY 1994 to 2002 engines. ARB has already verified two types of Level 3 DECS for a number of engines in this group. The MY 1988 to 1993 engines are expected to be able to use either a Level 1 or Level 2 DECS, or to repower to a 0.01 g/bhp-hr PM emissions certified engine, or to use an alternative-fuel or heavy-duty pilot-ignition engine (see Technical Support Document for additional discussion). The repower may be accomplished through one of two means, either through the purchase of a new 2007 MY engine or through the installation of a 1994 to 2002 MY engine and a diesel particulate filter. Thus, the first group includes both engines that should achieve the highest emission reductions through application of a DECS and engines that have higher emissions and may either be retired or have lower level DECS applied.

In addition, based on ARB surveys of the industry, staff believes public and private fleets will be impacted equally in Group 1 (MY 1988 – 2002). Public and large private fleets tend to buy vehicles new and sell them to smaller companies after ten years. Since Group 1 includes both newer and older engines, the three fleet types should be impacted similarly.

The higher emitting, mechanical engines in the Group 2, MY 1960 to 1987 engines, are more difficult to retrofit with DECSs. The best means to reduce PM emissions from these vehicles may be to replace the engines with newer engines plus a Level 3 verified DECS. In other words, an owner could repower with a MY 1994 – 2002 engine and add a diesel particulate filter. Alternately, with engines this old, the best strategy may be a complete replacement. Group 2 engines are brought into compliance later than the Group 1 engines in order to allow additional time technology.development and for owners to plan for engine replacement.

The use of Level 1 technology, however, is restricted in Group 2 engines. Owners with fewer than 15 collection vehicles would be allowed to use a Level 1 DECS, if any is available and verified, in addition to the options available to larger fleets. Owners of larger fleets are required to retire these engines or use Level 2 or 3 verified DECS by the end of 2010. The majority of diesel PM emissions from collection vehicles are produced by this engine model year group.

Group 3 engines, the newest engines with MYs 2003 to 2006, are to be brought into compliance by the end of 2010. This group comprises the smallest portion of the fleet in both vehicle numbers (nine percent of the total California collection vehicle fleet) and diesel PM emissions (two percent of total SWCV emissions). Staff anticipates Level 3 technologies to be verified for these MY engines in the future, although the use of exhaust gas recirculation (EGR) to reduce NOx emissions in these engines may make application of particulate filters challenging. The possibility also exists that one or more engine manufacturers could make 2007 emission standard compliant engines available for purchase before 2007.

A dual-fuel collection vehicle implements according to its model year. Any dual-fuel collection vehicle that has been retrofitted with a diesel particulate filter, for example to comply with the SCAQMD Rule 1193, is in compliance with the BACT requirement. Level 3 DECSs are currently verified for specific dual-fuel vehicles, thus owners should be able to comply with the proposed regulation according to the implementation schedule.

New technologies may be verified by ARB during the seven-year implementation period, resulting in additional Level 2 and 3 technologies available at lower cost, thus resulting in more cost-effective overall diesel PM emission reductions over time. Also, the possibility exists that 2007 emission standard compliant engines could be available for purchase earlier, if a heavy-duty diesel engine manufacturer made them available.

E. Calculating Active Fleet Size

The total number of vehicles comprising an owner's active fleet may vary from year to year because of new purchases and retirement of older vehicles, thus complicating the calculation of the number of vehicles that must be in compliance each year. ARB staff, therefore, proposes to define the owner's active fleet in the following manner.

The active fleet comprises 1960 to 2006 engine MY residential and commercial collection vehicles with a manufacturer's gross vehicle weight rating greater than 14,000 pounds, including back-up or spare vehicles that accrue greater than 1000 miles per year, and is calculated by terminal. The owner may include alternative-fueled collection vehicles in this calculation.

To determine compliance with this phase-in, the owner must calculate active fleet size annually beginning January 1, 2004. In order to ensure equity regarding the locations of PM reductions and public exposure, the active fleet is calculated by terminal, not by an owner's entire fleet, which may be spread out through the state. Many of the larger companies operate out of multiple terminals, and the potential exists for a company to bring one entire terminal's fleet into compliance before another, which would lead to a neighborhood being exposed to higher diesel PM concentrations than the one brought into compliance first.

Two equations are used to calculate fleet size for any given year:

(1) TotVeh = Group%BACT * (#SWCV), and

(2) TotAddComp = TotVeh – TotComp,

where,
TotVeh = total number of collection vehicles required to be in compliance by the "Compliance Deadline,"
Group%BACT = "Percentage of Group to Use Best Available Control Technology" for the particular year,
#SWCV = sum of the number of collection vehicles in an engine model year group,
TotComp = total number of collection vehicles in compliance as of the calculation date, and
TotAddComp = total number of additional collection vehicles required to be brought into compliance before the next compliance deadline

If the TotAddComp is not equal to a whole number of collection vehicles, the owner is expected to round up to the nearest collection vehicle when the fractional part of TotAddComp is greater than or equal to one-half of a collection vehicle, and expected to round down to the nearest collection vehicle when the fractional part of TotAddComp is less than one-half of a collection vehicle.

Four active fleet size calculations are given below to illustrate various cases owners might experience. The first is a regular implementation schedule with no early implementation. The second is a fleet that implements early. The third is a fleet with fewer than four vehicles in a model year group. The fourth is a fleet experiencing turnover with engines being retired and other engines being purchased.

1. Active Fleet Size Calculation – Regular Implementation Example

A fleet with 30 collection vehicles with a portion of vehicles in each engine model year group (**Table 9**) would implement using Equations (1) and (2) as calculated below.

Table 9. Regular Implementation Schedule Example.

Engine MY Group	January 1, 2004 Inventory (#SWCV)	Number of Collection Vehicles to Implement By December 31st of Each Year (TotAddComp)						
		2004	2005	2006	2007	2008	2009	2010
1	16	4	4	4	4	—	—	—
2	10	—	—	—	3	2	3	2
3	4	—	—	—	—	—	2	2

The fleet inventory does not change throughout the phase-in period. Therefore the #SWCV remains the same each year.

Since only engines in model year Group 1 are to be brought into compliance in 2004, 2005 and 2006, there is only one group to calculate for in 2004,
TotVeh = 0.25 * (16) = 4,
TotAddComp = 4 – 0 = 4.

In 2005, Group 1 continues to implement,
TotVeh = 0.5*(16) = 8,
TotAddComp = 8 – 4 = 4.

In 2006, Group 1 continues to implement,
TotVeh = 0.75*(16) = 12,
TotAddComp = 12 – 8 = 4.

In 2007, the calculation for engine model year Group 1 is the same,
TotVeh = 1*(16) = 16,
TotAddComp = 16 – 12 = 4.
But now Group 2 begins to implement, and, therefore, must also be calculated,
TotVeh = 0.25*(10) = 2.5 ⇨ 3 (The number of vehicles to implement must be rounded up to a whole number, when the fractional part of a vehicle is 0.5 or greater)
TotAddComp = 3 – 0 = 3.

In 2008, since engine model year Group 1 has finished implementing, the calculation is only for Group 2,
TotVeh = 0.5*(10) = 5,
TotAddComp = 2.

In 2009, Group 2 continues implementing,
TotVeh = 0.75*(10) = 7.5 ⇨ 8,
TotAddComp = 8 – 5 = 3,
And, Group 3 begins implementing,
TotVeh = 0.5*4 = 2,
TotAddComp = 2 – 0 = 2.

In 2010, Group 2 completes implementation,
TotVeh = 1*(10) = 10,
TotAddComp = 10 – 8 = 2,
As does Group 3,
TotVeh = 1*(4) = 4,
TotAddComp = 4 – 2 = 2.

2. Active Fleet Size Calculation – Early Implementation Example

A fleet with 30 collection vehicles with a portion of vehicles in each engine model year group that implements early (**Table 10**) would implement using Equations (1) and (2) as calculated below.

Table 10. Early Implementation Schedule Example.

Engine MY Group	January 1, 2004 Inventory (#SWCV)	Number of Collection Vehicles to Implemented By December 31st of Each Year (TotAddComp)								
		2004	2005	2006	2007	2008	2009	2010	2011	2012
1	16	12	—	—	—	—	4	—	—	—
2	10	—	—	5	—	—	3	—	—	2
3	4	—	—	—	—	—	2	2	—	—

The fleet inventory does not change throughout the phase-in period; therefore #SWCV remains the same each year. The owner implemented BACT on seventy-five percent of his Group 1 collection vehicles by December 31, 2004,

TotVeh = 0.75*(16) = 12,

so the owner could delay the 100 percent compliance deadline for Group 1 to December 31, 2009,

TotVeh = 1*(16) = 16,
TotAddComp = 16 – 12 = 4.

The owner also implemented BACT on fifty percent his Group 2 collection vehicles by December 31, 2006,

TotVeh = 0.5*(10) = 5.

The owner would still need to implement BACT on 75 percent of his Group 2 collection vehicles by December 31, 2009,

TotVeh = 0.75*(10) = 7.5 ⇨ 8
TotAddComp = 8 – 5 = 3.

The owner could delay the 100 percent compliance deadline for Group 2 to December 31, 2012,

TotVeh = 1*(10) = 10
TotAddComp = 10 – 8 = 2.

3. Active Fleet Size Calculation – Small Fleet Example

A fleet with fewer than four collection vehicles per engine model year group can ignore 25, 50 and 75 percent implementations and is only required to implement by the 100 percent implementation date for each engine model year group (**Table 11**). A fleet with three collection vehicles in engine model year Group 1 would implement all three vehicles by December 31, 2007. Likewise, a fleet with three collection vehicles in Groups 2 and 3, respectively, would implement bring all three vehicles into compliance by December 31, 2010.

Table 11. Small Fleet Example.

Engine MY Group	January 1, 2004 Inventory (#SWCV)	Number of Collection Vehicles to Implement By December 31st of Each Year (TotAddComp)						
		2004	2005	2006	2007	2008	2009	2010
1	3	—	—	—	3	—	—	—
2	3	—	—	—	—	—	—	3
3	3	—	—	—	—	—	—	3

4. Active Fleet Size Calculation – Fleet Turnover Example

A fleet with 30 collection vehicles with a portion of vehicles in each engine model year group (**Table 12**) and which changes its fleet composition over time would implement using Equations (1) and (2) as calculated below.

Table 12. Fleet Turnover Example.

Engine MY Group	January 1st Inventory of Each Year (#SWCV = #)/ Number of Collection Vehicles to Implement By December 31st of Each Year (TotAddComp = Tot)													
	2004		2005		2006		2007		2008		2009		2010	
	#	Tot	#	Tot	#	Tot	#	Tot	#	Tot	#	Tot	#	Tot
1	16	4	18	5	18	5	18	4	18	0	18	0	18	0
2	10	0	8	0	8	0	6	2	6	1	4	0	2	0
3	4	0	4	0	4	0	6	0	6	0	8	4	10	6

The fleet inventory changes throughout the phase-in period, but the total number of vehicles in the fleet remains at 30.

Since only engines in model year Group 1 are to be brought into compliance in 2004, 2005 and 2006, there is only one group to calculate for in 2004,

TotVeh = 0.25 * (16) = 4,
TotAddComp = 4 – 0 = 4.

In 2005, two vehicles are added to Group 1 and, therefore, implementation continues as follows,

TotVeh = 0.5*(18) = 9,
TotAddComp = 9 – 4 = 5.

In 2006, Group 1 continues to implement with the enhanced inventory,

TotVeh = 0.75*(18) = 13.5 ⇨ 14,
TotAddComp = 14 – 9 = 5.

In 2007, the calculation for engine model year Group 1 is the same,

TotVeh = 1*(18) = 18,
TotAddComp = 18 – 14 = 4.

But now Group 2 begins to implement, and, therefore, must also be calculated,

TotVeh = 0.25*(6) = 1.5 ⇨ 2 (The number of vehicles to implement must be rounded up to a whole number, when the fractional part of a vehicle is 0.5 or greater)
TotAddComp = 2 – 0 = 2.

In 2008, since engine model year Group 1 has finished implementing, the calculation is only for Group 2,

TotVeh = 0.5*(6) = 3,
TotAddComp = 3 – 2 = 1.

In 2009, Group 2 continues implementing,

TotVeh = 0.75*(4) = 3,
TotAddComp = 3 – 3 = 0,

and, Group 3 begins implementing,
TotVeh = 0.5*8 = 4,
TotAddComp = 4 – 0 = 4.

In 2010, Group 2 completes implementation,

TotVeh = 1*(2) = 2,
TotAddComp = 2 – 3 = -1 = 0.

As does Group 3,

TotVeh = 1*(10) = 10,
TotAddComp = 10 – 4 = 6.

Collection vehicles within one year of retirement would be exempt from compliance with the proposed regulation as described in the following section.

F. Compliance Extensions

Staff believes owners may experience conditions justifying a compliance extension. Three main categories of compliance extensions exist: early implementation, no verified DECS, and active fleets with fewer than four vehicles.

1. Early Implementation

Staff recognizes some companies have already made considerable efforts to reduce emissions from their vehicles through early application of BACT. Staff proposes to give some allowance to these fleets in the following two situations.

If an owner has applied BACT to 50 percent of the collection vehicles in Group 1 (MY 1988 – 2002) in his or her active fleet before December 31, 2004, the owner may delay 100 percent compliance of the Group 1 vehicles to December 31, 2009. Likewise, if an owner has applied BACT to 50 percent of the collection vehicles in Group 2 (MY 1960 – 1987) in his or her active fleet before December 31, 2006, the owner may delay 100 percent compliance of the Group 2 vehicles to December 31, 2012. An owner who implements early will not be required to install a higher level DECS if one becomes available between the time the DECS is installed early and the mandated compliance date. A compliance extension for early implementation allows SWCV owners to stretch out implementation beyond required dates while at the same time implementing early in at least half of the vehicles. Owners may qualify for local funding based on early implementation because it is voluntary and occurs prior to the mandated implementation dates.

2. No Verified Diesel Emission Control Strategy

An owner may be granted a delay in implementing the BACT if no verified DECS exists for an engine and application. This delay recognizes the higher cost of an engine repower or replacement and provides the owner additional time to plan for this cost. In addition, during the time allowed for a delay, effective DECSs may become verified. Annual delays will be granted for a specified period of time only.

Two methods of granting delays are proposed. Either the Executive Officer would grant a blanket one-year compliance extension, or, if the owner has an engine not granted a blanket one-year compliance extension, the owner may apply for a compliance extension. Staff proposes if no DECS has been verified for a specific engine or application, or one is not commercially available, by ten months prior the implementation date for that group, then the Executive Officer may grant a one-year implementation delay without requiring documentation from the owner as to the unavailability of verified technology. Vehicle owners should look for this implementation delay on the ARB's website.

In the second case, a DECS could be verified for an engine, but not able to be used in a specific application. In this case, staff proposes an owner may apply no later than July 31st of the year for which he or she is requesting an extension. The owner must provide documentation that DECSs have been investigated and shown not to work on a particular engine or set of engines, or in the owner's vehicle application. Evidence convincing to ARB would include, for example, a letter from a DECS manufacturer showing evidence of data collected that demonstrates the DECS will not function on that particular vehicle because of its duty cycle. Other examples of justified reasons for an owner applying for an implementation delay would be if the owner has an engine in his fleet which is used in a small number of collection vehicles in California and for which no DECS has been verified, if the engine is under an original engine warranty and application of a DECS would void that warranty, or if a DECS is not commercially available. In these cases, the owner should provide sufficient documentation to validate the need for a delay.

ARB has an existing procedure for responding to requests for extension as codified in title 17, CCR, section 60030. When an extension is requested, the Executive Officer of the ARB will respond to the collection vehicle owner that the application has been received within 30 days of receipt, and that it is "complete and accepted for filing or that the application is deficient and identify the specific information required to make the application complete." If additional information has been requested to complete the application, within 15 days of receipt of that information the Executive Officer will inform the collection vehicle owner of either acceptance of the application for filing or of another deficiency in the application. Within 90 days after the application is accepted for filing, the Executive Officer will issue her approval or disapproval of the compliance extension request.

Staff proposes, however, an owner not be granted extensions indefinitely. Staff proposes that if no DECS for a specific engine or application is available through 2007 for a Group 1 (MY 1988 – 2002) engine, the owner would be required to use one of the following BACT: an engine that achieves the 0.01 g/bhp-hr PM standard, or an alternative-fueled or heavy-duty pilot ignition engine, by December 31, 2008. Similarly, for Groups 2 (MY 1960 – 1987) and 3 (MY 2003-2006) collection vehicle engines, compliance extensions are not given for longer than to December 31, 2011. The owner would, therefore, be required to employ another BACT by December 31, 2011.

If an owner is granted a compliance extension for an engine, the owner should apply the best available technology options to the maximum number of vehicles that can be retrofitted up to the applicable percentage for each year. Thus, if the applicable phase-in percentage is 25 percent, and the owner has received compliance extensions for some engines, the owner is still required to apply BACT to 25 percent of his fleet that year if possible. In the final year of each group's phase-in, if the owner still has some engines for which a delay has been granted, the owner is allowed to delay until no more delays are available, at which time the engine would be required to be scrapped, repowered to the 0.01 g/bhp-hr standard, or converted to an alternative-fueled, or heavy duty pilot-ignition engine.

3. Active Fleet with Fewer than Four Vehicles

An owner with three or fewer collection vehicles in his or her active fleet would be able to delay the compliance deadline of any engine in Group 1 to December 31, 2007, and in Group 2 to December 31, 2010. No extensions will be granted for Group 3. The owner need not apply for this extension, but if requested to justify apparent non-compliance an owner would need to supply proof of the size of his or her active fleet to ARB enforcement personnel.

G. Diesel Emission Control Strategy Special Circumstances

Owners would be required to maintain BACT on each vehicle once that vehicle is in compliance. If the BACT is a DECS, an owner would not be required to upgrade to a higher level of DECS if the DECS is functioning as verified. The following special circumstances, however, would apply.

1. Failure or Damage of a Diesel Emission Control Strategy

For various reasons, a DECS might fail or be damaged during the lifetime of an engine. The intent of this regulation is to reduce diesel PM emissions for the life of an engine, therefore the owner is required to fix the failed or damaged DECS or install a new one. For heavy heavy-duty engines, ARB requires that DECS manufacturers provide, at a minimum, a commercial warranty of five years or 150,000 miles (title 13, CCR, section 2707). However, long-term usage on heavy-duty vehicles has shown DPFs to last for more than 400,000 miles and over four year, in some cases (Kimura 2003). The average collection vehicle mileage is 15,635 miles per year.[3]

Staff proposes if a DECS fails or is damaged while it is within its warranty period, the owner be allowed to repair or replace the DECS with the same or comparable DECS, as provided under the DECS manufacturer's warranty. If, however, the DECS fails or is damaged outside of its manufacturer-provided warranty, staff proposes the owner would be required to install the highest verified level DECS available. If the owner had previously installed a Level 1 (25%+) DECS, for example, and a Level 2 (50%+) or Level 3 (85%+) DECS is available, then the owner would be required to upgrade the DECS to the higher level DECS.

2. Discontinuation of Fuel as a Diesel Emission Control Strategy

If an owner chooses to discontinue use of fuel verified as a DECS under section 2021.2 (b)(3) of the proposed regulation, the owner would be required to use another BACT. In the event another BACT is not commercially available within 30 days from the date of discontinuation of a fuel verified as a DECS, the owner would be required to submit a compliance plan to the Executive Officer no later than 60 days after discontinuation of the use of the fuel verified as a DECS that demonstrates how the owner will bring his or her vehicles into compliance within six months. In other words, the owner is required to apply another BACT within 30 days unless no DECS is commercially available. In that case, the owner must comply within six months.

3. Level 1 Diesel Emission Control Strategy

While use of a Level 1 DECS is approved in most cases by this proposed regulation, the relatively low level of PM reduction (25 percent) is a concern. Widespread use of Level 1 DECS would not achieve the goals set forth in the DRRP (ARB 2000b) of 75 percent diesel PM reduction by 2010 and 85 percent diesel PM reduction by 2020. Staff realizes, however, in some cases a Level 1 device may be the only verified DECS for a specific engine and application.

[3] ARB. 2001. Averages of survey of three solid waste collection vehicle companies.

Requiring immediate use of either an engine that meets the 0.01 g/bhp-hr PM standard or an alternative-fuel or heavy-duty pilot-ignition engine might be overly burdensome financially for the owner. As such, staff proposes a vehicle owner be allowed to use a Level 1 DECS for a limited time period as a BACT. The time limit for Group 1 (MY 1988 – 2002) is ten years.

The time limit on use of a Level 1 DECS for Group 2 (MY 1960-1987) for companies with fewer than 15 vehicles is also ten years, but this special circumstance may not be applicable as no Level 1 devices have been verified for Group 2 engines. If an owner has 15 or more vehicles in his or her active fleet, he or she may not use a Level 1 DECS on any Group 2 vehicle. If no DECS is verified or available for Group 2 vehicles, then the owner would be eligible to apply for a compliance extension, after which the owner would have to repower or replace the engine as per sections 2021.2 (b)(1) or (b)(2).

Staff proposes that the time limit for use of a Level 1 DECS on Group 3 (MY 2003-2006) vehicles be five years.

4. Engine Retirement

An owner may retire an engine, either by selling it outside of the State of California, scrapping the engine, or using it in a backup vehicle. If the engine is within one year of retirement as of the applicable compliance date, then staff proposes that the owner would not be required to install a DECS. Similarly, if an installed DECS fails and it cannot be repaired, the owner of a vehicle within one year of retirement would not be required to replace or upgrade the device. In order for ARB to determine, for enforcement purposes, this engine is going to be retired, the owner must maintain records both at the facility and on-board the vehicle stating the retirement date. Otherwise, the owner would be subject to enforcement for non-compliance. The owner would also be subject to enforcement if he then kept the vehicle in the active fleet after the stated retirement date and did not install the required DECS.

5. Use of Experimental Diesel Particulate Matter Emission Control Technology

An owner may want to participate in a demonstration of experimental technology designed to reduce diesel PM. This regulation requires the use of verified DECS, and by its nature an experimental technology will not have received verification. Staff, therefore, proposes an owner be allowed to install experimental technology on no more than ten vehicles at any time in his active fleet for testing and evaluation. Each vehicle being used for the demonstration would be deemed to be in compliance with this rule for the duration of the experiment, provided the experimental technology reduces diesel PM and a valid experimental permit has been obtained from ARB. At the termination of the experiment, the experimental technology should be removed, unless it has received appropriate verification from ARB, and replaced with the verified DECS as required, within six months of termination of the experiment.

H. Record Keeping

ARB proposes that owners keep records and make those records available for inspection during enforcement audits by ARB personnel. Staff had previously proposed in preliminary drafts of this regulation that owners submit records of compliance to ARB, but has removed this requirement from the proposed regulation after considerable consultation with interested persons. Staff is now proposing only that owners maintain certain records, both at the terminal where the vehicle normally resides and in the vehicle. If an owner is found to be out of compliance with this regulation, enforcement may be taken against the owner.

1. Records Accessible at Terminal

Records to be kept at the terminal or facility where the vehicle normally resides include a list of the collection vehicles covered by the proposed regulation which identifies each vehicle type, engine manufacturer, engine model and engine model year. That information must be tied to specific DECS that are installed in each vehicle. DECS information includes the type of DECS, its serial number, manufacturer, model, level, and date of installation, or first date of use if a fuel DECS. If using a Level 1 or Level 2 verified DECS, the reason for choosing that DECS must also be provided. This could simply be a statement that no Level 3 verified DECS were available. If a Level 3 verified DECS is available, then the DECS manufacturer or authorized dealer must provide reasoning for not using that DECS. DECS maintenance records would also need to be available. In the case of fuel or fuel additives used as a DECS, purchase records would need to be kept for the most current two years worth of purchases.

Backup vehicles, engines with planned retirement within one year, and engines using experimental diesel PM DECS would need to be identified in the records as well. Each backup vehicle would need to have its vehicle identification number (VIN) and mileage recorded as of January 1st of each year beginning January 1, 2005. If the engine is exempt because it is to be retired within one year, the owner must have records of the retirement date tied to specific engine information, including VIN, engine manufacturer, engine model, and engine model year. Similarly, this specific engine information must be kept with documentation of the experimental program.

2. Records Kept in Vehicle

Staff also proposes owners be required to keep certain information in the vehicle, which can be accessed during roadside inspections. Numerous individuals have told staff that keeping information inside the vehicle is impractical, so ARB suggests a label with the required information be affixed to the driver's side door jam, or in another readily accessible location known by the driver and readily visible to an inspector. Illegible or inaccessible records would not be acceptable. The information required is the same as that required under the Verification Procedure in section 2706 (g), which includes the manufacturer's name, address, and phone number; the DECS family name; product serial number, month and year of manufacture plus the date of installation of the DECS, or date of first use if the DECS is a fuel.

Staff has concluded that any inconvenience to owners of being required to have this information in the vehicle are out-weighed by the necessity for inspectors to have information available during a roadside inspection verifying the DECS has been installed. Otherwise, an inspector might have to dismantle a muffler housing, for example, to determine that a diesel particulate filter was installed. In addition, other regulations require certain records be kept in vehicles, such as manifests, therefore staff believes it is not unreasonable to require these records be kept in collection vehicles also.

I. Enforcement

A number of enforcement options exist with this regulation. The regulation may be enforced by ARB on the collection vehicle owner or a municipality. For collection vehicle owners, ARB staff may inspect the records kept at the facility and, if they find the fleet is in non-compliance with the regulation may impose penalties of up to $1000 per vehicle per day. If further investigation determines the fleet owner neglected or intended to violate the regulation, then up to $10,000 per vehicle per day may be imposed on the collection vehicle owner.

ARB may impose similar penalties against municipalities for contracting with collection vehicle owners in non-compliance with the regulation, or for not submitting reports or for submitting false statements in the reports. Municipalities may determine non-compliance either through lack of a signed statement of compliance from the collection vehicle owner, or through notice from ARB that a collection vehicle owner they contract with, permit, or license is in non-compliance, or through independent investigation by the municipality. Staff believes this mechanism is likely to be the most effective means to compel compliance, as the loss of a contract, permit, or license to operate and provide service would significantly impact an owner's ability to do business.

VI. AVAILABILITY AND TECHNOLOGICAL FEASIBILITY OF CONTROL MEASURE

Diesel engines have long been the engines of choice for use in collection vehicles because of the efficiency and durability of diesel engines, as well as the operators' familiarity with diesel engine technology. Historically, a lack of viable alternative-fuel engine technology for use in heavy-duty vehicle applications has also maintained the dominance of the diesel engines. Existing and emerging technologies are making both alternative-fuel engines and diesel engines options for reducing toxic diesel PM emissions.

A. Availability of Best Available Control Technologies

Many options for reducing diesel PM emissions exist and are being developed in order to comply with this proposed regulation. Both hardware strategies, such as diesel particulate filters, diesel oxidation catalysts and repowering, and fuel and fuel additive solutions are explored in the Technical Support Document. In addition, the Technical Support Document discuses the in-use experience and status of verification for each of the technologies. ARB conducted extensive research into feasibility of these technologies in a number of studies, which are also discussed in the Technical Support Document and its appendices.

B. Availability of Diesel Fuel with 15 ppmw or Less Sulfur Content

The use of diesel fuel with 15 ppmw or less sulfur content ("low sulfur") will not be mandated prior to the 2006 national implementation date unless it's use is required as a condition of verification for specific DECSs to achieve the verified emission reductions. BP is the major producer and wholesaler of low sulfur diesel at this time and the fuel is currently available at two terminals in California, in Long Beach and Richmond. In response to market needs, BP has certified fuel resellers to handle the low sulfur fuel, thus making the product widely available in California by truck. BP is also selling low sulfur fuel through its ARCO stations that carry diesel fuel.

Other fuel refiners are considering selling this fuel, but have not yet made it available to the general market. This fuel will likely not be made available through the pipeline distribution system until July 2006, at which time, low sulfur diesel will be mandated to be available nationwide.

VII. REGULATORY ALTERNATIVES

No alternative considered by the ARB would be more effective in carrying out the purpose for which the regulation is proposed nor would be both as effective and least burdensome to affected private persons than the proposed regulation. A comparison of emission reductions from each regulatory alternative considered can be found at the end of this section (**Table 13**).

A. Do Not Adopt This Regulation

With full implementation of this control measure, the estimated reduction in diesel PM ranges from 72 to 81 percent in 2010, and from 67 to 82 percent in 2020, when compared to the not adopting this regulation (**Figure 3**). The recommended actions in this plan will have a great impact on reducing the localized risks associated with activities that expose nearby individuals to diesel

PM emissions. This diesel PM control measure will result in additional benefits associated with reducing diesel PM emissions, including reducing NOx emissions by 57 percent from baseline in 2010, reducing ambient fine PM levels, increasing visibility, reducing material damage due to soiling of surfaces, and reducing incidences of non-cancer health effects, such as bronchitis and asthma.

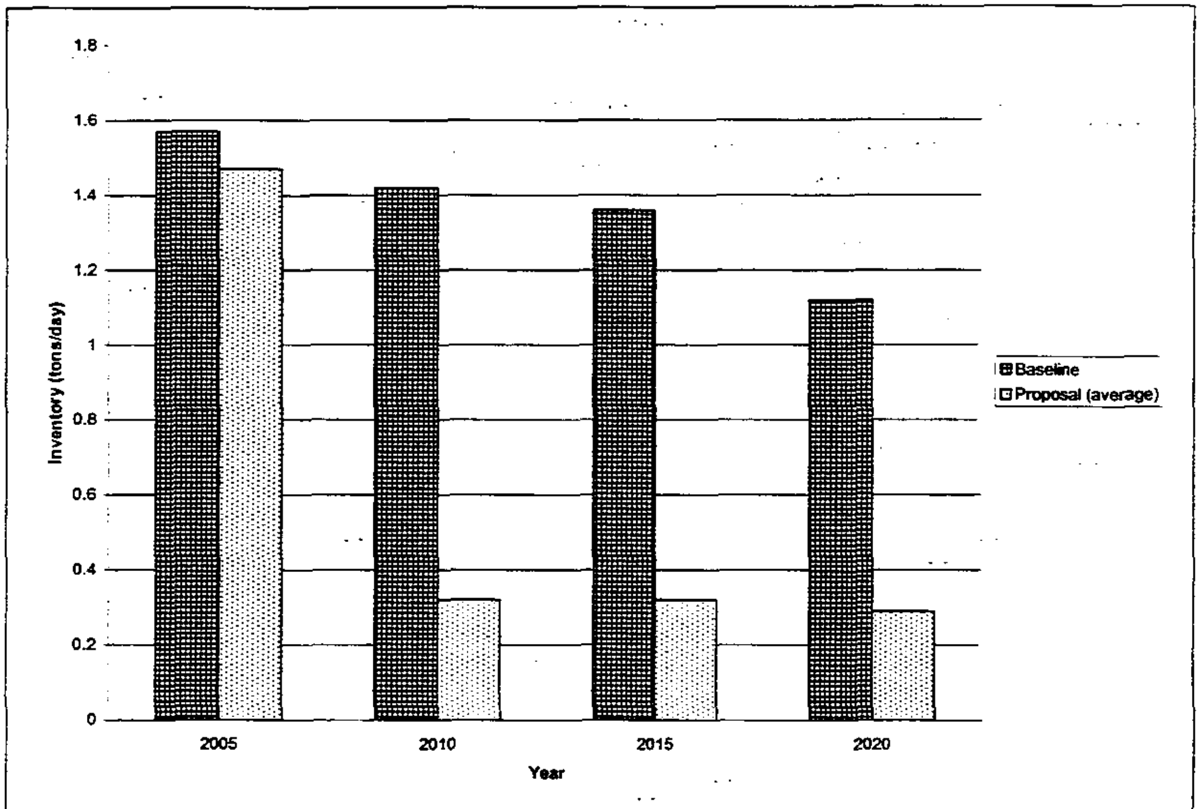

Figure 3. Comparison of Baseline and Proposed[4] Diesel Particulate Matter Inventory.

In not adopting this regulation ARB would be disregarding the potential risk posed by diesel PM. In consideration of the potential health impacts discussed earlier, and ARB's mandate to protect the public health of all Californians, this alternative is not considered a reasonable option. ARB staff does not recommend this alternative because it would result in approximately 80 percent greater PM emissions over the next few decades than the proposed plan, thus adversely impacting the health of Californians.

B. Rely Only on Local Regulations in the South Coast Air Quality Management District

As discussed earlier, the SCAQMD adopted Rule 1193, which requires collection vehicle owners to purchase only alternative-fuel or dual-fuel vehicles when

[4] The average of the three scenarios was used to construct this table.

replacing vehicles or adding to their fleets. SCAQMD estimated that in 2010 this rule will reduce diesel PM emissions by 68 tons per year (or 0.19 tpd) and NOx emissions by 695 tons per year (or 1.9 tpd) at a cost of $28,000 per ton of PM + NOx. The rule, however, only applies to vehicles operating in the South Coast Air Basin in fleets of 15 vehicles or more. Reliance on this rule would leave other parts of the state to continue to suffer from unacceptable diesel PM levels. In addition, because the rule does not address diesel PM emissions from current, in-use vehicles, reductions in diesel PM will occur too slowly. ARB staff does not, therefore, recommend this alternative because it would result in less diesel PM emission reductions and would be effective only in the South Coast Air Basin.

C. Rely on Federal Voluntary Program

The federal rules for new diesel engines will not begin to take effect for several years and do not affect existing vehicles. As discussed earlier, the U.S. EPA developed the Voluntary Diesel Retrofit Program to reduce diesel PM emissions in the immediate future. The program addresses pollution from diesel construction equipment and heavy-duty vehicles on the road today.

Although the U.S. EPA program is well suited for the nationwide needs of voluntary retrofit programs, it is not sufficient for meeting ARB's overall goals. The large number of diesel engines in California, over 1.2 million, makes reliance on a purely voluntary program unreasonable. ARB staff does not recommend this alternative because it would result in less diesel PM emission reductions.

D. Require all Collection Vehicles to Repower with Engines Certified to 0.01 g/bhp-hr Particulate Matter Standard in 2007

Another alternative staff considered, which would result in similar, if not greater, reductions in diesel PM emissions, is to require all collection vehicles to repower with diesel engines certified to the 0.01 g/bhp-hr particulate standard in 2007. This option is significantly more expensive than the proposed alternative. The estimated capital cost of repowering all engines in 2007 is approximately $501 million, which is a factor of ten above the $73 million expected to implement this proposed regulation, for a similar reduction in diesel PM. The estimated cost could be even higher than this as many vehicles cannot be repowered. A repower may be incompatible with older engine and drive train technology or the size of the engine compartment, thus the owner would have to purchase a new vehicle to accomplish the lower PM emissions. Nevertheless, some stakeholders have favored this option despite the higher cost.

Staff predicts a complete turnover of collection vehicles by 2020 would reduce diesel PM emissions by up to 90 percent as some owners would be eligible for a financial hardship exemption. This is an estimated reduction of 1.0 tpd, which is slightly higher than the recommended alternative in 2020 (**Table 13**). ARB staff does not recommend mandating this as the sole option, however, because of the high cost of implementation compared to the amount of PM emissions reduced and significantly poorer cost effectiveness.

E. Require all Collection Vehicles to Convert to Alternative-Fuel Vehicles

Requiring all collection vehicles to repower or be replaced with alternative-fuel engines, such as LNG engines, would result in elimination of diesel PM emissions from these vehicles, with the exception of vehicles that might be exempted because of an incompatible duty cycle or financial hardship. This option is also significantly more expensive, costing $904 million for capital costs alone, over twelve times the $73 million total in capital and operation and maintenance (O & M) costs expected to implement this proposed regulation.

The amount of PM reduction would be slightly higher than the recommended alternative. If we assume 85 percent of collection vehicles convert to alternative-fuel by 2020, for example, the predicted emission reduction would be 0.95 tpd compared to the proposal predicted emission reduction of 0.83 tpd in 2020 (**Table 13**). ARB staff does not recommend this alternative because it would be significantly more costly than the recommended alternative without significantly increasing the amount of PM emissions reduced. In addition, growing evidence suggests that PM emissions from alternative fuel engines are not less hazardous than PM emissions from diesel engines.

F. Require Collection Vehicles to Use Diesel Oxidation Catalysts as of 2005.

Another alternative is to require relatively inexpensive DOCs on collection vehicles by 2005. ARB analysis concluded this option, while less expensive, would achieve minimal diesel PM reductions (**Table 13**) of less than 25 percent. Currently DOCs are only verified for 1991 and newer engines. This alternative would never result in the 75 to 85 percent reductions expected with the proposed regulation. ARB staff does not, therefore, recommend this alternative because it would produce less diesel PM emission reductions and not achieve the goal set in the Diesel Risk Reduction Plan.

Table 13. Diesel PM Reductions by Alternative Compared to the Proposal.

Year	Proposal (tpd)	Regulatory Alternatives Reductions (tpd)					
		Adopt Nothing	SCAQMD	Voluntary	Repower to 0.01	Repower to Alt Fuel	Require all DOC
2010	**1.1**	0	0.19	n.q	n.a	n.a	0.31
2020	**0.83**	0	n.q	n.q	1.0	0.95	0.24

n.q. – not quantified
n.a. – not applicable

VIII. ECONOMIC IMPACT

A. Legal Requirement

Sections 11346.3 and 11346.5 of the Government Code require state agencies to assess the potential for adverse economic impacts on California business enterprises and individuals when proposing to adopt or amend any administrative regulation. The assessment shall include a consideration of the impact of the proposed regulation on California jobs, business expansion, elimination, or creation, and the ability of California business to compete.

State agencies are also required to estimate the cost or savings to any state or local agency and school districts in accordance with instruction adopted by the Department of Finance. This estimate is to include any nondiscretionary costs or savings to local agencies and the costs or savings in federal funding to the state.

B. Affected Manufacturers

Businesses that may be affected as a result of the proposed regulation include manufacturers of heavy heavy-duty diesel and alternative-fuel engines, collection vehicles, engine retrofit kits, DECS, and advanced, alternative-fuel technologies, such as CNG, LNG, dual-fuel and hybrid electric vehicles/engines. Since no collection vehicle engine or vehicle manufacturer, either diesel or alternative-fuel powered, is located in California, most impacts to these businesses, both positive and negative, will occur in other states.

As of March 2003, seven DECS manufacturers are located in California[5] and may be positively affected by this regulation. Some diesel, natural gas and dual-fuel collection vehicle assembly centers and distributors are located in California. Since some solid waste vehicle owners may choose to purchase new diesel or

[5] The seven companies based in California are Clēaire, Clean Air Partners, Extengine, GTAT California, KleenAir Systems, Olson Engineering, and Technical Associates. There may be additional companies unknown to ARB.

alternative-fuel collection vehicles as a means to meet the proposed regulation requirements, these manufacturers may experience a positive impact. Staff does not expect the proposed regulation to significantly influence owners' decisions on whether or not to purchase new vehicles though, as the difference in cost between a new vehicle and a DECS is very large. An owner may purchase a new vehicle sooner, rather than using a DECS, but staff does not expect this to be a large effect.

C. Estimated Costs to Collection Vehicle Owners

The proposed regulation would impose costs on private, government-contracted (publicly-contracted), and government (publicly-owned) residential and commercial solid waste collection fleets statewide because of the proposed requirement for diesel PM emission reduction. The following provides a summary of the costs to private and publicly-contracted companies for complying with the proposed regulation. The cost to publicly-owned agencies is discussed in section VII.H.

Under the proposed diesel PM control requirement, collection vehicle owners are responsible for selecting and implementing BACT. Publicly-owned agencies and larger private, both publicly-contracted and not publicly-contracted, companies typically turn over their fleets every five to ten years. The second owners of these collection vehicles are generally smaller private companies. Staff has, therefore, illustrated the cost using two scenarios: (1) a small private company with ten vehicles, and (2) a large private company with 100 vehicles.

1. Implementation Scenarios

The implementation schedule dictates a phase-in by fleet and engine model year (see **Table 8**). Staff assumed collection vehicle owners would choose the least expensive of the BACT options to comply with this regulation. Staff, therefore, assumed a DECS would be employed in lieu of more expensive options of repowering or replacing the vehicle or engine, whenever possible. PM emissions and exhaust temperatures dictate the type of DECS a collection vehicle can use. Based on available data on DECS currently available to the entire collection vehicle fleet, staff created three scenarios to determine economic impacts: the first is based on currently verified DECSs (**Table 14**), the second assumes no Level 2 DECSs are verified and is based on verifications of only Level 1 and 3 DECSs through the life of this rule (**Table 15**), and the third assumes that DECSs will be verified at all three levels (**Table 16**). All three of these scenarios are discussed in more detail in Section IV.B. and the Technical Support Document.

Table 14. Implementation Scenario (Current).

Group	Eng MY	%BACT	Implementation Date	Technology Option (By Percent Phase-In) Level 1	Level 2	Level 3[a]	Repower	OE[h] 0.01
1	1994-2002[g] 32% of fleet	10%	12/31/2004	2.0%		8.0%		
		25%	12/31/2005	7.0%		8.0%		
		50%	12/31/2006	17.0%		8.0%		
		100%	12/31/2007	25.0%		5.0%	20.0%	
1	1991-1993[g] 14% of fleet	10%	12/31/2004	10.0%				
		25%	12/31/2005	15.0%				
		50%	12/31/2006	25.0%				
		100%	12/31/2007	30.0%			20.0%	
1	1988-1990[c] 18% of fleet	10%	12/31/2004					
		25%	12/31/2005					
		50%	12/31/2006					
		100%	12/31/2007				50.0%	
		Delay	12/31/2008				50.0%	
2	1960-1987[b] 27% of fleet	25%	12/31/2007				22.8%	
		50%	12/31/2008				22.8%	
		75%	12/31/2009				22.8%	
		100%	12/31/2010				22.8%	
		Delay	12/31/2011				9.0%	
3	2003-2006[d,e] 9% of fleet	50%	12/31/2009	14.1%		15.9%		20.0%
		100%	12/31/2010	14.1%		15.9%		20.0%
Percent of California's Collection Vehicle Fleet Total:				30%	0%	12%	54%	4%

Notes:

[a] Only 1994-2002 MY engines were considered for passive diesel particulate filters based on verification data. Assumption based on manufacturer with lowest engine exhaust temperature requirement.

[b] Nine percent of 1960-1986 vehicles are owned by companies with less than 15 vehicles (63 percent of surveyed companies).

[c] Assume all vehicles will repower and have BACT delays since no DECS are currently available.

[d] Assume current Level 3 verification will be extended to 2003-2006 MYs.

[e] Assume current Level 1 verification will be extended to 2003-2006 MYs.

[f] Assume small fleets (<15 vehicles) will have no DECS available and receive implementation delay to 2011.

[g] Assume 20 percent repower even though DECS currently available to these model years due to expected preference of some collection vehicle owners.

[h] Original equipment – purchased new.

Table 15. Implementation Scenario (Potential 1) - No Level 2 Verified.

Group	Eng MY	%BACT	Implementation Date	Technology Option (By Percent Phase-In)				
				Level 1	Level 2	Level 3[a]	Repower	OE[g]-0.01
1	1994-2002[f]	10%	12/31/2004	2.0%		8.0%		
	32% of fleet	25%	12/31/2005	7.0%		8.0%		
		50%	12/31/2006	17.0%		8.0%		
		100%	12/31/2007	25.0%		5.0%	20.0%	
1	1991-1993[c, f]	10%	12/31/2004	10.0%				
	14% of fleet	25%	12/31/2005	15.0%				
		50%	12/31/2006	25.0%				
		100%	12/31/2007	30.0%			20.0%	
1	1988-1990[c, f]	10%	12/31/2004	10.0%				
	18% of fleet	25%	12/31/2005	15.0%				
		50%	12/31/2006	25.0%				
		100%	12/31/2007	30.0%			20.0%	
2	1960-1987[b,c, f]	25%	12/31/2007	2.3%			22.8%	
	27% of fleet	50%	12/31/2008	2.3%			22.8%	
		75%	12/31/2009	2.3%			22.8%	
		100%	12/31/2010	2.3%			22.8%	
3	2003-2006[d,e]	50%	12/31/2009	14.0%		16.0%		20.0%
	9% of fleet	100%	12/31/2010	14.0%		16.0%		20.0%
Percent of California's Collection Vehicle Fleet Total:				47%	0%	12%	37%	4%

Notes:

[a] Only 1994-2002 MY engines were considered for passive diesel particulate filters based on verification data.

Assumption based on manufacturer with lowest engine exhaust temperature requirement.

[b] Nine percent of 1960-1986 vehicles are owned by companies with less than 15 vehicles (63 percent of surveyed companies).

[c] Assume current Level 1 verification will be extended to 1960-1993 MYs.

[d] Assume current Level 3 verification will be extended to 2003-2006 MYs.

[e] Assume current Level 1 verification will be extended to 2003-2006 MYs.

[f] Assume 20 percent repower even though DECS either currently or expected to be available to these model years due to expected preference of some collection vehicle owners.

[g] Original equipment – purchased new.

Table 16. Implementation Scenario (Potential 2) – All Levels Verified.

Group	Eng MY	%BACT	Implementation Date	Technology Option (By Percent Phase-In)				
				Level 1	Level 2	Level 3[a]	Repower	OE[h] 0.01
1	1994-2002[c, e] 32% of fleet	10%	12/31/2004		2.0%	8.0%		
		25%	12/31/2005		7.0%	8.0%		
		50%	12/31/2006		17.0%	8.0%		
		100%	12/31/2007		25.0%	5.0%	20.0%	
1	1991-1993[c,e] 14% of fleet	10%	12/31/2004		10.0%			
		25%	12/31/2005		15.0%			
		50%	12/31/2006		25.0%			
		100%	12/31/2007		30.0%		20.0%	
1	1988-1990[c,e,f] 18% of fleet	10%	12/31/2004	2.0%	8.0%			
		25%	12/31/2005	2.0%	13.0%			
		50%	12/31/2006	2.0%	23.0%			
		100%	12/31/2007	2.0%	28.0%		20.0%	
2	1960-1987[b,e,f] 27% of fleet	25%	12/31/2007	2.0%	0.25%		22.75%	
		50%	12/31/2008	2.0%	0.25%		22.75%	
		75%	12/31/2009	2.0%	0.25%		22.75%	
		100%	12/31/2010	2.0%	0.25%		22.75%	
3	2003-2006[d,e] 9% of fleet	50%	12/31/2009		14.0%	16.0%		20.0%
		100%	12/31/2010		14.0%	16.0%		20.0%
Percent of California's Collection Vehicle Fleet Total:				4%	43%	12%	37%	4%

Notes:
[a] Only 1994-2002 MY engines were considered for passive diesel particulate filters based on verification data. Assumption based on manufacturer with lowest engine exhaust temperature requirement.
[b] Nine percent of 1960-1986 vehicles are owned by companies with less than 15 vehicles. (63 percent of surveyed companies.)
[c] Assume 20 percent repower even though DECS currently or expected to be available to these model years due to expected preference of some collection vehicle owners.
[d] Assume current Level 3 verification will be extended to 2003-2006 MYs.
[e] Assume a PuriNOx+DOC Level 2 could be verified for all model years.
[f] Assume a small percentage of fleet may not be able to use Level 2 devices.
[g] Assume low sulfur fuel used for only installed diesel particulate filters before 2006.
[h] Original equipment – purchased new.

