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California Environmental Protection Agency

AIR RESOURCES BOARD

Evaluation of Port Trucks and Possible Mitigation Strategies

Stationary Source Division
Project Assessment Branch

April 2006

The Air Resources Board (ARB/Board) Staff is soliciting comments on this draft report, E*valuation of Port Trucks and Possible Mitigation Strategies.* This report presents an analysis of the air quality impacts and the potential options for reducing emissions in a cost effective manner from on-road heavy duty diesel trucks dedicated to goods movement at California ports.

Please submit your comments to Mr. Michael Miguel, Manager of the Project Support Section, by May 12, 2006. Your comments may be submitted via email to mmiguel@arb.ca.gov or by phone at 916.445.4236, or mail to:

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Any questions you may have on this report can be directed to Mr. Michael Miguel at 916.445.4236 or Mr. Mike Sutherland at 916.323.1079.

4/12/2006

California Environmental Protection Agency
Air Resources Board

EVALUATION OF PORT TRUCKS AND POSSIBLE MITIGATION STRATEGIES

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Executive Summary

Background

This report presents an analysis of the air quality impacts and the potential options for reducing emissions in a cost effective manner from on-road heavy duty diesel trucks dedicated to goods movement at California ports. Air Resources Board (ARB) staff estimates that approximately 12,000 on-road heavy duty trucks routinely transport containerized and bulk cargo to and from California's three largest ports.

The Ports of Long Beach, Los Angeles, and Oakland are ranked as some of the largest ports in the world. Air pollution from port activities is a significant and growing concern. Diesel-fueled engines powering vehicles and equipment at the ports emit diesel particulate matter (PM) and other pollutants that increase health risks to nearby residents. Port operations are also a significant source of oxides of nitrogen (NOx) which contributes to the formation of regional smog, or ozone, and fine particulate matter.

Living in communities significantly impacted by air pollution causes adverse health effects, particularly for children, the elderly, and those with compromised health. The communities closest to the ports, adjacent to heavily traveled freeways, and near rail facilities are subjected to even greater impacts and have a greater localized risk due to exposures to unacceptably high levels of diesel PM. Diesel PM poses a lung cancer hazard and causes respiratory and cardiovascular health effects that increase the risk of premature death.

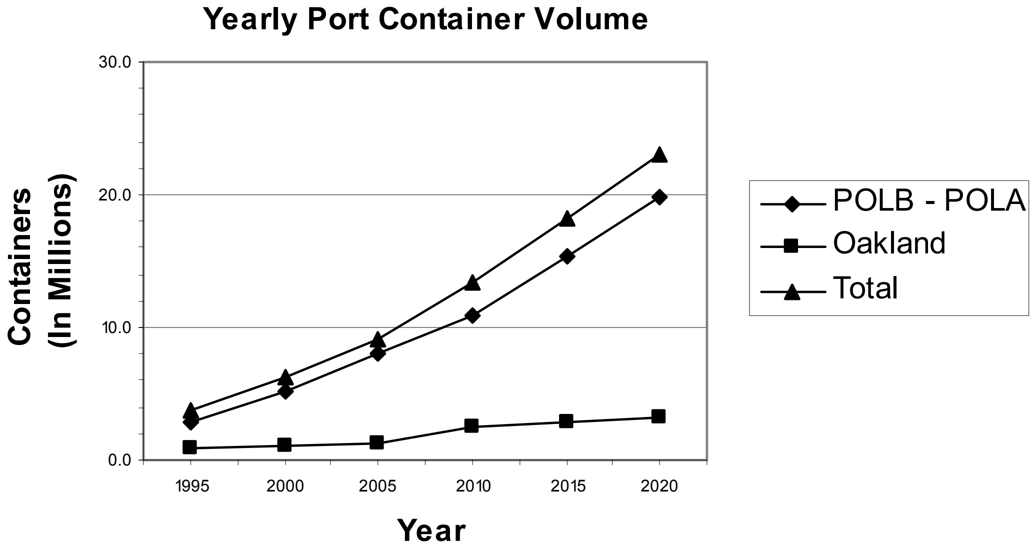
Goods Movement

Virtually all seaborne containerized goods in California enter through the Ports of Oakland, Long Beach (POLB), and Los Angeles (POLA). Combined, the container volume at the three ports was approximately 9.3 million in 2005. The largest ports in California are, by far, the Ports of Los Angeles and Long Beach. These ports are located adjacent to each other in Southern California and account for approximately 87 percent of total yearly State container volume. The Port of Oakland is the third largest port in California with a yearly volume of approximately 1.3 million containers. Other ports in California, such as San Diego and Stockton, generate volumes of less than 42,000 containers yearly.

The movement of this container freight through California ports is a vital component of the State's trade oriented economy and provides a key link to international goods, both for California and much of the rest of the United States of America. Trade is expected to increase significantly by 2020. Container volume is projected to increase to

23.1 million containers annually by 2020. Figure 1 shows expected container growth at the Ports of Long Beach, Los Angeles, and Oakland from 1995 through 2020.

Figure 1: Actual 1995 – 2004 and Estimated 2005 and Later Yearly Port Container Volume



Loaded with every imaginable product, containers are standard sized 'boxes' of either 20 foot or 40 to 53 foot lengths. Loaded containers are transported via ship from a port of origin (e.g. Hong Kong) and delivered to ports around the world. Once at a destination port, the containers are offloaded from the ship and transported to a final destination by truck or train. Once empty, the containers are then either reloaded or transported empty to a new destination to start the cycle over again. At California's two largest ports, Los Angeles and Long Beach, approximately 75 percent of all in bound containers are transported by on-road heavy-duty diesel trucks from the terminals. The remaining 25 percent are transferred via yard hostler to rail staging areas on port property for later train transportation. Rail facilities at the Port of Oakland are located just outside the port properties. On-road heavy-duty diesel trucks are used to transport ship borne containers from the port to rail facilities. On average, approximately 35 percent of the port trucks in Oakland are used in this capacity.

In addition to containerized cargo, bulk cargo such as grain or gypsum, which are typically transported within the hold of a ship, may also utilize heavy-duty diesel trucks for transportation. After arriving at the port, bulk cargo is either offloaded from trucks, or loaded on to trucks for shipment inland or moved directly into manufacturing facilities located at the ports. Trucks that transport bulk cargo are a relatively minor part of port truck traffic, and account for roughly 4 percent of the trucks operating in the ports.

Port Trucks and Economics

The California container goods movement industry utilizes large class 8[1] heavy-duty diesel-fueled vehicles (HDDV) with maximum capacities up to 80,000 pounds (truck and cargo).[2] Trucks that operate at the ports for local or regional service are typically older models with high mileage and are generally much older than trucks used for long haul activities. After an HDDV vehicle accumulates 500,000 – 750,000 miles, it approaches the end of its useful life as a long-haul truck. Often, the truck is auctioned or sold to an owner that may utilize the vehicle for purposes other than long-haul activities, such as transporting containers.

Most port trucks are driven by owner/operators in an economically competitive business that generates low profit margins with little ability to increase rates to cover the costs of complying with potential emission reduction strategies. Port truck owners arrange for business through dispatching companies, which in turn, contract with port terminals to transport containers or bulk cargo.

Considering annual operating costs, such as fuel, maintenance, and mandated fees, truck drivers' annual pre-tax net earnings, which are essentially their wages, appear to average about $30,000. The low wages and difficult working conditions experienced by port truck owner/operators limits the supply of available port trucks to haul containers.

Emissions and Health Risks

Port truck activities generate approximately 7,075 tons per year (TPY) of NOx and 564 tons[3] per year of diesel PM in 2005. These emissions represent 23 percent of all port-related NOx emissions and nine percent of all port-related diesel PM emissions. Table 1 lists the emissions of diesel PM and NOx for the Ports of Long Beach, Los Angeles, and Oakland. Mitigating port truck emissions to the greatest extent possible will help lessen the harmful effects of pollution on the surrounding population centers.

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[1] Class 8 vehicles are defined as having a gross vehicle weight of 33,001 lbs and over

[2] California Vehicle Code 35551, http://www.dmv.ca.gov/pubs/vctop/d15/vc35551.htm

[3] Calculations for emissions are explained in the Emissions section of this report.

Table 1: Estimated 2005 Port Truck Emissions for the Ports of Los Angeles, Long Beach and Oakland (rounded)

PORT	**PM** (TPY)	**NOx** (TPY)
Port of Long Beach (POLB) Port of Los Angeles (POLA) (including regional on-road)	491	6,048
Port of Oakland (including regional on-road)	73	1,027
Total	**564**	**7,075**

The Ports of Long Beach, Los Angeles, and Oakland are located adjacent to population centers. These communities have imbedded major traffic arteries that provide access to the ports. On a typical weekday, approximately 10,000 individual trucks make an estimated 2-3 trips each, either to or from the Ports of Los Angeles and Long Beach principally along the 110 and 710 freeways. In addition, 2,000 trucks travel to the port of Oakland an average of 2-3 times each day. Traffic conditions along the major thoroughfares into the ports are often congested, and the fleet of older, or high polluting trucks result in high levels of exposure to diesel PM in adjacent communities. Emissions and resulting risk are expected to increase with the expected growth in trade unless substantial additional control measures are implemented to reduce port related emissions.

Emission Reduction Strategies

Emissions reductions from port trucks can be obtained by fleet modernization through the installation of diesel particulate filters (DPFs), oxidation catalysts, NOx reduction technologies, or possibly through the use of other verified strategies. These technologies represent varying degrees of effectiveness for PM control and their application, especially with DPFs, can be limited. Replacement of older higher emitting engines with newer cleaner emitting engines by repowering or replacing the existing truck is the most effective strategy, although significantly more expensive, for reducing both PM and NOx emissions.

In 2002, ARB staff estimates that approximately 72 percent of port trucks are model year 1993 or older and operate using older, higher PM and NOx emitting engines. Furthermore, only 28 percent of the existing port truck fleet was new enough (truck model year 1994 and newer) to support retrofit with a DPF for PM control.

In evaluating strategies, ARB staff sought to maximize early diesel PM reductions, create significant NOx reductions, and maintain cost effectiveness with the goal of modernizing and/or retrofitting the entire port truck fleet of approximately 12,000 vehicles. The three strategies presented in this report share three common goals. The first is to install DPFs on all trucks that routinely visit the ports to ensure maximum and timely PM reductions. We estimate this measure alone will reduce diesel PM emissions by 85 percent or better on vehicles that have been upgraded. The second goal is to modernize the fleet using truck replacements that provide for the purchase of much less expensive depreciated used trucks in a way that enables retrofit of DPFs and achieves lower NOx emissions. Regardless of which strategy is implemented, trucks that are taken out of service and replaced should be scrapped to ensure emission reductions are permanent and the trucks are not introduced into another line of service. The third is to establish a regulatory or other equally enforceable program to implement minimum requirements for bringing additional trucks into port service and to ensure that emissions reductions obtained through retrofit or replacement are not eroded by the use of older, dirtier trucks, as the need for more trucks occurs.

Under this approach, drivers entering port service starting after the measure is established would be required to use trucks meeting cleaner truck requirements based on the year the truck would be brought into port service. It is envisioned that, from program start through 2011, any truck brought into port service would have to meet 2003 model year (MY) or later standards, and be equipped with a DPF. Starting in 2012 and through 2014, trucks brought into port service would need to meet 2007 MY or later standards. For 2015 and beyond, only trucks meeting 2010 MY and later standards would be allowed. Establishing requirements for new trucks entering port service ensures that all vehicles used to handle expected growth at California ports meet very stringent PM standards and meet progressively lower NOx standards. With these measures in place, port trucks would, in the 2010 through 2020 period, be among the cleanest fleets in the State.

Three separate strategies were analyzed to reduce emissions of NOx and PM from the existing port truck fleet. Strategy 1 puts the highest priority on reducing diesel PM emissions by replacing model year 1993 and older trucks with 1998 and newer model year trucks and equipping the entire fleet with DPFs over a 2007-2010 implementation period. The use and installation of DPFs would reduce diesel PM emissions by 85 percent or more. These filters are widely available for installation on model year 1994 and later trucks. Additionally, replacing older, higher NOx emitting trucks with 1998 or newer model year trucks would generate some amount of fleet wide NOx reductions after full implementation in 2010.

Strategy 2 combines a high level of diesel PM reduction with a substantial reduction in NOx by replacing model year 2002 and older trucks with newer 2003 to 2006 model year trucks. Similar to strategy 1, all trucks operating at the ports will be equipped with a DPF that achieves an 85 percent PM reduction. Substantial NOx reductions would be achieved through replacing all pre-2003 MY trucks with 2003-2006 MY trucks, which corresponds to the first year of the 2003 NOx + HC engine standard of 2.5 g/bhp-h. Replacing the older, higher NOx emitting (4 g/bhp-h and higher) trucks with newer model year 2003 trucks would generate substantial fleet wide NOx reductions after full implementation in 2010.

The third strategy also seeks a high level of NOx control and consists of two phases. The first phase would replace pre-1994 trucks with 1998-2002 trucks that meet at least a 4.0 g/bhp-h NOx certification standard. These trucks, along with existing 1994-2002 trucks, would be retrofitted with NOx/DPF control combination to achieve 85 percent or better PM control and 25 percent or better NOx control. Existing 2003 MY and later trucks would be retrofitted with DPFs. The second phase would require the retirement or replacement of the 1994 through 2002 trucks by 2017. In order for drivers to continue to work in port services, these trucks would have to be replaced with 2010 MY or later trucks. The remaining 2003 through 2006 trucks would need to be replaced with 2010 MY or later trucks by 2019. This strategy provides most of the short term NOx reductions obtained through strategy 2; however, it provides much greater long term NOx benefits, and does so at a much lower cost.

Additionally, all three strategies would be combined with a regulatory or other enforceable program that imposes stringent PM and progressively tighter NOx requirements on new entrants to the port truck fleet. Table 2 summarizes the cost effectiveness for all three strategies.

Table 2: Costs, Emission Reductions, and Cost Effectiveness over Capital Recovery Period (10 Years)

Strategy	Cost (2005) (Millions)	Emission Reductions (Cumulative TPY)		Average Annual Cost Effectiveness ($/Ton)		
		PM	NOx	PM	NOx	Moyer[4]
Strategy 1 Existing Fleet	$180	5,000	4,800	$37,000	$8,000	$4,500
Strategy 2 Existing Fleet	$570	5,300	23,000	$35,000	$17,000	$11,800
Strategy 3 Existing Fleet	$280	5,200	20,000	$28,000	$7,000	$5,900
Strategy 3 Phase 2	$200		47,500		$4,000	
Trucks Entering Port Service	$110	1,200	15,300	$34,000	$5,000	

Figures 2 and 3 summarize existing fleet baseline PM and NOx emissions and emission reductions in 2010, 2015, and 2020 for each of the three strategies. PM emission reductions (Figure 2) are expected to be virtually identical after 2010, as all strategies will effectively require DPF retrofits or 2007 MY trucks (with DPFs). Strategies 1 and 2 NOx emissions (Figure 3) are expected to increase as the fleet ages after 2010.

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[4] See Appendix B for Cost Effectiveness using Carl Moyer Methodology

Conversely, as strategy 3 requires additional fleet upgrades in 2017 and 2019, long-term NOx emission benefits are expected to be greater.

Figure 2: Comparison of PM Emissions for the Period 2005 – 2020

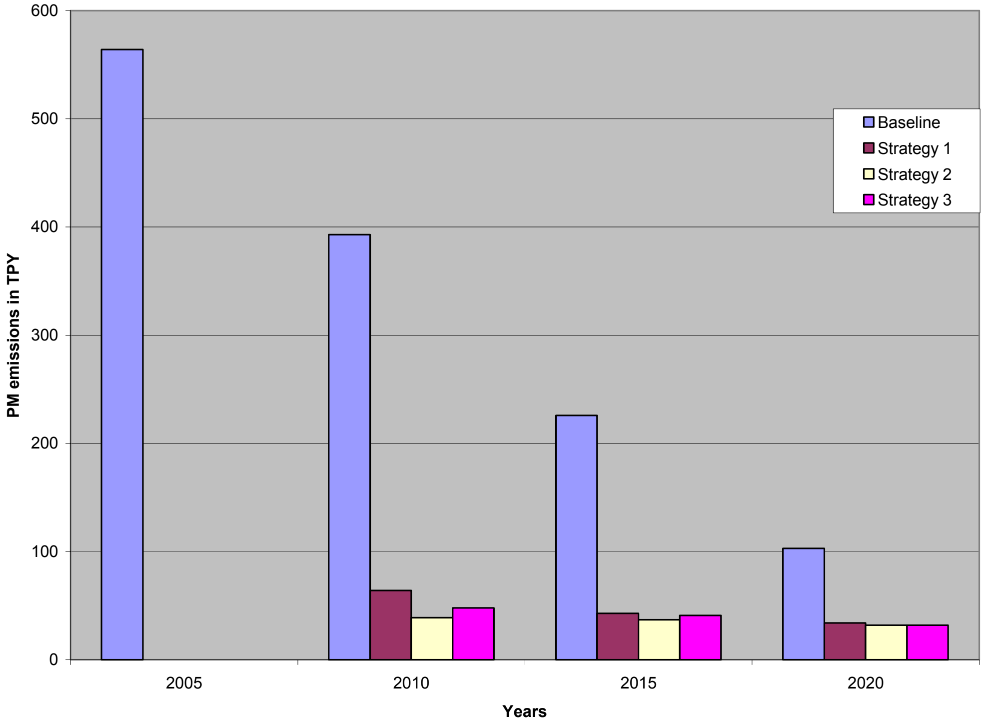
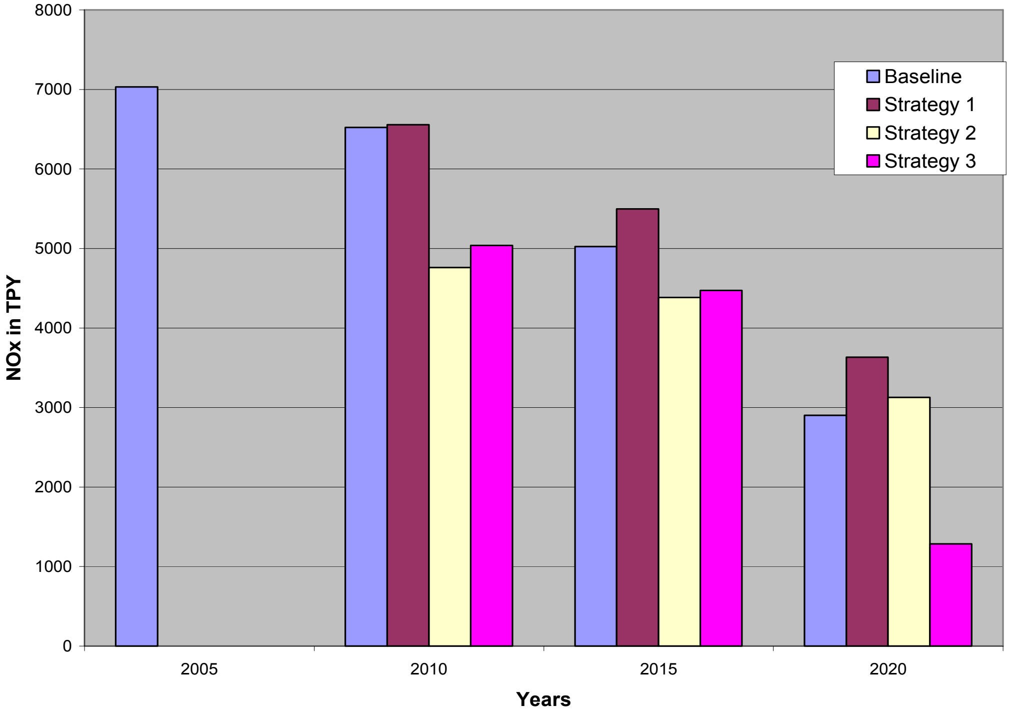


Figure 3: Comparison of NOx Emissions for the Period 2005 – 2020



Conclusions

The port truck fleet modernization program has significant emission reduction benefits. However, any strategy to reduce emissions from port trucks must account for a variety of issues. Chief among these issues is the ability and willingness of the port truck owner to participate in the desired retrofit and modernization efforts. Profit margins for port truck drivers are slim and they lack the ability to raise rates in order to generate the money to pay for the costs associated with modernization. Any attempt to use regulatory mechanisms alone to induce truck owners into paying for modernization or retrofit of their trucks could well create a shortage of trucks willing to move goods at ports. Based on the results of this study, ARB staff concludes the following:

- The 12,000 port trucks operating at the 3 major California ports are a significant source of air pollution and operate in close proximity to communities.

- A fleet modernization strategy can be implemented that will substantially reduce emissions of diesel PM and oxides of nitrogen by 2010 with additional reductions by 2020.

- The most cost-effective strategy involves retrofitting the existing fleet with DPFs and NOx emission reduction strategies in combination with limited newer truck purchases. The strategy would also require new trucks entering port service to meet increasingly stringent emission standards, as well as additional emission reductions from the existing fleet when feasible.

- The recommended existing fleet modernization strategy is costly ($280 million) and likely cannot be paid entirely by the truck owners; thus, funding sources must be secured to help defer the cost of the replacement trucks and retrofit technologies.

- An enforceable mechanism is necessary to ensure that the modernized and retrofitted trucks stay in port service. This could be done by refunding the costs to the truck owners over time, perhaps in the form of a per-trip credit. Owners/operators would get points or credit each time containers were picked up or delivered to the port. A minimum number of trips would be required in order to receive the full incentive payment. Another option would be to establish contracts or binding agreements with the owners/operators. This option would also require a process for monitoring individual truck activity.

- A mechanism is also necessary to ensure that older, dirtier trucks do not enter port service as the fleet grows. This could be accomplished by requiring trucks that enter port service after 2006 meet increasingly stringent emission standards. These trucks would be equipped with DPFs and OEM engines that meet 2003[5], 2007, or 2010 standards.

- The recommended fleet modernization strategy would be accomplished in two phases. Phase 1 requires the retrofitting of the entire fleet (12,000 trucks) with highly effective DPFs. NOx reductions would be achieved by equipping the 10,500 pre-2003 trucks with a NOx reduction catalyst system. All pre-1994 vehicles would be retired (scrapped) and replaced with 1998-2002 MY vehicles. Phase 2 would require the entire port truck fleet to meet 2007 or 2010 engine standards by the year 2020.

- Program enforcement could be the responsibility of the ports through the terminal operators. Trucks would be monitored when they are processed at the terminals before container pick-up or delivery.

- The port truck fleet modernization program presents several challenges and will take intensive planning, coordination, and cooperation of all parties involved.

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[5] 2.5 g/bhp-h certification standard for NOx+HC

Evaluation of Port Trucks and Possible Mitigation Strategies

I. Background

A. Port Trucks

Port trucks are typically class 8[1] heavy-duty vehicles with maximum hauling capacities up to 80,000 pounds[2] (combined weight of truck and cargo). For the purposes of this report, heavy-duty vehicles (HDDV), regardless of fuel type, are defined as vehicles with gross vehicle weight ratings (GVWR) greater than 33,000 pounds. Examples of HDDVs include fuel cargo tankers, long-haul trucks, and vehicles that transport containers and bulk cargo to and from ports.

Trucks that transport containers to and from ports are almost universally large class 8 sleeper-equipped tractors. Due to the size (loading capacity) of most cargo containers, only the larger class 8 trucks are able to move fully loaded containers.

Trucks that transport containers from the ports typically do not bring their own container chassis. They may bring a container to the port and drop the container and chassis, or arrive without a trailer as a bobtail. The trucks check in with the terminal operators to obtain instructions and locations for their loads. The terminal will mate an outgoing container with a container chassis and assign it to a truck. After the truck picks up the container, it is then processed and allowed to leave the port.

This report will focus on the evaluation of heavy-duty diesel-fueled class 8 vehicles that routinely operate at the three major California ports (See example shown in Photograph I-1).

Photograph I-1: **Heavy-Duty Diesel-Fueled Trucks with Containers at the Port of Long Beach**

Photo source: http://www.polb.com/images/PhotoGallery/PortTour/index.htm

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[1] Class 8 vehicles are defined as having a gross vehicle weight of 33,001 lbs and over. Federal Code of Regulations, Title 49: Part 565, http://www.washingtonwatchdog.org/documents/cfr/title49/part565.html

[2] California Vehicle Code 35551, http://www.dmv.ca.gov/pubs/vctop/d15/vc35551.htm

B. Emissions from Heavy-Duty Diesel-Fueled Vehicles in California

In 1998, the Air Resources Board (ARB) identified diesel particulate matter (PM) as a toxic air contaminant (TAC). Diesel PM contributes to over 70 percent of the estimated risk from air toxics today. In September 2000, ARB approved the "Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles" (DRRP). The goal of the DRRP is to reduce diesel PM emissions and the associated cancer risk up to 85 percent by 2020. In 2001, the Office of Environmental Health Hazard Assessment (OEHHA), pursuant to the requirements of Senate Bill 25 (1999, Escutia), determined diesel PM to cause children or infants to be more susceptible to illness.[3]

Diesel exhaust also contains oxides of nitrogen (NOx) and hundreds of different volatile organic compounds (VOC). Ozone is formed by the reaction of VOCs and NOx in the atmosphere in the presence of heat and sunlight. The highest levels of ozone are produced when both VOC and NOx emissions are present in significant quantities on clear summer days. Ozone is a powerful oxidant that can damage the respiratory tract, causing inflammation and irritation, which can result in breathing difficulties.[3]

Diesel trucks are major contributors to California's continuing air quality challenges. Per vehicle, they emit relatively high levels of NOx and diesel PM. Based on current emission modeling estimates for the South Coast Air Basin, heavy-duty diesel vehicles (which represent only two percent of the total on-road fleet) will emit about 50 percent of the NOx emissions and about 37 percent of the PM emissions from all on-road mobile sources by 2010. These are significant emission contributions from a relatively small fraction of the total on-road fleet.[4]

C. Goods Movement at California Ports

The California goods movement industry is driven by both the rise in United States demand for foreign imports and the growing California marketplace. In the last 25 years, both California and the United States, driven by rising demand for lower cost products and a desire to take advantage of production costs overseas, have assumed expanded roles in global trade, particularly as importers. The system comprising product request, movement from producer, and delivery to customer is commonly referred to as the "supply chain". This supply chain is a dynamic system influenced heavily by customer demand. The more global the supply chain becomes, the greater the impact on the State's goods movement transportation system of streets and highways, rail lines and yards, and seaports.

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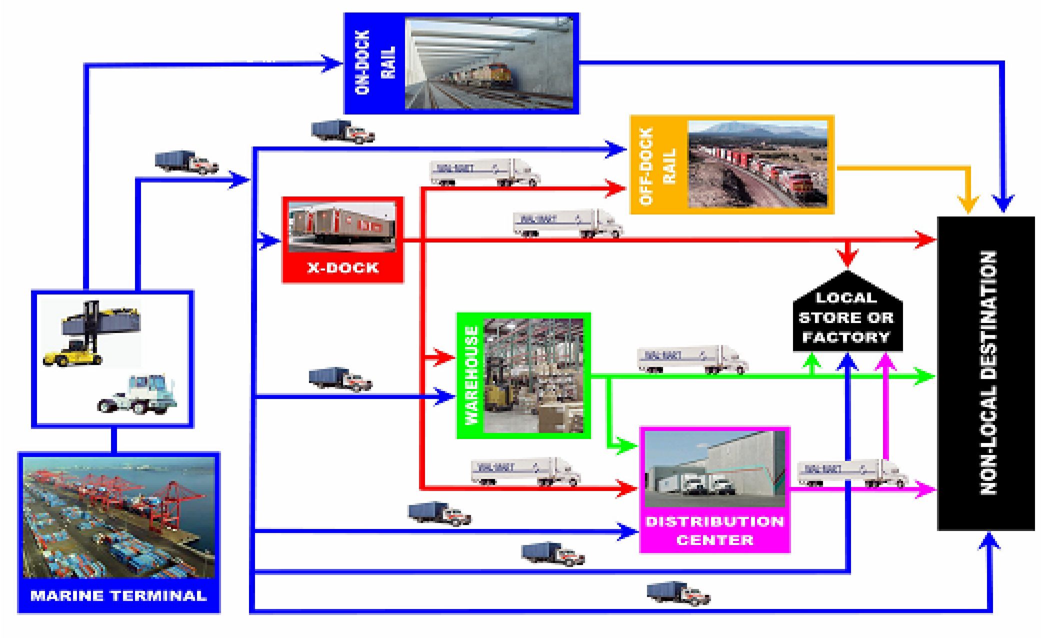
[3] California Air Resources Board, "Airborne Toxic Control Measure To Limit Diesel-Fueled Commercial Motor Vehicle Idling", July 2004

[4] California Air Resources Board, "Proposed 2003 State and Federal Strategy for the California State Implementation Plan", August 25, 2003

Schematic I-1: Intermodal Container Supply Chain



Graphic source: **Port container movement.ppt provided by TIAX LLC.**

Goods arrive at ports either as bulk cargo or within containers. Bulk items are transported within the hull of a ship and then transferred to waiting trucks or offloaded directly into manufacturing facilities located at the port. Examples of bulk items are grains, gypsum, and petroleum coke. Trucks that transport bulk material are a relatively minor part of the port traffic and account for roughly 4 percent of the on-road trucks operating at the ports. The age distributions and economics of bulk transport trucks are assumed to mirror those of the container transport trucks. Sections E and F elaborate on container transport truck age distributions and economics, respectively.

The primary method of goods movement at the three major ports is by container. At points of origin, goods are loaded into standard sized containers of either 20 foot, 40 foot, or 40+ foot lengths and transported by ship, train or truck (Photograph I-2). After the containers are emptied, they are then either reloaded or transported empty to the next destination. When discussing container traffic and volume, containers are also referred to as TEU units. A ‘TEU’ is shorthand for a ‘twenty-foot equivalent unit’. Thus, a 40 foot container would be the equivalent of two TEUs.

Photograph I-2: Intermodal Container Movement

Photo source: http://www.polb.com/images/PhotoGallery/PortTour/index.htm

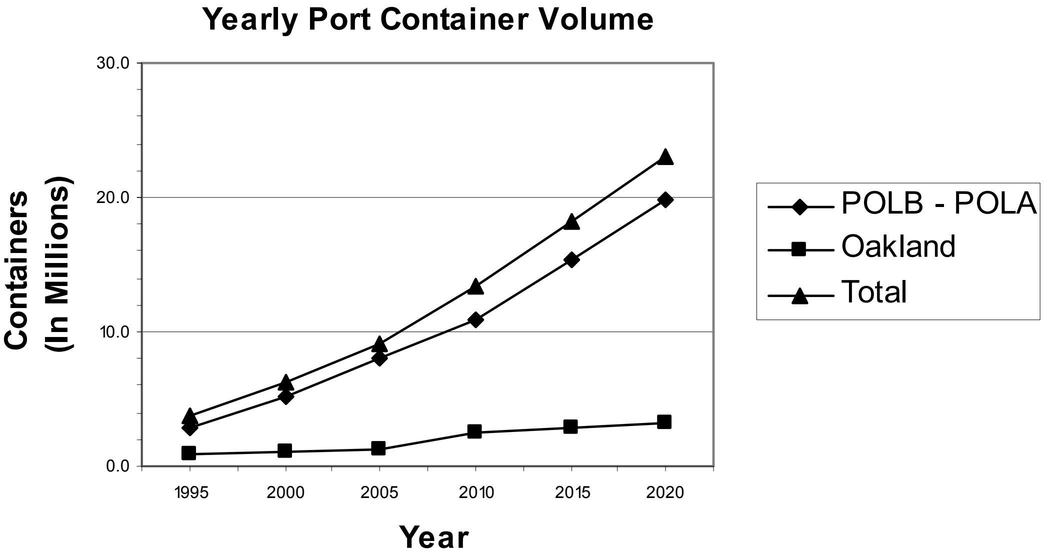
Containers may be transported by trains and on-road vehicles. Trains are used for both container and bulk transport and are typically used for long distance deliveries from ports in California to Chicago. Train yards (where containers are off-loaded from trailer chassis and loaded on rail cars) may be located on a port terminal or at a common yard within or next to a port. The train yards servicing the ports of Long Beach and Los Angeles are located both on and off port property, while the Port of Oakland's train yards are located just outside the port. When train yards are located within port boundaries, off-road vehicles such as yard hostlers may transport containers directly from ship to train without the use of on-road trucks. When containers must be transported to train yards located off port property via public roads, they are typically staged on port property and transferred via on-road truck to the train yard. Currently, trains transport 25 percent of the total container traffic directly from the ports of Long Beach and Los Angeles.

