Appendix F

Standardized Regulatory Impact Assessment

(SRIA)

State of California
AIR RESOURCES BOARD

Proposed Regulatory Amendments to the Heavy-Duty Vehicle Inspection Program and Periodic Smoke Inspection Program

Standardized Regulatory Impact Assessment (SRIA)

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A. SUMMARY

Opacity limits were established by the California Air Resources Board (CARB) to identify heavy-duty (HD) vehicles (greater than 6,000 pounds gross vehicle weight rating (GVWR)) with excess PM emissions due to maintenance issues and tampering. The Heavy-Duty Vehicle Inspection Program (HDVIP) program requires CARB enforcement staff to inspect HD trucks and buses for compliance with opacity limits, labeling and other requirements. Any HD vehicle traveling in California, including vehicles registered in other states and foreign countries, are subject to testing under HDVIP. Inspections are typically performed at border crossings, California Highway Patrol (CHP) weigh stations, fleet facilities, and randomly selected roadside locations.

The Periodic Smoke Inspection Program (PSIP), a companion self-inspection program to the HDVIP, requires California HD diesel vehicle fleets of two or more to test their vehicles annually to ensure the vehicles meet the in-use opacity limits. HDVIP on-road testing by CARB can only test a limited number of HD vehicles per year due to staff resource limitations. The PSIP ensures most in-state HD vehicles are tested each year by placing testing requirements on the diesel vehicle fleets. Vehicles that do not meet the required opacity limits must be repaired and retested. CARB randomly audits fleets, reviews on-site maintenance and inspection records, and tests a representative sample of vehicles to enforce compliance with the PSIP. The HDVIP and PSIP both require HD vehicles to meet the same opacity limits, which currently require 1991 and newer model year (MY) HD diesel engines to meet a 40 percent opacity limit and pre-1991 MY HD diesel engines to meet a 55 percent opacity limit.

The proposed amendments include the following changes; a description and rational for each change follows:

- Update the opacity limits (affects HDVIP and PSIP)
- Establish PSIP reporting requirements (affects PSIP only)
- Establish PSIP smoke tester training requirements (affects PSIP only)

Since the opacity limits were established in the 1990's, improved engine design, cleaner diesel fuel specifications, and aftertreatment technologies have significantly reduced tailpipe particulate matter (PM) emissions less than 2.5 microns in diameter (PM2.5) from HD vehicles. Both the U.S. EPA and CARB have promulgated regulations that set emissions standards for new vehicles, and CARB has established fleet rules, to reduce diesel particulate matter emissions from HD vehicles. The requirements for a specific vehicle depend on the GVWR and MY, along with other factors. Many, but not all, HD vehicles will use diesel particulate filter (DPF) aftertreatment systems to meet current U.S. EPA and CARB requirements.

Advances in technology, fuels, and federal and State emission requirements mean the current opacity limits are too lax. Vehicles operating with properly functioning DPFs emit exhaust at opacity levels at or near zero percent. Even vehicles with heavily damaged

and malfunctioning emission control systems emit exhaust at opacity levels below the current, out-of-date, opacity limits. The proposed amendments to the HDVIP and PSIP (proposed amendments) are intended to lower the in-use opacity limits which would identify and require repair of malfunctioning PM emission control components on HD diesel vehicles in California. The proposed amendments will help ensure that the opacity limits reflect current emission control technology and that vehicles above the new opacity limits get repaired. This will reduce PM emissions from the HD diesel vehicle sector by reducing the number of vehicles operating with damaged engine components and aftertreatment systems.

The current and proposed opacity limits are shown in Table 1 and Table 2, respectively.

Table 1: Current Opacity Limits for the HDVIP and PSIP

Engine Model Year (MY)	Opacity Limit
1991 and Newer MY Engines	40% Opacity Limit
Pre-1991 MY Engines	55% Opacity Limit

Table 2: Proposed Opacity Limits for the HDVIP and PSIP

2006 MY and older engines without DPFs	
Pre-1991 MY	40% Opacity Limit
1991 -1997 MY	30% Opacity Limit
1997-2006 MY	20% Opacity Limit
2007 MY and Newer Engines, and any Engines Equipped with a DPF	
5% Opacity Limit	

In addition to lowering the in-use opacity limits in the HDVIP and PSIP, the proposed amendments include reporting requirements and smoke tester training requirements within the PSIP. These two requirements apply to the PSIP only, and do not apply to the HDVIP. Under the proposed amendments, fleets subject to the PSIP would be required to electronically report vehicle information and annually submit an affirmation stating that all required annual opacity testing has been conducted and that all vehicles meet the opacity requirements. The affirmation is a legal document signed electronically through the CARB reporting database by a responsible official of the fleet who attests that all vehicle information is up to date and all vehicles were opacity tested during the previous calendar year and met the requirements of the PSIP. Previously, fleets were required to perform annual opacity tests on their vehicles and retain the records for two years, but were not required to submit any data to CARB. The new reporting requirements would be phased in starting with the largest fleets in calendar year (CY) 2020 (Table 3).

Table 3: Proposed PSIP Reporting Schedule

Fleet Size	Reporting of Opacity Tests Starting in CY:	Affirmation Submission Deadline:
50+ Vehicles	2019	April 2020
20-49 Vehicles	2021	April 2022

2-19 Vehicles	2023	April 2024

The proposed amendments would also require PSIP smoke testers to receive training on how to properly perform the Society of Automotive Engineers (SAE) J1667[1] opacity smoke test. Starting in 2019, contracted smoke testers would have to receive hands-on training on how to properly perform the SAE J1667 opacity test (for example, through the training course offered by the California Council on Diesel Education and Technology (CCDET)), whereas individuals who are testing their own fleet vehicles would be required to take a brief online training course.

The proposed opacity limits would go into effect in 2018 for both the HDVIP and PSIP while smoke tester training requirements would go into effect in 2019. Proposed PSIP reporting updates would go into effect between 2020 and 2024 (Table 3) providing time for fleets to adjust. The proposed amendments would be fully implemented in April 2024. The SRIA analyzes the economic impacts of the proposed amendments from 2018 through 2025, a full year after complete implementation.

Benefits and costs of the proposed amendments are analyzed in sections B and C, respectively. The Regional Economic Models, Inc. (REMI), Policy Insight Plus Version 2.1.1 is used to estimate the macroeconomic impacts of the proposed amendments on the California economy and is discussed in detail in section D. Alternatives to the proposed amendments are discussed in section E and fiscal impacts on both state and local government are discussed in section F.

1. Statement of the Need of the Proposed Regulation

HD trucks account for about 26 percent of statewide PM emissions.[2] These diesel PM emissions pose a significant health risk because diesel PM is a carcinogenic toxic air contaminant (TAC) linked to an increase in both serious illness and premature mortality rates.[3] Individuals that live in highly impacted trucking areas such as near major highway arteries or near major seaports are at even greater risks. Major portions of California are not in attainment with the federal PM2.5 standards including population rich areas such as the South Coast basin, the San Joaquin Valley, and parts of the Bay Area. In an effort to attain air quality standards and reduce the health risks to individuals living in California, large PM emission reductions are needed from the HD trucking sector.

The current opacity limits are not adequate to ensure that damaged PM emission control components on HD vehicles get identified and repaired. Due to this, many HD vehicles are operating in California with damaged emission control components and emitting PM emissions well in excess of a properly functioning vehicle. Emission control components include, but are not limited to, DPFs, diesel oxidation catalysts (DOCs), and Exhaust Gas Recirculation (EGR). The proposed amendments reduce the in-use opacity limits to

[1] 1. Society of Automotive Engineers (SAE) J1667 Recommended Practice, Snap Acceleration Smoke Test Procedure for Heavy-Duty Powered Vehicles, 1996. https://www.arb.ca.gov/enf/hdvip/saej1667.pdf

[2] U.S. and California Heavy-Duty Truck Program, Workshop on Heavy-Duty Vehicle Regulations. CARB, 2015. https://www.iea.org/media/workshops/2015/heavydutyfuelworkshopindia/2.4_US.pdf

account for improvements in emission control technologies that have significantly reduced tailpipe PM emissions over the last two decades. These lower opacity limits will reduce the number of HD diesel vehicles in California operating with excess PM emissions from the HD trucking sector, leading to a reduction in the health risks associated with toxic diesel PM emissions from the HD trucking sector.