2. Implementation Costs

The initial cost per truck will vary depending on the BACT used for the truck. The initial costs listed in this section are based on capital and O & M costs applied to the scenarios. Staff assumed that a vehicle owner would use the least cost alternative for compliance and attributed that cost to the rule. Capital costs per vehicle and technology for various DECS options are listed in **Table 17**. Staff assumed no capital cost would be required for collection vehicle owners that used the fuel-water emulsion option. O & M costs will be higher from fiscal years

2004 to 2005 to account for the incremental costs of fuel and fuel transportation (**Table 18**) for the diesel particulate filters and oxidation catalysts that will be required to use low sulfur diesel fuel. After July 1, 2006, this added cost will disappear, because the federal low sulfur diesel fuel rule will mandate low sulfur fuel for use by all on-road diesel vehicles and, therefore, no incremental costs are associated with its use. Costs to vehicle owners will vary depending on individual company implementation schedules.

Table 17. Average Capital Costs for Diesel Emission Control Strategies.

	Average Cost ($)		
Cost Description	**Passive Diesel Particulate Filter** [a, b]	**Active Diesel Particulate Filter** [e,f]	**Diesel Oxidation Catalyst** [g,h,i,j]
Device	3,980	10,500	2,830
Installation [c, d]	290	290	290
Engine Backpressure Monitor [k]	1,000	1,000	0
Total Cost:	$5,260	$11,790	$3,120

Note: Costs and how they are derived are described in detail in Appendix F.
[a]MECA, November 2000, Study of DECS costs. 100-500 hp for varying production costs.
[b] U.S. EPA, May 2000, Draft RIA. Cost in 2007, pg. V-9.
[c]U.S. EPA, May 2000, Draft RIA. Includes trap cost, labor, warranty and muffler removal savings.
[d]ARB, June 2001. Installation cost for a muffler through phone conversations with Cummins, Golden State Ford Truck Sales, Caterpillar, and Performance Truck and Diesel.
[e]ARB, 2002. Cost to ARB demonstration program (device plus regeneration unit)
[f] ARB, October 2001. Cost quoted to ARB at Oct. 2001 meeting with active diesel particulate filters providers from Europe
[g]MECA, March 2000. Emission Control Retrofit of Diesel-Fueled Vehicles.
[h]Clean Air Counts, 2002.
[i]Fuelstar, 2000.
[j]Parsons, February 2001.
[k]Cost given at September 4-5, 2001 workshop by MECA members.

Table 18. Incremental Operation and Maintenance Costs for a Retrofitted Collection Vehicle.

Cost Description	Average Cost for Passive and Active DPF and DOC ($) FY 2004 to 2005	Average Cost for Passive and Active DPF and DOC ($) FY 2006 and beyond	Average Cost for Fuel-Water Emulsion ($) FY 2004 and beyond
Increased Maintenance/Cleaning - 1 hour	80[a]	80	0
Incremental Fuel	200[b]	0	2,750[d]
Incremental Fuel Transportation	230[c]	0	0
Total:	$510	$80	$2,750

Note: Costs and how they are derived are described in detail in Appendix F.
[a]Johnson Matthey Guidelines and phone conversation on 6/12/01; MECA meeting 5/19/2001.
[b]Diesel Fuel News, 5/14/01, Vol. 5(10); U.S. EPA, 5/00, Draft RIA.; BP, 6/21/01, meeting.
[c]Benetto, Inc., June, 20 2001.; Diamond Truck Lines. June 20, 2001.
[d]ARB, 2002. Cost quoted to ARB Verification Program.

The cost to repower an engine to meet a 0.01 g/bhp-hr PM emission standard (2007 or later MY) will vary according to the engine model year and vehicle type from which it is being converted. Replacing an electronically-controlled fuel injection engine (1994 and newer MYs) with a 2007 or later MY engine is expected to cost less than replacing a mechanically-controlled fuel injection engine of earlier vintage due to the challenges associated with conversion of mechanical to electronic systems. In some instances it may not be possible to upgrade engines because of space constraints in the engine compartment of the vehicle. An owner would, therefore, need to consider using a DECS or replacing the entire vehicle. In other cases it may be more cost effective to comply by replacing a pre-1994 MY engine with a 1994 to 2006 MY engine and installing a diesel particulate filter.

To determine the costs associated with repowering an engine to meet the 0.01 g/bhp-hr PM emission standard ARB staff surveyed engine providers. Based on the data, the average total cost is $45,000, with a range of $21,000 to $90,000, depending on the engine manufacturer, model, and model year. A DECS, likely a diesel particulate filter, will also be required, which brings the average cost to $50,000 (**Table 19**).

Table 19. Engine Repower.

New Engine Plus Installation	Cost
Average Cost of Repower	$45,000
Average Cost of DECS	$5,000
Average Total Cost:	**$50,000**

While not quantified, two benefits offset the initial cost of repowering an engine, increased fuel economy and decreased maintenance costs. The fuel economy benefit will vary depending on the engine replaced, but as collection vehicles typically achieve only two to three miles per gallon, any fuel economy benefit would result in a significant savings, helping the owner recoup the costs associated with the repower. Similarly, decreased maintenance would result in increased time on the road and fewer repair costs, thus reducing repower costs.

D. Potential Impact on Small Businesses

Staff calculated the average cost for a small fleet of ten vehicles, the typical sized fleet of collection vehicles in California. Staff assumed 80 percent of the vehicles would fall under Group 1 (MY 1988 – 2002), and 20 percent of the vehicles would fall under Group 2 (MY 1960 – 1987) implementation phase-in. For comparison, staff also calculated the average cost for a large fleet of 100 collection vehicles. For the large company staff assumed 80 percent of the vehicles would fall under Group 1, and 20 percent under Group 3 (MY 2003 – 2006) implementation phase-in, because larger companies are assumed to only keep vehicles for five to ten years. The average total estimated costs for a large and small private company to implement this regulation between fiscal years 2004 and 2010[6] are $420,000 and $47,600, respectively (**Table 20**).

[6] Assumes costs paid for during the year leading up to December 31st implementation.

Table 20. Estimated Average Cost to a Small or Large Fleet Collection Vehicle Owner Based on the Average of Three Implementation Scenarios.

Fleet	Number of Vehicles Retrofit	Calendar Years	Discounted Annual Capital Costs [a]	Average Annual O&M Costs [b]	Total Average Annual Cost
Small					
	Varies	2004 – 2005	$100	$600	$700
	Varies	2005 – 2006	$300	$2,200	$2,500
	Varies	2006 – 2007	$400	$4,000	$4,400
	Varies	2007 – 2008	$2,600	$4,400	$7,000
	Varies	2008 – 2009	$5,700	$4,100	$9,800
	Varies	2009 – 2010	$5,700	$3,900	$9,600
	Varies	2010 – 2011	$10,000	$3,600	$13,600
	10	Total:	$24,800	$22,800	$47,600
Large					
	Varies	2004 – 2005	$2,000	$2,000	$4,000
	Varies	2005 – 2006	$5,000	$14,000	$19,000
	Varies	2006 – 2007	$9,000	$29,000	$38,000
	Varies	2007 – 2008	$55,000	$32,000	$87,000
	Varies	2008 – 2009	$52,000	$29,000	$81,000
	Varies	2009 – 2010	$62,000	$29,000	$91,000
	Varies	2010 – 2011	$70,000	$29,000	$99,000
	100	Total	$255,000	$164,000	$419,000

[a] Derived from capital costs using A = (Net Present Value)*(Capital Recovery Factor of 0.07).
[b] Discounted average annual O&M costs for fiscal years 2004 and 2005, include incremental fuel and fuel transportation costs for those vehicle using DECS requiring low sulfur diesel fuel.

As described in the cost effectiveness methodology (Appendix F), in order to translate the capital costs into annualized capital costs, staff used the cost recovery factor of 0.07[7]. For a small fleet of ten collection vehicles, including both annualized capital, such as the DECS, and O & M costs, such as fuel, the average total cost over the implementation phase-in period from fiscal year 2004 to 2010 would range from a minimum of $29,600 to a maximum of $77,400 and have an average total cost of $47,600. For a large fleet of 100 collection vehicles, the total cost would range from $236,000 to $728,000 with an average cost of $419,000. This accounts for variability found in implementing a full range of BACT as discussed in the implementation scenarios based on Current, Potential 1 and Potential 2 verification of DECS.

[7] Capital recovery factor is r(1+r)^N/[(1+r)^N-1] (Linsley, 1977), where r = 0.07 discount rate, and N = 5 years.

E. Potential Impact on Businesses

The regulation allows collection vehicle owners a variety of options to meet the proposed regulation requirements. The proposed regulation may have some cost impact on companies involved in the manufacture and production of engines and collection vehicles by creating the need for new engines and vehicles. The regulation may also impact fuel distributors because it requires early usage of low sulfur diesel fuel. Currently, no solid waste collection engine manufacturers and no solid waste vehicle chassis manufacturers are located in California.

Two solid waste vehicle body manufacturers are located in California. No cost to these manufacturers would exist, although they may experience benefits from increased business due to a potential increase in purchase of new vehicles as a means to meet BACT. Costs to comply with this diesel PM control measure would be borne by the collection vehicle owner. These manufacturers may choose to reduce diesel PM emissions voluntarily by installing DECS before selling new and used vehicles and engines to vehicle owners, but staff expects they would charge for the installation. Specific to the retrofit requirements, California businesses capable of performing engine retrofits will be positively affected with increased workload. As well, the seven DECS manufacturers located in California may be positively affected by this regulation.

F. Potential Impact on Business Competitiveness

The proposed regulation is not expected to impact the ability of California businesses to compete with businesses in other states. As indicated above, many of the businesses that produce the products needed to meet the proposal are located in other states. By requiring new, clean technology, this proposal may actually provide new opportunities for California businesses engaged in advanced technology.

Solid waste collection is, in general, an intrastate activity. Recycling is not. By restricting the scope to residential and commercial collection vehicles in this regulation and not transfer vehicles, staff is attempting to ensure interstate recycling companies will not be adversely affected or unable to compete in the recycling market. Staff also attempted to minimize adverse effects on intrastate business competitiveness by allowing for phase-in of the requirements, giving all vehicle owners time to budget for compliance.

G. Potential Impact on Employment

The proposed regulation will likely create a market for manufacturers of heavy-duty diesel or natural gas solid waste collection engines, vehicles, and emission control systems. For those businesses located in California, the creation of new jobs is expected to meet this demand. Services to retrofit existing collection vehicles are expected to create new opportunities for existing businesses.

H. Potential Impact on Business Creation, Elimination or Expansion

The proposed regulation could impact California companies involved in the manufacture and production of engines, collection vehicles, and DECS. Currently, no solid waste engine or vehicle chassis manufacturers, two collection vehicle body manufacturers, and seven DECS manufacturers are located in California. Allowing new, cleaner engine and collection vehicle purchases as a means to meet the diesel PM control measure could create new business opportunities for manufacturers of heavy-duty diesel or natural gas bus engines, collection vehicles, and DECS. While most businesses that could benefit from the increased business are located outside of California, the total impact on California business will be determined by the extent to which these companies choose to expand in California. This expansion is a result of the expected new business opportunities created by the need for cleaner transportation technologies.

Staff believes this regulation would not significantly impact independent fuel distribution companies. Collection vehicles represent only one percent of the entire diesel-fueled fleet in California and use relatively few gallons of diesel fuel annually in comparison to other fleets.

I. Potential Costs to Local and State Agencies

The proposed regulation is expected to have an impact on public agencies statewide that contract with or own solid waste collection fleets. The following provides a summary of the costs to agencies for complying with the proposed regulation.

Under the proposed requirements, agencies are responsible for installing BACT. Since most public fleets have a fleet turnover rate of about five to seven years, we assumed 80 percent of the vehicles would fall under Group 1, and 20 percent of the vehicles under Group 3. From our inventory of collection vehicles, a total of 1,280 collection vehicles are owned by public agencies; 56 by state agencies (California Department of Transportation or Caltrans), six by federal military agencies, and the remainder by local agencies, such as city and county governments. Based on our vehicle and engine survey, the average number of vehicles owned by public agencies affected by this regulation is 55.

Caltrans and federal agencies will likely not be affected by this regulation as it only applies to those agencies that collect residential and commercial solid waste for a fee. The total estimated statewide cost for local government agencies with solid waste collection fleets would range from $2,869,000 to $8,863,000 with a total average cost of $5,114,000 (**Table 21**) over the entire implementation phase-in period for the three implementation scenarios based on Current, Potential 1, and Potential 2 verification scenarios.

Table 21. Total Estimated Statewide Cost for Local Government Agencies Based on the Average of Three Implementation Scenarios.

Fiscal Year	Discounted Annual Capital Costs [a]	Average Annual O&M Costs [b]	Total Average Annual Cost
2004 – 2005	$29,000	$30,000	$59,000
2005 – 2006	$63,000	$165,000	$228,000
2006 – 2007	$106,000	$356,000	$462,000
2007 – 2008	$667,000	$384,000	$1,051,000
2008 – 2009	$637,000	$359,000	$996,000
2009 – 2010	$751,000	$359,000	$1,110,000
2010 – 2011	$850,000	$358,000	$1,208,000
TOTAL	$3,103,000	$2,011,000	$5,114,000

For public agencies that contract with private solid waste collection companies, an increase in the contract cost may occur within the terms of the contract or at the renewal of the contract.

J. Cost to the Average Household Receiving Waste Collection Service

Municipalities, or collection vehicles owners directly, are expected to pass through the cost to implement the proposed regulation on to ratepayers. The total cost per household in California, over the implementation period of fiscal year 2004 to 2010, would be approximately $5.90, or $0.85 annually. This figure was derived from dividing the total statewide dollar costs that businesses and individuals may incur from this proposed regulation over its lifetime of about $73,100,000 by the number of estimated households in California from fiscal year 2004 to 2010, or 12,500,000 households (Center for Continuing Study of the California Economy 2001).

IX. Environmental Impacts and Cost-Effectiveness

The proposed regulation would provide significant cost-effective diesel PM emission reductions throughout California, especially at the neighborhood level. The air quality benefits statewide would be not only from reduction of diesel PM emissions, but also from reduction of NOx, HC, and CO emissions as well. For the purposes of the cost effectiveness analysis, staff not only considered the benefits of reducing diesel PM, but also the benefits from reducing HC and NOx emissions. Furthermore, cancer risk as a result of exposure to diesel PM will be reduced by a factor of ten from a high of about 31 cases per million to about three in a million in the highest exposed areas (See Section III. F.). In determining costs associated with air quality benefits, staff relied on the results of an extensive survey of the solid waste management industry and queries of the DMV database.

A. Benefits

1. Statewide Benefits

ARB staff estimates the proposed diesel PM control measure would result in the reduction of between 1.03 and 1.15 tpd of diesel PM emissions in 2010 and between 0.75 and 0.91 tpd diesel PM reduced in 2020 (**Table 22**). The reduction of diesel PM emissions attributed to this regulation peaks around 2010 because all collection vehicles are expected to meet the diesel PM control measure by 2010. After 2010 the benefits attributed to this regulation decline to between 0.75 and 0.91 tpd in 2020 as vehicles are retired and replaced with new engines that meet the federal 2007 0.01 g/bhp-hr PM standard.

Table 22. Statewide Diesel PM Emission Reduction Benefits.

Calendar Year	Baseline Inventory (tpd)	Diesel PM Reduction (tpd)		
		Current	Potential 1	Potential 2
2005	1.57	0.05	0.09	0.15
2010	1.42	1.15	1.03	1.12
2015	1.36	1.16	0.97	1.06
2020	1.12	0.91	0.75	0.84

Other air quality benefits also exist as a result of the use of the various BACT, including reduced emissions of CO, HC, and NOx. The reductions in HC are also accounted for in the State Implementation Plan. Based on expected reduction capabilities from the various DECS that might be used (**Table 23**), reductions of up to 9.44 tons of CO per day (**Table 24**), 3.69 tons of HC per day (**Table 25**), and 20.5 tons of NOx per day (**Table 26**) are predicted.

Table 23. Other Pollutant Potential Reductions from Diesel Emission Control Strategies.

Diesel Emission Control Strategy	Emission Reduction (Percent)			
	PM	CO	HC	NO_x
Passive Diesel Particulate Filter	85[a]	90[b]	95[b]	0[c]
Fuel-Water Emulsion[h]	50[a]	35[d]	60[d]	50[d]
Average Diesel Oxidation Catalyst	25[a]	47[e, f]	76[e, f]	0[c]

[a]Verified Level Reduction Goals for ARB. Strategies will not be verified without meeting this standard at a minimum.
[b]Allansson, R, Cooper, BJ, Thoss, JE, Uusimaki, A, Walker, AP, Warren, JP, 2001, European Experience of High Mileage Durability of Continuously Regenerating Diesel Particulate Filter Technology. SAE. 2001-01-0480.
[c]Majewski, W. Addy, 2001, Diesel Net Technology Guide: Diesel Particulate Traps. www.dieselnet.com.
[d]Diesel Net Technology Guide: Emission Control Technologies, 1998. www.dieselnet.com.
[e]Diesel Net Technology Guide: Diesel Oxidation Catalyst, 1999. www.dieselnet.com.
[f]Khair, Magdi; McKinnon, Dale L. Performance Evaluation of Advanced Emission Control Technonlogies for Diesel Heavy-Duty Engines. SAE. 1999-01-3564.
[h]Fuel-water emulsion increases CO and HC emissions. Although can be verified alone for the purposes of simplifying calculations, assumed it would be used in conjunction with a diesel oxidation catalyst to decrease impact of increase. Choose least decrease to account for offset of increase from fuel-water emulsion.

Table 24. Statewide Diesel Carbon Monoxide Emission Reduction Benefits.

Calendar Year	Baseline Inventory (tpd)	Diesel CO Reduction (tpd)		
		Current	Potential 1	Potential 2
2005	11.9	0.70	1.20	0.80
2010	11.8	9.11	9.44	8.86
2015	11.5	9.24	9.02	8.23
2020	9.59	7.15	7.00	6.44

Table 25. Statewide Diesel Hydrocarbon Emission Reduction Benefits.

Calendar Year	Baseline Inventory (tpd)	Diesel HC Reduction (tpd)		
		Current	Potential 1	Potential 2
2005	4.20	0.27	0.45	0.38
2010	4.10	3.45	3.69	3.55
2015	3.90	3.49	3.45	3.35
2020	3.04	2.59	2.60	2.50

Table 26. Statewide Diesel Oxides of Nitrogen Emission Reduction Benefits.

Calendar Year	Baseline Inventory (tpd)	Diesel NOx Reduction (tpd)		
		Current	Potential 1	Potential 2
2005	33.8	0	0	0
2010	27.4	16.2	13.0	18.1
2015	31.5	19.3	14.6	20.5
2020	27.5	15.6	11.3	17.0

2. Impacts on the State Implementation Plan for PM_{10}

The anticipated benefits of this proposed rule is part of the draft State Implementation Plan (SIP) for PM_{10} in the San Joaquin Valley. That plan is scheduled for adoption in June 2003, with attainment of the federal PM_{10} standard projected by 2010. As a "serious" nonattainment area, the San Joaquin Valley must use best available control measures for all sources of PM_{10} in its district and must also achieve five percent annual emission reductions in PM_{10} and its precursors. The San Joaquin Valley has seven percent of the statewide solid waste collection vehicles and will see a benefit of 0.07 to 0.08 tpd of PM reduced by 2010. In addition, the NOx and volatile organic carbon (VOC) benefits of the proposed rule are contained in the plan, as they are precursors to secondary PM formation.

The South Coast air basin is also classified as "serious" for PM_{10} but it attainment deadline is 2006, before most of the benefits of the proposed rule will be achieved. Nonetheless, the proposed rule will help that District maintain compliance with the federal PM_{10} standard. The rule also serves as a down payment on future plans to achieve the federal $PM_{2.5}$ standards and California's own, more stringent standards. Thirty-five percent of California's solid waste collection vehicles are in the South Coast region. By 2010, the proposed rule will reduce emissions from those vehicles by 0.36 to 0.40 tpd.

All other PM_{10} nonattainment areas in California will benefit from the proposed rule in a general way. Every district buy Lake County is nonattainment for the California PM_{10} standard. In addition, four other areas in California are nonattainment for the federal PM_{10} standards: Owens Valley, Searles Valley, Coachella Valley, and Imperial Valley.

For ozone SIPs there is a similar situation. The South Coast and San Joaquin Valley have new federal ozone plans under development, with adoption tentatively scheduled for September 2003 and December 2003, respectively.

Both districts have an attainment deadline of 2010 for the federal one-hour ozone standard. The overall NOx and VOC benefits of ARB's planned diesel in-use PM reduction rules are contained in the draft South Coast ozone plan and will be included in the San Joaquin Valley ozone plan once it is released for public review. The Sacramento Metropolitan region is considering an ozone plan update and would include ARB's diesel in-use PM reduction control measures if its attainment deadline ultimately shifts from 2005 to 2010.

As with PM_{10}, all other ozone nonattainment areas in California will benefit from the proposed rule in a general way as it reduces the precursors to ozone formation (see **Tables 25 and 26**).

3. Cost-Effectiveness of Proposed Regulation

The estimated average cost-effectiveness of this proposed diesel PM emission reduction regulation, considering only the benefits of reducing diesel PM, is approximately $28/lb of PM reduced annually from fiscal years 2004 to 2010. This rule will also result in significant emission reductions of HC and NOx, however, thus it is valid to allocate half of the cost of compliance to the benefits of HC and NOx reduction. The cost-effectiveness for reducing HC and NOx, which are ozone precursors and contributors to secondary PM formation, is $0.71/lb HC+NOx. The cost-effectiveness of PM reduction declines to $13/lb when half of the cost of compliance is allocated to HC+NOx reduction in this way. The costs and emission reductions associated with this regulation and how they were derived are discussed in Appendix F. Both capital costs, such as the purchase and installation of a DECS or new engine, and O & M costs, such as incremental fuel cost for low sulfur diesel fuel, are included in this analysis.

The cost-effectiveness of this regulation is consistent with the predicted costs associated with other regulations. Other California mobile source regulations adopted over the past decade had cost-effectiveness values ranging from $0.17 to $2.55/lb of ozone precursors reduced. The cost-effectiveness of the fleet rule for transit agencies, which calculated the cost effectiveness by allocating all of the costs to reducing diesel PM, was $25/lb of PM reduced.

B. Potential Negative Impacts

Certain potential negative impacts could be associated with elements of this proposed regulation. Those potential negative impacts are discussed below.

1. Creation Of Nitrogen Dioxide By Passive Catalyzed Diesel Particulate Filters

Measurements of NO_X emissions for heavy-duty diesel vehicles equipped with passive catalyzed filters have shown an increase in the portion of NO_2 emissions in total NO_X emissions, although the total NO_X emissions remain approximately the same. The passive catalyzed filters oxidize some of the nitrogen oxide (NO) emissions to NO_2 to burn soot captured in the filter. More NO_2 is created than is actually being used in the regeneration process; and the excess is emitted. The NO_2 to NO_X ratios could range from 20 to 70 percent, depending on factors such as the diesel particulate filter systems, sulfur level in diesel fuel, and the duty cycle (DaMassa 2002).

Formation of NO_2 is a concern because it irritates the lungs and lowers resistance to respiratory infections. Individuals with respiratory problems, such as asthma, are more susceptible to the effects. In young children, nitrogen dioxide may also impair lung development.

In addition, even though a relatively small portion of collection vehicles are expected to use diesel particulate filters, model simulations based on a 90 percent market penetration of diesel particulate filters with assumed NO_2 to NOx ratios at 15, 20, 25, 30, and 50 percent, found a NO_2 to NO_X emission ratio of approximately 20 percent would nearly eliminate any impact of increased NO_2 emissions (ARB, 2002a; **Table 27**). According to the model, at the NO_2 to NOx ratio of 20 percent, there will be a decrease of the 24-hour ozone exposure (greater than 90 parts per billion) by two percent while an increase of the peak 1-hour NO_2 by six percent (which is still within the NO_2 standard). The health benefits derived from the use of PM filters are immediate and offset the possible adverse effects of increases in NO_2 emissions. For this reason, a cap of 20 percent NO_2 to NO_X emission ratio was established for all DECSs through ARB's Verification Procedure.

Table 27. Summary of Potential Impact from Modeled NO_2/NOx Ratios.

Diesel NO_2/NOx Ratios:	**15%**	**20%**	**25%**	**30%**	**50%**
Summer 24-hour O_3 Exposure >90 ppb (%)	-3	-2	0	+2	+5
Winter Peak 1-hr Exposure NO_2 (%)	+1	+6	+12	+18	+41

2. Diesel Oxidation Catalyst Emissions and Disposal

Two potential adverse environmental impacts of the use of diesel oxidation catalysts have been identified. First, as is the case with most processes that incorporate catalytic oxidation, the formation of sulfates increases at higher temperatures. Depending on the exhaust temperature and sulfur content of the fuel, the increase in sulfate particles may offset the reductions in soluble organic fraction emissions. Using low sulfur diesel fuel can minimize this effect. Second, a diesel oxidation catalyst could be considered a "hazardous waste" at the end of its useful life depending on the materials used in the catalytic coating. However, diesel oxidation catalysts are usually recycled for their precious metal content and thus are not managed as hazardous wastes in practice. Recycling also reduces any potential impact on landfill capacity.

3. Ash Management

Diesel particulate filter technology may generate a new hazardous waste stream. The carbonaceous component of the PM captured by the filter is burned off when the filter regenerates. Any inorganic components left behind after regeneration as ash in the filter must eventually be cleaned from the filter. Based on preliminary data from two samples, the ash may be classified as hazardous waste because of its zinc content.

Ash collected from a diesel engine using a typical lubrication oil and no fuel additives has been analyzed and is primarily composed of oxides of the following elements: calcium, zinc, phosphorus, silicon, sulfur, and iron. Zinc is the element of primary concern because, if present in high enough concentration, it can make a waste a hazardous waste. Title 22, CCR, section 66261.24 establishes two limits for zinc in a waste: 250 milligrams per liter for the Soluble Threshold Limit Concentration and 5,000 milligrams per kilogram for the Total Threshold Limit Concentration. The presence of zinc at or above these levels would cause a sample of ash to be characterized as a hazardous waste.

Under California law, it is the generator's responsibility to determine whether their waste is hazardous or not. Applicable hazardous waste laws are found in the HS&C, division 20; title 22, CCR, division 4.5; and title 40 of the Code of Federal Regulations. Staff recommends owners that install a diesel particulate filter on a vehicle contact both the manufacturer of the DECS and the California Department of Toxic Substances Control (DTSC) for advice on waste management.

ARB staff has consulted with personnel of the DTSC regarding management of the ash from diesel particulate filters. DTSC personnel have advised ARB that it has a list of facilities that accept waste from businesses that qualify as a conditionally exempt small quantity generator. Such a business can dispose of a specific quantify of hazardous waste at certain Household Hazardous Waste events, usually for a small fee. An owner who does not know whether or not he qualifies or who needs specific information regarding the identification and acceptable disposal methods for this waste should contact the California DTSC.[8]

X. ISSUES

Over the course of development of this proposal, staff has met many times with various stakeholders and received written and verbal comments. Although staff has considered each comment, not all issues could be resolved and achieve

[8] Information can be obtained from local duty officers and from the website: http://www.dtsc.ca.gov.

ARB's goals to reduce diesel PM emissions from solid waste collection vehicles. Following is a discussion of major outstanding issues.

A. Cost Recovery by Rate-Regulated Companies

The main issue raised by the industry workgroup to ARB is cost recovery by companies that have their rates regulated by contract with a municipality. These companies, termed "rate-regulated," have long-term contracts and are unable to raise their rates without amending their contracts. As a municipality is often under no obligation to amend the contract until its term is up, the industry workgroup members felt that rate-regulated companies would be at risk of losing profitability because of this proposed regulation.

The industry workgroup therefore recommended ARB require municipalities to bear full responsibility for implementation of the regulation. Collection vehicle owners under contract would not be directly obligated to comply, but rather ARB would enforce against the appropriate municipality if a vehicle was found to be out of compliance. For example, if a collection vehicle working in a specific city on a specific day were found to be out of compliance, that city would be subject to enforcement. By placing the responsibility of implementation on the municipalities, workgroup members felt the financial burden would also be placed upon the municipalities and that rates would be raised to cover the compliance costs.

Staff agrees compliance costs should be reflected in solid waste collection contracts and related fees passed onto households. The industry workgroup proposal, however, creates other issues that will complicate and potentially frustrate implementation. Imposing the burden of implementation on a municipality that has a contract with a solid waste collection company would make the municipality the de facto owner of the vehicle. The municipality, however, does not make purchasing or leasing decisions regarding the vehicles, although it may specify the types of vehicles acceptable through the contract. In addition, the municipality does not employ the maintenance staff, nor schedule or supervise maintenance. Further, placing this responsibility directly on municipalities would require them to hire and train staff to oversee maintenance and ensure compliance, thus duplicating a responsibility of a collection vehicle owner. The costs of this rule would therefore be higher than under the recommended alternative.
Under this proposal, enforcement would be overly cumbersome and create confusion. ARB inspectors would have to determine the municipality for which each truck is working under contract and deliver notices of violation or tickets to the responsible municipality. A truck working for one municipality, however, could be redirected to work for another on a different day because of scheduling needs.

In summary, the industry proposal lacks sufficient enforcement mechanisms, misplaces operational compliance with the control measure, and is neither effective nor efficient at achieving the goals of the Diesel Risk Reduction Plan. This industry proposal would also be more costly than the staff proposal. Staff, therefore, has not proposed placing the sole responsibility for compliance on a municipality that contracts for service. Municipalities do, however, share responsibility for compliance and ARB may enforce against either or both parties when vehicles are found to be out of compliance.

B. Accelerated Implementation

Staff has also met several times with a group representing environmental organizations concerned with air pollution. This group has proposed accelerating the implementation schedule to achieve PM emission reductions sooner than in the staff proposal. Two objectives have been presented to staff: first, to accelerate the oldest vehicles to implement in advance of 2007, and second, to accelerate implementation of the newest vehicles, those with MY 2003-2006 engines.

Staff has already accelerated one group of vehicles in response to this request by moving MY 1988 through 1993 engines into the first implementation group. Staff is continuing to analyze the potential costs and benefits of this option, but our analysis to date does not show a great enough benefit from further implementation acceleration to justify the greater expense of compressing the compliance schedule

Group 2 (MY 1960 – 1987) engines are the most challenging to retrofit with a DECS because they have higher PM emissions and tend to have colder engine exhaust temperatures. Manufacturers of DECSs have also not moved to verify technology for these engines. Staff therefore believes the majority of these engines will have to be repowered. As the new engine standard of 0.01 g/bhp-hr PM begins with the 2007 model year, staff proposes beginning implementation in 2007 to get the maximum PM emission reductions at the most reasonable cost. An earlier start date for implementation would mean that the owner would be required to purchase an engine certified to 0.1 g/bhp-hr and install a DECS to comply. An owner may be able to install a Level 3 DECS, achieving close to 0.01 g/bhp-hr PM emissions, but if Level 3 is not indicated for that engine and duty cycle combination an owner may instead have to use a Level 1 or Level 2 technology, thus achieving lower PM reductions in practice.

Group 3 (MY 2003-2006) engines, while seemingly easy to retrofit, actually suffer from a similar issue. Manufacturers of DECS have thus far had difficulties in verifying passive DPFs for these engines because of the use of exhaust gas recirculation (EGR) to reduce NOx emissions as required. An accelerated implementation schedule could, therefore, result in more of these vehicles using Level1 or Level 2 technology, thus losing emission benefits staff anticipates under its current schedule. An additional issue is that overlapping compliance schedules with Groups 1 (MY 1988 – 2002) and 2 (MY 1960 – 1987) would increase the year-by-year costs of compliance for owners and make the cost of this rule more burdensome for vehicle owners.

Staff has not, therefore, incorporated the recommendations for accelerating the implementation schedule presented by the environmentalist groups.

XI. SUMMARY AND STAFF RECOMMENDATION

Despite significant success in reducing overall pollution levels, air pollution continues to be an important public health problem. Air monitoring shows over 90 percent of Californians breathe unhealthy levels of one or more air pollutants during some part of the year. ARB has set standards for eight criteria pollutants, such as ozone and PM. In addition to this standard, ARB identified diesel PM as a TAC – a pollutant that even at low levels, may cause serious long-term health effects, such as cancer. These toxics have no known safe levels, and some may accumulate in the body from repeated exposures. ARB must continue its effort to protect the health of Californians, particularly those most sensitive to the effects of air pollution, such as children and the elderly, by reducing pollution from all sources.

Therefore, ARB staff recommends the Board adopt new sections 2020, 2021.1 and 2021.2, title 13, chapter 1, article 4, CCR, in its entirety. The regulation is set forth in the proposed regulation order in Appendix A.

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APPENDIX A

PROPOSED DIESEL PARTICULATE MATTER CONTROL MEASURE FOR ON-ROAD HEAVY-DUTY DIESEL-FUELED RESIDENTIAL AND COMMERCIAL SOLID WASTE COLLECTION VEHICLES

1. Adopt article 4 within chapter 3, division 3, title 13, California Code of Regulations, and new sections 2020, 2021.1, and 2021.2, to read as follows: (Note: The entire text of sections 2020, 2021.1, and 2021.2 set forth below is new language proposed to be added to the California Code of Regulations.)

Section 2020 Purpose and Definitions for Diesel Particulate Matter Control Measures

(a) **Purpose**. Diesel particulate matter was identified in 1998 as a toxic air contaminant. According to California law, an airborne toxic control measure using the best available control technology shall, therefore, be employed to reduce the public's exposure to diesel particulate matter.

(b) **Definitions**. For the purposes of the fleet rule specified in article 4, the following definitions apply:

"Active fleet" means the total, by terminal, of an owner's vehicles, excluding backup vehicles.

"Alternative fuel" means the same as in title 13, California Code of Regulations, section 1956.2(b)(1).

"Backup vehicle" means a vehicle that is driven less than 1000 miles annually.

"Commercially available" means available for purchase and installation at a reasonable cost.

"Contract" means to authorize an owner, through a contract, franchise agreement, permit, license or similar approval from a municipality, to perform residential or commercial solid waste collection service.

"Contractor" means an owner with a contract, franchise agreement, permit, license or similar approval from a municipality to collect residential or commercial solid waste.

"Heavy-duty pilot ignition engine" means an engine designed to operate using an alternative fuel, except that diesel fuel is used for pilot ignition at an average ratio of no more than one part diesel fuel to ten parts total fuel on an energy equivalent basis. An engine that can operate or idle solely on diesel fuel at any time does not meet this definition.

"Level" means one of three categories of Air Resources Board-verified diesel emission control strategies: Level 1 means the strategy reduces engine diesel particulate matter emissions by between 25 and 49 percent, Level 2 means the strategy reduces engine diesel particulate matter emissions by between 50 and 84 percent, and Level 3 means the strategy reduces engine diesel particulate matter emissions by 85 percent or greater, or emits less than or equal to 0.01 grams per brakehorse power-hour diesel particulate matter.

"Municipality" means a city, county, city and county, special district, or a public agency of the United States of America or the State of California, and any department, division, public corporation, or public agency of this State or of the United States, or two or more entities acting jointly, or the duly constituted body of an Indian reservation or rancheria.

"Owner" means the same as in title 13, California Code of Regulations, section 2180.1(21).

"Retirement" means the vehicles will no longer be used as part of an active fleet in California. It may be sold outside of California, scrapped, or used as a back up vehicle.

"Residential and commercial solid waste" means all putrescible and nonputrescible solid, and semisolid wastes, including garbage, trash, refuse, rubbish, ashes, yard waste, recyclable materials, industrial wastes, demolition and construction wastes, abandoned vehicles and parts thereof, discarded home and industrial appliances, manure, vegetable or animal solid and semisolid wastes, and other discarded solid and semisolid wastes originating from single-family or multiple family dwellings, stores, offices, and other commercial sources, and construction and demolition projects in residential and commercial zones, not including hazardous, radioactive, or medical waste.

"Roll off vehicle" means any heavy-duty vehicle used for transporting waste containers such as open boxes or compactors that may be removed from the tractor.

"Solid waste collection vehicle" means an on-road heavy-duty vehicle with a manufacturer's gross vehicle weight rating of greater than 14,000 pounds used for the purpose of collecting residential and commercial solid waste for a fee, including roll off vehicles.

"Terminal" means any place or places where a vehicle is regularly garaged or maintained, or from which it is operated or dispatched, which may include a private business or residence.

"Verified" means that a diesel emission control strategy or system has received approval from the Executive Officer according to the "Verification Procedure for In-Use Strategies to Control Emissions from Diesel Engines" in title 13, California Code of Regulations, commencing with section 2700, and incorporated by reference.

"Warranty Period" means the same as in title 13, California Code of Regulations, section 2707.

NOTE: Authority cited: Sections 39600 and 39601, Health and Safety Code. Reference: Sections 39002, 39003, 39658, 43000, 43013, 43018, 43101, 43102, 43104, 43105 and 43700.

Section 2021 . Diesel Particulate Matter Control Measure for On-road Heavy-duty Diesel-fueled Residential and Commercial Solid Waste Collection Vehicles

(a) **Scope and Applicability.** Section 2021, 2021.1, and 2021.2 shall apply to solid waste collection vehicles owners, both private and government entities, and to municipalities that authorize owners through a contract, franchise agreement, permit, license or similar approval for residential and commercial solid waste collection service. These regulations mandate the reduction of diesel PM emissions from 1960 to 2006 model-year engines in on-road diesel-fueled heavy-duty residential and commercial solid waste collection vehicles with a manufacturer's gross vehicle weight rating greater than 14,000 pounds.

(b) **Definitions.** The definitions in section 2020 shall apply to sections 2021, 2021.1, and 2021.2.

NOTE: Authority cited: Sections 39600 and 39601, Health and Safety Code, Reference: Sections 39002, 39003, 39658, 43000, 43013, 43018, 43101, 43102, 43104, 43105, and 43700.

Section 2021.1. Methods for Determining Compliance with the Diesel Particulate Matter Control Measure for a Municipality that Contracts with Owners for Solid Waste Collection.

(a) **Compliance Requirement.** As of December 31, 2004, a municipality shall ensure that each contractor, for which it regulates the rates that may be charged to those who receive solid waste collection services, is in compliance with title 13, California Code of Regulations, section 2021.2.

(b) **Reporting Requirement.** A municipality shall submit the following reports to the Executive Officer as described in subparagraphs (1) and (2) below:

(1) Initial Report. A municipality shall submit a report by August 1, 2004, to the Executive Officer listing all its contractors as of June 30, 2004. Each report shall include the following:

(A) Municipality name, address, telephone number, fax number, contact name and electronic mail address;

(B) For each contract, the contractor name, owner name, contact name, if different from owner name, business address, business telephone number, business fax number, the address of each terminal, California Highway Patrol issued California fleet identification, terminal identification numbers of terminals serving that municipality, and an active fleet list by vehicle identification numbers serving the municipality;

(C) A description of total cost and a funding source to bring a contractor into compliance with title 13, California Code of Regulations, section 2021.2 to the extent to which a municipality regulates rates.

(2) Annual Reports. A municipality shall submit annual reports to the Executive Officer listing all its contractors as of January 1st of each applicable year beginning January 31, 2006, and every January 31st through the year 2013. Each report shall include all of the information in paragraph (b)(1), and in addition the following:

(A) An annual signed statement from each contractor stating it is in compliance with title 13, California Code of Regulations, section 2021.2; or

(B) An annual signed statement from the municipality stating that signed statements have been received from each contractor in accordance with paragraph (b)(2)(A); and

(C) Any new contractor information since the previous report as specified in (b)(1)(B); and

(D) The name of any contractor who has not submitted the annual signed statement required in (b)(2)(A) and the information for that contractor as specified in (b)(1)(B).

(c) **Non-Compliance by a Contractor**. Following submission of the initial or annual report required in (a) or (b):

(1) Upon determination by the municipality that a contractor is not in compliance with title 13, California Code of Regulations, section 2021.2, the municipality shall notify the Executive Officer in writing of the non-compliance within 30 days of the determination.

(2) Within seven days of receipt of any notification that the contractor's solid waste collection vehicle is not in compliance with title 13, California Code of Regulations, section 2021.2, the contractor shall send the municipality or municipalities served the notification or a copy thereof.

(d) **Non-Compliance by a Municipality**. Any violations of this section may carry civil penalties as specified in state law and regulations, including, but not limited to, Health and Safety Code section 44381.

NOTE: Authority cited: Sections 39600 and 39601, Health and Safety Code. Reference: Sections 39002, 39003, 39658, 43000, 43013, 43018, 43101, 43102, 43104, 43105 and 43700.

Section 2021.2 Methods for Determining Compliance with Diesel Particulate Matter Control Measure for an Owner of Solid Waste Collection Vehicles and a Municipality that Contracts for Solid Waste Collection Service.

(a) **Compliance Requirements**. As of the applicable effective dates, an owner who operates an active fleet of one or more solid waste collection vehicles and a municipality that contracts for solid waste collection service are required to comply with this diesel particulate matter control measure. Compliance requires:

(1) Use of a best available control technology for each solid waste collection vehicle in the active fleet as specified in paragraph (b),

(2) Implementation for solid waste collection vehicles in the active fleet as specified in paragraph (c), and

(3) If a compliance deadline extension is granted by the Executive Officer per paragraph (d), the owner shall be deemed to be in compliance as specified by the Executive Officer's authorization.

(4) Special circumstances may apply when a diesel emission control strategy is used as a best available control technology as specified in paragraph (e).

(5) Record keeping as specified in paragraph (f).

(6) Continuous Compliance. Once a vehicle is in compliance with this regulation it must remain in compliance for the life of the vehicle while it is operated in California.

(b) **Best Available Control Technology**. Each owner shall use one of the following best available control technologies on each engine in his active fleet as required by the implementation schedule in paragraph (c):

(1) An engine or power system alone, or used in combination with a verified diesel emission control strategy, that is certified to the optional 0.01 g/bhp-hr particulate emission standard as specified in title 13, California Code of Regulations, section 1956.8(a)(2), or the 0.01 g/bhp-hr particulate emission standard as specified in title 13, California Code of Regulations, section 1956.8(a), when effective; or

(2) An alternative fuel or heavy-duty pilot ignition engine. Model Year 2004 – 2006 engines must be certified to the optional, reduced emission standards as specified in title 13, California Code of Regulations, section 1956.8 (a)(2)(A); or

(3) The highest level diesel emission control strategy per title 13, California Code of Regulations, section 2702 (f), Table 1, that is verified for a specific engine to reduce diesel particulate matter and which the diesel emission control

strategy manufacturer or authorized dealer agrees can be used on a specific engine and vehicle combination, without jeopardizing the original engine warranty in effect at the time of application.

(c) **Implementation Schedule.** The owner shall comply with the schedule in Table 1 - Implementation Schedule for Solid Waste Collection Vehicles, Model Years 1960 to 2006, for the specified percentage of vehicles by each applicable compliance deadline.

Table 1 - Implementation Schedule for Solid Waste Collection Vehicles, Model Years 1960 to 2006.

Group	Engine Model Years	Percentage of Group to Use Best Available Control Technology	Compliance Deadline
1	1988 – 2002	10	December 31, 2004
		25	December 31, 2005
		50	December 31, 2006
		100	December 31, 2007
2[a]	1960 – 1987	25	December 31, 2007
		50	December 31, 2008
		75	December 31, 2009
		100	December 31, 2010
3	2003 – 2006	50	December 31, 2009
		100	December 31, 2010

[a]Group 2: An owner of an active fleet of 15 or more collection vehicles may not use Level 1 technology as best available control technology.

(1) Calculating Number of Vehicles Required for Implementation based on Active Fleet Size. The owner shall calculate the size of his active fleet on January 1st of each year. The total number of solid waste collection vehicles required to be in compliance by the "Compliance Deadline" (TotVeh) is calculated by multiplying "Percentage of Group to Use Best Available Control Technology" (Group%BACT) for that year by the sum of the number of solid waste collection vehicles in an engine model year group (#SWCV) as in this following expression:

TotVeh= Group%BACT * (#SWCV)

(A) The total number of solid waste collection vehicles in compliance (TotComp) as of the calculation date shall be subtracted from TotVeh to determine the total number of additional solid waste collection vehicles required to be brought into compliance (TotAddComp) before the next compliance deadline as in the following expression:

TotAddComp = TotVeh – TotComp

(B) If the TotAddComp is not equal to a whole number of solid waste collection vehicles, the owner is expected to round up to the nearest solid waste collection vehicle when the fractional part of TotAddComp is greater than or equal to one-half of a solid waste collection vehicle, and expected to round down to the nearest solid waste collection vehicle when the fractional part of TotAddComp is less than one-half of a solid waste collection vehicle.

(d) **Compliance Extensions**. An owner may receive an extension in compliance for the following reasons:

(1) Compliance Deadline Extensions based on Early Implementation.

(A) If an owner has implemented best available control technology on fifty percent or more of his Group 1 solid waste collection vehicles by December 31, 2004, then the owner may delay the 100 percent compliance deadline for Group 1 to December 31, 2009.

(B) If an owner has implemented best available control technology on fifty percent or more of his Group 2 solid waste collection vehicles by December 31, 2006, then the owner may delay the 100 percent compliance deadline for Group 2 to December 31, 2012.

(2) No Verified Diesel Emission Control Strategy. If the Executive Officer has not verified a diesel emission control strategy, or one is not commercially available, for a particular engine and vehicle combination, an annual extension in compliance may be granted by the Executive Officer under the conditions specified in (A) or (B) below:

(A) Executive Officer Compliance Extension. The Executive Officer shall grant a blanket one-year compliance extension if a diesel emission control strategy is not verified for an engine ten months prior to each compliance deadline specified in paragraph (c).

(i) For Group 1 solid waste collection vehicle engines, the Executive Officer shall grant an annual extension through 2007, after which the owner shall comply with paragraph (b) by December 31, 2008.

(ii) For Groups 2 and 3 solid waste collection vehicle engines, the Executive Officer shall grant an annual extension through 2010, after which the owner shall comply with paragraph (b) by December 31, 2011.

(B) Owner Application Compliance Extension. An owner may apply to the Executive Officer for a compliance extension for one or more engines if a diesel emission control strategy is not verified by the Executive Officer, it would jeopardize the original engine warranty, or is not commercially available, for an engine six months prior to each compliance deadline specified in paragraph (c). The owner must provide documentation as follows:

(i) Identification of each engine for which no diesel emission control strategy has been verified, or

(ii) Identification of each engine for a specific diesel emission control strategy would jeopardize the original engine warranty and a statement from each engine manufacturer or authorized dealer stating the original engine warranty would be jeopardized.

(iii) Identification of each engine and vehicle combination for which no diesel emission control strategy is commercially available and a list of manufacturers that have been contacted with their responses to a request to purchase.

(iv) The owner shall certify by signature that he is in compliance as required in paragraph (b) for all applicable active fleet vehicles.

(v) The application for compliance extension must be received by the Executive Officer no later than July 31 annually beginning 2004. For Group 1 solid waste collection vehicle engines, the Executive Officer will accept an annual compliance extension application until July 31, 2007, after which the owner shall comply with paragraph (b) by December 31, 2008. For Groups 2 and 3 solid waste collection vehicle engines, the Executive Officer will accept an annual compliance extension application until July 31, 2010, after which the owner shall comply with paragraph (b) by December 31, 2011.

(3) Active Fleet with Fewer than Four Vehicles. An owner with three or fewer solid waste collection vehicles in his active fleet may delay the compliance deadline of any engine in Group 1 to December 31, 2007, and in Group 2 to December 31, 2010.