Containers bound for destinations, such as local distribution facilities, off-port train yards and neighboring cities and states, are typically transported by on-road heavy-duty diesel trucks. Destinations include local businesses, distribution facilities, and rail facilities. On average, trucks that make local deliveries are able to deliver about two containers per day from the port. When used efficiently, these same trucks will deliver out-bound containers on their trip to the port. As each trip includes driving to and from the port, a truck may pass particular points (such as communities located near ports) four times per day. Additionally, various communities may be disproportionately affected due to the limited availability of accessible trucks routes.

D. Container Growth / Operation Characteristics

When discussing annual port container throughput volumes, the industry wide standard is to express such volumes in TEUs. Converting TEUs into actual containers can be approximated by multiplying TEUs by 0.55.[5] Thus, 100 TEUs are, on average, transported in 55 containers. The remainder of this report will now express port goods movement volume in 'containers'. The volume of containers imported into California is illustrated in Figure I-1. Between 1995 and 2000, a steady increase in container volume was recorded. The total number of containers for the three major ports (Los Angeles, Long Beach, and Oakland combined) increased by ~2.5 million. The ports estimated volumes increased another 3 million containers between 2000 and 2005 to a total of 9.2 million containers by the end of 2005. The actual container volume in 2004 was 7.2 million at Los Angeles/Long Beach and 1.1 million at Oakland, for a total of 8.3 million. Container volumes for the period of 2005-2010 are projected to continue to increase at a strong pace, increasing approximately 4.2 million to 13.4 million (a 45 percent increase). From 2005 to 2020, container volume is projected to increase to approximately 13.9 million containers — a 152 percent increase in the 15-year period. If the projections prove to be accurate, combined container volumes for the three California ports between 1995 and 2020 would increase by more than 19.3 million.[6]

Figure I-1: Actual (1995 – 2004) and Estimated (2005 and later) Yearly Port Container Volume



As mentioned earlier, containers are typically transported by truck or train after being off-loaded from a ship. The method of transportation depends on variables such as the distance to the end destination and the availability of infrastructure (such as train yards). The Port of Oakland moves 100 percent of the containers from the terminals by heavy-duty diesel truck. The containers are delivered to local destinations such as on-port (but not on-terminal) train yards or local distribution centers. The Ports of Long Beach and

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[5] See Appendix A, Table 2.

[6] Business, Transportation and Housing Agency and California Environmental Protection Agency' "Goods Movement Action Plan – Phase I`: Foundations", May 2005 - TEUs converted to 'containers' by using a multiplication factor of .55.

Los Angeles also have train yards located within port property and within individual terminals. Hence, a large percentage of containers destined for train transportation are moved directly from the ship to the train by yard hostlers. Hostler-to-train container movement accounts for roughly 25 percent of the ports' container volume. The remaining 75 percent of the containers are transported off the port property by on-road heavy-duty trucks. With the advent of extended port hours in 2005, 70 percent of trucked containers are now moved during normal hours (7am – 5pm) Monday through Friday. The remaining 30 percent[7] of the containers are picked up on weekends or after 5pm.

E. Port Truck Population and Age Distribution

1. Population of Trucks in Routine Port Service

Precise port truck population data were not available as we prepared this report. As a result, ARB staff utilized an indirect method (detailed below) to estimate the population of the port truck fleet.

ARB staff utilized Caltrans traffic data to estimate port truck population for the ports of Long Beach, Los Angeles, and Oakland. A port truck population estimated at 12,000 was derived using truck population data from the Caltrans publication "Annual Average Daily Traffic Count on the California State Highway System." The publication details actual counts of specific types of vehicles using California's roadways. ARB staff used Caltrans traffic volume data for the major arteries servicing the ports of Long Beach, Los Angeles and Oakland (Freeways 710, 110 and 880).

Ports of Long Beach and Los Angeles

- Freeway 710: ARB staff used daily traffic value of 28,550 trips **(~14,000 each direction**) for class 8-14 trucks, at post mile 011.264 from Caltrans Highway Log.
- Freeway 110: ARB staff used daily traffic value of 12,500 trips **(~6,000 each direction**) for class 8-14 trucks, at post mile 09.87 from Caltrans Highway log.

ARB staff then added the two freeway counts together to obtain an estimated total volume of 20,000 trips per day. Assuming 2 round trips per day for an average port truck (which equates to 3-4 containers per day based on conversation with port officials), approximately 10,000 port trucks[8] operate at POLA and POLB per day.

Port of Oakland

- Freeway 880: ARB staff used daily traffic value of 14,300 trips **(~7,000 each direction**) for class 8-14 trucks, at post mile 31.091 from Caltrans Highway Log.

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[7] Port of Long Beach Green Port Program – Quarterly Report #3", December 13, 2005. PierPass, a monetary incentive program initiated in July of 2005 by the ports to promote after hours goods movement, has currently increased off-peak activity from 20 percent to 30 percent of all gate moves.

[8] 20,000 trips per day/2 trips per day per truck = 10,000 trucks per day

Freeway 880 services more than just the Port of Oakland. Therefore, staff subtracted trips generated from nearby freeways in an attempt to ferret out non-port traffic. Subtracting the 3,896 trips[9] from nearby freeways from the 14,300 trips from freeway 880, and, assuming port trucks generated 80 percent of the remaining trips (conversation with CalTrans officials), yield a result of 4,000 trips each direction from port trucks.[10]

Assuming an average port truck makes 3 trips per day (conversation with Port of Oakland officials), a total of 1,333 port trucks operate at the Port of Oakland each day using the freeway. Additionally, according to port officials, approximately 35 percent of the Port of Oakland truck fleet does not use the freeway. Combining the off and on freeway truck fleet yields a population of approximately 2,000[11] port trucks servicing the Port of Oakland.

Thus, a 2005 population of 12,000 trucks (10,000 for POLA and POLB + ~2,000 for Oakland) was derived.

In section IV of this report, staff will develop three strategies for modernizing the port truck fleet. The strategies require staff to estimate future port truck populations and age distributions until the year 2020. To estimate future populations and age distributions, staff must first factor in fleet growth. Lacking data on future growth, staff utilized estimated port container volume growth as a guide. Accurate data detailing fleet growth does not exist. Figure I-2 shows estimated total growth at the ports of Long Beach, Los Angeles, and Oakland from 13.3 million containers in 2010 to more than 23.1 million containers in 2020.

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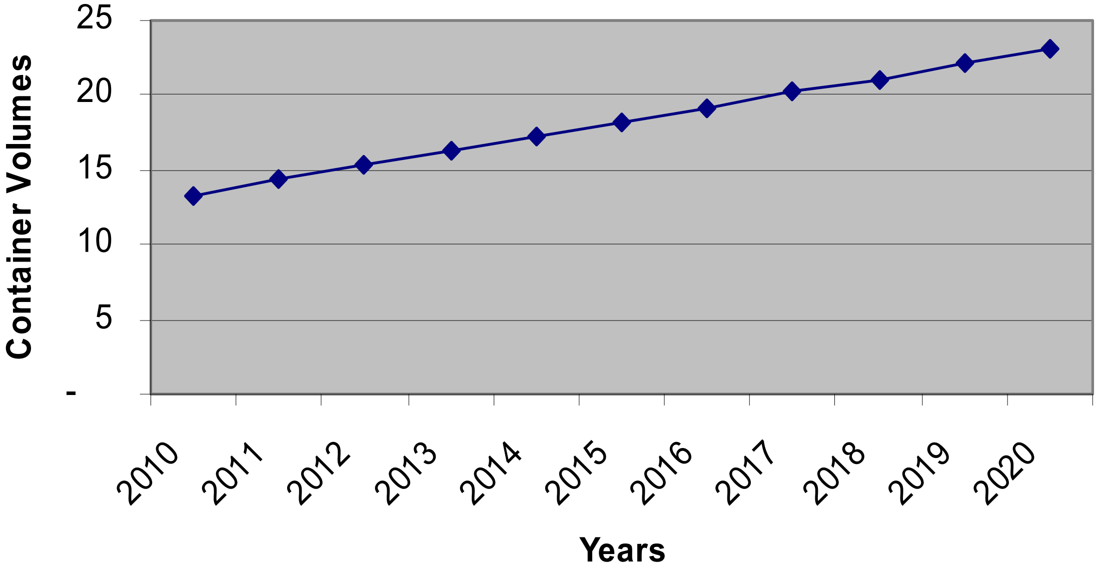
[9] 1,490 trips from I-80 and 2,406 trips from freeway 980

[10] Port trips: (14,300 – 3,896) * 0.8 = 8,323 (approximately 4,000 trips each direction)

[11] Oakland truck fleet: 1,333 trucks / .65 = 2,050 trucks (approximately 2,000 trucks)

Figure I-2: Estimated Growth at the Ports of Long Beach, Los Angeles, and Oakland from 2010 to 2020



Factoring in continuing port congestion and the likelihood that ports will significantly increase after-hours and weekend container throughput, staff anticipates existing port trucks will also service the ports after hours and transport a net increase of containers per truck per day. Staff also assumes that existing trucks will not be able to transport all future container volume increases without an increase in the port fleet. Again, because fleet growth data does not exist, staff has assumed half of the future container volume increases will be transported by new port trucks and half will be transported through greater efficiency by existing port trucks. Staff started with the estimated 2005 port truck population of 12,000 trucks and grew the fleet annually by assuming half the container volume increase will directly result in a proportional increase in port population. Staff assumed a five percent fleet growth rate with a resultant annual population increase of 600 port trucks. Table I-1 details the resulting estimated future port truck population of 15,000 trucks in 2010 to greater than 20,000 trucks in 2020.

Table I-1: Estimated Port Truck Population from 2005 to 2020

Year	**2005**	**2010**	**2015**	**2020**
Population	12,000	15,000	18,000	21,000

2. Age Distribution

The largest concentration of port trucks operates at the ports of Long Beach and Los Angeles in the South Coast Air Basin. The most common vehicle configuration is that of a tractor and trailer totaling five axles. A characteristic of many port trucks is that the trucks are configured with sleeper cabs. Sleeper cabs are generally not required for driver resting because container movement to and from ports is mostly local. The predominance of sleeper equipped trucks likely reflects the more wide spread availability of used high mileage long-haul vehicles on the used truck market. In 2002, the Starcrest Consulting Group, with assistance from the South Coast Air Quality Management District (SCAQMD) and ARB, initiated a study to provide data on the characteristics of the port truck fleet. The study recorded license plate numbers of trucks that entered three terminals at the ports of Long Beach and Los Angeles during 2002. The license numbers were then cross referenced with data supplied by the California Department of Motor Vehicles (DMV) to determine the age of the vehicles. The resulting age distribution is shown in the following table (See Table I-2 - Starcrest Consulting Group Survey of Truck Population and Corresponding DMV Age Distribution).

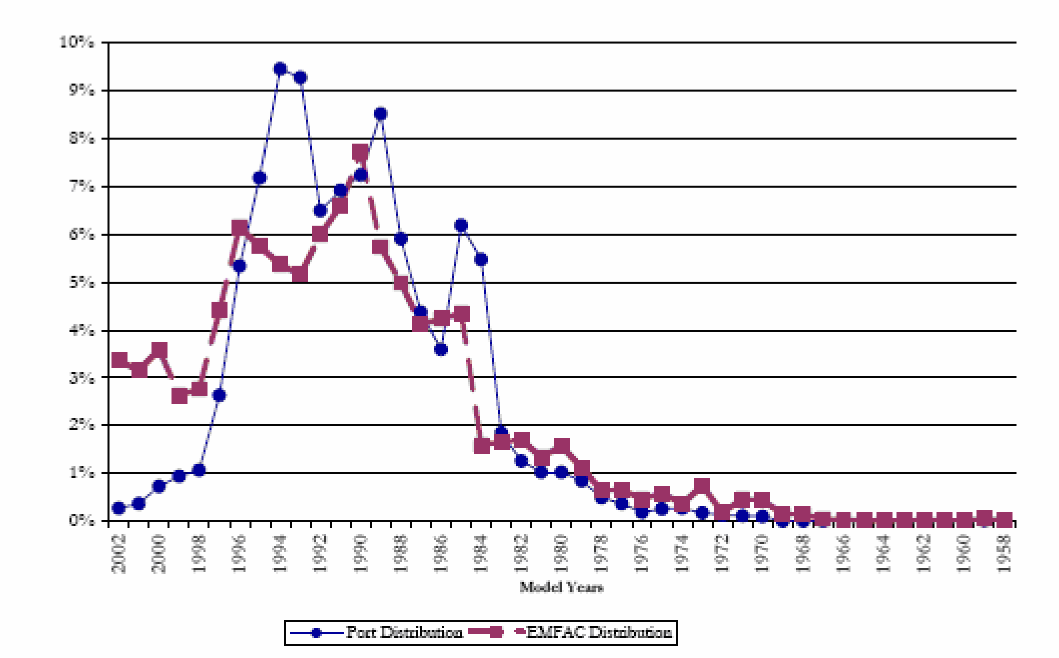
Table I-2: 2002 Starcrest Consulting Group Survey of Truck Population and Corresponding DMV Age Distribution

Model Year	Number of Trucks	Percent of Population	Weighted Average Age
1994-2002	2,001	28	1996
1988-1993	3,175	44	1991
1983-1987	1,537	22	1985
1970-1982	443	6	1979
Total	**7,156**	**100**	

The sampled population is 7,156 trucks and reflects only the three terminals within POLA and POLB that took part in the survey. Given that the survey size of 7,156 port trucks is approximately 70 percent of the entire fleet of 10,000, staff assumes the survey age distribution is representative of the port truck fleet as a whole.

According to the analysis performed by Starcrest, the average age of the port specific truck fleet is 12.9 years as opposed to 12.2 years for the average age of ARB's Emission Factors Model (EMFAC) California fleet values. Thus, port trucks are approximately 0.7 years (~8 months) older than trucks in the overall California fleet (See Figure I-3) next page. However, unlike the general HHDV truck fleet, where newer trucks accrue more miles per year than older trucks, ARB staff believes that trucks in port service likely drive similar amounts, regardless of age. This results in a much higher average emission factor for this fleet than an age only comparison would suggest. This effect is factored into the staff's assessment by not factoring for miles traveled based on age distribution.

Figure I-3: Port Truck Heavy-Duty Model Year Distributions[12]



The Starcrest analysis shows that approximately 28 percent of the trucks represented in the survey were at least 16 years old (model year 1987 or older) and are powered by older, higher PM and NOx emitting engines. Additionally, the survey also revealed that only 28 percent of the fleet, as it existed in 2002, could be successfully retrofitted with a highly effective diesel particulate filter (truck model year 1994 and newer).

From the analysis of the Starcrest data, the port truck age profile appears to reflect older vehicles with higher mileages. Most long-haul trucks are initially purchased and operated for 500,000 – 750,000 thousand miles (5 - 7 years of use), after which the trucks are sold. These used vehicles are then typically used in operations other than long haul (where newer more reliable trucks are a common practice), such as for movement of containers at ports.

Using the port trucks specific fleet average age developed by Starcrest, the ARB staff predicted a population and age distribution for the port fleet for 2005 (see Table I-3).

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[12] Starcrest Consulting Group LLC., “Port-Wide Baseline Air Emissions Inventory”, June 2004

Table I-3: ARB Predicted 2005 Port fleet Population and Age Distribution

Model Year	Number of Trucks	Percent
2003-2006	120	1
1994-2002	5880	49
1988-1993	4320	36
1983-1987	1320	11
pre-1982	360	3
Total	**12,000**	**100**

F. Driver Economic Profile

In July 1980, Congress passed the Motor Carrier Act of 1980 (1980 MCA). The 1980 MCA substantially reduced the Interstate Commerce Commission regulation of the trucking industry by permitting any carrier to establish and publish its own shipping rates[13]. The passage of the 1980 MCA resulted in a substantial increase in the number of trucking firms and produced price competition between individual truck drivers and shipping lines. This background of events reflects the current relationship between container movement and the independent truck driver.

Under the current port/port truck dynamic, individual truck owners/operators cannot individually solicit business from a terminal. Port truck owners must work through dispatching companies that negotiate and provide trucks to port terminals. Truck dispatch companies then in turn contract with individual port terminals to provide trucking services. Competition between dispatching companies to supply trucks to terminals is very high and contract specifics are confidential. The contract between terminal operators and the dispatcher's typically dictate a fixed price for each transported container. Prices will vary, in part, on the distance the container must be moved. The resulting competitive bidding between dispatching companies supplying port trucks typically results in low compensation for truck drivers. Although pay scales are confidential, conversations with port officials indicate an average pay rate of approximately $100 - $125 per local container move. Containers that are transported over longer distances (e.g. out-of-state) or shorter distances (e.g. nearby intermodal train facility) have pay scales adjusted accordingly. An indication of the marginal profits arose in May 2004 when 300 port truck drivers in Oakland went on strike because of diminishing profit returns in relation to rising fuel prices. The strike was subsequently settled by agreeing to a rate increase for the truck drivers.[14]

In 2003, the South Coast Air Quality Management District and the ports of Long Beach and Los Angeles initiated a fleet modernization program called Gateway Cities. A

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[13] History of Trucking Regulation at LawDog©, "Partial Deregulation", 1996-2000. http://www.lawdog.com/transport/tp1.htm

[14] International Longshore and Warehouse Union, "High costs, low pay spark port truckers action", July 2004. http://ilwu.nisgroup.com/dispatcher/2004/05/truckers-action.cfm

private company, TIAX, was contracted to administer the fleet modernization program. Although the program funds the replacement of any heavy-duty diesel-powered truck that operates within the geographical area of the ports, a number of port truck owners also took advantage of the replacement option within the program. The Gateway Cities program replaced approximately 180 port trucks with newer models. In the process of administering this voluntary program, TIAX collected data regarding port truck driver economics. TIAX representatives estimate that gross yearly earnings for truck operators are approximately $40,000 - $80,000 per year. These are gross earnings which must cover operational and maintenance truck related costs such as insurance, loan payments, taxes, fuel, and maintenance.

Conversations with a Port of Oakland truck dispatcher and ARB staff analysis indicate an average port truck driver can generate about $60,000 gross income while logging some 40,000 miles. Subtracting out annual costs of fuel ($17,000), maintenance ($2,200), and mandated fees ($11,000), an average port truck driver nets $30,000 in pre-tax income.

Additionally, TIAX concluded port truck operators are able to incur only a finite amount of additional debt. To encourage port truck operators to participate in the Gateway Cities voluntary truck replacement program, TIAX structured the program so that truck operators would incur a maximum loan amount (of $5,000 - $10,000) with a maximum monthly payment of $400 - $600. Loan amounts above $15,000 or monthly payments above $600 attracted very few truck operators into the program. Typically, the replacement program would combine a loan to the operator with roughly $25,000 in grant money to cover costs.

G. Estimated Emissions from Port Trucks

ARB staff estimates emissions from trucks operating at, and resulting regional travel from, the Ports of Oakland, Los Angeles and Long Beach to be 564 TPY PM and 7,075 TPY NOx[15]. California's two largest ports, Los Angeles and Long Beach, account for the vast majority of generated emissions at ~490 TPY PM and ~6,000 TPY NOx.

There are four components of port truck emissions: emissions associated with terminal travel; terminal idling; port road travel; and regional on-road travel. Terminal travel is defined as travel from a terminal gate to a container storage area. Terminal idling is idling at the terminal gate as well as idling at the container storage area. Port road travel is defined as travel outside of an individual terminal but still within the ports boundaries. Regional on-road travel is defined as travel from the edge of the port property to the truck's first localized destination. Such destinations include delivery to customers and transloading facilities (warehouses) located throughout the area.

The calculation of emissions from trucks is not a simple process. Estimating emissions requires knowledge detailing population, engine characteristics, travel activity, and

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[15] Emission data obtained from PTSD, calculation methodology discussed in detail in the emission section of this report.

emission factors by type of truck. Engine characteristics include engine model year, manufacturer, and emission reduction technologies. Travel activity includes not just an assessment of the number of trucks and the distance each truck travels in an area, but also the distribution of speeds at which trucks travel and the number of miles the average truck travels per year. At the time of this draft report, the emission inventory numbers are undergoing further review and may result in additional changes.

Staff calculated baseline port truck emissions for 2005 using composite emission rates at 500,000 miles and vehicle miles traveled (VMT). Port truck VMT was estimated using a container balancing method. The method was based upon the number of inbound and outbound loaded containers, as well as outbound empty containers. Staff assumed that the number of containers would be proportional to the flow of ship-transported containers and would be consistent with the number of containers being moved by trucks and trains. A detailed discussion on emission calculation methodologies is provided in Appendix A.

The summary of the estimated emissions for the ports of Long Beach, Los Angeles and Oakland are presented in Table I-4.

Table I-4: Estimated 2005 Port Truck Emissions for the Ports of Los Angeles, Long Beach and Oakland

PORT	**PM** (TPY)	**NOx** (TPY)
Port of Long Beach (POLB) Port of Los Angeles (POLA) (including regional on-road)	491	6,048
Port of Oakland (including regional on-road)	73	1,027
Total	**564**	**7,075**

II. Health Risk Assessment for Heavy-Duty Diesel Vehicles

This section examines the potential cancer health risks associated with exposure to diesel PM emissions from heavy-duty diesel vehicles operating near ports. ARB staff based this risk assessment on an area along a typical 4,000 meter stretch of the 710 freeway. The 710 freeway serves as the main thoroughfare used by port trucks when traveling to and from the ports of Long Beach and Los Angeles. The freeway, which has many adjacent residential areas, provides an example of congestion and very heavy truck traffic, and the accompanying potential health risks to adjacent communities.

Risk assessment is a complex process that requires the analysis of many variables to simulate real-world situations. There are several key variables that can impact the results of a health risk assessment for the diesel truck engine operations: 1) the amount of diesel PM emissions emitted from the diesel truck engine operations, 2) the meteorological conditions that affect the dispersion of diesel PM in the air, 3) the inhalation rate of the receptor, 4) the distance between the receptor and the emission source, 5) the emission source configuration (e.g.., number of lanes, lane width, highway width, etc.) ,and 6) the duration of exposure to the diesel PM emissions.

For the first key variable, ARB staff modeled the amount of diesel PM emissions as a function of the total diesel truck traffic, speed, and emissions per mile traveled. Meteorological conditions, the second key variable, can have a large impact on the resultant ambient concentrations of diesel PM, with higher concentrations found along the predominant wind direction and under calm wind conditions. The meteorological conditions and proximity of the receptor to the source(s) of emissions affect the concentration of the diesel PM in the air where the receptor is located. ARB staff utilized Long Beach meteorological data with urban dispersion coefficients. In addition, the exposure duration and inhalation rates are key factors in determining potential risk, with longer exposure times and higher inhalation rates typically resulting in higher estimated risk levels. For this analysis, staff assumed an adult 70 year exposure duration and inhalation rate of 302 liters/Kg-day, as recommended for estimating health impacts in the current OEHHA guidelines [OEHHA, 2003[1]].

The fourth variable, distance between the receptor and the emission source, staff utilized data provided by Caltrans. The data included specific measurements for the 710 freeway, post mile 11.5 (North of Del Amo Boulevard), as well as truck count by hour (Figure II-1). The data also included highway configuration data such as, the inside shoulder width, outside shoulder width, number of lanes, median width, and the width of the 710 freeway. Additionally, the truck speed, lane usage, and traveling time per lane at 60 percent, 30 percent and 10 percent for lanes 1, 2, and 3, respectively

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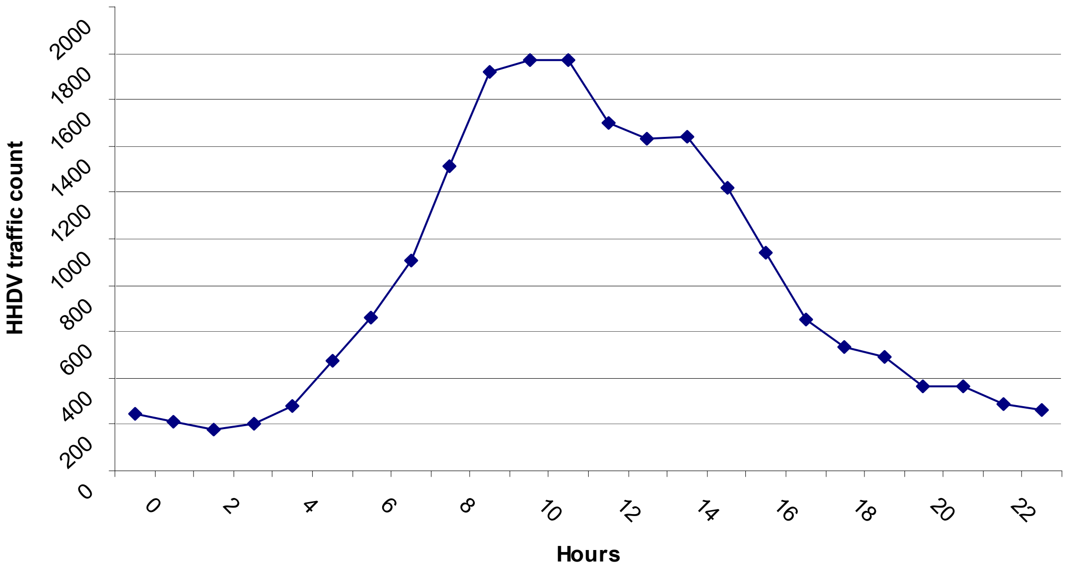
[1] Office of Environmental Health Hazard Assessment (OEHHA, August 2003. The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments. www.oehha.ca.gov/air/hot_spots/GRSguide.html

(Figure II-2). Staff made the assumption that there is no HHDV traffic on lane 4 north bound as it is the fast traffic lane. Lanes 4 (south bound) and 5 (north bound) are the car pool/bus lanes, respectively.

Figure II-1: HHDV Counts vs. Diurnal Variation for the 710 Freeway[2]



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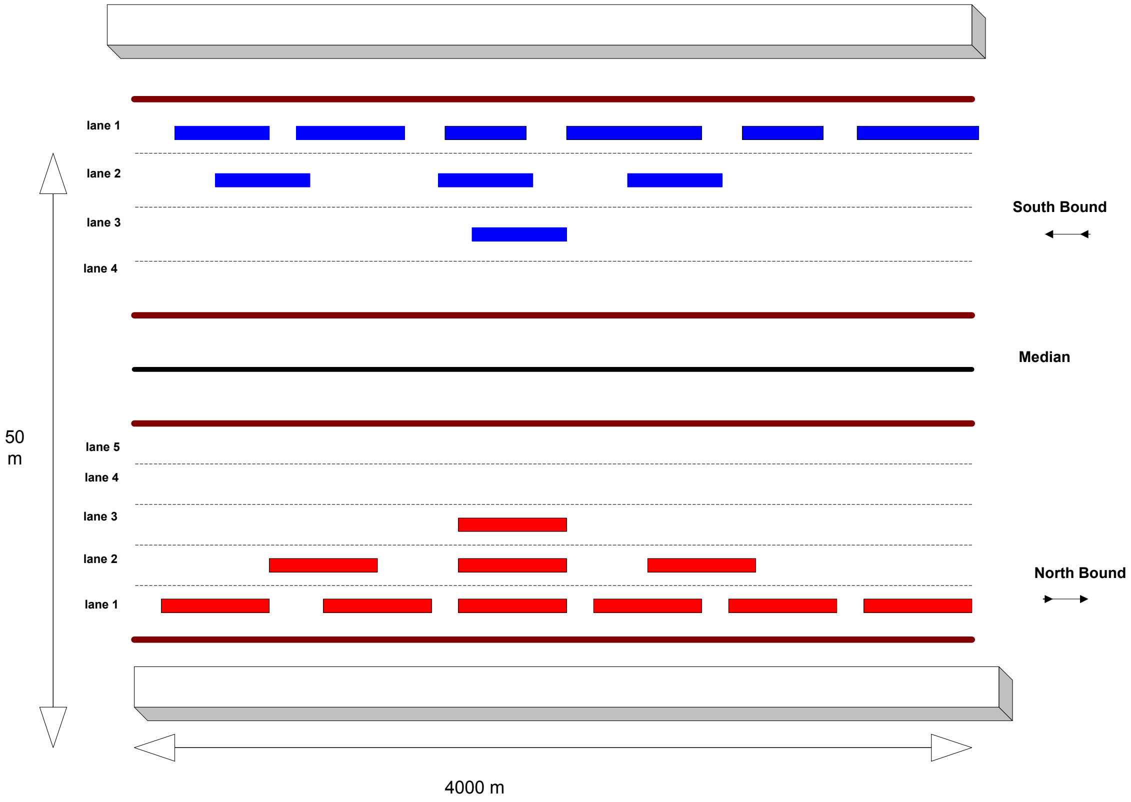
[2] Caltrans Traffic Volume Report: detail vehicle classification hourly count - July 2005.

Figure II-2: Arbitrary Segment of 710, Post Mile 11.5, North of Del Amo Boulevard



The risk estimates show the relative magnitude of potential cancer risk based on total truck traffic. These results can be used to give a general indication of the potential risk at other locations with similar truck volumes, however, a site-specific analysis would be needed to better represent the cancer risk at a specific location.

For heavy-duty diesel-fueled vehicles operating near the ports, the receptors that are likely to be exposed include residents located near the port or the main traffic route into and out of the port. Exposure was evaluated for diesel PM via the breath or inhalation pathway only. The magnitude of exposure was assessed through the following process. Emission rates were developed using emission parameters determined from site visits, from Starcrest's port truck population distribution survey, and ARB's EMFAC emission's model. During the site visits, other information such as physical dimensions of the source, operation schedules, and receptor locations were obtained. Computer air dispersion modeling (CAL3QHCR) was used to provide downwind ground-level concentrations of the diesel PM at near-source locations.

Meteorological data is Long Beach with urban dispersion coefficients was selected to evaluate meteorological conditions with lower wind speeds, which result in less pollutant dispersion and higher estimated ambient concentrations.

Figure II-3 shows the potential cancer risks to nearby receptors between 25 to 6,400 meters from the center of the source of emissions. The two curves represent risks from the west side and the east side of the freeway. The west side shows a slight reduction in risk compared to the east side due to eastwardly wind conditions.

Figure II-3: Potential Cancer Health Impacts[3]

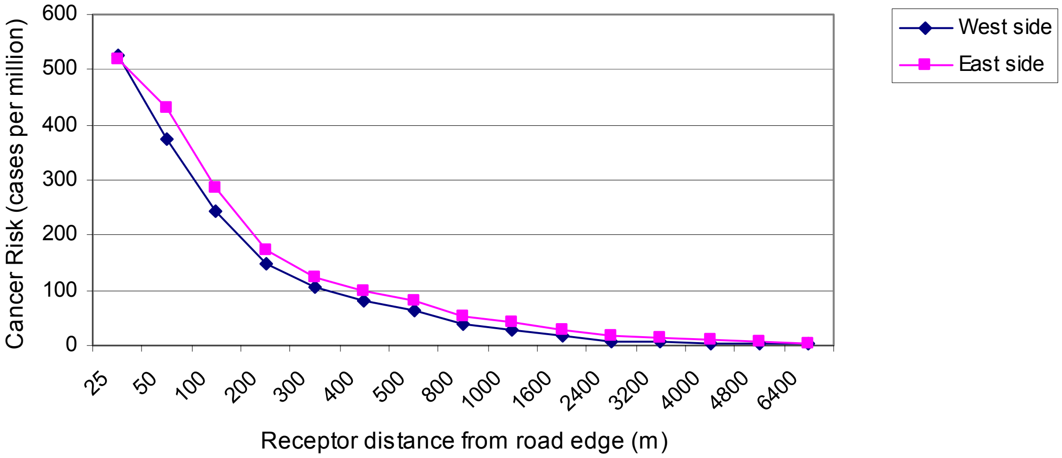


Figure II-3 assumptions:

- The total width of I-710 freeway is 50 meters, and an arbitrary segment length of 4000 meters is considered.
- Each direction has three lanes (most outside lanes) for HDDV traveling. In reality there are five lanes in North bound and 4 lanes in South bound.