In addition to reducing the opacity limits, smoke tester training and reporting requirements are also being proposed, which affect the PSIP, but do not affect the HDVIP. With lower opacity limits, proper testing procedures become more critical. The training requirements applicable to PSIP smoke testers will help ensure better accuracy and consistency in the PSIP annual opacity testing that is performed by HD vehicle fleets or contracted smoke testers, making sure vehicles with damaged PM emission control components are readily identified.

The proposed PSIP reporting requirements will help improve compliance with the PSIP testing requirements. CARB enforcement findings currently estimate PSIP testing is at 50 percent compliance. This is likely because it is difficult for CARB to identify fleets that are not performing testing. The proposed reporting requirements will allow CARB to more effectively enforce the PSIP testing requirements, ensure damaged vehicles get repaired, and provide data necessary to improve future emission inventory estimates. CARB's Enforcement Division will analyze the submitted data to identify trends and anomalies that indicate the likelihood of noncompliance. This will allow for better identification and enforcement of HD fleets that are in violation and do not perform the annual PSIP opacity testing or continue to operate vehicles above the allowable opacity limits. This would ensure increased compliance compared to today, where enforcement personnel must verify paper records in person to determine PSIP testing compliance, and to identify if any tested trucks are operating above opacity limits.

2. Major Regulation Determination

The proposed amendments are determined to be a major regulation requiring a Standardized Regulatory Impact Assessment (SRIA) as the estimated cost impacts exceed $50 million in 2019. Because the proposed amendments are fully implemented in 2024, this cost triggers the threshold for a major regulation. The proposed amendments could increase repair costs for HD diesel vehicle owners; which is defined as a direct cost to the regulated community. CARB has estimated that the proposed amendments could result in direct costs to regulated parties of up to $102 million in a given year.

3. Baseline Information

To estimate the economic impacts of the proposed amendments, a baseline or business-as-usual (BAU) characterization was developed. The economic impact of the proposed amendments is then evaluated against the BAU scenario.

Under the existing HDVIP and PSIP regulations, HD vehicles are subject to opacity tests through both the HDVIP and the PSIP. The HDVIP consists of roadside inspections by CARB enforcement personnel and the PSIP consists of annual self-testing for California fleets of 2 or more vehicles. Fleets that are subject to the PSIP regulation must maintain their annual testing records for 2 years. 1991 MY and newer HD diesel engines must

comply with a 40 percent opacity limit to legally operate on California roadways, whereas 1990 MY and older diesel engines must comply with a 55 percent opacity limit (Table 4).

The current in-use opacity limits for the HDVIP and PSIP regulations are used for the baseline. To establish the BAU, staff gathered repair shop opacity testing data and recently performed roadside opacity tests during HDVIP enforcement activities to determine the percentage of the statewide trucking fleet which operate at opacity levels above the current opacity limits. Staff did the same analysis for the proposed opacity limits. In 2016 staff embarked on an intensive months long roadside testing campaign randomly pulling over thousands of vehicles and performing opacity tests conducted using the SAE J1667 testing protocol.[3] Staff travelled to multiple locations throughout the state, including rural and urban areas in both Northern and Southern California, to ensure an unbiased sampling of vehicles. The random sampling of thousands of vehicles enabled an accurate depiction of the current state of opacity levels for the statewide fleet to help estimate emissions and costs for both the BAU and the proposed amendments.

Table 4 shows the percentage of trucks that are estimated to be operating above the current opacity limits. There is a small percentage of vehicles, estimated at less than 1 percent overall, that presently do not meet the current opacity limit requirements and need repairs. Extrapolating the opacity data collected from the 2016 opacity testing campaign to statewide HD vehicle populations, staff estimates that there are currently just under 3,300 vehicles above the current opacity limits statewide, with the majority of these being non-DPF equipped vehicles. Only about 650 DPF-equipped vehicles are currently estimated to be above the current opacity limits. For calendar year 2010, staff previously estimated an average repair cost of $581 for all vehicles above the current 40 and 55 percent opacity limits to obtain repairs and get into compliance.[4] After adjusting this repair cost to 2017 dollars[5], staff estimated the repair costs to comply with the current regulation (or BAU) following the methodology described in the “Direct Costs” section. Table 5 projects the annual repair costs to meet the current opacity requirements. Staff will subtract these baseline costs from the total regulatory costs estimated for the proposed amendments because it is assumed these repairs would occur in the BAU, and these costs are not a consequence of the proposed amendments.

[3] Society of Automotive Engineers (SAE) J1667 Recommended Practice, Snap Acceleration Smoke Test Procedure for Heavy-Duty Powered Vehicles, 1996. https://www.arb.ca.gov/enf/hdvip/saej1667.pdf

[4] Technical Support Document: Heavy-Duty Vehicle Inspection Program, Periodic Smoke Inspection Program, CARB, October 1997.

[5] Consumer Price Index Forecast, Department of Finance.
http://www.dof.ca.gov/Forecasting/Economics/Eco_Forecasts_Us_Ca/index.html

Table 4: Percentage of HD Diesel Vehicles Operating in California above the Current Opacity Limits Based on Roadside Testing

Non-DPF Engines	Current Opacity Limit	Vehicles Operating Above the Current Opacity Limits
Pre-1991 MY	55%	1%
1991-1996 MY	40%	2%
1997-2007 MY	40%	2%
DPF Equipped Engines	**Current Opacity Limit**	**Vehicles Operating Above the Current Opacity Limits**
Pre 2007 MY	40%	0%
2007-2009 MY	40%	1%
2010+ MY	40%	0%

Table 5: Estimated Repair Costs Associated with the Baseline Regulatory Requirements for the Statewide Fleet

Year	Repair Cost ($)
2018	1,027,061
2019	934,001
2020	685,242
2021	400,580
2022	378,014
2023	130,422
2024	119,112
2025	107,769
Total	3,782,201

The proposed amendments reduce the opacity limit for HD vehicles starting in 2018. See Table 2 for the proposed opacity limits. To come into compliance, vehicles with elevated opacity levels will need to repair damaged emission control components to meet the proposed lower opacity limits. Table 6 shows the percentage of vehicles that are expected to be operating above the proposed opacity limits once the proposed amendments are implemented. These percentages will be used to assess both the repair costs and emission benefits associated with the proposed amendments. Although the HDVIP can target both HD gasoline and diesel engines for inspection, the proposed amendments are only expected to impact diesel engines. Staff does not anticipate any impact on HD gasoline vehicles due to the proposed amendments as all gasoline vehicles and diesel vehicles below 14,000 pounds GVWR are subject to the Bureau of Automotive Repair's (BAR) light-duty smog check program and are assumed to be compliant and in working condition. Thus, for the current analysis, staff projects repair estimates based only on diesel vehicles with a GVWR above 14,000 pounds.

Table 6: Percent of Vehicles Operating Above the Proposed Opacity Limits Based on 2016 Roadside Testing

Non-DPF Engines	Proposed Opacity Limit	Percent of Vehicles Above the Proposed Opacity Limits
Pre-1991 MY	40%	2%
1991-1996 MY	30%	4%
1997-2007 MY	20%	12%
DPF Equipped Engines	**Proposed Opacity Limit**	**Percent of Vehicles Above the Proposed Opacity Limits**
Pre 2007 MY	5%	12%
2007-2009 MY	5%	22%
2010+ MY	5%	3%

Staff is proposing reporting requirements for the PSIP in addition to the current record keeping requirements. The BAU assumes a 50 percent compliance rate with the testing and record keeping portion of the PSIP program. This is based on CARBs enforcement data for historical PSIP audits. Estimated direct costs as a consequence of the proposed reporting requirement will be assessed relative to this BAU.