(e) **Diesel Emission Control Strategy Special Circumstances.** An owner shall maintain best available control technology on each vehicle once that vehicle is in compliance, and is not required to upgrade to a higher level of best available control technology, except under specified special circumstances.

(1) Diesel Emission Control Strategy Failure or Damage. In the event of a failure or damage of a diesel emission control strategy, the following conditions apply:

(A) Failure or Damage During Warranty Period. If a diesel emission control strategy fails or is damaged within its warranty period and the diesel emission control strategy manufacturer or authorized dealer determines it can not be repaired, the owner shall replace the diesel emission control strategy with either the same level diesel emission control strategy or another best available control technology as defined in paragraph (b).

(B) Failure or Damage Outside of Warranty Period. If a diesel emission control strategy fails or is damaged outside of its warranty period, and it cannot be repaired, the owner shall install a diesel emission control strategy that is the best available control technology at that time as defined in paragraph (b) unless it meets (4) below.

(2) Discontinuation of Fuel Verified as a Diesel Emission Control Strategy. In the event another best available control technology is not commercially available within 30 days from the date of discontinuation of a fuel verified as a diesel emission control strategy, the owner shall submit a compliance plan to the Executive Officer no later than 60 days after discontinuation that demonstrates the owner will bring his active fleet into compliance within six months.

(3) Level 1 Diesel Emission Control Strategy. If a Level 1 diesel emission control strategy is identified as the best available control technology pursuant to paragraph (b), an owner is subject to the following limitations:

(A) Group 1. An owner may use a Level 1 diesel emission control strategy in a Group 1 engine for ten years, after which the owner shall replace the Level 1 diesel emission control strategy with the best available control technology from subparagraph (b), except that a Level 1 diesel emission control strategy cannot be installed.

(B) Group 2. An owner with fewer than 15 vehicles in his active fleet may use a Level 1 diesel emission control strategy in a Group 2 engine for ten years, after which the owner shall replace the Level 1 diesel emission control strategy with the best available control technology from subparagraph (b), except that a Level 1 diesel emission control strategy cannot be installed.

(C) Group 2. An owner with 15 or more vehicles in his active fleet may not use a Level 1 diesel emission control strategy on any Group 2 engine.

(D) Group 3. An owner may use a Level 1 diesel emission control strategy in a Group 3 engine for five years, after which the owner shall replace the Level 1 diesel emission control strategy with the best available control technology from subparagraph (b), except that a Level 1 diesel emission control strategy cannot be installed.

(4) Engine Retirement Exemption. If an owner determines that an engine is within one year of retirement from the active fleet, the owner is exempt from applying the best available control technology as defined in paragraph (b) to that engine, provided documentation of expected retirement date is kept in records as specified in paragraph (f) and the engine is retired as of the stated

expected retirement date. An owner may not roll the expected retirement date of a vehicle into the future to avoid compliance.

(5) Use of Experimental Diesel Particulate Matter Emission Control Technologies. An owner may use an experimental diesel particulate matter emission control strategy provided by or operated by the manufacturer in no more than ten solid waste collection vehicles in his active fleet for testing and evaluation purposes. Documentation of this use shall be kept in records as specified in paragraph (f). Each solid waste collection vehicle will be considered to be in compliance for the length of the testing and evaluation period of the experimental technology on that solid waste collection vehicle. The owner must bring the solid waste collection vehicle into compliance within six months of the end of the testing and evaluation period.

(f) **Record Keeping Requirement.** As of December 31, 2004, an owner shall maintain the following records. The owner shall provide the following records to an agent or employee of the Air Resources Board upon request for all solid waste collection vehicles in his active fleet subject to compliance with this regulation.

(1) Records Accessible at Terminal. The owner shall keep the following records accessible either in hard copy format or computer records at the terminal where a solid waste collection vehicle normally resides:

(A) A list by vehicle license or identification number of solid waste collection vehicles identifying each vehicle type, engine manufacturer, engine model, engine model year, usage status as active fleet or back-up vehicle, and

(B) Correlated to each solid waste collection vehicle, the installed diesel emission control strategy, its serial number, manufacturer, model, level, installation date, and if using a Level 1 or Level 2 verified diesel emission control strategy, reason for the choice, and

(C) Records of maintenance for each installed diesel emission control strategy, and

(D) For fuel or fuel additives, if used as a diesel emission control strategy, the most recent two years worth of records of purchase that demonstrate usage, and

(E) For each backup vehicle, its vehicle license or identification number and mileage as of January 1st of each year beginning January 1, 2005, and

(F) For each engine for which an owner is claiming an exemption pursuant to paragraph (e)(4), the vehicle license or identification number, engine manufacturer, engine model, engine model year, and retirement date, and

(G)For each engine for which an owner is claiming an extension pursuant to paragraph (e)(5), the vehicle license or identification number, engine model, engine model year, and documentation of the experimental program.

(2) Records Kept in the Vehicle. For each solid waste collection vehicle, the owner shall keep the following information affixed to the driver's side door jam, or another readily accessible location known by the driver of each vehicle, in the form of a legible and durable label:

(A) For a vehicle operated under contract to a municipality, the name of the municipality or municipalities, and

(B) For each installed diesel emission control strategy, label information as specified in title 13, California Code of Regulations, section 2706 (g), and the installation date, or

(C) Engine model year and planned compliance date, or

(D) Experimental diesel emission control system manufacturer name, type of experimental diesel emission control system, beginning date and ending date of testing and evaluation period, or

(E) Designation as a backup vehicle and its mileage as of January 1st of each year beginning January 1, 2005, or

(F) Engine model year and retirement date for vehicles for which an owner is claiming an exemption pursuant to paragraph (e)(4), or

(G)Engine model year and duration of experimental program for each vehicle for which an owner is claiming an extension pursuant to paragraph (e)(5).

(3) Each owner shall maintain records for each solid waste collection vehicle until it is sold outside of the State of California or is no longer used as a solid waste collection vehicle for the purpose of residential or commercial solid waste collection in the State of California.

(g) **Non Compliance**. Any violations of this section may carry civil penalties as specified in state law and regulations, including, but not limited to, Health and Safety Code section 39674.

NOTE: Authority cited: Sections 39600, 39601, and 39658, Health and Safety Code. Reference: Sections 39002, 39003, 39658, 43000, 43013, 43018, 43101, 43102, 43104, 43105 and 43700.

APPENDIX B

LISTING OF PUBLIC WORKSHOP ATTENDEES

Sacramento Workshop - June 26, 2001 2:30 - 4:30 PM

Company	Public/ Private	Industry
City of Fresno	Public	Government agency
California Natural Gas Vehicle Coalition	Public	Environmental agency
Ramos Oil Co Inc.	Private	Oil company
Daedalus	Private	Electronics manufacturer
Waste Management	Private	Collection vehicle owner
Santa Clara County & NAFA	Public	Government agency
Cummins West	Private	Engine manufacturer
Con-Way Transportation & Menlo Worldwide	Private	Trucking
Johnson Matthey	Private	Emission control manufacturer
County of Sacramento	Public	Government agency
Browning-Ferris Industries - San Mateo	Private	Collection vehicle owner
Fleetguard / Nelson	Private	Emission control manufacturer
International Truck & Engine	Private	Engine manufacturer
Browning-Ferris Industries	Private	Collection vehicle owner
California Refuse Removal Council (CRRC)	Private	Collection vehicle owner association
Engine, Fuel, and Emissions Engineering, Inc.	Consultant	Environmental consultant
California Trucking Association (CTA)	Private	Trucking association
City of Sacramento	Public	Government agency
Golden State	Private	Trucking
California Chamber of Commerce	Private	Government agency
Tri Cities Waste Management	Private	Collection vehicle owner
Sacramento Air Pollution Control District	Public	Government agency
Donaldson Company, Inc.	Private	Emission control manufacturer
Cleaire	Private	Emission control manufacturer
Clear Air Systems	Private	Emission control manufacturer
MECA	Private	Emission control manufacturer association
Federal Express	Private	Mail delivery
Redwood Empire	Private	Retail truck sales
United States Environmental Protection Agency	Public	Government agency
City of Merced	Public	Government agency
British Petroleum	Private	Fuel company
Norcal Waste Systems, Inc.	Private	Collection vehicle owner
Amer Trucking	Private	Trucking
San Joaquin County	Public	Government agency
Green Team of San Jose	Private	Collection vehicle owner
Sacramento Metropolitan Air Quality Management District	Public	Government agency

Sacramento Workshop - June 26, 2001 6:30 - 8:30 PM

Company	Public/Private	Industry
Donaldson Company, Inc.	Private	Emission control manufacturer
Johnson Matthey	Private	Emission control manufacturer
Cleaire	Private	Emission control manufacturer
Clean Air Systems	Private	Emission control manufacturer
MECA	Private	Emission control manufacturer association
Federal Express	Private	Mail delivery
Corning	Private	Emission control manufacturer

El Monte Workshop - June 28, 2001 1:00-3:00PM

Company	Public/ Private	Industry
City Of Riverside	Public	Government agency
Natural Resources Defense Council	Private	Environmental protection agency
Johnson Matthey	Private	Emission control manufacturer
Big Bear City Community Services District	Public	Government agency
San Diego Environmental Service	Public	Government agency
City of Whittier	Public	Government agency
Eco Power System	Public	Emission control manufacturer
Cummins Cal Pacific	Private	Engine manufacturer
Los Angeles County Sanitation District	Public	Government agency
British Petroleum	Private	Oil company
Ware Disposal	Private	Collection vehicle owner
ARTS Disposal	Private	Collection vehicle owner
Taormina	Private	Collection vehicle owner
MECA	Private	Emission control manufacturer association
City of San Diego	Public	Government agency
Ventura County Air Pollution Control District	Public	Government agency
Cleaire	Private	Emission control manufacturer
Car Sound Exhaust	Private	Emission control manufacturer
Hilton Farnkopf & Hobson, LLC	Private	Environmental consultant
City of Los Angeles	Public	Government agency
Valley Detroit Diesel Allison	Private	Engine manufacturer
Looney Bins	Private	Collection vehicle owner
Clean Diesel	Private	Emission control manufacturer
Navy Public Works Center	Public	Government agency
City of Pomona	Public	Government agency
Norcal Waste	Private	Collection vehicle owner
CRRC	Private	Collection vehicle owner association

El Monte Workshop - June 28, 2001 4:00 - 6:00PM

Company	Public/Private	Industry
MECA	Private	Emission control manufacturer association
Johnson Matthey	Private	Emission control manufacturer
Norcal Waste	Private	Collection vehicle owner
General Waste Disposal	Private	Collection vehicle owner

Sacramento Workshop - September 4, 2001 1:30 - 3:30 PM

Company	Public/ Private	Industry
MECA	Private	Emission control manufacturer association
Peterbilt	Private	Engine manufacturer and sales
United States Environmental Protection Agency	Public	Government agency
City of Fresno	Public	Government agency
British Petroleum	Private	Oil company
Norcal Waste Systems, Inc.	Private	Collection vehicle owner
American Trucking	Private	Trucking association
National Biodiesel Board	Public	Government agency
Waste Management	Private	Collection vehicle owner
California Trucking Association	Private	Trucking association
California Independent Oil Marketers Association	Private	Oil company association
City of Merced	Public	Government agency
San Joaquin County	Public	Government agency
CRRC	Private	Collection vehicle owner association
Green Team of San Jose	Private	Collection vehicle owner

Los Angeles Workshop - September 5, 2001 1:30 - 3:30PM

Company	Public/ Private	Industry
Valley Detroit Diesel Allison	Private	Engine manufacturer
Cummins	Private	Engine manufacturer
Norcal Waste Inc.	Private	Collection vehicle owner
Gladstein & Associates	Private	Environmental consultant
Riverside County	Public	Government agency
Sector Strategies	Public	Government agency
CRRC	Private	Collection vehicle owner association
Clean Diesel Technologies	Private	Emission control manufacturer
Detroit Diesel Corporation	Private	Engine manufacturer
Donaldson	Private	Emission control manufacturer
Advance Disposal	Private	Collection vehicle owner
FleetGuard	Private	Emission control manufacturer
International Truck and Engine Corporation	Private	Engine manufacturer
Los Angeles County Sanitation District	Public	Government agency
Johnson-Matthey	Private	Emission control manufacturer
City of Glendale	Public	Government agency
Ware Disposal	Private	Collection vehicle owner
Filter Technology Australia	Private	Emission control manufacturer
Cleaire	Private	Emission control manufacturer
New York State D.E.C	Public	Government agency
Nett Technologies	Private	Emission control manufacturer
Manufacturers of Emission Controls Association	Private	Emission control manufacturer
California Trucking Association	Private	Trucking association
Mack Trucks, Inc.	Private	Truck manufacturer
Clean Air Systems	Private	Emission control manufacturer
Lubrizol Engine Control Systems	Private	Emission control manufacturer
Varner Bros., Inc.	Private	Collection vehicle owner
Price Disposal	Private	Collection vehicle owner
City of Los Angeles	Public	Government agency
HJS	Private	Diesel equipment manufacturer
Nav-International	Private	Engine manufacturer
Caterpillar	Private	Engine manufacturer
Ventura County Air Pollution Control District	Public	Government agency

Los Angeles Workshop - September 5, 2001 1:30 - 3:30PM

Company	Public/ Private	Industry
Arvinmeritor Inc.	Private	Automotive equipment supplier
Engine Manufacturers Association	Private	Engine manufacturer association
Heknek	Private	Engine manufacturer
Foothill Waste	Private	Collection vehicle owner
TEC of CA/Mack Trucks	Private	Truck sales
Arthur D. Little	Private	Environmental consultant
Sacramento Metropolitan Air Quality Management District	Public	Government agency
SynchroEnergies	Private	Energy and Equipment Industry
San Joaquin Valley Air Pollution Control District	Public	Government agency
Golden State	Private	Truck sales
British Petroleum (BP)	Private	Fuel company
TTM (Switzerland)	Public	Environmental protection agency
California Refuse Removal Council	Private	Collection vehicle owner
City of Fresno	Public	Government agency
California Independent Oil Marketers Association	Private	Oil company association
Environmental Fleet Services	Private	Environmental consultant
Valley Waste Management	Private	Collection vehicle owner
Norcal Waste System	Private	Collection vehicle owner
Solano Garbage Company	Private	Collection vehicle owner
Gilton Solid Waste	Private	Collection vehicle owner
Waste Management	Private	Collection vehicle owner
Sierra Research	Public	Environmental agency
City of Sacramento	Public	Government agency

Oakland Workshop - February 26, 2002 2:00 - 4:00PM

Company	Public/ Private	Industry
MECA	Private	Emission control manufacturer association
Stewart & Stevenson	Private	Specialty equipment manufacturer
Engine Manufacturers Association	Private	Engine manufacturer association
City of Sacramento	Public	Government agency
East Bay Sanitary	Private	Collection vehicle owner
California Trucking Association	Private	Trucking association
FreightLiner	Private	Trucking
SEG Trucking	Private	Truck sales
Browning-Ferris Industries	Private	Collection vehicle owner
CRRC	Private	Collection vehicle owner association
Sacramento Municipal Utility District	Public	Government agency
South San Francisco Scavenger Company	Private	Collection vehicle owner
Cleaire	Private	Emission control manufacturer
Ensight	Private	Collection vehicle owner
Detroit Diesel	Private	Engine manufacturer
Engine, Fuel and Emissions Engineering, Inc.	Private	Environmental engineering consultant
Sacramento County	Public	Government agency
International Truck and Engine Corporation	Private	Engine manufacturer
Fleetguard Nelson	Private	Emission control manufacturer
CD Waste	Private	Collection vehicle owner
Caterpillar	Private	Engine manufacturer
Turlock Irrigation District Water & Power	Private	Irrigation
Allied Waste Management	Private	Collection vehicle owner

El Monte Workshop - February 28, 2002 4:00-6:00PM

Company	Public/ Private	Industry
MECA	Private	Emission control manufacturer association
Valley Detroit Diesel Allison	Private	Engine sales
South Coast Air Quality Management District	Public	Government agency
International Trucking, Inc.	Private	Truck sales
Advance Disposal	Private	Collection vehicle owner
Ware Disposal	Private	Collection vehicle owner
CRRC	Private	Collection vehicle owner association
Cummins	Private	Engine manufacturer
City of Santa Clarita	Public	Government agency
City of Big Bear	Public	Government agency
City of San Bernardino	Public	Government agency
County of Santa Barbara	Public	Government agency
Environ Strategy	Private	Environmental consultant
Ventura County Air Pollution Control District	Public	Government agency
Sanitation Districts of Los Angeles County	Public	Government agency
City of Los Angeles	Public	Government agency
City of Pomona	Public	Government agency
City of Redondo Beach	Public	Government agency
Taormina	Private	Collection vehicle owner
City of Torrance	Public	Government agency
CR&R/ Solag Disposal Inc.	Private	Collection vehicle owner

Sacramento Workshop – December 9, 2002 2:00 - 5:00 PM

Company	Public/ Private	Industry
California Trucking Association	Private	Trucking association
Cleaire	Private	Emission control manufacturer
Norcal Waste Systems, Inc.	Private	Collection vehicle owner
California Natural Gas Vehicle Coalition	Public	Government agency
S.E.G. Trucking	Private	Collection vehicle owner
California Chamber of Commerce	Private	Government agency
BFI Waste Services	Private	Collection vehicle owner
EF & EE Engineering, Inc.	Private	Environmental engineering consultant
American Trucking Association	Private	Trucking association
Waste Management	Private	Collection vehicle owner
Engelhard Corporation	Private	Emission control manufacturer
Gilton Solid Waste Mgt. Inc.	Private	Collection vehicle owner
City of Sacramento Public Works	Public	Government agency
County of Sacramento Public Works	Public	Government agency
Johnson Matthey	Private	Emission control manufacturer
National Biodiesel Board	Public	Fuel association
Pacific Waste Svcs	Private	Collection vehicle owner
MECA	Private	Emission control manufacturer association
Waste Connection	Private	Collection vehicle owner

El Monte Workshop – December 10, 2002 2:00 - 5:00 PM

Company	Public/Private	Industry
Ventura County APCD	Public	Government agency
Boerner Truck Center	Private	Truck maintenance
Engelhard	Private	Emission control manufacturer
Advance Disposal	Private	Collection vehicle owner
International Truck & Engine	Private	Engine manufacturer
City of San Diego PWD	Public	Government agency
Los Angeles County Sanitation	Public	Government agency
D 3 Construction	Private	Construction company
Burrtec Industries	Private	Collection vehicle owner
Fleetguard	Private	Emission control manufacturer
BP	Private	Fuel company
Waste Management	Private	Collection vehicle owner
San Joaquin Valley APCD	Public	Government agency
Donaldson	Private	Emission control manufacturer
South Coast AQMD	Public	Government agency
MECA	Private	Emission control manufacturer association
Engine Dealer	Private	Engine sales
BFI	Private	Collection vehicle owner
City of Long Beach	Public	Government agency
CRRC	Private	Collection vehicle owner association
Varner Bros	Private	Collection vehicle owner
Product Supply	Private	Trucking industry
Big Bear City	Public	Government agency
Wane Disposal	Private	Collection vehicle owner
Kludjian Disposal	Private	Collection vehicle owner
EDCO	Private	Collection vehicle owner

APPENDIX C

VERIFIED DIESEL EMISSION CONTROL STRATEGIES AS OF APRIL 2003

LEVEL 3 Verification: The Engelhard DPX and Johnson Matthey CRT particulate filters are verified for use with the following engine families: Caterpillar (Table 1), Cummins (Table 2), DDC (Table 3), Mack (Table 4), Navistar (Table 5), Volvo (Table 6)

Table 1. Caterpillar

Model Year	Engine Family	Series
1994	RCP403DZDAAA	--
	RCP403DZDABA	--
	RCP629EZDARA	--
	RCP638EZDARA	--
	RCP893EZDARA	--
1995	SCP403DZDAAA	--
	SCP403DZDABA	--
	SCP403DZDARK	--
	SCP442DZDARK	3126
	SCP629EZDARK	--
	SCP629EZDARM	C10, 3176
	SCP638EZDARA	--
	SCP729EZDARL	C12
	SCP893EZDARK	--
1996	TCP403DZDAAA	3116
	TCP403DZDABA	3116
	TCP403DZDARK	3116
	TCP442DZDAAK	3126
	TCP442DZDARK	3126
	TCP629EZDARK	3176
	TCP629EZDARM	C10
	TCP638EZDARA	3306
	TCP729EZDARL	C12
	TCP893EZDARK	3406
1997	VCP403DZDAAA	3116
	VCP403DZDABA	3116
	VCP403DZDARK	3116
	VCP442DZDAAK	3126
	VCP442DZDARK	3126
	VCP629EZDARK	3176
	VCP629EZDARX	C10
	VCP638EZDARA	3306
	VCP729EZDARX	C12
	VCP893EZDARA	3406
	VCP893EZDARX	3406
	VCP967EZDARK	3406
1998	WCPXH0442HRK	3126
	WCPXH0442HSK	3126
	WCPXH0629ERK	C10
	WCPXH0729ERK	C12
	WCPXH0893ERK	3406
	WCPXH0967ERK	3406
1999	XCPXH0442HRK	3126
	XCPXH0442HSK	3126
	XCPXH0629ERK	C10
	XCPXH0729ERK	C12
	XCPXH0893ERK	3406
	XCPXH0967ERK	3406
2000	YCPXH0442HRK	3126
	YCPXH0629ERK	C10
	YCPXH0729ERK	C12
	YCPXH0893ERK	C15
	YCPXH0967ERK	C16
2001	1CPXH0442HAK	3126
	1CPXH0442HBK	3126
	1CPXH0442HRK	3126
	1CPXH0629ERK	C10
	1CPXH0729ERK	C12
	1CPXH0893ERK	C15
	1CPXH0967ERK	C16
2002	2CPXH0442HAK	3126
	2CPXH0442HBX	3126
	2CPXH0442HRK	3126
	2CPXH0629ERK	C10
	2CPXH0729ERK	C12
	2CPXH0893ERK	C15
	2CPXH0967ERK	C16

Table 2. Cummins

Model Year	Engine Family	Series
1994	RCE359D6DAAB	B5.9
	RCE359D6DAAW	B5.9
	RCE359D6DABW	B5.9
	RCE505D6DAAA	C8.3
	RCE505D6DAAB	C8.3
	RCE505D6DAAC	C8.3
	RCE505F6DAAW	C8.3
	RCE611EGDARW	L10
	RCE661EJDARA	M11
	RCE661EJDARC	M11
	RCE661EJDARW	M11
	RCE661FJDAAA	M11
	RCE855EJDARW	N14
	RCE855EJDASW	N14
1995	SCE239D6DAAA	B3.9
	SCE359D6DAAA	B5.9
	SCE359D6DAAW	B5.9
	SCE359D6DABW	B5.9
	SCE505D6DAAA	C8.3
	SCE505D6DAAW	C8.3
	SCE505D6DABW	C8.3
	SCE505F6DAAW	C8.3
	SCE611EGDARW	L10
	SCE661EJDARA	M11
	SCE661EJDARC	M11
	SCE661EJDARW	M11
	SCE661EJDASW	M11
	SCE661EJDATW	M11
	SCE661FJDAAA	M11
	SCE855EJDARA	N14
	SCE855EJDARB	N14
	SCE855EJDARW	N14
	SCE855EJDASW	N14
	SCE855EJDATW	N14
1996	TCE239D6DAAA	B3.9
	TCE359D6DAAA	B5.9
	TCE359D6DABW	B5.9
	TCE505D6DAAA	C8.3
	TCE505D6DAAW	C8.3
	TCE505D6DABW	C8.3
	TCE661EJDARA	M11
	TCE661EJDARB	M11
	TCE661EJDARC	M11
	TCE661EJDARW	M11
	TCE661EJDASW	M11
	TCE661EJDATW	M11
	TCE661FJDABA	M11
1996	TCE855EJDARA	N14
	TCE855EJDARB	N14
	TCE855EJDARW	N14
	TCE855EJDASW	N14
	TCE855EJDATW	N14
1997	VCE239D6DAAA	B3.9
	VCE359D6DAAA	B5.9
	VCE359D6DABW	B5.9
	VCE359DJDARA	–
	VCE505D6DAAA	C8.3
	VCE505D6DAAW	C8.3
	VCE505D6DABW	C8.3
	VCE661EJDARB	M11
	VCE661EJDARC	M11
	VCE661EJDASA	M11
	VCE661EJDATW	M11
	VCE661FJDABA	M11
	VCE855EJDARA	N14
	VCE855EJDARB	N14
	VCE855EJDARC	N14
	VCE855EJDATW	N14
1998	WCEXA0359BAH	ISB
	WCEXH0359BAD	ISB
	WCEXH0359BAE	ISB
	WCEXH0505CAC	ISC
	WCEXH0505CAD	ISC
	WCEXH0505CAE	ISC
	WCEXH0505CAF	ISC
	WCEXH0661MAA	M11
	WCEXH0661MAB	M11
	WCEXH0661MAC	M11
	WCEXH0661MAD	ISM
	WCEXH0661MAE	ISM
	WCEXH0855NAA	N14
	WCEXH0855NAB	N14
	WCEXH0855NAC	N14
	WCEXH0912XAA	Signature

Table 2. Cummins (continued)

Model Year	Engine Family	Series
1999	XCEXH0359BAI	ISB
	XCEXH0359BAJ	ISB
	XCEXH0359BAK	ISB
	XCEXA0359BAN	ISB
	XCEXA0359BAT	ISB
	XCEXH0505CAC	ISC
	XCEXH0505CAD	ISC
	XCEXH0505CAE	ISC
	XCEXH0505CAF	ISC
	XCEXH0661MAC	M11
	XCEXH0661MAG	ISM
	XCEXH0661MAH	ISM
	XCEXH0661MAI	ISM
	XCEXH0855NAD	N14
	XCEXH0855NAE	N14
	XCEXH0855NAF	N14
	XCEXH0912XAB	Signature
	XCEXH0912XAD	ISX
2000	YCEXH0359BAI	ISB
	YCEXH0359BAO	ISB
	YCEXH0359BAP	ISB
	YCEXA0359BAZ	ISB
	YCEXH0505CAF	ISC
	YCEXH0505CAG	ISC
	YCEXH0505CAH	ISC
	YCEXH0505CAI	ISC
	YCEXH0540LAA	ISL
	YCEXH0661MAG	ISM
	YCEXH0661MAH	ISM
	YCEXH0661MAI	ISM
	YCEXH0855NAD	N14
	YCEXH0855NAE	N14
	YCEXH0855NAF	N14
	YCEXH0912XAC	ISX
	YCEXH0912XAD	ISX
	YCEXH0912XAE	Signature, ISX

Model Year	Engine Family	Series
2001	1CEXA0359BAZ	ISB
	1CEXH0239BAD	ISB
	1CEXH0239BAE	ISB
	1CEXH0359BAO	ISB
	1CEXH0359BAU	ISB
	1CEXH0359BAV	ISB
	1CEXH0505CAM	ISC
	1CEXH0505CAN	ISC
	1CEXH0505CAO	ISC
	1CEXH0505CAP	ISC
	1CEXH0540LAA	ISL
	1CEXH0540LAB	ISL
	1CEXH0540LAC	ISL
	1CEXH0661MAP	ISM
	1CEXH0661MAQ	ISM
	1CEXH0661MAR	ISM
	1CEXH0855NAD	N14
	1CEXH0855NAE	N14
	1CEXH0855NAF	N14
	1CEXH0912XAC	ISX
	1CEXH0912XAD	ISX
	1CEXH0912XAE	Signature, ISX
2002	2CEXA0359BAZ	ISB
	2CEXH0239BAD	ISB
	2CEXH0239BAE	ISB
	2CEXH0359BAB	ISB
	2CEXH0359BAO	ISB
	2CEXH0505CAM	ISC
	2CEXH0505CAN	ISC
	2CEXH0505CAQ	ISC
	2CEXH0540LAB	ISL
	2CEXH0540LAC	ISL
	2CEXH0661MAP	ISM
	2CEXH0661MAS	ISM
	2CEXH0855NAA	N14
	2CEXH0912XAF	ISX

Table 3. DDC

Model Year	Engine Family	Series
1994	RDD11.EJDARA	Series 60
	RDD12.EJDARA	Series 60
	RDD8.5EJDARA	Series 50
	RDD8.5EJDARW	Series 50
	RDD8.5FJDABA	Series 50
1995	SDD11.EJDARA	Series 60
	SDD12.EJDARA	Series 60
	SDD8.5EJDABA	Series 50
	SDD8.5EJDARA	Series 50
	SDD8.5EJDARW	Series 50
1996	TDD11.EJDARA	Series 60
	TDD12.EJDARA	Series 60
	TDD12.EJDATW	Series 55
	TDD8.5EJDARA	Series 50
	TDD8.5EJDARW	Series 50
	TDD8.5FJDABA	Series 50
1997	VDD11.EJDARA	Series 60
	VDD12.EJDARA	Series 60
	VDD12.EJDATA	Series 55
	VDD3.8C8DABA	Series VM 638
	VDD8.5EJDARA	Series 50
	VDD8.5FJDABA	Series 50
1998	WDDXH11.1EHD	Series 60
	WDDXH12.7EGD	Series 60
	WDDXH08.5EJD	Series 50
	WDDXH08.5FJC	Series 50
	WDDXH03.8C1C	Turbotronic 638
1999	XDDXH11.1EHL	Series 60
	XDDXH12.7EGL	Series 60
	XDDXH14.0ELL	Series 60
	XDDXH08.5EJL	Series 50
	XDDXH08.5FJN	Series 50
	XDDXH03.8C1N	-
2000	YDDXH12.7EGL	Series 60
	YDDXH14.0ELL	Series 60
	YDDXH08.5EJB	Series 50
	YDDXH08.5EJL	Series 50
	YDDXH08.5FJN	Series 50
	YDDXH03.8C1N	Turbotronic 638
2001	1DDXH12.7EGL	Series 60
	1DDXH14.0ELL	Series 60
	1DDXH08.5EJB	Series 50
	1DDXH08.5EJL	Series 50
2002	2DDXH12.7EGL	Series 60
	2DDXH14.0ELL	Series 60
	2DDXH12.7FGN	Series 60
	2DDXH08.5EJL	Series 50

Table 4. Mack

Model Year	Engine Family	Series
1994	RMK728EGDARA	E7, EM7
	RMK728EJDARA	E7, EM7
1995	SMK728EGDARA	E7, EM7
	SMK728EJDARA	E7
1996	TMK728EGDARA	E7, EM7
	TMK728EJDARA	E7
1997	VMK728EGDARA	E7, EM7
	VMK728EJDARA	E7, EM7
	VMK728EJDAYW	E7, EM7
1998	WMKXH11.9E51	E7
	WMKXH11.9E52	E7
	WMKXH11.9E53	EM7
1999	XMKXH11.9E54	E7
2000	YMKXH11.9H56	E7, EM7
	YMKXH11.9V57	E7, EM7
2001	1MKXH11.9H56	E7, EM7
	1MKXH11.9H59	E7
	1MKXH11.9V57	E7, EM7
	1MKXH11.9V60	E7
	1MKXH11.9V61	EM7
2002	2MKXH11.9H63	E7
	2MKXH11.9V60	E7
	2MKXH11.9V61	EM7
	2MKXH11.9V65	E7
	2MKXH11.9V66	EM7
	2MKXH11.9V67	E7

Table 5. Navistar (International)

MY	Engine Family	Series
1994	RNV408D6DAAW	–
	RNV444C8DABA	–
	RNV466D6D0TW	–
	RNV466D6DAAA	–
	RNV466D6DABA	–
	RNV466D6DARW	DT 466HT, DT 466
	RNV466D6DASW	DT 466HT, DT 466
	RNV530D6DAAA	–
	RNV7.3C8DAAA	–
1995	SNV444C8DOAA	–
	SNV444C8DORA	–
	SNV444C8DOSA	–
	SNV466D6DARA	DT 466HT, DT 466
	SNV466D6DASA	DT 466
	SNV466D6DATA	–
	SNV466D8DARB	DT 466HT, DT 466
	SNV466D8DASB	DT 466
	SNV466D8DATB	–
	SNV530D6DARA	–
	SNV530E6DASA	–
	SNV530F6DATA	530 Bus
	SNV7.3C8DAAA	–
1996	TNV444C8DORA	–
	TNV444C8DOSA	–
	TNV466D6DARB	DT 466, DT 466HT
	TNV466D6DATB	–
	TNV466D8DARB	DT 466, DT 466HT
	TNV466D8DATB	–
	TNV530D6DARA	–
	TNV530D8DARA	–
	TNV530E6DASA	–
	TNV530E8DASA	–
	TNV7.3B8DOAA	–
	TNV7.3C8DAAA	–
1997	VNV444C8DARW	T444E
	VNV444C8DASW	T444E HT
	VNV466D6DARA	DT 466HT, DT 466
	VNV466D8DARW	DT 466E, DT 466 HT
	VNV466D8DASA	–
	VNV530D6DARA	530 MGD
	VNV530D8DARA	530E
	VNV530E6DASA	530 HVY
	VNV530E8DASA	530E
	VNV7.3C8DAAA	–
	VNV7.3C8DAAW	–
	VNV7.3W8DOAK	7.3 DIT
1998	WNVXH0444CCB	T 444E
	WNVXH0444CCD	T 444E
	WNVXH0466CCB	DT 466E
	WNVXH0466CCD	DT 466E
	WNVXH0530CCB	530E
1998	WNVXH0530CCD	530E
1999	XNVXH0444ANA	T 444E
	XNVXH0444ANB	T 444E
	XNVXH0466ANA	DT 466E
	XNVXH0466ANB	DT 466E
	XNVXH0530ACT	530E
	XNVXH0530ANA	530E
	XNVXH0530ANB	530E
	XNVXH07.3ACA	7.3 DIT
	XNVXH07.3ACB	7.3 DIT
	XNVXH07.3ACC	7.3 DIT
	XNVXH07.3ANE	7.3 DIT
	XNVXH07.3ANF	7.3 DIT
	XNVXA07.3CCD	7.3 DIT
	XNVXA07.3CNJ	7.3 DIT
2000	YNVXH0444ACT	T 444E
	YNVXH0444ANA	444 P
	YNVXH0444ANB	T 444E
	YNVXH0444ANC	T 444E
	YNVXH0466ANA	DT 466E, DT 466E HT
	YNVXH0466ANB	DT 466E, DT 466E HT
	YNVXH0530ACT	530E
	YNVXH0530ANA	DT 530E
	YNVXH0530ANB	DT 530E, DT 530E HT
	YNVXH07.3ANA	7.3 DIT
2001	1NVXH0444ANA	444 P
	1NVXH0444ANB	T 444E
	1NVXH0444ANC	T 444E
	1NVXH0466ANA	DT 466, DT 466 HT
	1NVXH0466ANB	DT 466, DT 466 HT
	1NVXH0466ANB	DT 466, DT 466 HT
	1NVXH0530ACT	DT 530
	1NVXH0530ANA	DT 530
	1NVXH0530ANB	DT 530, DT 530 HT
	1NVXH07.3ACE	7.3 DIT
	1NVXH07.3ACF	7.3 DIT
	1NVXH07.3ANA	7.3 DIT
	1NVXH07.3ANC	7.3 DIT
	1NVXA07.3CND	7.3 DIT
2002	2NVXH0444ANA	T 444E
	2NVXH0444ANB	T 444E
	2NVXH0444ANC	T 444E
	2NVXH0466ANA	DT 466, DT 466 HT
	2NVXH0466ANB	DT 466, DT 466 HT
	2NVXH0530ANA	DT 530
	2NVXH0530ANB	DT 530, DT 530 HT
	2NVXH0530ANC	DT 530
	2NVXH07.3ACE	7.3 DIT
	2NVXA07.3ACF	7.3 DIT
	2NVXH07.3ANA	7.3 DIT
	2NVXH07.3ANC	7.3 DIT
	2NVXA07.3CND	7.3 DIT

Table 6. Volvo

Model Year	Engine Family	Series
1994	RVT12.EJDBRA	VE D12
	RVT6.7D6DBRA	VE D7A
1995	SVT12.EJDBRA	VE D12
	SVT6.7D6DBRA	VE D7A
1996	TVT12.EJDBRA	VE D12
	TVT6.7D6DBRA	VE D7A
1997	VVT12.EJDBRA	VE D12
	VVT6.7D6DBRA	VE D7A
1998	WVTXH12.150S	VE D12B
	WVTXH07.350S	VE D7C
1999	XVTXH12.150S	VE D12B
	XVTXH07.399B	VE D7C
	XVTXH07.350S	VE D7C
2000	YVTXH07.350S	VE D7C
	YVTXH12.150S	VE D12C
2001	1VTXH07.350S	VE D7C
	1VTXH12.150S	VE D12
2002	2VTXH07.350S	VE D7C
	2VTXH12.150S	VE D12

LEVEL 3 Verification:

Table 7. Clean Air Partners' DPF is verified for use with the following Power Systems Associates Engine Families:

Model Year	Engine Families
1996	TPS629EZJARK
1997	VPS442DZJ6RK, VPS442DZJARK, VPS629EZJ6RK, VPS629EZJ6RM
1998	WPSXH0629E6J, WPSXH0729E6J
1999	XPSXH0442E6J, XPSXH0629E6J, XPSXH0729E6J
2000	YPSXH0442E6J, YPSXH0629E6J, YPSXH0729E6J
2001	1PSXH0442E6J, 1PSXH0629E6J, 1PSXH0629E6K, 1PSXH0729E6J
2002	2PSXH0442E6J, 2PSXH0629E6J, 2PSXH0629E6K, 2PSXH0729E6J

LEVEL 3 Verification:

Table 8. Clean Air Partners' DPF is verified for use with the following Caterpillar Engine Families when converted to Bi-Fuel Operation:

Model Year	Engine Families	Bi-Fuel Retrofit Executive Orders
1998	WCPXH0442HRK	B-49-16
	WCPXH0629ERK	B-49-9
	WCPXH0729ERK	B-49-12
1999	XCPXH0442HRK	B-49-14
	XCPXH0629ERK	B-49-8
	XCPXH0729ERK	B-49-11
2000	YCPXH0442HRK	B-49-13
	YCPXH0629ERK	B-49-7
	YCPXH0729ERK	B-49-10
2001	1CPXH0442HRK	B-40-10
	1CPXH0629ERK	B-40-11
	1CPXH0729ERK	B-40-12
2002	2CPXH0442HRK	B-40-7
	2CPXH0629ERK	B-40-8
	2CPXH0729ERK	B-40-9

LEVEL 3 Verification:

Table 9. The Cleaire Flash and Catch™ system is verified for use with the following Cummins engine families:

Engine Family	Control Parts List Number
RCE661EJDARW	1856
RCE661FJDARA	1855, 1857
SCE661EJDARW	1856
SCE661EJDARA	1855, 1857
SCE661EJDASW	2036
SCE661EJDATW	2037
TCE661EJDARW	1856
TCE661EJDASW	1855, 1857
TCE661EJDARB	2036
TCE661EJDATW	2037
VCE661EJDATW	2037
VCE661EJDASA	1855, 1856, 1857
VCE661EJDARB	2036
WCEXH0661MAA	2371
WCEXH0661MAB	2370

LEVEL 1 Verification:

Table 10. The Cleaire Flash and Match™ system is verified for use with the following Cummins engine families:

Engine Family	Control Parts List Number
RCE661EJDARW	1856
RCE661FJDARA	1855, 1857
SCE661EJDARW	1856
SCE661EJDARA	1855, 1857
SCE661EJDASW	2036
SCE661EJDATW	2037
TCE661EJDARW	1856
TCE661EJDASW	1855, 1857
TCE661EJDARB	2036
TCE661EJDATW	2037
VCE661EJDATW	2037
VCE661EJDASA	1855, 1856, 1857
VCE661EJDARB	2036
WCEXH0661MAA	2371
WCEXH0661MAB	2370

LEVEL 1 Verification: The Donaldson DCM DOC muffler with 6000 Series catalyst formulation together with the Spiracle closed crankcase filtration system with California diesel fuel and the Donaldson DCM DOC mufflers with 6100 Series catalyst formulation plus closed loop crankcase with Donaldson Spiracle ™ closed crankcase filtration systems with 15 ppmw or less sulfur diesel fuel are verified for use with the following engine families: (Tables 11 –13)

Table 11. DOC Engines

Model Year	Engine Family	Series
Caterpillar		
1991	MCT0403FZC1	3116
	MCT0403FZD2	3116
	MCT0403FZE3	3116
	MCT0629FZD4	3176
	MCT0893FPBX	3406
	MCT0893FZD5	3406
1992	NCT0403FZC0	3116
	NCT0403FZD1	3116
	NCT0403FZE2	3116
	NCT0403FZF3	3116
	NCT0629FZD3	3176
	NCT0638FPCX	3306
	NCT0893FPB9	3406
	NCT0893FZD4	3406
1993	PCT0403FZC9	3116
	PCT0403FZDX	3116
	PCT0403FZE0	3116
	PCT0629FZD1	3176
	PCT0629FZE2	3176
	PCT0638FPC8	3306
	PCT0893FPB7	3406
	PCT0893FZD2	3406
	PCT0893FZE3	3406
	PCTO403FZF1	3116
DDC		
1991	MDD11.1FZA2	*
	MDD12.7FZAX	*
1992	NDD11.1FZA1	*
	NDD12.7FZA9	*
1993	PDD08.5FZB7	*
	PDD08.5FZK7	*
	PDD11.1FZAX	*
	PDD11.1FZD2	*
	PDD12.7FZA7	*
	PDD12.7FZDX	*
Mack		
1991	MMT0728FAF1	E7,EM7
	MMT0728FAG2	E7,EM7
	MMT0728FAH3	E7,EM7
1992	NMT0728FAA6	E7
	NMT0728FAB7	EM7
	NMT0728FAC8	EM7

Model Year	Engine Family	Series
Mack (continued)		
1992	NMT0728FAD9	E7, EM7
	NMT0728FAEX	E7
	NMT0728FAF0	EM7
	NMT0728FAG1	E7
	NMT0728FAH2	E7
	NMT0728FAK7	EM7
	NMT0728FAL8	EM7
1993	PMT0728FAC6	EM7
	PMT0728FAD7	EM7
	PMT0728FAE8	E7
	PMT0728FAF9	E7
	PMT0728FAGX	E7
	PMT0728FAH0	EM7
	PMT0728FAJ4	EM7
	PMT0728FAL6	E7
	PMTO728FAB5	E7
Navistar		
1991	MNV0360EPC7	*
	MNV0360FPCX	*
	MNV0466EPC4	*
	MNV0466FPC7	*
1992	NNV0360EPC6	*
	NNV0360FPC9	*
	NNV0466EPA1	*
	NNV0466FPC6	*
1993	PNV0360FPC7	DTA360
	PNV0408FPA2	DT408
	PNV0408FPB3	DT408
	PNV0466EPAX	DT466
	PNV0466FPC4	DTA466
	PNV0466FPD5	DTA466
	PNV0466FPE6	DT466
	PNV0466FPF7	DT466
	PNV0530FPA2	*
	PNV07.3EPA2	*
Volvo		
1991	MVT12.0FAA0	*
	NVT06.7FAA0	*
1992	MVT06.7FAA1	*
	NVT12.0FAAX	*
	NVT12.0FAB0	*
1993	PVT06.7FAA9	*
	PVT12.0FAA8	*
	PVT12.0FAB9	*

Table 12. DOC Engines

Model Year	Engine Family	Series
Ford		
1991	MFM07.8FPK8	*
1992	NFM07.8FPK7	*
1993	none	*
General Motors		
1991	none	*
1992	NGM06.5EAB5	*
1993	none	*
Hino		
1991	MHM03.8FAA0	*
	MHM06.5FAA6	*
1992	NHM03.8FAAX	*
1993	PHM03.8FAA8	*
	PHM06.5FAA3	*
Isuzu		
1991	none	*
1992	NSZ0396FAB7	*
1993	PSZ0396FAB5	*
Mercedes Benz		
1991	MMB5.96FAA3	*
1992	NMB5.96FAA2	*
	NMB12.0FAA4	*
1993	PMB5.96FAA1	*
	PMB12.0FAA2	*

Model Year	Engine Family	Series
Mitsubishi		
1991	none	*
1992	NMM0302FAA0	*
	NMM0460FAA6	*
1993	PMM0302FAA9	*
	PMM0460FAA4	*
Nissan		
1991	none	*
1992	NND0423FAC9	*
	NND0452FAC9	*
1993	PND0423FAC7	*
	PND0452FAC7	*
Perkins		
1991	MPE0365FAA1	Phaser 180Ti
1992	NPE0365FAA0	Phaser 180Ti
1993	PPE0365FAA9	Phaser 180Ti
Renault		
1991	MRE0335FAA4	*
1992	NRE0335FAA3	*
	NRE0377FAC0	*
	NRE0377FABX	*
1993	PRE0335FAA0	*
	PRE0377FAB8	*
	PRE0377FAC9	*

Table 13. DOC Cummins Engines

Model Year	Engine Family	Series
1991	MCE0359FAA9	B5.9
	MCE0359FABX	B5.9
	MCE0505FAA2	C8.3
	MCE0611FZA2	L10
	MCE0611FZB3	L10
	MCE0611FZD5	L10
	MCE0855FZA6	N14
	MCE0855FZB7	N14
	MCE0855FZC8	N14
	MCE0855FZD9	N14
1992	NCE0359FAA8	B5.9
	NCE0359FAB9	B5.9
	NCE0359FAB9	B5.9
	NCE0359FACX	C8.3
	NCE0505FAA1	C8.3
	NCE0505FAB2	C8.3
	NCE0611FZA1	L10
	NCE0611FZB2	L10
	NCE0611FZB2	L10
	NCE0611FZD4	L10
	NCE0855FZA5	N14
	NCE0855FZB6	N14
	NCE0855FZC7	N14
	NCE0855FZD8	N14
	NCE0855FZFX	N14
	NCE0855FZG0	N14
1993	PCE0359FAA6	B5.9
	PCE0359FAB7	B5.9
	PCE0359FAC8	B5.9
	PCE0359FAD9	B5.9
	PCE0505FAAX	C8.3
	PCE0505FAB0	C8.3
	PCE0611FZAX	L10
	PCE0611FZB0	L10
	PCE0661FZA2	M11
	PCE0661FZB3	M11
	PCE0855FZA3	N14
	PCE0855FZB4	N14
	PCE0855FZC5	N14
	PCE0855FZD6	N14
	PCE0855FZF8	N14
	PCE0855FZG9	N14
	PCE0855FZHX	N14
	PCE0855FZK4	N14

LEVEL 1 Verification: The Donaldson DCM DOC muffler with 6000 Series catalyst formulation together with the Spiracle closed crankcase filtration system with California diesel fuel; the Donaldson DCM DOC mufflers with 6100 Series catalyst formulation plus closed loop crankcase with Donaldson Spiracle ™ closed crankcase filtration systems with 15 ppmw or less sulfur diesel fuel; and the Donaldson DCM DOC mufflers with 6100 Series catalyst formulation alone on 15 ppmw or less sulfur fuel are verified for use with the following engine families: (Tables 14 – 19)