Figure II-4, on the next page, shows an aerial view of the immediate area surrounding the Port of Long Beach. The coordinates of the emission source were plotted and superimposed on a GIS map. This map shows neighborhoods that may be affected by port truck traffic. The potential cancer health impacts for diesel truck operations based on the distance from freeway 710 are also shown.

Staff used the census track[4] data to get an estimation of the population distribution along the 710 freeway, extending from the Port of Long Beach to California highway 60. The population distribution at distances of 100, 300 and 1000 meters on either side of the 710 freeway (in the 20 miles from the ports where it intersects highway 60), was estimated at 35,000, 140,000, and 469,000, respectively (see Figures II-4 and II-5).

Figure II-5 is an enlarged image of the boxed section shown in Figure II-4. This image provides a view of the housing distribution around the freeway.

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[3] Emission factors calculated based on recently available data for trucks

[4] U.S. Geographical Census 2000. http://censtats.census.gov/

Figure II-4: Aerial Photo of Port of Long Beach – GIS Map

GIS map procured from:
http://terraserver.homeadvisor.msn.com/image.aspx?T=4&S=14&Z=11&X=121&Y=1168&W=1

Figure II-5: Enlarged View of a Segment of the 710 Freeway near the Port of Long Beach Showing the Housing Distribution

The estimated potential cancer risk is based on a number of assumptions (detailed in the previous discussion); actual risks to individuals may be less than or greater than those presented here. For example, increasing the truck traffic would increase the potential risk levels. Decreasing the exposure duration or increasing the distance from the source to the receptor location would decrease the potential risk levels. The estimated risk levels will also decrease over time as lower-emitting diesel engines become more common within the fleet and this has not been included in the assessment of lifetime risk.

Diesel PM is not only a lung cancer hazard but also contributes to many other serious health effects such as heart attacks, pulmonary inflammation, and asthma. Other chronic effects include respiratory symptoms such as bronchitis, decreased lung function, and neurotoxic effects. Because of their small size, the diesel PM particles can be inhaled easily and effectively reach the inner sections of the lungs along with compounds on the surface of PM[5]. The increasing on-road diesel truck traffic from expanding port cargo handling volumes is a concern due to its effect on community exposure and ambient air quality. Recent evidence attributes a greater portion of premature deaths to cardiovascular disease[6], especially when the established ambient air quality standards have been exceeded.

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[5] Scientific Review Panel (SRP): Report to the Air Resources Board on the Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant. Part A: Exposure Assessment, As approved by the SRP on April 22, 1998.

[6] Brook et al. (2004). Brook RD, Franklin B, Cascio W, Hong Y, Howard G, Lipsett M, *et al*. (2004). Air pollution and cardiovascular disease: a statement for healthcare professionals from the Expert Panel on Population and Prevention Science of the American Heart Association. Circulation 109(21):2655-2671.

III. Strategies to Reduce Emissions

In this section, ARB staff reviews the diesel PM and NOx reduction approaches currently available and projected to be available in the near future for diesel-fueled on-road engines. Retrofit control technologies along with additional strategies, such as engine replacement or repower, have the potential to significantly reduce emissions from port trucks and are integral to any port truck modernization strategy.

A. Verification of Diesel Emission Control Strategies

In order to thoroughly evaluate the emissions reduction capabilities and durability of emission reduction technologies, ARB has developed the Diesel Emission Control Strategy Verification[1] Procedure (Procedure). The purpose of the Procedure is to lay out the requirements for verifying strategies that provide reductions in diesel PM and NOx emissions. There are currently three verification levels for emission reduction technologies: Level 1 achieves a minimum emission reduction of 25 percent, level 2 achieves a minimum of 50 percent, and level 3 achieves a minimum of 85 percent. All technologies must be verified for one of these levels.

A complete and up-to-date list of verified technologies and the engine families, for which they have been verified, along with letters of verification, warranty, and coverage information may be found on our web site at:
http://www.arb.ca.gov/diesel/verdev/verdev.htm[2]

B. Hardware Diesel Emission Control Strategies

1. Diesel Particulate Filter (DPF)

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 diesel PM emissions and achieve typical diesel PM reductions in excess of 90 percent. Most DPFs employ some means to periodically regenerate the filter (burn off the accumulated PM). A particulate filter can either be regenerated passively or actively.

a. Passive Diesel Particulate Filter[3]

A passive catalyzed DPF reduces diesel 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

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[1] ARB 2003. California Air Resources Board rulemaking on the Adoption of 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.

[2] http://www.arb.ca.gov/diesel/verdev/verdev.htm

[3] Manufacturers of Emission Controls Association: Briefing on Recent Emission Control Technology Development, May 2004.

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 diesel PM ignition temperature through the use of a catalyst. The type of filter technology that uses a catalyst to lower the diesel 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 diesel 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.

The successful application of a passive DPF is primarily determined by the average exhaust temperature at the filter's inlet and the rate of diesel 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 diesel PM emission levels in-use. Testing done by West Virginia University (ASME 2000-01-2818), for example, shows that a given diesel truck can generate a wide range of diesel PM emission levels depending on the test cycle. Engine maintenance is another factor in determining the actual diesel 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)[4].

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. Vehicle-specific characteristics enter the heat loss equation, such as the length of piping the 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.

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[4] ARB 1999 California Air Resources Board Informational Package for the Heavy-Duty Vehicle Inspection Program, Periodic Smoke Inspection Program. Mobile Source Operations Division, Mobile Source Enforcement Branch.

Passive DPF can only be used on trucks with engines meeting 0.1 g/bhp-hr PM emissions standards and using diesel fuel with less than 15 parts per million by weight sulfur content. ARB staff expects that all 1994 MY and newer ports trucks could be successfully equipped with passive DPFs.

Passive DPFs have been successfully used in numerous applications and, as of 2005, over 130,000 trucks and buses had been retrofitted worldwide (Manufacturers of Emission Controls Association [MECA] 2005). In the United States, the use of DPFs is growing largely due to DPF retrofit programs underway in California, New York, and Texas. In California, diesel-fueled school buses, solid waste collection vehicles, urban transit buses, medium-duty delivery vehicles, and fuel tanker trucks have been retrofitted with DPFs.

b. Active Diesel Particulate Filter

An active DPF system uses an external source of heat to oxidize the accumulated PM trapped in the filter. The most common methods of generating additional heat for oxidation involve passing a current through the filter medium, injecting fuel, or adding a fuel-borne catalyst or other reagent. Some active DPFs induce regeneration automatically 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. Still other active systems collect and store diesel PM during engine operation and are regenerated at the end of the shift when the vehicle or equipment is shut off. Some filters may also be removed and regenerated externally at a regeneration station.

For applications in which engine diesel PM emissions are relatively high, and the exhaust temperature is relatively cool, actively regenerated systems may be more effective than passive systems because active DPFs[5] are not dependent on the heat carried in the exhaust for regeneration.

ARB staff verified electrically regenerated active DPFs in December 2005. Currently, active DPFs have been successfully used in school bus and refuse hauler applications. This technology may be less attractive than passive DPF technology for port truck owners due to the additional cost of installing electrical regeneration infrastructure.

2. Diesel Oxidation Catalyst

A diesel oxidation catalyst (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

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[5] ARB 2003 California Air Resources Board Staff Report Proposed Control Measure for Diesel Particulate Matter from On-road Heavy-Duty Diesel-Fueled Residential and Commercial Solid Waste Collection Vehicle Diesel Engines.

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 diesel PM emissions up to 30 percent (level 1 emissions control).

This technology is commercially available and devices have been installed on tens of thousands of mobile diesel fueled engines. As a result of the U.S. EPA's Urban Bus Retrofit/Rebuild program, several DOC 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. In general, DOCs functioned well on all of these vehicles. In port truck applications, a DOC installation will provide only a 30 percent diesel PM emissions reduction versus a 90 percent reduction for an installed DPF.

3. Flow-Through Filter

Flow-through filter technology (FTF) 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 diesel 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 diesel 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 in the device. 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 engine emissions and low exhaust temperatures. Therefore, the FTF is a candidate for use in some applications unsuitable for DPFs. It is expected that an FTF will achieve between 30 and 60 percent PM reduction.

Relative to a diesel oxidation catalyst (DOC), which typically has straight flow passages and laminar flow conditions, the FTF achieves a greater diesel PM reduction because of enhanced contact of the PM with the 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.

Since FTFs are verified as level 2 devices they would not provide maximum PM reduction efficiency for the port truck fleet compared to the efficiency of a level 3 verified DPF.

C. Fuel Additives as Diesel Emission Control Strategies

1. Fuel-Borne Catalyst

Fuel additives are designed to reduce exhaust emissions by being added to fuel or fuel systems so it is present in the cylinder during combustion. Additives can reduce the total mass of exhaust PM, with variable effects on CO, NO_x and gaseous HC production. Particulate matter emission reductions range from 10 percent to 33 percent (not CARB verified), but could be as high as 95 percent when used in conjunction with a DPF. Most additives are fairly insensitive to fuel sulfur content and will work with a range of sulfur concentrations as well as with different fuels and other fuel additives.

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). Fuel born catalysts 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 widely used in Europe and typically achieve a minimum 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.

There is a recurrent cost associated with FBC usage; approximately 1 gallon of FBC is required per 1,500 gallons of diesel fuel consumed by the engine. ARB staff has determined that FBC costs could be in the range of $90 to $105 per gallon or approximately $0.05 to $0.07 per gallon of diesel fuel (Clean Diesel Technology, 2005).

D. Technology Combinations

A trend in technologies is to combine more than one technology to maximize the amount of diesel PM reduction and achieve additional NOx reduction. This section discusses some of these combinations.

1. Diesel Particulate Filter with NOx Catalyst[1,2]

The Clēaire Longview system for specific 1994 to 2003 year diesel engines combines a catalyzed DPF and a NOx reducing catalyst to achieve 85 percent PM reduction, and 25 percent NOx reduction, respectively. The system is verified to Level 3 for PM reduction and Level 1 for NOx reduction.

This system would provide additional NOx reduction from port trucks without using engines with EGR systems (2.5g/bhp-hr standard). The drawbacks are the high costs of the system (see Table 6) and limited useful life of 4 to 5 years compared to the lifespan of approximately 20 years of an EGR equipped newer engine.

2. Fuel-Borne Catalyst with DPF Hardware Technology[6]

A fuel-borne catalyst can be combined with any of the three hardware technologies discussed above, the DPF, DOC, or FTF. 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, and lowers the regeneration temperature of the filter to 300 – 350 degrees Celsius. The FBC plus DPF combination reduces both the carbonaceous

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[6] Diesel Net Report

and soluble organic fractions of diesel PM. The primary benefit of this combination is a reduction of up to 95 percent in diesel PM emissions.

This technology is not currently verified for use in on-road engine applications.

3. Summary of HHDV Diesel Emissions Control Technologies

A comparative analysis of the control technologies discussed above is summarized in Table III-1.

Table III-1: Comparative Analysis of HDV Diesel Emissions Control Technologies

DIESEL EMISSIONS CONTROL TECHNOLOGY	ESTIMATED 2005 EQUIPMENT COSTS	INSTALLATION COSTS	EMISSIONS CONTROL EFFICIENCY	CARB VERIFICATION
Passive DPF	$7,900	$600	85% PM or Greater	Level 3 Verified
Active DPF	$14,000	Regeneration Infrastructure $3,000 - $5,000	85% PM or Greater	Level 3 Verified
DPF with NOx Catalyst	$19,000-$21,000	Included	85% PM or Greater 25% NOx	Level 3 Verified
FTF	$2,000-$4,000	$600	50% PM or Greater	Level 2 Verified
DOC	$1,000-$1,900	$100	15 - 30% PM	Level 1 Verified
FBC with Hardware Technology* (DOC / DPF / FTF)	$90-$105/gal FBC $0.05-$ 0.07/ gal diesel fuel + Cost of Hardware (DOC/DPF/FTF)	Hardware Installation Costs Dependent Upon Technology Used As Listed Above	Up to 95% PM	Not Verified

- ARB staff estimates a port truck consumes ~7,000 gallons of diesel fuel annually

E. Engines

1. New Diesel Engine Meeting 0.01 g/bhp-hr for PM as a Repower[7] or as Original Equipment

The particulate emission standard of 0.01 g/bhp-hr for heavy-duty highway diesel engines will take effect nationally and in California beginning with model year 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 used to meet the standard are made less efficient by sulfur in the exhaust stream, low sulfur fuel (< 15 ppmw) is required for these engines.

Repowering engines is a widespread practice by owners of heavy-duty trucks to extend the useful life of an expensive vehicle. So far, there is little actual in-use experience with a new engine certified to 0.01 g/bhp-hr PM emission standard, because the certification standard for truck engines is not required until 2007. However, Detroit Diesel Corporation, Caterpillar, Cummins, and International have each certified engines to the California urban bus standard of 0.01 g/bhp-hr, by using a DPF to achieve the low PM standard.

2. Repower with Newer Retrofitted Engine[8]

Another option is to repower an older vehicle by installing a pre-2007 model year (MY) engine along with a verified control device. For example, any 1994 to 2006 MY engine with an aftermarket verified DPF would achieve PM emissions near 0.01 g/bhp-hr.

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. The cost of converting from mechanical to electronic fuel injection may outweigh the value of the vehicle or remaining vehicle life.

ARB staff estimates that the typical cost of repowering is $15,000 for replacing a mechanical fuel injection engine with a newer mechanical fuel injection engine (this repower would be not practical for port trucks due to minimal emissions benefits). The cost of repower for conversion from mechanical to electronic fuel injection, if feasible, is estimated to be $35,000 to $45,000. This conversion provides emissions benefits but would be to expensive and time consuming for typical port truck operators. Engine replacement and vehicle modifications may take up to 6 weeks.

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[7] International Green Diesel Technology Vehicles. www.greendieseltechnology.com

[8] Cummins West Port, 2005. http://www.cumminswestport.com

ARB staff believes the only viable repower option for port truck operators would be to replace engines MY 1994 – 2002 with MY 2003 or newer (engines meeting 2.5 g/bhp-hr NOx emissions standard). The cost of engine replacement plus electronic engine management upgrade would be $20,000 to $30,000.

3. Heavy-Duty Pilot Ignition Engine[8]

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 rule for solid waste collection vehicles 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. This technology is still in the development stages and might not be applicable for the engines power needed in port truck application. Other issues with this technology include limited range, limited power, cost, and the widespread availability of alternate fuels.

IV. Evaluated Strategies for Reducing Emissions from Existing Port Trucks

Staff evaluated three different strategies to cost effectively reduce diesel PM and NOx emissions from port trucks. The existing fleet of approximately 12,000 short-haul trucks routinely moves goods to and from California's major container intermodal facilities, distribution centers, and warehouses. A priority is placed on rapidly reducing diesel PM and achieving maximum possible reductions by 2010. This provides for risk reduction in communities that are adjacent to ports, distribution centers, and intermodal rail facilities, as well as risk reduction in neighborhoods adjacent to heavily traveled freeways and arterial streets used by ports and intermodal trucks. These strategies also achieve modest to significant NOx reductions in the near term (2010) and significant to very large NOx reductions by 2020. The strategies assess potential costs, emission benefits, and cost-effectiveness.

In evaluating strategies, staff sought to maximize early diesel PM reductions, create significant NOx reductions, and maintain cost effectiveness with the goal of modernizing and/or retrofitting the entire port truck fleet of approximately 12,000 vehicles. Implementation of any one of the following strategies is expected to result in very significant local and overall rapid reductions in health risks. The analysis for each strategy is intended as a general overview for comparative purposes.

Common to all Strategies

All strategies assume an existing fleet of 12,000 port trucks in 2005 collectively generating 2005 baseline emissions of 564 TPY PM and 7,075 TPY NOx. The emission reduction calculation methodology is discussed in Appendix A.

Additionally, the three strategies share a common approach that ensures entry of new port trucks into routine service after 2006 meet increasing stringent emission standards. This ensures that older, dirtier trucks do not enter port service as the fleet grows. The common approach requires trucks that are new entrants to port service be equipped with DPFs and have OEM engines that meet at least 2003[1] standards through 2011. Starting in 2012 to the end of 2014, trucks entering port service would need to meet, at a minimum, 2007 engine standards[2]. Finally, starting in 2015, all trucks coming into port service will need to meet or exceed 2010 engine standards[3].

The following analysis determines the overall strategy costs without identifying the funding source.

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[1] 2.5 g/bhp-h certification standard for NOx+HC

[2] Expected to average 1.1 g/bhp-h certification for NOx+HC, 0.01 g/bhp-h for PM

[3] Expected to average 0.2 g/bhp-h certification for NOx+HC, 0.01 g/bhp-h for PM

A. Strategy 1: Replacement of Pre-1994 MY Trucks with 1998 or Newer MY Trucks and Installation of DPFs on the Entire Fleet

This strategy puts a priority on reducing diesel PM emissions and NOx emissions by replacing model year 1993 and older trucks with 1998 or newer model year trucks and equipping the entire fleet with level three DPFs over the 2007-2010 implementation period. The use and installation of diesel particulate filters will reduce diesel PM emissions by approximately 85 percent. These filters are widely available for installation on model year 1994 and later trucks. Additionally, the program's implementation start date of 2007 ensures that the ultra-low sulfur diesel needed by particulate filters will be universally available. The installation of DPFs[4] will achieve an overall diesel PM reduction of approximately 500 TPY after full implementation in 2010.

This strategy provides the lowest cost approach and achieves significant PM reductions (PM reductions are equal for all three strategies). This strategy will replace approximately 6,000 1993 MY and older port trucks with 1998 or newer MY vehicles and upgrade the entire port truck fleet of ~12,000 trucks with level three DPFs. The replaced trucks would be scrapped to prevent them from reentering service.

The overall cost of this strategy to clean the existing fleet and regulate the incoming trucks is approximately $290 million (see Appendix B – Table 12).

B. Strategy 2: Replacement of Pre-2003 MY Trucks with 2003 to 2006 MY Trucks and Installation of DPFs on the Entire Fleet

This strategy combines a high level of diesel PM reduction with a substantial reduction in NOx by replacing model year 2002 and older trucks with newer 2003 to 2006 model year trucks and equipping the entire fleet with DPFs. Diesel particulate filters will again reduce fleet wide diesel PM emissions by 85 percent or more. Strategy 2 would replace all pre-2003 MY trucks with model years 2003-2006, which corresponds to the first year of the 2003 NOx emissions of about 2.5 g/bhp-h, thus taking advantage of the engine's lower NOx emission levels. Similar to strategy 1, the replaced trucks would be scrapped.

Fleet wide diesel PM reductions will be approximately 530 TPY after full existing fleet implementation in 2010 (2007–2010 implementation period). Additionally, replacing older, higher NOx emitting trucks with newer model year 2003 trucks will generate fleet wide NOx reductions of approximately 2,300 TPY after full implementation in 2010.

This strategy achieves significant NOx reductions by replacing almost 12,000 pre-2003 MY port trucks operating 4.0 g/bhp-h engines with 2003-2006 MY trucks operating 2.5 g/bhp-hr engines.

The overall cost of this strategy to clean the existing fleet and regulate the incoming trucks is approximately $680 million (see Appendix B – Table 19).

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[4] The cost of DPF is estimated to be $8,500.

C. Strategy 3: Replacement of Port Trucks, Implemented in Two Phases

The first two strategies only reflect changes to the existing port truck fleet and new trucks entering service through 2010. Strategy 3 increases reductions by further modernizing the existing fleet in 2017 and again in 2019. The first phase of this strategy reduces emissions from the existing fleet through fleet modernization and emission control retrofits for both PM and NOx. Emission reductions are achieved by replacing pre-1994 MY trucks with 1998 to 2002 MY trucks and retrofitting the entire fleet with DPFs that reduce emissions by 85 percent. NOx emission reductions would be achieved by equipping pre 2003-trucks with NOx reduction catalysts that reduce emissions by at least 25 percent. Additionally, long term NOx emission reductions occur when model year 2007[5] and 2010[6] engines become widely available on used truck markets. With this strategy, the entire fleet of port trucks will be required to meet the 2007 or 2010 engine standards by 2020 (phase 2 below).

1. Strategy 3: Phase 1

In phase 1 of this strategy, reductions are achieved by retrofitting the entire fleet of port trucks (12,000) with highly effective DPFs that reduce diesel PM emissions by at least 85 percent. NOx reductions can be achieved by equipping the 10,500 pre-2003 trucks with a NOx reduction catalyst system that reduces NOx by at least 25 percent. To enable these retrofits, all 6,000 pre-1994 model year vehicles would be retired and replaced with 1998 to 2002 model year trucks with fully functional OEM engines that meet at least a 4.0 g/bhp-h NOx+HC certification standard. Similar to strategies 1 and 2, the replaced trucks would be scrapped to prevent them from reentering service.

2. Strategy 3: Phase 2

The final phase of this strategy will require the entire future port truck fleet meet 2007 or 2010 engine standards by the year 2020. In phase 2, pre-2003 trucks would be retired and replaced with trucks that meet 2010 engine standards in 2017. The remaining 2003 to 2006 MY trucks would be retired and replaced with trucks meeting the 2010 engine standards by 2019. After the conclusion of both phases in 2020, strategy 3 would leave a small fleet of 2007-2009 trucks with a much larger fleet of trucks meeting 2010 engine standards. As port trucks generally operate until 20 years of age, the remaining 2007 - 2009 trucks would gradually retire until the entire fleet operates with 2010 standard engine by approximately 2030.

Strategy 3 reduces annual PM emissions by approximately 520 TPY by 2010 (phase 1). Similarly, annual NOx emission reductions are estimated to be reduced approximately 2,000 TPY by 2010, an additional 4,750 TPY after full implementation of phase 2.

The overall cost of this strategy to clean the existing fleet and regulate the incoming trucks is approximately $590 million (see Appendix B – Table 26).

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[5] Expected to average 1.1 g/bhp-h certification for NOx+HC, 0.01 g/bhp-h for PM

[6] Expected to average 0.2 g/bhp-h certification for NOx+HC, 0.01 g/bhp-h for PM

V. Economic Assessment of Recommended Strategies

This section presents a summary of the cost and associated cost-effectiveness for each strategy. A detailed discussion on the methodology used to determine total program costs and cost effectiveness is presented in Appendix B.

All program cost estimates utilize a forecasting model developed to predict port truck replacement costs when older model year trucks are replaced with newer model year vehicles. A discussion of this price forecasting model is also presented in Appendix B.

One potential cost not included in the following analysis is the cost associated with program administration. A modernization effort of this size most likely cannot be administered by state agencies. One possible solution is to contract with an outside company that will oversee and coordinate the overall effort and be responsible for meeting any program milestones. Further feasibility and cost analysis will need to be performed as the program develops if an outside administrator is considered.

Additionally, most of the existing port trucks are driven by owner/operators who do not have the access to capital to pay for the needed improvements. One possible solution would have the cost of truck upgrades and retrofits be financed through guaranteed loans; drivers would receive credits that retire these loans each time a container is picked up or dropped at the port. Payments would be “metered out” over an extended period to ensure that upgraded trucks have a strong financial incentive to remain in port trucking through at least 2015.

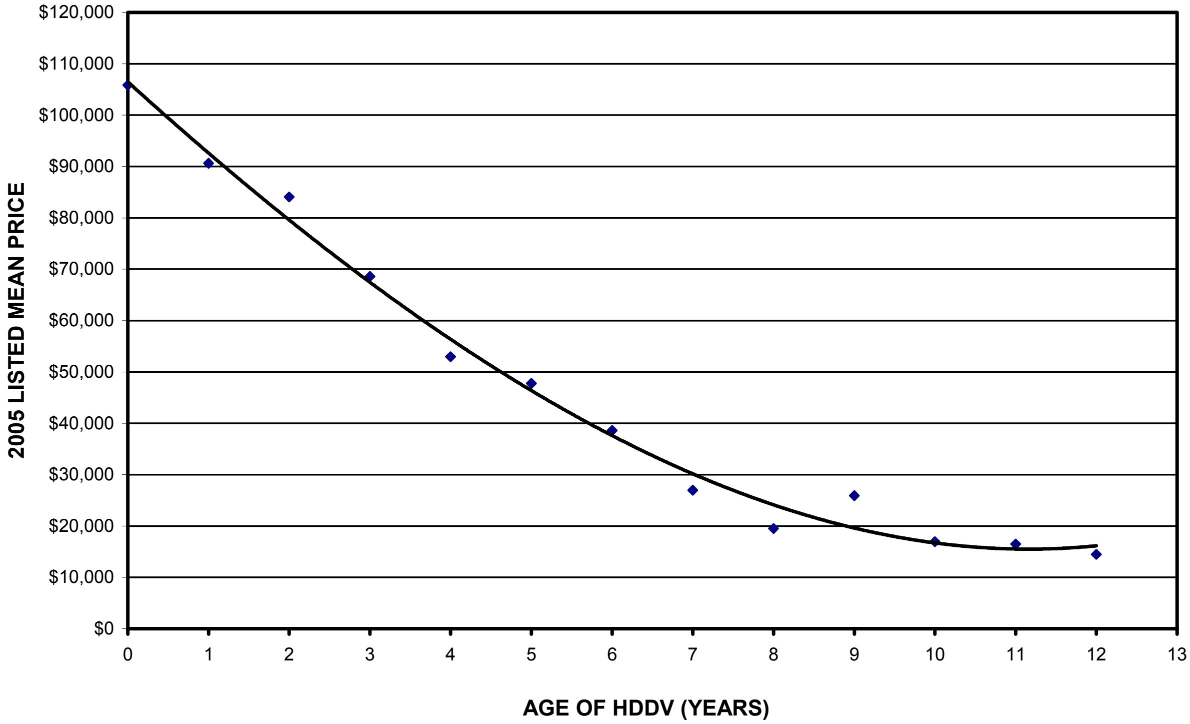
A. Common Costs to Prevent High Polluting Trucks from Entering Port Service

All three strategies will require new trucks beginning port operation to meet progressively stringent emission standards once the program starts. To meet these requirements, truck owners may need to purchase a newer MY truck than they would have normally purchased, and, at least in the early years, will need to install a PM control device. In the future, newer trucks will be manufactured with the needed PM control devices and used trucks will meet required emission standards. Staff utilized the cost scenario of truck operators purchasing ‘newer’ than normal trucks and installing a DPF depending on the MY year of the truck. Trucks entering the fleet will be required to meet increasingly stringent standards during three different time periods: 2007-2011, 2012-2014, and 2015 and later.

From program start up until the end of 2011, new trucks would be required to meet 2003 emission standards with a DPF. Since no information exists detailing the typical age of a port truck when first entering port service, staff will assume the average age of a truck entering port service is 10 years. The ‘10 year old truck’ assumption takes into account port truck operator economics which typically dictates the purchase of much older, less expensive trucks and the expected availability of such trucks on the used market. Using this simple scenario, in 2007, the average port truck MY entering port service is estimated to be 1997[1]. Similarly, the average MY of a truck entering port service in 2011 is estimated to be a MY 2001. By requiring MY 2003 trucks with an installed DPF, port truck owners may be required to purchase a truck that is 2-6 years 'newer' than otherwise expected in addition to installing a DPF. Staff estimates the truck owner will see increased costs from the installation of a DPF and the differential cost in used truck prices. For example, a truck operator that would normally purchase a 1997 MY truck in 2007 would instead be required to purchase a 2003 MY truck – a difference of 6 years.

In 2005, ARB staff surveyed used HDDV prices in California and the neighboring (~5 percent of total listings) States of Arizona and Nevada. Utilizing the survey results, staff developed a depreciation trend line to approximate the costs of replacing the pre-1994 trucks with newer 1998+ MY trucks in future years (Figure V-1).

FIGURE V-1: 2005 California Used Truck Price-Age Distribution Profile from Survey



Utilizing the 'Used Truck Price-Age Distribution Profile' (Figure V-1), staff estimated that the added differential costs of purchasing a 6 year old truck (2003 MY truck in 2009) over a 10 year old truck (the assumed typical age of a used truck) is ~$22,000.[2]

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[1] MY 2007 – 10 years = MY 1997

[2] 6 Year old MY truck (~$38,000) – 10 Year old MY truck (~$16,000) = ~$22,000

Using the above methodology, the estimated additional cost to truck operators purchasing ~2,400 (see Appendix B – Table 7) 'newer' than normal trucks from 2007 to 2011 is ~$42 million. When combined with DPF retrofit costs ($8,500 + O&M per truck), the total 2007–2011 program costs are ~$72 million (see Appendix B – Table 11). The estimated emission reductions are approximately 85 TPY PM and 400 TPY NOx after full implementation in 2011 (see Appendix A - Emissions Reduction Section) when compared to the 2011 baseline emissions.

Similarly, the cost to truck operators entering port service during 2012-2014 is also comprised of the differential cost of buying a newer than normal truck, but, because owners would be required to operate trucks with 2007 emissions standards, no DPF retrofits would be needed. The average differential cost to purchase a 2007 MY truck over a 2002-2004 MY truck is approximately $28,000. Staff estimates additional cost to truck operators purchasing ~1,300 (see Appendix B) 'newer' than normal trucks from 2012 to 2014 is ~$22 million. After full implementation in 2014, staff estimates annual emission reductions of 35 TPY PM and 400 TPY NOx.

Starting in 2015, trucks entering port service would be required to meet 2010 engine standards. This would require trucks to be, at a maximum, 5 years old when entering port service in 2015. The differential cost of requiring the purchase of a 'newer' used truck is ~$17,000. The estimated annual cost to modernize ~2,000 (see Appendix B) trucks entering port service during 2015-2020 is estimated to be $16 million with NOx reductions of 730 TPY when compared to the 2020 baseline emissions. Staff expects additional annual costs to truck owners and annual emissions reductions to gradually diminish in the future until such time as a MY 2010 truck would be the typical truck entering port service without this mandate.

Table V-1 summarizes the costs for new trucks entering port service from 2007-2020.

Table V-1: Trucks Entering Port Service Costs
10 Year Capital Recovery Period (millions)

YEAR	2007 - 2011		2012 - 2014	2015 +	TRUCKS ENTERING PORT SERVICE COSTS
	TOTAL DPF, INSTALLATION & O&M COSTS	TOTAL INCREMENTAL TRUCK REPLACEMENT COSTS	TOTAL INCREMENTAL TRUCK REPLACEMENT COSTS	TOTAL INCREMENTAL TRUCK REPLACEMENT COSTS*	
2007	$0.9	$1.3			$2.2
2008	$1.6	$2.4			$4.0
2009	$2.3	$3.3			$5.6
2010	$2.9	$4.2			$7.1
2011	$3.4	$4.9			$8.3
2012	$3.2	$4.6	$1.0		$8.8
2013	$3.0	$4.3	$2.0		$9.3
2014	$2.8	$4.0	$2.7		$9.5
2015	$2.7	$3.7	$2.6	$0.5	$9.5
2016	$2.5	$3.5	$2.4	$0.9	$9.3
2017	$1.9	$2.6	$2.2	$1.3	$8.0
2018	$1.4	$1.8	$2.1	$1.6	$6.9
2019	$0.9	$1.1	$2.0	$1.8	$5.8
2020	$0.4	$0.5	$1.8	$1.7	$4.4
2021			$1.7	$1.6	$3.3
2022			$1.1	$1.5	$2.6
2023			$0.5	$1.4	$1.9
2024				$1.3	$1.3
2025				$1.0	$1.0
2026				$0.7	$0.7
2027				$0.4	$0.4
2028				$0.2	$0.2
Total	$29.9	$42.2	$22.1	$15.9	$110.1

-Costs are amortized over 10 years using a capital recovery interest rate of 5 percent[3].
-All costs are rounded and presented in 2005 dollars.

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[3] 5% interest rate is consistent with the capital recovery interest rate used in ARB staff's Port Cold Ironing analysis.