Staff is also proposing to require new smoke tester training requirements for PSIP smoke testers. Contracted smoke testers would be required to receive training through a CARB approved training facility, such as CCDET. Owners or employees who perform their own vehicle fleet testing would be required to take an online training course developed by CARB. Staff used survey data to identify the current tester training for development of the BAU, as discussed below. Any additional costs to comply with the proposed amendments are assessed compared to the BAU of current testing conditions.

Some smoke testers already receive CCDET training, and would not be required to do anything differently to comply with the proposed amendments. To identify this number for the BAU, staff performed a survey, reaching out to approximately 50 companies that offer smoke testing services . CCDET is currently the only program in California that offers a smoke tester training course that would meet the requirements of the proposed amendments. CCDET smoke tester certification is valid for 4 years, whereupon retraining is needed. Based on the 2016 survey results, staff estimates that about 90 percent of contracted PSIP smoke testers already receive CCDET training every 4 years. This existing training rate is accounted for in the BAU.

To identify the total number of contracted PSIP smoke testers throughout the state (both trained and untrained), CARB analyzed historical CCDET training rates. CCDET has given out 2,133 certificates between 2014 and 2016.[6] Staff scaled up this data to estimate the total number of CCDET certificates in the last 4 years. CCDET provided 2,133 certificates over three years, or an average of 711 per year. Therefore, over four years CCDET would provide 2,844 certifications (2,133 plus 711). Using the assumption

[6] California Council on Diesel Technology Education and Training "CCDET". December, 2016. http://ccdet.org/wp-content/uploads/2017/01/CCDET-Report_12122016.pdf

above that 90 percent of testers are already CCDET trained, the total number of smoke testers (both trained and untrained) is approximately 3,160.

Staff also reached out to large fleets to estimate the percentage of mechanics and employees who perform smoke testing for their fleet which may have already received smoke tester training through CCDET. A small percentage of fleet employees who do smoke testing as a side business have received CCDET training; however, the majority of fleet employees have not received any smoke tester training. Since the percentage of trained fleet employees is small, staff is taking a conservative approach for the purposes of setting the BAU for this proposed training requirement and assuming no individuals who perform smoke testing for their fleets have received training and all of them will need to take the online training course. In summary, staff assumes 90 percent of contracted smoke testers already receive the required training under the BAU, however, no individuals who test their own fleet vehicles have received the required training.

The BAU for PM emissions is derived from CARB's Emission FACtors (EMFAC) model,[7] which estimates emission rates from motor vehicles in California. Regulatory requirements from the Truck and Bus Rule, vehicle certification standards, and the current opacity limits are already embedded into EMFAC's baseline emission and malmaintenance rates. The proposed amendments will force vehicles to make repairs to PM emission control components, effectively reducing malmaintenance rates of the in-use vehicle population. Staff will assess the emission benefits by decreasing the malmaintenance rates in the EMFAC model based on the estimated number of repairs that will occur due to the proposed amendments relative to the BAU emissions in the EMFAC model. The assumptions used to estimate the number of repairs as a consequence of the proposed amendments are discussed in detail later in the Direct Costs section.

4. Public Outreach and Input

Staff held multiple public workshops on the proposed amendments to the HDVIP and PSIP starting with introductory workshops in El Monte on August 25, 2016 and in Sacramento on September 9, 2016. Additional workshops were held in Diamond Bar on February 28, 2017 and in Sacramento on May 17, 2017. Every workshop was webcasted except for the August 25, 2016 workshop in El Monte. These workshops engaged representatives from vehicle and instrument manufacturers, trucking fleets, the HD repair industry, and environmental advocates. Following each workshop and throughout the regulatory development process, CARB received input from and worked with stakeholders on a variety of proposed amendments to the HDVIP and PSIP regulations. CARB created a public webpage where related workshop materials and relevant information were posted to keep stakeholders up to date on the latest developments in the regulatory process and distributed announcements and workshop materials through the CARB list serves which, based on individual subscribers to the list serves, reach up to 90,000 individuals.

[7] EMFAC2014 Volume III - Technical Documentation, CARB, 5/12/2015. https://www.arb.ca.gov/msei/downloads/emfac2014/emfac2014-vol3-technical-documentation-052015.pdf

In an effort to reach as many stakeholders as possible throughout the state, staff sent out multiple emails to over 24,000 fleets providing a description of the proposed amendments, announcements to upcoming workshops, and contact information for relevant staff. Additionally, announcements and program information were broadcast via various social media sites such as Facebook and Twitter and on CARB's Truck Stop website. A mail-out campaign was conducted on May 1 announcing the May 17, 2017 workshop in an effort to reach fleets and individual owner operators who may not have access to the internet or do not follow CARB's website and list serve announcements to ensure their thoughts and concerns could be heard. Email announcements and website posts will continue throughout the regulatory process to help inform stakeholders of any upcoming changes. A follow up mail-out is also planned for all HD fleet owners registered in California to distribute information and details regarding the proposed amendments to make sure that every stakeholder potentially affected by the proposed amendments is informed about the potential changes moving forward.

B. BENEFITS

The proposed amendments to the HDVIP and PSIP are anticipated to deliver PM emission reductions starting in the year 2018. Staff does not anticipate quantifiable benefits for other pollutants. PM benefits are the direct result of engine and aftertreatment repairs on vehicles with excess opacity and PM emissions. Vehicles emitting above the proposed opacity limits are operating with damaged emission control components, such as a compromised DPF, which results in the release of significantly more PM emissions relative to a vehicle operating with properly functioning emission control systems. By repairing or replacing damaged emission control components (the costs of which are estimated in the Direct Cost section), the proposed amendments can result in significant PM emission benefits.

The proposed amendments are projected to deliver an estimated 1,695,300 pounds of PM emission benefits from the HD trucking transportation sector from 2018 to 2025, with an average of just under 190,000 pounds PM per year. Total statewide PM emissions from the HD vehicle sector over the same time period are estimated to be about 13 million pounds. Table 7 shows the projected annual PM emission benefits projected for the proposed amendments in both tons per day and pounds per year. Emission benefits are greatest in the early years of the proposed amendments before CARB's existing Truck and Bus Rule requires the turnover of many 2009 MY and older engines to newer vehicles by 2023. Most of the emission benefits are obtained from repairs to 2009 MY and older engines which, as shown in Table 6, are model years anticipated to have a higher percentage of vehicles above the proposed opacity limits. Once these vehicles are retired, the emission benefits decrease.

Table 7: Projected Annual Statewide PM Emission Benefits of the Proposed Amendments Relative to the BAU

Year	PM Tons per Day	PM Pounds per Year
2018	0.174	127,260
2019	0.542	395,660
2020	0.496	362,080
2021	0.411	300,030
2022	0.382	278,860
2023	0.102	74,460
2024	0.106	77,380
2025	0.109	79,570
Total	2.322	1,695,300

1. Benefits to Individuals

The proposed amendments will reduce PM2.5 diesel exhaust which results in health benefits for individuals in California.[8] These health benefits lead to benefits to individuals, businesses, and government agencies due to fewer premature mortalities, fewer hospital and ER visits, and fewer lost days of work. As part of setting the National Ambient Air Quality Standard for PM, the U.S. EPA quantifies the health risk from exposure to PM,[9] and CARB uses the same health studies for this evaluation.

CARB analyzed the cost-savings of the proposed amendments associated with five health outcomes: cardiopulmonary[10] mortality, hospitalizations for cardiovascular[11] illness, hospitalizations for respiratory[12] illness, emergency room (ER) visits for respiratory illness, and ER visits for asthma. These health outcomes were selected because U.S. EPA has identified these as having a *causal* or *likely causal* relationship with exposure to PM2.5.[13] The U.S. EPA examined other health endpoints such as cancer, reproductive and developmental effects, but determined there was only *suggestive* evidence for a relationship between these outcomes and PM exposure, and insufficient data to include these endpoints in the national health assessment analyses routinely performed by U.S. EPA.