Table 14. Caterpillar

Model Year	Engine Family	Series
1994	RCP629EZDARA	*
	RCP638EZDARA	*
	RCP893EZDARA	*
1995	SCP403DZDARK	*
	SCP442DZDARK	3126
	SCP629EZDARK	*
	SCP629EZDARM	C-10, 3176
	SCP638EZDARA	*
	SCP729EZDARL	C-12
	SCP893EZDARK	*
1996	TCP403DZDARK	3116
	TCP442DZDARK	3126
	TCP629EZDARK	3176
	TCP629EZDARM	C-10
	TCP638EZDARA	3306
	TCP729EZDARL	C-12
	TCP893EZDARK	3406
1997	VCP403DZDARK	3116
	VCP442DZDARK	3126
	VCP629EZDARK	3176
	VCP629EZDARX	C-10
	VCP638EZDARA	3306
	VCP729EZDARX	C-12
	VCP893EZDARA	3406
	VCP893EZDARX	3406
	VCP967EZDARK	3406

Model Year	Engine Family	Series
1998	WCPXH0442HRK	3126
	WCPXH0442HRK	3126
	WCPXH0442HSK	3126
	WCPXH0442HSK	3126
	WCPXH0629ERK	C-10
	WCPXH0629ERK	C-10
	WCPXH0729ERK	C-12
	WCPXH0729ERK	C-12
	WCPXH0893ERK	3406
	WCPXH0893ERK	3406
	WCPXH0967ERK	3406
	WCPXH0967ERK	3406
1999	XCPXH0442HRK	3126
	XCPXH0442HSK	3126
	XCPXH0629ERK	C10
	XCPXH0729ERK	C12
	XCPXH0893ERK	3406
	XCPXH0967ERK	3406
2000	YCPXH0442HRK	3126
	YCPXH0629ERK	C-10
	YCPXH0729ERK	C-12
	YCPXH0893ERK	C-15
	YCPXH0967ERK	C-16
2001	1CPXH0442HRK	3126
	1CPXH0629ERK	C-10
	1CPXH0729ERK	C-12
	1CPXH0893ERK	C-15
	1CPXH0967ERK	C-16
2002	2CPXH0442HRK	3126
	2CPXH0629ERK	C-10
	2CPXH0729ERK	C-12
	2CPXH0893ERK	C-15
	2CPXH0967ERK	C-16

Table 15. Cummins

MY	Engine Family	Series
1994	RCE611EGDARW	L10
	RCE661EJDARA	M11
	RCE661EJDARC	M11
	RCE661EJDARW	M11
	RCE855EJDARW	N14
	RCE855EJDASW	N14
1995	SCE611EGDARW	L10
	SCE661EJDARA	M11
	SCE661EJDARC	M11
	SCE661EJDARW	M11
	SCE661EJDASW	M11
	SCE661EJDATW	M11
	SCE855EJDARA	N14
	SCE855EJDARB	N14
	SCE855EJDARW	N14
	SCE855EJDASW	N14
	SCE855EJDATW	N14
1996	TCE661EJDARA	M11
	TCE661EJDARB	M11
	TCE661EJDARC	M11
	TCE661EJDARW	M11
	TCE661EJDASW	M11
	TCE661EJDATW	M11
	TCE855EJDARA	N14
	TCE855EJDARB	N14
	TCE855EJDARW	N14
	TCE855EJDASW	N14
	TCE855EJDATW	N14
1997	VCE359DJDARA	*
	VCE661EJDARB	M11
	VCE661EJDARC	M11
	VCE661EJDASA	M11
	VCE661EJDATW	M11
	VCE855EJDARA	N14
	VCE855EJDARB	N14
	VCE855EJDARC	N14
	VCE855EJDATW	N14
1998	WCEXA0359BAH	ISB
	WCEXH0359BAD	ISB
	WCEXH0359BAE	ISB
	WCEXH0505CAC	ISC
	WCEXH0505CAD	ISC
	WCEXH0505CAE	ISC
	WCEXH0505CAF	ISC
	WCEXH0661MAA	M11
	WCEXH0661MAB	M11
	WCEXH0661MAD	ISM
	WCEXH0661MAE	ISM
	WCEXH0855NAA	N14
	WCEXH0855NAB	N14
1998	WCEXH0855NAC	N14
	WCEXH0912XAA	Signature
1999	XCEXH0359BAJ	ISB
	XCEXH0359BAK	ISB
	XCEXA0359BAN	ISB
	XCEXA0359BAT	ISB
	XCEXH0505CAC	ISC
	XCEXH0505CAD	ISC
	XCEXH0505CAE	ISC
	XCEXH0661MAH	ISM
	XCEXH0661MAI	ISM
	XCEXH0855NAD	N14
	XCEXH0855NAE	N14
	XCEXH0855NAF	N14
	XCEXH0912XAB	Signature
	XCEXH0912XAD	ISX
2000	YCEXH0359BAO	ISB
	YCEXH0359BAP	ISB
	YCEXA0359BAZ	ISB
	YCEXH0505CAG	ISC
	YCEXH0505CAH	ISC
	YCEXH0505CAI	ISC
	YCEXH0540LAA	ISL
	YCEXH0661MAH	ISM
	YCEXH0661MAI	ISM
	YCEXH0855NAD	N14
	YCEXH0855NAE	N14
	YCEXH0855NAF	N14
	YCEXH0912XAC	ISX
	YCEXH0912XAD	ISX
	YCEXH0912XAE	Signature, ISX
2001	1CEXA0359BAZ	ISB
	1CEXH0239BAD	ISB
	1CEXH0239BAE	ISB
	1CEXH0359BAU	ISB
	1CEXH0359BAV	ISB
	1CEXH0505CAN	ISC
	1CEXH0505CAO	ISC
	1CEXH0505CAP	ISC
	1CEXH0540LAA	ISL
	1CEXH0540LAC	ISL
	1CEXH0661MAQ	ISM
	1CEXH0661MAR	ISM
	1CEXH0855NAD	N14
	1CEXH0855NAE	N14
	1CEXH0855NAF	N14
	1CEXH0912XAC	ISX
	1CEXH0912XAD	ISX
	1CEXH0912XAE	Signature, ISX

Table 15. Cummins (continued)

2002	2CEXA0359BAZ	ISB
	2CEXH0239BAD	ISB
	2CEXH0239BAE	ISB
	2CEXH0359BAB	ISB
	2CEXH0505CAN	ISC
	2CEXH0505CAQ	ISC
	2CEXH0540LAC	ISL
	2CEXH0661MAS	ISM
	2CEXH0855NAA	N14
	2CEXH0912XAF	ISX

Table 16. DDC

Model Year	Engine Family	Series
1994	RDD11.EJDARA	Series 60
	RDD12.EJDARA	Series 60
	RDD8.5EJDARA	Series 50
	RDD8.5EJDARW	Series 50
1995	SDD11.EJDARA	Series 60
	SDD12.EJDARA	Series 60
	SDD8.5EJDARA	Series 50
	SDD8.5EJDARW	Series 50
1996	TDD11.EJDARA	Series 60
	TDD12.EJDARA	Series 60
	TDD12.EJDATW	Series 55
	TDD8.5EJDARA	Series 50
	TDD8.5EJDARW	Series 50
1997	VDD11.EJDARA	Series 60
	VDD12.EJDARA	Series 60
	VDD12.EJDATA	Series 55
	VDD8.5EJDARA	Series 50
1998	WDDXH11.1EHD	Series 60
	WDDXH12.7EGD	Series 60
	WDDXH08.5EJD	Series 50
1999	XDDXH11.1EHL	Series 60
	XDDXH12.7EGL	Series 60
	XDDXH14.0ELL	Series 60
	XDDXH08.5EJL	Series 50
2000	YDDXH12.7EGL	Series 60
	YDDXH14.0ELL	Series 60
	YDDXH08.5EJB	Series 50
	YDDXH08.5EJL	Series 50
2001	1DDXH12.7EGL	Series 60
	1DDXH14.0ELL	Series 60
	1DDXH08.5EJB	Series 50
	1DDXH08.5EJL	Series 50
2002	2DDXH12.7EGL	Series 60
	2DDXH14.0ELL	Series 60
	2DDXH08.5EJL	Series 50

Table 17. Mack

Model Year	Engine Family	Series
1994	RMK728EGDARA	E7, EM7
	RMK728EJDARA	E7, EM7
1995	SMK728EGDARA	E7, EM7
	SMK728EJDARA	E7
1996	TMK728EGDARA	E7, EM7
	TMK728EJDARA	E7
1997	VMK728EGDARA	E7, EM7
	VMK728EJDARA	E7, EM7
	VMK728EJDAYW	E7, EM7
1998	WMKXH11.9E51	E7
	WMKXH11.9E52	E7
	WMKXH11.9E53	EM7
1999	XMKXH11.9E54	E7
2000	YMKXH11.9H56	E7, EM7
	YMKXH11.9V57	E7, EM7
2001	1MKXH11.9H56	E7, EM7
	1MKXH11.9H59	E7
	1MKXH11.9V57	E7, EM7
	1MKXH11.9V60	E7
	1MKXH11.9V61	EM7
2002	2MKXH11.9H59	E7
	2MKXH11.9H63	E7
	2MKXH11.9V60	E7
	2MKXH11.9V61	EM7
	2MKXH11.9V65	E7
	2MKXH11.9V66	EM7
	2MKXH11.9V67	E7

Table 18. Navistar (International)

Model Year	Engine Family	Series
1994	RNV466D6D0TW	*
	RNV466D6DARW	DT 466HT, DT 466
	RNV466D6DASW	DT 466HT, DT 466
1995	SNV444C8DORA	*
	SNV444C8DOSA	*
	SNV466D6DARA	DT 466HT, DT 466
	SNV466D6DASA	DT 466
	SNV466D6DATA	*
	SNV466D8DARB	DT 466HT, DT 466
	SNV466D8DASB	DT 466
	SNV466D8DATB	*
	SNV530D6DARA	*
	SNV530E6DASA	*
1996	TNV444C8DORA	*
	TNV444C8DOSA	*
	TNV466D6DARB	DT 466, DT 466HT
	TNV466D6DATB	*
	TNV466D8DARB	DT 466, DT 466HT
	TNV466D8DATB	*
	TNV530D6DARA	*
	TNV530D8DARA	*
	TNV530E6DASA	*
	TNV530E8DASA	*
1997	VNV444C8DARW	T444E
	VNV444C8DASW	T444E HT
	VNV466D6DARA	DT 466HT, DT 466
	VNV466D8DARW	DT 466E, DT 466 HT
	VNV466D8DASA	*
	VNV530D6DARA	530 MGD
	VNV530D8DARA	530E
	VNV530E6DASA	530 HVY
	VNV530E8DASA	530E
1998	None	*
1999	XNVXH0444ANA	T 444E
	XNVXH0444ANB	T 444E
	XNVXH0466ANA	DT 466E
	XNVXH0466ANB	DT 466E
	XNVXH0530ANA	530E
	XNVXH0530ANB	530E
	XNVXH07.3ANE	7.3 DIT
	XNVXH07.3ANF	7.3 DIT
	XNVXA07.3CNJ	7.3 DIT

Model Year	Engine Family	Series
2000	YNVXH0444ANA	444 P
	YNVXH0444ANB	T 444E
	YNVXH0444ANC	T 444E
	YNVXH0466ANA	DT 466E, DT 466E HT
	YNVXH0466ANB	DT 466E, DT 466E HT
	YNVXH0530ANA	DT 530E
	YNVXH0530ANB	DT 530E, DT 530E HT
	YNVXH07.3ANA	7.3 DIT
2001	1NVXH0444ANA	444 P
	1NVXH0444ANB	T 444E
	1NVXH0444ANC	T 444E
	1NVXH0466ANA	DT 466, DT 466 HT
	1NVXH0466ANB	DT 466, DT 466 HT
	1NVXH0466ANB	DT 466, DT 466 HT
	1NVXH0530ANA	DT 530
	1NVXH0530ANB	DT 530, DT 530 HT
	1NVXH07.3ANA	7.3 DIT
	1NVXH07.3ANC	7.3 DIT
	1NVXA07.3CND	7.3 DIT
2002	2NVXH0444ANA	T 444E
	2NVXH0444ANB	T 444E
	2NVXH0444ANC	T 444E
	2NVXH0466ANA	DT 466, DT 466 HT
	2NVXH0466ANB	DT 466, DT 466 HT
	2NVXH0530ANA	DT 530
	2NVXH0530ANC	DT 530
	2NVXH0530ANB	DT 530, DT 530 HT
	2NVXH07.3ANA	7.3 DIT
	2NVXH07.3ANC	7.3 DIT
	2NVXA07.3CND	7.3 DIT

Table 19. Other Engine Makes

Model Year	Engine Family	Series
Volvo		
1994	RVT12.EJDBRA	VE D12
	RVT6.7D6DBRA	VE D7A
1995	SVT12.EJDBRA	VE D12
	SVT6.7D6DBRA	VE D7A
1996	TVT12.EJDBRA	VE D12
	TVT6.7D6DBRA	VE D7A
1997	VVT12.EJDBRA	VE D12
	VVT6.7D6DBRA	VE D7A
1998	WVTXH12.150S	VE D12B
	WVTXH07.350S	VE D7C
1999	XVTXH12.150S	VE D12B
	XVTXH07.399B	VE D7C
	XVTXH07.350S	VE D7C
2000	YVTXH07.350S	VE D7C
	YVTXH12.150S	VE D12C
2001	1VTXH07.350S	VE D7C
	1VTXH12.150S	VE D12
2002	2VTXH07.350S	VE D7C
	2VTXH12.150S	VE D12
General Motors		
1994	none	*
1995	none	*
1996	none	*
1997	VGM6.5C6DARW	*
1998	none	
1999	XGMXH06.5523	
Hino		
1994	RHM3.8C7DARW	*
	RHM6.5D7DARW	*
1995	SHM6.5D7DARW	*
	SHM3.8C7DARW	*
1996	THM6.5D7DARW	*
	THM3.8C7DARW	*
1997	VHM8.0DHDARA	*
Isuzu		
1994	none	*
1995	none	*
1996	none	*
1997	none	*
1998	WSZXH07.84RA	*
1999	XSZXH07.84RA	*
2000	YSZXH07.84RA	*
2001	1SZXH06.63RK	*
2002	2SZXH07.84RA	*
	2SZXH06.64RA	*

Model Year	Engine Family	Series
Mercedes Benz		
1994	SMB6.0D6DARA	*
1995	none	*
1996	none	*
1997	WMBXH4.25DJA	*
1998	XMBXH6.37DJA	*
1999	XMBXH4.25DJA	*
	YMBXH6.37DJA	*
2000	YMBXH4.25DJA	*
	1MBXH6.37DJC	*
2001	1MBXH4.25DJA	*
	1MBXH6.37DJA	*
	1MBXH12.0DJA	*
	1MBXH12.8DJA	*
	2MBXH4.25DJA	*
2002	2MBXH6.37DJA	*
	2MBXH6.37DJC	*
	2MBXH12.0DJA	*
	2MBXH12.8DJA	*
	2MBXH15.9DJB	*

APPENDIX D

SOLID WASTE COLLECTION VEHICLE HEALTH RISK ASSESSMENT METHODOLOGY

I. Methodology

This appendix presents the methodology used to estimate the potential cancer risk from exposure to particulate matter (PM) from solid waste collection vehicle activities. This methodology was developed to assist in the development of the proposed *Diesel PM Control Measure for On-Road Heavy-Duty Diesel-Fueled Residential and Commercial Solid Waste Collection Vehicles.* The assumptions used to determine these risks are not based on a specific solid waste collection vehicle daily activity pattern. Instead, source parameters that bracket a broad range of possible operating scenarios were used. These estimated risks are used to provide an approximate range of potential risk levels from solid waste collection vehicle activities. Actual risk levels will vary due to site specific parameters, including the number of solid waste collection vehicles, emission rates, operating schedules, site configuration, site meteorology, and distance to receptors.

A. Source Description

To provide an estimate of the potential cancer risks associated with exposure to diesel PM emissions associated with solid waste collection vehicle activity, ARB staff developed three hypothetical scenarios. The first scenario examined the potential cancer risk in a residential neighborhood. The second scenario examined the potential cancer risk in a mixed commercial/residential neighborhood with more frequent refuse collection than in the first scenario. The third scenario examined the potential cancer risk to residents living along a roadway leading to a solid waste disposal site.

The methodology used in this risk assessment is consistent with the Tier-1 analysis presented in the draft Office of Environmental Health Hazard Assessment (OEHHA), Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments (OEHHA 2002a). The OEHHA draft guidelines and this assessment use health and exposure assessment information that is contained in the Air Toxics Hot Spot Program Risk Assessment Guidelines, Part II, Technical Support Document for Describing Available Cancer Potency Factors (OEHHA 2002b); and the Air Toxics Hot Spot Program Risk Assessment Guidelines, Part IV, Technical Support Document for Exposure Analysis and Stochastic Analysis (OEHHA 2000).

B. Modeling Assumptions

ARB staff modeled three different hypothetical scenarios. The first scenario examined the potential cancer risk in a residential neighborhood due to diesel PM emission from solid waste collection activities. The second scenario examined the potential cancer risk in a mixed commercial/residential neighborhood with more frequent solid waste collection than in the first scenario. The third scenario examined the potential cancer risk to residents living along a roadway leading to a solid waste disposal site, or landfill. For the residential neighborhood scenario, we selected a hypothetical residential area with a dimension of 2440 ft x 2440 ft as depicted in Figure D1. The area is divided into

60 blocks and each block occupies 12 single homes (two rows each with 6 homes). Each home lot occupies about 0.14 acres with the dimension of 60 ft x 100 ft. All streets have a width of 40 ft. In this example, the area will have 18 links and 60 receptors, and the receptors are placed in the center of each block. For the mixed-use neighborhood scenario, using the same pattern of 60 receptors, one street had apartments along one side and a commercial complex on the other side as shown in Figure D2. For the solid waste disposal site scenario, one segment of 800 meters with 56 receptors spaced in a pattern on a two-lane freeway leading to a solid waste disposal site was assumed.

Three different operating activity patterns were modeled as follows:

(1) Solid waste collection vehicles in a single use neighborhood. In this case, we assumed that one or two solid waste collection vehicles collect garbage once a week in a single-use hypothetical residence neighborhood as shown in Figure D1. Pickup occurred during weekdays between 7 AM and 8 AM with each truck making 2 passes per pick-up.

(2) Solid waste collection vehicles in a mixed multi-use neighborhood. In this case, we assumed that two solid waste collection vehicles pick garbage up once a week in the residential area and twice a week in the commercial complex. In addition, one vehicle picks garbage up once a week in the apartment area. The configuration of the mixed multi-use neighborhood is presented in Figure D2. This configuration included a pattern of 18 links and 60 receptors. As with the first scenario, pick-up occurred during weekdays between 7 AM and 8 AM with each truck making 2 passes per pick-up.

(3) Solid waste collection vehicles near a solid waste disposal site. In this case we assumed that a fleet of solid waste collection vehicles with a traffic flow volume of 50 vehicles or 100 vehicles per day travel on a two-lane freeway toward a solid waste disposal site to dispose of the garbage. The potential diesel PM cancer risk downwind of the solid waste disposal site was examined. The following parameters were used in this scenario: 1) the diesel PM emission factor is 1.4 g/mile, which is estimated from EMFAC2000; 2) accessing the solid waste disposal site occurs Monday through Friday from 7 AM to 3 PM; 3) one segment of 800 meters in the local freeway leading to the solid waste disposal site was modeled; 4) 56 receptors are placed at the downwind locations and are perpendicular to the edge of the freeway.

In each case the estimated risk levels without the regulation (base case) were determined as well as the risk levels that would be predicted with varying levels of PM emission reductions (25 percent, 50 percent, and 85 percent) that would result from the emission controls being applied to solid waste collection vehicles.

C. Model and Meteorological Data

The PM emissions are modeled in these scenarios using the United States Environmental Protection Agency's (U.S. EPA) CAL3QHCR dispersion model to evaluate the annual average above ambient diesel PM concentrations from solid waste collection vehicles in the scenarios as described above. The potential cancer risk to receptors is obtained by multiplying annual average above-ambient concentration of diesel PM by the unit risk factor (URF) for diesel PM (300 excess cancers/ug/m^3 over a 70-year exposure period). The results are expressed as an estimate of potential cancer risk in chances per million. In these scenarios, residents were assumed to have a 70-year exposure period.

Meteorological data are site-specific parameters that are input to the air dispersion model to calculate pollutant concentrations and, subsequently, risk. For these scenarios, meteorological data input to the CAL3QHCR air dispersion model is selected from Anaheim (1981), which represents an urban setting.

D. Model Parameters and Emission Factors

The solid waste collection vehicle emission factors and key modeling parameters are presented in Tables 1 and 2, respectively. The diesel PM emission factors for solid waste collection vehicles were obtained from two sources. The emission rates for solid waste collection vehicles for the 1991 to 1993 and 1994 to 1997 model years were compiled from the New York Garbage Truck Cycle (NYGTC) testing conducted by West Virginia University and the Colorado School of Mines. The emission factors for model years not included in the NYGTC were estimated by multiplying their respective heavy heavy-duty diesel (HHD) truck emission factors in EMFAC2000 by the ratio of the NYGTC emission factor to the corresponding EMFAC2000 emission factor for known model years.[1] The weighted average diesel PM emission factor for all solid waste collection vehicles was 4.0 g/mile and is calculated using the HHD truck age distribution in EMFAC2000.

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[1] *Emission factors were estimated using the following equation:*

$$\left(\text{Calculated NYGTC EF for model year } i\right)_{refuse} = \left(\text{Known NYGTC EF for model year } j\right)_{refuse} \times \left(\frac{\text{Known HHD EF for model year } i}{\text{Known HHD EF for model year } j}\right)_{EMFAC2000}$$

where EF is the emission factor (g/mile).

Table 1. Diesel PM Emission Factors for Collection Vehicles and HHD

Model Year	Truck Age	Truck Age Distribution	Refuse Truck EF (g/mile)	HHD* ZM (g/mile)	HHD* DR (g/10,000 miles)	HHD* EMFAC 2000 (miles/yr)	HHD* Accrued Miles	HHD* EF (g/mile)
2002	0	0.026	0.8531	0.26	0.003	60,701	60,701	0.2782
2001	1	0.050	0.8531	0.26	0.003	71,088	131,789	0.2995
2000	2	0.031	0.8531	0.26	0.003	75,525	207,314	0.3222
1999	3	0.024	0.8531	0.26	0.003	75,636	282,950	0.3449
1998	4	0.062	0.8531	0.26	0.007	72,756	355,706	0.5090
1997	5	0.060	1.05	0.32	0.01	67,962	423,668	0.7437
1996	6	0.050	1.05	0.32	0.01	62,102	485,770	0.8058
1995	7	0.054	1.05	0.32	0.01	55,827	541,597	0.8616
1994	8	0.030	1.05	0.32	0.01	49,615	591,212	0.9112
1993	9	0.083	3.002	0.51	0.009	43,800	635,012	1.0815
1992	10	0.058	3.002	0.51	0.009	38,591	673,603	1.1162
1991	11	0.084	3.002	0.51	0.009	34,100	707,703	1.1469
1990	12	0.043	4.945	0.84	0.008	30,355	738,058	1.4304
1989	13	0.039	4.945	0.84	0.008	27,324	765,382	1.4523
1988	14	0.039	4.945	0.84	0.008	24,929	790,311	1.4722
1987	15	0.037	4.945	0.84	0.008	23,059	813,370	1.4907
1986	16	0.044	6.947	1.18	0.012	21,587	834,957	2.1819
1985	17	0.016	6.947	1.18	0.012	20,376	855,333	2.2064
1984	18	0.029	6.947	1.18	0.012	19,292	874,625	2.2296
1983	19	0.025	10.89	1.85	0.018	18,211	892,836	3.4571
1982	20	0.025	10.89	1.85	0.018	17,021	909,857	3.4877
1981	21	0.036	10.89	1.85	0.018	16,000	925,857	3.5165
1980	22	0.018	10.89	1.85	0.018	15,404	941,261	3.5443
1979	23	0.012	10.89	1.85	0.017	14,137	955,398	3.4742
1978	24	0.007	10.89	1.85	0.017	13,289	968,687	3.4968
1977	25	0.005	10.89	1.85	0.017	12,492	981,179	3.5180
1976	26	0.004	10.89	1.85	0.016	11,742	992,921	3.4387
1975	27	0.003	10.89	1.85	0.016	11,038	1,003,959	3.4563
pre-1975	28	0.008	11.66	1.98	0.016	10,375	1,014,334	3.6029
Composite			**4.0 g/mile**					**1.4 g/mile**

*ZM = Zero mile emission rate; DR = Deterioration rate per 10,000 miles.

Table 2. Modeling and Health Risk Assessment Parameters

Modeling Parameters	
Weekly Truck Flow	2 or 4 trucks/hr
Dispersion Setting	Urban
Receptor Height	1.5 m
Source Height	2.5 m
Run Averaging Time	60 min
Receptor Height	1.5 m
Number of Links	18
Number of Receptors	60
Setting Velocity	0 cm/s
Deposition Velocity	0 cm/s
Roughness Length	175 cm
PM Emission Factor	0.85, 4.0, 11.7 g/mile
Meteorological Data	Anaheim (1981)
Health Risk Assessment Parameters	
Residents' Hypothetical Exposure Time	70 years
Adult Daily Breathing Rate Range	271 - 393 l/kg body weight -day [2]
Adult Body Weight	70 kg

[2] The low end of the breathing rate range is the mean of the OEHHA breathing rate distribution and the high end is the 95th percentile of the distribution.

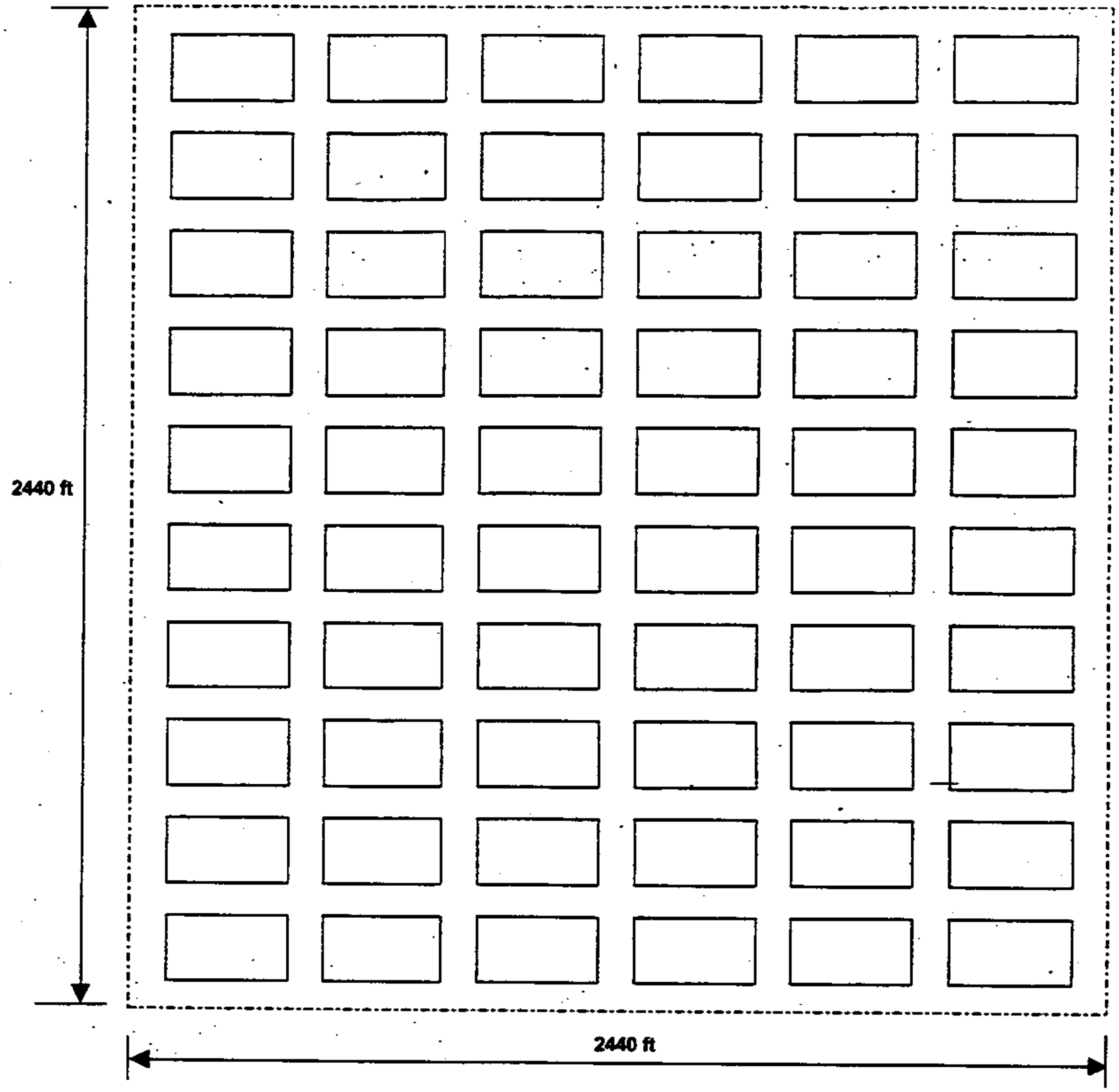

Figure 1. Layout of A Single Use Neighborhood
(A block occupies 12 home lots with two rows and each home lot occupies about 0.138 acres with a dimension of 60' x 100'. The street's width is 40'.)

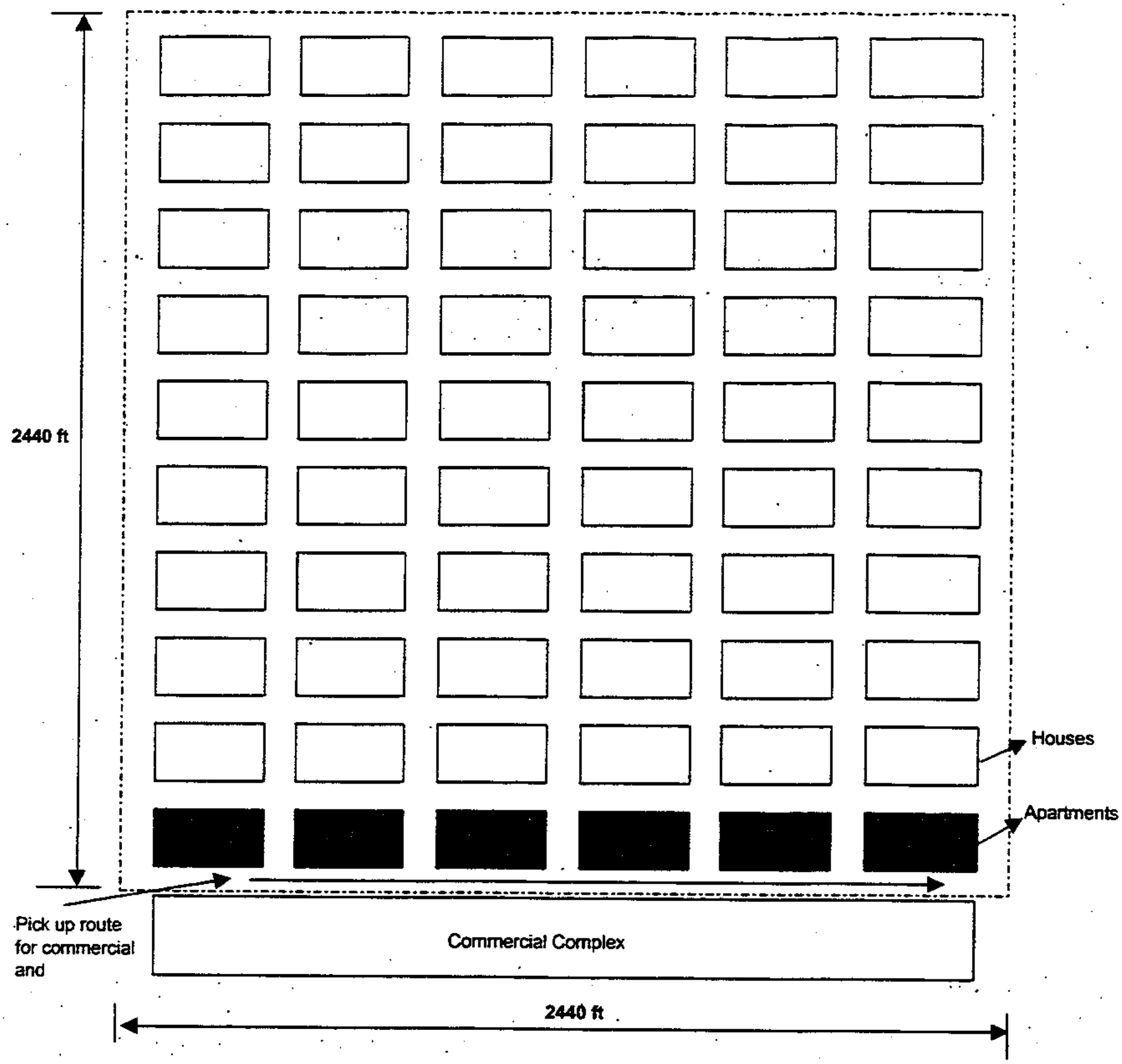

Figure 2. Layout of A Mixed Multi-Use Neighborhood

(A block occupies 12 home lots with two rows and each home lot occupies about 0.138 acres with a dimension of 60' x 100'. The street's width is 40'.)

E. Results

The estimated cancer risk from solid waste collection vehicles operating in a residential area varies depending on the age and quantity of collection vehicles operating in the neighborhood on a weekly basis (Table 3). The estimated cancer risk is calculated assuming different emission rates for the truck(s) servicing the neighborhood depending on if they are new, old, or a mix of new and old (fleet average). As expected, the maximum risk and the highest average risk would occur in neighborhoods serviced by older trucks and multiple trucks servicing the area (for example separate collection for trash and recyclable). The estimated maximum cancer risk ranges from a low of 0.2 (single newer truck per week) to a high of 6.0 (two older trucks per week) potential excess cancer cases in a million. The neighborhood average cancer risk ranges from a low of 0.2 (single newer truck per week) to 4.1 (two older trucks per week) potential excess cancer cases in a million.

The estimated cancer risk from solid waste collection vehicles operating in a mixed commercial/residential area also varies depending on the age and quantity of collection vehicles operating in the neighborhood on a weekly basis. Staff assumed twice a week pickup in the commercial area, and once a week collection using two trucks at the residences and apartments. The maximum cancer risk ranges from a low of 0.3 (newer trucks) to a high of 6.0 (older trucks) potential excess cancer cases in a million (Table 4). The neighborhood average cancer risk ranges from a low of 0.2 (newer trucks) to 3.9 (older trucks) potential excess cancer cases in a million.

The estimated cancer risk level near a roadway handling 50 or 100 refuse trucks per day is greater than in residential and mixed commercial/residential neighborhoods by an order or one to two magnitudes. The diesel PM emission rate was lower (1.4 grams per mile) compared to the first two scenarios because of the steady state operating condition associated with transporting material to a solid waste disposal site. The higher the traffic volume and the closer the receptors are to the roadway, the greater the potential cancer risk (Table 5).

Table 3. Potential Cancer Risks (Per Million) from Collection Vehicles in a Neighborhood Before Retrofit

	Maximum Risk at Residence		**Average Risk in Neighborhood**	
Fleet Condition	**Single Truck (2 Pass)**	**Two Trucks (4 Pass)**	**Single Truck (2 Pass)**	**Two Trucks (4 Pass)**
New Trucks (0.85 g/mile)	0.2 – 0.3	0.4 – 0.6	0.2 – 0.3	0.4 – 0.6
Old Trucks (11.7 g/mile)	2.0 – 3.0	4.0 – 6.0	1.4 – 2.1	2.9 – 4.1
Fleet Average (4.0 g/mile)	0.7 – 1.0	1.3 – 2.0	0.5 – 0.7	1.0 – 1.4

Notes: The low-end risk is based on the mean breathing rate and high-end risk is based on the 95th percentile breathing rate. These risk values assume an exposure duration of 70 years for nearby residents.

Table 4. Potential Cancer Risks (Per Million) from Collection Vehicles in a Mixed Multi-Use Neighborhood Before Retrofit

Fleet Condition	Maximum Risk at Residence	Average Risk in Neighborhood
New Trucks (0.85 g/mile)	0.3 – 0.4	0.2 – 0.3
Old Trucks (11.7 g/mile)	4.0 – 6.0	2.7 – 3.9
Fleet Average (4.0 g/mile)	1.4 – 2.0	1.0 – 1.4

Notes: The low-end risk is based on the mean breathing rate and high-end risk is based on the 95th percentile breathing rate. These risk values assume an exposure duration of 70 years for nearby residents.

Table 5. Potential Cancer Risks (Per Million) from Solid Waste Collection Vehicles Near a Solid Waste Disposal Site before Retrofit

Receptor Distance (m)	Risk Traffic Volume = 50 veh/d	Risk Traffic Volume = 100 veh/d
20	10.7 – 15.6	21.5 – 31.2
50	6.3 – 9.1	12.5 – 18.2
75	4.2 – 6.1	8.4 – 12.1
100	3.1 – 4.6	6.3 – 9.1
200 (1/8 mile)	1.5 – 2.2	3.0 – 4.4
400 (1/4 mile)	0.7 – 1.0	1.3 – 1.9
800 (1/2 mile)	0.2 – 0.3	0.4 – 0.6

Notes: The low-end risk is based on the mean breathing rate and high-end risk is based on the 95th percentile breathing rate. These risk values assume an exposure duration of 70 years for nearby residents.

Implementation of the proposed *Diesel PM Control Measure for On-Road Heavy-Duty Diesel-Fueled Residential and Commercial Solid Waste Collection Vehicles* will result in reduced PM emissions from solid waste collection activities. Estimates of the predicted risk levels that would result from a 25, 50, or an 85 percent reduction in PM emissions are presented in Tables 6 through 10. Not surprisingly, risk levels with implementation of this diesel PM reduction measure are lower than uncontrolled risk levels with greater reductions in potential risk resulting from the higher reductions in diesel PM emissions.

Table 6. Potential Cancer Risks (Per Million) from Collection Vehicles in a Neighborhood with 25 Percent Reduction in Diesel PM Emissions

	Maximum Risk at Residence		Average Risk in Neighborhood	
Fleet Condition	Single Truck (2 Pass)	Two Trucks (4 Pass)	Single Truck (2 Pass)	Two Trucks (4 Pass)
New Trucks (0.85 g/mile)	0.2 – 0.2	0.3 – 0.5	0.2 – 0.2	0.3 – 0.5
Old Trucks (11.7 g/mile)	1.5 – 2.3	3.0 – 4.5	1.1 – 1.6	2.2 – 3.1
Fleet Average (4.0 g/mile)	0.5 – 0.8	1.0 – 1.5	0.4 – 0.5	0.8 – 1.1

Notes: The low-end risk is based on the mean breathing rate and high-end risk is based on the 95th percentile breathing rate. These risk values assume an exposure duration of 70 years for nearby residents.

Table 7. Potential Cancer Risks (Per Million) from Collection Vehicles in a Neighborhood with 50 Percent Reduction in Diesel PM Emissions

	Maximum Risk at Residence		Average Risk in Neighborhood	
Fleet Condition	Single Truck (2 Pass)	Two Trucks (4 Pass)	Single Truck (2 Pass)	Two Trucks (4 Pass)
New Trucks (0.85 g/mile)	0.1– 0.2	0.2 – 0.3	0.1 – 0.2	0.2 – 0.3
Old Trucks (11.7 g/mile)	1.0 – 1.5	2.0 – 3.0	0.7 – 1.0	1.5 – 2.1
Fleet Average (4.0 g/mile)	0.4 – 0.5	0.7 – 1.0	0.3 – 0.4	0.5 – 0.7

Notes: The low-end risk is based on the mean breathing rate and high-end risk is based on the 95th percentile breathing rate. These risk values assume an exposure duration of 70 years for nearby residents.

Table 8. Potential Cancer Risks (Per Million) from Collection Vehicles in a Neighborhood with 85 Percent Reduction in Diesel PM Emissions

	Maximum Risk at Residence		Average Risk in Neighborhood	
Fleet Condition	Single Truck (2 Pass)	Two Trucks (4 Pass)	Single Truck (2 Pass)	Two Trucks (4 Pass)
New Trucks (0.85 g/mile)	0.03 – 0.05	0.06 – 0.09	0.03 – 0.05	0.06 – 0.09
Old Trucks (11.7 g/mile)	0.3 – 0.5	0.6 – 0.9	0.2 – 0.3	0.4 – 0.6
Fleet Average (4.0 g/mile)	0.1 – 0.2	0.2 – 0.3	0.08 – 0.1	0.1 – 0.2

Notes: The low-end risk is based on the mean breathing rate and high-end risk is based on the 95th percentile breathing rate. These risk values assume an exposure duration of 70 years for nearby residents.

Table 9. Potential Cancer Risk (Per Million) from Collection Vehicles in a Mixed Multi-Used Neighborhood with Varying Levels of Diesel PM Emission Reductions

	25% PM Emission Reduction		50% PM Emission Reduction		85% PM Emission Reduction	
Vehicle Category	Max. Risk at Residence	Ave. Risk in Neighborhood	Max. Risk at Residence	Ave. Risk in Neighborhood	Max. Risk at Residence	Ave. Risk in Neighborhood
New Trucks (0.85 g/mile)	0.2 - 0.3	0.2 - 0.2	0.2 - 0.2	0.1 – 0.2	0.05 - 0.06	0.03 - 0.04
Old Trucks (11.7 g/mile)	3.0 - 4.5	2.0 - 2.9	2.0 - 3.0	1.4 - 1.9	0.6 - 0.9	0.4 - 0.6
Fleet Average (4.0 g/mile)	1.1 - 1.5	0.8 - 1.1	0.7 - 1.0	0.5 - 0.7	0.2 - 0.3	0.2 - 0.2

Note: The low-end risk is based on the mean breathing rate and high-end risk is based on the 95th percentile breathing rate. These risk values assume an exposure duration of 70 years for nearby residents.

Table 10. Potential Cancer Risk (Per Million) from Collection Vehicles Near a Solid Waste Disposal Site with Varying Levels of Diesel PM Emission Reductions

Receptor Distance (M)	25% PM Emission Reduction		50% PM Emission Reduction		85% PM Emission Reduction	
	Traffic Volume 50 veh/d	Traffic Volume 100 veh/d	Traffic Volume 50 veh/d	Traffic Volume= 100 veh/d	Traffic Volume 50 veh/d	Traffic Volume 100 veh/d
20	8.0 – 11.7	16.1 – 23.4	5.4 – 7.8	10.7 – 15.6	1.6 – 2.3	3.2 – 4.7
50	4.7 – 6.8	9.4 – 13.7	3.2 – 4.6	6.2 – 9.1	0.9 – 1.4	1.9 – 2.7
75	3.2 – 4.6	6.3 – 9.1	2.1 – 3.2	4.2 – 6.0	0.6 – 0.9	1.3 – 1.8
100	2.3 – 3.5	4.7 – 6.8	1.6 – 2.3	3.2 – 4.6	0.5 – 0.7	0.9 – 1.4
200	1.1 – 1.7	2.3 – 3.3	0.8 – 1.1	1.5 – 2.2	0.2 – 0.3	0.5 – 0.7
400	0.5 – 0.8	1.0 – 1.4	0.4 – 0.5	0.7 – 1.0	0.1 – 0.2	0.2 – 0.3
800	0.2 – 0.2	0.3 – 0.5	0.1 – 0.2	0.2 – 0.3	0.03 – 0.05	0.06 – 0.09

Note: The low-end risk is based on the mean breathing rate and high-end risk is based on the 95th percentile breathing rate. These risk values assume an exposure duration of 70 years for nearby residents

These estimated risk levels provide a quantitative assessment of the potential risk levels in hypothetical neighborhoods. Actual risk levels from solid waste collection vehicles at any individual site will vary due to site specific parameters, including engine technologies, emission rates, fuel properties, operating schedules, meteorology, and the actual location of off-site receptors. Nevertheless, based on the risk scenarios above, it can be concluded that the reductions in diesel PM emissions that will result from implementation of the solid waste collection vehicle control measure will result a reduction in the associated potential cancer risk. As shown above, based on the hypothetical risk scenarios above, an 85 percent reduction in diesel PM emissions will reduce the potential health risk levels in most cases to less than one in a million.

In addition, although the overall magnitude of the diesel PM emissions and risk reductions from the collection vehicle control measure may appear modest, reducing these emissions are necessary if we are to achieve the goals outlined in the Diesel Risk Reduction Plan and to fulfill the requirements of H&SC section 39666. As described in the Diesel Risk Reduction Plan, it is necessary to reduce diesel PM emissions from essentially all diesel-fueled engines if we are to be successful in reducing the significant public health risk associated with diesel PM. Also, because diesel PM is a non-threshold carcinogen we are required under H&SC section 39666 to reduce emissions to the lowest level achievable through the application of best available control technology.

II. References

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APPENDIX E

SOLID WASTE COLLECTION VEHICLE EMISSIONS INVENTORY

I. Methodology

The EMFAC model used by the Air Resource Board (ARB) does not specifically address the emissions inventory of solid waste collection vehicles (collection vehicles), including these trucks as part of the heavy heavy-duty diesel (HHD) truck fleet. This is largely because of the lack of emission and activity data specific to collection vehicles, which operate differently on local streets from trucks driving on highways or freeways. In addition, ARB has not previously needed a detailed specific inventory for these vehicles. As ARB developed this regulation, however, staff required a more detailed inventory of emissions than was previously available.

A number of studies have been carried out recently to explore the effects of emission control technologies and to test collection vehicles for emission data. Staff has reviewed available collection vehicle activity information and emission testing data and has estimated an emissions inventory for collection vehicles. The following sections discuss the collection vehicle activity and emission data and present an emissions inventory for collection vehicles in California.

A. Collection Vehicle Activity Data

The following collection vehicle activity data were gathered from different sources and analyzed:

- Accrual rate and cumulative mileage;
- Population (POP) and age distribution; and
- Vehicle mile traveled (VMT).

The accrual rate for collection vehicles, estimated to be 15,635 miles per year, is based on the annual mileage data gathered from three solid waste collection companies. Staff assumes that this average annual mileage would apply to collection vehicles of all model years. The cumulative mileage for collection vehicles with age *i* is then the sum of accrual rates of collection vehicles with ages 1 through *i*.

A statewide collection vehicle population (POP) of 11,778 vehicles in year 2000 was obtained from the Department of Motor Vehicle (DMV) annual vehicle registration database. Collection vehicle populations for future years were projected from the following linear growth rate equation:

$$\text{Population} = 1.2\text{x}10^6 \text{ (Calendar Year)} - 2.34\text{x}10^9. \qquad (1)$$

Equation 1 is derived from the statewide annual solid waste generation from 1989 to 2000, which was provided by the California Integrated Waste Management Board. The projected future populations were adjusted with the survival rates of urban diesel buses used in EMFAC model.

The age distribution for collection vehicles was determined from the year 2000 DMV registration data. The populations of individual model years were obtained by applying the age distribution to the total collection vehicle population for a given year.

The collection vehicle daily VMT for a given year was estimated from the collection vehicle POP and accrual rate using the following equation:

$$VMT = \Sigma\ (POP_i \times \text{Accrual Rate}_i),\ i = 1 \text{ to } 45 \qquad (2)$$

The collection vehicle accrual rate, cumulative mileage, and age distribution are shown in Table 3.