B. Cost of Strategy Options

1. Cost Assessment for Strategy 1

The focus of this strategy is the reduction of PM emissions and would require the entire port truck fleet of 12,000 trucks be equipped with DPFs after full implementation. To enable the installation of DPFs on the entire fleet, approximately 6,000 pre-1994 model year port trucks will be replaced with 1998 or newer model year vehicles. ARB staff envisions a phased-in modernization scenario whereby 25 percent of the fleet is replaced and / or retrofitted each year from 2007-2010. After full implementation in 2010, this strategy would reduce diesel PM emissions by an estimated 500 TPY.

a. Costs for Retrofitting the Port Truck Fleet with Diesel Particulate Filters

The total cost to retrofit ~12,000 port trucks is estimated to be $103 million (in present value 2005 dollars), utilizing a discount rate of 5 percent. Approximately 3,000 trucks per year will be retrofitted with DPFs during the implementation period of 2007 - 2010. The hardware and installation cost of a verified passive DPF is approximately $8,500[4] and staff assumes the cost of a DPF will remain constant in the foreseeable future due to economies of scale. This cost estimate is exclusive of state and local taxes. A DPF also requires service at recommended 50,000 mile intervals or once a year (Fleetgaurd Emissions Solutions / Ironman Parts & Service, 2005). Staff assumes annual O&M costs of ~$200 in 2005 to service the DPF product over capital recovery period of ten (10) years. Operation and maintenance costs are projected to increase by roughly 5 percent per year due to increases in labor rates. Annual DPF and O&M costs are presented in Table V-2.

b. Costs for Replacing Port Trucks

The estimated cost of replacing a pre-1994 model year port truck with a 10-year old truck is approximately $16,000 (Figure V-1). Staff utilizes a 10 year old replacement truck for the low price, remaining useful life, and additional NOx benefits over pre-1998 trucks. The original truck will be destroyed with no assumed salvage value (applies to all three strategies - unless noted). Strategy 1 truck replacement costs for 6,000 qualifying pre-1994 vehicles is expected to be $79 million (2005 dollars), corresponding to a discount rate of 5 percent. Annual truck replacement costs are presented in Table V-2.

Program costs are calculated over a 10 year capital recovery period (See Appendix B). Operators routinely operate twenty year old port trucks to haul containers locally or to nearby rail facilities. By utilizing 10 year old replacement trucks, staff reasons that the replacement truck would be operational for another 10 years beyond the replacement date. Appendix B details the yearly costs during the capital recovery period.

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[4] Ironman Parts and Service, 2005

c. Total Retrofit and Replacement Costs

Total costs for Strategy 1 (~12,000 existing fleet trucks) are ~$180 million (2005 Dollars). Table V-2 summarizes the strategy's annual program costs including costs to trucks entering port service.

Table V-2: Strategy 1 - Combined Costs for Replacement & Retrofit
10 Year Capital Recovery Period
(millions)

YEAR	TOTAL DPF, INSTALLATION & O&M COSTS	TOTAL TRUCK REPLACEMENT COSTS	TRUCKS ENTERING PORT SERVICE	TOTAL PROGRAM COSTS
2007	$3.6	$2.9	$2.2	$8.7
2008	$6.8	$5.4	$4.0	$16.2
2009	$9.6	$7.6	$5.6	$22.8
2010	$12.0	$9.5	$7.1	$28.6
2011	$11.3	$8.9	$8.3	$28.5
2012	$10.7	$8.3	$8.8	$27.8
2013	$10.1	$7.7	$9.3	$27.1
2014	$9.5	$7.2	$9.5	$26.2
2015	$9.0	$6.8	$9.5	$25.3
2016	$8.5	$6.3	$9.3	$24.1
2017	$6.0	$4.4	$8.0	$18.4
2018	$3.8	$2.8	$6.9	$13.5
2019	$1.8	$1.3	$5.8	$8.9
2020			$4.4	$4.4
2021			$3.3	$3.3
2022			$2.6	$2.6
2023			$1.9	$1.9
2024			$1.3	$1.3
2025			$1.0	$1.0
2026			$0.7	$0.7
2027			$0.4	$0.4
2028			$0.2	$0.2
Total	$102.7	$79.1	$110.1	$291.9

-Costs are amortized over 10 years using a capital recovery interest rate of 5 percent.
-All costs are rounded and presented in 2005 dollars.

2. Cost Assessment for Strategy 2

The focus of this strategy is the reduction of PM and NOx emissions. Like strategy 1, this strategy would require the entire port truck fleet of 12,000 trucks be equipped with DPFs after full implementation. Strategy 2 differs from the previous strategy by requiring replacement of pre-2003 MY trucks with model year 2003 or newer trucks to reduce NOx emissions. Strategy 2 would require almost the entire port fleet of 12,000 be replaced with newer 2003+ trucks because virtually no newer model trucks operate in frequent port service. Again, ARB staff envisions a phased-in modernization scenario whereby 25 percent of the fleet is replaced and / or retrofitted each year from 2007-2010. After full implementation in 2010, this strategy would reduce diesel PM emissions by an estimated 530 TPY and reduce NOx emissions by 2,300 TPY. Please see Appendix B for expanded discussion and methodologies.

a. Costs for Retrofitting the Port Truck Fleet with Diesel Particulate Filters

Because strategy 1 and strategy 2 require the same DPF retrofit scenario, with the same assumptions, methodologies, and deadlines, costs are expected to again be ~$103 million (2005 dollars). Annual DPF and O&M costs are presented in Table V-3.

b. Costs for Replacing Port Trucks

Staff again used the depreciation trend line to approximate the costs of replacing pre-2003 trucks with newer 2003+ MY trucks in future years (Appendix B: Figure 1). The estimated cost of replacing a pre-2003 model year port truck with a 2003 model year truck is approximately $48,000[5]. Strategy 2 truck replacement costs for 11,800 qualifying pre-2003 vehicles is expected to be ~$470 million (2005 Dollars), corresponding to a discount rate of 5 percent and a 10 year capital recovery period. Annual truck replacement costs are presented in Table V-3.

c. Total Retrofit and Replacement Costs

Total costs for Strategy 2 (12,000 existing fleet trucks) are estimated to be ~$570 million (2005 Dollars). Table V-3 summarizes the strategy's annual program costs.

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[5] Staff assumes a 5 year old truck for availability, ~$48,000. From depreciation curve (figure 1).

Table V-3: Strategy 2 - Combined Replacement & Retrofit Costs (millions)

YEAR	TOTAL DPF, INSTALLATION & O&M COSTS	TOTAL TRUCK REPLACEMENT COSTS	TRUCKS ENTERING PORT SERVICE	TOTAL PROGRAM COSTS
2007	$3.6	$17.1	$2.2	$22.9
2008	$6.8	$32.0	$4.0	$42.8
2009	$9.6	$44.9	$5.6	$60.1
2010	$12.0	$56.0	$7.1	$75.1
2011	$11.3	$52.3	$8.3	$71.9
2012	$10.7	$48.9	$8.8	$68.4
2013	$10.1	$45.7	$9.3	$65.1
2014	$9.5	$42.7	$9.5	$61.7
2015	$9.0	$39.9	$9.5	$58.4
2016	$8.5	$37.3	$9.3	$55.1
2017	$6.0	$26.1	$8.0	$40.1
2018	$3.8	$16.3	$6.9	$27.0
2019	$1.8	$7.6	$5.8	$15.2
2020			$4.4	$4.4
2021			$3.3	$3.3
2022			$2.6	$2.6
2023			$1.9	$1.9
2024			$1.3	$1.3
2025			$1.0	$1.0
2026			$0.7	$0.7
2027			$0.4	$0.4
2028			$0.2	$0.2
Total	$102.7	$466.8	$110.1	$679.6

-Costs are amortized over 10 years using a capital recovery interest rate of 5 percent.
-All costs are rounded and presented in 2005 dollars.

3. Cost Assessment for Strategy 3

In addition to the early PM reduction, this strategy would provide a significant early reduction in NOx emissions, and very large NOx benefits by 2020. The first phase of strategy 3 reduces emissions from the existing fleet through fleet modernization and emission control retrofits for both PM and NOx. Emission reductions are achieved by replacing pre-1994 MY trucks with 1998 MY trucks and retrofitting the entire fleet with highly effective DPFs, DPF/NOx systems that reduce emissions by 85 percent. NOx emission reductions are achieved by equipping pre 2003 trucks with NOx reduction catalysts that reduce NOx emissions by at least 25 percent. Additional long term NOx emission reductions occur when model 2007[6] and 2010[7] engines become available on used truck markets, and entire fleet of port trucks will be required to meet the 2007 and 2010 engine standards by 2020 (phase 2 of strategy 3). A detailed description of this strategy can be found in Section IV.

Staff estimates strategy 3 phase 1 annual emission reductions to be 520 tons PM and 2,000 tons NOx after full implementation in 2010. Strategy 3 Phase 2 will further reduce annual NOx emissions by an estimated ~5,000 TPY. Please see Appendix A for expanded discussion and methodologies.

a. Costs for Strategy 3: Phases 1 & 2

Phase 1 requires the entire existing port fleet to install either a DPF or a DPF / NOx retrofit system dependant on the trucks model year. Because the NOx retrofit cannot be installed on 2003+ MY engines with EGR valves, 2003+ MY engines will only be required to install a DPF. The fleet breakdown of Phase 1 is as follows:

2003+ MY Trucks -	approximately 1,200 install DPFs
Pre-2003 MY Trucks -	approximately 10,500 install DPF / NOx system

The cost of a DPF is $8,500 plus $200 annual O&M. The cost of the combination DPF / NOx system is approximately $20,000 plus $200 O&M (for the DPF). Fleet wide, the costs of truck replacement and retrofitting the existing fleet of 12,000 trucks is ~$280 million over a 10 year capital recovery period.

Phase 2 (2017-2019) will further reduce NOx emissions (over phase 1) by requiring the modernization of the oldest pre-2007 standard trucks currently in the port fleet with trucks meeting 2010 emission standards. The differential cost of retiring a truck earlier than normal and purchasing a 2010 emission standard equivalent would be borne exclusively by the truck owner. Unlike the previous strategies, staff envisions that truck drivers may sell the old trucks to recoup a portion of the costs needed to purchase the newer truck. Selling the old trucks may be an option as the replaced trucks currently generate low PM and NOx emissions from phase 1 emission reduction efforts. Although not quantified, staff believes the cost benefits of selling the older used trucks may be minimal due to the age (~15 years) of the vehicles. Staff estimates the cost of Phase 2 is approximately $200 million with NOx emission benefits of ~5,000 TPY after full implementation. Please see Appendix B for strategy 3 methodologies. Total costs for Strategy 3 are estimated to be $590 million (2005 Dollars). Table V-4 summarizes the strategy's annual program costs.

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[6] Expected to average 1,1 g/bhp-h certification for NOx + HC, 0.01 g/bhp-h for PM

[7] 0.2 g/bhp-h certification for NOx + HC, 0.01 g/bhp-h for PM

Table V-4: Strategy 3 - Combined Strategy Costs (millions)

YEAR	PHASE 1			PHASE 2	TRUCKS ENTERING PORT SERVICE	TOTAL PROGRAM
	DPF, INSTALLATION and O&M	DPF / NOx, INSTALLATION & O&M	TRUCK REPLACEMENT	TRUCK REPLACEMENT		
2007	$0.4	$6.8	$2.9		$2.2	$12.3
2008	$0.7	$12.8	$5.4		$4.0	$22.9
2009	$1.0	$18.1	$7.6		$5.6	$32.3
2010	$1.2	$22.6	$9.5		$7.1	$40.4
2011	$1.2	$21.2	$8.9		$8.3	$39.6
2012	$1.1	$19.9	$8.3		$8.8	$38.1
2013	$1.0	$18.7	$7.7		$9.3	$36.7
2014	$1.0	$17.6	$7.2		$9.5	$35.3
2015	$0.9	$16.5	$6.8	$7.4	$9.5	$41.1
2016	$0.9	$15.5	$6.3	$13.9	$9.3	$45.9
2017	$0.6	$11.0	$4.4	$19.2	$8.0	$43.2
2018	$0.4	$6.9	$2.8	$23.7	$6.9	$40.7
2019	$0.2	$3.2	$1.3	$22.1	$5.8	$32.6
2020				$20.7	$4.4	$25.1
2021				$19.3	$3.3	$22.6
2022				$18.1	$2.6	$20.7
2023				$16.9	$1.9	$18.8
2024				$15.8	$1.3	$17.1
2025				$11.0	$1.0	$12.0
2026				$6.7	$0.7	$7.4
2027				$3.2	$0.4	$3.6
2028					$0.2	$0.2
Total	$10.6	$190.8	$79.1	$197.9	$110.1	$588.5

C. Cost Effectiveness Comparison of Strategies

The cost-effectiveness of each strategy is determined by computing the ratio of the total annualized strategy costs to the total annual NOx and PM emissions reductions. Staff endeavored to split the strategy into component PM and NOx cost effectiveness determinations to provide further detail. In determining the individual pollutant cost effectiveness, strategy costs were allocated base on the pollutant reduced. PM cost effectiveness was determined using costs associated with the retrofit, operation, and maintenance of DPFs. Similarly, the cost of NOx control systems (Strategy 3: Phase 1) or the decision to buy used newer (MY 2003+) replacement trucks due to their lower NOx levels (strategy 2) were used to only determine NOx cost effectiveness. When a strategy requires replacing port trucks, the truck replacement costs are divided equally between the two pollutants, as both are typically reduced. However, when only one pollutant is reduced by truck replacement (i.e.: when a 2007 standard truck is replaced be a 2010 standard truck – NOx benefits) only the reduced pollutant is analyzed for cost effectiveness utilizing 100 percent of the costs.

The annualized strategy costs are based on a capital recovery period (project life) of ten years at an interest or discount rate of 5 percent. A detailed discussion on the derivation of the total annualized costs for the cost-effectiveness determination is presented in Appendix B. Since staff envisions each strategy to be implemented over a period of at least four years with a capital recovery period of at least 10 years, the annual cost effectiveness will vary. The cost effectiveness for each strategy is presented as a range and then as an average. All costs are in present value 2005 dollars.

1. Cost Effectiveness – Fleet Growth

All three strategies require identical standards for trucks that are new entrants to port service. The following analyzes the cost effectiveness (in present value 2005 dollars) for trucks entering port service (fleet growth) during three distinct time periods with resulting costs and emission reductions. As required emissions standards, costs, and emission reductions are unique for each time period, staff will present the cost effectiveness for each. (See Appendix B for a detailed analysis and staff's assumptions)

The first time period, from 2007 to 2011, requires trucks entering port service must be MY 2003+ with an installed DPF. Assuming the average age of a truck entering port service is 10 years old, staff determined this implementation period will require a newer than normal truck for NOx reductions and the installation of a DPF for PM reductions. Staff estimates that a pre-strategy truck entering port service would normally be 1997 MY or newer, which is already DPF capable. By requiring model year 2003+ trucks (instead of 1997 MY trucks), staff reasons 100 percent of the differential port truck replacement costs should be attributed to NOx cost effectiveness. PM cost effectiveness calculations will utilize one hundred percent of the DPF retrofit cost. Table V-5 details the estimated annual cost effectiveness for the estimated 2,400 trucks entering port service from 2007 to 2011.

**Table V-5: Trucks Entering Port Service 2007-2011
Summarized Cost Effectiveness: Annual Range & Annual Average
NOx and PM (rounded)**

Pollutant	Annual Cost Effectiveness Range ($/Ton)		Average Annual Cost Effectiveness ($/Ton)	Annual Pollutant Reductions After Full Implementation (TPY)
	Low	High		
PM	$25,000	$50,000	$35,000	85
NOx	$7,000	$16,000	$11,000	400

Second, trucks entering port service from 2012 to 2014 must meet MY 2007+ emission standards. During this time period, truck owners will most likely have to purchase newer than normal trucks and obtain both NOx and PM benefits. To determine the cost effectiveness by pollutant, staff will assume half the differential truck replacement costs are attributed to PM and half to NOx. Table V-6 details the estimated annual cost effectiveness for trucks entering port service in 2012 to 2014.

**Table V-6: Trucks Entering Port Service 2012-2014
Summarized Cost Effectiveness: Annual Range & Annual Average
NOx and PM (rounded)**

Pollutant	Annual Cost Effectiveness Range ($/Ton)		Average Annual Cost Effectiveness ($/Ton)	Annual Pollutant Reductions After Full Implementation (TPY)
	Low	High		
PM	$21,000	$45,000	$32,000	35
NOx	$2,000	$4,000	$3,000	400

The last time period states that, beginning in 2015, all new trucks in port service must meet 2010 engine standards. Staff will assume that a truck entering port service would normally have been a 2007 MY or newer (~8 year old truck) with minimal PM emissions. Therefore, the resulting costs of requiring 2010 MY trucks vs. a 2007 MY trucks are attributed solely to NOx reductions. Table V-7 details the estimated cost effectiveness for trucks entering port service in 2015-2020.

Table V-7: Trucks Entering Port Service 2015-2019
Summarized Cost Effectiveness: Annual Range & Annual Average
NOx (rounded)

Pollutant	Annual Cost Effectiveness Range ($/Ton)		Average Annual Cost Effectiveness ($/Ton)	Annual Pollutant Reductions After Full Implementation (TPY)
	Low	High		
NOx	$1,000	$3,000	$2,000	730

2. Cost Effectiveness – Strategy 1

In addition to the costs during fleet growth (above), strategy 1 also includes truck replacement and DPF retrofit costs. In this strategy, 100 percent of the DPF retrofit costs and half the truck replacement costs will determine the PM cost effectiveness. NOx cost effectiveness will utilize half the cost of truck replacement as the port fleet will see NOx reduction by replacing older engines. The cost effectiveness for strategy 1 (existing fleet only) is summarized in Table V-8 below:

Table V-8: Strategy 1 Summarized Cost Effectiveness: Annual Range & Annual Average during Capital Recovery Period 2007-2019 (rounded)

Pollutant	Annual Cost Effectiveness Range ($/Ton)		Average Annual Cost Effectiveness ($/Ton)	Annual Pollutant Reduced After Full Implementation (TPY)
	Low	High		
PM	$25,000	$52,000	$37,000	500
NOx	$5,000	$12,000	$8,000	480

3. Cost Effectiveness – Strategy 2

Similar to strategy 1, strategy 2 costs are comprised of replacing trucks, retrofitting the fleet with DPFs, and costs of fleet growth. Staff again assumes 100 percent of the cost for replacing the DPFs and a portion of the truck replacement costs will determine the PM cost effectiveness. However, this strategy requires a newer replacement truck than strategy 1 (MY 2003+ vs. MY 1998+) and truck replacement costs will be substantially greater. Because modernizing to MY 2003+ is strictly for added NOx reductions, the differential costs of the 2003 replacement truck over the 1994 replacement truck will be solely associated with NOx cost effectiveness and the PM cost effectiveness will be the same as strategy 1. The annual cost effectiveness for strategy 2 is summarized in Table V-9.

**Table V-9: Strategy 2 Summarized Cost Effectiveness:
Annual Range & Annual Average during Capital Recovery Period 2007-2019
(rounded)**

Pollutant	**Annual Cost Effectiveness Range ($/Ton)**		**Average Annual Cost Effectiveness ($/Ton)**	**Annual Pollutant Reduced After Full Implementation (TPY)**
	Low	High		
PM	$23,000	$49,000	$35,000	530
NOx	$11,000	$25,000	$17,000	2,300

4. Cost Effectiveness – Strategy 3

As strategy 3 has two distinct phases, staff will present the cost effectiveness for each of the two phases separately. By separating the cost effectiveness into phases, staff provides analysis which can aid in determining future action.

The Phase 1 cost effectiveness determination utilizes identical program parameters and costs as the first strategy except pre-2003 MY trucks will be required to retrofit with a NOx reduction strategy. As the only change between the two strategies results in NOx reductions, the PM cost effectiveness for the first phase is identical to strategy 1. Again, PM cost effectiveness will account for all the DPF retrofit costs and a portion of the truck replacement costs. NOx cost effectiveness utilizes costs of truck replacement and all the costs to retrofit applicable vehicles with NOx reduction strategies. The cost effectiveness for Phase 1 is summarized in Table V-10 below:

Table V-10: Strategy 3 Phase 1 Summarized Cost Effectiveness Annual Range & Annual Average during Capital Recovery Period 2007-2019 (rounded)

Pollutant	Annual Cost Effectiveness Range ($/Ton)		Average Annual Cost Effectiveness ($/Ton)	Annual Pollutant Reduced After Full Implementation (TPY)
	Low	High		
PM	$19,000	$40,000	$28,000	520
NOx	$5,000	$10,000	$7,000	2,000

Phase 2 is strictly a NOx reduction element of strategy 3 as all port trucks will currently meet the strict PM emission standards by 2017 (phase 1). Phase 2 consists of two components. The first component dictates all pre-2003 MY port trucks must be replaced with truck meeting 2010 emission standards starting in 2017. Costs resulting from this component are expected to come from the differential cost of purchasing a newer MY truck than would normally have been purchased. The second component mandates that all MY 2003-2006 truck be replaced with truck meeting the 2010 emission standards by 2019. Again, this is strictly a NOx reduction component of phase 3 and all costs will be allocated towards NOx cost effectiveness. Not factored in the analysis is the potential value of the replaced truck. Unlike phase 1, in which staff assumes the older, higher emission trucks will be destroyed, the trucks being retired out of the fleet meet low PM emission standards and relatively low NOx standards. It is possible, depending on factors such as demand and the age of the truck, that some of the program costs could be recouped by selling the truck to other markets. The cost effectiveness for Phase 2 is summarized in Table V-11 below:

Table V-11: Strategy 3 Phase 2 Summarized Cost Effectiveness Annual Range & Annual Average during Capital Recovery Period (rounded)

Pollutant	Annual Cost Effectiveness Range ($/Ton)		Average Annual Cost Effectiveness ($/Ton)	Annual Pollutant Reduced After Full Implementation (TPY)
	Low	High		
NOx (2017)	$7,000	$13,000	$9,000	1,150
NOx (2019)	$2,000	$3,000	$3,000	3,600

D. Summary of Potential Emission Reductions, Costs, and Annual Cost Effectiveness Over a 10 Year Capital Recovery Period for all Three Strategies

Table V-12 summarizes the potential emission reductions, costs, and annual cost effectiveness over a ten year capitol recovery period for all three strategies.

Table V-12: Costs, Emission Reductions, and Cost Effectiveness over Capitol Recovery Period (10 Years)

	Cost (Millions)	Emission Reductions (tons)		Average Annual Cost Effectiveness ($/ton)		
		PM	**NOx**	**PM**	**NOx**	**Moyer**
Strategy 1 Existing Fleet	$180	5,000	4,800	$37,000	$8,000	$ 4,500
Strategy 2 Existing Fleet	$570	5,300	23,000	$35,000	$17,000	$11,800
Strategy 3 Existing Fleet	$280	5,200	20,000	$28,000	$7,000	$ 5,900
Strategy 3 Phase 2	$200		47,500		$4,000[8]	
Trucks Entering Port Service	$110	1,200	15,300	$34,000[8]	$5,000[8]	

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[8] Average annual cost effectiveness combined and weighted by TPY reductions

E. Potential Funding Sources

1. Container Fee Comparison for all Three Strategies

As stated earlier in this report, the ability of the port truck owner / operator to afford the costs necessary to modernize their truck is questionable and a substantial level of outside funding will likely be necessary. One possible solution would be to levy a fee on containers and use those funds to finance much of the cost to modernize and retrofit the trucks. One possible repayment scenario for reimbursing the cost to the truck owner would be to 'pay' a predetermined amount each time the truck picked up a container from the port until the modernization cost to the truck driver is refunded. The fees collected would be disbursed to truck owners as they move containers to and from the port or until a predetermined amount is reimbursed to the truck owner.

Staff has calculated a fee estimate on only those incoming containers (via ship) that are transported by truck after being off-loaded. Containers bound for on-dock rail at the ports of Long Beach were excluded. Table V-12 summarizes the annual containers transgressing through POLA, POLB, and Oakland and also the estimated containers entering the ports destined for truck transport (see appendix B).

Table V-12: Annual Container Traffic - POLA, POLB, and Oakland (millions)

Year	Containers Oakland	Containers POLA, POLB	Trucked Imported Containers
2007	1.7	9.1	4.3
2008	1.9	9.7	4.6
2009	2.2	10.3	4.9
2010	2.5	10.8	5.3
2011	2.6	11.7	5.7
2012	2.6	12.6	6.1
2013	2.7	13.5	6.4
2014	2.8	14.4	6.8
2015	2.9	15.3	7.2
2016	2.9	16.2	7.6
2017	3.1	17.1	7.9
2018	3.1	18.0	8.3
2019	3.2	18.9	8.7
2020	3.3	19.8	9.1
2007-2015 Totals (Rounded)			51
2007-2020 Totals (Rounded)			93

To determine the per container costs to modernize the existing fleet for each strategy, staff divided the total strategy costs for the existing port fleet of 12,000 existing trucks by the total expected incoming trucked containers for the period 2007-2015 of ~51 million containers. Potential strategy container fees are summarized in Table V-13.

Table V-13: Cost per Container for Each Strategy

	Total Costs Existing Fleet of 12,000 Trucks (millions)*	**Incoming Trucked Containers 2007-2015 (millions)**	**Cost Per Container***
Strategy 1	$180	51	$4
Strategy 2	$570	51	$11
Strategy 3	$280	51	$5

* 2005 Dollars

The projected per in-bound container costs to modernize the existing fleet of 12,000 trucks, vary by strategy, and ranges from $4 per container to $11 per container. Strategy 2 costs per container are significantly higher because the costs of replacement trucks are approximately 3 times that of the other strategy. In addition, the per-container costs only includes direct costs to modernize the fleet and not include expenses such as program administration costs or potential costs to the terminals for added enforcement. Additionally, if other strategy costs are included (such as new entry truck costs on subsequent phases) the costs per container will increase. Ultimately, any program that will be developed must anticipate costs to be reimbursed and which attach container fees.

2. Public Financing

In recent years regulatory programs in some sectors have been supplemented with incentives to accelerate voluntary actions such as replacing older equipment. Incentive programs like the Carl Moyer Program are both popular and effective but require the allocation of public funds which are in limited supply. Most of the existing incentive programs are designed to pay for the differential cost between what is required and advanced technology that exceeds that level. The incentive programs are currently funded by general fund taxes or by fees imposed on California drivers as part of their annual registrations, smog inspections or new tire purchases.

California is currently investing up to $140 million per year to clean up older, higher emission sources. Ten percent of the Carl Moyer funds that flow through the state budget are reserved, by ARB, for projects of statewide significance, including goods movement-related clean up. The Carl Moyer Program funds used for port-related goods movement emissions will likely focus on efforts to reduce diesel emissions through vehicle retrofits or upgrades; such as, funding the clean-up of older, high emitting port trucks.

Another likely source of public funding is the use of state general obligation bonds issued to generate revenues for a special port-related incentive program. Governor Schwarzenegger has proposed $1 billion in bonds to be matched by another $1 billion in funding from other sources to reduce goods-movement related pollution.

Federal funding is one funding mechanism currently being used or considered at the ports. The U.S. EPA has provided several small grants thus far, through the West Coast Clean Diesel Collaborative, for California goods movement-related projects. The Collaborative is a partnership between federal, state, and local governments, the private sector, and environmental groups throughout the west coast. The goal of the Collaborative is to allocate federal funds to reduce emissions from the most polluting diesel sources in the most affected communities and to significantly improve air quality and public health. Last year, EPA allocated $15 million in funding for a National Clean Diesel Initiative that will in part fund the Collaborative. Additional information is available on the West Coast Collaborative website, http://www.westcoastcollaborative.org/.

F. Replacing Fleet with New 2007 MY Diesel or LNG Powered Trucks

As part of this assessment, staff estimated the emission benefits and costs of two additional approaches which would rapidly replace all existing port trucks with new trucks meeting new engine standards. Model year 2007 trucks would produce much greater near term NOx reductions than strategies that purchase older used trucks and retrofit the fleet with PM and NOx controls. Other advantages are the OEM installation of diesel particulate filters, which eliminates any DPF retrofitting concerns on used trucks, and the estimated lifespan of new 2007 MY trucks (~20 years) vs. older trucks (~10 years). With a longer remaining useful life, a new truck could be in port service for a greatly extended period, which could eliminate the necessity of a second modernization effort.

The annual fleet wide PM emission benefits of ~520 TPY is roughly equal to the estimated PM benefits from each of the three base case strategies, which all require 100 percent DPF retrofits. Assuming the same staggered implementation scenario of modernizing ~3,000 trucks annually from 2007 to 2010, staff estimates significantly greater NOx reductions (~5,000 TPY) after full implementation in 2010.

Staff estimates the costs of purchasing 12,000 2007 MY trucks (~$126,000[9] per truck) to be approximately $1.2 billion 2005 dollars using a 10 year capital recovery period. Assigning $180 million of the costs as attributable to PM reductions and the remaining

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1. [9] Listed Price for 2007 MY Volvo T780, Conventional Heavy-Duty Diesel vehicle with a 530 hp Cummins engine, tandem axle. Price listing was obtained from TruckPaper.com on March 17, 2006.

to NOx reductions, yields average annual PM and NOx cost effectiveness to be approximately $35,000 per ton and $22,000 per ton respectively over the capital recovery period. The annual weighted emission cost effectiveness using Carl Moyer Methodologies is ~$12,300 ton (using a 10 year capitol recovery period for new trucks).

A second possibility assessed was to replace all existing trucks with LNG powered vehicles. Additional financial and technical hurdles exist for this approach. Chief among these is the lack of fueling infrastructure, limited operating range, and possible incompatibility of LNG engines with some port truck duty cycles. Staff estimates the cost of an LNG powered heavy-duty truck to be ~$150,000[10]. The total cost to replace the existing 12,000 port truck fleet with new LNG powered trucks is ~$1.5 billion (2005 dollars) over a 10 year capitol recovery period. The annual fleet-wide PM emission benefits of ~520 TPY is again roughly equal to the estimated PM benefits from each of the three strategies. Staff expects NOx reductions to be somewhat greater, about 5,600 TPY after full implementation in 2010 assuming Natural Gas Engines that fully meet 2010 NOx standards are available in 2007. Again assigning $180 million of the costs as attributable to PM reductions and the remaining to NOx reductions, staff estimates the annual PM and NOx cost effectiveness to be approximately $35,000 per ton and $23,000 per ton, respectively over the capital recovery period. The annual weighted emission cost effectiveness using Carl Moyer Methodologies is ~$13,900 per ton (using a 10 year capitol recovery period for new trucks).

Overall, the cost to replace the existing fleet with new 2007 MY or LNG powered trucks is approximately 3 times the cost of strategy 3 with no appreciable differences in the annual NOx and PM reductions after full implementation.

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[10] ARB, “The Carl Moyer Program Guidelines”, 2005 Revision

VI. Implementation

Implementing a strategy to modernize the port truck fleet and reduce emissions could generate a variety of issues and industry specific concerns. The following are issues that staff has identified that would likely affect the viability of any modernization effort, and which would need to be resolved. As staff develops the modernization effort, with extensive public and industry outreach, it is likely that other issues will materialize and will require further analysis.

A. Port Truck Business Dynamics

1. Port truck owners operate on minimal profit margins. Any strategy must include a detailed analysis on the operation of port trucks and the amount of debt the owners could incur to modernize trucks. To minimize the financial impacts on port truck owners, programs would likely need to assist in the funding of the modernization effort. Potential sources of funding could come from fees assessed on port containers, or government funded incentive programs. Fees could be assessed on loaded containers only or on both loaded and empty containers. Funding could come from the Governor's bond proposal currently being developed, or through systems established by the ports.

2. Any program must account for possible movement of truck operators from the ports to other occupations to avoid program costs. Currently, port truck owners operate older, used, easier to personally maintain (less complex older engines), and inexpensive trucks. If program costs to the port truck owners are too cumbersome or expensive, truck owners may choose to pursue other aspects of trucking (where no mandated modernization efforts exist). To minimize transference, costs to the port truck owner must be kept below the 'threshold' where other occupations become attractive.

3. Used 2003 or newer trucks could become a scarce commodity with ensuing price premiums as demand grows. Trucks typically take 4-5 years to cycle from new to used and there may be later model year truck shortages early in the program if the program mandates newer replacement vehicles. A possible solution to a potential truck shortage would be to ensure any milestone replacement model year allow adequate time for the required truck to be available on the used truck market.

B. Attracting New Entrants to Port Trucking

1. Port container volume is increasing. With already limited availability of port trucks, additional analysis may explore possible economic and emission impacts of any strategy on the future availability and potential pool of port trucks. If port truck operational costs increase resulting from regulatory action, port terminals

and dispatch companies may find it necessary to increase the pay scale to attract new, and retain exiting, port trucks operators.