[8] Report to the Air Resources Board on the Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant, Part A. 1998. https://www.arb.ca.gov/toxics/dieseltac/part_a.pdf
[9] U.S. EPA, 2010. Quantitative Health Risk Assessment for Particulate Matter (Final Report). https://www3.epa.gov/ttn/naaqs/standards/pm/data/PM_RA_FINAL_June_2010.pdf
[10] Outcomes related to the heart or lungs
[11] Outcomes related to the heart or blood vessels
[12] Respiratory illness such as chronic obstructive pulmonary disease, and respiratory infections
[13] U.S. EPA, 2010. Quantitative Health Risk Assessment for Particulate Matter (Final Report). https://www3.epa.gov/ttn/naaqs/standards/pm/data/PM_RA_FINAL_June_2010.pdf

The U.S. EPA has determined that both long-term and short-term exposure to PM2.5 plays a *causal* role in premature mortality, meaning that a substantial body of scientific evidence shows a relationship between PM2.5 exposure and increased risk of death. This relationship persists when other risk factors such as smoking rates, poverty and other factors are taken into account.[14] While other mortality endpoints could be analyzed, the strongest evidence exists for cardiopulmonary mortality.[15] The greater scientific certainty for this effect, along with the greater specificity of the endpoint, leads to an effect estimate for cardiopulmonary deaths that is both higher and more precise than that for all-cause mortality.[16]

The U.S. EPA has also determined a *causal* relationship between non-mortality cardiovascular effects and short and long-term exposure to PM2.5, and a *likely causal* relationship between non-mortality respiratory effects (including worsening asthma) and short and long-term PM2.5 exposure.[17] These outcomes lead to hospitalizations and ER visits, and are included in this analysis.

In general, health studies have shown that populations with low socioeconomic standings are more susceptible to health problems from exposure to air pollution.[18,19] However, the models currently used by U.S. EPA and CARB do not have the granularity to account for this impact. The location and magnitude of projected emission reductions resulting from the Proposed Amendments are not known with sufficient accuracy to account for socioeconomic impacts, and an attempt to do so would produce uncertainty ranges so large as to make conclusions difficult. CARB acknowledges this limitation.

Individuals who live in high risk areas near major trucking and freight corridors, for example near ports and rail yards, are exposed to higher PM concentrations from HD vehicles than the average person. These individuals are at higher risks of developing respiratory impairments as a result of HD vehicle PM emissions, especially those included in the sensitive groups, such as those with low socioeconomic standing mentioned above. Although it is difficult to quantitatively determine the emission benefits in these high-risk

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[14] U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2009). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/139F, 2009. http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=494959

[15] U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2009). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/139F, 2009. http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=494959

[16] Air Resources Board (ARB), 2010. Estimate of Premature Deaths Associated with Fine Particle Pollution (PM2.5) in California Using a U.S. Environmental Protection Agency Methodology. https://www.arb.ca.gov/research/health/pm-mort/pm-report_2010.pdf

[17] U.S. EPA. Integrated Science Assessment (ISA) for Particulate Matter (Final Report, Dec 2009). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/139F, 2009. http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=494959

[18] Krewski et al. (2009) Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality. Health Effects Institute Research Report 140. https://ephtracking.cdc.gov/docs/RR140-Krewski.pdf.

[19] Gwynn RC, Thurston GD. (2001) The burden of air pollution: impacts among racial minorities. Environ Health Perspectives;109(4):501–6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1240572/

areas, the proposed amendments are expected to provide the largest PM emission reductions in regions with the most HD truck traffic.

The following discussion provides an estimate of the health benefits to individuals throughout the state as a result of the proposed amendments. A detailed summary of the health modeling methodology is included in Appendix A of this document. As will be shown, the largest health impacts correspond to regions with the most truck traffic and high-risk areas such as the South Coast Air Basin and the San Joaquin Valley Air Basin. The reduction in PM will also likely result in better visibility throughout the state due to the improved air quality, an unquantified benefit to individuals in California.

Table 8 shows the estimated reduction in premature mortality, hospitalizations, and emergency room visits associated with the proposed amendments. Regional emission reductions as a consequence of the proposed amendments were estimated by EMFAC, and used in combination with the IPT methodology to estimate avoided health outcomes by air basin. Significant health benefits are expected to be obtained throughout the state, with the majority of benefits coming in the South Coast, San Joaquin Valley, and Bay Area regions. Figure 1 presents a map of health outcomes by air basin and associated disadvantaged communities as identified by the top 25 percent highest scoring census tracts in CalEnviroscreen 3.0.[20]

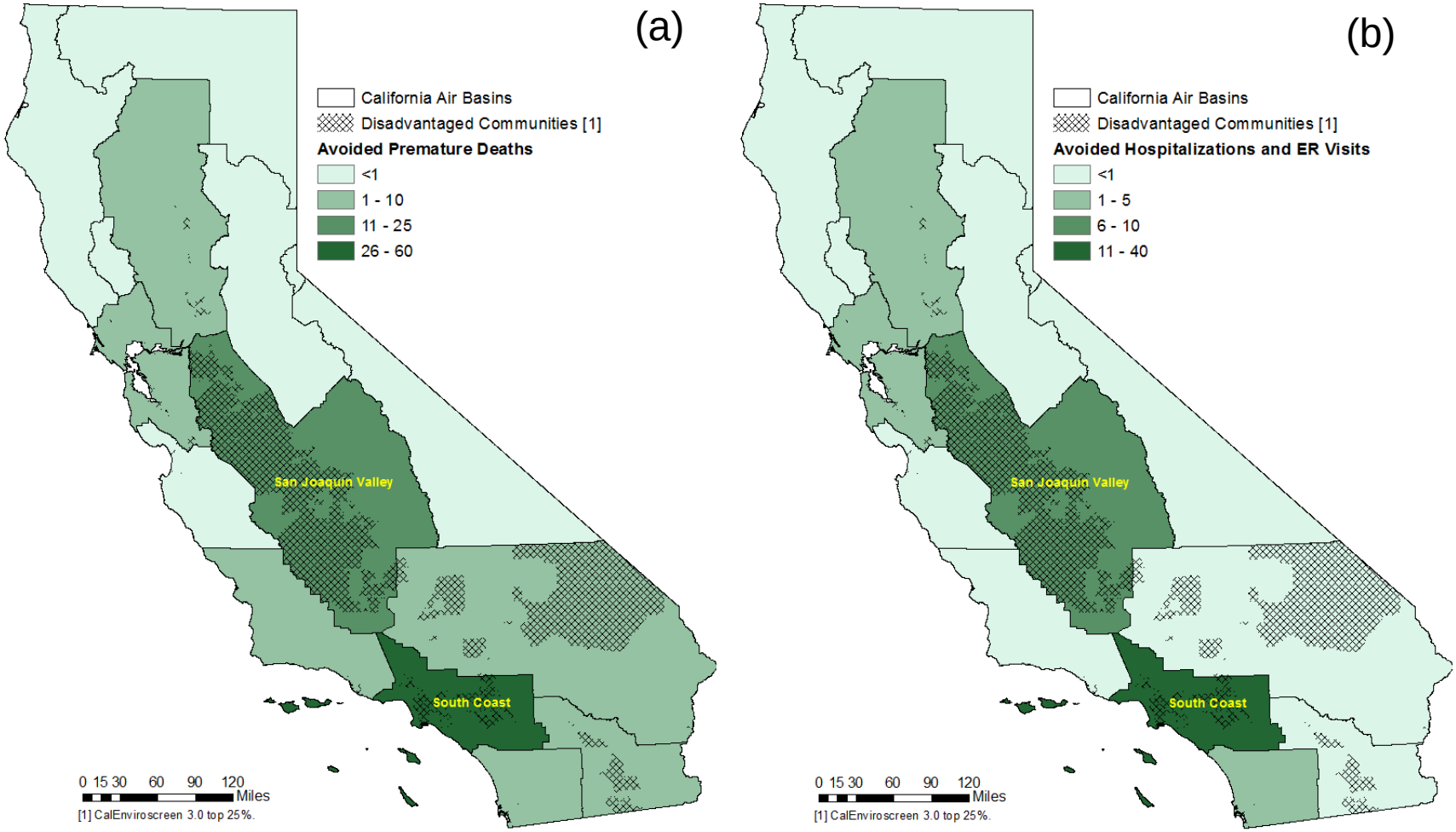
Table 8: Cumulative Regional and Statewide Avoided Health Incidences from 2018 to 2025*