B. Collection Vehicle Emission Rates

In estimating the emissions inventory for collection vehicles, both the HHD truck emission rates and emission rates derived from collection vehicle testing cycle were used (Table 1). HHD truck emission rates, which were based on test data collected over the Urban Dynamometer Driving Schedule (UDDS), were taken directly from EMFAC2000. In EMFAC2000, all HHD trucks were grouped into different model year groups based on emission characteristics and emission standards. Vehicles with in the same model year group were assumed to have the same emission rates.

Table 1. NYGTC and EMFAC2000 HHD Truck Emission Rates (g/mi)

Model Year Group	Avg. NYGTC Emission Rates				EMFAC2000 HHD Truck Emission Rates*							
	HC	CO	NOx	PM	HC		CO		NOx		PM	
					ZM	DR	ZM	DR	ZM	DR	ZM	DR
Pre 1975	47.6	104	158	11.66	1.60	0.017	8.36	0.095	28.5	0.013	1.98	0.016
1975-76	43.2	97.0	150	10.89	1.45	0.017	7.81	0.095	27.2	0.013	1.85	0.016
1977-79	43.2	97.0	150	10.89	1.45	0.017	7.81	0.095	27.2	0.013	1.85	0.016
1980-83	43.2	97.0	150	10.89	1.45	0.017	7.81	0.095	27.2	0.013	1.85	0.016
1984-86	22.0	60.5	112	6.947	0.74	0.017	4.87	0.095	20.2	0.013	1.18	0.016
1987-90	10.1	30.8	92.9	4.945	0.34	0.009	2.48	0.065	16.8	0.015	0.84	0.008
1991-93	8.33	21.6	88.4	3.002	0.28	0.009	1.74	0.056	16.0	0.030	0.51	0.009
1994-97	3.21	13.2	92.1	1.050	0.19	0.016	0.84	0.068	19.1	0.042	0.32	0.010
1998	3.05	9.86	111	0.853	0.18	0.014	0.63	0.049	23.0	0.037	0.26	0.007
1999-02	3.05	9.86	64.5	0.853	0.18	0.009	0.63	0.031	13.4	0.013	0.26	0.003
2003-06	2.37	15.8	32.3	0.853	0.14	0.003	1.01	0.023	6.68	0.007	0.26	0.003
2007+	0.663	4.43	3.23	0.0853	0.039	0.003	0.283	0.023	0.668	0.007	0.026	0.003

* ZM = Zero mile emission rate; DR = Deterioration rate per 10,000 miles.

Collection vehicle specific average emission rates were calculated from test data collected over the New York Garbage Truck Cycle (NYGTC; Table 1). Test data from six 1992 model year and eight 1994 model year collection vehicles were obtained from National Renewable Energy Laboratory heavy-duty truck database. Emission rates for other model years were estimated from the rates of 1991 to 1993 and 1994 to 1997 groups using ratios of the emission rates of 1991 to 1993 or 1994 to 1997 HHD truck groups and the rates of other HHD truck groups.

The NYGTC simulates the operation of a collection vehicle on a metropolitan local street; that is, stop-and-go travel at low speed, picking up and emptying trash containers and compacting waste. The NYGTC does not include a collection vehicle's trip from its collection location to its designated dump site. Such a trip is typically highway or freeway type of driving and may be similar to the operation of a HHD truck. Operation information from solid waste collection companies shows the typical waste collection trip of a collection vehicle consists of activities on both local streets and driving on highways, although the fractions of the two can vary from location to location.

To reflect this observation, the NYGTC emission rates and EMFAC2000 HHD truck emission rates were combined using fractions of local street versus highway driving. The composite BER for a given model year group was calculated as follows:

$$BER_X = f\,BER_{NYGTC} + (1-f)\,BER_{HHDD} \qquad (3)$$

Where, BER_X is the composite basic emission rate for model year group x; BER_{NYGTC} and BER_{HHDD} are, respectively, the NYGTC and EMFAC2000 HHD truck rates for model year group x; and f is the fraction of trip on local streets. Data furnished by three solid waste collection companies showed that about half of a collection vehicle's travel was spent on local street picking up and compacting waste and the other half spent on highway en route to a dump site. Staff has initiated a project utilizing GPS (global position system) data loggers to study the collection vehicle activities and the data will be used in a future update.

II. Collection Vehicle Emission Inventory

Table 2 shows the collection vehicle emissions inventory for calendar years 2005, 2010, and 2020. In calculating the inventory, an f value of 0.47 was used in Equation 3; i.e., on average 47 percent of a typical collection vehicle's trip would be on local streets and 53 percent on highways or freeways. The inventory given in Table 3 includes the U.S. EPA 2007 heavy-duty diesel engine regulations and U.S. EPA 2006 low sulfur diesel fuel regulation.

Table 2. Statewide Collection Vehicle Emissions Inventory (tons/day)

	2005	2010	2020
HC	4.20	4.10	3.04
CO	11.9	11.8	9.59
NOx	33.8	27.4	27.5
PM	1.57	1.42	1.12

Table 3. Accrual Rate, Cumulative Mileage, and Population Distribution for SWCV

Age	Accrual Rate (mi/year)	Cumulative Mileage	Population*
0	15,635	15,635	306
1	15,635	31,270	586
2	15,635	46,905	361
3	15,635	62,540	287
4	15,635	78,175	728
5	15,635	93,810	707
6	15,635	109,445	592
7	15,635	125,080	632
8	15,635	140,715	355
9	15,635	156,350	977
10	15,635	171,985	686
11	15,635	187,620	987
12	15,635	203,255	503
13	15,635	218,890	455
14	15,635	234,525	460
15	15,635	250,160	431
16	15,635	265,795	522
17	15,635	281,430	186
18	15,635	297,065	344
19	15,635	312,700	290
20	15,635	328,335	297
21	15,635	343,970	420
22	15,635	359,605	212
23	15,635	375,240	147
24	15,635	390,875	80
25	15,635	406,510	56
26	15,635	422,145	42
27	15,635	437,780	36
28	15,635	453,415	32
29	15,635	469,050	15
30	15,635	484,685	12
31	15,635	500,320	12
32	15,635	515,955	5
33	15,635	531,590	4
34	15,635	547,225	3
35	15,635	562,860	1
36	15,635	578,495	3
37	15,635	594,130	3
38	15,635	609,765	3
39	15,635	625,400	0
40	15,635	641,035	0
41	15,635	656,670	0
42	15,635	672,305	0
43	15,635	687,940	0
44	15,635	703,575	0
TOTAL	703,575	16,182,225	11,778

*Year 2000 population in California.

APPENDIX F

COST EFFECTIVENESS METHODOLOGY

I. METHODOLOGY

The basic methodology ARB uses to determine cost-effectiveness of a regulation is to determine what costs are involved to comply with the proposed regulation, and to compare those costs to the emission reduction benefits to the public. Staff summarizes this cost effectiveness as cost (in $) per pound of air pollutant reduced, in this case diesel particulate matter (PM). Staff calculated cost effectiveness two ways for this regulation because although this rule is primarily a PM-reduction measure, staff also estimates that significant reductions in HC and NOx emissions will take place.

A. Implementation Schedule

The implementation schedule for the proposed regulation dictates a phase-in by fleet and engine model year group (**Table 1**). Staff assumed a best available control technology (BACT) would be available for each model year engine. Staff also assumed collection vehicle owners would choose the least expensive BACT to comply with this regulation.

Table 1. Implementation Schedule for Solid Waste Collection Vehicles, Model Years 1960 to 2006.

Group	Engine Model Years	Percentage of Group to Use BACT	Compliance Deadline
1	1988 – 2002	10	December 31, 2004
		25	December 31, 2005
		50	December 31, 2006
		100	December 31, 2007
2[a]	1960 – 1987	25	December 31, 2007
		50	December 31, 2008
		75	December 31, 2009
		100	December 31, 2010
3	2003 – 2006	50	December 31, 2009
		100	December 31, 2010

[a]Group 2: An owner of an active fleet with 15 or more solid waste collection vehicles may not use Level 1 technology as BACT.

B. Implementation Scenarios

PM emissions and exhaust temperatures dictate the type of diesel emission control strategy (DECS) that can be used on a collection vehicle (See Technical Support Document for further discussion). Based on available data on DECS, staff created three scenarios to determine emission reductions and economic impacts: the first is based on use of current verified DECSs (**Table 2**), the second is based on an expansion of Level 1 verifications but no Level 2 DECS verified (potential 1) (**Table 3**), and the third is based an expansion of Level 1 verifications plus Level 2 DECS verifications (potential 2) (**Table 4**).

Table 2. Implementation Scenario (Current).

Group	Eng MY	%BACT	Implementation Date	Technology Option (By Percent Phase-In)				
				Level 1	Level 2	Level 3[a]	Repower	OE[h] 0.01
1	1994-2002[g] 32% of fleet	10%	12/31/2004	17.0%		8.0%		
		25%	12/31/2005	17.0%		8.0%		
		50%	12/31/2006	17.0%		8.0%		
		100%	12/31/2007			5.0%	20.0%	
1	1991-1993[g] 14% of fleet	10%	12/31/2004	25.0%				
		25%	12/31/2005	25.0%				
		50%	12/31/2006	25.0%				
		100%	12/31/2007	5.0%			20.0%	
1	1988-1990[c] 18% of fleet	10%	12/31/2004					
		25%	12/31/2005					
		50%	12/31/2006					
		100%	12/31/2007				50.0%	
		Delay	12/31/2008				50.0%	
2	1960-1987[b] 27% of fleet	25%	12/31/2007				22.8%	
		50%	12/31/2008				22.8%	
		75%	12/31/2009				22.8%	
		100%	12/31/2010				22.8%	
		Delay	12/31/2011				9.0%	
3	2003-2006[d,e] 9% of fleet	50%	12/31/2009	14.1%		15.9%		20.0%
		100%	12/31/2010	14.1%		15.9%		20.0%
Percent of California's Collection Vehicle Fleet Total:				30%	0%	12%	54%	4%

Notes:

[a] Only 1994-2002 MY engines were considered for passive diesel particulate filters based on verification data. Assumption based on manufacturer with lowest engine exhaust temperature requirement.

[b] Nine percent of 1960-1986 vehicles are owned by companies with less than 15 vehicles (63 percent of surveyed companies).

[c] Assume all vehicles will repower and have BACT delays since no DECS are currently available.

[d] Assume current Level 3 verification will be extended to 2003-2006 MYs.

[e] Assume current Level 1 verification will be extended to 2003-2006 MYs.

[f] Assume small fleets (<15 vehicles) will have no DECS available and receive implementation delay to 2011.

[g] Assume 20 percent repower even though DECS currently available to these model years due to expected preference of some collection vehicle owners.

[h] Original equipment – purchased new.

Table 3. Implementation Scenario (Potential 1) - no Level 2 verified.

Group	Eng MY	%BACT	Implementation Date	Technology Option (By Percent Phase-In)				
				Level 1	Level 2	Level 3[a]	Repower	OE[g] 0.01
1	1994-2002[f]	10%	12/31/2004	17.0%		8.0%		
	32% of fleet	25%	12/31/2005	17.0%		8.0%		
		50%	12/31/2006	17.0%		8.0%		
		100%	12/31/2007			5.0%	20.0%	
1	1991-1993[c, f]	10%	12/31/2004	25.0%				
	14% of fleet	25%	12/31/2005	25.0%				
		50%	12/31/2006	25.0%				
		100%	12/31/2007	5.0%			20.0%	
1	1988-1990[c, f]	10%	12/31/2004	25.0%				
	18% of fleet	25%	12/31/2005	25.0%				
		50%	12/31/2006	25.0%				
		100%	12/31/2007	5.0%			20.0%	
2	1960-1987[b,c, f]	25%	12/31/2007	2.3%			22.8%	
	27% of fleet	50%	12/31/2008	2.3%			22.8%	
		75%	12/31/2009	2.3%			22.8%	
		100%	12/31/2010	2.3%			22.8%	
3	2003-2006[d,e]	50%	12/31/2009	14.0%		16.0%		20.0%
	9% of fleet	100%	12/31/2010	14.0%		16.0%		20.0%
Percent of California's Collection Vehicle Fleet Total:				47%	0%	12%	37%	4%

Notes:

[a] Only 1994-2002 MY engines were considered for passive diesel particulate filters based on verification data.

Assumption based on manufacturer with lowest engine exhaust temperature requirement.

[b] Nine percent of 1960-1986 vehicles are owned by companies with less than 15 vehicles (63 percent of surveyed companies).

[c] Assume current Level 1 verification will be extended to 1960-1993 MYs.

[d] Assume current Level 3 verification will be extended to 2003-2006 MYs.

[e] Assume current Level 1 verification will be extended to 2003-2006 MYs.

[f] Assume 20 percent repower even though DECS either currently or expected to be available to these model years due to expected preference of some collection vehicle owners.

[g] Original equipment – purchased new.

Table 4. Implementation Scenario (Potential 2) – All Levels Verified.

Group	Eng MY	%BACT	Implementation Date	Technology Option (By Percent Phase-In)				
				Level 1	Level 2	Level 3[a]	Repower	OE[h] 0.01
1	1994-2002[c,e] 32% of fleet	10%	12/31/2004		17.0%	8.0%		
		25%	12/31/2005		17.0%	8.0%		
		50%	12/31/2006		17.0%	8.0%		
		100%	12/31/2007			5.0%	20.0%	
1	1991-1993[c,e] 14% of fleet	10%	12/31/2004		25.0%			
		25%	12/31/2005		25.0%			
		50%	12/31/2006		25.0%			
		100%	12/31/2007		5.0%		20.0%	
1	1988-1990[c,e,f] 18% of fleet	10%	12/31/2004	2.0%	23.0%			
		25%	12/31/2005	2.0%	23.0%			
		50%	12/31/2006	2.0%	23.0%			
		100%	12/31/2007	2.0%	3.0%		20.0%	
2	1960-1987[b,e,f] 27% of fleet	25%	12/31/2007	2.0%	0.25%		22.75%	
		50%	12/31/2008	2.0%	0.25%		22.75%	
		75%	12/31/2009	2.0%	0.25%		22.75%	
		100%	12/31/2010	2.0%	0.25%		22.75%	
3	2003-2006[d,e] 9% of fleet	50%	12/31/2009		14.0%	16.0%		20.0%
		100%	12/31/2010		14.0%	16.0%		20.0%
Percent of California's Collection Vehicle Fleet Total:				4%	43%	12%	37%	4%

Notes:
[a] Only 1994-2002 MY engines were considered for passive diesel particulate filters based on verification data. Assumption based on manufacturer with lowest engine exhaust temperature requirement.
[b] Nine percent of 1960-1986 vehicles are owned by companies with less than 15 vehicles. (63 percent of surveyed companies.)
[c] Assume 20 percent repower even though DECS currently or expected to be available to these model years due to expected preference of some collection vehicle owners.
[d] Assume current Level 3 verification will be extended to 2003-2006 MYs.
[e] Assume a PuriNOx+DOC Level 2 could be verified for all model years.
[f] Assume a small percentage of fleet may not be able to use Level 2 devices.
[g] Assume low sulfur fuel used for only installed diesel particulate filters before 2006.
[h] Original equipment – purchased new.

C. Cost Calculations

Two types of costs were accounted for in the cost effectiveness analysis, capital costs and operation and maintenance (O & M) costs. For each cost, ARB determined the range of costs from the published literature and from estimates supplied by experts during phone inquiries. Taking the collected data, staff calculated a low, average, and high amount for each cost. It is important to note that since most of these costs are predictive, they could vary significantly depending on the state of the economy, demand, competition, and other as yet unknown factors.

1. Capital Costs

As an example of how costs will likely decrease over time, staff compared future predicted and current capital costs for a passive diesel particulate filter (DPF). Capital costs for a passive DPF include the cost of the device, an engine backpressure monitor, and its installation. In general, the horsepower of the engine determines a passive DPF's cost. **Table 5** provides an estimate of the current cost to retrofit on-road engines and vehicles with catalyst-based DPFs. This information assumes a cost of $10 to $20 per horsepower, as reported by the Manufacturers of Emission Controls Association (MECA 2000). Based on an ARB survey, the average horsepower of a collection vehicle engine is 245, falling around the medium heavy-duty (MHD) categories' costs of $2,500 to $5,000.

Table 5. Capital Costs Associated with a Passive DPF Retrofit of On-Road Engines

Vehicle Class	LHD	MHD	HHD
Average Horsepower[1]	**190 hp**	**250 hp**	**475 hp**
Passive DPF	$1,900 - $3,800	$2,500 - $5,000	$4,750 - $9,500

In contrast to the retrofit costs presented in **Table 5, Table 6** presents the United States Environmental Protection Agency's (U.S. EPA's) estimate of the future (2007) costs of applying passive DPFs to new on-road engines and vehicles (U. S. EPA 2000). The U.S. EPA estimates are based on higher production volumes, and they are similar to the future cost projections presented by manufacturers (MECA 2000).

Table 6. Future (2007) Catalyst-Based DPF Costs for On-Road Engines

Vehicle Class	LHD	MHD	HHD
Average Horsepower[2]	**190 hp**	**250 hp**	**475 hp**
Catalyst-Based DPF Costs[3]	$670	$890	$1,100

Based on the costs from these two tables and the average horsepower for a collection vehicle, the estimated average passive DPF capital costs could be a

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1 The average horsepower was derived from the U.S. EPA's engine certification database for LHDD, MHDD, and HHDD engines for model years 1999 and 2000.

2 The engine horsepower ranges were derived from the U.S. EPA's engine certification database for LHDD, MHDD, and HHDD engines for model years 1999 and 2000.

3 The U.S. EPA Catalyst Based-DPF cost estimates include both fixed costs (e.g., tooling, research and development, and certification) and variable costs (e.g., hardware, assembly and markup).

high of $5,000 currently to a low of $890 in 2007. The current cost is consistent with those City of Los Angeles recently paid for an order of passive DPF, $4,900, which included the cost of backpressure monitors (ARB 2003). A stark contrast therefore exists between the current costs associated with retrofitting existing engines and the future costs associated with applying DPFs to new engines and vehicles.

Staff expects, however, these costs will decline as production volumes and experience increase, and that, over the next five years, the current retrofit costs (**Table 5**) will approach the new engine DPF costs (**Table 6**).

The cost of installation and an engine backpressure monitor were not factored into these current and projected costs. Staff interviewed heavy-duty diesel repair shop personnel for the cost of a muffler installation to estimate the time needed for installation and the cost associated with the mechanic's time. Installation takes between two and a half to five hours of time for installation, and labor costs ranged from $160 to $480. This was also consistent with a recent fleet purchase experience. The City of Los Angeles paid $475 per unit installed (ARB 2003). Staff assumed this cost would be applicable to all hardware DECS, i.e., DPFs and diesel oxidation catalysts (DOCs). An engine backpressure monitor costs between $1000 and $1200 currently. Therefore, the current average capital cost for a passive DPF would be approximately $5300.

Also, the current costs are not representative of the higher end of the range of capital costs associated with a passive DPF. Additional sources quote costs upwards of $9000 (Cai-infopool 2002) and $8000 (Fuelstar 2000). Factoring these higher costs into the capital cost provides a high capital cost of $10,700. These high end costs for passive DPF are reflective of the current costs associated with the capital costs associated with active DPF. No capital active DPF costs were discovered in the literature, but from meetings with manufacturers and quotes for demonstration devices, ARB staff found the range of capital costs to be from $6200 to $16,700 with an average cost of $11,800.

On the other hand, the current capital costs of DOCs are nearer the low end of the range of costs associated with passive DPF. The costs for these devices range from $700 to $6500 with an average of $3100 (MECA 2000, Clean Air Counts 2002, Fuelstar 2000, Worldbank 2001).

2. Operation and Maintenance Costs

O & M costs considered by staff included the cost for cleaning the trap, the incremental fuel cost to convert to diesel fuel with a sulfur content of 15 parts per million by weight or less (low sulfur diesel fuel), and the incremental cost associated with transportation of this fuel. Based on conversations with the DECS manufacturers and personnel involved with demonstration programs, staff determined the number of cleanings would be on the average one to two times a year or less, dependent on the DECS and other vehicle variables, such as oil consumption.

The incremental cost of producing low sulfur diesel fuel is expected to be somewhat higher than CARB diesel. Until low sulfur diesel fuel is used on a statewide basis for all diesel fleets, beginning with the federal diesel fuel rule in mid-2006, fuel will likely not be transported through the existing pipeline but by delivery trucks. Staff assumed an incremental fuel transportation cost for fiscal years (FY) 2004 and 2005 would vary depending on the distance from the refinery rack to the tank. In phone conversations with fuel transporters, staff calculated a range of transportation costs in dollars per gallon for transportation from zero to 50 miles, 50 to 100, 100-200, and 200-300, the assumed maximum distance needed to travel from the rack to any location requiring the low sulfur diesel fuel in California. Total O & M costs per vehicle ranged from $220 to $910 with an average cost of $510 per year before the mid-2006 low sulfur diesel fuel federal rule begins.

Those who do opt to use an ARB verified fuel DECS in lieu of low sulfur diesel fuel may do so. The only option currently available, but not ARB verified, is Lubrizol's PuriNOx™, a fuel-water emulsion. PuriNOx™ costs are based solely on incremental O & M costs of approximately 25 cents per gallon.

After the U.S. EPA low sulfur diesel fuel rule is implemented in mid-2006, no additional fuel or fuel transportation costs would apply, since all on-road heavy-duty diesel trucks would be expected to use this fuel regardless of our regulation, and, therefore, the volume would be sufficient to transport the fuel the normal method, which is via the pipeline and then fuel tanker trucks, not just fuel tanker trucks, as discussed above. The only additional cost to owners for O & M would then be the cost of increased inspection and DECS cleanings, which ranged from zero cost to $190 per year, with an average cost of $80.

The costs for various DECS staff believes might be used as options to meet the requirements of this regulation, therefore, might vary substantially between the strategies (**Table 7**). The option that is most cost effective (i.e., the least cost option responsible for the greatest decrease in diesel PM emissions) is the passive DPF. Since this option will likely not be available to all, staff have accounted for the other technologies that might be used in the cost effectiveness of this regulation.

Table 7. Average Costs Associated with Possible DECS used for Collection Vehicles.

Cost	Passive DPF	Active DPF	PuriNOx[TM, a]	DOC
Capital				
Hardware	$3,980	$10,500	N/A	$2,830
Installation	$290	$290	N/A	$290
Engine Backpressure Monitor	$1,000	$1,000	N/A	N/A
Total	$5,270	$11,790	N/A	$,3120
Annual O & M				
Increased Maintenance	$80	$80	N/A	$80
Incremental Fuel	$200[b]	$200	$2750	$200
Incremental Transportation of Fuel	$230	$230	Included	$230
Total	$510	$510	$2750	$510

[a] In order to verify PuriNOx[TM] as a Level 2 DECS, it will likely need to use a DOC.

[b] This is the fuel cost for 15 ppmw or less sulfur diesel fuel.

D. Repower Costs

The cost to repower an engine to meet a 0.01 g/bhp-hr PM emission standard (2007 or later model years) will vary according to the engine model year and vehicle type from which it is being converted. Replacing an electronically-controlled fuel injection engine (1994 and newer model years) with a 2007 or later model year engine is expected to cost less than replacing a mechanically-controlled fuel injection engine of earlier vintage due to the challenges associated with conversion of mechanical to electronic systems. In some instances it may not be possible to upgrade engines because of space constraints in the engine compartment of the vehicle. An owner would, therefore, need to consider using a DECS or replacing the entire vehicle. In other cases it may be more cost effective to comply by replacing a pre-1994 model year engine with a 1994 to 2006 model year engine and installing a diesel particulate filter.

To determine the costs associated with repowering an engine to meet the 0.01 g/bhp-hr PM emission standard ARB staff surveyed engine providers. While engine providers could not predict the cost of a 2007 engine, they could supply ARB staff with current cost of repowering an older model year engine to a newer model year engine to meet current particulate emission standards. Staff found the cost to repower to a pre-2007 model year engine ranged from $21,000 to $90,000, according to the original and the new makes and model years of the engines. Since these engines would still require additional diesel emission control to meet the best available control technology requirement for this regulation, staff included the average cost of a DPF. Based on the data, the average total cost used in this analysis is $50,000 **(Table 8)**

Table 8. Engine Repower Capital Costs.

New Engine (pre-2007) Plus Installation	Capital Cost
Average Total Cost	$45,000
Average Cost of DPF	$5,000
Total Repower Capital Costs	$50,000

While not quantified, two benefits offset the initial cost of repowering an engine, increased fuel economy and decreased maintenance costs. The fuel economy benefit will vary depending on the engine replaced, but as collection vehicles typically achieve only two to three miles per gallon, any fuel economy benefit would result in a significant savings, helping the owner recoup the costs associated with the repower. Similarly, decreased maintenance would result in increased time on the road and fewer repair costs, thus reducing repower costs.

E. Cost-Effectiveness Calculation

Staff determined the amount of PM, HC, and NOx reduced per year based on the implementation of this proposed regulation. Using one method, staff determined cost-effectiveness by dividing the total discounted capital costs plus annual O & M costs by the annual tons of diesel PM reduced. Using the second method, staff allocated half of the costs to PM reduced and half of the costs to HC and NOx reduced.

In order to arrive at the discounted capital costs for the regulation, staff multiplied the capital costs by the capital recovery factor[4], and assumed a lifetime of the DECS based on the minimum warranty period of five years with an annual interest rate of seven percent.[5] Certain technologies, such as a DPF, will likely last much longer than five years in a well-maintained vehicle, as some DPFs have been operating for over 300,000 miles in the U.S. Average collection vehicle mileage is 15,635 miles per year[6] and thus at a minimum a DPF is expected to operate for about ten years. Five years life for DECSs was used in an effort to make a conservative estimate. Clearly, the cost-effectiveness would be lower if a DECS has a longer lifetime than estimated here.

1. All Costs Allocated to PM Reduction

The average costs of implementing the program from December 31, 2004, to December 31, 2010, were included in the cost-effectiveness calculation (**Tables 9, 10, & 11**). The average cost effectiveness of the program, considering the

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[4] Capital Recovery Rate Factor: 480r(1+r)^N/[(1+r)^N-1], where r = the annual interest rate, and N = lifetime of project (in years) (Linsley 1977).
[5] USEPA uses the factor to calculate costs of environmental programs.
[6] ARB. 2001. Averages of survey of three solid waste collection vehicle companies.

range of costs and implementation scenarios, is about $28 per pound diesel PM reduced. The staff predicts the cost may be lower than this average, based on past experience and because engine manufacturers will need to begin ordering DPFs to the meet 2007 federal PM emission standard of 0.01 g/bhp-hr, thus increasing volume.

In comparing the three implementation scenarios, the current (**Table 9**) and potential 1 (**Table 10**) implementation scenarios are the most cost-effective due to their low operation and maintenance costs. The Level 2 DECS used in the calculation for potential 2 implementation scenario is the fuel-water emulsion strategy (**Table 11**). It is also possible the flow through filter will be verified (see Technical Support Document). This would bring the costs down closer to the current (**Table 9**) or potential 1 (**Table 10**) values.

Table 9. Average Cost Effectiveness Current Implementation Scenario: All Costs Allocated to PM Reduction.

Fiscal Year	Diesel PM Reduced (lb/yr)	Total Annual Cost ($/yr)	Cost per Pound PM Reduced
2004	14,600	312,629	
2005	36,500	1,053,949	
2006	58,400	1,944,575	
2007	292,000	9,594,848	
2008	529,980	14,133,995	
2009	677,440	16,680,221	
2010	836,580	18,991,886	
TOTAL	2,445,500	62,712,103	$26/lb

Table 10. Average Cost Effectiveness of Potential 1 Implementation Scenario: All Costs Allocated to PM Reduction.

Fiscal Year	Diesel PM Reduced (lb/yr)	Total Annual Cost ($/yr)	Cost per Pound PM Reduced
2004	29,200	404,300	
2005	65,700	1,385,794	
2006	189,800	2,568,926	
2007	284,700	8,340,353	
2008	435,080	10,248,704	
2009	589,110	12,775,813	
2010	748,250	15,046,370	
TOTAL	2,341,840	50,770,260	$22/lb

Table 11. Average Cost Effectiveness of Potential 2 Implementation Scenario: All Costs Allocated to PM Reduction.

Fiscal Year	Diesel PM Reduced (lb/yr)	Total Annual Cost ($/yr)	Cost per Pound PM Reduced
2004	51,100	780,217	
2005	109,500	3,675,875	
2006	365,000	7,450,861	
2007	355,510	17,968,961	
2008	525,600	19,294,463	
2009	659,190	21,572,430	
2010	819,060	23,678,553	
TOTAL:	2,884,960	94,421,361	$33/lb

2. Costs Split Between PM and HC+NOx Reductions

Along with reducing diesel PM, each control technology also reduces HC emissions, and some, such as a new engine, also reduce NOx emissions. Staff therefore has calculated cost-effectiveness by allocating half of the costs to HC and NOx reductions and the other half to PM reductions. Using this method, the average cost-effectiveness over the implementation of this rule is $0.71/lb HC+NOx and $13/lb PM reduced (**Tables 12, 13, & 14**).

Table 12. Average Cost-Effectiveness of Current Implementation Scenario: Costs Split Between PM and HC+NOX.

Fiscal Year	Diesel PM Reduced (lb/yr)	HC+NOX Reduced (lb/yr)	Half of Annual Costs ($/yr)	Cost per Pound Reduced	
				PM	HC+NOx
2004	14,600	102,200	156,315		
2005	36,500	197,100	526,974		
2006	58,400	299,300	972,288		
2007	292,000	6,862,000	4,797,424		
2008	529,980	11,300,400	7,066,997		
2009	677,440	12,132,600	8,340,110		
2010	836,580	14,344,500	9,495,943		
TOTAL	2,445,500	45,238,100	31,356,051	$12.82/lb	$0.69/lb

Table 13. Average Cost-Effectiveness of Potential 1 Implementation Scenario: Costs Split Between PM and HC+NOX.

Fiscal Year	Diesel PM Reduced (lb/yr)	HC+NOX Reduced (lb/yr)	Half of Annual Costs ($/yr)	Cost per Pound Reduced	
				PM	HC+NOx
2004	29,200	167,900	202,150		
2005	65,700	328,500	692,897		
2006	189,800	496,400	1,284,463		
2007	284,700	6,007,900	4,170,177		
2008	435,080	8,548,300	5,124,352		
2009	589,110	9,862,300	6,387,906		
2010	748,250	12,185,890	7,523,185		
TOTAL	2,341,840	37,597,190	25,385,130	$10.84/lb	$0.67/lb

Table 14. Average Cost-Effectiveness of Potential 2 Implementation Scenario: Costs Split Between PM and HC+NOX.

Fiscal Year	Diesel PM Reduced (lb/yr)	HC+NOX Reduced (lb/yr)	Half of Annual Costs ($/yr)	Cost per Pound Reduced	
				PM	HC+NOx
2004	51,100	1,533,000	390,109		
2005	109,500	3,197,400	1,837,938		
2006	365,000	4,657,400	3,725,430		
2007	355,510	10,891,600	8,984,481		
2008	525,600	12,972,100	9,647,231		
2009	659,190	13,505,000	10,786,215		
2010	819,060	15,786,980	11,839,276		
TOTAL	2,884,960	62,543,480	47,210,680	$16.36/lb	$0.75

II. OTHER COST FACTORS

A number of costs are not factored into the cost effectiveness analysis because of lack of available information. The costs accounted for above do not include administrative costs (see form 399 attachment for these). From discussions with trap manufacturers, ARB staff assumed the DECS manufacturer would provide maintenance training at no additional charge.

Staff also assumed incremental fuel transportation cost would disappear for those collection vehicles using DECS requiring the use of low sulfur diesel fuel after July 1, 2006, when, for on-road vehicles nationwide, diesel fuel will all be low sulfur. The incremental fuel transportation cost is based on the assumption that the cost to transport the low sulfur diesel fuel will be higher than after the fuel is required nationwide. With low throughput of the fuel would come a greater transmix between gasoline and diesel grade fuel, increasing the cost to the fuel providers. Staff assumes the 2006 fuel rule full conversion of the fleet would be the maximum required to return to use of the pipeline. The possibility exists that the pipeline could be used earlier, making our calculation of cost high for this item.

Staff assumed no fuel economy penalty would exist from the use of a DECS. This is based on staff experience with the verification procedure and the inability of studies to determine an impact, either positive or negative (LeTavec *et al* 2000, LeTavec *et al* 2002). A slight penalty or benefit may exist, but until more conclusive data is available staff assumed either would be negligible. Also, staff did not include costs associated with any fuel economy and maintenance benefits that might be associated with repowers. Staff believes these savings likely exist.

Staff also assumed the fee for disposal of ash from a DPF would be negligible. From cleaning of the DPF during the ARB demonstration and testing program, ARB staff estimated the weight of weight ash to be approximately ten to 15 grams per disposal, which is dependent upon oil consumption. The quantity of ash would be greater with more than average oil consumption. Based on conversations with the DECS manufacturers and demonstration program experience, staff determined the number of cleanings would be one to two times a year or less, dependent on the DECS and other vehicle variables, such as oil consumption.

Staff determined the quantity of ash that might be generated by a fleet of ten, 100, or 1000 collection vehicles (**Table 15**). Since the quantity was so low, the collection vehicle owner would qualify as a conditionally exempt small quantity generator. According to the Department for Toxic Substances Control, no permit is required for less than 55 gallons of hazardous waste accumulation (DTSC 2001). Typically, a hazardous waste may be stored on-site for 180 days or less, after the site has accumulated 100 kilograms of waste. In order to accumulate 100 kg of ash for this scenario, it would take between three and ten years. Due to the length of time to accumulate ash and to the variability in ash quantity, staff did not include this cost in the cost effectiveness analysis. The cost to dispose of a 55-gallon drum of ash would cost about $200 (Girstenson 2001).

Table 15. Ash Disposal Analysis

Number of Trucks	Ash Accumulation (in grams per year)			Years to Accumulate 100 kg of Ash
	Low	Average	High	
10	100	200	300	10
100	1000	2000	3000	5
1000	10,000	20,000	30,000	3

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California Environmental Protection Agency
AIR RESOURCES BOARD

Technical Support Document for the Proposed Control Measure For Diesel Particulate Matter From On-Road Heavy-Duty Residential And Commercial Solid Waste Collection Vehicle Diesel Engines

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List of Acronyms

ARB, or the Board	Air Resources Board
BACT	Best available control technology
CAS	Clean Air Systems
CNG	Compressed natural gas
CO	Carbon monoxide
DECS	Diesel emission control strategy or system
DOC	Diesel oxidation catalyst
DPF	Diesel particulate filter
FBC	Fuel borne catalyst
FTF	Flow through filter
g/bhp-hr	Grams per brakehorse power hour
HC	Hydrocarbon
JM	Johnson Matthey
LNG	Liquified natural gas
Low sulfur diesel fuel	Diesel fuel with a sulfur content less than 15 parts per million by weight
LPG	Liquid petroleum gas
MY	Model year
NO_x	Oxides of nitrogen
PM	Particulate matter
Procedure	Diesel Emission Control Strategy Verification Procedure
SAEFL	Swiss Agency for the Environment, Forests, and Landscape
SCAQMD	South Coast Air Quality Management District
SWCV	Solid waste collection vehicle
U. S. EPA	United States Environmental Protection Agency

I. Summary

Recognizing the considerable impacts of implementing a regulation to reduce the health risks from diesel particulate matter emission from solid waste collection vehicles, the staff of the Air Resources Board has undertaken this technical review in support of its proposed control measure for diesel particulate matter from on-road heavy-duty diesel-fueled residential and commercial solid waste collection vehicle engines.

In this report, Air Resources Board staff reviews the PM reduction technologies both currently available and projected to be available in the near future, not only for solid waste collection vehicles but also for other diesel mobile and stationary engines. For each type of technology, staff describes the technology, discusses potential limitations and in-use experiences, and identifies technology that has been verified by the Air Resources Board. The Report also discusses in more detail in-use experiences with diesel particulate matter reduction technologies by the City of Los Angeles and internationally. Demonstrations conducted by Air Resources Board are also reviewed. Finally, staff reports on the results of studies undertaken to investigate the applicability of potential diesel emission control technologies to California's collection vehicles and the implications of the data for retrofit feasibility.

II. Introduction

Recognizing the considerable impacts of implementing a regulation to reduce the health risks from diesel particulate matter (PM) emission from solid waste collection vehicles (SWCVs), the Air Resources Board (ARB or the Board) has undertaken this technical review in support of its proposed control measure for diesel PM from on-road heavy-duty diesel-fueled residential and commercial SWCV engines. In this report, ARB staff reviews the PM reduction technologies both currently available and projected to be available in the near future, not only for SWCVs but also for other diesel mobile and stationary engines. More specifically to support the proposed SWCV rule, staff also reports on the results of studies undertaken to investigate the applicability of potential diesel emission control technologies to California's collection vehicles.

Throughout this report, a diesel emission control strategy or system (DECS) is the term used to mean any device, system, or strategy employed with an in-use diesel vehicle or piece of equipment that is intended to reduce emissions. While this definition does not exclude systems that reduce emissions of oxides of nitrogen, in this report we focus on strategies that reduce PM engine exhaust emissions. Examples of DECSs include, but are not limited to, add-on hardware, such as a diesel particulate filter (DPF), a diesel oxidation catalyst (DOC), or flow-through filter; alternative diesel fuels or fuel additives; and integrated systems that combine hardware with an alternative diesel fuel or fuel additive. The effectiveness of a DECS to reduce PM ranges, by Board regulation, from 25 percent (Level 1) up the maximum achievable. For example, a DOC may achieve the minimum 25 percent reduction, primarily from removal of the soluble organic fraction of diesel PM, whereas the effectiveness of a DPF ranges from 85 to over 99 percent.

Integrated systems, such as a DOC coupled with a fuel-water emulsion or a lightly-catalyzed DPF used with a fuel additive, may also be an effective DECS. Such systems are capable of functioning in a range of engines/vehicles and applications, which will help to ensure that an emission control strategy option should be available to most, if not all, SWCVs by the proposed implementation dates.

III. Verification of Diesel Emission Control Strategies

As a way to thoroughly evaluate the emissions reduction capabilities and durability of a variety of DECSs, ARB has developed the Diesel Emission Control Strategy Verification Procedure (Procedure).[1] The purpose of the Procedure is to verify strategies that provide reductions in diesel PM emissions, which include, but are not limited to, DPFs, DOCs, exhaust gas recirculation, selective catalytic

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[1] Approved by the Board in May 2002. Sections 2700 through 2710, Title 13, California Code of Regulations.

reduction systems, fuel additives, and alternative diesel fuel systems. The development of the verification procedure is based on experience gained with passive DPFs, but has been crafted to apply to all DECSs.

Those DECS currently verified for use in SWCV applications are listed in the "BACT Status" section at the end of each technology discussion below. A complete and up-to-date list of verified DECSs and the engine families for which they have been verified, along with letters of verification, may be found on our web site:

http://www.arb.ca.gov/diesel/verifieddevices/verdev.htm.

IV. Best Available Control Technology for Particulate Matter Reduction in Solid Waste Collection Vehicles

A variety of strategies can be used for controlling emissions from diesel engines, including aftertreatment hardware, such as filters, fuel strategies, and engine modifications. The two main types of technologies discussed here are hardware, add-on technologies such as DPF and DOC, and fuel or fuel additives. These technologies can be combined to form additional DECSs. In addition, this report will discuss alternative fuels, such as compressed natural gas (CNG) and repowering to a cleaner engine.

A. Hardware Diesel Emission Control Strategies

Currently, hardware DECSs consist of the DPF, both passive and active, and the DOC, each of which have been used in both on- and off-road vehicles and equipment for many years. Recently, a new hardware DECS has been developed, which is termed the flow through-filter (FTF).

1. Diesel Particulate Filter

In general, a DPF consists of a porous substrate that permits gases in the exhaust to pass through but traps the PM. DPFs are very efficient in reducing PM emissions, achieving typical PM reductions in excess of 90 percent. Most DPFs employ some means to periodically regenerate the filter (i.e., burn off the accumulated PM). These can be divided into two types of systems, passive and active.

a. Passive Diesel Particulate Filter

A passive catalyzed DPF reduces PM, carbon monoxide (CO) and hydrocarbon (HC) emissions through catalytic oxidation and filtration. Most of the DPFs sold in the United States use substrates consisting of ceramic wall-flow monoliths to capture the diesel particulates. Some manufacturers offer silicon carbide or other metallic substrates, but these are less commonly used in the United States.

These wall-flow monoliths are either coated with a catalyst material, typically a platinum group metal, or a separate catalyst is installed upstream of the particulate filter. The filter is positioned in the exhaust stream to trap or collect a significant fraction of the particulate emissions while allowing the exhaust gases to pass through the system.

Effective operation of a DPF requires a balance between PM collection and PM oxidation, or regeneration. Regeneration is accomplished by either raising the exhaust gas temperature or by lowering the PM ignition temperature through the use of a catalyst. The type of filter technology that uses a catalyst to lower the PM ignition temperature is termed a passive DPF, because no outside source of energy is required for regeneration.

Passive DPFs have demonstrated reductions in excess of 90 percent for PM, along with similar reductions in CO and HC. A passive DPF is a very attractive means of reducing diesel PM emissions because of the combination of high reductions in PM emissions and minimal operation and maintenance requirements.

i. In-Use Experience with Passive Diesel Particulate Filters

Passive DPFs have been successfully used in numerous applications, including collection vehicles. As of 2000, over 10,000 trucks and buses had been retrofitted worldwide (MECA 2000). Internationally, retrofit programs exist in Sweden, Germany, Switzerland, Hong Kong, Taiwan, London, Paris, Mexico City, and Tokyo (MECA 2002). In the United States, the use of DPFs is growing more common, with DPF retrofit programs underway in California, New York, and Texas. In California, diesel-fueled school buses, SWCVs, urban transit buses, medium-duty delivery vehicles, people movers, and fuel tanker trucks have been retrofitted with DPFs through various demonstration programs (See Section V).

ARCO, a BP company, completed a one-year demonstration program in 2001 to evaluate its low sulfur (<15 parts per million by weight sulfur content) diesel fuel and passive DPFs in five truck and bus fleets (LeTavec *et al.* 2002). The five fleets, all of which operated in southern California, included grocery trucks, tanker trucks, refuse haulers, school buses, and transit buses. Data on the SWCV demonstration fleet will be discussed in greater detail in Section V.A.

Over the one-year demonstration, DPF-equipped vehicles accumulated over 3,525,000 miles without any major incidents attributed to the DPFs or the low sulfur diesel fuel. Most of the grocery trucks and all of the tanker trucks accumulated over 100,000 miles of operation between test rounds. Diesel PM emission reductions were maintained after one year, with no signs of deterioration. The test vehicles retrofitted with the passive DPFs and fueled with low sulfur diesel had over 90 percent lower PM emissions when operated on the low sulfur than the control vehicles with factory mufflers and operated on CARB diesel fuel. In addition, the passive DPF and low sulfur diesel fuel combination either did not or only had a minor affect on fuel economy (LeTavec *et al.* 2002).

As of March 2003, many of the trucks still have their DPFs operating. Data are currently available for the grocery trucks. Six out of ten of the grocery trucks with DPFs have accumulated over 300,000 miles each without needing cleaning of the traps; the other four trucks accumulated over 250,000 miles with one DPF cleaning. After three years of operation, the emission reductions have been maintained and there has been no fuel economy penalty (Smith 2003).

ii. BACT Status of Passive Diesel Particulate Filters

The Engelhard DPX and the Johnson Matthey CRT DPF plus low sulfur diesel fuel have been verified for use with most 1994 to 2002 model year (MY) diesel engines in on-road applications (**Table 1**). All of the applicable engines are four-stroke, turbocharged, and were certified in California to the 0.1 g/bhp-hr PM emission standard. Also, the Clean Air Partners passive DPF, manufactured by Engelhard, is verified for use with certain Power Systems Associates and Caterpillar engines converted to bi-fuel operation using the Power Systems Associates and Clean Air Partners bi-fuel retrofit system. All three passive DPF achieve a Level 3 verified 85 percent or greater PM reduction.

Table 1. 1994 to 2002 Model Year Verified Engines for Use with Engelhard's DPX Catalyzed DPF (ARB 2003b) and Johnson-Matthey's CRT Catalyzed DPF (ARB 2003a).

Make	Engine Series (All Horsepower)
Caterpillar	3116, 3126, 3176, 3306, 3406, C10, C12, C15, C16
Cummins	L10, M11, N14, ISB, ISC, ISM, ISX, Signature, B-Series, C-Series
Detroit Diesel	Series 50, Series 60
International	T444, DT466, 530, 7.3 DIT
Mack	E7, EM7
Volvo	VE D7, VE D12

iii. Successful Use of a Passive DPF

The successful application of a passive DPF is primarily determined by the average exhaust temperature at the filter's inlet and the rate of PM generated by the engine. These two quantities are determined by a host of factors pertaining to both the details of the application and the state and type of engine being employed. As a result, the technical information provided to ARB for verification by the manufacturer serves as a guide, but additional information may be required to determine whether a passive DPF will be successful in a given application.

The rate of PM generation is influenced by a variety of factors and the engine certification level cannot be used, in all cases, to predict PM emission levels in-use. Testing done by West Virginia University, for example, shows that a given diesel truck can generate a wide range of PM emission levels depending on the test cycle (Nine *et al.* 2000). Engine maintenance is another factor in determining the actual PM emission rate. The ARB's informational package for the heavy-duty vehicle inspection programs lists sixteen different common causes of high smoke levels related to engine maintenance (ARB 1999).

The average exhaust temperature in actual use is also difficult to predict based on commonly documented engine characteristics, such as the exhaust temperature at peak power and peak torque. The exhaust temperature at the DPF inlet is highly application dependent, in that the particular duty cycle of the truck plays a prominent role, as do heat losses in the exhaust system. Very vehicle-specific characteristics enter the heat loss equation, such as the length of piping exhaust must travel through before it reaches the DPF. Lower average exhaust temperatures can also be the result of operating vehicles with engines oversized for the application.

The applicability of passive DPFs in SWCVs will be discussed in detail in the second half of this report.

b. Active Diesel Particulate Filter

An active DPF system uses an external source of heat to oxidize the PM. The most common methods of generating additional heat for oxidation involve electrical regeneration by passing a current through the filter medium, injecting fuel to provide additional heat for particle oxidation, or adding a fuel-borne catalyst or other reagent to initiate regeneration. Some active DPFs induce regeneration automatically on-board the vehicle or equipment when a specified backpressure is reached. Others use an indicator, such as a warning light, to alert the operator that regeneration is needed, and require the operator to initiate the regeneration process. Some active systems collect and store diesel PM over the course of a full shift and are regenerated at the end of the shift with the vehicle or equipment shut off. A number of the filters are removed and regenerated externally at a regeneration station.

For applications in which the engine-out PM is relatively high, and the exhaust temperature is relatively cool, actively regenerating systems may be more effective than a passive DPF. Because active DPFs are not dependent on the heat carried in the exhaust for regeneration, they potentially have a broader range of application than passive DPFs.

i. In-Use Experience with Active Diesel Particulate Filters

Active DPFs have been used successfully in Europe (Zelenka *et al.* 2002). Their use in Europe has been more successful, however, with applications with a regular driving pattern, such as forklifts (MTC AB 2003). Off-road applications of these active systems have been implemented in Europe since the early 1990's.