C. Funding Source

1. Increased container fees could encourage some diversion of container freight to ports where such fees do not exist. An analysis may account for possible diversion of business to other ports to escape container fees but at the amounts discussed in this report any such effect is expected to be very small. Container fees should be set based on a determination of the amount necessary, when combined with private funding, to accomplish the modernization effort. Port container fees could also have a sunset date.

2. Container fees could not be established except by carefully crafted State Legislation or by voluntary methods, such as a mutual agreement with the ports and terminal operators. Obtaining agreement on either approach could present significant challenges.

3. Most of the funding programs that are now in existence are voluntary and have had mixed results with participation from truck owners. Because profit margins are so low for port truck drivers, many are unwilling to assume any additional expenses when they can continue to function with their existing trucks. One option is for the ARB to establish a time period during which funding for retrofits and replacements will be available. Once the time period has ended, the truck owner would have to assume all expenses and would not be allowed to operate, or be severely restricted in their ability to continue operating in port service.

4. While public funding in the form of state general obligation bonds issued to generate revenues for a special port-related incentive program have been proposed, these bonds must still be placed on the ballot and approved by the voters. If approved at the $1 billion level, to be matched by another $1 billion in funding from other sources, these funds could provide much of the needed incentives for a truck upgrade program.

D. Implementation

1. Potential unusual situations, such as short peak demand periods, may arise and cause a shortage of qualifying port trucks. How are these non-compliant trucks to operate in light of economic / consumer impacts? A possible solution is to define times of emergency when (and by whom) port truck requirements could be temporarily suspended.

2. It is possible when owners are operating newer and more reliable replacement trucks, they might choose to operate at other venues other than ports to increase income. Restrictions may be necessary to ensure replacement trucks continue to operate at ports until program requirements are fulfilled. The most effective method to guarantee port truck owners continue to fulfill port servicing requirements may effectively ‘tie’ such requirements to funding or the ownership of the vehicle. One possible solution is to require the port truck owner to assume 100 percent of the existing financial liability with the costs being refunded over time, perhaps in the form of a per-trip credit. A minimum number of trips would be required in order to receive the full incentive payment. Another option would be to establish contracts or binding agreements with the owners/operators.

3. Ensuring only compliant trucks are in port service could present significant challenges. One possible solution could require the terminal operators to be responsible for enforcement. Under this scenario, trucks are monitored for compliance when they are processed before container pick-up or delivery.

E. Fleet Growth

1. With the expected growth in goods movement at California ports, the port truck population is expected to increase to accommodate the increase in container volume. The same issues with earnings and profits faced by existing truck owners will exist for new participants in moving cargo by truck. In order to ensure that any growth in the number of trucks at ports does not erode emission reductions obtained through replacement and retrofitting of the existing fleet, minimum emission performance requirements should be established for trucks new to port service. This could entail requiring any truck new to port service to meet certain emission standards or be equipped with certain control technologies. Another option to promote growth could be to provide some level of co-funding, similar to the existing fleet funding.

Ultimately, the final strategy, and success thereof, will require a detailed analysis of all the issues listed above.

VII. Index of Acronyms

1980 MCA	Motor Carrier Act of 1980
AB	Assembly Bill
AQMD	California Air Quality Management Districts
ARB	California Air Resources Board
ATCM	Air Toxic Control Measure
BAAQMD	Bay Area Air Quality Management District
BACT	Best Available Technology
California Ports	Port of Los Angeles, Port of Long Beach, Port of Oakland, and Port of San Diego
Cal/EPA	California Environmental Protection Agency
Caltrans	California Department of Transportation
CCR	California Code of Regulations
CE	Cost Effectiveness
Carl Moyer Program	Carl Moyer Air Quality Standards Attainment Program
CFR	Code of Federal Regulations
Chip Reflash	Heavy-duty diesel-fueled Engine Software Upgrade
CMAQ	Congestion Mitigation Air Quality
CO	Carbon Monoxide
Collaborative	West Coast Collaborative
CRF	Capital Recovery Factor
Day Cabs	Trucks without an Attached Sleeper Berth
DECS	Diesel Emission Control Strategy
Diesel PM	Diesel Particulate Matter
DMV	Department of Motor Vehicles
DRRP	Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicle”
DOC	Diesel Oxidation Catalyst
DPF	Diesel Particulate Filters
ECM	Electronic Control Module
EMFAC	Emission Factors Model
FBC	Fuel Borne Catalyst
FTF	Flow Through-Filter
g/bhp-hr	grams per brake horsepower-hour
GCCOG	Gateway Cities Council of Governments
GVWR	Gross Vehicle Weight Ratings
HC	Hydrocarbon
HDDV	Heavy-Duty Diesel Vehicle
HP	Horsepower
HSC	California Health and Safety Code
ICC	International Chamber of Commerce
MATES II	Multiple Air Toxics Exposure Study in the South Coast Basin area
MECA	Manufacturers of Emission Controls Association

MMA	Meyer, Mohaddes & Associates a consulting firm
MPH	Miles Per Hour
MY	Model Year
NADA	National Automobile Dealers Association
NAFTA	The North American Free Trade Agreement
NOx	Oxides of Nitrogen
NMHC	Non Methane Hydrocarbons
O&M	Overhead & Maintenance Including Installation
OBD	On-Board Diagnostic Systems
OEHHA	Office of Environmental Health Hazard Assessment
PMc	Combustible Particulate Matter
PMnc	Non-combustible Particulate Matter
POLA	Port of Los Angeles
POLB	Ports of Long Beach
PPM	Parts Per Million
Procedure	Diesel Emission Control Strategy Verification Procedure
RFA	Request for Applications
ROG	Reactive Organic Gases
SACAQMD	Sacramento Metropolitan Air Quality Management District
SACOG	Sacramento Area Council of Governments
SCAQMD	South Coast Air Quality Monitoring District
SECAT	Sacramento Emergency Clean Air and Transportation Program
SWCV	Solid Waste Collection Vehicle
TAC	Toxic Air Contaminant
TEU	‘Twenty-Foot Equivalent Unit’
TPD	Tons per day
TPY	Tons per year
TRU	Transport Refrigeration Unit
TRU gen set	Diesel-Powered Generator
URF	Unit risk factor
VC	California Motor Vehicle Code
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound
U.S. EPA	United States Environmental Protection Agency

VIII. References

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APPENDIX A

Emission Reduction Calculation Methodology

Appendix A

Emission Reduction Calculation Methodology

A. Introduction

In this appendix, ARB staff discusses the calculation methodology used to determine potential emission reductions from implementing the port truck strategies outlined in this report.

B. Port Truck Population and Age Distribution

1. Population of Trucks in Routine Port Service

Precise port truck population data was not available as we prepared this report. As a result, ARB staff utilized an indirect method (detailed below) to estimate the population of the port truck fleet.

ARB staff utilized Caltrans traffic data to estimate port truck population for the ports of Long Beach, Los Angeles, and Oakland. A port truck population estimated at 12,000 was derived using truck population data from the Caltrans publication "Annual Average Daily Traffic Count on the California State Highway System." The publication details actual counts of specific types of vehicles using California's roadways. ARB staff Used Caltrans traffic volume data for the major arteries servicing the ports of Long Beach, Los Angeles and Oakland (Freeways 710, 110 and 880).

Ports of Long Beach and Los Angeles

- Freeway 710: ARB staff used daily traffic value of 28,550 trips **(~14,000 each direction**) for class 8-14 trucks, at post mile 011.264 from Caltrans Highway Log.
- Freeway 110: ARB staff used daily traffic value of 12,500 trips **(~6,000 each direction**) for class 8-14 trucks, at post mile 09.87 from Caltrans Highway log.

ARB staff then added the two freeway counts together to obtain an estimated total volume of 20,000 trips per day. Assuming 2 round trips per day for an average port truck (which equates to 3-4 containers per day based on conversation with port officials), approximately 10,000 port trucks[1] operate at POLA and POLB per day.

Port of Oakland

- Freeway 880: ARB staff used daily traffic value of 14,300 trips **(~7,000 each direction**) for class 8-14 trucks, at post mile 31.091 from Caltrans Highway Log.

Freeway 880 services more than just the Port of Oakland. Therefore, staff subtracted trips generated from nearby freeways in an attempt to ferret out non-port traffic.

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[1] 20,000 trips per day/2 trips per day per truck = 10,000 trucks per day

Subtracting the 3,896 trips[2] from nearby freeways from the 14,300 trips from freeway 880, and, assuming port trucks generated 80 percent of the remaining trips (conversation with CalTrans officials), yield a result of 4,000 trips each direction from port trucks.[3]

Assuming an average port truck makes 3 trips per day (conversation with Port of Oakland officials), a total of 1,333 port trucks operate at the Port of Oakland each day using the freeway. Additionally, according to port officials, approximately 35 percent of the Port of Oakland truck fleet does not use the freeway. Combining the off and on freeway truck fleet yields a population of approximately 2,000[4] port trucks servicing the Port of Oakland.

Thus, a 2005 population of 12,000 trucks (10,000 for POLA and POLB + ~2,000 for Oakland) was derived.

2. Age Distribution

The age distribution for port trucks is based on a 2002 study by Starcrest. Starcrest surveyed ~7,200 trucks operating at three terminals at the ports of Long Beach and Los Angeles. ARB staff assumed that the average port truck age of 12.9 years (derived from Starcrest Study) will remain constant over time in this analysis. Table 1 represents projected baseline fleet age distributions.

Table1: Baseline Port Truck Fleet Age Distribution

Age Group	2005 %	2010 %	2015 %	2020 %
pre-‘88	14	3	1	0
88-‘93	36	17	3	1
94-‘02	49	62	38	12
03-‘06	1	16	30	20
07-‘09	0	2	22	23
2010+	0	0	6	44
Total	100	100	100	100

3. Population Growth

There is no data available detailing the growth in the port truck fleet compared to container volume growth. ARB staff assumed that half of the future container growth will be satisfied through port truck fleet increases and half through increases in efficiency of port operations and increased use of rail transportation. Assuming a five

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[2] 1,490 trips from I-80 and 2,406 trips from freeway 980

[3] Port trips: (14,300 – 3,896) * 0.8 = 8,323 (approximately 4,000 trips each direction)

[4] Oakland truck fleet: 1,333 trucks / .65 = 2,050 trucks (approximately 2,000 trucks)

percent fleet growth rate staff calculated an annual increase of 600 port trucks. The anticipated port truck population through 2020 is presented in Table 2.

Table 2: Estimated port truck population

Year	2005	2010	2015	2020
Number of trucks	12,000	15,000	18,000	21,000

4. Vehicle Miles Traveled

Port truck vehicle miles traveled (VMT) were calculated using the container balancing method. The method is based upon the number of inbound and outbound containers, as well as empty containers being moved out. Staff assumed that the number of containers would be balanced and the flow of ship containers would be consistent with the number of containers being moved by trucks and trains. Table 3 presents the projected VMT for ports trucks.

Table 3: Port Trucks VMT

Year	2005	2010	2015	2020
VMT	66.04	60.1	68.4	77.7

C. Baseline Emissions

ARB staff is currently in the process of developing a new version of California’s EMFAC model for estimating emissions from on-road motor vehicles. While this model is not yet complete, we included some recently available data for the trucks considered in this analysis.

At the time of this draft report, the emission inventory numbers are undergoing further review and may result in additional changes in future versions of this report. Baseline port truck emissions for 2005 were based on composite emission rates at 500,000 miles (Table 4). The weighted emission factors were calculated by multiplying the truck fleet percent of population by the composite emission rates (See Table 4).

Table 4: Baseline Emissions (2005) from Existing Port Trucks Fleet

Age Group	Population	Percent of Population (rounded)	Composite Emission Rate		Weighted Composite Emission Rate	
			NOx (g/mile)	PM (g/mile)	NOx (g/mile)	PM (g/mile)
Pre '88	1,680	14	24.00	3.11	3.26	0.42
88-'93	4,320	36	22.80	2.30	8.16	0.82
94-'02	5,880	49	21.60	1.05	10.58	0.51
03-'06	120	1	15.20	0.62	0.21	0.01
07-'09	0	0	9.17	0.09	0.00	0.00
post 2009	0	0	2.72	0.07	0.00	0.00
Total	12,000	100				
Fleet Emission Rate					22.21	1.77
Per Truck VMT		66.4	Annual Emission NOx			7075
			Annual Emissions PM			564

Baseline emissions for 2005 were calculated as follows:

Baseline NOx = VMT * Weighted Fleet Emission Rate * Number of Days * Number of Vehicles / Conversion Factors

Baseline NOx = 66.04 * 22.21 * 365 * 12,000 / 454 / 2,000 = 7075 TPY

Baseline PM = VMT * Weighted Emission Rate * Number of Days * Number of Vehicles / Conversion Factor

Baseline PM = 66.04 * 1.77 * 365 * 12,000 / 454 / 2,000 = 564 TPY

D. Expected Emission Reductions

1. PM Emission Reduction

To maximize PM emission reductions, ARB staff is proposing replacement of all trucks that can't be retrofitted with DPFs (level 3 PM emission control technologies). Since model year 1994 and later trucks meet 0.1g/bhp-hr PM emission standards and can be equipped with a DPF, all pre-1994 trucks (which do not meet 0.1g/bhp-hr PM emission standards) would have to be replaced. Assuming a typical DPF efficiency of 85 percent[5], we can expect the retrofitted port fleet to experience PM emission reductions of approximately 85 percent. Since all proposed strategies recommend replacement of

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[5] ARB – level 3 verified technologies achieve a minimum 85% emission reduction

all pre-1994 trucks and installation of DPFs, PM emission reduction for all strategies would be approximately equal.

2. NOx Emission Reduction

NOx emission reductions can be achieved through fleet modernization programs that replace the older trucks that have higher NOx emissions with newer trucks that have lower NOx emissions. Additionally, reductions can also be achieved through the use of verified reduction technologies, such as a catalyst that reduces NOx emissions by 25 percent.

E. Trucks Replacement Strategies

Strategy 1 requires the replacement of 1993 MY and older trucks with 1998 MY or newer trucks and the installation of DPFs on the entire existing fleet by 2010, as well as place emission requirements on trucks entering port service.

Strategy 2 requires the replacement of 2002 MY (NOx engine standard 4.0 g/bhp-h and 6.0 g/bhp-h) and older trucks with 2003 MY (NOx engine standard 2.5 g/bhp-h) or newer trucks and the installation of DPFs on the entire existing fleet by 2010. Strategy 2 also places the same emission requirements on trucks entering port service as strategy 1.

Strategy 3 would require the replacement of 1993 MY and older trucks with 1998 MY or newer trucks and the installation of DPFs or a DPF / NOx combination system (1994-2002 MY trucks only) on the entire existing fleet by 2010. Like the first two strategies, strategy 3 places the same emission requirements on trucks entering port service. However, strategy 3 also has a second phase which further reduces emissions starting in 2017.

Strategy 3: Phase 2

- By 2017, all pre-2003 trucks must be replaced with trucks meeting 2010 OEM engine standards.
- By 2019, all 2003-2006 existing trucks must be replaced with trucks meeting 2010 OEM engine standards.

The following requirements for trucks entering port service are applicable to all strategies.

- From 2007 – 2011 trucks must meet 2003 OEM engine standards and be equipped with a DPF.
- From 2012 – 2014 trucks must meet 2007 OEM engine standards.

- Beginning in 2015 trucks must meet 2010 OEM engine standards.

F. Emissions Benefits from Proposed Strategies

1. Strategy 1: Truck Upgrades and Emission Benefits - Existing Fleet

a. Truck Upgrades

Staff assumed the 2005 port truck age distribution (Table 1) would remain constant through the start of strategy 1 in 2007. Staff also assumed that most of the truck operators, having the knowledge of an impending funded fleet modernization program, would postpone natural fleet turnover until program implementation in 2010. Staff then assumed that the age distribution of the upgraded trucks would be heavily influenced with 2002 or older MY trucks with some 2003+ MY trucks as shown in Table 5. To determine the number of pre-1994 MY trucks that would need to be upgraded with 1998+ MY trucks, staff summed the pre-1994 MY trucks from the 2005 baseline in Table 5. To determine the number of trucks that would need to be retrofitted with DPFs, staff summed the pre-2007 MY trucks from the 2010 anticipated age distribution in Table 5.

Table 5: Strategy 1 - Age Distributions of Port Trucks after Full Implementation in 2010 - Existing Fleet

Age Group	2005 Baseline		2010		# upgrades	# DPF
	%	# trucks	%	# trucks		
pre-‘88	14	1,680	0	0		
88-‘93	36	4,320	0	0		
94-‘02	49	5,880	88	10,528	6,000	
03-‘06	1	120	10	1,200		11,728
07-‘09	0	0	2	240		
2010+	0	0	0	32		
Total	100%	12,000	100%	12,000		

b. Emission Benefits

Staff assumed the reduction in emission rates (g/mile) would be proportional to the reductions in total emissions, assuming constant miles traveled. Staff calculated the weighted (Percent of Population x Base Emission Rate) emission rates after the full implementation of strategy 1 – existing fleet (Table 6). Fleet weighted emissions rates are the sums of weighted emission rates for all age groups.

Table 6: Emission Rates after Implementation of Strategy 1 Existing Fleet

Age Group	Population	Percent of Population (rounded)	Composite Emission Rates		Weighted Composite Emission Rates	
			NOx (g/mile)	PM (g/mile)	NOx (g/mile)	PM (g/mile)
Pre '88	0	0	24.00	3.11	0.00	0.00
88 to '93	0	0	22.80	2.30	0.00	0.00
94 to '02	10,528	88	21.60	0.16	19.01	0.14
03 to '06	1,200	10	15.20	0.62	1.52	0.06
07 to '09	240	2	9.17	0.09	0.18	0.00
post 2009	32	0	2.72	0.07	0.00	0.00
Total	12,000	100				
Fleet Emission Rate					20.71	0.20

The percent difference in baseline weighted fleet emission rates (Table 4) and the strategy 1 weighted fleet emission rates (Table 6) is equal to the percent emission reductions[6]. Emission benefits from strategy 1 are presented in Table 7.

Table 7: Emission Benefits from Strategy 1 - Existing Fleet

	Base NOx (2005)	NOx (2010)	NOx Reduction	Base PM (2005)	PM (2010)	PM Reduction
Emission Rate (g/mile)	22.21	20.71	7 %	1.77	0.20	89 %
Emissions (TPY)	7,075			564		
Emission Reductions (TPY)			478			500

c. New Trucks Entering Port Service after 2006

i. From 2007-2011

For calculations purposes, ARB staff assumed that trucks entering port service in 2006 would be MY 1994-2002. From 2007-2011, trucks must meet the 2003 OEM engine standards and be equipped with DPF's.

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[6] Assuming constant miles traveled

To determine the number of pre-2003 MY trucks that would need to be replaced with 2003+ MY trucks, staff summed the pre-2003 MY trucks from the 2011 "baseline" in (Table 8).

Table 8: Number of Trucks and Age Distribution Entering Service 2007-2011 (Fleet Growth)

Age Group	2011 "Baseline"		2011 New Fleet
	%	# trucks	# trucks
pre-'88	3	89	0
88-'93	17	504	0
94-'02	62	1,852	600*
03-'06	16	486	2,918
07-'09	2	61	72
2010+	0	8	10
Total	100	3,000	3,600

*600 Trucks entering service in 2006

Emissions Benefits from Trucks Entering Port Service 2006-2011

Given the 2010-2020 "baseline" age distribution (Table 1) and composite emissions rates in g/mile, staff calculated base average weighted emission rates (Percent of Population x Base Emission Rates) for years 2010, 2015 and 2020. Using linear regression staff calculated values for the remaining years (Table 9).

Table 9: Fleet weighted Base Emission Rates in g/mile 2010 to 2020

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NOx	20.60	19.65	18.71	17.76	16.82	15.87	14.53	13.19	11.85	10.51	9.17
PM	1.24	1.13	1.03	0.92	0.82	0.71	0.63	0.55	0.48	0.40	0.32

Then, staff calculated the weighted average emission rates for the new fleet in 2011 (Table 10).

Table 10: Emission Rates from Trucks Entering Port Service through 2011

Age Group	Population	Percent Of Population	Composite Emission Rates		Weighted Composite Emission Rate	
			NOx (g/mile)	PM (g/mile)	NOx (g/mile)	PM (g/mile)
Pre '88	0	0	24.00	3.11	0.00	0.00
88-'93	0	0	22.80	2.30	0.00	0.00
94-'02	600	17	16.20	0.16	2.70	0.03
03-'06	2,918	81	15.20	0.12	12.32	0.10
07-'09	72	2	9.17	0.09	0.18	0.00
post 2009	10	0	2.72	0.07	0.01	0.00
Total	3,600	100				
Fleet Emission Rate					15.21	0.13

Emission benefits from truck upgrade versus baseline 2011

E = C * VMT * F* D / B

Where:
VMT = Vehicle Miles Traveled
B = Conversion factor from grams to tons
C = Fleet average emissions rates
D = number of trucks in the fleet
F = number of days

NOx emission benefits:

E1 = (19.65-15.21) * 61.76 * 365 * 3,600 / 454 / 2,000 = 397 TPY

PM emission benefits:

E2 = (1.13-0.13) * 61.76 * 365 * 3,600 / 454 / 2,000 = 84 TPY

ii. 2012-2014

From 2012 – 2014 trucks must meet 2007 OEM engine standard. Table 11 presents age distributions of the trucks entering port service in 2012 to 2014. To determine the number of pre-2007 MY trucks that would need to be replaced with 2007+ MY trucks, staff summed the pre-2007 MY trucks from the 2014 “baseline” in (Table 11).

Table 11: Number of Trucks and Age Distribution Entering Service 2012-2014 (Fleet Growth)

Age Group	2014 "Baseline"		2014 New Fleet
	%	# trucks	# trucks
pre-'88	1	15	0
88-'93	3	57	0
94-'02	38	687	0
03-'06	30	538	0
07-'09	22	395	1,692
2010+	6	108	108
Total	100	1,800	1,800

Emissions Benefits from Trucks Entering Port Service 2012-2014

Staff calculated the weighted average emission rates for the fleet in 2014 using the same methodology as described in section b. (Table 12).

Table 12: Emission Rates from Trucks Entering Port Service through 2012-2014

Age Group	Population	Percent Of Population	Composite Emission Rates		Weighted Composite Emission Rates	
			NOx (g/mile)	PM (g/mile)	NOx (g/mile)	PM (g/mile)
Pre '88	0	0	24.00	3.11	0.00	0.00
88-'93	0	0	22.80	2.30	0.00	0.00
94-'02	0	0	16.20	0.16	0.00	0.00
03-'06	0	0	15.20	0.12	0.00	0.00
07-'09	1,692	94	9.17	0.09	8.62	0.08
post 2009	108	6	2.72	0.07	0.16	0.00
Total	1,800	100				
Fleet Emission Rate					8.78	0.09

Emission benefits from trucks upgrade versus baseline 2014 (same methodology as described in section c-i.

NOx emission benefits:

E3= (16.82-8.78) * 66.74 * 365 * 1,800 / 454 / 2,000 = 388 TPY

PM emission benefits:

E4= (0.82-0.09) * 66.74 * 365 * 1,800 / 454 / 2,000 = 35 TPY

iii. 2015-2020

From 2015 – 2020 trucks must meet 2010 OEM engine standard. Table 13 presents age distributions of the trucks entering port service in 2015 to 2020. To determine the number of pre-2010 MY trucks that would need to be replaced with 2010+ MY trucks, staff summed the pre-2010 MY trucks from the 2020 “baseline” in (Table 13).

Table 13: Number of Trucks and Age Distribution Entering Service 2015-2020 (Fleet Growth)

Age Group	2020 "Baseline"		2020 New Fleet
	%	# trucks	# trucks
pre-'88	0	0	0
88-'93	1	37	0
94-'02	12	449	0
03-'06	20	722	0
07-'09	23	816	0
MY 2010+	44	1,573	3,600
Total	100%	3,600	3,600

Emissions Benefits from Trucks Entering Port Pervice 2015-2020

Staff calculated the weighted average emissions rates for the fleet in 2020 using the same methodology as described in section b (Table 14).

Table 14: Emission Rates from Trucks Entering Port Service through 2015-2020

Age Group	Population	Percent Of Population	Composite Emission Rates		Weighted Composite Emission Rates	
			NOx (g/mile)	PM (g/mile)	NOx (g/mile)	PM (g/mile)
Pre '88	0	0	24.00	3.11	0	0
88-'93	0	0	22.80	2.30	0	0
94-'02	0	0	16.20	0.16	0	0
03-'06	0	0	15.20	0.12	0	0
07-'09	0	0	9.17	0.09	0	0
post 2009	3,600	100	2.72	0.07	2.72	0.07
Total	3,600	100				
Fleet Emission Rate					2.72	0.07

Emission benefits from trucks upgrade versus baseline 2020 (same methodology as described in section c- i.

NOx emission benefits:

E5 = (9.17-2.72) * 77.7 * 365 * 3,600 / 454 / 2,000 = 725 TPY

PM emission benefits:

E6 = (0.32-0.07) * 77.7 * 365 * 3,600 / 454 / 2,000 = 28 TPY

2. Strategy 2: Truck Upgrades and Emission Benefits - Existing Fleet

a. Truck Upgrades

Staff assumed that the 2005 port truck age distribution (Table 1) would remain constant through the start of strategy 2 in 2007. Staff again assumed that most of the truck operators, having the knowledge of an impending funded fleet modernization program, would postpone natural fleet turnover until program implementation by 2010. Staff then assumed that the age distribution of the upgraded trucks would be heavily weighted with 2003 MY trucks with some 2007+ MY trucks as shown in Table 15. To determine the number of pre-2003 MY trucks that would need to be replaced with 2003+ MY trucks, staff summed the pre-2003 MY trucks from the 2005 baseline in Table 15. To determine the number of trucks that would need to be retrofitted with DPFs, staff summed the pre-2007 MY trucks from the 2010 anticipated age distribution in Table 15.

Table 15: Strategy 2 - Age Distributions of Port Trucks after Full Implementation Existing Fleet

Age Group	2005 Baseline		2010		# upgrades	# DPF
	%	# trucks	%	# trucks		
pre-'88	14	1,680	0	0	11,728	11,728
88-'93	36	4,320	0	0		
94-'02	49	5,880	0	0		
03-'06	1	120	98	11,728		
07-'09	0	0	2	240		
2010+	0	0	0	32		
Total	100	12,000	100%	12,000		

b. Emission Benefits

Again, staff assumed the reduction in emission rates (g/mile) would be proportional to the reductions in total emissions, assuming constant miles traveled. Staff calculated the weighted (Percent of Population x Base Emission Rate) emission rates after the full implementation of strategy 2 – existing fleet (Table 16). Fleet weighted emissions rates are the sums of weighted emission rates for all age groups.

Table 16: Emission Rates after Implementation of Strategy 2 - Existing Fleet

Age Group	Population	Percent of Population (rounded)	Weighted Emission Rates		Composite Weighted Emission Rates	
			NOx (g/mile)	PM (g/mile)	NOx (g/mile)	PM (g/mile)
Pre '88	0	0	24.00	3.11	0.00	0.00
88-'93	0	0	22.80	2.30	0.00	0.00
94-'02	0	0	21.60	0.16	0.00	0.00
03-'06	11,728	98	15.20	0.12	14.86	0.12
07-'09	240	2	9.17	0.09	0.18	0.00
post 2009	32	0	2.72	0.07	0.00	0.00
Total	12,000	100				
Fleet Emission Rate					15.04	0.12

The percent difference in baseline weighted fleet emission rates (Table 4) and the strategy 2 weighted fleet emission rates (Table 16) is equal to the percent emission reductions[7]. Emission benefits from strategy 2 are presented in Table 17.

Table 17: Emission Benefits from Strategy 2 - Existing Fleet

	Base NOx (2005)	NOx (2010)	NOx Reduction	Base PM (2005)	PM (2010)	PM Reduction
Emission Rate (g/mile)	22.21	15.04	32 %	1.77	0.12	93 %
Emissions (TPY)	7,075			564		
Emission Reductions (TPY)			2,285			525

c. New Trucks Entering Port Service after 2006

Since the new trucks entering port service after 2006 for all strategies have to meet the same requirements, the emission benefits from the new fleet would be equal (see section 1-c-i-ii-iii.

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[7] Assuming constant miles traveled

3. Strategy 3: Truck Upgrades and Emission Benefits - Existing Fleet

a. Truck Upgrades

Staff assumed the 2005 port truck age distribution (Table 1) would remain constant through the start of Strategy 3 in 2007. Staff assumed that most of the truck operators, having the knowledge of an impending funded fleet modernization program, would postpone natural fleet turnover until program implementation by 2010. Staff then assumed that the age distribution of the upgraded trucks would be heavily weighted with 2002 or older MY trucks with some 2003+ MY trucks as shown in Table 18. To determine the number of pre-1994 MY trucks that would need to be replaced with 1998+ MY trucks, staff summed the pre-1994 MY trucks from the 2005 baseline in Table 18. To determine the number of trucks that would need to be retrofitted with DPFs, staff summed the 2003-2006 MY trucks from the 2010 anticipated age distribution in Table 18. To determine the number of trucks that would need to be retrofitted with DPFs / NOx systems, staff summed the 1994-2002 MY trucks from the 2010 anticipated age distribution in Table 18.

Table 18: Strategy 3 - Age Distributions of Port Trucks after Full Implementation Existing Fleet

Age Group	2005 Baseline		2010		# upgrades	# DPF	# DPF+ NOx
	%	# trucks	%	# trucks			
pre-'88	14	1,680	0	0			
88-'93	36	4,320	0	0			
94-'02	49	5,880	88	10,528	6,000		10,528
03-'06	1	120	10	1,200		1,200	
07-'09	0	0	2	240			
2010+	0	0	0	32			
Total	100	12,000	100	12,000			

b. Emission Benefits

Again, staff assumed the reduction in emission rates (g/mile) would be proportional to the reductions in total emissions, assuming constant miles traveled. Staff calculated the weighted (Percent of Population x Base Emission Rate) emission rates after the full implementation of strategy 3 – existing fleet (Table 19). Fleet weighted emissions rates are the sums of weighted emission rates for all age groups.

Table 19: Emission Rates after Implementation of Strategy 3
Existing Fleet

Age Group	Population	Percent Of Population	Weighted Emission Rates		Weighted Composite Emission Rates	
			NOx (g/mile)	PM (g/mile)	NOx (g/mile)	PM (g/mile)
Pre '88	0	0	24.00	3.11	0.00	0.00
88-'93	0	0	22.80	2.30	0.00	0.00
94-'02	10,528	88	16.20	0.16	14.21	0.14
03-'06	1,200	10	15.20	0.12	1.52	0.01
07-'09	240	2	9.17	0.09	0.18	0.00
post 2009	32	0	2.72	0.07	0.00	0.00
Total	12,000	100				
Fleet Emission Rate					15.92	0.15

The difference in baseline weighted fleet emission rates (Table 4) and the strategy 3 weighted fleet emission rates (Table 19) is equal to the percent emission reductions[8] (Table 20).

Table 20: Emission Benefits from Strategy 3
Existing Fleet

	Base NOx (2005)	NOx (2010)	NOx Reduction	Base PM (2005)	PM (2010)	PM Reduction
Emission Rate (g/mile)	22.21	15.92	28%	1.77	0.15	91%
Emissions (TPY)	7,075			564		
Emission Reductions (TPY)			2,006			516

Using the same methodology as described above to determine emission benefits for the Strategy 3 existing fleet in 2010; staff calculated the emission benefits from existing fleet in 2015 and 2020 (Table 21).

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[8] Assuming constant miles traveled

Table 21: Emission Benefits from Strategy 3 Existing Fleet in 2015 and 2020

	Base NOx (2005)	NOx (2015)	NOx (2020)	NOx Reduction (2015)	NOx Reduction (2020)	Base PM (2005)	PM (2015)	PM (2020)	PM Reduction (2015)	PM Reduction (2020)
Emission Rate (g/mile)	22.21	14.13	4.07	36%	81%	1.77	0.13	0.10	93%	94%
Emissions (TPY)	7,075					564				
Emission Reductions (TPY)				2,574	5,779				523	532

d. Strategy 3: Phase 2 Emission Benefits

Phase 2 of strategy 3 requires accelerated fleet turn over:

- By 2017, all pre-2003 port trucks must be replaced with trucks meeting 2010 OEM engine standards.
- By 2019, all 2003-2006 port trucks must be replaced with trucks meeting 2010 OEM engine standards.