	Avoided Premature Deaths	Avoided Hospitalizations	Avoided ER Visits
Great Basin Valleys	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Lake County	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Lake Tahoe	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Mojave Desert	2 (1 - 2)	0 (0 - 1)	1 (0 - 1)
Mountain Counties	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
North Central Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
North Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Northeast Plateau	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Sacramento Valley	4 (3 - 5)	1 (0 - 1)	1 (1 - 2)
Salton Sea	2 (1 - 2)	0 (0 - 1)	1 (0 - 1)
San Diego County	5 (4 - 6)	1 (0 - 2)	2 (1 - 3)
San Francisco Bay	9 (7 - 11)	2 (0 - 4)	4 (2 - 5)
San Joaquin Valley	13 (10 - 16)	2 (0 - 4)	5 (3 - 7)
South Central Coast	1 (1 - 1)	0 (0 - 0)	0 (0 - 1)
South Coast	58 (45 - 71)	8 (1 - 19)	25 (16 - 34)
Statewide	84 (65 - 100)	12 (2 - 29)	35 (22 - 48)

*Values in parenthesis represent the 95% confidence interval. Totals may not add due to rounding.

[20] Office of Environmental Health Hazard Assessment, 2017. CalEnviroscreen 3.0. https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30

Figure 1. Avoided premature deaths (a) and avoided hospitalizations and ER visits (b) from 2018 through 2025 as a result of the proposed amendments.



In accordance with U.S. EPA practice, health outcomes are monetized by multiplying incidence by a standard value derived from economic studies.[21] Discounting was not used for costs in this analysis, so was also not used for cost-savings to maintain consistent methodology.

The valuation per incident is included in Table 9. The valuation for avoided premature mortality is based on willingness to pay.[22] This value is a statistical construct based on the aggregated dollar amount that a large group of people would be willing to pay for a reduction in their individual risks of dying in a year. This is not an estimate of how much any single individual would be willing to pay to prevent a certain death of any particular person,[23] nor does it consider any specific costs associated with mortality such as hospital expenditures. While the valuation associated with reductions in premature mortality is an important benefit of the proposed amendments, the valuation used to monetize the benefit does not easily lend itself to macroeconomic modeling. The benefits associated with premature mortality is reported here, but is not included in macroeconomic modeling (Section D).

Unlike premature mortality valuation, the valuation for avoided hospitalizations and ER visits are based on a combination of typical costs associated with hospitalization and the willingness of surveyed individuals to pay to avoid adverse outcomes that occur when hospitalized. These include hospital charges, post-hospitalization medical care, out-of-pocket expenses, and lost earnings or both individuals and family members, lost recreation value, and lost household production (e.g., valuation of time-losses from inability to maintain the household or provide childcare).[24] Because these are most closely associated with specific cost-savings to individuals (and costs to the healthcare system), monetized benefits from avoided hospitalizations and ER visits are included in macroeconomic modeling (Section D).

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[21] U.S. Environmental Protection Agency, 2010. "Appendix B: Mortality Risk Valuation Estimates, Guidelines for Preparing Economic Analyses." EPA 240-R-10-001. National Center for Environmental Economics, Office of Policy Economics and Innovation. Washington, DC. December. Available at: http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-22.pdf/$file/EE-0568-22.pdf

[22] U.S. Environmental Protection Agency Science Advisory Board (U.S. EPA-SAB). 2000. "An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reduction." EPA-SAB-EEAC-00-013. July. Available at: http://yosemite.epa.gov/sab%5CSABPRODUCT.NSF/41334524148BCCD6852571A700516498/$File/eeacf013.pdf

[23] U.S. Environmental Protection Agency. Mortality Risk Valuation – What does it mean the place a value on a life? Accessed 7/2017. https://www.epa.gov/environmental-economics/mortality-risk-valuation#means

[24] Chestnut, L. G., Thayer, M. A., Lazo, J. K. And Van Den Eeden, S. K.. 2006. "The Economic Value Of Preventing Respiratory And Cardiovascular Hospitalizations." Contemporary Economic Policy, 24: 127–143. doi: 10.1093/cep/byj007 Available at: http://onlinelibrary.wiley.com/doi/10.1093/cep/byj007/full

Table 9: Valuation per Incident for Avoided Health Outcomes

Outcome	Cost-Savings per Incident
Avoided Premature Deaths	$8,629,716
Avoided Acute Respiratory Hospitalizations	$45,221
Avoided Cardiovascular Hospitalizations	$51,844
Avoided ER Department Visits	$742

Statewide valuation of health benefits were calculated by multiplying the avoided health outcomes by the valuation per incident. The total statewide valuation due to avoided health outcomes between 2018 and 2025 is summarized in Table 10. The spatial distribution of these benefits follow the distribution of emission reductions and avoided health outcomes, therefore most cost savings to individuals will occur in the South Coast and San Joaquin Valley Air Basins.

Table 10: Statewide Valuation from Avoided Health Outcomes between 2018 and 2025 as a Result of the Proposed Amendments

Outcome	Cost-Savings (Million $)
Avoided Premature Deaths	$722.3
Avoided Hospitalizations	$0.6
Avoided ER Visits	$0.0
Total Cost-Savings	**$722.9**

2. Benefits to California Businesses

Vehicles with malfunctioning emission control systems will replace DPFs and potentially repair engine components that have resulted in excess opacity and PM emissions to meet the requirements of the proposed amendments. Reduced emissions will likely reduce occupational exposure to PM for truck drivers, as well as other workers near high trucking areas such as port or warehouse employees. This reduced exposure may result in fewer lost workdays due to health issues and better productivity. The improved quality of life may help businesses improve the recruitment and retention of the workers. In the HD trucking sector, the lack of driver retention is currently an area that transportation companies struggle with as the need to find and train new drivers on a consistent basis has hurt their bottom line. Worker retention stems from multiple attributes of a job, and the impact of reduced air pollutant exposure due to these proposed amendments cannot be quantified separately from other attributes.

The demand for replacement DPFs and HD vehicle repairs is expected to increase due to the lowering of the allowable opacity limit, resulting in monetary benefits to HD part manufacturers and repair shops. Increased employment in these sectors is expected in an effort to meet the increased demand for DPF replacements and engine component repairs. Staff anticipates there will be a slight increase in demand for smoke meters as

the reporting requirements are phased in; this increase will be discussed in Section C. Some medium and large fleets are expected purchase smoke meters in an effort to do their own annual PSIP testing. A full analysis of these effects is included in the macroeconomic modeling section.

3. Benefits to Small Businesses

Many small businesses in the HD vehicle repair sector are expected to be positively impacted by these proposed rule changes. Independent HD repair shops, many of which are small businesses, are expected to see an uptick in business due to the increased demand for vehicle repairs. Small businesses in the aftermarket DPF sector are expected to see an increase in demand for their products as their parts are typically cheaper than those provided by the OEM. Aftermarket DPFs can be installed in 2007-2009 MY engines and staff anticipates that the majority of replacement DPFs on 2007-2009 MY engines will come from the aftermarket DPF sector.

C. DIRECT COSTS

1. Direct Cost Inputs

The proposed amendments are expected to only affect HD diesel vehicles, as described previously. The transportation and goods movement industry is expected to face increased costs due to vehicle repairs, roadside citations, reporting and training. The following sections describe the detailed methodology used to estimate each of these direct costs. All costs listed are $2016.

a. Repair Costs Assumptions

Vehicles that exceed the proposed opacity limits will need to repair or replace emission control components. Staff contacted manufacturers and analyzed 1.5 years of HD repair shop invoices to estimate repair costs of the typical emission control technologies which may need to be repaired to meet the lower opacity limits.

DPF-equipped vehicles with a properly functioning DPF measure at opacity levels at or near 0 percent. Staff assumed that a DPF-equipped vehicle with excess opacity emissions has a compromised DPF, which must be replaced to meet the proposed opacity limit. Table 11 shows the current estimated market costs an owner must pay to get a replacement DPF. DPF replacement costs vary by engine MY.