Additionally, a system manufactured by Clēaire, which combines an active DPF with a lean NO_x catalyst, has been demonstrated in the U.S. on a transit bus with a 2000 Cummins ISM engine. Testing conducted after 1000 hours of operation indicated PM emission reductions in excess of 85 percent could be achieved on stop and go duty cycles when operated using low sulfur (sulfur content less than 15 parts per million by weight) diesel fuel.

ii. BACT Status of Active Diesel Particulate Filters

No active DPF system is currently verified for use in SWCVs or any other application. If one were to become verified, it would likely achieve a Level 3 DECS status.

2. Flow Through Filter

Flow-through filter technology is a relatively new method for reducing diesel PM emissions. Unlike a DPF, in which only gases can pass through the substrate, the FTF does not physically "trap" and accumulate PM. Instead, exhaust flows through a medium (such as a wire mesh) that has a high density of torturous flow channels, thus giving rise to turbulent flow conditions. The medium is typically treated with an oxidizing catalyst that is able to reduce emissions of PM, HC, and CO, or used in conjunction with a fuel-borne catalyst. Any particles that are not oxidized within the FTF flow out with the rest of the exhaust and do not accumulate.

Consequently, the filtration efficiency of an FTF is lower than that of a DPF, but the FTF is much less likely to plug under unfavorable conditions, such as high PM emissions and low exhaust temperatures. The FTF, therefore, is a candidate for use in applications unsuitable for DPFs. Staff expects that an FTF will achieve between 30 and 60 percent PM reduction, lower than a DPF, for a Level 1 or 2 verification.

Relative to a DOC, which typically has straight flow passages and laminar flow conditions, the FTF achieves a greater PM reduction owing to enhanced contact of PM with catalytic surfaces and longer residence times. The better performance of an FTF when compared to a DOC may come at the cost of increased backpressure. No data are available on how the capital cost of the two technologies will compare in the marketplace.

a. In-Use Experience with Flow Through Filters

In September 2002, ARB began demonstrating a FTF plus fuel additive system on collection vehicles in the South Coast Air Basin. Beginning Spring 2003, ARB will demonstrate six FTFs without the use of a fuel additive on SWCVs also in the South Coast Air Basin. Additional details of these demonstrations are found in Section V.

b. BACT Status of Flow Through Filters

No FTF system is currently verified by ARB.

3. Diesel Oxidation Catalyst

A DOC reduces emissions of CO, HC, and the soluble organic fraction of diesel PM through catalytic oxidation alone. Exhaust gases are not filtered, as in the DPF. In the presence of a catalyst material and oxygen, CO, HC, and the soluble organic fraction undergo a chemical reaction and are converted into carbon dioxide and water. Some manufacturers integrate HC traps (zeolites) and sulfate suppressants into their oxidation catalysts. HC traps enhance HC reduction efficiency at lower exhaust temperatures and sulfate suppressants minimize the generation of sulfates at higher exhaust temperatures. A DOC can reduce total PM emissions up to 30 percent.

a. In-Use Experience with Diesel Oxidation Catalysts

This technology is commercially available and devices have been installed on tens of thousands of mobile diesel-fueled engines. As a result of the United States Environmental Protection Agency's (U.S. EPA's) Urban Bus Retrofit/Rebuild program, several models have been certified by the U.S. EPA and through ARB's aftermarket parts certification program. Nationwide, thousands of DOCs are installed on urban transit buses with engines older than 1994 MYs.

In general, DOCs function well on all vehicle and equipment types. ARB has begun a demonstration to explore the applicability of DOCs on older, higher emitting SWCVs.

b. BACT Status of Diesel Oxidation Catalysts

ARB has verified one stand-alone DOC, which is manufactured by Donaldson Company, at Level 1, or a minimum of 25 percent PM reduction. This stand-alone DOC is verified for some 1991 to 2002 MY engines using low sulfur diesel fuel.

B. Fuels and Fuel Additives Diesel Emission Control Strategies

1. Fuel Additives

A fuel additive is a DECS when it is designed to be added to fuel or fuel systems so that it is present in-cylinder during combustion and its addition causes a reduction in exhaust emissions. Additives can reduce the total mass of PM, with variable effects on CO, oxides of nitrogen (NO_x) and gaseous HC production. The range of PM reductions that have been published in studies of fuel additives is from 15 to 50 percent reduction in mass. Most additives are fairly insensitive to fuel sulfur content and will work with a range of sulfur concentrations as well as different fuels and other fuel additives (DieselNet 2002).

An additive added to diesel fuel in order to aid in soot removal in DPFs by decreasing the ignition temperature of the carbonaceous exhaust is often called a fuel borne catalyst (FBC). These can be used in conjunction with both passive and active filter systems to improve fuel economy, aid system performance, and decrease mass PM emissions. FBC/DPF systems are in wide spread use in Europe in both on-road and off-road, mobile and stationary applications and typically achieve a minimum of 85 percent reduction in PM emissions. Additives based on cerium, platinum, iron, and strontium are currently available, or may become available for use in the future in California.

a. In-Use Experience with Fuel Additives

ARB is currently demonstrating an additive plus a FTF on SWCVs.

Cerium based additives are in wide spread use in Europe and VERT-approved when used with DPFs. A cerium-based additive is part of Peugeot's new passenger car filter-based system and, in addition to on-road applications, cerium additives are used off-road in construction and forklift applications (Lemaire 2002).

Platinum based additives are in use in Europe with DPF systems for both on and off road applications and stationary sources (Clean Diesel Technologies 2002).

Iron based fuel additives are in-use in construction vehicles and building machinery in Germany, Austria and Switzerland for greater than five years. Additionally, several hundred city buses, garbage trucks, forklifts and cleaning machinery have used these additives for the last several years (Werner 2002).

b. BACT Status of Fuel Additives

No fuel additives are verified by ARB currently. One manufacturer has a fuel additive currently being demonstrated in conjunction with a DOC, a FTF, and a lightly catalyzed DPF on collection vehicles as of March 2002. All fuel additives must undergo an assessment of multimedia effects prior to ARB verification.

2. Alternative Diesel Fuels

An alternative diesel fuel is a fuel that can be used in a diesel engine without modification to the engine and that is not just a reformulated diesel fuel. This definition of alternative diesel fuels includes emulsified fuels, biodiesel fuels, Fischer Tropsch fuels, and any combination of these fuels with regular diesel fuel. The emissions effects of these fuels can vary widely.

No alternative diesel fuels are currently verified by ARB.

a. Fuel-Water Emulsion

A demonstrated alternative diesel fuel that reduces both PM and NO_x emissions is an emulsion of diesel fuel and water. The process mixes water with diesel and adds an agent to keep the fuel and water from separating. The water is suspended in droplets within the fuel, creating a cooling effect on the fuel that decreases NO_x emissions. A fuel-water emulsion creates a leaner fuel environment in the engine, thus lowering PM emissions. The major manufacturer of this fuel-water emulsion is Lubrizol Corporation, which produces PuriNOx™ (U.S. EPA 2002b).

According to data submitted for the ARB's fuels certification procedure, PuriNOx™, achieved a 14 percent reduction in NO_x emissions and a 63 percent reduction in PM emissions, based on tests on one engine (ARB 2001). Similar results were found in a U.S. EPA analysis. According to U.S. EPA's analysis of available literature, a medium to heavy heavy-duty vehicle may achieve between a 51 and 58 percent reduction in PM in conjunction with a 10 to 13 percent reduction in NO_x emissions (U.S. EPA 2002b).

i. In-Use Experience with Fuel-Water Emulsion

PuriNOx™ has been used in a variety of vehicles, including construction equipment operated by the California Department of Transportation and transit buses, but not on collection vehicles to date. The California Department of Transportation experience with the fuel was generally positive, except that the emulsion tended to break down when held for over 30 days. Several companies operating at the Port of Los Angeles are also using PuriNOx™.

ii. BACT Status of Fuel-Water Emulsion

No fuel-water emulsion fuel is currently verified as a DECS for SWCVs or any other applications. ARB has granted Lubrizol's PuriNOx™ an alternative diesel fuel emissions certification through its fuels certification procedure, but not a DECS verification, which would be required in order to comply with the proposed regulation. The ARB is waiting for the completion of a multi-media analysis for toxics before a verification can be issued. Staff expects this technology will achieve a Level 2 verification, or a minimum of a 50 percent PM reduction.

b. Biodiesel

Biodiesel is a mono-alkyl ester-based oxygenated fuel, a fuel made from vegetable oils, such as oilseed plants or used vegetable oil, or animal fats. It has similar properties to petroleum-based diesel fuel, and can be blended into petroleum-based diesel fuel at any ratio. Biodiesel is most commonly blended into petroleum-based diesel fuel at 20 percent (ARB 2000), and called B20. Pure biodiesel is called B100.

Using publicly available data, the U.S. EPA recently analyzed the impacts of biodiesel on exhaust emissions from heavy-duty on-road engines (U.S. EPA 2002a). While biodiesel and biodiesel blends reduce PM, HC, and CO emissions, NO_x emissions increase, depending on the biodiesel to diesel fuel blend ratio. As the proportion of biodiesel increases, the PM, HC and CO emissions decrease while the NO_x emissions increase. For B20, the NO_x increase is reported to be two percent, with reductions of ten percent PM, 21 percent HC, and 11 percent CO. In addition, the U.S. EPA states a B20 blend is predicted to reduce fuel economy by one to two percent. The data were qualified with conclusions that the impact of biodiesel on emissions varied depending on the type of biodiesel (soybean, rapeseed, or animal fats) and the quality of the diesel fuel used in biodiesel blends.

i. In-Use Experience with Biodiesel

Biodiesel has been used successfully in heavy-duty diesel-fueled vehicles. There are no technical limitations to the use of biodiesel; rather the limitations concern cost and the increased NO_x emissions associated with biodiesel use.

ii. BACT Status of Biodiesel

B100 is not currently verified as an alternative fuel, or verified as a DECS. A biodiesel blend must meet the ASTM and ARB diesel specification when used in a motor vehicle.

C. Technology Combinations

A trend in technologies presented to ARB for verification is for applicants to combine more than one technology to maximize the amount of diesel PM reduction. This section discusses some of these combinations, including technology not yet verified.

1. Diesel Oxidation Catalyst plus Engine Modifications

The Clēaire Flash and Match™ system combines a DOC with engine modifications to achieve 25 percent PM reductions, and under certain conditions, a reduction in NO_x of 25 percent. The system is verified to Level 1 for use with specific 1994 through 1998 MY diesel engines, specifically Cummins M11 engines used in steady state application, such as a long haul truck.

2. Diesel Oxidation Catalyst plus Spiracle™

The Donaldson Company has verified two combination systems at Level 1. Each system uses a different DOC, but both systems install a closed loop crankcase with the Donaldson Spiracle ™ closed crankcase filtration system. The systems are verified for use in certain 1991 and later MY collection vehicles. One system is verified for use with California diesel fuel and the other is verified for use with low sulfur diesel fuel.

3. Fuel-Borne Catalyst with Hardware Technology

A fuel-borne catalyst can be combined with any of the three hardware technologies discussed above, the DPF, DOC, or FTF, although no system using a FBC has been verified yet. The combination of a FBC with a DPF functions similarly to a catalyzed DPF, but a FBC allows the DPF to be lightly catalyzed. The FBC enhances DPF regeneration by encouraging better contact between the PM and the catalyst material. The FBC plus DPF combination reduces both the carbonaceous and soluble organic fractions of diesel PM. The primary benefit of this combination is a reduction in the amount of NO_2 generated as a proportion of NO_x.

D. Engines

There are several types of engines that will qualify as best available control technology (BACT) and meet the 0.01 g/bhp-hr standard.

1. New Diesel Engine Meeting 0.01 g/bhp-hr for PM Either as a Repower or as Original Equipment

The particulate emission standard of 0.01 grams per brake horsepower-hour (g/bhp-hr) for heavy-duty highway diesel engines will take effect nationally and in California beginning with MY 2007, except for urban bus engines to be sold in California. The same standard for urban bus engines is already in effect in California for engines produced after October 1, 2002. These standards are based on the use of high-efficiency catalytic exhaust emission control devices or comparably effective advanced technologies. Because the devices expected to be used to meet the standard are made less efficient by sulfur in the exhaust stream, the level of sulfur in highway diesel fuel will also be reduced by 90 percent, relative to California diesel fuel sulfur levels, by mid-2006 to less than 15 ppmw.

Any engine certified to this standard in California meets BACT. Another option is to re-engine, or repower, an older vehicle by installing a pre-2007 MY engine along with a DECS. For example, any 1994 to 2002 MY engine with an aftermarket verified DPF would achieve PM emissions near 0.01 g/bhp-hr and would be considered to meet BACT.

a. In-Use Experience with 0.01 g/bhp-hr Engines

There is, as yet, little experience with a new engine certified to this low PM standard because the certification standard for truck engines is not required until 2007. Currently Detroit Diesel Corporation and Caterpillar have each certified engines to the California urban bus standard of 0.01 g/bhp-hr, using a DPF to achieve the low PM standard. Cummins, Inc. reported it will certify an urban bus engine to this standard by the third quarter of 2003. Experience with this bus engine is still developing, but there is no reason to expect that these engines will experience any service problems.

b. BACT Status of 0.01 g/bhp-hr Engines

Prior to 2007, staff expects that engines certified to the 2007 PM standard may be offered for sale if there is consumer demand. This proposed rule may create this demand, as some owners will likely prefer installing a new engine as a repower over installing a DECS onto an older engine. Repowering engines is a widespread practice by owners of heavy-duty trucks to extend the useful life of an expensive vehicle. From 2007 on, all heavy-duty engines will be certified to this standard.

2. Alternative-Fuel Engines

Conventional diesel engines are internal combustion, compression-ignition engines. In contrast, engines that operate on an alternative fuel, such as CNG, liquified natural gas (LNG), and liquid petroleum gas (LPG), are spark-ignited. Engines certified to operate on alternative fuels produce substantially lower PM and NO_x emissions than diesel-fueled engines not equipped with exhaust aftertreatment. Alternative-fuel engines are available for most of the same applications as heavy-duty diesel applications.

a. In-Use Experience with Alternative-Fuel Engines

Alternative-fueled engines are being used in SWCVs today and are feasible. LNG is the most widely used alternative fuel to power collection vehicles. Over 3,000 LNG vehicles are currently in use nationwide (EIA 2002). The City of San Francisco is converting entirely to LNG when technically feasible. In addition, a large collection vehicle owner in Northern California has stated it plans to adopt this technology in the near future (Olson 2001). Over 13,000 total alternative-fueled vehicles are in use by California state agencies. Approximately 8,000 of those are heavy-duty alternative fuel vehicles. Waste Management has approximately 300 natural gas vehicles currently operating in California. The City of Los Angeles has over 200 alternative fuel vehicles currently in use in their fleet, with an additional 120 on order (Wunder 2002). The City of Long Beach is converting it's fleet to alternative fueled vehicles also.

The South Coast Air Quality Management District (SCAQMD) adopted Rule 1193 in 2001. The rule requires solid waste collection companies in the South Coast Air Basin to purchase or lease alternative fuel trucks when adding to their fleets. The number of alternative-fuel SWCVs in California will, therefore, increase over time as the majority of the population is found in the South Coast Air Basin.

b. BACT Status of Alternative-Fuel Engines

Alternative-fuel engines are currently certified and available for use on SWCVs.

3. Heavy-Duty Pilot Ignition Engine

A heavy-duty pilot ignition engine is a compression-ignition engine that operates on natural gas but uses diesel as a pilot ignition source. The total use of diesel is around six percent of the fuel consumed. ARB has defined this engine in its fleet rule for transit agencies and in the proposed rule for SWCVs as an engine that uses diesel fuel at a ratio of no more than one part diesel fuel to ten parts total fuel on an energy equivalent basis. Furthermore, the engine cannot idle or operate solely on diesel fuel at any time. An engine that meets this definition and is certified to the lower optional PM standard (0.01 g/bhp-hr) would be classified as an alternative-fuel engine.

a. In-Use Experience with Heavy-Duty Pilot Ignition Engines

Cummins Westport Inc. states the ISXG is currently being field tested with over two million miles of experience so far in road trials. Norcal, a solid waste collection company in northern California, is one of the companies demonstrating the ISXG engine (NREL 2002).

b. BACT Status of Heavy-Duty Pilot Ignition Engines

Westport Fuel Systems, Inc., currently has California certification on a base Cummins ISX (14.9 L) engine. Although the engine was certified for MY 2001 in California, the ISXG is slated for commercial production in mid-2004, with the smaller ISMG on schedule for commercial production in 2005 (Cummins Westport 2003).

V. In-Use Experience and Demonstrations

The previous section of this report discussed in-use experiences with specific DECSs, including experiences with new diesel engines complying with the 0.01 g/bhp-hr PM standard and alternative-fuel engines. This section will expand on the in-use experience with DPFs in three specific areas: the City of Los Angeles's experience with retrofitting its solid waste collection trucks, experiences outside of the United States, and demonstrations conducted in California under the supervision of the ARB.

A. City of Los Angeles

Through 2002, SCAQMD and various agencies with heavy-duty diesel vehicles have spent approximately $18 million to retrofit over 2800 diesel vehicles to reduce PM emissions (Appendix D) in the South Coast Air Basin, including collection vehicles with the City of Los Angeles. The City of Los Angeles began its experience with DECS in 1999, when it agreed to participate in an experimental program to study the durability, performance, and emission characteristics of passive DPFs used with low sulfur diesel fuel. The willingness by the City to try DPF technology was then reflected in a City Council resolution to retrofit all City owned vehicles. ARB staff has inspected most of the vehicles that have been retrofitted and discussed future plans with City of Los Angeles officials. The following describes the experience by Los Angeles, primarily in terms of its fleet of collection vehicles.

1. BP-Arco Demonstration

The City of Los Angeles participated in the EC-Diesel Technology Validation program from 1999 to 2001, funded by SCAQMD in conjunction with Cummins Cal/Pacific. Installations began in June 1999 and testing was completed by May 2001. The program provided passive-DPF and low sulfur diesel fuel to be used on 15 of the City's collection vehicles during routine operations. The 1999 Peterbilt vehicles were equipped with Cummins ISM 10.8 liter engines rated at 305 hp with five speed automatic transmissions.

The researchers designed a study in which vehicles used a mixture of fuel types and filter types (**Table 2**) to test the effects of the low sulfur diesel fuel alone and in conjunction with one of two types of filters, Engelhard's DPX and Johnson Matthey's CRT. BP-Arco's two fuels ECD and ECD-1, differed only in their aromatics content and cetane number, of which the ECD had a lower aromatics content and higher cetane number than the ECD-1, whose specifications more closely matched current CARB diesel fuel (Le Tavec *et al.* 2002).

Table 2. City of Los Angeles Collection Vehicle Passive Diesel Particulate Filter Demonstration Parameters (LeTavec *et al.* 2002).

Vehicle Type	Number	Fuel Type	Diesel Emission Control System
Control	2	CARB	Factory Muffler
Test	3	CARB	Factory Muffler
	2	ECD	Factory Muffler
	1	ECD	Engelhard DPX DPF
	2	ECD	Johnson Matthey CRT DPF
	3	ECD-1	Factory Muffler
	1	ECD-1	Engelhard DPX DPF
	2	ECD-1	Johnson Matthey CRT DPF

Five of these vehicles were tested for emissions at the beginning and end of an 11 month time frame during which they were driven about 20,000 miles (LeTavec *et al.* 2002). A 95 percent reduction in PM emissions was measured in a comparison between collection vehicles equipped with factory mufflers and DPFs. No deterioration of the filter efficiencies occurred. There was no apparent difference detected between the use of the two fuels, ECD and ECD-1, signifying that the sulfur content is the critical component, over aromatics and cetane, for filter efficiency.

2. ARB Inspection of Study Vehicles

In order to determine the on-going retrofit experience and to understand the maintenance aspects of the demonstration, ARB staff inspected and gathered information on the City of Los Angeles collection vehicles in early 2003. Fleet supervisors, mechanics, and operators supplied information on service, maintenance and operation of collection vehicles with passive DPFs installed.

Cummins Cal/Pacific, SCAQMD and the DECS manufacturers were in charge of all installation, maintenance and repairs of the passive DPFs on this fleet. Fleet supervisors were instructed to notify Cummins Cal/Pacific representatives or the appropriate DECS manufacturer, either Johnson Matthey or Engelhard, if any problems or repairs were necessary. If a vehicle was out of service an excess of five days, the original muffler was replaced to return the vehicle to service until the DPF could be replaced.

The City has experienced no problems with these units, with the longest DPF in operation for about three and a half years. Four of the original filters are still in service and have been operated over 141,500 miles since installation. The rest of the filters have been removed by the manufacturers for analysis and evaluation, both for confirmation of filter durability and future product improvements. Replacement filters were installed on all of the test vehicles.

During the early stages of DPF use, the City of Los Angeles also participated in an EGR retrofit demonstration that was not successful. Cummins introduced EGR controls on four engines equipped with Johnson Matthey CRT units to reduce NO_x emissions, but some of these units experienced clogging or blockage problems and spent a lot of time out of service. One collection vehicle remained in the shop at Cummins for repairs of an Engelhard DPX filter with EGR for over 30 days (**Table 3**). Also, of the four Cummins ISM electronic engines equipped with EGR, two had experienced fuel injector problems, which led to clogging of the DPX filters and their subsequent replacement. The EGR systems appear to have been the source of problems with these DPFs as the other DPFs functioned with minimal incident.

Table 3. DPF plus EGR Technical Issues by Collection Vehicle.

Technical Issue	Resolution
DPF + EGR problem	Repair/replacement required over 30 days in the shop.
Smoke opacity 20 to 25 percent under load conditions	Repaired.
Excessive white smoke during warm-up	Repaired.
DPF burned up	New unit installed in February 2002.
Backpressure light problems, showed DPF clogged regularly	Repaired.

With the resolution of the EGR issues, fleet managers and drivers have been comfortable and satisfied with the operation of the DPF-equipped collection vehicles.

3. Expansion of Retrofit Program

In 2000, the Los Angeles City Council adopted a motion that all City-owned diesel trucks would be retrofitted with DPFs by the end of 2002, if retrofitting is feasible. The motion was later amended to require retrofit of 50 percent of the diesel truck fleet within 18 months of ARB verification of a DPF and 100 percent within 30 months of verification. Based on the initial ARB DPF verification letter date of August 2, 2001, those deadlines would be the end of February 2003 for 50 percent installation and the end of February 2004 for 100 percent installation. Propelled by the City Council resolution, City staff scheduled retrofitting all 354 1996 and newer automated collection vehicles for July 2002 through January 2003.

ARB staff inspected the vehicles and maintenance shops in January 2003. At that time, 339 of the collection vehicles were retrofitted with DPFs (**Table 4**). Boerner Truck Center installed and services the units while under warranty. DPFs installed are the Engelhard DPX, and all units inspected had been installed vertically on the trucks. Boerner did all installations of the Engelhard DPX filters after 2:00 a.m. so there would be no vehicles out of service for installations. In-use exhaust temperatures were recorded through datalogging on a small subset of collection vehicles before installation.

Table 4. Summary of Diesel Particulate Filter Installations for the City of Los Angeles Bureau of Sanitation.

Engine Model	Model Year	Engine Family	Number
Cummins L10	1995	SCE611EGDARW	20
Cummins M11	1995	SCE611EJDARW	2
Cummins M11	1995	SCE611EJDARA	4
Cummins M11	1996	TCE661EJDARA	90
Cummins ISM	1999	XCEXHO66AMA1	39
Cummins ISM	2000	YCEXH0661MA1	73
Cummins ISM	2001	1CEXHO661MAP	55
Caterpillar 3126	2001	YCPXHO442HRK	56
TOTAL	-	-	339

The sanitation trucks have logged over 966,000 miles on DPF units with only a few minor problems. According to City staff, all problems have been resolved satisfactorily with Boerner Truck Center. In one case, the back pressure warning light came on. In two cases, the weld on the can came apart. The City of Los Angeles' mechanics welded the cans shut, and Boerner agreed to provide the

City with four new cans to replace the two that broke and provide them with two spares.

4. Future Retrofit Plans by City of Los Angeles

The City's refuse fleet comprises approximately 683 trucks, 661 of which belong to the Bureau of Sanitation. The City has determined not all of the trucks are able to be retrofit with DPFs because of age, duty cycle, or other factors. An additional 75 collection vehicles, including rear loaders, front loaders, transfer and roll-off trucks, for a total of 429, will be retrofitted.

For the remainder of the Sanitation fleet, the City is replacing older trucks with new dual-fuel (Caterpillar/Clean Air Partners) trucks, which are allowed under the SCAQMD Rule 1193. The City has 120 of these dual-fuel trucks on order, with an option for 120 more if the first ones are satisfactory. A DECS will need to be added to these dual fuel collection vehicles to meet the requirements of the both the SCAQMD Rule 1993 and the ARB proposed regulation for SWCVs.

Los Angeles will be retrofitting another 592 on-road medium and heavy heavy-duty diesel trucks by the end of January 2004, to comply with the City Council motion to retrofit everything that can be retrofitted with ARB verified technologies. Of these, the City plans to retrofit 82 trucks, including tractors and dump trucks, by March 2003. Trucks owned by the Fire Department, Department of Water and Power, Los Angeles World Airports, and Ports are not included, and the Fire Department is exempt.

B. International Experiences

In 2000, the ARB established the International Diesel Retrofit Advisory Committee, which met six times from 2000 through 2002, to provide ARB with technical information regarding retrofitting diesel vehicles. In addition to technical experts in the United States, ARB invited knowledgeable persons from countries in Europe and Asia with diesel vehicle retrofit programs to join the group. The following summarizes some of the information ARB gained as a consequence of working with international experts on retrofit experiences in countries other than the United States.

1. Sweden

Sweden requires heavy-duty diesel trucks operating in certain urban areas to have reduce diesel PM emissions. Because of this, ARB contracted with MTC AB of Sweden to describe the number and success of vehicles operating in Sweden using DECS (MTC AB 2003). Of all the vehicles surveyed, there were 46 collection vehicles equipped with DPFs, which ranged in engine MY from 1991 to 2001. Twenty-four of the DPFs were installed as original equipment and the rest were retrofitted.

The engine manufacturers represented in the study were Scania and Volvo. While Scania does not sell engines in the California market, Volvo represents a significant portion of California's engine fleet, especially in the model years surveyed (about 13 percent). The vehicle types surveyed were rear loaders, roll offs, front loaders, and others not covered by the proposed regulation, such as sludge tankers (**Figure 1**). All except one vehicle are automatic transmissions and all of the collection vehicles operate in a city stop-and-go duty cycle.

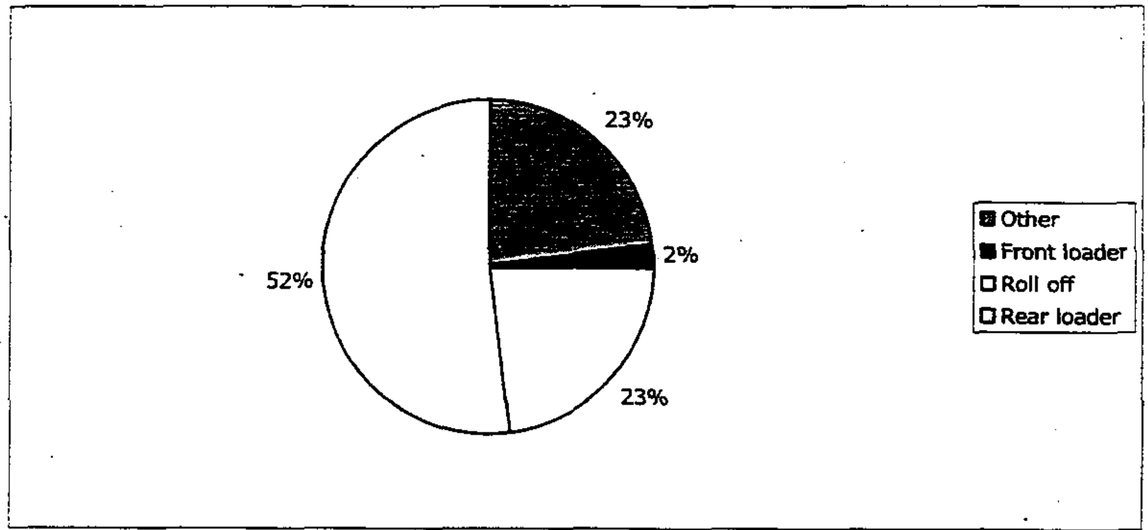

Figure 1. Types of Collection Vehicles with Passive Diesel Particulate Filters in Sweden.

For these 46 refuse haulers, no filter-related problems were reported related to fuel consumption or driveability. Fleet owners also reported no problems with clogged filters. Owners reported they regularly clean the filters during an annual or biannual service, depending on the mileage traveled. The average annual mileage for these vehicles was about 21,700 miles.

2. Switzerland

The Swiss Agency for the Environment, Forests, and Landscape (SAEFL) has sponsored research on the technical aspects of retrofitting all heavy-duty vehicles with DPFs (SAEFL 2000). As of 1999, Switzerland had approximately 66,000 heavy-duty vehicles registered, including 1,230 disposal trucks. The study concluded most vehicles could be retrofitted, except for those with high emissions, and excessive fuel and oil consumption.

As of the report, about a dozen trucks and a few hundred buses had been operating successfully with DPF systems for almost ten years and over 311,000 miles.

3. Japan

The Tokyo government has adopted regulations to reduce diesel PM emissions from cars and trucks operating within the city. An ordinance was adopted in December 2000 and the major provisions are establishment of PM emission standards and the prohibition of operation in Tokyo of diesel vehicles that do not meet those standards. The regulations take effect October 2003 and apply to vehicles more than seven years old. Installation of a PM reduction filter, replacement with gasoline-fueled or other non-diesel vehicles, or use of vehicles meeting the PM standard are allowable strategies (Tokyo Metro 2003). ARB has no data at this time specifically on collection vehicles, however.

4. Hong Kong

In 2000, the Hong Kong government adopted a program to retrofit approximately 30,000 delivery vans, sanitation trucks, construction equipment, and other diesel vehicles with DOCs (DieselNet 2003). The program is voluntary for vehicle owners, but the Hong Kong government is providing rebates to cover the cost of the installation. The current program covers vehicles operating in the Hong Kong Special Administrative Region, but will be extended to vehicles that travel to the mainland in 2003. For the Hong Kong program, qualifying emission control devices must reduce PM emissions by 35 percent when new and by 25 percent at 250,000 kilometers or five years. For the vehicles that travel to the mainland, which must use fuel with a higher sulfur content than available in Hong Kong, required PM emission reductions are 25 percent when new and at 250,000 kilometers or five years.

C. Demonstrations

While ARB bases much of its evaluation of technological feasibility on the immense amount of worldwide experience on many vehicle categories, smaller test programs on SWCV fleets are being conducted by ARB to investigate various technologies operating outside of the areas already demonstrated worldwide. Some of the technology being tested has already been proven on certain model years and applications and the focus of the demonstration is to examine if it can be expanded out to other engines and operating conditions. Other technologies being tested are under development and may become commercially available in the near future. The BP-Arco demonstration was discussed above in the context of the City of Los Angeles' sanitation vehicles, so it will not be discussed here.

All of ARB's demonstrations are scheduled to continue operating into the future. Since the technologies being tested would only broaden the availability of technology, staff felt it was not necessary to wait for them to be concluded. Preliminary results are discussed below.

1. DPF Use on Older Collection Vehicles

In July 2001, ARB initiated a demonstration with a privately-owned solid waste collection company, Burrtec Waste Industries, Inc., to gain information on the emission reduction potential, as well as the durability, of passive and active particulate filters when operated on older collection vehicles. Six pre-1994 collection vehicles (**Table 5**), operating in Riverside, California, were selected for the demonstration. Johnson Matthey (JM) and Clean Air Systems (CAS) installed DPFs in July 2001, and the project is expected to be completed by December 2003. The cost of the demonstration was shared between ARB and Burrtec Waste Industries, Inc.

Table 5. Collection Vehicles Involved in Demonstration.

Vehicle ID	Engine Model Year	Engine Model	Vehicle Type	Trap Type
3623	1991	Volvo TD73EB	Side Loader	Passive JM CRT
3710	1991	Cum L10	Side Loader	Passive JM CRT
2443	1989	Cat 3208-T	Side Loader	Active JM CRT
3722	1990	Cum L10	Side Loader	Active JM CRT
2764	1987	Cat 3306	Side Loader	Passive CAS
3708	1991	Cum L10	Side Loader	Passive CAS

a. Demonstration Emission Results

Two vehicles were tested for emissions pre- and post-installation of DPF at ARB's vehicle emissions testing lab in Los Angeles. The results for these two vehicles indicate a decrease in PM, HC, CO, and NO_x for the DPFs. While the HC and CO reductions are consistently high, the PM reductions are lower than expected. The trucks demonstrated good PM reduction for the first few months after DPF installation, however.

For vehicle #3710 (**Table 6**), the reduction of 72 percent PM experienced is likely a result of a filter blow-out due to high engine backpressure (see section below). Even with a blown-out filter, however, the truck had a significant reduction in diesel PM emissions. In addition, this vehicle experienced a slight fuel economy benefit of five percent.

For vehicle #3722 (**Table 7**), the active DPF reduced PM emission by a higher percentage, 88 percent. Emission reductions for HC and CO were also high. In this case, however, NO_x emissions increased slightly by four percent. The data show a fuel economy penalty of seven percent.

Table 6. Pre- and Post-Installation Test Results under UDDS Test Cycle For Passive DPF-Equipped Collection Vehicle (ID # 3710).

Date	PM (g/mi)	HC (g/mi)	CO (g/mi)	NO_x (g/mi)	MPG
1/17/02	1.06	2.70	4.26	15.53	5.78
11/26/02	0.30	0.04	0.18	15.17	6.06
%Change	-72 %	-99 %	-96 %	-2 %	-5%

Table 7. Pre- and Post-Installation Test Results under UDDS Test Cycle For Active DPF-Equipped Collection Vehicle (ID # 3722).

Date	PM (g/mi)	HC (g/mi)	CO (g/mi)	NO_x (g/mi)	MPG
11/20/01	1.04	2.44	6.63	18.44	5.37
3/28/02	0.12	0.25	0.27	19.23	4.98
%Change	-88 %	-90 %	-96 %	+4%	+7 %

b. Demonstration Operations Results

Two of the six units have been operating successfully since installation. ARB staff inspected and smoke-tested these two vehicles, trucks #3623 and 3708, in early 2003 and found operations to be as expected with very low smoke emissions. A third unit, an active DPF on truck #2764, was operating successfully for nearly a year until early 2003. The DPF was installed under the truck floor and was damaged while the truck was driving on rugged terrain at a landfill.

The other three units experienced failures for various reasons.

Truck #3710 exhibited high backpressure readings in late October 2002. According to automated data collection on-board, the collection vehicle continued to be operated despite the warning light with no service call to the manufacturer and as a result the passive DPF eventually failed.

Truck #2443 was equipped with an active filter that required overnight regeneration using a wall-plug. Data suggest maintenance personnel did not properly regenerate the system over several days resulting in partial DPF failure.

Truck #3722 had been operating well until a turbocharger failure caused sudden excessive PM emissions, resulting in trap failure.

c. Lessons from the Demonstration

This demonstration illustrated some of the challenges of retrofitting with passive DPFs, especially on pre-1994 trucks. First, operation on older diesel engines with mechanical engine control and operating under extreme duty cycles may not be a good match for the passive DPF. Second, successful operation of DPF requires a commitment from the drivers and maintenance staff to service the units promptly and correctly. Third, placement of the DPF requires drivers take care during operation not to damage the unit.

Many solid waste collection companies operate and depend on older pre-1994 trucks to perform a significant percentage of their daily operations. It may be prudent to utilize other PM control strategies, such as FTFs and DOCs, that offer less PM emissions benefits (25 to 50 percent efficiency), but higher probabilities of good durability, with these older vehicles.

2. Fuel-Borne Catalyst Effect Demonstration

In September 2002 ARB began a demonstration on collection vehicles with 1992 and 1996 model year engines using Clean Diesel Technologies and Clean Air Systems DECS. The solid waste collection partner is Waste Management. The objective of this demonstration is to quantify the emission reduction potential and in-use durability of using a Platinum-Based Fuel Additive (FBC) combined with three different aftertreatment technologies: a DOC, a DOC combined with a flow through particulate filter (FTF), and a lightly catalyzed (LC) ceramic wall flow DPF, on six collection vehicles with differing certified PM emission levels. Engines from 1992 were certified to 0.25 g/bhp-hr PM, whereas the 1996 engines were certified to 0.1 g/bhp-hr PM.

Table 8. Test Vehicles and Installed DECS.

Engine & Type	Device
1992 Cummins L10 Residential Front Loader	DOC/FTF
1996 Cummins C8.3 Automated Side Loader	DOC/FTF
1992 Cummins L10 Recycling	DOC (LC)
1996 Cummins C8.3 Commercial Rear Loader	DOC (LC)
1992 Cummins C8.3 Recycling Side Loader	DPF (LC)→FTF
1996 Cummins C8.3 Automated Side Loader	DPF (LC)→FTF

The DECS manufacturers installed the emission control devices in Fall 2002. ARB completed baseline testing of three trucks in October 2002. The second round of testing is scheduled for 2003 and results are not yet available. The final round of testing will be conducted after the test vehicles have completed at least one year of in-use operation to assess durability. The demonstration has provided data already on proper dosing of the FBC in combination with the add-on technologies.

Two issues have arisen thus far. First, a malfunction of the dosing system for the FBC caused untreated low sulfur diesel to be delivered to the demonstration trucks for several weeks. One of the lightly-catalyzed DPFs was damaged and replaced. Second, in March it was determined that, even with the FBC, the lightly-catalyzed DPFs were not regenerating sufficiently. Rather than changing the dosage, staff decided to remove the lightly-catalyzed DPFs and replace them with stand-alone FTFs.

3. Older SWCVs and Lower Efficiency DECSs

In addition to the demonstrations already discussed, ARB has also committed additional funding to demonstrate DOCs and FTFs on older collection vehicles using Johnson Matthey technology. This demonstration will begin in mid-2003 and is expected to last for a minimum of one year after DECS installation. The DECSs are to be installed on a range of engines in front and side loaders owned by up to three companies (**Table 9**). The goal is to demonstrate the durability of DOCs and FTFs operating successfully on collection vehicles not compatible with DPF technology.

Table 9. Proposed Matrix for DOC & FTF Demonstration on Older SWCVs.

Engine	Model Year	DECS
CAT 3208	1985	FTF
CAT 3208	1988	FTF
CAT 3208	1984	DOC
Mack E7	1988	DOC
Mack E7	1988	DOC
Mack E7	1989	FTF
Mack E7	1993	FTF
Volvo TD-73	1993	FTF
Cummins M11	1997	FTF

ARB has committed funding long term for demonstrations in SWCVs to assess durability and operations over time, in addition to measuring emission reductions. ARB is continuing demonstrations to provide additional data to collection vehicle owners regarding operating characteristics of the various diesel emission control technologies. In addition, ARB staff has collected useful data during these demonstrations that we will pass on to owners through outreach programs.

VIII. Predicting Retrofit Feasibility for Solid Waste Collection Vehicles

In addition to the demonstrations, ARB staff has carried out three studies to determine the potential success and limitations of implementing this proposed regulation given the use of DECS as BACT. The studies were initially focused on testing the feasibility of the passive DPF, but the data collected have been expanded to the feasibility of additional DECS technologies. The results of the most narrowly focused study, the engine exhaust temperature study, are applicable to any technology that relies on engine exhaust temperature for successful operation – at present the DPF and FTF technologies fit this description.

In combination with the demonstrations, the fleet maintenance (Appendix A), engine exhaust temperature (Appendix B), engine inventory (Appendix C) studies have enabled staff to determine not only technical limitations of DECS, but also develop realistic expectations of implementation. Details about each study are found in the appendices of this document. This section will discuss the results and conclusions as they relate to the feasibility of implementing the proposed regulation of SWCVs.

A. DECS Technical Limitations

Each DECS verified thus far is limited to specific engines and operating conditions. DECSs may have additional limitations based on the duty cycle experienced by the vehicle, environmental conditions, and the willingness of the operator to perform required maintenance. The DECS technical limitations discussed here represent a conservative analysis of data collected from the studies, demonstrations, verifications, and published literature. Some of these limitations may be a consequence of lack of data on in-use experience. Some of these limitations may disappear when new technology is verified. Thus the following discussion is based on currently available data and is not a prediction of the applicability of all DECS that may be available in the future.

1. Passive DPF

Forty-four percent of California collection vehicles have 1994 and newer model year engines (**Table 10**). Passive DPFs are verified for nearly all of the engine families used in these 1994 and newer collection vehicle engines, for a total of approximately 42[2] percent of California SWCVs theoretically being able to be retrofit with a DPF. Thus, about 42 percent of the collection vehicles could have their PM emissions reduced by 85 percent diesel.

ARB's study of engine exhaust temperatures (Appendix B), however, plus data from a private collection vehicle company (Stoddard 2001) and a DECS manufacturer (Donaldson 2003), suggest that many collection vehicles may not achieve the engine exhaust temperatures required by the two currently verified passive DPFs, depending on the duty cycle of each specific vehicle.

Meeting a minimum engine exhaust temperature is a technical limitation of a DPF because a minimum temperature is required to ignite the soot for regeneration. The minimum required temperature may vary depending on the amount of catalyst material, but the two verified passive DPF devices must achieve an

[2] This figure assumes verification will be extended to 2003 to 2006 model year engines, which are predicted to comprise approximately ten percent of the collection vehicle fleet in California.

average temperature of 225 degrees Celsius with ten percent of the duty cycle above 300 degrees Celsius, and a temperature of 260 degrees Celsius for 40 percent of the duty cycle, respectively (ARB 2001b; ARB 2000).

Engine exhaust temperatures were found to vary between the four main types of collection vehicles: front, side, and rear loaders and roll offs (**Figure 2**). Applying the results from the study to the inventory by engine model year group and vehicle type (**Table 10**), approximately 32 percent of 1994 to 2002 model years are expected to be able to use passive DPFs. If verification of these passive DPFs is extended to 2003 to 2006 engine model years, then the same percentage of those vehicles are expected to be able to use passive DPFs.

Table 10. Fleet Composition by Engine Model Year Group and Vehicle Type.

Engine Model Year Group	Collection Vehicle Type				
	Front Loader	Rear Loader	Roll Off	Side Loader	Total
1960-1987	5%	8%	3%	2%	18%
1988-1990	6%	9%	2%	4%	21%
1991-1993	5%	4%	1%	7%	17%
1994-2002	10%	6%	3%	25%	44%
Total	26%	27%	9%	38%	100%

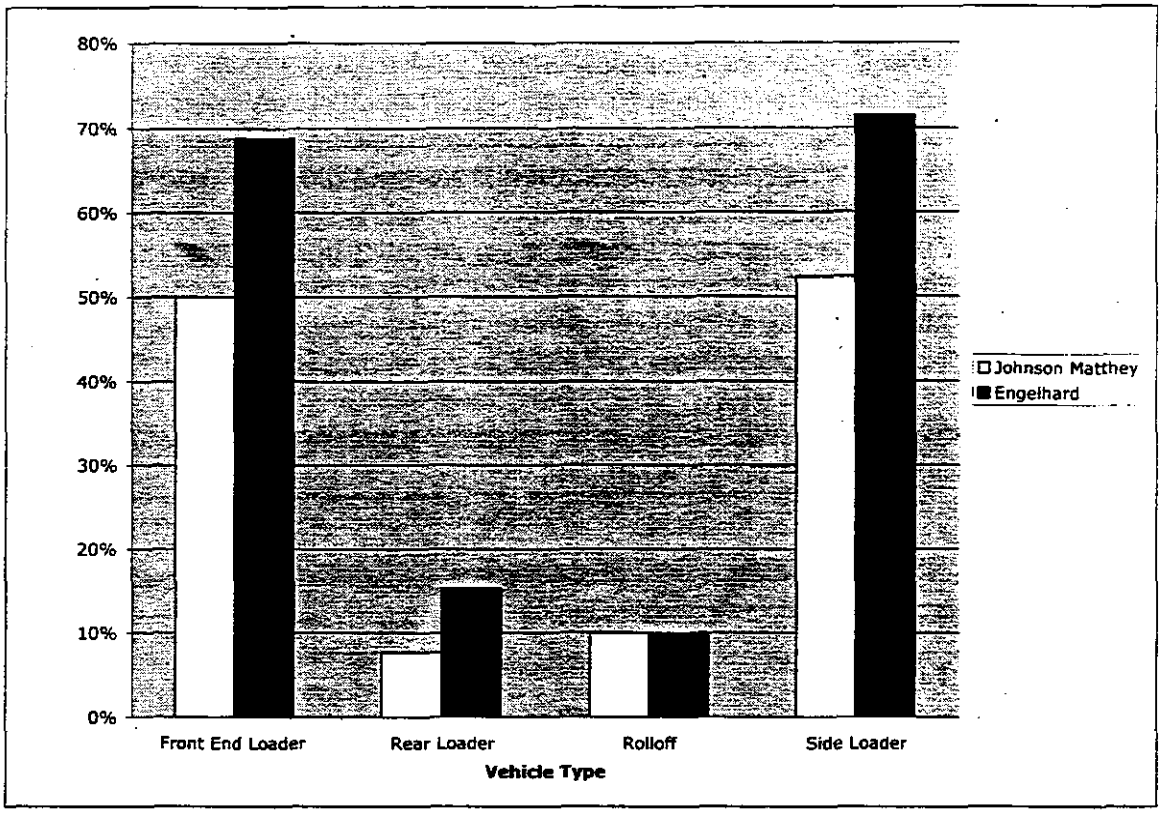

Figure 2. Percentage of Collection Vehicles by Vehicle Type that Met Engine Exhaust Temperature Requirements for Two Variations of Passive Diesel Particulate Filters.

2. Level 1 and 2 DECS

Staff expects fewer limitations with the use of DECS technologies other than the passive DPFs discussed above. Following is a discussion of specific verified and potential DECS Level 1 and 2 technologies.

a. Fuel-Water Emulsion

A fuel-water emulsion, such as that produced by PuriNOx™, is not limited by engine model year, PM emissions, or engine exhaust temperature, and could potentially be utilized in all collection vehicles. Some limitations, however, may exist with this technology. Winter-time temperatures, turnover of fuel in storage tankage, and the power loss associated with the fuel-water emulsion may limit its application. Low winter temperatures cause an increase in viscosity, and the fuel-water emulsion has separated if allowed to sit for too long. In addition, a company that operates its vehicles to the maximum power available on a frequent basis, such as one operating in a hilly area, may have difficulty using a fuel-water emulsion.

b. Flow Through Filter

An emerging technology, FTF, has the potential to achieve verification at Level 2, although addition of a fuel additive may be necessary for Level 2 emission reduction. This technology is expected to be more widely applicable, but achieve lower emission reductions, than a DPF. The technology does have a requirement for minimum engine exhaust temperature, but that minimum is lower than required for a passive DPF.

Although ARB does not have any FTF verified yet, at least one manufacturer requires that the exhaust temperature from vehicles reach 200 degrees Celsius for approximately 50 percent of the duty cycle to use an FTF. ARB's analysis of the engine exhaust temperature study shows that 80 percent of the collection vehicles are capable of achieving this temperature in-use (**Figure 3**, Appendix B). Based on the data, all front end loaders, 62 percent of rear loaders, 40 percent of roll-offs, and 95 percent of side loaders could use a flow-through filter.