Staff estimates no additional PM benefits from this effort as all trucks are currently equipped with DPFs from Phase 1. Phase 2 would provide additional NOx emission benefits. The port truck fleet would have approximately 25% meeting MY 2007 engine standards and 75% of the fleet meeting 2010 MY engine standards.

To determine the overall emission benefits, staff calculated NOx emission benefits from natural fleet turnover for 2005 – 2020 (base emission reductions – Table 22). Then, staff calculated the NOx emission benefits for 2005 – 2020 for strategy 3 phase 2 implementation.

Total emission reductions from phase 2 of 1,154 TPY in 2017 and 3,576 TPY in 2020 were calculated by subtracting the base emission reductions from phase 2 emissions reductions and adding emission benefits from trucks entering port service (2006 – 2020).

Table 22: Strategy 3: Phase 2 - NOx Emission Benefits

Base Emission Reductions						
	2015	**2016**	**2017**	**2018**	**2019**	**2020**
Reductions NOx (TPY)	2,006	2431	2855	3280	3704	4,129
Strategy 3 - Phase 2 Emission Reductions						
	2015	2016	2017	2018	2019	2020
Reductions NOx (TPY)	2558	3195	3832	4469	5106	5743
12,000 Existing Fleet Benefits			977			1,614
New Port Fleet Benefits			177			1,962
Total Fleet Reductions NOx (TPY)			1,154			3,576

c. New Trucks Entering Port Service after 2006

Since the new trucks entering port service after 2006 for all strategies have to meet the same requirements, the emission benefits from the new fleet would be equal (see section 1-c-i-ii-iii.

APPENDIX B

Vehicle Costs and Cost Methodology

Appendix B

Vehicle Costs and Cost Methodology

A. Introduction

This Appendix discusses the costs associated with replacing and retrofitting on-road, Class 8 (GVWR > 33,000 lbs), heavy duty diesel vehicles (HDDV) operating at California's ports. The analysis begins with a discussion on the 2005 California Used HDDV market, and the price forecasting model developed to predict used port truck replacement costs when older model year port trucks are being replaced with newer model year vehicles.

The discussion of the used HDDV market is followed by a generalized discussion on cost methodology. Staff then determined truck modernization costs and the cost effectiveness for each of the three strategies. Finally, staff estimated container fees needed to fund each of the three strategies and the cost effectiveness using Carl Moyer methodologies.

B. Analysis of the 2005 California Used HDDV Market

In this section of the Appendix, values of used port trucks are forecasted using a trend line established from sample price data for HDDVs available for sale in California and the neighboring (~ 5 percent of listings) States of Arizona and Nevada. Projected prices are used to determine port truck replacement costs for each of the three strategies.

The marketplace of HDDVs consists of several types of HDDVs. These include, but are not limited to: beverage trucks, car carriers, crane trucks, concrete mixers, dump trucks, flatbed trucks, fire trucks, van trucks, and refuse haulers. However, only specific class 8 HDDVs are capable of hauling containers at ports. These were considered for developing program costs. Other HDDVs which are not typically engaged in the transport of containers were excluded from this analysis.

In selecting sample criteria to develop the vehicle age-price distribution profile, ARB staff surveyed an internet site (TruckPaper.com, 2005) where listings of HDDVs for sale in California and the neighboring states are consolidated. Class 8 HDDVs with GVWR > 33,000 pounds, with or without sleeper cabins, were selected. Of the 130 used and new HDDV qualified listings, 80 (62 percent) were equipped with sleeper cabins, and 50 (38 percent) were not equipped sleeper cabins. Since many of the on-road HDDV operators engaged in the transport of containers at California Ports operate short haul routes, ARB staff determined that including trucks without sleeper cabins in the search criteria was appropriate. Listed prices for vehicles obtained were for tractors only as trailers at California's ports are typically supplied by the terminal. Data from the 2005 California Used HDDV Market Survey is presented in Table 1:

Table 1: Data from the 2005 California Used HDDV Market Survey

MODEL YEAR	MAKE	ENGINE	HP	HDV TYPE	LISTED MILEAGE	LIST PRICE
4/18/2005 Data						
1994	Freightliner	Cummins	370	HDD Conventional, Sleeper		$ 14,900
1995	International	Cummins	280	HDD Conventional	375,938	$ 17,431
1995	Peterbilt	Caterpillar	500	HDD Conventional, Sleeper	898,000	$ 27,950
1996	Freightliner	Cummins	330	HDD Conventional	320,806	$ 20,950
1996	Freightliner	Cummins	330	HDD Conventional, Sleeper	292,036	$ 20,950
1996	Freightliner	Cummins	350	HDD Conventional	296,095	$ 24,450
1996	International	Detroit Diesel	430	HDD Conventional		$ 16,500
1996	International	Detroit Diesel	470	HDD Conventional	771,635	$ 18,500
1996	International	Cummins	370	HDD Conventional	672,108	$ 20,353
1996	Peterbilt	Caterpillar	380	HDD Conventional		$ 35,500
1997	Freightliner	Cummins	370	HDD Conventional, Sleeper	498,725	$ 23,825
1997	Freightliner	Detroit Diesel	400	HDD Conventional	440,000	$ 24,500
1997	Freightliner	Cummins	330	HDD Conventional	449,031	$ 24,575
1997	Freightliner	Cummins	250	HDD Conventional	129,255	
1997	Freightliner	Detroit Diesel	400	HDD Conventional, Sleeper	767,173	
1997	Peterbilt	Cummins	400	HDD Conventional		$ 32,500
1997	Peterbilt	Cummins	435	HDD Conventional, Sleeper		$ 38,500
1997	Peterbilt	Caterpillar	410	HDD Conventional	590,000	
1998	Freightliner	Cummins	330	HDD Conventional, Sleeper	828,169	$ 14,585
1998	Freightliner	Cummins	330	HDD Conventional, Sleeper	93,937	$ 15,500
1998	Freightliner	Cummins	330	HDD Conventional	713,382	$ 19,950
1998	Freightliner	Cummins	370	HDD Conventional		$ 21,500
1998	Freightliner	Cummins	435	HDD Conventional, Sleeper	709,282	$ 27,382
1998	Freightliner	Cummins	330	HDD Conventional	385,827	$ 27,475
1998	Freightliner	Cummins	330	HDD Conventional	279,626	$ 27,475

1998	Freightliner	Cummins	330	HDD Conventional	307,848	$ 27,475
1998	Freightliner	Cummins	370	HDD Conventional, Sleeper	586,114	$ 29,364
1998	Freightliner	Detroit Diesel	400	HDD Conventional	515,000	$ 32,500
1998	Freightliner	Detroit Diesel	400	HDD Conventional	350,000	$ 32,500
1998	Freightliner	Detroit Diesel	430	HDD Conventional	435,000	$ 32,500
1998	International	Cummins	350	HDD Conventional	634,524	$ 21,021
1998	International	Cummins	350	HDD Conventional	575,044	$ 25,223
1998	International	Cummins	280	HDD Conventional	403,634	$ 30,225
1998	Mack	Mack	350	HDD Conventional	358,914	$ 31,725
1998	Peterbilt	Cummins	400	HDD Conventional		$ 39,500
1999	Freightliner	Cummins	370	HDD Conventional	856,385	$ 18,194
1999	Freightliner	Cummins	370	HDD Conventional	781,373	$ 19,353
1999	Freightliner	Cummins	350	HDD Conventional	675,533	$ 20,900
1999	Freightliner	Cummins	350	HDD Conventional	722,844	$ 20,905
1999	Freightliner	Cummins	350	HDD Conventional	705,148	$ 21,557
1999	Freightliner	Cummins	350	HDD Conventional	647,255	$ 23,702
1999	Freightliner	Cummins	350	HDD Conventional	638,567	$ 24,021
1999	Freightliner	Cummins	350	HDD Conventional	678,336	$ 24,195
1999	Freightliner	Cummins	350	HDD Conventional	627,203	$ 24,443
1999	Freightliner	Cummins	370	HDD Conventional, Sleeper	648,187	$ 26,426
1999	Freightliner	Cummins	350	HDD Conventional	571,557	$ 26,471
1999	Freightliner	Cummins	370	HDD Conventional, Sleeper	553,836	$ 27,750
1999	Freightliner	Detroit Diesel	400	HDD Conventional		$ 28,000
1999	Freightliner	Detroit Diesel	360	HDD Conventional		$ 34,500
1999	Freightliner	Detroit Diesel	500	HDD Conventional, Sleeper		$ 37,500
1999	Freightliner	Detroit Diesel	430	HDD Conventional	185,000	$ 41,900
1999	International	Cummins	350	HDD Conventional	462,645	$ 27,769
1999	Kenworth	Cummins	370	HDD Conventional, Sleeper	515,000	$ 29,750

1999	Mack	Mack	310	HDD Conventional	820,141	$ 20,875
1999	Peterbilt	Cummins	370	HDD Conventional, Sleeper		$ 38,500
1999	Peterbilt	Caterpillar	435	HDD Conventional, Sleeper		$ 43,500
1999	Peterbilt	Cummins	370	HDD Conventional, Sleeper	591,000	$ 45,500
2000	Freightliner	Cummins	370	HDD Conventional, Sleeper	732,188	$ 24,066
2000	Freightliner	Cummins	370	HDD Conventional, Sleeper	780,223	$ 24,635
2000	Freightliner	Cummins	435	HDD Conventional, Sleeper	423,192	$ 36,950
2000	Kenworth	Cummins	460	HDD Conventional, Sleeper	495,601	$ 41,150
2000	Kenworth	Caterpillar	435	HDD Conventional		$ 44,500
2000	Peterbilt	Caterpillar	475	HDD Conventional, Sleeper	577,000	$ 54,900
2001	Freightliner	Caterpillar	475	HDD Conventional, Sleeper	431,578	$ 47,950
2001	Freightliner	Detroit Diesel	470	HDD Conventional, Sleeper	351,227	$ 49,950
2001	Freightliner	Detroit Diesel	470	HDD Conventional, Sleeper	351,227	$ 49,950
2001	Freightliner	Detroit Diesel	470	HDD Conventional, Sleeper	408,637	
2001	Kenworth	Cummins	460	HDD Conventional, Sleeper		$ 43,900
2001	Kenworth	Cummins	500	HDD Conventional, Sleeper	511,000	$ 46,500
2001	Peterbilt	Cummins	410	HDD Conventional		$ 43,500
2001	Peterbilt	Caterpillar	500	HDD Conventional, Sleeper		$ 52,500
2003	Peterbilt	Caterpillar	410	HDD Conventional		$ 57,500
2003	Peterbilt	Caterpillar	430	HDD Conventional		$ 82,500
2004	Peterbilt	Caterpillar	430	HDD Conventional		$ 83,500
2005	International	Caterpillar	430	HDD Conventional, Sleeper		$ 79,740
2005	Peterbilt	Caterpillar	475	HDD Conventional, Sleeper	-	$ 99,999
7-28-05 DATA						
1994	Freightliner	Detroit Diesel	470			$ 9,500
1994	Freightliner	Detroit Diesel	360			$ 17,500
1994	Freightliner	Detroit Diesel	360			$ 17,500
1994	Freightliner	Detroit Diesel	360			$ 17,500

1994	Freightliner	Detroit Diesel	360			$ 17,500
1995	Freightliner	Cummins	435	HDD Conventional, Sleeper		$ 9,500
1995	Freightliner	Cummins	365	HDD Conventional, Sleeper	900,000	$ 11,000
1996	International	Cummins	370	HDD Conventional, Sleeper		$ 9,000
1997	International	Caterpillar	410	HDD Conventional, Sleeper		$ 23,000
1999	Freightliner	Detroit Diesel	430	HDD Conventional, Sleeper	625,000	$ 28,500
2000	Freightliner	Detroit Diesel	430	HDD Conventional, Sleeper	488,369	
2000	Freightliner	Detroit Diesel	500	HDD Conventional, Sleeper		$ 36,500
2000	Freightliner	Detroit Diesel	500	HDD Conventional, Sleeper		$ 36,500
2000	Freightliner	Detroit Diesel	500	HDD Conventional, Sleeper		$ 36,500
2000	Freightliner	Detroit Diesel	430	HDD Conventional, Sleeper	500,000	$ 42,500
2000	Freightliner	Detroit Diesel	430	HDD Conventional, Sleeper	500,000	$ 42,500
2000	Freightliner	Detroit Diesel	430	HDD Conventional, Sleeper	500,000	$ 42,500
2002	Peterbilt	Caterpillar	475	HDD Conventional, Sleeper	528,087	
2004	Volvo	Volvo	465	HDD Conventional, Sleeper	119,000	
8-30-05 Data						
2006	Freightliner	Caterpillar	475	HDD Conventional, Sleeper	-	$ 95,000
2006	Freightliner	Caterpillar	475	HDD Conventional, Sleeper	-	$ 95,000
2006	Freightliner	Caterpillar	475	HDD Conventional, Sleeper	-	$ 95,000
2006	Volvo	Cummins	530	HDD Conventional, Sleeper		$ 119,995
2006	Volvo	Cummins	475	HDD Conventional, Sleeper		$ 109,995
2006	Volvo	Cummins	530	HDD Conventional, Sleeper		$ 106,612
2006	Freightliner	Detroit Diesel	515	HDD Conventional, Sleeper	-	$ 107,000
2006	Freightliner	Caterpillar	475	HDD Conventional, Sleeper	-	$ 95,000
2006	Freightliner	Detroit Diesel	515	HDD Conventional, Sleeper	-	$ 92,500
2006	Volvo	Cummins	530	HDD Conventional, Sleeper		$ 119,995
2006	Volvo	Cummins	475	HDD Conventional, Sleeper		$ 109,995
2006	Volvo	Cummins	530	HDD Conventional, Sleeper		$ 123,995

2005	Peterbilt	Caterpillar	435	HDD Conventional, Sleeper		$ 89,900
2005	Freightliner	Detroit Diesel	500	HDD Conventional, Sleeper		$ 84,900
2005	Kenworth	Caterpillar	475	HDD Conventional, Sleeper		$ 99,500
2004	Peterbilt	Caterpillar	475	HDD Conventional, Sleeper		$ 76,000
2004	Kenworth	Caterpillar	475	HDD Conventional, Sleeper		$ 75,000
2004	Kenworth	Caterpillar	475	HDD Conventional, Sleeper		$ 75,000
2004	Peterbilt	Caterpillar	475	HDD Conventional, Sleeper		$ 89,500
2004	Kenworth	Caterpillar	475	HDD Conventional, Sleeper		$ 75,500
2004	Freightliner	Detroit Diesel	500	HDD Conventional, Sleeper		$ 109,000
2004	Freightliner	Caterpillar	475	HDD Conventional, Sleeper		$ 92,500
2003	Kenworth	Cummins	475	HDD Conventional, Sleeper		$ 83,500
2003	Freightliner	Detroit	500	HDD Conventional, Sleeper		$ 42,000
2003	Freightliner	Detroit	470	HDD Conventional, Sleeper		$ 49,900
2003	Freightliner	Detroit	500	HDD Conventional, Sleeper		$ 62,500
2003	Freightliner	Detroit	500	HDD Conventional, Sleeper		$ 66,000
2003	Kenworth	Cummins	400	HDD Conventional, Sleeper		$ 56,900
2003	Kenworth	Cummins	400	HDD Conventional, Sleeper		$ 58,500
2003	Kenworth	Cummins	450	HDD Conventional, Sleeper		$ 67,000
2003	Peterbilt	Caterpillar	475	HDD Conventional, Sleeper		$ 78,000
2003	Peterbilt	Caterpillar	550	HDD Conventional, Sleeper		$ 87,500
2003	Volvo	Cummins	500	HDD Conventional, Sleeper		$ 89,500
2002	Freightliner	Detroit	470	HDD Conventional, Sleeper		$ 49,999
2002	Freightliner	Detroit	430	HDD Conventional, Sleeper		$ 55,950
Total Number of Sample Points			**130**			

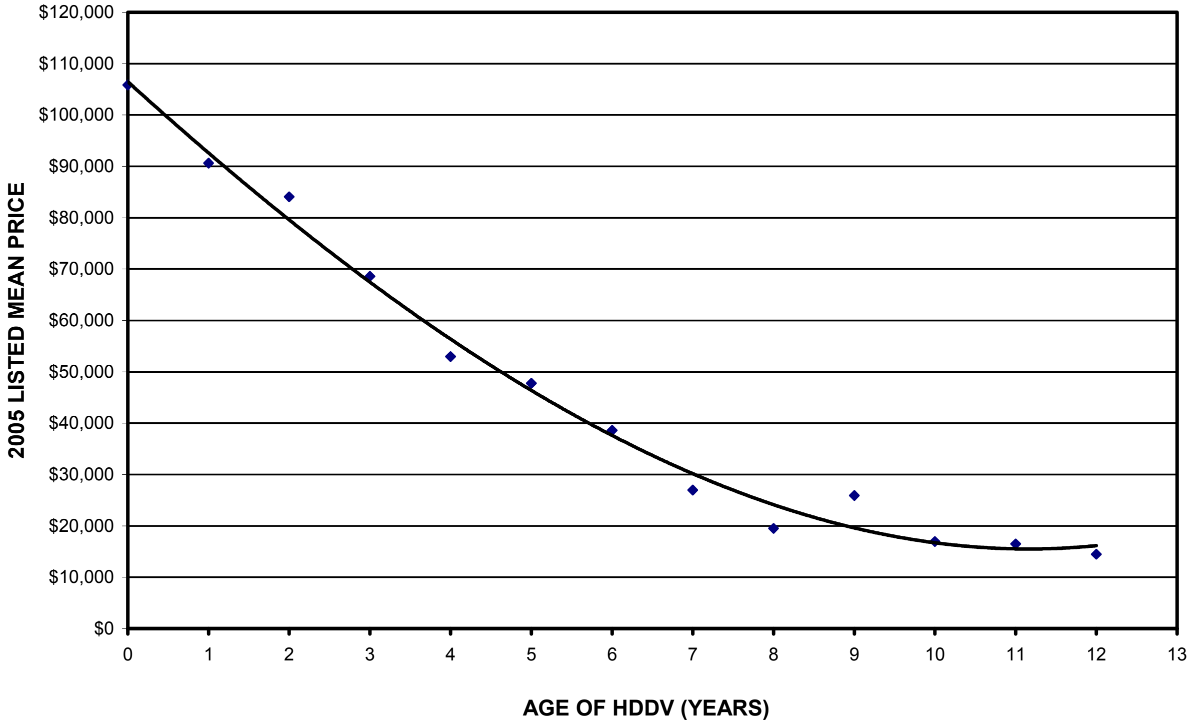
1. 2005 Used HDDV Prices and Forecasts of Prices for Program Years

The above internet survey was used to develop a vehicle age-price distribution profile for the year 2005. ARB staff further assumed that the value of a used port truck established in 2005 will be an average value derived from the survey results. The used

HDDV value may differ depending on unforeseen fluctuations in market demand and prevailing economic conditions.

To determine the HDDV average value, price listings were grouped by model year and a mean price for each model year was developed. ARB staff then used the mean price to develop a trend line for used HDDVs based on the age of the vehicle. Figure 1 below depicts this trend line developed from the survey.

Figure 1: 2005 California Used Truck Price-Age Distribution Profile from Survey



C. Cost Methodology – Common Methodologies and Assumptions for all Three Strategies

Staff determined program strategy costs assuming a capital recovery period of 10 years to correspond with staff's estimation that replacement trucks will be in port service for at least 10 additional years after purchase. The capital recovery analysis used a 5 percent discount rate for consistency with ARB's cold ironing analysis. The individual strategy program costs were developed annually until the end of the capital recovery period and then brought back into present value 2005 dollars using a rate of 7 percent (which includes a cost of money factor of 2 percent). The annual costs during the capital recovery period were then added up for total program costs (present value 2005 dollars). Additionally, annual program costs were combined with estimated annual emission benefits for each phase within each of the three strategies to estimate the cost effectiveness. Lastly, total program costs were combined with estimated port container import volumes through 2015 to estimate container fees needed to fund the modernization of the existing fleet of 12,000 port trucks.

1. Annualized Costs

Annualized Costs = Program Costs x Capital Recovery Factor

The capital recovery factor (CRF) can be derived from the following equation by assuming a discount rate, (i), per period, and the number of compounding periods, (n). The number of compounding periods (n) corresponds to the project life of the strategy:

$$\text{Capital Recovery Factor (CRF)} = \frac{(i) * (1 + i)^n}{(1 + i)^n - 1}$$

Where:
i = 5 percent discount rate
n = 10 year capital recovery period

ARB staff estimated that retrofit and replacement costs of California Port trucks would each have a project life of 10 years, and the prevailing discount rate would be 5 percent. Assuming a 5 percent discount rate (i) scenario, and a 10 year project life (n), the CRF is calculated using the above equation and found to be ~0.1295.

The annualized cost is obtained from the product of the capital recovery factor and the individual strategy cost estimate for its program cost.

2. Present Value

Once the annualized costs are determined, they are then brought back into present value 2005 year costs, as the 2006 calendar year is not yet over. The present value formula is as follows.

$$\text{Present Value (PV)} = \frac{\text{Annual Costs}}{(1 + i)^n}$$

Where:
i = 7 percent discount rate (which includes a 2 percent cost of money factor)
n = Years into the future

3. Cost Effectiveness

The cost effectiveness (CE) measure permits a direct comparison of one strategy with another. Annualized costs and annual emission reductions are used to determine the cost effectiveness of each strategy as show by the following formula.

$$\text{Cost Effectiveness (\$ / Ton)} = \frac{\text{Annualized costs (\$ / Yr)}}{\text{Annual Emission Reductions (Tons / Yr)}}$$

The annualized cost is the amortization (capital recovery) of the individual strategy costs in present value 2005 dollars divided by the annual emissions reduced. All strategies assume a staggered implementation scenario. In years where only a portion of the fleet modernization costs are represented, only the corresponding portion of emission reductions are used to determine the cost effectiveness. This will result in a per-truck cost effectiveness comparison. Also, the cost effectiveness is determined for each pollutant and given in an annual range over the capital recovery period and finally stated as an average of the annual cost effectiveness values.

4. Per-Container Costs

Should funding be needed for port truck modernization efforts, staff analyzed the possible scenario of obtaining funding through an assessment on containers at the ports. One possible approach would levy a fee on all incoming containers bound for port truck transport. Staff obtained data from the “Goods Movement Action Plan: Phase 1”[1] detailing the actual and estimated TEU[2] volumes at the ports of Long Beach (POLB), Los Angeles (POLA) and Oakland in the years 2005, 2010, and 2020. Staff then assumed a linear series between each of the years 2005 - 2010 and 2010 - 2020 to obtain estimated TEU volumes for each year from 2005 – 2020 as shown in Table 2.

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[1] Prepared by Business, Transportation and Housing Agency & CAL/EPA

[2] TEU stands for ‘Twenty Foot Equivalent Unit’.

Table 2: Estimated and Actual TEU Volumes for Ports of Los Angeles, Long Beach, and Oakland (2005 – 2020) (millions)

Year	OAKLAND	POLA & POLB
2005	2.2	14.5
2006	2.7	15.5
2007	3.1	16.6
2008	3.6	17.6
2009	4.0	18.7
2010	4.5	19.7
2011	4.7	21.3
2012	4.8	22.9
2013	4.9	24.6
2014	5.1	26.2
2015	5.3	27.9
2016	5.4	29.5
2017	5.6	31.1
2018	5.7	32.7
2019	5.9	34.4
2020	6.0	36.0

As this analysis will discus some costs on a per-container basis, staff converted TEUs into containers. This conversion utilized Pacific Maritime Association information detailing the amount and lengths of containers entering each of the three ports in 2004 (Table 3: Highlighted Information).

Table 3: Container and TEU Volumes by Port in 2004

	Container Lengths			Total
	20 foot	40 foot	45 foot	
POLB	350,014	1,221,366	79,732	1,651,112
POLA	463,230	1,649,877	164,784	2,277,891
Oakland	120,645	334,630	17,754	473,029
Total Containers	933,889	3,205,873	262,270	4,402,032
Container to TEU Conversion Factor	1.00	2.00	2.25	
Total TEUs	933,889	6,411,746	590,108	7,935,743

The TEU-to-container conversion factor was derived from the definition of a TEU being equivalent to a 20 foot container. Thus, a 40 foot container would be equivalent to 2

TEUs and a 45 foot container is the equivalent of 2.25 TEUs. The TEU conversion factor of 0.55 (rounded) is derived by dividing total containers (4,402,032) by total TEUs (7,935,743).

Staff then converted the TEUs in Table 2 into containers. To obtain the total incoming containers transported by truck, staff assumed half the containers are incoming and half outgoing. All of the containers at the port of Oakland and 75 percent of the containers at POLA & POLB are transported by truck[3]. Multiplying the Port of Oakland containers by 0.5 and POLB & POLA containers by 0.5 and 0.75 yields the estimated imported containers transported by truck. Staff then summed the annual imported containers to determine the 2007-2020 total imported containers (Table 4).

Table 4: Estimated Yearly Imported Trucked Containers (millions)

Year	Containers Oakland	Containers POLA, POLB	Trucked Imported Containers
2007	1.7	9.1	4.3
2008	1.9	9.7	4.6
2009	2.2	10.3	4.9
2010	2.5	10.8	5.3
2011	2.6	11.7	5.7
2012	2.6	12.6	6.1
2013	2.7	13.5	6.4
2014	2.8	14.4	6.8
2015	2.9	15.3	7.2
2016	2.9	16.2	7.6
2017	3.1	17.1	7.9
2018	3.1	18.0	8.3
2019	3.2	18.9	8.7
2020	3.3	19.8	9.1
2007-2015 Totals (Rounded)			51
2007-2020 Totals (Rounded)			93

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[3] Conversations with port officials

D. Program Costs for the Proposed Strategies

1. Strategy 1

Program costs for strategy 1 consists of costs to modernize trucks entering port service and costs to modernize the existing fleet.

a. Existing Fleet

Strategy 1 requires the existing port fleet of 12,000 trucks to be retrofitted with DPFs for PM reduction. As DPFs can only be retrofitted to 1994+ MY trucks, staff estimates ~ 6,000 trucks will have to be replaced (See Appendix A). Staff will assume the replacement trucks to be 1998+ MY to avoid chip reflash concerns. Staff further assumes 11,800 DPFs will be retrofitted to the existing fleet (See Appendix A). Annual PM and NOx emissions reductions are estimated to be 500 TPY and 480 TPY respectively (See Appendix A). Staff will assume the older pre-1994 MY trucks that are replaced have little intrinsic value due to age and wear and will be destroyed to ensure these trucks do not end up operating (and polluting) in California again. The cost ($16,000) of the 10 year old replacement truck is again derived from the used truck price distribution profile (Figure 1). Also, the replacement truck value will be assumed to be constant over the implementation period as with previous analysis. Tables 5 and 6 show the annual capital recovery of replacement truck costs and DPF retrofits costs, respectively.

Table 5: Strategy 1 – Existing Fleet Truck Replacement Costs
10 Year Capital Recovery Period

Capital Recovery Year	2007	2008	2009	2010	Annual Total	Present Value 2005 dollars
2007	$3,108,109.80				$3,108,109.80	$ 2,904,775.51
2008	$3,108,109.80	$3,108,109.80			$6,216,219.60	$ 5,429,486.94
2009	$3,108,109.80	$3,108,109.80	$3,108,109.80		$9,324,329.40	$ 7,611,430.29
2010	$3,108,109.80	$3,108,109.80	$3,108,109.80	$3,108,109.80	$12,432,439.20	$ 9,484,648.34
2011	$3,108,109.80	$3,108,109.80	$3,108,109.80	$3,108,109.80	$12,432,439.20	$ 8,864,157.32
2012	$3,108,109.80	$3,108,109.80	$3,108,109.80	$3,108,109.80	$12,432,439.20	$ 8,284,259.18
2013	$3,108,109.80	$3,108,109.80	$3,108,109.80	$3,108,109.80	$12,432,439.20	$ 7,742,298.30
2014	$3,108,109.80	$3,108,109.80	$3,108,109.80	$3,108,109.80	$12,432,439.20	$ 7,235,792.80
2015	$3,108,109.80	$3,108,109.80	$3,108,109.80	$3,108,109.80	$12,432,439.20	$ 6,762,423.18
2016	$3,108,109.80	$3,108,109.80	$3,108,109.80	$3,108,109.80	$12,432,439.20	$ 6,320,021.67
2017		$3,108,109.80	$3,108,109.80	$3,108,109.80	$9,324,329.40	$ 4,429,921.73
2018			$3,108,109.80	$3,108,109.80	$6,216,219.60	$ 2,760,075.84
2019				$3,108,109.80	$3,108,109.80	$ 1,289,755.07
Total	$31,081,097.99	$31,081,097.99	$31,081,097.99	$31,081,097.99		$ 79,119,046.18

-Trucks per implementation year = 1,500 (6,000 total trucks / 4 years)

-Trucks costs per implementation year = $24,000,000 (1,500 trucks * $16,000 per truck)
-Annual capital recovery per implementation year = ~$3,108,000 ($24,000,000 *0.1295 capital recovery factor)

Table 6: Strategy 1 – Existing Fleet DPF, O&M Costs during 10 Year Capital Recovery Period

Capital Recovery Year	2007	2008	2009	2010	O&M Costs	Extended O&M Costs	Annual Total	Present Value 2005 dollars
2007	$3,247,327				$200.00	$590,000.00	$3,837,327.22	$3,586,287.12
2008	$3,247,327	$3,247,327			$210.76	$1,243,484.00	$7,738,138.43	$6,758,789.79
2009	$3,247,327	$3,247,327	$3,247,327		$222.10	$1,965,575.16	$11,707,556.81	$9,556,853.77
2010	$3,247,327	$3,247,327	$3,247,327	$3,247,327	$234.05	$2,761,764.14	$15,751,073.01	$12,016,418.18
2011	$3,247,327	$3,247,327	$3,247,327	$3,247,327	$246.64	$2,910,347.05	$15,899,655.92	$11,336,234.93
2012	$3,247,327	$ 3,247,327	$3,247,327	$3,247,327	$259.91	$3,066,923.72	$16,056,232.59	$10,698,945.73
2013	$3,247,327	$3,247,327	$3,247,327	$3,247,327	$273.89	$3,231,924.21	$16,221,233.08	$10,101,768.72
2014	$3,247,327	$3,247,327	$ 3,247,327	$3,247,327	$288.63	$3,405,801.74	$16,395,110.61	$9,542,103.64
2015	$3,247,327	$3,247,327	$3,247,327	$3,247,327	$304.16	$3,589,033.87	$16,578,342.74	$9,017,520.01
2016	$3,247,327	$3,247,327	$3,247,327	$3,247,327	$320.52	$3,782,123.89	$16,771,432.76	$8,525,745.97
2017		$3,247,327	$3,247,327	$3,247,327	$337.76	$2,989,201.62	$12,731,183.27	$ 6,048,493.46
2018			$3,247,327	$3,247,327	$355.93	$2,100,013.78	$8,594,668.21	$3,816,135.47
2019				$3,247,327	$375.08	$1,106,497.26	$4,353,824.48	$1,806,682.37
Total	$32,473,272.17	$32,473,272.17	$32,473,272.17	$32,473,272.17				$102,811,979.16

-DPFs per implementation year = 2,950 (11,800 total DPFs / 4 years)
-DPF costs per implementation year = ~$25,075,000 (2,950 DPFs * $8,500) Not including O&M
-Annual capital recovery per implementation year (not including O&M) = ~$3,247,000 ($25,075,000 *0.1295 capital recovery factor)
-Year 2007 O&M per-DPF costs of $200 to increase ~5 percent per year

b. Trucks Entering Port Service

All three strategies will require trucks entering port service to meet the same emission standards; therefore staff assumes the costs and benefits will be identical. Trucks entering port service will be required to meet increasingly stringent emission standards during three different time periods: 2007-2011, 2012-2014, and 2015 and later.

i. 2007-2011 Cost Analysis

From program start (2007) until 2011, trucks will be required to meet 2003 emission standards for both NOx and PM. Trucks must be MY 2003+ to meet the NOx emission standard. Since very little information exists detailing the typical age of a port truck when first entering port service, staff will assume the average age of pre-2003 MY trucks entering port service is 10 years. This assumption applies to those trucks that are estimated to be pre-2003 upon entering the fleet. Trucks MY 2003+ will only require a DPF and therefore do not require a differential truck cost analysis. The ‘10’ year old truck’ assumption take into account port truck operator economics which typically dictates the purchase of much older, less expensive trucks and the expected availability of such trucks on the used market. Using this generalization, in 2007, the average model year (MY) a truck entering port service would be 1997. By requiring a 2003 MY truck with a DPF, staff reasons that the program costs will result from a difference in costs of a 10 year-old truck to a newer truck plus a DPF. Staff assumes a uniform annual implementation from 2007-2011. Therefore, the 2,400 (see Appendix A) pre-2003 MY trucks entering port service during 2007-2011 results in 480 trucks per year. Because future used truck prices are unknown to a high degree of accuracy, staff assumes that the price differential derived from using Figure 1 data is applicable. Similarly, staff also assumes constant used truck prices through 2011. In reality, future used truck prices could vary from those assumed depending on supply and demand. Staff also assumes the price of DPFs ($8,500[4]) will be constant due to economies of scale and increased production. DPFs also require yearly maintenance. Annual operation and maintenance of DPFs cost ~$200[4]. Since O&M costs are mainly labor costs, staff assumes a 5 percent yearly increase in costs after implementation start year of 2007.