Table 11: Estimated DPF Replacement Costs Based on Engine MY

Engine Model Year	Replacement DPF Cost
2010+ MY Engine	$2,927
2007-2009 MY Engine	$2,198
Pre-2007 MY Engine	$5,385

A compromised DPF is typically thought to result from an upstream engine issue which significantly increases engine-out PM emissions[25] and overloads the DPF. When this occurs, the upstream engine component creating excess PM emissions should also be repaired when the DPF is replaced. Staff analyzed HD repair invoices to estimate which upstream engine issues typically lead to a compromised DPF and the typical costs owners incur to remedy these issues. Table 12 lists the major engine components that lead to a compromised DPF and estimates the repair costs and relative frequencies at which these upstream issues occur. The average upstream repair cost shown in Table 12 weighs each individual part cost with its relative frequency of getting repaired. For example, the diesel oxidative catalyst is repaired most frequently when replacing a DPF, thus is weighted more heavily in the estimated average cost of an upstream repair than the other upstream engine parts.

Table 12: Costs and Relative Frequency of Upstream Repairs

Upstream Engine Part	Repair Cost	Relative Frequency of Repair
Diesel Oxidative Catalyst (DOC)	$3,454	45%
Exhaust Gas Recirculation (EGR) Valve	$1,266	21%
EGR Cooler	$2,464	9%
Turbocharger	$3,497	16%
Fuel Injector	$1,202	9%
Weighted Average Upstream Repair	**$2,707**	

Repairing the upstream engine issue helps ensure the durability of the replacement DPF. However, some owners choose to forgo the upstream repair and only replace the DPF. Staff further analyzed the HD repair invoices to estimate the rate of occurrence of an upstream engine repair relative to a DPF replacement. The data suggest that at about 62 percent of the time, there are upstream repairs with a DPF replacement. This ratio (0.62) is applied to the average upstream repair cost ($2,707 x 0.62 = $1,678) for DPF-equipped vehicles to estimate the average overall repair cost (Table 13). For a non-DPF equipped vehicle, the weighted average upstream repair cost shown in Table 12 is assumed for repairs.

Table 13: Estimated Average Repair Cost for a Non-Compliant Vehicle to Meet the Proposed Opacity Limit

Engine Model Year	DPF Cost	Average Upstream Repair Cost	Average Total Repair Cost
2010+ MY Engine	$2,927	$1,678	$4,605
2007-2009 MY Engine	$2,198	$1,678	$3,876
Pre-2007 MY Engine (DPF-Equipped)	$5,385	$1,678	$7,063
Non-DPF Engine	N/A	$2,707	$2,707

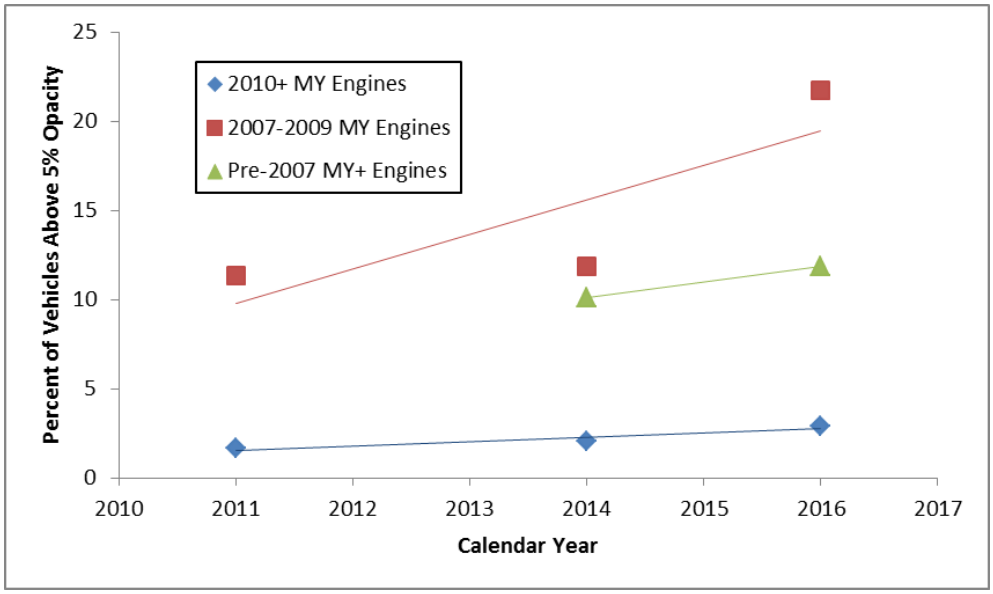
[25] Evaluation of Particulate Matter Filters in On-Road Heavy-Duty Diesel Vehicle Applications, May 8, 2015. https://www.arb.ca.gov/msprog/onrdiesel/documents/DPFEval.pdf

b. Vehicles Operating Above the Proposed Opacity Limits

To estimate the population of vehicles operating above the proposed opacity limits, an intensive roadside testing campaign was performed by CARB staff throughout the state. Staff randomly pulled over thousands of DPF-equipped HD vehicles and performed an opacity test following the Society of Automotive Engineers (SAE 1667) testing protocol.[26] Testing was performed in 2011, 2014, and 2016 to document trends over time. Figure 2 shows the percent of vehicles that tested above the proposed 5 percent opacity limit by engine model year. Staff estimated the percentage of DPF-equipped vehicles operating above the proposed 5 percent opacity limit upon rule implementation (Table 14) by extrapolating the data in Figure 2 out to 2018, the year the proposed opacity limits are expected to become effective.

Some vehicles that are initially below the 5 percent opacity limit in CY 2018 may need repairs in subsequent years. These include vehicles that degrade over time and also vehicles that have reoccurring problems resulting in excess emissions at a later date. The percentage of vehicles exceeding the 5 percent opacity limit in subsequent years (Table 14) is estimated based on the annual rate of increase (slope of the line) of the opacity data presented in Figure 2.

Figure 2: Percent of Vehicles Above a 5 Percent Opacity Level from CARB Roadside Testing Campaigns in 2011, 2014, and 2016



[26] Technical Support Document: Proposed Regulation For In-Use On-Road Diesel Vehicles, CARB, October 2008. https://www.arb.ca.gov/regact/2008/truckbus08/tsd.pdf

Table 14: Percentage of DPF Equipped Vehicles Estimated to be Above the Proposed Opacity Limit Based on Field Testing Campaigns in 2011, 2014, and 2016

Engine Type	Implementation Year (2018)	Subsequent Years
2010+ MY Engine	3%	0.2%
2007-2009 MY Engine	23%	2%
Pre-2007 MY Engines	14%	1%

The percentage of Non-DPF equipped vehicles projected to be above the proposed opacity limits are estimated from testing data supplied by participating HD repair shops. Opacity test data from thousands of Non-DPF equipped vehicles were provided to CARB staff for analysis. Data from multiple calendar years were not available for Non-DPF equipped vehicles, so staff estimated subsequent year rates based on engineering judgment and analysis of the DPF-equipped vehicle data. The estimated percentage of Non-DPF equipped vehicles above the proposed opacity limits in CY 2018 and subsequent years are provided in Table 15.