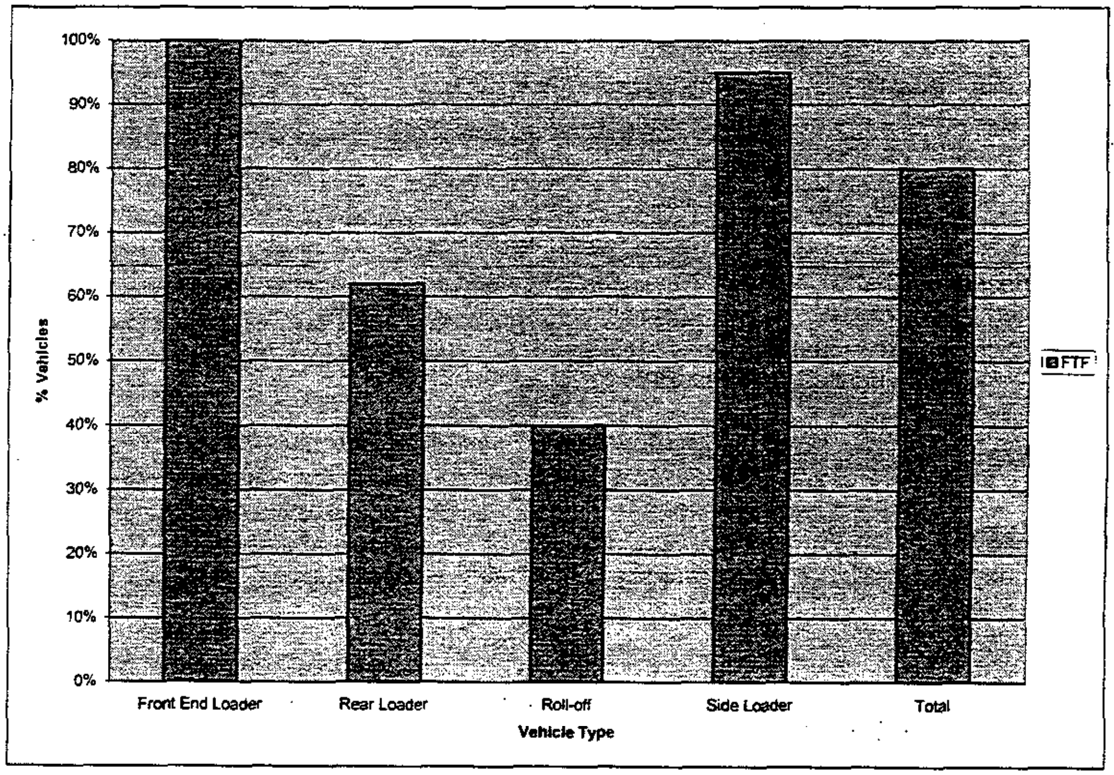

Figure 3. Percentage of Collection Vehicles by Vehicle Type that Met Engine Exhaust Temperature Requirements for Flow-Through Filters.

c. Diesel Oxidation Catalyst

DOCs are expected to be widely applicable in collection vehicles. Technical limitations may be associated with retrofitting pre-1988 collection vehicles with the verified DOC with closed loop crankcase, however, based on the verification conditions. Engine emissions from pre-1988 collection vehicles vary significantly and in some cases may be too high for effective operation.

B. Engine Repower Limitations

Repowering to a 0.01 g/bhp-hr engine is not always possible. The engine compartment may not be large enough to install a newer, electronic controlled engine where previously a mechanical engine was housed. Otherwise, the cost of converting from mechanical to electronic fuel injection may outweigh the value of the vehicle or remaining vehicle life.

Alternative-fueled engines do not have widespread acceptance among SWCV companies because of perceived issues with higher maintenance, unavailability and high cost of fueling infrastructure, horsepower, and other factors related to reliability, durability, and cost. Within the SCAQMD, where companies are required to acquire alternative-fuel vehicles when purchasing or leasing, fueling infrastructure is rapidly expanding and many companies are purchasing dual-fuel and 100% alternative fuel collection vehicles.

Heavy-duty pilot ignition engines will have the same fueling infrastructure problem as 100 percent natural gas engines, but may have more acceptance because of the inherent features of the compression-ignition engine, such as reliability, durability, and power.

These limitations are not expected to hinder many collection vehicle owners from purchasing or repowering engines, rather than using DECS. A new engine has many benefits over retrofitting an old engine, such as longer useful life, engine warranty, and familiarity with the technology.

C. Impact of Fleet Maintenance Practices

Fleet maintenance practices will play a critical role in the successful implementation of this proposed regulation. A company with good maintenance practices will have greater success with using DECSs on its vehicles than a company with poor maintenance practices. In addition, diagnosis of engine problems will be more difficult given the masking of excessive smoke caused by the use of DECS. If the only mechanism used by fleet maintenance personnel to detect engine problems is the appearance of excessive smoke, then problems may not be detected until so much PM is generated that damaged is caused to the DECS. A well-maintained vehicle, therefore, is crucial to the operating success of BACT on SWCVs.

Lack of maintenance is reportedly responsible for 50 percent of engine and equipment failures in SWCVs (Dolce 2000). ARB staff conducted a study on sixty solid waste collection companies and found most were well-maintained according to the maintenance parameters captured (Appendix A). Based on observed maintenance practices, the publicly-owned fleets have the highest probability of successfully retrofitting their collection vehicles with DECS, followed by the large then small private companies.

The most important recommendation arising from this study is for companies to ensure their mechanics are well-trained on proper engine care. Secondly, the mechanics must be trained appropriately on inspection, maintenance and service of DECS. Finally, the operators must be aware of and drive with care and attention to the DECS to avoid damage or failure from driver error.

D. Implications for Solid Waste Collection Vehicle Fleet Retrofit Feasibility for Emission Reductions

Based on the foregoing, staff developed three implementation scenarios for calculating technology usage from the proposed rule: a scenario based on currently verified DECS, a scenario based on expected verifications of DECS, and a scenario based on potential verifications of DECS. Each of these three scenarios assumes some engines would either be repowered to 0.01 g/bhp-hr engines or would purchase new 0.01 g/bhp-hr engines. The option of converting to alternative-fuel or heavy-duty pilot ignition engines exists for all engines either through vehicle replacement or conversion of the engine.

Each scenario was then fed into ARB's mobile source emission inventory, EMFAC2002, to generate predicted emission benefits from implementation of this rule. The inventory methodology is discussed in more detail in the Staff Report: Initial Statement of Reasons for this proposed rule and Appendix E of that document.

1. Scenario 1: Currently Verified DECS

The first scenario is based on the use of currently verified DECS (**Table 11**). Staff assumed no additional technologies would be verified before implementation of the proposed regulation begins in 2004 and no new technologies would be verified throughout the implementation phase-in period to 2010. This scenario is weighted more so on the use of the currently verified Level 1 DECS, and the use of engines meeting a 0.01 g/bhp-hr PM emissions standard, either through repowering or as an original engine purchase.

In Group 1, the 1994 to 2002 MY engines would use a combination of passive DPF Level 3 DECS, Level 1 DECS, and repower. As discussed above, passive DPF is technically limited by engine exhaust temperature requirements and high PM emissions on pre-1994 engine model years. Staff assumes a new engine, through repower or new vehicle purchase, would only become available with the 2007 engine model year, and, therefore, the first three implementations dates would be met only by the use of DECS.

Also in Group 1, the 1991 to 1993 MY engines would use primarily the Level 1 DECS throughout the four years of implementation phase-in. Again, staff assumes a new vehicle or engine repower would only become available with MY 2007.

The Group 1 1988 to 1990 MY engines would not have any verified DECS available. Therefore, staff assumes new vehicle or engine repower will be implemented beginning in 2007. Since no DECS are currently available for those engine model years, staff assumed 50 percent of the engines would receive a delay in implementation.

All vehicles in Group 2 are expected to repower or replace with a 0.01 g/bhp-hr engine because of the requirements of the proposed regulation and lack of other available technologies. Companies with fewer than 15 vehicles would be expected to receive a delay in this requirement.

Group 3 MY engines would use either DECS Level 3 or passive DPF or Level 1, but would also be able to use 0.01 g/bhp-hr engines. Staff expects some owners would purchase these 0.01 g/bhp-hr engines new, but this assumption is not critical to the scenario.

This scenario produced the following estimated technology use (**Table 11**).

Table 11. Implementation Scenario 1 (Current).

Group	Eng MY	%BACT	Implementation Date	Technology Option (By Percent Phase-In)				
				Level 1	Level 2	Level 3[a]	Repower	OE[h] 0.01
1	1994-2002[g] 32% of fleet	10%	12/31/2004	2.0%		8.0%		
		25%	12/31/2005	7.0%		8.0%		
		50%	12/31/2006	17.0%		8.0%		
		100%	12/31/2007	25.0%		5.0%	20.0%	
1	1991-1993[g] 14% of fleet	10%	12/31/2004	10.0%				
		25%	12/31/2005	15.0%				
		50%	12/31/2006	25.0%				
		100%	12/31/2007	30.0%			20.0%	
1	1988-1990[c] 18% of fleet	10%	12/31/2004					
		25%	12/31/2005					
		50%	12/31/2006					
		100%	12/31/2007				50.0%	
		Delay	12/31/2008				50.0%	
2	1960-1987[b] 27% of fleet	25%	12/31/2007				22.8%	
		50%	12/31/2008				22.8%	
		75%	12/31/2009				22.8%	
		100%	12/31/2010				22.8%	
		Delay	12/31/2011				9.0%	
3	2003-2006[d,e] 9% of fleet	50%	12/31/2009	14.1%		15.9%		20.0%
		100%	12/31/2010	14.1%		15.9%		20.0%
Percent of California's Collection Vehicle Fleet Total:				30%	0%	12%	54%	4%

[a] Only 1994-2002 MY engines were considered for passive diesel particulate filters based on verification data. Assumption based on manufacturer with lowest engine exhaust temperature requirement.
[b] Nine percent of 1960-1986 vehicles are owned by companies with less than 15 vehicles (63 percent of surveyed companies).
[c] Assume all vehicles will repower and have BACT delays since no DECS are currently available.
[d] Assume current Level 3 verification will be extended to 2003-2006 MYs.
[e] Assume current Level 1 verification will be extended to 2003-2006 MYs.
[f] Assume small fleets (<15 vehicles) will have no DECS available and receive implementation delay to 2011.
[g] Assume 20 percent repower even though DECS currently available to these model years due to preference by some collection vehicle owners.

2. Scenario 2: Potential 1 DECS

The second scenario is based on a combination of currently verified DECS and DECS that may be verified before the beginning of the implementation period (**Table 12**). For this scenario, staff assumes verification of Level 1 DECS technologies would be extended to all engine model years of collection vehicle engines.

1991 to 2002 engine MYs in Group 1 remain unchanged in this scenario. 1988 to 1990 engine MYs would now have the option of using a Level 1 DECS, but would still be expected to repower a fraction of these vehicles. The use of 0.01 g/bhp-hr diesel engines is still weighted heavily because, based on discussions with fleet owners, staff assumes given the option many owners will opt to use such an engine in lieu of retrofitting their engines. This is especially true given that Level 1 technologies would be permitted for use on the collection vehicles for a limited timeframe of ten years for Groups 1 and 2 and five years for Group 3.

Group 2 vehicles are expected to be able to use a Level 1 DECS on some portion of their fleet. PM emissions are expected to limit applicability to 1960 to 1987 MY engines, especially the highest emitters. Repowers are, therefore, still heavily weighted.

Group 3 remains unchanged in this scenario relative to the first scenario.

Table 12. Implementation Scenario (Potential 1) - No Level 2 Verified.

Group	Eng MY	%BACT	Implementation Date	Technology Option (By Percent Phase-In)				
				Level 1	Level 2	Level 3[a]	Repower	OE[g] 0.01
1	1994-2002[f]	10%	12/31/2004	2.0%		8.0%		
	32% of fleet	25%	12/31/2005	7.0%		8.0%		
		50%	12/31/2006	17.0%		8.0%		
		100%	12/31/2007	25.0%		5.0%	20.0%	
1	1991-1993[c, f]	10%	12/31/2004	10.0%				
	14% of fleet	25%	12/31/2005	15.0%				
		50%	12/31/2006	25.0%				
		100%	12/31/2007	30.0%			20.0%	
1	1988-1990[c, f]	10%	12/31/2004	10.0%				
	18% of fleet	25%	12/31/2005	15.0%				
		50%	12/31/2006	25.0%				
		100%	12/31/2007	30.0%			20.0%	
2	1960-1987[b,c, f]	25%	12/31/2007	2.3%			22.8%	
	27% of fleet	50%	12/31/2008	2.3%			22.8%	
		75%	12/31/2009	2.3%			22.8%	
		100%	12/31/2010	2.3%			22.8%	
3	2003-2006[d,e]	50%	12/31/2009	14.0%		16.0%		20.0%
	9% of fleet	100%	12/31/2010	14.0%		16.0%		20.0%
Percent of California's Collection Vehicle Fleet Total:				47%	0%	12%	37%	4%

[a] Only 1994-2002 MY engines were considered for passive diesel particulate filters based on verification data.
Assumption based on manufacturer with lowest engine exhaust temperature requirement.
[b] Nine percent of 1960-1986 vehicles are owned by companies with less than 15 vehicles (63 percent of surveyed companies).
[c] Assume current Level 1 verification will be extended to 1960-1993 MYs.
[d] Assume current Level 3 verification will be extended to 2003-2006 MYs.
[e] Assume current Level 1 verification will be extended to 2003-2006 MYs.
[f] Assume 20 percent repower even though DECS either currently or expected to be available to these model years due to preference by some collection vehicle owners.
[g] Original equipment – purchased new.

3. Scenario 3 – Potential 2 DECS

The third scenario is more optimistic regarding the verification of Level 2 technology (**Table 13**). Examples of potential Level 2 technologies include a fuel-water emulsion or a FTF plus a fuel additive. These verifications may be limited as discussed above and therefore, especially for older vehicles, Level 1 DECSs are still predicted to fulfill a small percentage of the compliance requirements for these collection vehicles.

In Group 1 1991 to 2002 MY engines, no changes would occur for the use of Level 3 DECSs, but a shift from using Level 1 to Level 2 DECSs would occur. Additionally for Group 1 1988 to 1990 MY engines and Group 2 MY engine, a portion of the fleets would use Level 2 DECSs. Group 3 assumptions remain unchanged.

Table 13. Implementation Scenario (Potential 2) – All Levels Verified.

Group	Eng MY	%BACT	Implementation Date	Technology Option (By Percent Phase-In)				
				Level 1	Level 2	Level 3[a]	Repower	OE[h] 0.01
1	1994-2002[c, e] 32% of fleet	10%	12/31/2004		2.0%	8.0%		
		25%	12/31/2005		7.0%	8.0%		
		50%	12/31/2006		17.0%	8.0%		
		100%	12/31/2007		25.0%	5.0%	20.0%	
1	1991-1993[c,e] 14% of fleet	10%	12/31/2004		10.0%			
		25%	12/31/2005		15.0%			
		50%	12/31/2006		25.0%			
		100%	12/31/2007		30.0%		20.0%	
1	1988-1990[c,e,f] 18% of fleet	10%	12/31/2004	2.0%	8.0%			
		25%	12/31/2005	2.0%	13.0%			
		50%	12/31/2006	2.0%	23.0%			
		100%	12/31/2007	2.0%	28.0%		20.0%	
2	1960-1987[b,e,f] 27% of fleet	25%	12/31/2007	2.0%	0.25%		22.75%	
		50%	12/31/2008	2.0%	0.25%		22.75%	
		75%	12/31/2009	2.0%	0.25%		22.75%	
		100%	12/31/2010	2.0%	0.25%		22.75%	
3	2003-2006[d,e] 9% of fleet	50%	12/31/2009		14.0%	16.0%		20.0%
		100%	12/31/2010		14.0%	16.0%		20.0%
Percent of California's Collection Vehicle Fleet Total:				4%	43%	12%	37%	4%

[a] Only 1994-2002 MY engines were considered for passive diesel particulate filters based on verification data. Assumption based on manufacturer with lowest engine exhaust temperature requirement.
[b] Nine percent of 1960-1986 vehicles are owned by companies with less than 15 vehicles. (63 percent of surveyed companies.)
[c] Assume 20 percent repower even though DECS currently or expected to be available to these model years due to preference by some collection vehicle owners.
[d] Assume current Level 3 verification will be extended to 2003-2006 MYs.
[e] Assume a PuriNOx+DOC Level 2 could be verified for all model years.
[f] Assume a small percentage of fleet may not be able to use Level 2 devices.
[g] Assume low sulfur fuel used for only installed diesel particulate filters before 2006.
[h] Original equipment – purchased new.

4. Predicted Emission Benefits

According to the emissions benefits calculated by the EMFAC2002 model using these three scenarios, California's SWCV fleet would be able to achieve between 72 and 81 percent diesel PM emission reductions by 2010, between 71 and 85 percent diesel PM emission reductions by 2015, and between 67 and 82 percent diesel PM emission reductions by 2020 (**Table 14**). Natural fleet turnover accounts for the slightly lower predicted PM reductions in 2020.

Table 14. Percent Reduction in Diesel PM Emissions From California's Solid Waste Collection Vehicle Fleet.

		Reduction		
Calendar Year	**Baseline Inventory (tpd)**	**Current**	**Potential 1**	**Potential 2**
2005	1.57	3%	6%	10%
2010	1.42	81%	72%	79%
2015	1.36	85%	71%	78%
2020	1.12	82%	67%	75%

The "current" scenario achieves the greatest percent reductions in PM emissions because staff assume a higher use of repowers, whereas in the two "potential" scenarios staff assumes a higher usage rate for Level 1 and 2 technologies. As this rule allows owners to choose from a menu of options, with differing levels of effectiveness, staff is unable to predict the emission benefits with more precision than shown here.

None of these scenarios assumes Level 3 DECS will be verified for a wider range of engines than currently. Additionally, the widespread use of alternative-fuel and heavy-duty pilot ignition engines would reduce diesel PM emissions further. ARB staff is certain alternative-fuel and heavy-duty pilot ignition engines will used in the SWCV fleet motivated in part by municipality and air quality district edicts, such as SCAQMD's Rule 1193 (SCAQMD 2000) and, in part, by companies' self-motivation.

The three scenarios are, therefore, conservative in their emissions benefits reduction estimates. With the additional emission benefits from the use of alternative-fuel and heavy-duty pilot ignition engines, all three scenarios would be able to meet the goals of 75 percent reduction in diesel PM by 2010 and 85 percent reduction in diesel PM by 2020 in the SWCV fleet.

IX. Conclusions and Recommendations

A variety of options are available for applying BACT to California's SWCV fleet today. By the time implementation begins, staff predicts that additional DECS options will have been verified, with the result of wider applicability of DECSs for the vehicles and engines.

Staff recommends that owners and operators of collection vehicles be sufficiently informed and trained in maintenance practices for these BACTs. This should take the form of appropriate training of mechanics and operators and establishment of procedures to meet any potential issues that might arise as a result of a new technology being available.

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APPENDIX A

FLEET MAINTENANCE STUDY

I. Introduction

Air Resources Board (ARB) staff conducted a survey to determine the quality of fleet maintenance in California's solid waste collection vehicle (collection vehicle) industry, and to ascertain whether a difference exists in the level of maintenance between three types of fleets: public, large and small private fleets. These fleets differ in that public fleets operate in a non-competitive collection environment, which staff hypothesized to influence the quality of maintenance. Furthermore, larger private and public fleets purchase new vehicles more frequently than smaller private fleets, which appear to purchase used vehicles and maintain them for a much longer time period. Given these differences in fleet types, staff believed a difference might exist in a fleet owner's ability to maintain the vehicles, and subsequently impact the success of implementation of the proposed diesel PM control measure for California's collection vehicle fleet.

Particulate matter (PM) emissions dictate, in part, the ability of a vehicle to be retrofitted using diesel emission control strategies (DECS), especially a passive diesel particulate filter, since the filter can only accommodate a certain maximum amount of PM. While 1994 and newer vehicles have certified emissions of 0.1 grams per brake horsepower-hour (g/bhp-hr), PM from these vehicles can increase with because of engine deterioration, tampering, or poor maintenance. The effectiveness of other DECS may also be impacted by higher PM emissions.

ARB regulations require smoke opacity to be below certain thresholds (55 percent for 1990 and older model year engines; 40 for 1991 and newer model year engines) using a snap-idle test (ARB 1999). While this test is only designed to find gross polluters, the ability of a company's vehicles to pass this test demonstrates the owner's willingness to maintain his fleet in a manner sufficient to comply with regulations. Therefore, the smoke opacity test is a reasonable indicator of the likelihood of a successful retrofit based on maintenance levels. The results from the smoke opacity test illustrate at a minimum the percentage of vehicles likely not to be successfully retrofit. It is possible a greater percentage of vehicles cannot be successfully retrofit based solely on their PM emissions.

Other measures are believed to be good indicators of ability to maintain collection vehicles using DECS. These are mechanic to fleet size ratio, level of training of mechanics, organization of inspection, maintenance and service (IMS) forms, and cleanliness of the shop. The mechanic to number of collection vehicles ratio approximates the amount of time a mechanic can spend inspecting, maintaining and servicing a vehicle. Additionally, the amount of training a mechanic has had illuminates the extent to which a mechanic can diagnose and resolve problems with components of the collection vehicles. This is critical because the DECS will reduce smoke emissions historically used to diagnose problems with the engine. These problems could lead to a spike in PM emissions and to a failure of the device.

Further, usage of IMS schedules and forms (shop organization) illustrates a shop's interest in maintaining well-functioning vehicles. Finally, cleanliness of the shop in the form of visible leaks from vehicles and on the shop floor, as well as visible exhaust from the collection vehicles verifies the extent to which the collection vehicles are well-maintained. Each of these measures plus smoke opacity results is expected to help determine the overall capability of a fleet to successfully maintain DECS, and are thus calculated and discussed below..

II. Methodology

Approximately fifteen percent of the collection vehicle fleets in California, or sixty fleets, were selected to participate in the study. Twenty of each of the following fleets - publicly owned, large privately owned, defined as more than ten vehicles, and small privately owned, defined as five to ten vehicles per fleet – were selected (Table 1). Based on expected variability by fleet type, the simple random sample was chosen by applying a random number generating table to a stratified alphabetized inventory of collection vehicle fleets in California according to ARB's Diesel Retrofit Implementation and Evaluation Database. The sample was proportional by fleet type.

To maximize the sample size of vehicles and the number of companies surveyed, five vehicles from each fleet were smoke opacity tested. With a few exceptions in the small fleets, which did not have all five vehicles available for testing either due to maintenance or long distance routes, staff achieved this goal.

Table 1. Fleet Types.

Fleet Type	Number of Fleets
Public	20
Small private (<11 vehicles)	20
Large private (≥11 vehicles)	20
Total	60

Staff visited the collection vehicle yards and collected data regarding fleet maintenance (Figure 1). Using the smoke opacity meter test, ARB staff[1] tested five collection vehicles from each fleet for their emissions and recorded these results (Figure 2). These vehicles were selected by testing the first five to arrive on the site upon beginning the survey.

[1] One staff person, Charles Ross, conducted all of the smoke tests. Mr. Ross is certified in visible emissions evaluation.

CONTACT INFORMATION		Date:	ARB Init:
1. Fleet Contact Name:			
2. Fleet Business Name:			
3. Fleet California ID #:			
4. Fleet Terminal #:			
5. Fleet Terminal Address:			
FLEET INFORMATION			
6. How frequently are new collection vehicles (front, side, rear loaders or rolloffs) purchased?:			
7. How many are purchased at that frequency?:			
8. No. side loaders:		Comments:	
9. No. front loaders:			
10. No. rear loaders:			
11. No. rolloffs:			
MAINTENANCE INFORMATION			
12. No. of mechanics:		13. What is training/ background of each mechanic (if add'l, write below form):	
1.		5.	
2.		6.	
3.		7.	
4.		8.	
14. What is vehicle inspection schedule?			per
15. What is vehicle maintenance schedule?			per
16. What is vehicle service schedule?			
17. Do you have inspection/maintenance forms?		Y - N	(attach blank, if yes)
18. Do you have service forms outlining what is done at each service?		Y - N	(attach blank, if yes)
19. What is checked during inspection?			
20. What is checked during maintenance?			
FLEET INSPECTION			
21. Any visible leaks?		Y - N	# vehicles=
22. Any visible exhaust?		Y - N	# vehicles=
DATA FROM ARB PROGRAMS			
23. Age range of vehicles:	-	24. Forms & records organized & easily accessed?	Y - N
25. Periodic Smoke Inspection Records	Y - N	(attach copies, if yes)	
FUEL DATA			
26. Where do you buy your diesel fuel?			
27. How frequently do you buy your fuel?			per
28. How much do you buy each time?			Gallons
ADDITIONAL INFORMATION			
40. Where are vehicles kept when not in service:	Maintenance facility parking lot – Offsite location:		

Figure 1. Fleet Condition Survey Form.

VEHICLE INFORMATION: Vehicle 1	VIN No.:						
License Plate No.:			Vehicle GVWR:		lbs	Smoke Opacity Test Results	
Vehicle Application:	☐ Side loader ☐ Rear loader ☐ Front loader ☐ Rolloff		Vehicle Model Year:				
			Estimated mpg:		mpg		
Vehicle Manufacturer:			Vehicle Mileage:		miles	1:	
ENGINE Manufacturer:			Fuel Injection:	Mechanical - Automatic		2:	
Engine Model:			Aspiration:	Natural - Turbocharged		3:	
Engine Model Year:			Transmission:	Standard - Automatic		4:	
Engine Horsepower:		hp	Cycle:	Two - Four		5:	
Engine Displacement		in^3/liters	Fuel type:	CARB #2 - 15 ppm		6:	
EXHAUSTS Location:		Up - Down	Configuration:	Single - Dual	Using DPF?	Y - N	
Exhaust Pipe Diameter:		mm - inches	Underbody Clearance:			Inches	

VEHICLE INFORMATION: Vehicle 2	VIN No.:						
License Plate No.:			Vehicle GVWR:		lbs	Smoke Opacity Test Results	
Vehicle Application:	☐ Side loader ☐ Rear loader ☐ Front loader ☐ Rolloff		Vehicle Model Year:				
			Estimated mpg:		mpg		
Vehicle Manufacturer:			Vehicle Mileage:		miles	1:	
ENGINE Manufacturer:			Fuel Injection:	Mechanical - Automatic		2:	
Engine Model:			Aspiration:	Natural - Turbocharged		3:	
Engine Model Year:			Transmission:	Standard - Automatic		4:	
Engine Horsepower:		hp	Cycle:	Two - Four		5:	
Engine Displacement		in^3/liters	Fuel type:	CARB #2 - 15 ppm		6:	
EXHAUSTS Location:		Up - Down	Configuration:	Single - Dual	Using DPF?	Y - N	
Exhaust Pipe Diameter:		mm - inches	Underbody Clearance:			Inches	

VEHICLE INFORMATION: Vehicle 3	VIN No.:						
License Plate No.:			Vehicle GVWR:		lbs	Smoke Opacity Test Results	
Vehicle Application:	☐ Side loader ☐ Rear loader ☐ Front loader ☐ Rolloff		Vehicle Model Year:				
			Estimated mpg:		mpg		
Vehicle Manufacturer:			Vehicle Mileage:		miles	1:	
ENGINE Manufacturer:			Fuel Injection:	Mechanical - Automatic		2:	
Engine Model:			Aspiration:	Natural - Turbocharged		3:	
Engine Model Year:			Transmission:	Standard - Automatic		4:	
Engine Horsepower:		hp	Cycle:	Two - Four		5:	
Engine Displacement		in^3/liters	Fuel type:	CARB #2 - 15 ppm		6:	
EXHAUSTS Location:		Up - Down	Configuration:	Single - Dual	Using DPF?	Y - N	
Exhaust Pipe Diameter:		mm - inches	Underbody Clearance:			Inches	

VEHICLE INFORMATION: Vehicle 4	VIN No.:						
License Plate No.:			Vehicle GVWR:		lbs	Smoke Opacity Test Results	
Vehicle Application:	☐ Side loader ☐ Rear loader ☐ Front loader ☐ Rolloff		Vehicle Model Year:				
			Estimated mpg:		mpg		
Vehicle Manufacturer:			Vehicle Mileage:		miles	1:	
ENGINE Manufacturer:			Fuel Injection:	Mechanical - Automatic		2:	
Engine Model:			Aspiration:	Natural - Turbocharged		3:	
Engine Model Year:			Transmission:	Standard - Automatic		4:	
Engine Horsepower:		hp	Cycle:	Two - Four		5:	
Engine Displacement		in^3/liters	Fuel type:	CARB #2 - 15 ppm		6:	
EXHAUSTS Location:		Up - Down	Configuration:	Single - Dual	Using DPF?	Y - N	
Exhaust Pipe Diameter:		mm - inches	Underbody Clearance:			Inches	

VEHICLE INFORMATION: Vehicle 5	VIN No.:						
License Plate No.:			Vehicle GVWR:		lbs	Smoke Opacity Test Results	
Vehicle Application:	☐ Side loader ☐ Rear loader ☐ Front loader ☐ Rolloff		Vehicle Model Year:				
			Estimated mpg:		mpg		

Figure 2. Smoke Opacity Results Form.

III. Results and Discussion

As predicted, maintenance quality varied with the type and size of the company, in terms of the number of vehicles. In some private fleets the investigation demonstrated a lack of sufficient maintenance practices. Public fleets appeared to be well-maintained, likely because their vehicles are newer, easier to maintain, and, the lack of competition for contracts. Public fleets typically turn over their vehicle every five to seven years. Large private fleets have a slightly longer turnover timeframe for vehicles of seven to ten years. Small private fleets typically buy used vehicles from both of these fleets and use them for the lifetime of the vehicles. Because private fleets compete for contracts while public fleets do not, private fleets may conduct less complete maintenance to cut costs. Collection vehicles from 1966 are still in-use (ARB 2001) in private fleets.

According to the heavy-duty diesel vehicle industry, lack of maintenance accounts for 50 percent of equipment failures (Dolce 2000). Staff expected this percentage of the fleet would also fail the smoke opacity test, the surrogate used for fleet maintenance. Fortunately, this was not the case for California's collection vehicle fleet. In fact, results were very encouraging, with about 93 percent of the collection vehicles tested passing the smoke opacity test. These and other results from the fleet maintenance study are discussed in-depth in the following sections.

A. Specific Indicators of Fleet Maintenance

Five specific indicators of fleet maintenance were gathered from each fleet. First, five vehicles were smoke opacity tested in each fleet, except for those small private fleets with less than five vehicles available on the day of testing. Second, the number of mechanics per fleet size was calculated. Third, the extent to which the mechanics were trained was determined. Fourth, the organization of shop forms and schedules was captured. Fifth, the shop and fleet cleanliness was observed.

1. Smoke Opacity Testing

Of the 288 vehicles that were smoke opacity tested, 93 percent of the vehicles passed (Figure 3). When calculated by fleet type, government-owned collection vehicles had the greatest success rate (97 percent), followed by large private fleets (94 percent) and then small private fleets (88 percent).

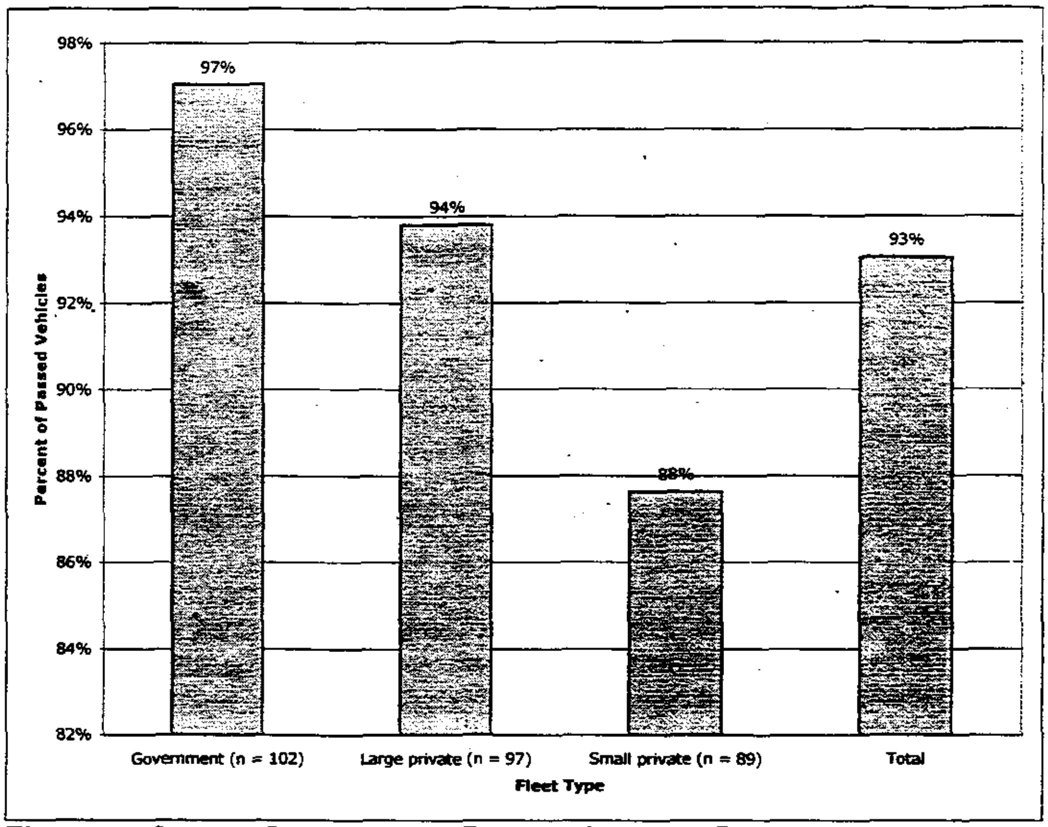

Figure 3. Smoke Opacity Test Results by Fleet Type.

In an effort to determine what segment of the vehicle population contributed most to the success rate, post-1991 and later model year vehicles were compared with pre-1991 and earlier model year vehicles. Regardless of fleet type, 1990 and earlier model year engines met with less success than 1991 and newer model year engines (Figure 4).

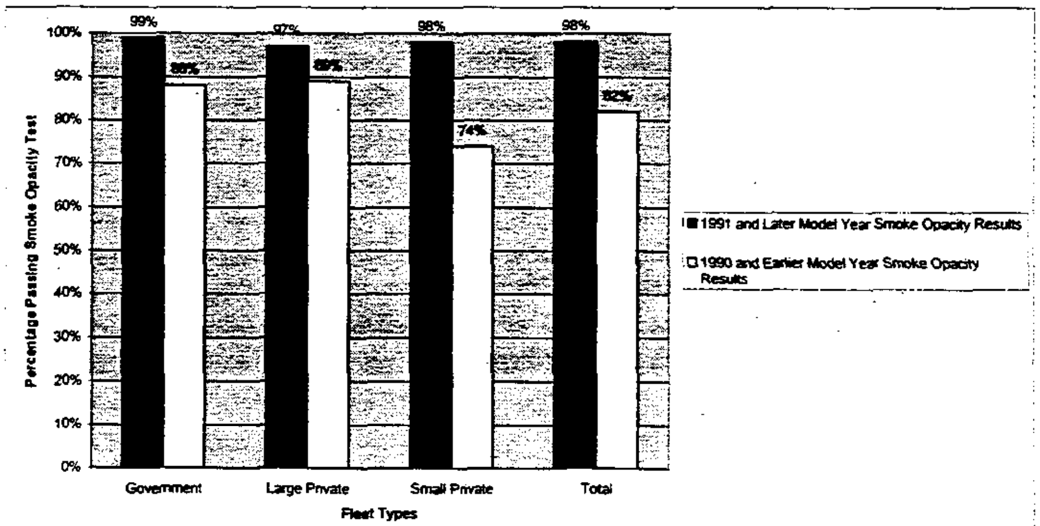

Figure 4. Comparison of 1991 and Later to 1990 and Earlier Model Year Smoke Opacity Results by Collection Vehicle Fleet Type.

In a more in-depth analysis by model year for all of the vehicles tested, average smoke opacity by model year results increased with the age of the vehicle engine (Figure 5). This is as expected with engine deterioration coupled with increasingly stringent diesel PM emissions regulations[2].

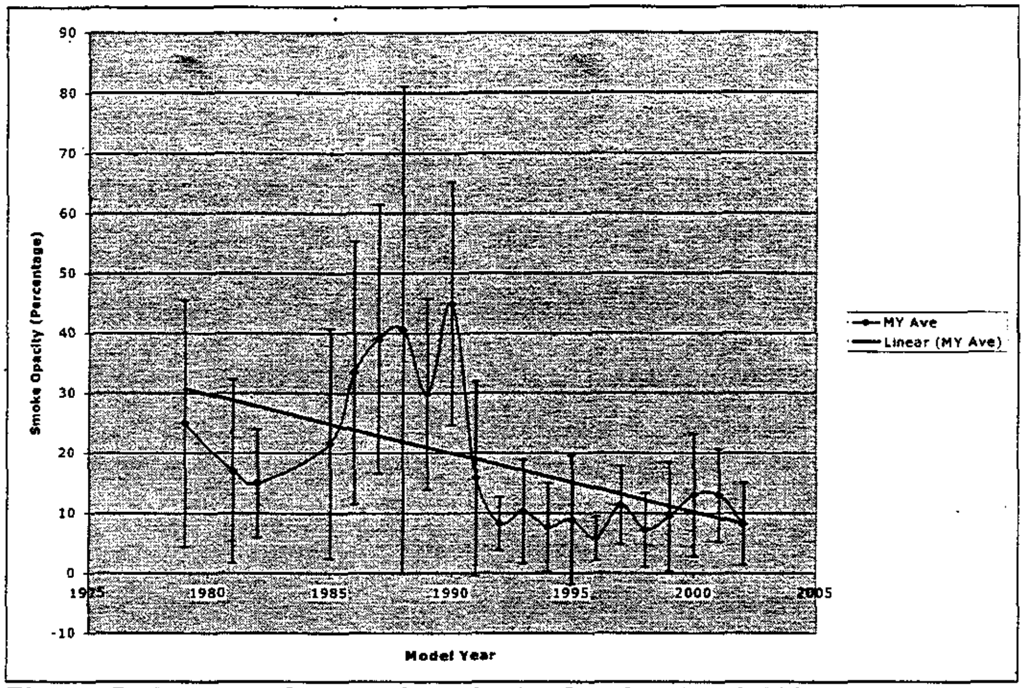

Figure 5. Average Smoke Opacity by Engine Model Year.

2. Number of Mechanics per Fleet Size

One reason for the increase in average collection vehicle smoke opacities from government to private large and then to private small fleet might be because the average number of mechanics to number of collection vehicles decreases accordingly (Figure 6). With fewer mechanics to work on the vehicles, one might predict those vehicles are not as well-maintained. Another potential variable, but which was not captured in this survey, would be number of mechanic-hours per number of vehicles in the fleet. An average work week of 40 hours per week was assumed for the purposes of this study.

[2] Pre-1988 engines were unregulated, 1988 to 1990 engines met 0.6 g/bhp-hr PM emission standard, 1991 to 1993 engines met 0.25 g/bhp-hr PM emission standard, 1994 to 2006 engines met 0.1 g/bhp-hr PM emission standard, 2007 and later engines to meet 0.01 g/bhp-hr PM emission standard.

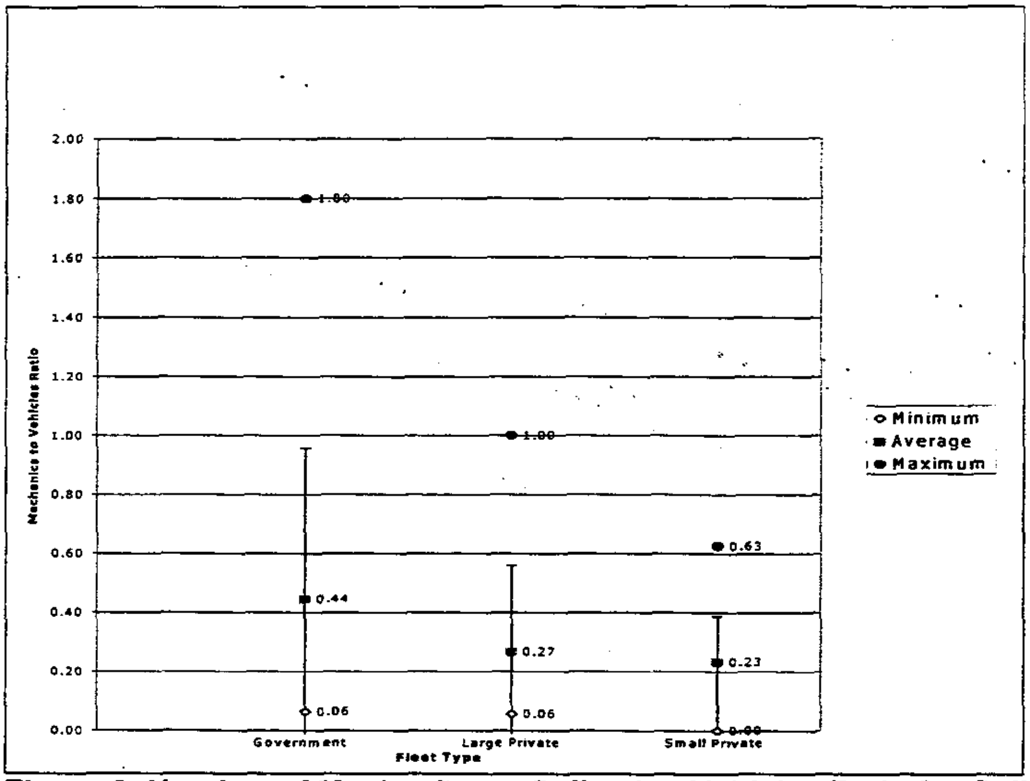

Figure 6. Number of Mechanics to Collection Vehicles Ratio for California's Solid Waste Collection Vehicle Fleets.

3. Training of Mechanics

Fifty-eight out of 60 shops had on-site mechanics, and two fleets (one government and one small private fleet) contract out for maintenance. ARB staff quantitatively ranked the training of the mechanics on a scale of one to four, one being the least amount of training and four being the most amount of training. A rank of (1) meant the mechanics had taken no classes or certification work and were not mechanics for extended periods of time. A rank of (2) was assigned to those who have been mechanics for a long time were considered to be journey level, but were not certified or did not have specific training courses. Mechanics received a rank of (3) if they had training in specific courses, such as hydraulics or alternative-fueled vehicles maintenance, or were ASE certified. Those mechanics with the most training were class A mechanics or had taken extensive coursework were assigned a rank of (4).

The ranking for each company was based on the highest ranked mechanic in the fleet. Staff reasoned that the highest ranked mechanic would be in charge of the others and their training, thus raising the general level of competency for the entire group of mechanics.

This parameter similarly supports the conclusions drawn from the smoke opacity tests. Government fleets have the most training and small private fleets have the least amount of training (Figure 7). The more training the mechanics have had, the better they are able to maintain their fleets. Better training may also correlate to more time and money for training, which smaller fleets often do not have.

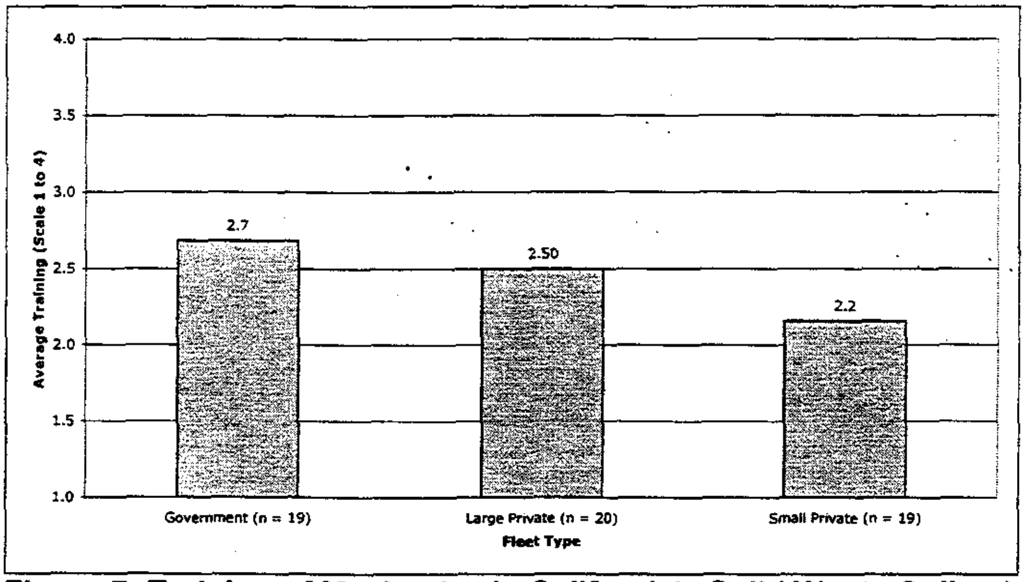

Figure 7. Training of Mechanics in California's Solid Waste Collection Vehicle Fleets.

4. Organization of Shop

In general, the companies were well-organized in terms of having forms and schedules for IMS. For this category, ARB staff quantified shop organization by assigning a "yes" response as a (1), and a "no" response as a (0) to the two questions of whether the owner had (1) forms and (2) schedules for IMS. These ranks were summed and normalized to arrive at average shop organization by fleet type. The government and large privately-owned fleets were slightly more organized than smaller fleets receiving a ranking of 100 percent organization and 82 percent organization, respectively.

5. Cleanliness of Shop and Fleet

The measure of cleanliness also supports the previous results with the government fleets having the fewest visible leaks and exhaust (Figure 8). In order to arrive at the measurements, those fleets with leaking vehicles or spills on the floors received a score of (0). Those with visible exhaust received an additional score of (0). Those without leaks received a score of (1) as well as those without visible exhaust received a score of (1). Therefore, the cleanest fleets received scores of (2) and the dirtiest fleets, scores of (0).

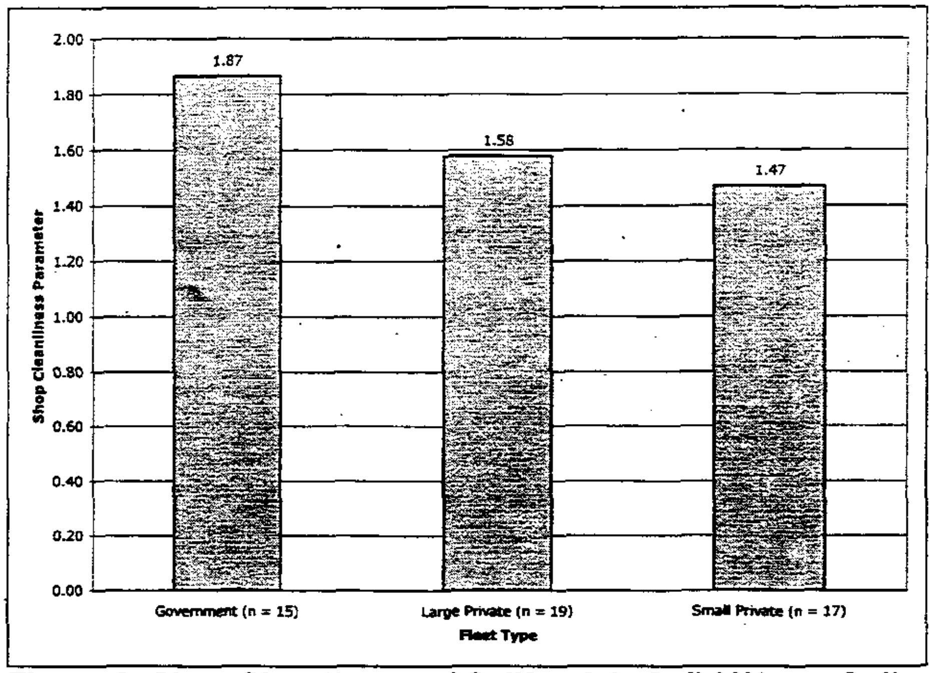

Figure 8. Shop Cleanliness of California's Solid Waste Collection Vehicle Fleets.