To estimate the average differential cost to the truck owner for purchasing a ‘newer’ than normal used truck, staff used the mid-year (2009) of the 2007-2011 time period. In 2009, a truck entering port service would normally be 10 years old, but, the strategy will require a 2003 MY truck, which is now only 6 years old. Utilizing Figure 1, the differential cost from a 10 year old truck ($16,000) to a 6 year old truck ($38,000) is $22,000 per truck. Using $22,000 per truck, $8,500 for a DPF, and $200 annual DPF O&M costs, will yield the present value program costs for trucks entering port service 2007-2011. The present value in program costs for 2,400 trucks entering port service is $42 million (rounded) as shown in Table 7.

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[4] Ironman Parts and Service, 2005

Table 7: Trucks Entering Port Service 2007-2011
Differential Truck Costs during 10 Year Capital Recovery Period

Capital Recovery Year	2007	2008	2009	2010	I2011	Annual Total	Present Value 2005 dollars
2007	$1,367,568.31					$1,367,568.31	$ 1,278,101.23
2008	$1,367,568.31	$1,367,568.31				$2,735,136.62	$2,388,974.25
2009	$1,367,568.31	$1,367,568.31	$1,367,568.31			$4,102,704.93	$3,349,029.33
2010	$1,367,568.31	$1,367,568.31	$1,367,568.31	$1,367,568.31		$5,470,273.25	$4,173,245.27
2011	$1,367,568.31	$1,367,568.31	$1,367,568.31	$1,367,568.31	$1,367,568.31	$6,837,841.56	$4,875,286.53
2012	$1,367,568.31	$1,367,568.31	$1,367,568.31	$1,367,568.31	$1,367,568.31	$6,837,841.56	$4,556,342.55
2013	$1,367,568.31	$1,367,568.31	$1,367,568.31	$1,367,568.31	$1,367,568.31	$6,837,841.56	$4,258,264.07
2014	$1,367,568.31	$1,367,568.31	$1,367,568.31	$1,367,568.31	$1,367,568.31	$6,837,841.56	$3,979,686.04
2015	$1,367,568.31	$1,367,568.31	$1,367,568.31	$1,367,568.31	$1,367,568.31	$6,837,841.56	$3,719,332.75
2016	$1,367,568.31	$1,367,568.31	$1,367,568.31	$1,367,568.31	$1,367,568.31	$6,837,841.56	$3,476,011.92
2017		$1,367,568.31	$1,367,568.31	$1,367,568.31	$1,367,568.31	$5,470,273.25	$2,598,887.41
2018			$1,367,568.31	$1,367,568.31	$1,367,568.31	$4,102,704.93	$1,821,650.06
2019				$1,367,568.31	$1,367,568.31	$2,735,136.62	$1,134,984.46
2020					$1,367,568.31	$1,367,568.31	$530,366.57
Total	$13,675,683.12	$13,675,683.12	$13,675,683.12	$13,675,683.12	$13,675,683.12		$42,140,162.43

-Trucks per implementation year = 480 (2,400 total trucks / 5 years)
-Trucks costs per implementation year = $10,560,000 (480 trucks * $22,000 per truck)
-Annual capital recovery per implementation year = $1,367,568.31 ($10,560,000 *0.1295 capital recovery factor (rounded)

Similar analysis was used to quantify the cost of retrofitting DPFs. Staff estimates 3,500 DPFs will be required (See Appendix A). Again, staff used a 10 year capital recovery period to generate present value 2005 costs of retrofitting 3,500 DPFs on trucks entering port service to be $30 million (rounded) as shown in Table 8.

Table 8: Trucks Entering Port Service 2007-2011
DPF, O&M Costs during 10 Year Capital Recovery Period

Capital Recovery Year	2007	2008	2009	2010	2011	O&M Costs	Extended O&M Costs	Annual Total	Present Value 2005 dollars
2007	$770,552					$200.00	$140,000.00	$910,552.22	$850,983.38
2008	$770,552	$770,552				$210.76	$295,064.00	$1,836,168.44	$1,603,780.63
2009	$770,552	$770,552	$770,552			$222.10	$466,407.66	$2,778,064.33	$2,267,728.01
2010	$770,552	$770,552	$770,552	$770,552		$234.05	$655,333.86	$3,737,542.75	$2,851,353.47
2011	$770,552	$770,552	$770,552	$770,552	$770,552	$246.64	$863,238.53	$4,715,999.64	$3,362,442.56
2012	$770,552	$770,552	$770,552	$770,552	$770,552	$259.91	$909,680.76	$4,762,441.87	$3,173,416.11
2013	$770,552	$770,552	$770,552	$770,552	$770,552	$273.89	$958,621.59	$4,811,382.69	$2,996,287.33
2014	$770,552	$770,552	$770,552	$770,552	$770,552	$288.63	$1,010,195.43	$4,862,956.54	$2,830,284.98
2015	$770,552	$770,552	$770,552	$770,552	$770,552	$304.16	$1,064,543.94	$4,917,305.05	$2,674,688.14
2016	$770,552	$770,552	$770,552	$770,552	$770,552	$320.52	$1,121,816.41	$4,974,577.51	$2,528,822.96
2017		$770,552	$770,552	$770,552	$770,552	$337.76	$945,736.11	$4,027,944.99	$1,913,647.65
2018			$770,552	$770,552	$770,552	$355.93	$747,462.53	$3,059,119.19	$1,358,285.51
2019				$770,552	$770,552	$375.08	$525,117.34	$2,066,221.79	$857,408.58
2020					$770,552	$395.26	$276,684.33	$1,047,236.55	$434,565.94
2021									
Total	$7,705,522	$7,705,522	$7,705,522	$7,705,522	$7,705,522				$29,703,695.24

-DPFs per implementation year = 700 (3,500 total DPFs / 5 years)
-DPF costs per implementation year = $5,950,000 (700 DPFs * $8,500) Not including O&M
-Annual capital recovery per implementation year (not including O&M) = $770,552 ($5,950,000 *0.1295 capital recovery factor)
-Year 2007 O&M per-truck costs of $200 to increase ~5 percent per year
-Extended O&M costs = O&M costs per DPF * number of truck during capital recovery year.
(e.g. Year 2013 = $273.89 * 3,500 trucks = ~$958,000 and
Year 2018 = $355.93 * 2,100 trucks = ~$747,000)

ii. 2012-2014 Cost Analysis

From 2012-2014, trucks will be required to meet 2007 emission standards. Staff will assume the 2012-2014 costs to truck owners will again comprise of buying ‘newer’ than normal used trucks. But, because 2007 emission standard trucks will be equipped with a DPF, there will be no additional costs for DPF retrofits.

However, the price of a used 2007 truck could increase over model predictions because of the potential increase in new 2007 MY trucks over 2006 MY trucks. A 2005 staff survey showed that the average price of available, new 2006 MY conventional, class 8, heavy-duty diesel vehicles was ~ $106,000. In 2006, staff further surveyed the California marketplace for new 2007 MY HDV listings, and found the listed price to be ~ $126,000. This price increase between the 2006 MY and 2007 MY price reflects the normal annual price increase for new Model Year vehicles (~3 percent), and the additional cost of compliance with the federal EPA heavy-duty diesel engine PM standards which go into effect for the 2007 Model Year. Specifically, the price increase reflects the inclusion of an active diesel particulate filter integrated with the engine's combustion and air-handling system, a backpressure monitor, a crankcase ventilation system with a coalescing filter, an electronic control module (ECM), and in-cab displays. Staff estimates a 15 - 20 percent price increase for 2007 MY trucks. To compensate for this price increase, staff will increase the used truck price accordingly (20 percent) when the strategy requires the purchase of a 2007 MY or newer truck.

While staff assumes static used truck prices until 2011, it is unreasonable to assume static prices past 2011. For simplicity, staff will assume a 3 percent annual inflation rate for the trucks purchased after 2011. Staff estimates that the 1,300 trucks (see Appendix A) entering port service during 2012-2014 will be required to be 'newer' than they would have normally been. Again taking the mid year of 2013, the difference is between a 10 year old truck and a 6 year old truck (2013 – 2007). Again, a ten year old truck is $16,000 and a 6 year old truck is $38,000 for a difference of $22,000. Growing $22,000 at 3 percent a year past 2011 and increasing it by 20 percent (2007 price adjustment) yields a differential truck price of ~$28,000. Table 9 displays the capital recovery and present value costs for new trucks entering the fleet from 2012-2014.

Table 9: Trucks Entering Port Service 2012-2014
Incremental Truck Costs during 10 Year Capital Recovery Period

Capital Recovery Year	2012	2013	2014	Annual Total	Present Value 2005 dollars
2012	$1,571,322.18			$1,571,322.18	$1,047,038.31
2013	$1,571,322.18	$1,571,322.18		$3,142,644.35	$1,957,080.96
2014	$1,571,322.18	$1,571,322.18	$1,571,322.18	$4,713,966.53	$2,743,571.44
2015	$1,571,322.18	$1,571,322.18	$1,571,322.18	$4,713,966.53	$2,564,085.46
2016	$1,571,322.18	$1,571,322.18	$1,571,322.18	$4,713,966.53	$2,396,341.55
2017	$1,571,322.18	$1,571,322.18	$1,571,322.18	$4,713,966.53	$2,239,571.54
2018	$1,571,322.18	$1,571,322.18	$1,571,322.18	$4,713,966.53	$2,093,057.51
2019	$1,571,322.18	$1,571,322.18	$1,571,322.18	$4,713,966.53	$1,956,128.52
2020	$1,571,322.18	$1,571,322.18	$1,571,322.18	$4,713,966.53	$1,828,157.49
2021	$1,571,322.18	$1,571,322.18	$1,571,322.18	$4,713,966.53	$1,708,558.41
2022		$1,571,322.18	$1,571,322.18	$3,142,644.35	$1,064,522.37
2023			$1,571,322.18	$1,571,322.18	$497,440.36
Total	$15,713,221.76	$15,713,221.76	$15,713,221.76		$22,095,553.92

-Trucks per implementation year = 433.33 (1,300 total trucks / 3 years)
-Trucks costs per implementation year = $12,100,000 (433.33 trucks * $28,000 per truck)
-Annual capital recovery per implementation year = ~$1,570,000 ($12,100,000 *0.1295 capital recovery factor)

iii. 2015-2019 Cost Analysis

From 2015 on, trucks will be required to meet 2010 emission standards. As this will be the continuing standard, staff will analyze costs for 2015-2019 with the knowledge that after 2019 it is expected that 2010 standard trucks would naturally come into service without the strategy (assuming 10 year old used truck). Staff assumes that the 2015-2019 costs to truck owners will again comprise of buying 'newer' than normal used trucks with no additional DPFs. Staff will also assume the 3 percent annual inflation rate for the used truck inflation rate past 2011. Staff estimates the 2,000 trucks entering port service during 2015-2019 will be required to be 'newer' than they would have normally been (see Appendix A). Taking the mid year 2017, the difference between a 10 year old truck and a 7 year old truck (2017 – 2010). A 10 year old truck is $16,000 and a 7 year old truck is $30,000 for a difference of $14,000. Growing $14,000 at 3 percent a year past 2011 yields a differential truck price of ~$17,000. Table 10 displays the capital recovery and present value costs for new trucks entering the fleet from 2015-2019.

Table 10: Trucks Entering Port Service 2015-2019
Incremental Truck Costs during 10 Year Capital Recovery Period

Capital Recovery Year	2015	2016	2017	2018	2019	Annual Total	Present Value 2005 dollars
2015	$880,631.11					$880,631.11	$479,004.98
2016	$880,631.11	$880,631.11				$1,761,262.22	$895,336.40
2017	$880,631.11	$880,631.11	$880,631.11			$2,641,893.33	$1,255,144.49
2018	$880,631.11	$880,631.11	$880,631.11	$880,631.11		$3,522,524.44	$1,564,042.98
2019	$880,631.11	$880,631.11	$880,631.11	$880,631.11	$880,631.11	$4,403,155.55	$1,827,153.01
2020	$880,631.11	$880,631.11	$880,631.11	$880,631.11	$880,631.11	$4,403,155.55	$1,707,619.64
2021	$880,631.11	$880,631.11	$880,631.11	$880,631.11	$880,631.11	$4,403,155.55	$1,595,906.20
2022	$880,631.11	$880,631.11	$880,631.11	$880,631.11	$880,631.11	$4,403,155.55	$1,491,501.12
2023	$880,631.11	$880,631.11	$880,631.11	$880,631.11	$880,631.11	$4,403,155.55	$1,393,926.28
2024	$880,631.11	$880,631.11	$880,631.11	$880,631.11	$880,631.11	$4,403,155.55	$1,302,734.84
2025		$880,631.11	$880,631.11	$880,631.11	$880,631.11	$3,522,524.44	$974,007.36
2026			$880,631.11	$880,631.11	$880,631.11	$2,641,893.33	$682,715.44
2027				$880,631.11	$880,631.11	$1,761,262.22	$425,367.88
2028					$880,631.11	$880,631.11	$198,770.04
Total	$8,806,311.10	$8,806,311.10	$8,806,311.10	$8,806,311.10	$8,806,311.10		$15,793,230.66

-Trucks per implementation year = 400 (2,000 total trucks / 5 years)
-Trucks costs per implementation year = $6,800,000 (400 trucks * $17,000 per truck)
-Annual capital recovery per implementation year = ~$880,000 ($6,800,000 *0.1295 capital recovery factor)

Combining all the implementation time periods into Table 11 yields total program costs of approximately $110 million (2005 dollars) for trucks entering port service. Once again, staff assumes these costs to be identical for all three strategies analyzed later in this appendix.

Table 11: Trucks Entering Port Service 2007-2019
10 Year Capital Recovery Period (rounded)(millions)

	2007 - 2011		2012 - 2014	2015 +	
Capital Recovery Year	TOTAL DPF, INSTALLATION & O&M COSTS	TOTAL INCREMENTAL TRUCK REPLACEMENT COSTS	TOTAL INCREMENTAL TRUCK REPLACEMENT COSTS	TOTAL INCREMENTAL TRUCK REPLACEMENT COSTS*	TRUCKS ENTERING PORT SERVICE COSTS
2007	$0.9	$1.3			$2.2
2008	$1.6	$2.4			$4.0
2009	$2.3	$3.3			$5.6
2010	$2.9	$4.2			$7.1
2011	$3.4	$4.9			$8.3
2012	$3.2	$4.6	$1.0		$8.8
2013	$3.0	$4.3	$2.0		$9.3
2014	$2.8	$4.0	$2.7		$9.5
2015	$2.7	$3.7	$2.6	$0.5	$9.5
2016	$2.5	$3.5	$2.4	$0.9	$9.3
2017	$1.9	$2.6	$2.2	$1.3	$8.0
2018	$1.4	$1.8	$2.1	$1.6	$6.9
2019	$0.9	$1.1	$2.0	$1.8	$5.8
2020	$0.4	$0.5	$1.8	$1.7	$4.4
2021			$1.7	$1.6	$3.3
2022			$1.1	$1.5	$2.6
2023			$0.5	$1.4	$1.9
2024				$1.3	$1.3
2025				$1.0	$1.0
2026				$0.7	$0.7
2027				$0.4	$0.4
2028				$0.2	$0.2
Total	$29.9	$42.2	$22.1	$15.9	$110.1

The costs to modernize the existing fleet and trucks entering port service were combined into Table 12 with resultant total strategy costs of $290 million in present value 2005 dollars (rounded).

Table 12: Strategy 1 – Total Costs During Capital Recovery Period (rounded)(millions)

Capital Recovery Year	TOTAL DPF, INSTALLATION & O&M COSTS	TOTAL TRUCK REPLACEMENT COSTS	TRUCKS ENTERING PORT SERVICE	TOTAL PROGRAM COSTS
2007	$3.6	$2.9	$2.2	$8.7
2008	$6.8	$5.4	$4.0	$16.2
2009	$9.6	$7.6	$5.6	$22.8
2010	$12.0	$9.5	$7.1	$28.6
2011	$11.3	$8.9	$8.3	$28.5
2012	$10.7	$8.3	$8.8	$27.8
2013	$10.1	$7.7	$9.3	$27.1
2014	$9.5	$7.2	$9.5	$26.2
2015	$9.0	$6.8	$9.5	$25.3
2016	$8.5	$6.3	$9.3	$24.1
2017	$6.0	$4.4	$8.0	$18.4
2018	$3.8	$2.8	$6.9	$13.5
2019	$1.8	$1.3	$5.8	$8.9
2020			$4.4	$4.4
2021			$3.3	$3.3
2022			$2.6	$2.6
2023			$1.9	$1.9
2024			$1.3	$1.3
2025			$1.0	$1.0
2026			$0.7	$0.7
2027			$0.4	$0.4
2028			$0.2	$0.2
Total	$102.7	$79.1	$110.1	$291.9

c. Strategy 1 – Cost Effectiveness – Trucks Entering Port Service

As mentioned earlier, the cost effectiveness analysis allows a direct comparison of one strategy with another. In years where only a portion of total annual fleet costs are represented (resulting from staggered implementation), only the corresponding portion of total annual emission reductions are used to determine the cost effectiveness. Staff further bisected annual program costs into those costs primarily responsible for PM reductions and those primarily responsibly for NOx reductions. The cost effectiveness is then presented as a range of annual values over the entire capital recovery period and finally as an average of all annual CE values over the capital recovery period for each pollutant reduced.

i. 2007-2011 - Cost Effectiveness Analysis

Table 13 presents the cost effectiveness determination results for new trucks entering the port fleet during 2007-2011. Staff estimates annual reductions of PM and NOx after full implementation to be 85 TPY and 400 TPY respectively (See Appendix A). One hundred (100) percent of DPF installation and O&M costs are attributed to PM benefits as DPFs are PM reduction technologies. Assuming a 10 year old truck entering port service during 2007-2011 would already be compatible with the installation of a DPF[5], the only additional NOx reductions will be gained by requiring a 2003+ MY truck. Therefore, all differential truck replacement costs will be attributed to NOx reductions.

Table 13: Trucks Entering Port Service 2007-2011
Cost Effectiveness: Annual Range & Annual Average NOx and PM

Capital Recovery Year	Annual $ to PM	Apportioned Annual PM Reductions TPY	Annual PM Cost Effectiveness ($/Ton)	Annual $ to NOx	Apportioned Annual NOx Reductions TPY	Annual NOx Cost Effectiveness ($/Ton)
2007	$850,983.38	17.00	$50,057.85	$1,278,101.23	80	$15,976.27
2008	$1,603,780.63	34.00	$47,170.02	$2,388,974.25	160	$14,931.09
2009	$2,267,728.01	51.00	$44,465.26	$3,349,029.33	240	$13,954.29
2010	$2,851,353.47	68.00	$41,931.67	$4,173,245.27	320	$13,041.39
2011	$3,362,442.56	85.00	$39,558.15	$4,875,286.53	400	$12,188.22
2012	$3,173,416.11	85.00	$37,334.31	$4,556,342.55	400	$11,390.86
2013	$2,996,287.33	85.00	$35,250.44	$4,258,264.07	400	$10,645.66
2014	$2,830,284.98	85.00	$33,297.47	$3,979,686.04	400	$9,949.22
2015	$2,674,688.14	85.00	$31,466.92	$3,719,332.75	400	$9,298.33
2016	$2,528,822.96	85.00	$29,750.86	$3,476,011.92	400	$8,690.03
2017	$1,913,647.65	68.00	$28,141.88	$2,598,887.41	320	$8,121.52
2018	$1,358,285.51	51.00	$26,633.05	$1,821,650.06	240	$7,590.21
2019	$857,408.58	34.00	$25,217.90	$1,134,984.46	160	$7,093.65
2020	$434,565.94	17.00	$25,562.70	$530,366.57	80	$6,629.58
	$29,703,695.24			$42,140,162.43		
Average	$2,121,692.52		$35,417.03	$3,010,011.60		$10,678.59
MIN	$434,565.94		$25,217.90	$530,366.57		$6,629.58
MAX	$3,362,442.56		$50,057.85	$4,875,286.53		$15,976.27

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[5] DPFs are ARB verified on 1994 MY and newer trucks

All future cost effectiveness determinations in this appendix (with the exception of those determinations using Carl Moyer methodologies) utilize the same methodologies presented in Table 13. Any differences in staff's assumptions are presented before each summary table.

Sample Calculation - 2009:

In 2009, 60 percent of the 3,500 total trucks expected to enter port service during 2007-2011 will generate the ~$5.6 million annual capital recovery costs (see Tables 7 & 8). Therefore, only 60 percent of the estimated total annual emission reductions after FULL implementation will be used.

85 TPY Total Annual PM Reductions * 0.60 = 51 TPY
400 TPY Total Annual NOx Reductions * 0.60 = 240 TPY

Again, attributing 100 percent of DPF capital recovery costs during 2009 to PM yields a cost effectiveness of ~$44,000 / Ton PM Reduced.

$$\frac{(\$2{,}267{,}728.01 \text{ PM Capital Recovery in 2009})}{(51 \text{ Tons PM Reduced in 2009})} =$$

=~$44,000 per Ton PM Reduced During Capital Recovery Year 2009

Using the same methodology for the NOx capital recovery cost effectiveness in 2009 yields ~$14,000 per ton NOx Reduced. Staff then obtained the minimum, maximum, and average of the annual cost effectiveness determination during the capital recovery years 2007-2020 (Table 13). The rounded results are summarized in Table 14.

Table 14: Trucks Entering Port Service 2007-2011 Summarized Cost Effectiveness: Annual Range & Annual Average NOx and PM (rounded)

Pollutant	Annual Cost Effectiveness Range ($ / Ton)		Average Annual Cost Effectiveness	Annual Pollutant Reductions After Full Implementation (TPY)
	Low	High		
PM	$25,000	$50,000	$35,000	85
NOx	$7,000	$16,000	$11,000	400

ii. 2012-2014 - Cost Effectiveness Analysis

The same methodology was used to determine the annual cost effectiveness during the 2012-2023 (Table 9) capital recovery period for trucks entering port service during 2012-2014. As trucks enter port service during this time, they will be required to operate using 2007 emission standards. No DPF costs are applicable. The only cost is to buy a 'newer' than normal used truck (2007 MY vs. ~10 year old 2003 MY). Since the truck will reduce both NOx and PM emissions, staff estimated half the annual capital recovery costs are attributable to PM reduction and half to NOx reductions. Table 15 provides the summarized annual costs effectiveness determinations for trucks entering port service during 2012-2014 utilizing estimated annual PM and NOx emission reductions of 35 TPY (see Appendix A) and 400 TPY respectively after full implementation.

TABLE 15: Trucks Entering Port Service 2012-2014 Summarized Cost Effectiveness: Annual Range & Annual Average NOx and PM (rounded)

Pollutant	Annual Cost Effectiveness Range ($/Ton)		Average Annual Cost Effectiveness	Annual Pollutant Reductions After Full Implementation (TPY)
	Low	High		
PM	$21,000	$45,000	$32,000	35
NOx	$2,000	$4,000	$3,000	400

iii. 2015-2019 - Cost Effectiveness Analysis

The same methodology was used to determine the annual cost effectiveness during the 2015-2028 (Table 10) capital recovery period for trucks entering port service during 2015-2019. As trucks enter port service during this time, they will be required to operate using 2010 emission standards. No DPF costs are applicable. The only cost is to buy a 'newer' than normal used truck (2010 MY vs. ~10 year old 2007 MY). Because this 'newer' truck will only reduce NOx emissions over the older truck, staff estimated all the annual capital recovery costs are attributable to NOx reductions. Table 16 provides the summarized annual costs effectiveness determinations for trucks entering port service during 2015-2019 utilizing estimated annual NOx emission reductions of 730 TPY (see Appendix A) after full implementation.

Table 16: Trucks Entering Port Service 2015-2019 Summarized Cost Effectiveness: Annual Range & Annual Average NOx (rounded)

Pollutant	Annual Cost Effectiveness Range ($/Ton)		Average Annual Cost Effectiveness	Annual Pollutant Reductions After Full Implementation (TPY)
	Low	High		
NOx	$1,000	$3,000	$2,000	730

d. Strategy 1 – Cost Effectiveness – Existing Fleet

All costs are attributable to PM reductions as there are no NOx reductions. Staff estimates PM of 280 TPY after full implementation (See Appendix A). Table 17 provides the summarized annual costs effectiveness for the existing fleet during the capital recovery period of 2007-2019.

Table 17: Strategy 1 – Summarized Cost Effectiveness: Annual Range and Annual Average during Capital Recovery Period (2007-2019) (rounded)

Pollutant	Annual Cost Effectiveness Range ($/Ton)		Average Annual Cost Effectiveness ($/Ton)	Annual Pollutant Reduced After Full Implementation (TPY)
	Low	High		
PM	$25,000	$52,000	$37,000	500
NOx	$5,000	$12,000	$8,000	480

e. Strategy 1 – Existing Fleet Per-Container Recovery Costs

To estimate the per-container fee to recover the costs of modernizing the existing fleet, staff simply divided total program costs by the number of incoming containers destined for truck transport through 2015 (see Tables 4, 5, and 6 and corresponding analysis). Staff divided the total program costs of ~$180 million by 51 million containers to yield the potential per-container fee to fund modernizing the existing fleet of approximately $4 per container.

2. Program Costs – Strategy 2

Program cost and annual cost effectiveness for strategy 2 was determined using the same methodology as strategy 1. Strategy 2 requires the existing port fleet of 12,000 trucks retrofit with DPFs for PM reduction. Strategy 2 reduces NOx by requiring that all pre-2003 MY trucks be replaced with 2003+ MY trucks. Staff estimates ~ 11,800 trucks will have to be replaced and retrofitted with DPFs (See Appendix A). For this analysis, staff will not factor in potential benefits of the replaced vehicles. Although not quantified here, potentially, truck owners could recoup some costs by selling the newer portion of the replaced fleet (e.g. model year 1998-2002 trucks) and lower the net costs of truck replacement. Staff estimates the cost of a 5 year old[6] replacement truck to be $48,000 (Figure 1). The replacement truck value is assumed to be constant over the implementation period as with previous analysis. The DPF cost analysis in strategy 2 is identical to the DPF cost analysis for strategy 1 and will cost ~$103 million. Table 18 show the annual capital recovery of replacement truck cost and DPF retrofits costs, respectively.

Table 18: Strategy 2 – Existing Fleet Truck Replacement Costs
10 Year Capital Recovery Period

Capital Recovery Year	2007	2008	2009	2010	Annual Total	Present Value 2005 dollars
2007	$18,337,847.82				$18,337,847.82	$17,138,175.53
2008	$18,337,847.82	$18,337,847.82			$36,675,695.63	$32,033,972.95
2009	$18,337,847.82	$18,337,847.82	$18,337,847.82		$55,013,543.45	$44,907,438.71
2010	$18,337,847.82	$18,337,847.82	$18,337,847.82	$18,337,847.82	$73,351,391.26	$55,959,425.19
2011	$18,337,847.82	$18,337,847.82	$18,337,847.82	$18,337,847.82	$73,351,391.26	$52,298,528.21
2012	$18,337,847.82	$18,337,847.82	$18,337,847.82	$18,337,847.82	$73,351,391.26	$48,877,129.17
2013	$18,337,847.82	$18,337,847.82	$18,337,847.82	$18,337,847.82	$73,351,391.26	$45,679,559.97
2014	$18,337,847.82	$18,337,847.82	$18,337,847.82	$18,337,847.82	$73,351,391.26	$42,691,177.55
2015	$18,337,847.82	$18,337,847.82	$18,337,847.82	$18,337,847.82	$73,351,391.26	$39,898,296.77
2016	$18,337,847.82	$18,337,847.82	$18,337,847.82	$18,337,847.82	$73,351,391.26	$37,288,127.82
2017		$18,337,847.82	$18,337,847.82	$18,337,847.82	$55,013,543.45	$26,136,538.19
2018			$18,337,847.82	$18,337,847.82	$36,675,695.63	$16,284,447.47
2019				$18,337,847.82	$18,337,847.82	$7,609,554.89
Total	$183,378,478.15	$183,378,478.15	$183,378,478.15	$183,378,478.15		$466,802,372.45

-Trucks per implementation year = 2,950 (11,800 total trucks / 4 years)
-Trucks costs per implementation year = $141,600,000 (2,950 trucks * $48,000 per truck)
-Annual capital recovery per implementation year = ~$18,300,000 ($141,600,000 *0.1295 capital recovery factor)

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[6] A 2003 truck will be 5 years old in 2008 (approximately mid implementation period of 2007 – 2010)

Existing fleet costs and the costs of trucks entering port service (analyzed earlier) were combined into Table 19 for total strategy costs of $680 million (rounded).

Table 19: Strategy 2 – Total Costs during Capital Recovery Period (rounded)(millions)

Capital Recovery Year	TOTAL DPF, INSTALLATION & O&M COSTS	TOTAL TRUCK REPLACEMENT COSTS	TRUCKS ENTERING PORT SERVICE	TOTAL PROGRAM COSTS
2007	$3.6	$17.1	$2.2	$22.9
2008	$6.8	$32.0	$4.0	$42.8
2009	$9.6	$44.9	$5.6	$60.1
2010	$12.0	$56.0	$7.1	$75.1
2011	$11.3	$52.3	$8.3	$71.9
2012	$10.7	$48.9	$8.8	$68.4
2013	$10.1	$45.7	$9.3	$65.1
2014	$9.5	$42.7	$9.5	$61.7
2015	$9.0	$39.9	$9.5	$58.4
2016	$8.5	$37.3	$9.3	$55.1
2017	$6.0	$26.1	$8.0	$40.1
2018	$3.8	$16.3	$6.9	$27.0
2019	$1.8	$7.6	$5.8	$15.2
2020			$4.4	$4.4
2021			$3.3	$3.3
2022			$2.6	$2.6
2023			$1.9	$1.9
2024			$1.3	$1.3
2025			$1.0	$1.0
2026			$0.7	$0.7
2027			$0.4	$0.4
2028			$0.2	$0.2
Total	$102.7	$466.8	$110.1	$679.6

a. Strategy 2 - Cost Effectiveness Analysis – Existing Fleet

Only the existing fleet was analyzed in the cost effectiveness. All DPF costs are attributable to PM reductions. As the increase in replacement truck costs (over strategy 1 truck replacement costs) are strictly for added NOx reductions, staff will attribute all the additional truck replacement costs to NOx reductions. This will result in virtually identical strategy 2 PM cost effectiveness as in strategy 1. Staff estimates PM and NOx emission reduction of 530 TPY and 2,300 TPY, respectively after full implementation (See Appendix A). Table 20 provides the summarized annual costs effectiveness for the existing fleet during the capital recovery period of 2007-2019.