Table 15: Percentage of Non-DPF Equipped Vehicles Estimated to be Above the Proposed Opacity Limits

Engine Type	Implementation Year (CY 2018)	Subsequent Years
Non-DPF Vehicles	10%	1%

c. Repair Rate Estimates

The percentage of vehicles that get repaired is expected to be dependent on which regulatory programs (HDVIP and PSIP) each fleet is subject to. Some fleets are only subject to the HDVIP, whereas others are subject to both the HDVIP and PSIP. Owner operators and out-of-state fleets are only subject to the HDVIP, whereas California based fleets of 2 or more diesel vehicles are subject to both the HDVIP and PSIP. According to recent DMV data, owner operators represent about 20 percent of the registered HD vehicles in California, whereas multiple vehicle fleets account for about 80 percent of the total registered vehicles in the state.

i. Fleets subject only to HDVIP

Currently, CARB staff annually tests about 3 percent of the statewide vehicle population through roadside testing. In addition to the roadside testing, some owners will independently identify vehicles that need repairs and voluntarily repair those vehicles due to the deterrent effect provided by active HDVIP enforcement. Based on experience with light-duty inspection and maintenance (I/M) programs, staff estimates that this deterrent effect will result in about 33 percent of the tampered and malmaintained vehicles getting repairs to meet the opacity requirements.[27] Between these two factors, an active HDVIP

[27] Proposed Roadside Smoke Test Procedures and Opacity Standards for Heavy-Duty Vehicles, Technical Support Document, CARB, August 1990.

enforcement program and the deterrent effect, CARB projects that about 35 percent of vehicles above the proposed opacity limits that are subject only to the HDVIP will get repaired.

ii. Fleets subject to HDVIP and PSIP

Fleets subject to PSIP have additional testing requirements compared to those only subject to HDVIP. Fleets subject to PSIP can be audited by CARB enforcement staff at any time. Staff estimates that fleets subject to both the HDVIP and PSIP repair their vehicles at a higher rate than those subject only to HDVIP. Based on current PSIP auditing records, where staff audits fleets to ensure they are testing and repairing their vehicles, staff estimates that about 50 percent of fleets are in compliance with PSIP. Based on these data, staff estimates that about 50 percent of vehicles with excess opacity emissions subject to both the HDVIP and PSIP will get repaired.

The proposed amendments require fleets to annually affirm that all vehicles are tested and meet the proposed opacity limits. These requirements will be phased in starting with larger fleets first. Reporting requirements will increase repair rates with PSIP beyond current rates. Staff relied on other, related CARB programs to project potential compliance rates for the proposed amendments. For the Truck and Bus Rule, reporting is required for vehicles that are exempted from the program requirements or have applied for a compliance extension. Data suggest that the Truck and Bus Rule has about a 70 percent compliance rate. Based on this, staff estimates that the repair rate will increase to about 70 percent for fleets subject to PSIP reporting requirements. Table 16 details the estimated repair rates expected for vehicles with excess opacity emissions in the HDVIP and PSIP.

Table 16: Repair Rate Estimates for Vehicles Subject to HDVIP and PSIP

Programs Fleets are Subject To	Repair Rate Estimate
Only HDVIP	35%
HDVIP and PSIP (No Reporting)	50%
HDVIP and PSIP (Reporting Required)	70%

d. Projected Number of Repairs

Statewide vehicle populations for future years were projected using CARB's EMFAC model. Estimates of vehicles with excess opacity emissions and repair rate assumptions (sections 4b-c) are applied to the statewide vehicle population to estimate the number of repairs per year.

Because enforcement of the proposed amendments are projected to begin during the last 4 months of 2018, the repair rate estimates are reduced to 1/3 for 2018 and the rest of the projected repairs are expected to occur in 2019. Hence, more repairs are projected in 2019 than in 2018. In addition, it is assumed that there are a higher number of repairs in years when reporting requirements are first implemented. This is due to an increase in the repair rate (Table 16) when reporting is required relative to years when reporting is not required as the additional requirement of reporting is expected to increase compliance

rates with the PSIP. For fleets subject to reporting starting in 2023, it is assumed that the increase in repair rates only applies to 2010+ MY engines, whereas 2009 MY and older engines with excess opacity emissions are projected to be retired due to Truck and Bus Rule turnover requirements, that occur outside the proposed amendments. Table 17 shows the estimated annual number of vehicle repairs from 2018 to 2025.

Table 17: Estimated Annual Vehicle Repairs

Year	2010+ MY Engines	2007-2009 MY Engines	Pre-2007 MY DPF Equipped Engines	Non-DPF Engines	Total Vehicle Repairs
2018	1,440	4,137	1,538	1,997	9,113
2019	3,686	10,873	4,023	5,337	23,919
2020	518	1,075	265	403	2,260
2021	850	1,690	447	500	3,486
2022	677	1,000	183	174	2,035
2023	1,938	144	158	107	2,347
2024	979	138	143	96	1,356
2025	1,019	130	129	86	1,364

e. Additional Citation Costs

All vehicles are subject to the HDVIP if they are operating within the state of California. Drivers pulled over during a roadside inspection will receive a citation if their vehicle tests at an opacity level above the proposed limits. The fine for an opacity violation is $300 for the first offense and $1800 for a second offense within a 12 month period. Roadside inspections are only able to target about 3 percent of the vehicle population per year; therefore, staff anticipates that it will be rare for a vehicle to receive two opacity citations in a 12 month period. Staff assumes that all citations issued for an opacity violation result in a $300 fine.

Under the current HDVIP, about 1 percent of vehicles that are inspected are cited. This rate has been constant for the last 8 years. When the HDVIP was first established in 1991, however, approximately 45 percent of vehicles that were inspected were cited. This historical data indicates that citation rates should increase once the proposed opacity limits are implemented as more vehicles will be out of compliance due to the more stringent standards. However, staff does not expect the citation rate to increase to 45 percent following the implementation of these proposed amendments. The 45 percent citation rate was achieved the first year the HDVIP was in existence. As this program has been established for more than 20 years and stakeholders are more aware of the upcoming changes to the opacity limits than they were when the program was first established, staff expects the citation rate to be somewhere between 1 percent and 45 percent once the proposed amendments are implemented. As staff assumes the citation rate will fall somewhere in the middle of the high and low citation rate percentages seen in the current program, a citation rate of 23 percent for vehicles subject to roadside inspections is used following the implementation of the proposed amendments.

HDVIP citation rates dropped by about 50 percent from 1991 to 1992 following the establishment of the HDVIP as trucking companies adapted to the required opacity limits. Based on this, staff assumes the citation rate will drop by 50 percent each year following the establishment of the lower opacity limits until it reaches an equilibrium rate of about 1 percent as seen today. Table 18 shows the estimated increase in HDVIP citations that will be given out each year and the cost to industry that will occur as a result of these citations.

Table 18: Additional Citation Costs due to Lower Opacity Levels

Year	HDVIP Citations	Cost ($)
2018	1,035	310,500
2019	2,070	621,000
2020	1,035	310,500
2021	518	155,250
2022	259	77,625
2023	180	54,000
2024	180	54,000
2025	180	54,000
Total	5,456	1,636,875

f. Reporting Costs

The current PSIP regulation requires California fleets of two diesel vehicles or more to perform annual opacity tests on their vehicles to ensure compliance. Fleets must maintain these test records for two years and at any time CARB enforcement staff can audit fleets to ensure compliance. The proposed amendments phase in new reporting requirements for the PSIP testing program, as discussed previously. Fleets would submit an official affirmation that every HD diesel vehicle in the fleet has been opacity tested and is in compliance with the PSIP requirements along with vehicle information for each truck in their fleet including VIN number, engine MY, engine family, and license plate number. The reporting phase-in schedule is shown in Table 3, starting with large fleets of 50 vehicles or more reporting in for 2019 testing results. The deadline to submit testing results would be April of the following year.

Staff used DMV registration data to estimate the number of fleets that would be affected by the reporting requirements (presented in Table 19). A relatively small number of fleets represent the majority of the vehicle population. The top 5 percent of fleets subject to PSIP account for about 50 percent of the HD vehicle population in California.

Table 19: Fleets Subject to Proposed PSIP Reporting Requirements

Fleet Size	Number of Fleets in California	Percent of PSIP Vehicle Population
50+ Vehicles	764	37%
20-49 Vehicles	1,752	13%
2-19 Vehicles	47,078	50%

Staff estimated the average time fleets would need each year to report the required data. During the first year of reporting, fleets would need to input the required data for each vehicle and verify that all vehicles are in compliance with the opacity limits. In subsequent years, fleets would not have to input vehicle information for any vehicle already on file. Fleets would only have to add vehicles that are new to their fleet or delete vehicles that are no longer a part of their fleet. Therefore, staff estimates that the reporting requirements would require a larger time commitment in the first year than in subsequent years.

Time estimates for the first year of reporting are based on reporting cost assumptions used in the development of the Truck and Bus Rule[16] and are assumed to decrease by 50 percent in subsequent years. Table 20 shows the time estimates needed each year for reporting. Staff assumes a cost of $50[28] per hour for a clerical employee to input the PSIP reporting requirements.