B. Issues with Data Collection

A number of issues arose during data collection that may bias the results. These are discussed below.

1. Companies Bought Out

Many of the smaller companies are being purchased by the larger companies. These companies may, therefore, have a better ability to maintain their fleets, because of additional resources brought to them when they are bought. For the purpose of this study, staff categorized them as small companies, however, because staff determined they still tend to function as they did before purchase (i.e., have similar number of vehicles, same mechanics and staff; etc.).

2. Companies Gone Out of Business

Some companies that were on the initial randomly selected list went out of business in the time after the list was created. Therefore, additional companies had to be selected. While this was another random selection, bias may have a occurred as a result.

3. Potential Bias of Non-random Selection by Fleet Owners

ARB staff selected the first five vehicles to enter the maintenance facility to smoke opacity test. Owners of larger fleets may have ordered their collection vehicles as have the dirtiest vehicles enter the facility after the testing was complete and staff had left the premises. This would lead to a potential bias to overestimate the success of the fleets. Staff believes this would be minimal, given that all of the other measurements reveal similar results.

C. Overall Fleet Maintenance Indicator

Assuming all indicators are of equivalent weight, turning each measurement into a percentage and summing the five measurements of fleet maintenance, the rankings remained as they had for each individual measure (Table 2). Public fleets were the best maintained with an overall score of 4.01 out of five. Large private fleets were next with an overall score of 3.63 out of five. Small private fleets were the least well-maintained with a score of 3.21 out of five.

Table 2. Overall Fleet Ranking of Fleet Maintenance.

	Measurement (in percentage)					
Fleet Type	Smoke Opacity	Mechanics per Vehicles	Training	Forms	Shop Cleanliness	Overall
Public	0.97	0.44	0.67	1.00	0.93	4.01
Large Private	0.94	0.27	0.63	1.00	0.79	3.63
Small Private	0.88	0.23	0.54	0.82	0.74	3.21

Even if only the two true numerical ranked parameters, the smoke opacity and the mechanics per vehicles, were analyzed, the same conclusion would be arrived at as when the qualitative data were quantified. As such, ARB staff feels this ranking strategy is a valid indication of the overall fleet maintenance by fleet type.

IV. Implications for Solid Waste Collection Vehicle Fleet Retrofit Feasibility

Based on this study, ARB predicts that, on average, the best maintained DECS will be with those companies that have the most well-trained mechanics with the fewest amount of collection vehicles per mechanic. The government fleets will likely have a slightly higher success rate with retrofitting than the large private fleets, followed by the small private fleets. This study, however, is not truly a predictor of future practices, but only an observational study of past or current practices. Companies that invest in new technology may be more likely to concurrently invest in training and improve their maintenance practices to maintain their investments in the DECS technology.

ARB believes DECS manufacturers and dealerships should invest in training the mechanics on proper maintenance of these DECS. Operator training in the appropriate response to warning lights will also be a critical factor not explored in this study, but experienced in the demonstrations (See Technical Support Document). If the vehicle operators are communicative to the mechanics of any backpressure monitor lights that go on, or issues that may arrive while driving, then the possibility of failure of a DECS should decrease.

Staff expects poor fleet maintenance to only adversely impact the success of certain type of DECS, such as the diesel particulate filter. Other DECS, such as a diesel oxidation catalyst or fuel-based strategy, may be unaffected by maintenance practices. Staff can use the results of this study to focus outreach and education based on fleet type and size, and also the type of DECS the owner plans to implement.

V. References

Air Resources Board (ARB). April 1999. Information Package for the Heavy-Duty Vehicle Inspection Program, Periodic Smoke Inspection Program. Mobile Source Operations Division, Mobile Source Enforcement Branch.

Dolce, J. May 2000. The X's and O's of Warranties: How to Create a Winning Warranty Program. Utility & Telephone Fleets.

APPENDIX B

ENGINE EXHAUST TEMPERATURE STUDY

I. Introduction

The passive diesel particulate filter (DPF) is the only diesel emission control strategy verified to achieve greater than 85 percent diesel particulate matter (PM) as of March 2003. As this is the best available diesel emission retrofit control technology for solid waste collection vehicles (collection vehicles) to comply with the proposed regulation, this study was conducted to evaluate the applicability of passive DPFs to various types of collection vehicles through the measurement of engine exhaust temperature. The purpose of this study was to determine which collection vehicle duty cycles would be able to use passive DPF to reduce diesel PM emissions by 85 percent or greater. Secondarily, staff can use the results to evaluate the feasibility of a newer technology, a flow through filter (FTF), based on its projected requirements for a minimum engine exhaust temperature. Diesel oxidation catalysts (DOC) are not dependent on engine exhaust temperature for successful and efficient operation, thus the results of this study do not apply to DOCs.

The success of a passive DPF relies on four main components: NO_x to PM ratio, total PM emissions, vehicle space availability for the passive DPF, and engine exhaust temperature. Post-1991 heavy-duty diesel engines are best for achieving the NO_x to PM ratio. The maximum PM emissions the passive DPF can handle are predicated, in part, by the frequency of filter regeneration, which, in turn, is dictated by the engine exhaust temperature profile. Johnson Matthey's verified CRT (CRT) requires engine exhaust temperatures of 260 degrees Celsius for at least 40 percent of the duty cycle (ARB 2002a). Engelhard's verified DPX (DPX) requires an average of 225 degrees Celsius engine exhaust temperature with temperatures in excess of 300 degrees Celsius for a minimum of ten percent of the duty cycle (ARB 2002b).

A study by Engine, Fuel and Emission Engineering on Waste Management vehicles that found four out of five of collection vehicles could not meet the CRT regeneration temperature requirements (ARB 2002a, Stoddard 2001), prompted ARB staff to question what percentage of California's collection vehicle fleet might be able to achieve sufficient engine exhaust temperatures. Since the proposed regulation would apply to front, side and rear loader collection vehicles as well as roll offs in California, ARB staff datalogged 60 collection vehicles for engine exhaust temperature distributed across the vehicle types.

The four main types of collection vehicles used to collect solid waste are automated side loaders, front loaders, rear loaders, and roll offs. Automated side loaders experience an intense stop-and-go duty cycle, as these are typically the collection vehicles that service residential homes. Front loaders are used to collect bins from commercial facilities, apartment complexes, or in special circumstances. These vehicles can have significant idle time while the bin is moved out for dumping. Rear loaders historically serviced residential areas with a stop-and-go duty cycle at each home, but are now often used for bulk item collection. Roll offs are used in construction and bulk pick-up situations where a large bin is required for a time. The collection vehicle can only carry one bin at a time, and, therefore, experiences the duty cycle that has the least stop-and-go activity.

I. Methodology

The study was conducted from December 2001 to December 2002. Engine exhaust temperatures were measured from 60 vehicles in six collection vehicle fleets (three public, two private) based on a number of duty cycle variables: vehicle type (front, side, rear loader or roll off), engine model year and make. Staff correlated engine exhaust temperatures to these parameters and determined which percentage of the fleet might be able to use passive DPF successfully. In addition to engine exhaust temperature, load, speed, and location second-by-second data were collected for a number of the collection vehicles. Correlations between these additional parameters and engine exhaust temperature will be analyzed in a later document.

A. Vehicle Selection

ARB staff chose six representative fleets with a cross section of collection vehicles types. To capture the percentage of the fleet that can use passive DPFs, ARB staff acquired exhaust temperature data for 60 collection vehicles (Table 1) between January 2002 and January 2003. Four vehicles were measured again in March 2003 to verify captured data.

Table 1. Tested Collection Vehicles Profiles.

Vehicle Type	Engine			
	Number	Model Year	Manufacturer	Model
Front End Loader	1	1985	Navistar	DT 466
Front End Loader	1	1987	Cummins	L10
Front End Loader	3	1989	Cummins	L10
Front End Loader	5	1990	Cummins	L10
Front End Loader	1	1991	Caterpillar	3208
Front End Loader	1	1991	Cummins	L10
Front End Loader	2	1992	Cummins	L10
Front End Loader	1	1996	Volvo	D7
Front End Loader	1	1999	Volvo	D7
Rear Loader	6	1999	Caterpillar	3126
Rear Loader	3	2000	Cummins	ISC 8.3
Rear Loader	4	2001	Cummins	ISC 8.3
Roll off	1	1980	DDC	671 TA
Roll off	1	1988	Cummins	NTC-365
Roll off	1	1990	Cummins	C8.3
Roll off	1	1991	Cummins	C8.3
Roll off	1	1991	Cummins	NTC-350
Roll off	1	1992	Caterpillar	3406-B
Roll off	1	1993	Cummins	L10
Roll off	1	1994	Cummins	C8.3
Roll off	1	1995	Cummins	C8.3
Roll off	1	1996	Cummins	C8.3
Side Loader	1	1987	Cummins	L10
Side Loader	1	1989	Cummins	L10
Side Loader	3	1994	Cummins	L10
Side Loader	1	1997	Cummins	M11
Side Loader	4	1998	Cummins	M11
Side Loader	3	1999	Cummins	ISM
Side Loader	1	1999	Cummins	M11
Side Loader	2	2000	Caterpillar	C10
Side Loader	2	2001	Cummins	ISC
Small Side Loader	3	2000	Caterpillar	3126
Total	60			

B. Equipment

1. Engine Exhaust Temperature Dataloggers

The exhaust temperature dataloggers were four DT500 Series DataTakers purchased by the ARB in 2001. They collect engine exhaust temperature and rotations per minute (rpm; engine load) on a second-by-second basis, but can change to another interval if required (DataTaker no date).

2. Hertz Sensors

Sensors to register hertz were coupled with the engine exhaust temperature dataloggers. The data from these sensors were converted to rpm by multiplying the hertz by 60 and dividing by the number of teeth on the flywheel, which was 103 for all of the engines.

3. GPS Dataloggers

Four Nav Master Track Master GPS Data Recorders purchased by the ARB in 1999 were used to record latitude, longitude, and vehicle speed. The GPS recorder has an eight-megabyte memory, a magnetic GPS antenna, a lockable metal box, two sealed 12-volt lead-acid batteries, and a power harness with an added cigarette lighter adapter. The dimensions were small (2" by 6.75" by 7") enough to fit in the box that held the exhaust temperature datalogger. The GPS dataloggers collected data on a second-by-second basis.

C. Fleet Composition

ARB staff recorded basic information on each collection vehicle on the data collection sheet (Figure 1). Staff installed dataloggers on the 60 collection vehicles. The collection vehicles were representative of the vehicle types and engine makes (Tables 2 and 5). Front, side and rear loaders and rolloffs, were all represented in the datalogging. Also, all of the engines found in California's collection vehicle fleet were represented, except for Mack engines, which comprised only two percent of California's collection vehicle fleet as calculated from ARB's DRIED 2001 database (Appendix C).

ARB collected data from vehicles in six fleets – three government-owned: City of Los Angeles – Sanitation Department, City of Pasadena, City of Long Beach, and three privately-owned: CR&R, Big Bear City Community Services, and Waste Management. These fleets represented the variety of inclines these collection vehicles might experience in distinct geographic areas from high altitude to coast to desert. The data were collected for a minimum of one week (five days) on each vehicle with approximately 100,000 seconds worth of data for each parameter (exhaust temperature, rpm, and speed).

Table 2. Tested Fleet versus California's Collection Vehicle Fleet Composition.

Factor	Air Resources Board Test Fleet		California's Collection Vehicle Fleet
	No. Vehicles	Percentage	Percentage
Cummins	43	72%	65%
Caterpillar	13	22%	12%
DDC	1	2%	2%
Mack	0	0%	2%
Navistar	1	2%	7%
Volvo	2	3%	13%
TOTAL:	60	100%	100%
SL	21	35%	37%
FL	16	27%	27%
RL	13	22%	28%
Roll off	10	17%	8%
TOTAL:	60	100%	100%
1994 - 2002	37	62%	43%
1991 - 1993	8	13%	17%
1988 - 1990	11	18%	18%
1970 - 1987	4	7%	22%
TOTAL:	60	100%	100%

Figure 1. Vehicle Data Collection Sheet.

CONTACT INFORMATION		Date:	Init:
1. Fleet Contact Name:			
2. Fleet Business Name:			
3. Fleet Terminal #:			
4. Fleet Terminal Address:			
VEHICLE INFORMATION			
5. Vehicle Identification No.:			
6. License Plate No.:			Comments:
7. Vehicle Type/Model:			
8. Vehicle Manufacturer:			
9. Vehicle GVWR:		Pounds	
10. Vehicle Model Year:			
11. Estimated mpg:		Mpg	
12. Current Vehicle Mileage:		Miles	
ENGINE INFORMATION			
13. Engine Manufacturer:			
14. Engine Model:			
15. Engine Model Year:			
16. Engine Horsepower:			hp
17. Engine Displacement:			in^3/liters
18. Current Engine Mileage:			miles/hours
19. Engine Mileage at Last Rebuild, Repower, Replacement:			miles/hours
20. Engine Mileage when Next Expect to Rebuild Engine:			miles/hours
21. Fuel Injection:		Yes/No	
22. Aspiration:		Yes/No	
23. Transmission:			
24. Cycle		Two/four	
25. Fuel Sulfur Content:		CARB/15 ppm	
26. Number of teeth on the flywheel:			
27. Emission Certification:			
EXHAUST INFORMATION			
28. Exhaust Location:		Up/down	
29. Exhaust Configuration:		Single/dual	
30. Exhaust Pipe Diameter:			mm/inches
31. Underbody Clearance:			inches
32. Currently using DPF?		Yes/No	
OIL CONSUMPTION INFORMATION			
33. Current Engine Lubricating Oil Consumption			Qts/Wk
34. What is manufacturer's suggested oil consumption?			______/__
35. Does engine utilize devices that enable less frequent oil changes?		Yes/No	
36. How often is crankcase oil replaced with new oil?			______/__
FUEL DATA			
37. Where do you buy your diesel fuel?			
38. How frequently do you buy your fuel?			per
39. How much do you buy each time?			Gallons
ARB DATA COLLECTION			
40. Smoke opacity test results (attach results strip to this sheet)		1:	4:
		2:	5:
		3:	6:
40. Does the vehicle have access to power source for active DPF?		YES/NO What:	

II. Results and Discussion

A. Engine Exhaust Temperatures

Engine exhaust temperatures were collected and analyzed for the applicability of two types of passive DPFs or one type of FTF, for which ARB has data on required minimum engine exhaust temperatures. A greater percentage of the collection vehicles were able to meet the engine exhaust temperature requirements of the FTF than either passive DPF.

1. Passive Diesel Particulate Filters

In general, the collection vehicles experienced low engine exhaust temperatures. The CRT requirements were met by 35 percent of the tested vehicles, whereas the DPX requirements were met by 48 percent of the test vehicles.

a. Analysis By Vehicle Type

The results analyzed by vehicle type illustrate which collection vehicle duty cycles appear to be more difficult than others. In all cases, relative to the CRT, the DPX engine exhaust temperature requirements were easier to meet, or were equally met as in the case of roll offs. Side and front end loaders had duty cycles most amenable to the use of these passive DPFs (Figure 2), with approximately 70 percent achieving the DPX regeneration temperatures and 50 percent achieving CRT regeneration temperatures. Rear loaders and roll offs experienced little success with only one or two vehicles achieving the appropriate regeneration temperatures.

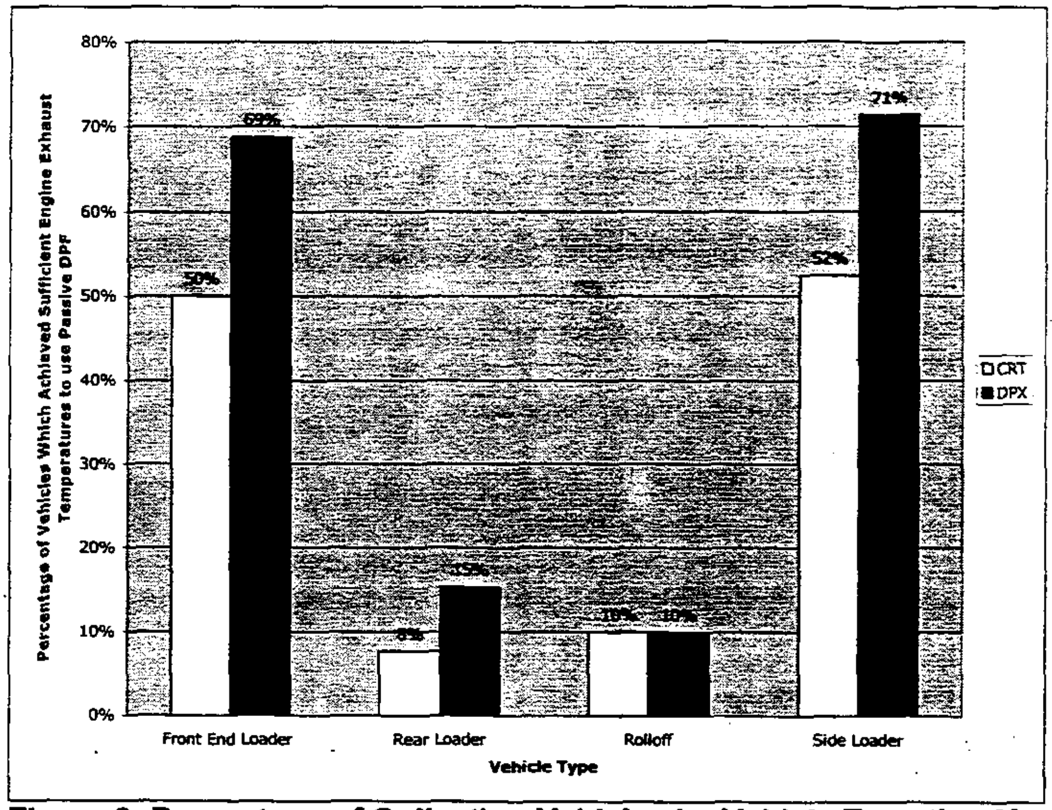

Figure 2. Percentage of Collection Vehicles by Vehicle Type that Met Engine Exhaust Temperature Requirements for Two Variations of Passive Diesel Particulate Filters.

b. Analysis By Engine Type

Cummins and Caterpillar engines comprise the greatest percent of test collection vehicles. Out of 60 vehicles tested, 56 had Cummins or Caterpillar engines. Of the Caterpillar engines, 23 or 31 percent achieved the CRT or DPX engine exhaust temperature requirements, respectively (Table 3). A greater percentage of the Cummins engines achieved the engine exhaust temperature requirements with 37 or 51 percent achieving the CRT or DPX engine exhaust temperature requirements, respectively (Table 3).

Table 3. Percentage of Collection Vehicles by Engine Make that Met Engine Exhaust Temperature Requirements for Two Variations of Passive Diesel Particulate Filters.

Engine Manufacturer	n	Achieved Exhaust Temperature Requirement CRT	DPX
Caterpillar	13	23%	31%
Cummins	43	37%	51%
DDC	1	0%	0%
Navistar	1	100%	100%
Volvo	2	50%	100%
Total	60	35%	48%

c. Analysis By Model Year

The data indicate a difference in exhaust temperature by model year (Table 4), but staff believes this may be an artifact attributed to the vehicle type more than the model year. For example, of the 1988 to 1990 vehicles tested, all of the vehicles that achieved the engine exhaust temperature requirements were front loaders (Table 5).

Table 4. Number of Collection Vehicles by Engine Model Year that Met Engine Exhaust Temperature Requirements for Two Variations of Passive Diesel Particulate Filters.

Engine Model Year	n	Achieved Exhaust Temperature Requirement CRT	DPX
Pre-1988	4	25%	25%
1988-1990	11	73%	82%
1991-1993	8	0%	13%
1994-2002	37	32%	49%

Table 5. Matrix of Test Collection Vehicle Engines and Ability to Achieve Engine Exhaust Temperature Requirements of Two Passive Diesel Particulate Filters and One Flow Through Filter.

		Engine Type			Achieved Engine Exhaust Temperature Requirement		
ID	Vehicle Type	Model Year	Manufacturer	Model	FTF	CRT	DPX
1	Front End Loader	1991	Caterpillar	3208	YES	NO	NO
2	Rear Loader	1999	Caterpillar	3126	YES	NO	NO
3	Rear Loader	1999	Caterpillar	3126	YES	NO	NO
4	Rear Loader	1999	Caterpillar	3126	YES	NO	NO
5	Rear Loader	1999	Caterpillar	3126	YES	NO	NO
6	Rear Loader	1999	Caterpillar	3126	NO	NO	NO
7	Rear Loader	1999	Caterpillar	3126	NO	NO	NO
8	Rolloff	1992	Caterpillar	3406-B	NO	NO	NO
9	Side Loader	2000	Caterpillar	C10	YES	NO	NO
10	Small Side Loader	2000	Caterpillar	3126	YES	NO	YES
11	Side Loader	2000	Caterpillar	C10	YES	YES	YES
12	Small Side Loader	2000	Caterpillar	3126	YES	YES	YES
13	Small Side Loader	2000	Caterpillar	3126	YES	YES	YES
14	Front End Loader	1987	Cummins	L10	YES	NO	NO
15	Front End Loader	1990	Cummins	L10	YES	NO	NO
16	Front End Loader	1990	Cummins	L10	YES	NO	YES
17	Front End Loader	1991	Cummins	L10	YES	NO	YES
18	Front End Loader	1992	Cummins	L10	YES	NO	NO
19	Front End Loader	1992	Cummins	L10	YES	NO	NO
20	Rear Loader	2000	Cummins	ISC 8.3	YES	NO	NO
21	Rear Loader	2000	Cummins	ISC 8.3	NO	NO	NO
22	Rear Loader	2000	Cummins	ISC 8.3	NO	NO	NO
23	Rear Loader	2001	Cummins	ISC 8.3	YES	NO	NO
24	Rear Loader	2001	Cummins	ISC 8.3	NO	NO	NO
25	Rear Loader	2001	Cummins	ISC 8.3	YES	NO	YES
26	Rolloff	1988	Cummins	NTC-365	NO	NO	NO
27	Rolloff	1991	Cummins	C8.3	NO	NO	NO
28	Rolloff	1991	Cummins	NTC-350	YES	NO	NO
29	Rolloff	1993	Cummins	L10	YES	NO	NO
30	Rolloff	1994	Cummins	C8.3	NO	NO	NO
31	Rolloff	1995	Cummins	C8.3	NO	NO	NO
32	Rolloff	1996	Cummins	C8.3	NO	NO	NO
33	Side Loader	1987	Cummins	L10	NO	NO	NO
34	Side Loader	1994	Cummins	L10	YES	NO	YES
35	Side Loader	1994	Cummins	L10	YES	NO	YES
36	Side Loader	1997	Cummins	M11	YES	NO	NO
37	Side Loader	1998	Cummins	M11	YES	NO	NO
38	Side Loader	1999	Cummins	ISM	YES	NO	NO
39	Side Loader	1999	Cummins	M11	YES	NO	NO
40	Side Loader	2001	Cummins	ISC	YES	NO	YES

ID	Vehicle Type	Engine Type			Achieved Engine Exhaust Temperature Requirement		
		Model Year	Manufacturer	Model Year	FTF	CRT	DPX
41	Front End Loader	1989	Cummins	L10	YES	YES	YES
42	Front End Loader	1989	Cummins	L10	YES	YES	YES
43	Front End Loader	1989	Cummins	L10	YES	YES	YES
44	Front End Loader	1990	Cummins	L10	YES	YES	YES
45	Front End Loader	1990	Cummins	L10	YES	YES	YES
46	Front End Loader	1990	Cummins	L10	YES	YES	YES
47	Rear Loader	2001	Cummins	ISC 8.3	YES	YES	YES
48	Rolloff	1990	Cummins	C8.3	YES	YES	YES
49	Side Loader	1989	Cummins	L10	YES	YES	YES
50	Side Loader	1994	Cummins	L10	YES	YES	YES
51	Side Loader	1998	Cummins	M11	YES	YES	YES
52	Side Loader	1998	Cummins	M11	YES	YES	YES
53	Side Loader	1998	Cummins	M11	YES	YES	YES
54	Side Loader	1999	Cummins	ISM	YES	YES	YES
55	Side Loader	1999	Cummins	ISM	YES	YES	YES
56	Side Loader	2001	Cummins	ISC	YES	YES	YES
57	Rolloff	1980	DDC	671 TA	YES	NO	NO
58	Front End Loader	1985	Navistar	DT 466	YES	YES	YES
59	Front End Loader	1996	Volvo	D7	YES	NO	YES
60	Front End Loader	1999	Volvo	D7	YES	YES	YES

2. Engine Exhaust Temperatures for Flow Though Filters

While no published literature exists on FTF engine exhaust temperature requirements, Johnson-Matthey representatives have suggested an engine exhaust temperature requirement at or above 200 degrees Celsius for 50 percent of the duty cycle as a guideline for a planned demonstration. Analyzing the data for this temperature guideline, staff determined that 48 out of 60 vehicles, or 80 percent, met this requirement. By vehicle type, 100 percent of front loaders, 62 percent of rear loaders, 40 percent of roll offs, and 95 percent of side loaders met this requirement. All of the engine model year groups met this requirement by 75 percent or more.

B. Implications for Solid Waste Collection Vehicle Fleet Retrofit Feasibility

The results suggest DPFs may not be able to be used on the full number of collection vehicles in the verified engine families (See Technical Support Document) without significant assistance in increasing the engine exhaust temperature through greater catalysis, using pipe insulation, or locating the DPF closer to the engine. For the FTF technology, the data indicate that this technology may be feasible for a much higher percentage of vehicles, as high as 80 percent. Front and side loaders appear to be most suitable to application of either the passive DPF or FTF, although a substantial percentage of rear loaders and roll offs may also find this technology to be feasible.

ARB will investigate further the source of engine exhaust temperature variability. The prediction is the duty cycles vary in terrain, or engine load, vehicle speed and distance. In addition, potential sources of error in the data exist, which will be further analyzed and reported.

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APPENDIX C

ENGINE INVENTORY

I. Introduction

In 2001 Air Resources Board (ARB) staff conducted a survey of solid waste collection vehicles (collection vehicles) in California, gathering engine and fleet data for approximately 70 percent of the fleet. The data were used to create the Diesel Retrofit Implementation and Evaluation Database (DRIED 2001). Before this survey, no aggregate data existed on the engines used in collection vehicles. ARB's emission inventory for heavy-duty vehicles is assembled on a vehicle level. Best available control technology is applied to the engine and vehicle combination, thus it is critical to understand the inventory of engines, in addition to the inventory of vehicles.

As with other heavy-duty vehicles, the make of a collection vehicle does not necessarily correlate with a specific engine make. Typically, a collection vehicle is put together piece by piece; thus two collection vehicles with Freightliner chassis could have engines manufactured by two different companies. In addition, each engine may have different specifications, such as horsepower and displacement, resulting in different operating characteristics, leading to different likelihood of successful application of passive diesel particulate filters. Vehicle owners also rebuild, replace, and repower engines periodically over the life of the vehicle. Thus the engine model year may not correspond to the vehicle or chassis model year.

II. Methodology

A. Databases

To construct DRIED 2001, we began with a search of other databases to determine if useful data for collection vehicles existed. Two main databases were used to obtain fleet names, owner contact information, and approximate fleet sizes. This information was used to contact fleet owners, to correlate with data collected by ARB, and to supply some additional specific collection vehicle data. The two main sources of this type of information are databases maintained by the California Department of Motor Vehicles and California Highway Patrol.

1. California Department of Motor Vehicles

The California Department of Motor Vehicles (DMV) database contains vehicle and owner information. The DMV database, therefore, was not used to establish the engine information database, although it provided a valuable comparison for the database ARB staff created.

2. California Highway Patrol By Identification Terminal

The California Highway Patrol By Identification Terminal (CHP BIT) database lists vehicles in a fleet by terminal and carrier identification number and simplifies identification of solid waste collection companies by listing the fleet by company name, not by individual vehicle owners. To compile a list of companies involved in the solid waste collection industry in California, we used this database in conjunction with other specialized lists.

3. Other Sources of Data

Specialized sources of data included the list of collection vehicle owners in the South Coast Air Basin obtained from South Coast Air Quality Management District (SCAQMD) and the membership list of the California Refuse Removal Council (CRRC). In addition, staff searched Internet yellow pages and verified lists of company owners and fleets with the California Trucking Association and CRRC.

B. Data Collection Survey

Staff developed a form and cover letter to collect engine data for companies involved in solid waste collection in California. To distribute the survey and gain cooperation, staff attended local solid waste collection association meetings, contacted fleet owners and managers by mail, telephone and direct site visits, posted the request for data on the Diesel Risk Reduction Program web site, and requested assistance in collecting data at each workshop. Staff followed up several times and worked with fleet owners to assist them in compiling the data, if requested. The return rate was high overall.

C. Confidentiality

A major concern early on was confidentiality of the data. Many owners stated they would not submit data unless they were assured their data would be kept confidential. Collection vehicle owners did not want other companies to gain access to their information. Staff consulted with ARB's legal office and determined company-level data could be kept confidential and was not reachable under the California Public Records Act. All company-level results from this survey, therefore, are confidential and only summary data are disseminated in aggregate form.

D. Software

Microsoft Access 2000 software was used to compile and analyze data. The fields in DRIED 2001 included contact, engine, and data entry data (**Figure 1**).

Figure 1. Fields in DRIED 2001.

Contact Information
Date
Type of Business
Fleet Type
Business Name
Alias
Parent Business Name
Carrier ID
Terminal ID
Business Address
City
State
Contact Name
Telephone Area Code
Telephone Number
Fax Area Code
Fax Number
E-Mail

Collection Vehicle Engine Data
Engine Manufacturer
Engine Model
Engine Model Year
Horsepower Range
Displacement
Auxiliary Engine
Fuel Type
Manual or Electronic Fuel Injection
Vehicle Usage/Application
Total Inventory
Data Entry

Survey Form Completed
Date Received
Date Input
Data Enterer

E. Quality Control

In order to assure accuracy in DRIED 2001, staff established a quality control procedure. First, each morning the data receiver entered form receipt information, checking a box on the data collection form in the database and selecting "refuse-general" for the "Business Type" field. In so doing, she verified those companies were in the database. She wrote, "REC'D" on the form, and distributed the updated "Forms Completed Report" to each of the team members for inventory confirmation.

Twice a week the data entry operator entered the engine data from the forms into the database. He double-checked each entry before dating and initialing that he had entered the data on the form. He also entered his initials and the date on the database form. He then deposited the completed forms in a special folder.

Once a week the data checker triple checked for accuracy the critical form information in the database: engine manufacturer, engine model year, and total inventory. After checking the information, she put a check mark on the form and placed the form in the final "forms completed" folder.

III. Results and Discussion

Analysis of the inventory was used to determine the fleet composition for the engine exhaust temperature and fleet maintenance studies as well as for predicting retrofit feasibility for California's collection vehicles. The results are discussed in this section and were communicated to ARB's emission inventory group.

As shown by the survey, Cummins is the most popular engine manufacturer for collection vehicles, with 65 percent of the market (**Figure 2**). Volvo and Caterpillar make up the next significant market share, with 13 and 12 percent respectively. Detroit Diesel, International/Navistar, and Mack comprised 9 percent of the fleet together.

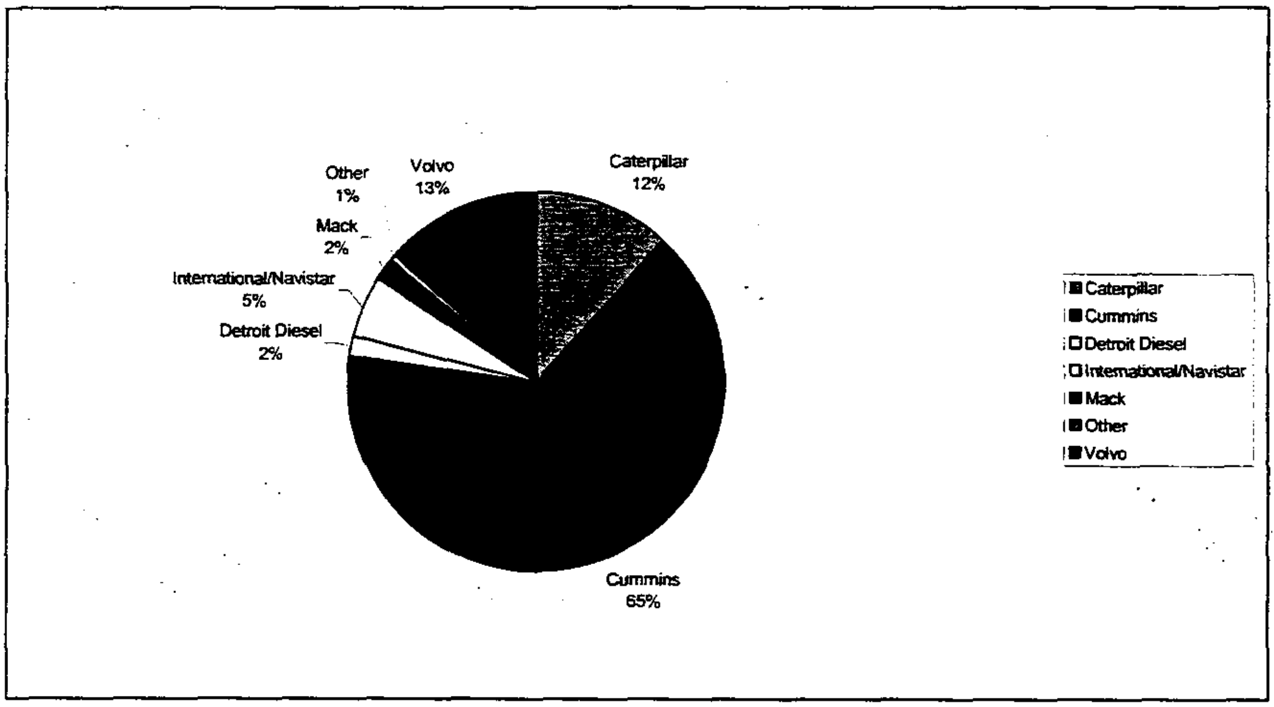

Figure 2. Percentage of Fleet by Engine Manufacturer.

Four main types of vehicles are covered by the proposed regulation: front end, rear and side loaders, and rolloffs (**Figure 3**). Side loaders comprise the largest segment of the fleet with 39 percent of the vehicles, followed by rear (29 percent) and front end (25 percent) loaders. Rolloffs comprised the smallest segment of the fleet with only seven percent.

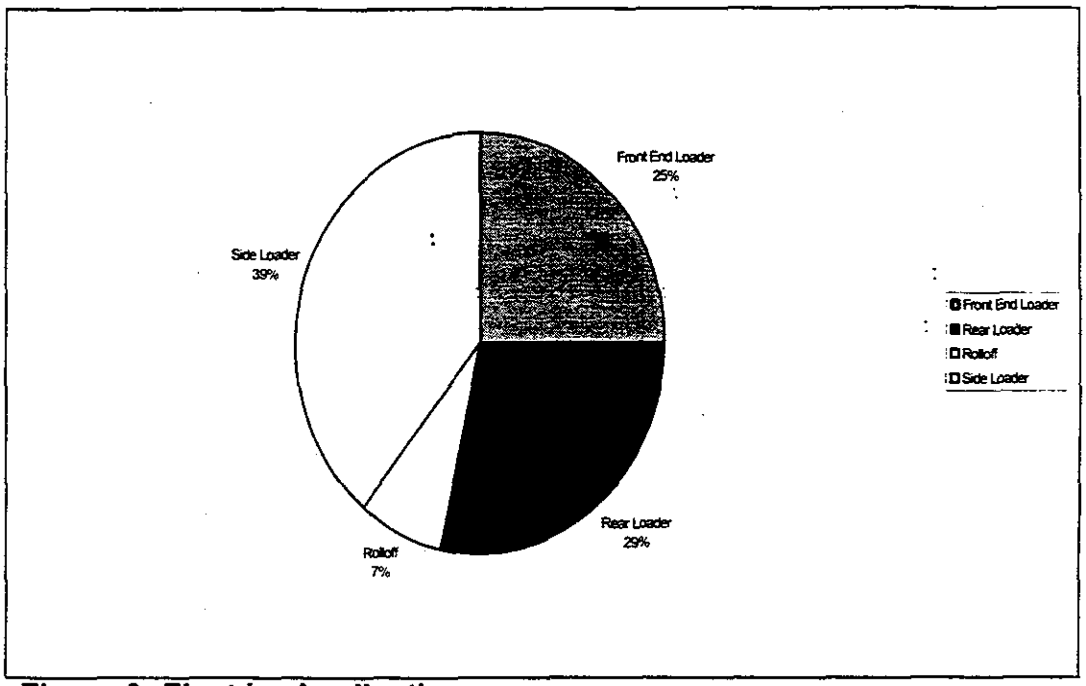

Figure 3. Fleet by Application.

Staff also analyzed the fleet by engine model year (**Figure 4**). The age distribution spans over three decades, extending from 2002 back to 1966 engine model years. The fleet distribution by engine model year is tri-modal with peaks at engine model years 1989, 1995, and 2000.

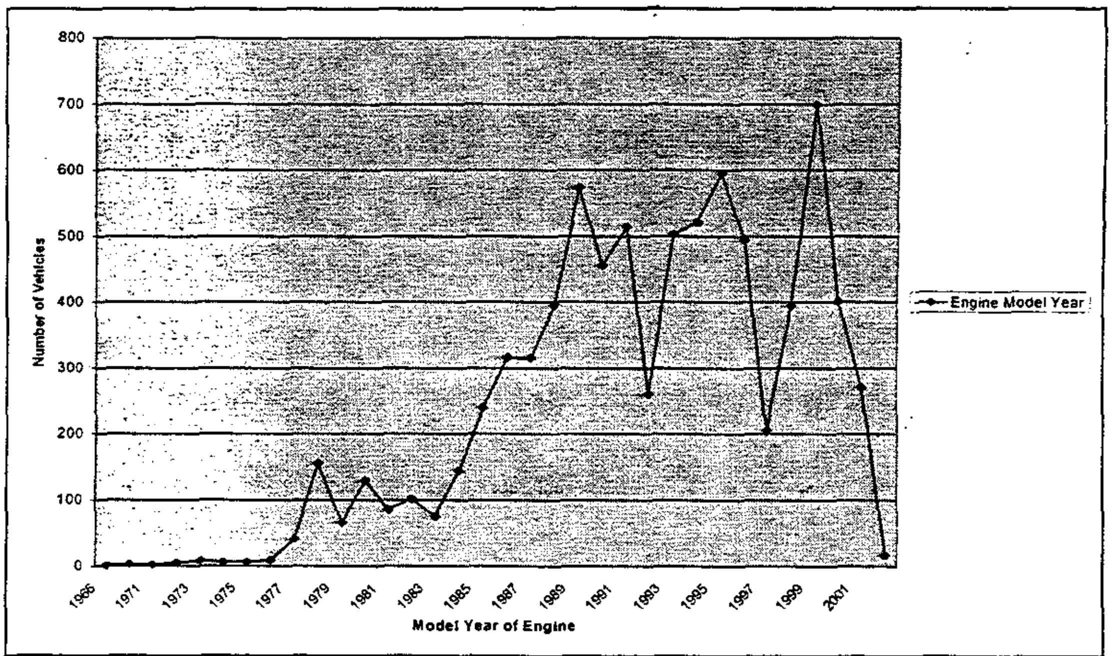

Figure 4. Collection Vehicle Fleet Age Distribution.

Four main categories of engine PM emission standards exist for heavy-duty diesel-fueled engines. The first category is pre-1988 engine model years that were not regulated for PM emissions. The second category is 1988 to 1990 engine model years with a PM emission standard of 0.6 grams per brakehorsepower-hour (g/bhp-hr). Since then, the standards have been tightened twice, first in 1991 to 0.25 g/bhp-hr and then again in 1994 to 0.1 g/bhp-hr. The largest percentage, 45 percent, of the statewide collection vehicle fleet consists of 1994 to 2002 model year engines (**Figure 5**). The rest of the fleet is distributed approximately evenly among the three other PM categories.

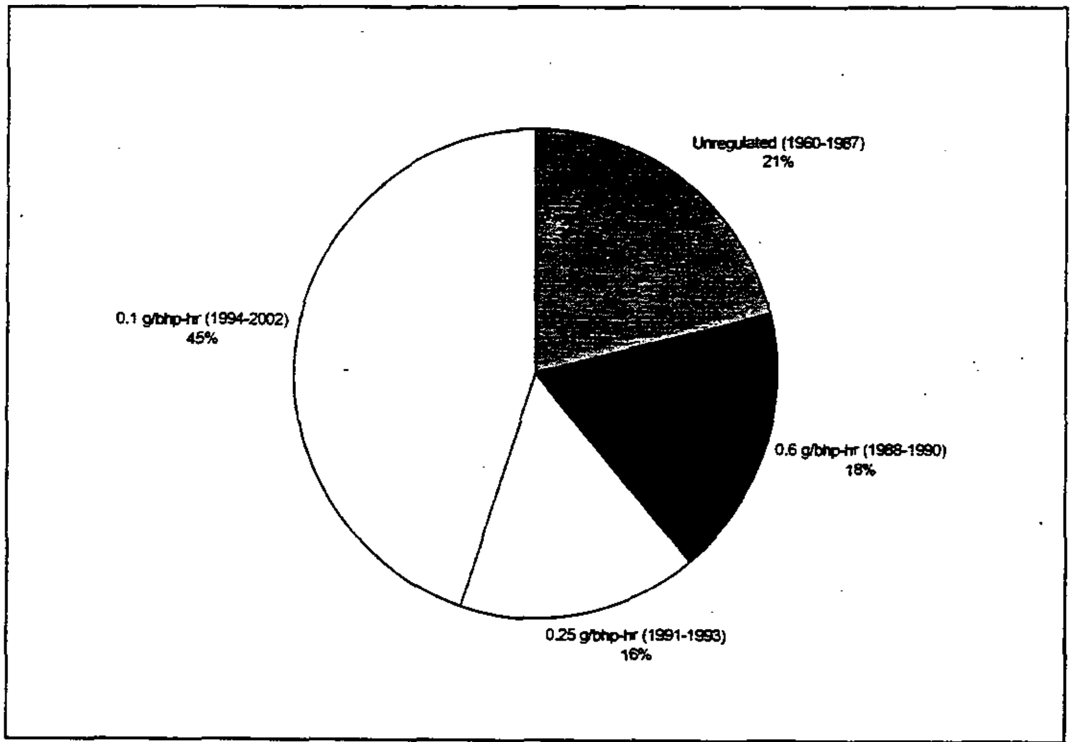

Figure 5. Percentage of Collection Vehicles by Regulated Particulate Emission Standard.

APPENDIX D

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT FUNDING FOR DIESEL PARTICULATE FILTER

As of February 2003, South Coast Air Quality Management District's (SCAQMD) Mobile Source Air Pollution Reduction Review Committee (MSRC) has granted approximately $18 million for diesel particulate matter reduction retrofits of over 2800 vehicles (Ranji 2003, Ravenstein 2003, SCAQMD 2002a, SCAQMD 2002b, SCAQMD 2002c, SCAQMD 2003d, White 2003). Table 1 provides a summary of the projects in the South Coast Air Basin.

Table 1. Summary of Particulate Matter Retrofit Projects in the South Coast Air Basin (SCAQMD, 2002a, 2002b, 2002c, and 2002d).

Funding Source	Project Proponent	No. of Vehicles	Vehicle Type	Project Cost ($)
Caltrans	Caltrans	150	Dump trucks, flatbed trucks, and service vehicles	$870,000
CARB, NREL, ARCO, Johnson Matthey, and Engelhard	ARCO	35	Ralphs grocery trucks, ARCO fuel trucks, school buses, collection vehicles, transit buses, Hertz utility trucks, and people movers at theme park	~$210,000
International Truck & Engine Corp., and individual fleet operators	International Green Diesel Program (Caltrans, Coca Cola, Laidlaw, Ryder, Durham, LA Unified)	20	Utility trucks, delivery trucks, and school buses	~$120,000
Long Beach Transit	Long Beach Transit	27	Transit buses	$193,266
City of Los Angeles	Los Angeles DOT	44	Transit buses	$332,200
Los Angeles MTA	Los Angeles MTA	20	Transit buses	$114,000
City of Los Angeles	City of Los Angeles, Bureau of Sanitation	500	Collection vehicles	$2,600,000
MSRC	Long Beach Transit	99	Transit buses	$688,500
MSRC, County of Riverside	County of Riverside	40	Public works vehicles (e.g., dump trucks)	$340,000*
MSRC	Pro Express	11	Delivery trucks	$93,500
MSRC, City of Los Angeles	City of Los Angeles	81	Flatbed trucks, truck tractors, and dump trucks	$493,000*
State Lower Emission School Bus Program	Various School Districts and private operators	1,058	School buses	$7,400,000*
SCAQMD	City of Azusa	6	Not available	$36,000
SCAQMD	City of Long Beach	24	Not available	$144,000
SCAQMD	Los Angeles County, Dept. of Public Works	60	Not available	$360,000
SCAQMD	City of Los Angeles, Dept. of Airports	6	Not available	$36,000
SCAQMD	City of Pasadena	23	Not available	$138,000
SCAQMD	City of Santa Fe Springs	2	Not available	$12,000
SCAQMD	City of Laguna Beach	7	Not available	$42,000

Funding Source	Project Proponent	No. of Vehicles	Vehicle Type	Project Cost ($)
SCAQMD	Eastern Municipal Water District	13	Not available	$78,000
SCAQMD	Elsinore Valley Municipal Water District	8	Not available	$48,000
SCAQMD	Rancho California Water District	2	Not available	$12,000
SCAQMD	City of Riverside	24	Not available	$144,000
SCAQMD, County of Riverside	County of Riverside	15	Not available	$90,000+340,000*
SCAQMD	City of Chino	1	Not available	$6,000
SCAQMD	Cucamonga County Water District	6	Not available	$36,000
SCAQMD, City of Los Angeles	City of Los Angeles**	384	Not available	$2,265,600
Los Angeles County Sanitation District	Los Angeles County Sanitation Districts	10	Construction vehicles	$55,000
ARB's State Emissions Mitigation Program through MSRC	City of Los Angeles	125	On-road, heavy-duty diesel vehicles (Class 7 and 8), including truck tractors, vans, and street sweepers	$750,000
Total		**2801**		**$18,047,066**

CIAQC – Construction Industry Air Quality Coalition
MSRC – Mobile Source Air Pollution Reduction Review Committee
MTA – Metropolitan Transit Authority
NREL – National Renewable Energy Laboratory
RFQ – Request for Qualifications

*Includes local matching funds.

** The application submitted by the City of Los Angeles involved a request for 384 retrofits. Of these, 197 were to be funded under PA2003-04, and the remaining 187 were to be funded, as approved by CARB, with reallocated funds from an unexecuted contract under the State Emissions Mitigation Fund.

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