Table 20: Strategy 2: Summarized Cost Effectiveness: Annual Range and Annual Average During Capital Recovery Period (2007-2019) (rounded)

Pollutant	Annual Cost Effectiveness Range ($/Ton)		Average Annual Cost Effectiveness ($/Ton)	Annual Pollutant Reduced After Full Implementation (TPY)
	Low	High		
PM	$23,000	$49,000	$35,000	530
NOx	$11,000	$25,000	$17,000	2,300

b. Strategy 2 – Existing Fleet Per-Container Recovery Costs

Staff divided the total existing fleet program costs of ~$570 million by 51 million containers to yield the potential per-container fee to fund modernizing the existing fleet of approximately $11 per container.

3. Program Costs – Strategy 3

Program cost and annual cost effectiveness for strategy 3 were determined using the same methodology as strategy 1. Strategy 3: Phase1 requires the existing port fleet of 12,000 trucks to be retrofitted with DPFs for PM reduction. As DPFs can only be retrofitted to 1994+ MY trucks, staff estimates ~ 6,000 trucks will have to be replaced (See Appendix A). Again, staff assumes the replacement trucks will be 1998+ MY to avoid chip reflash concerns. Strategy 3: Phase1 will result in increased NOx reductions over strategy 1 by requiring 1998-2002 MY trucks be equipped with NOx reduction technologies as well as DPFs. Staff assumes 1,200 DPFs and 10,500 DPF/NOx combination systems will be retrofitted to the existing fleet (See Appendix A). Annual PM and NOx emission reductions are estimated to be 520 TPY and 2,000 TPY, respectively (See Appendix A). Staff again assumes the older pre-1994 MY trucks that are replaced have little intrinsic value due to age and wear and will be destroyed to ensure these trucks do not end up operating (and polluting) in California again. The cost ($16,000) of the 10 year old replacement truck is again derived from the used truck price distribution profile (Figure 1). Also, the replacement truck value will assumed to be constant over the implementation period as with previous analysis. Tables 21, 22 and 23 show the annual capital recovery of replacement truck, DPF only retrofits, and DPF / NOx combination system retrofits costs, respectively.

Table 21: Strategy 3: Phase 1 – Existing Fleet Truck Replacement Costs 10 Year Capital Recovery Period

Capital Recovery Year	2007	2008	2009	2010	Annual Total	Present Value 2005 dollars
2007	$3,108,109.80				$3,108,109.80	$2,904,775.51
2008	$3,108,109.80	$3,108,109.80			$6,216,219.60	$5,429,486.94
2009	$3,108,109.80	$3,108,109.80	$3,108,109.80		$9,324,329.40	$7,611,430.29
2010	$3,108,109.80	$3,108,109.80	$3,108,109.80	$3,108,109.80	$12,432,439.20	$9,484,648.34
2011	$3,108,109.80	$3,108,109.80	$3,108,109.80	$3,108,109.80	$12,432,439.20	$8,864,157.32
2012	$3,108,109.80	$3,108,109.80	$3,108,109.80	$3,108,109.80	$12,432,439.20	$8,284,259.18
2013	$3,108,109.80	$3,108,109.80	$3,108,109.80	$3,108,109.80	$12,432,439.20	$7,742,298.30
2014	$3,108,109.80	$3,108,109.80	$3,108,109.80	$3,108,109.80	$12,432,439.20	$7,235,792.80
2015	$3,108,109.80	$3,108,109.80	$3,108,109.80	$3,108,109.80	$12,432,439.20	$6,762,423.18
2016	$3,108,109.80	$3,108,109.80	$3,108,109.80	$3,108,109.80	$12,432,439.20	$6,320,021.67
2017		$3,108,109.80	$3,108,109.80	$3,108,109.80	$9,324,329.40	$4,429,921.73
2018			$3,108,109.80	$3,108,109.80	$6,216,219.60	$2,760,075.84
2019				$3,108,109.80	$3,108,109.80	$1,289,755.07
Total	$31,081,097.99	$31,081,097.99	$31,081,097.99	$31,081,097.99		$79,119,046.18

-Trucks per implementation year = 1,500 (6,000 total trucks / 4 years)
-Trucks costs per implementation year = $24,000,000 (1,500 trucks * $16,000 per truck)
-Annual capital recovery per implementation year = ~$3,108,000 ($24,000,000 *0.1295 capital recovery factor)

Table 22: Strategy 3: Phase 1 – Existing Fleet DPF Only, O&M Costs 10 Year Capital Recovery Period

Capital Recovery Year	2007	2008	2009	2010	O&M Costs	Extended O&M Costs	Annual Total	Present Value 2005 dollars
2007	$330,237				$200.00	$60,000.00	$390,236.67	$364,707.16
2008	$330,237	$330,237			$210.76	$126,456.00	$786,929.33	$687,334.56
2009	$330,237	$330,237	$330,237		$222.10	$199,889.00	$1,190,599.00	$971,883.43
2010	$330,237	$330,237	$330,237	$330,237	$234.05	$280,857.37	$1,601,804.03	$1,222,008.63
2011	$330,237	$330,237	$330,237	$330,237	$246.64	$295,967.50	$1,616,914.16	$1,152,837.45
2012	$330,237	$330,237	$330,237	$330,237	$259.91	$311,890.55	$1,632,837.21	$1,088,028.38
2013	$330,237	$330,237	$330,237	$330,237	$273.89	$328,670.26	$1,649,616.92	$1,027,298.51
2014	$330,237	$330,237	$330,237	$330,237	$288.63	$346,352.72	$1,667,299.38	$970,383.42
2015	$330,237	$330,237	$330,237	$330,237	$304.16	$364,986.50	$1,685,933.16	$917,035.93
2016	$330,237	$330,237	$330,237	$330,237	$320.52	$384,622.77	$1,705,569.43	$867,025.01
2017		$330,237	$330,237	$330,237	$337.76	$303,986.61	$1,294,696.60	$615,101.03
2018			$330,237	$330,237	$355.93	$213,560.72	$874,034.06	$388,081.57
2019				$330,237	$375.08	$112,525.14	$442,761.81	$183,730.41
Total	$3,302,366.66	$3,302,366.66	$3,302,366.66	$3,302,366.66				$10,455,455.51

-DPFs per implementation year = 300 (1,200 total DPFs / 4 years)
-DPF costs per implementation year = ~$2,550,000 (300 DPFs * $8,500) Not including O&M
-Annual capital recovery per implementation year (not including O&M) = ~$330,000 ($2,550,000 *0.1295 capital recovery factor)
-Year 2007 O&M per-DPF costs of $200 to increase ~5 percent per year

Table 23: Strategy 3: Phase 1 – Existing Fleet DPF/NOx System, O&M Costs 10 Year Capital Recovery Period

Capital Recovery Year	2007	2008	2009	2010	O&M Costs	Extended O&M Costs	Annual Total	Present Value 2005 dollars
2007	$6,798,990				$200.00	$525,000.00	$7,323,990.19	$6,844,850.64
2008	$6,798,990	$6,798,990			$210.76	$1,106,490.00	$14,704,470.37	$12,843,453.90
2009	$6,798,990	$6,798,990	$6,798,990		$222.10	$1,749,028.74	$22,145,999.30	$18,077,732.21
2010	$6,798,990	$6,798,990	$6,798,990	$6,798,990	$234.05	$2,457,501.99	$29,653,462.73	$22,622,484.74
2011	$6,798,990	$6,798,990	$6,798,990	$6,798,990	$246.64	$2,589,715.59	$29,785,676.34	$21,236,775.57
2012	$6,798,990	$6,798,990	$6,798,990	$6,798,990	$259.91	$2,729,042.29	$29,925,003.03	$19,940,293.07
2013	$6,798,990	$6,798,990	$6,798,990	$6,798,990	$273.89	$2,875,864.77	$30,071,825.51	$18,727,221.57
2014	$6,798,990	$6,798,990	$6,798,990	$6,798,990	$288.63	$3,030,586.29	$30,226,547.03	$17,592,125.57
2015	$6,798,990	$6,798,990	$6,798,990	$6,798,990	$304.16	$3,193,631.83	$30,389,592.58	$16,529,924.83
2016	$6,798,990	$6,798,990	$6,798,990	$6,798,990	$320.52	$3,365,449.23	$30,561,409.97	$15,535,871.12
2017		$6,798,990	$6,798,990	$6,798,990	$337.76	$2,659,882.80	$23,056,853.35	$10,954,144.94
2018			$6,798,990	$6,798,990	$355.93	$1,868,656.33	$15,466,636.70	$6,867,371.66
2019				$6,798,990	$375.08	$984,595.02	$7,783,585.20	$3,229,911.14
Total	$67,989,901.86	$67,989,901.86	$67,989,901.86	$67,989,901.86				$191,002,160.97

-DPF / NOx systems per implementation year = 2,625 (10,500 total DPF- NOx systems / 4 years)
- DPF / NOx systems costs per implementation year = ~$52,500,000 (2,625 DPF / NOx systems * $20,000[7]) Not including O&M
-Annual capital recovery per implementation year (not including O&M) = ~$6,800,000 ($52,500,000 *0.1295 capital recovery factor)
-Year 2007 O&M per-DPF costs of $200 to increase ~5 percent per year

Unlike the first two strategies, strategy 3 has a second phase which further reduces emissions from the port fleet in 2017 and 2019. By 2017, pre-2003 MY trucks would be retired and replaced with trucks meeting 2010 emission standards. The second stage would require the remaining 2003-2009 MY trucks be replaced with trucks meeting 2010 emission standards. Truck owners may be able recoup some of the program costs by selling the older trucks. Staff believes this benefit will be minimal as the trucks will be close to the end of their useful lives. Staff estimates that the stages of phase 2 will be implemented uniformly over a span of two years before each deadline.

By the 2017 deadline, staff estimates 3,900 port trucks will need to be replaced with newer trucks meeting 2010 emission standards reducing NOx emissions by 1,150 TPY after full implementation (see Appendix A). In 2016 (the second year of implementation), a 2010 truck will be 6 years old. The price of a 6 year old truck, from figure 1, is ~$38,000. Again, to estimate future used truck prices beyond 2010, staff grew that figure 3 percent per year until 2016 and increased it by 20 percent (2007 MY

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[7] Clēaire Longview system – Diesel Net Report

truck price increase) yielding a cost of ~$54,000 per truck in 2016. The annual capital recovery is shown in Table 24.

Table 24: Strategy 3: Phase 2 Truck Replacement Costs - 2017 Deadline 10 Year Capital Recovery Period

Capital Recovery Year	2015	2016	Annual Total	Present Value 2005 dollars
2015	$13,636,831.74		$13,636,831.74	$7,417,532.93
2016	$13,636,831.74	$13,636,831.74	$27,273,663.49	$13,864,547.53
2017	$13,636,831.74	$13,636,831.74	$27,273,663.49	$12,957,521.05
2018	$13,636,831.74	$13,636,831.74	$27,273,663.49	$12,109,832.76
2019	$13,636,831.74	$13,636,831.74	$27,273,663.49	$11,317,600.71
2020	$13,636,831.74	$13,636,831.74	$27,273,663.49	$10,577,196.93
2021	$13,636,831.74	$13,636,831.74	$27,273,663.49	$9,885,230.77
2022	$13,636,831.74	$13,636,831.74	$27,273,663.49	$9,238,533.43
2023	$13,636,831.74	$13,636,831.74	$27,273,663.49	$8,634,143.39
2024	$13,636,831.74	$13,636,831.74	$27,273,663.49	$8,069,292.89
2025		$13,636,831.74	$13,636,831.74	$3,770,697.61
Total	$136,368,317.44	$136,368,317.44		$107,842,130.01

-Trucks per implementation year = 1,950 (3,900 total trucks / 2 years)
-Trucks costs per implementation year = $105,300,000 (1,950 trucks * $54,000 per truck)
-Annual capital recovery per implementation year = ~$13,600,000 ($105,300,000 *0.1295 capital recovery factor)

By the 2019 deadline, staff estimates 5,300 port trucks will need to be replaced with newer trucks meeting 2010 emission standards reducing NOx emissions by 3,600 TPY after full implementation (see Appendix A). In 2018 (the second year of implementation), a 2010 truck will be 8 years old. The price of an 8 year old truck, from figure 1, is ~$25,000. Again, to estimate future used truck prices beyond 2010, staff grew that figure 3 percent per year until 2018 and increased it by 20 percent (2007 MY truck price increase), yielding a cost of ~38,000 per truck in 2018. The annual capital recovery is shown in Table 25.

Table 25: Strategy 3: Phase 2 Truck Replacement Costs – 2019 Deadline
10 Year Capital Recovery Period

Capital Recovery Year	2017	2018	Annual Total	Present Value 2005 dollars
2015	$13,041,110.70		$13,041,110.70	$6,195,737.75
2016	$13,041,110.70	$13,041,110.70	$26,082,221.40	$11,580,818.22
2017	$13,041,110.70	$13,041,110.70	$26,082,221.40	$10,823,194.60
2018	$13,041,110.70	$13,041,110.70	$26,082,221.40	$10,115,135.14
2019	$13,041,110.70	$13,041,110.70	$26,082,221.40	$9,453,397.33
2020	$13,041,110.70	$13,041,110.70	$26,082,221.40	$8,834,950.77
2021	$13,041,110.70	$13,041,110.70	$26,082,221.40	$8,256,963.34
2022	$13,041,110.70	$13,041,110.70	$26,082,221.40	$7,716,788.17
2023	$13,041,110.70	$13,041,110.70	$26,082,221.40	$7,211,951.56
2024	$13,041,110.70	$13,041,110.70	$26,082,221.40	$6,740,141.64
2025		$13,041,110.70	$13,041,110.70	$3,149,598.90
Total	$126,979,235.75	$126,979,235.75		$90,078,677.44

-Trucks per implementation year = 2,650 (5,300 total trucks / 2 years)
-Trucks costs per implementation year = $100,700,000 (2,650 trucks * $38,000 per truck)
-Annual capital recovery per implementation year = ~$13,000,000 ($100,700,000 *0.1295 capital recovery factor)

Combined strategy 3 costs and the costs of trucks entering port service were combined into Table 26 for total strategy costs of ~$590 million (rounded).

Table 26: Strategy 3 – Total Costs During Capital Recovery Period (rounded)(millions)

Capital Recovery Year	PHASE 1			PHASE 2	TRUCKS ENTERING PORT SERVICE	TOTAL PROGRAM
	DPF, INSTALLATION and O&M	DPF / NOx, INSTALLATION & O&M	TRUCK REPLACEMENT	TRUCK REPLACEMENT		
2007	$0.4	$6.8	$2.9		$2.2	$12.3
2008	$0.7	$12.8	$5.4		$4.0	$22.9
2009	$1.0	$18.1	$7.6		$5.6	$32.3
2010	$1.2	$22.6	$9.5		$7.1	$40.4
2011	$1.2	$21.2	$8.9		$8.3	$39.6
2012	$1.1	$19.9	$8.3		$8.8	$38.1
2013	$1.0	$18.7	$7.7		$9.3	$36.7
2014	$1.0	$17.6	$7.2		$9.5	$35.3
2015	$0.9	$16.5	$6.8	$7.4	$9.5	$41.1
2016	$0.9	$15.5	$6.3	$13.9	$9.3	$45.9
2017	$0.6	$11.0	$4.4	$19.2	$8.0	$43.2
2018	$0.4	$6.9	$2.8	$23.7	$6.9	$40.7
2019	$0.2	$3.2	$1.3	$22.1	$5.8	$32.6
2020				$20.7	$4.4	$25.1
2021				$19.3	$3.3	$22.6
2022				$18.1	$2.6	$20.7
2023				$16.9	$1.9	$18.8
2024				$15.8	$1.3	$17.1
2025				$11.0	$1.0	$12.0
2026				$6.7	$0.7	$7.4
2027				$3.2	$0.4	$3.6
2028					$0.2	$0.2
Total	$10.6	$190.8	$79.1	$197.9	$110.1	$588.5

a. Strategy 3: Phase1 - Cost Effectiveness Analysis – Existing Fleet

All DPF costs are attributable to PM reductions and NOx system costs to NOx reductions. Staff simply split the costs of the $20,000 DPF / NOx systems between two pollutants. As replacement trucks enjoy NOx reductions and are necessary for PM reductions, staff assumes half the truck costs are attributable to PM and half to NOx. Staff estimates PM and NOx emission reductions of 520 TPY and 2,000 TPY respectively after full implementation (See Appendix A). Table 27 provides the summarized annual costs effectiveness for the existing fleet during the capital recovery period of 2007-2019.

Table 27: Strategy 3: Phase 1 Summarized Cost Effectiveness: Annual Range & Annual Average during Capital Recovery Period (rounded)

Pollutant	Annual Cost Effectiveness Range ($/Ton)		Average Annual Cost Effectiveness ($/Ton)	Annual Pollutant Reduced After Full Implementation (TPY)
	Low	High		
PM	$19,000	$40,000	$28,000	520
NOx	$5,000	$10,000	$7,000	2,000

b. Strategy 3: Phase 2 - Cost Effectiveness Analysis

As all the trucks to be retired have maximum PM reduction efficiency, phase 2 costs are solely for NOx reductions. Staff estimates 2017 NOx emission reductions of 1,150 tpy and NOx emission reductions of 3,600 TPY after full implementation (See Appendix A). Table 28 provides the summarized annual costs effectiveness for phase 2.

Table 28: Strategy 3: Phase 2 Summarized Cost Effectiveness: Annual Range & Annual Average during Capital Recovery Period (rounded)

Pollutant	Annual Cost Effectiveness Range ($/Ton)		Average Annual Cost Effectiveness ($/Ton)	Annual Pollutant Reduced After Full Implementation (TPY)
	Low	High		
NOx (2017)	$7,000	$13,000	$9,000	1,150
NOx (2019)	$2,000	$3,000	$3,000	3,600

c. Strategy 3 – Existing Fleet Per-Container Recovery Costs

Staff divided the total existing fleet program costs of ~$280 million by 51 million containers to yield the potential per-container fee to fund modernizing the existing fleet of approximately $5 per container.

E. Cost Effectiveness Using Carl Moyer Methodology

Staff also estimated the cost effectiveness for Strategy 3: Phase 1 using methodology developed for the Carl Moyer program. The Carl Moyer Program is a grant program, implemented as a partnership of ARB and local air districts, which funds incremental costs of cleaner-than-required engines and equipment (See Appendix C). Some Carl Moyer Program cost effectiveness calculation parameters differ from those previously used in this Appendix. Staff's assumptions, which differ from Carl Moyer assumptions, are explained within the previous cost effectiveness methodology discussion. The differences (between the previous analysis and the Carl Moyer based analysis) are listed below along with the reference to the "Carl Moyer Program Guidelines – Approved revision 2005" document.

- Default Project Life: Repowers and retrofits – 5 years (page D-2)
- Capital Recovery Discount Rate – 4 percent (page C-9: Formula C-13)
- Capital Recovery Factor – 0.225 (page B-3: Table 1)
- PM emission reductions are weighted by a factor of 20. (page C-1: Formula C-2)

The total cost for Strategy 3: Phase 1 is presented in Table 29 using Carl Moyer cost effective methodology.

Table 29: Strategy 3, Phase 1 Costs

	DPFs	DPF/NOx	Truck Replacement	Total
Quantity	1,200	10,500	6,000	
Unit Cost	$8,500	$20,000	$16,000	
Annual Unit O&M Costs	$200	$200		
Total	$11,400,000	$220,500,000	$96,000,000	$327,900,000

Where:

-$11,400,000 = (1,200 DPFs) * ($8,500 per DPF) + ($200 Annual O&M cost * 5 years – project life * 1,200 DPFs)
-$220,500,000 = (10,500) * ($20,000) + ($200 * 5 * 10,500)
-$96,000,000 = (6,000) * ($16,000)

The annualized cost (~$73.8 million / year) is simply the product of the total costs ($327,900,000) and the capital recovery factor (.225).

Staff estimated PM and NOx emission reductions after full implementation are 520 tpy and 2,000 tpy respectively. Carl Moyer requires weighting the PM reductions by a factor of 20, which yields an annual combined NOx and weighted PM emission reductions of 12,400 tons year [(520)(20) + (2,000)].

The cost effectiveness is derived by dividing the annualized cost (~$73.8 million / year) by the annual weighted emission reductions (12,400 TPY), which equals ~$5,900 / ton. The same methodology was used to determine the cost effectiveness for modernizing the existing fleet for each of the three strategies as shown in Table 30.

Table 30: Cost Effectiveness of Weighted Surplus Emissions Carl Moyer Method Strategies 1, 2, and 3 – Existing Fleet

	Cost Effectiveness Using Moyer Method ($/Ton)
Strategy 1	$4,500.00
Strategy 2	$11,800.00
Strategy 3	$5,900.00

APPENDIX C

Incentives

Appendix C

Incentives

This section describes and assesses incentive programs that may be available for engine and vehicle replacement for on-road heavy-duty diesel trucks in goods movement operations at California ports. The incentives focus primarily on federal and state grant programs, air quality management district assistance, port incentives, and other non-monetary incentives. In order to provide an informative analysis, ARB staff reviewed incentive program information, contacted major ports and local districts, and reviewed related literature.

A. Air Resources Board Carl Moyer Program [1]

California's Carl Moyer Memorial Air Quality Standards Attainment Program (Carl Moyer Program) is an incentive-based program to help achieve near-term emission reductions from heavy-duty diesel engines. Since 1998, the Carl Moyer Program has provided grants to encourage the owners of heavy-duty diesel engines to go beyond regulatory requirements by retrofitting, repowering, or replacing their engines with newer and cleaner ones.

The Carl Moyer Program is implemented through the cooperative efforts of ARB and the local air pollution control and air quality management districts (districts). Annually, ARB makes grant awards to air districts that apply to implement local incentive programs. The districts, following the Carl Moyer Program guideline criteria approved by ARB, provide grants for the incremental capital cost of cleaner-than-required engines and/or equipment. During the first five years, the Carl Moyer Program received annual budget appropriations totaling $154 million.

On January 1, 2005, new legislation (AB 923, Firebaugh) took effect, which expands the Carl Moyer Program to include additional pollutants, as well as new sources of air pollution. This and other legislation provided new sources of up to $141 million in annual funding for the Carl Moyer Program through 2015. The inclusion of additional project categories along with increased funding allows the Carl Moyer Program to provide more incentives to improve the air quality in California. Ten percent of the Carl Moyer funds that flow through the state budget are reserved, by ARB, for projects of statewide significance, including goods movement-related clean up. Guidelines are established to formalize the administrative requirements for both ARB and the local districts that administer the program. All emission reductions funded by the Carl Moyer Program funds must be real, surplus, quantitative, and enforceable. These guidelines describe project criteria to ensure that the projects funded achieve California State Implementation Plan (SIP) creditable emission reductions. Additional information regarding this program may be found on the Carl Moyer website http://www.arb.ca.gov/msprog/moyer/moyer.htm.

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[1] Carl Moyer Program. (2005). http://www.arb.ca.gov/msprog/moyer/moyer.htm

B. Sacramento Emergency Clean Air and Transportation Program (SECAT)[2,3]

The Sacramento Emergency Clean Air and Transportation Program (SECAT) was initiated in 2000 to reduce emissions from heavy-duty truck fleets operating in the Sacramento area. The SECAT program is a partnership between Sacramento Area Council of Governments (SACOG) and the Sacramento Metropolitan Air Quality Management District (SMAQMD). The goal of this partnership was primarily to reduce NOx emissions from on-road heavy-duty diesel engines. This program targeted mobile sources because these contribute more than 70 percent of the local air pollution.

SECAT provides $70 million in transportation funds to clean up the region's heavy-duty diesel truck fleet by 2005. The program is authorized by the State Legislature in Assembly Bill 2511 (AB 2511). The $70 million is funded by the governor, the local transportation office (from Congestion Mitigation Air Quality, or CMAQ funds), and matching funds allocated by the SACOG.

The funding provided by SECAT is awarded based on the emission reduction benefit achieved. The program uses a heavy-duty diesel emissions calculator to determine potential NOx reductions and corresponding incentive dollars. Applications are evaluated on a first come, first served basis. The incentive money can be used to purchase a new heavy-duty vehicle equipped with engines certified by the California Air Resources Board, re-power existing heavy-duty diesel vehicles with ARB-certified diesel or alternative-fuel engines, or retrofit existing heavy-duty diesel vehicles with exhaust after treatment devices.

The program has funded more than 1,300 projects, both public and private. These projects have resulted in NOx emission reductions of more than 1.3 tons per day in the Sacramento region. 400 trucks have been replaced, repowered, or retrofitted using $46 million of the SECAT funds. Additional information on eligibility criteria can be found on the SECAT website http://www.4secat.com

C. Gateway Cities Clean Air Program [4]

The Gateway Cities Clean Air Pilot Program was created by the Gateway Cities Council of Governments (GCCOG), ARB, South Coast Air Quality Management District (SCAQMD), and the Port of Long Beach to provide incentives to help truckers reduce pollution from heavy-duty vehicles. The Gateway Cities Clean Air Program is closely modeled after the SECAT program with the goal of reducing emissions of NOx and PM from diesel-fueled vehicles, and is intended to accelerate the replacement of older diesel trucks by providing funding for truck operators.

The Gateways Cities Clean Air Pilot Program was developed in response to a Multiple Air Toxics Exposure Study (MATES II)[5] in the South Coast Basin area, which identified

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[2] Sacramento Emergency Clean Air and Transportation (2005). www.4secat.com

[3] SECAT and Other Financial Incentive Programs Reducing NOx in the Sacramento Region. www.cleansirpartnership.org/ledge.html

[4] Gateway Cities Clean Air Program. (2002) Clean Air Program Guidelines.

the area as having the highest exposure of airborne contaminates in Southern California. It was found that the major source of pollutants comes from the cargo activities in the Ports.

The funding, which would assist truckers in fleet modernization, was provided by the U.S. EPA, ARB, Port of Long Beach, Port of Los Angeles, and SCAQMD. A total of $16.1 million in funding has been committed to the program since the program began operating in September 2002.

Under the Gateway Cities program, candidates must meet specific qualifications in order to be eligible for funding. The replaced vehicle must be a 1983 or older model year, the owner must have owned and operated the replaced vehicle for the previous two years, of which 85 percent of the miles driven were within the South Coast Air Basin, and the replaced vehicle must be in operational condition and insured by the State of California.

The program also compensates owners when they buy a 1999 or newer used diesel truck that is more reliable, cleaner and more fuel efficient than the original truck. The size of the grant awarded depends on the replacement trucks condition and how many miles it has been driven in the past two years. An average grant is between $20,000 and $25,000. As of April 4, 2003, the fleet modernization component of the Gateway Cities Clean Air Pilot Program has replaced 86 trucks, and awarded a total of $2.1 million[6] in incentive funds. The total estimated annual emission reductions from these 86 trucks are 67.8 tons of NOx and 17.2 tons of diesel PM. With the currently available funding from the Gateway Fleet Modernization Program, as many as 492 vehicles could be replaced, providing estimated emissions reductions of 1,942 tons of NOx and 447 tons of diesel PM over 5 years[38].

D. SmartWays [7]

SmartWay Transport Partnership is a voluntary public-private partnership between various freight industry sectors and the U.S. EPA that establishes incentives for fuel efficiency and emission reductions. There are three primary components of this program:

- Creating partnerships to reduce NOx, PM, CO2 and other air toxics that adversely affect air quality,
- Reducing unnecessary engine idling and establishing the National Transportation Idle-Free Corridors Program, and
- Increasing efficiency and use of rail and intermodal operations.

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[5] Multi Air Toxics Exposure Study in the South Coast Air Basin (MATESII), Published March 2000. www.aqmd.gov/matesiidf/matesdoc.htm

[6] Gateway Cities and Port of Long Beach Clean Air Program Business Plan. Adopted by Gateway Cities Council of Governments – July 2003. www.gatewaycog.org/cleanairprogram/pdf/bizplanjulyfinal.pdf

[7] SmartWays Partnership Program: www.epa.gov/smartway

The U.S. EPA encourages any company or organization to improve the environmental performance of their freight operations. Virtually any company can join at no cost. Examples of participants can include independent owner operators, large truck fleets, chain stores, and small business owners. The key partners are companies that ship products, and the truck and rail companies that deliver these products. Partners determine their own improvement goals based upon their business and environmental objectives. The U.S. EPA can provide the technical tools and assistance, while the companies develop emission reduction targets.

Reducing unnecessary idling improves air quality, saves fuel, and saves companies money. Another component of the SmartWay Transportation Partnership is to eliminate unnecessary truck and rail idling by developing a nationwide network of idle-reduction options along major transportation corridors such as truck stops, travel centers, distribution hubs, rail switch yards, borders, and ports. In April, 2005, the U.S. EPA released a request for applications (RFA) for $5 million in grants to demonstrate effective idle-reducing technologies for the trucking industry. The grant money is available to states, nonprofit organizations, and academic institutions (www.epa.gov/oar/grants/05-09.pdf).

Railways are a very efficient mode of transportation. SmartWay Transportation Partnership also encourages efficient railroad operations and technical innovations. To increase energy efficiency while reducing greenhouse gas emissions and air pollution, all seven major freight railroads have joined EPA's voluntary SmartWay Transport Partnership. These Class one freight railroads transport more than 90 percent of all domestic rail freight. Each railroad has committed to evaluate the environmental impacts of its operations and work jointly with U.S. EPA to develop and implement a plan to improve fuel efficiency and reduce emissions over the next several years. The seven railroads include-- BNSF Railway Company, Canadian National Railway Company, Canadian Pacific Railway, CSX Transportation, Kansas City Southern, Norfolk Southern Corporation and Union Pacific Railroad.

E. Port of Oakland[8]

The Port of Oakland has established a Truck Replacement program that will assist truckers in replacing old trucks. Under the truck replacement program, the port will provide a qualifying truck owner up to $25,000 to replace an on-road heavy-duty diesel truck, operating in the port's maritime area. A 1986 or older model year truck must be replaced with one that is 1999 or newer model year. The program is voluntary with the port providing up to $2 million in total funding to replace approximately 80 trucks. The port started collecting applications August 31, 2005, and currently has replaced 1 truck.

The port is also applying for other grants through the Bay Area Air Quality Management District that would allow for truck-replacement subsidies. Preference would be given to truck owner/operators and to vehicles that primarily remain within the Port Maritime Area. Additional information is available on the Port of Oakland website, www.portofoakland.com/environm/prog_06.asp.

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[8] Port of Oakland. (2005). Truck Air Quality Program www.portofoakland.com/environm/prog_06.asp

F. Energy Policy Act of 2005 – H.R. 6[9]

In September 2005, the U.S. Senate passed an amendment to the Energy Bill that would provide federal funding to reduce emissions from high polluting diesel engines. Senate Bill (SB) 1265 was introduced by Senator George Voinovich with the purpose of helping the nation's 495 and Ohio's 38 non-attainment counties meet the new ozone and PM air quality standards. This bill authorizes $1 billion over five years (2007-2011), or $200 million annually, for the retrofitting and replacement of diesel engines. The contents of this Bill are now included in the Energy Policy Act of 2005 under Title VII – Vehicles and Fuels, Subtitle G – Diesel Emission Reduction, Sections 791 through 797.

The U.S. Congress has not yet appropriated the annual funds of $200 million for the retrofitting and replacement of diesel engines. The Union of Concerned Scientists (UCS) is working with its allies in Washington as well as clean diesel advocates across the nation to ensure quick allocation of the funds and that the money authorized for this program is appropriated starting fiscal year 2007[10]

G. West Coast Diesel Emissions Reduction Collaborative [11]

The West Coast Collaborative (Collaborative) is a partnership between federal, state, and local governments, the private sector, and environmental groups throughout the west coast. The Collaborative brings attention to the need for additional funding for diesel emission reductions on the west coast, encourages voluntary projects that reduce diesel emissions, and provides grants for such projects. The goal of the Collaborative is to obtain and allocate federal funds to reduce emissions from the most polluting diesel sources in the most affected communities and to significantly improve air quality and public health.

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[9] http://thomas.loc.gov, Energy Policy Act of 2005, 109th Congress, House of Representatives, Report 109-190.

[10] http://www.ucsusa.org/clean_vehicles/big_rig_cleanup/diesel-emissions-reduction-act.html

[11] West Coast Diesel Emissions Reductions Collaborative. (2005). West Coast Collaborative fact sheet. http://www.westcoastdiesel.org/files/outreach.htm