Table 20: Time Estimates for Annual Reporting Requirements

Fleet Size	First Year Estimates	Subsequent Year Estimates
50+ Vehicles	8 hours	4 hours
20-49 Vehicles	4 hours	2 hours
2-19 Vehicles	2 hour	1 hours

Table 21 shows the average additional annual cost per fleet for the proposed reporting requirements and Table 22 projects the costs statewide.

Table 21: Yearly Reporting Costs per Fleet

Year	50+ Vehicle Fleet	20-49 Vehicle Fleet	2-19 Vehicle Fleet
2018	$0	$0	$0
2019	$0	$0	$0
2020	$400	$0	$0
2021	$200	$0	$0
2022	$200	$200	$0
2023	$200	$100	$0
2024	$200	$100	$100
2025	$200	$100	$50

[28] Bureau of Labor Statistics, May 2016 State Occupational Employment and Wage Estimates, Administrative Services (California). https://www.bls.gov/oes/current/oes_ca.htm#00-0000

Table 22: Statewide Annual Reporting Costs

Year	Cost ($)
2018	0
2019	0
2020	305,600
2021	152,800
2022	503,200
2023	328,000
2024	5,035,800
2025	2,681,900
Total	9,007,300

g. Additional PSIP Testing Costs

The repair rate in the PSIP is expected to increase from 50 percent to 70 percent when reporting becomes a requirement. Currently, many fleets do not perform the required opacity testing on an annual basis and this is one of the main reasons for the current 50 percent PSIP compliance rate. Staff expects the proposed reporting requirements will increase compliance with the PSIP annual opacity testing. An additional 20 percent of fleets are estimated to start participating in the PSIP annual testing due to the proposed amendments. This increase in testing comes at a cost to fleets that currently do not test their vehicles annually.

Staff estimated the number of fleets in California which are subject to the PSIP requirements (Table 19). Based on information from current HD fleets, staff assumes that large and medium sized fleets will purchase smoke meters and do their own testing. The cost of a smoke meter runs between $3,500 and $5,000. For the purposes of this analysis, staff assumes a cost $5,000 per smoke meter. The smoke meter is a one-time purchase for fleets which staff expects will be purchased in the year that reporting is first required for the fleet. Staff assumes a newly purchased smoke meter will last the duration of this analysis. Smoke meters have been shown to be durable and with lifetimes well past a decade.

Purchasing a smoke meter is not cost-effective for small fleets and the expectation is that small fleets will contract out their annual testing needs to trained smoke testers. Based on discussions with stakeholders, staff estimates a cost of $65 per vehicle for an annual PSIP smoke test. Again, staff assumes that this increase in PSIP participation will occur during the year when reporting is first required. For small fleets, reporting is first required for testing in 2023. Table 23 shows the breakdown of testing costs for fleets which are anticipated to start participating in the PSIP. The total cost for additional testing is estimated to be just over $15 million between the years 2018 and 2025.

Table 23: Additional PSIP Testing Costs

Year	Small Fleets ($)	Medium Fleets ($)	Large Fleets ($)
2018	0	0	0
2019	0	0	764,000
2020	0	0	0
2021	0	1,752,000	0
2022	0	0	0
2023	3,331,835	0	0
2024	3,457,115	0	0
2025	3,567,229	0	0
Total	12,872,179	1,752,000	764,000

h. PSIP Smoke Tester Training Costs

i. Contracted Smoke Testers

Under the proposed amendments, contracted smoke testers who perform PSIP testing services for a fee will be required to receive hands-on training on how to properly perform the SAE J1667 opacity test. Contracted smoke testers are projected to take the CCDET I training course on HDVIP and PSIP requirements, which is a 6-hour course costing $175. Currently, the CCDET course is the only course in the state meeting the proposed training requirements. The training course is valid for 4 years. Staff assumes $67 per hour for the time lost to take the training class, an estimate of a repair shop's lost revenue due to sending a mechanic to the training. The labor rate of a typical repair shop is estimated to be $100 per hour.[29] Technicians and mechanics at an average repair shop are able to report billable hours about 67 percent of the time they are on the job.[30] This results in about $67 of billable work per hour for the average mechanic. Table 24 lists the estimated costs for an individual to take the CCDET I course.

Table 24: Estimated Costs for CCDET Training

Cost of CCDET I Course	$175
Opportunity Cost Lost by Trainee per Hour	$67
Class Hours	6
Total Cost of Training per Trainee	**$577**

As discussed in detail in the baseline section, survey data showed that 90 percent of the estimated 3,160 contracted smoke testers in California already receive hands-on training through CCDET. The additional 10 percent of contracted smoke testers throughout the

[29] DMS Mechanix Truck, Trailer, and Equip Repair Labor Rates, 4/26/2017. http://www.24hourtruckrepiar.net/id78.htmlhttp://www.24hourtruckrepair.net/id78.html
What's a reasonable hourly rate for an auto mechanic? 4/26/2017. https://www.quora.com/Whats-a-reasonable-hourly-labor-rate-for-an-auto-mechanic

[30] Chris Frederick, How to Increase Shop Productivity. Motor Age. October 2007. https://www.autotraining.net/articles/2007-10_MotorAge_How%20to%20Increase%20Shop%20Productivity.pdf

state will face an added cost due to this regulatory requirement every 4 years. It is assumed that costs will not be passed through to the customer as smoke testers facing these additional training costs are not expected to raise prices as the vast majority of testers already incur this cost. There may be a slight increase in demand for contracted smoke testers starting in 2023 when small fleets are phased into the reporting requirements. However, it is expected the current smoke testers will be able to accommodate the additional testing demand.

ii. Self-Testers

Self-testers are those that perform the annual PSIP smoke tests on their own fleet vehicles. Under the proposed amendments, these testers would be required to take a 1-hour online training course designed by CARB to perform the annual PSIP tests. Once this training is successfully completed, there will be no requirements to repeat the training course at a later date. The hourly opportunity cost to take the online training course is assumed to be the same as for contracted PSIP testers. Table 20 shows the estimated costs per trainee to attend the online training course. CARB assumes that medium and large fleets will perform PSIP testing themselves, whereas, small fleets will contract this service out. This is due to the fact that opacity smoke meters can cost around $3,500-$5,000 and it is not cost effective for a small fleet to buy a meter for themselves.

Recent DMV registration data was analyzed to determine fleet sizes throughout the state. There are 2516 medium and large fleets in California. These fleets represent about half of the HD vehicles registered in California. Using EMFAC vehicle population projections, staff estimates California fleets containing 10 or more vehicles will account for 286,838 vehicles in 2018. Larger fleets often have vehicles spread over multiple base locations. These fleets will likely require multiple employees to receive the training due to the distance between base locations. Smaller fleets with a limited vehicle population and a single base will likely only require one employee to receive the training.

The industry standard is typically one technician for every 12.3 trucks on the road.[31] Not every technician will need to receive smoke tester training. Thus, staff assumes a ratio lower for the number of trained smoke testers per truck and estimates a vehicle to tester ratio of about 20 to 1, which results in an average of about 2.3 trainees per fleet. Staff assumes the same opportunity cost structure as for those individuals taking the CCDET training course and assumes none of these employees currently has the required training to perform the PSIP opacity tests. Table 25 breaks down the costs associated with taking the online training course. Table 26 shows the total annual costs estimated for training, combining both contracted smoke testers and self-testers.

[31] http://www.vehicleservicepros.com/ask-the-expert/article/10330286/what-is-the-actual-industry-standard-ratio-for-trucks-to-technicians

Table 25: Estimated Costs for Online Self-Tester Training Class

Cost of Online Training Course	$0
Opportunity Cost Lost by Trainee per Hour	$67
Class Hours	1
Total Cost of Training per Trainee	**$67**

Table 26: Total Annual Cost for All Smoke Tester Training Courses

Year	Cost ($)
2018	0
2019	1,143,239
2020	0
2021	0
2022	0
2023	182,332
2024	0
2025	0
Total	$1,325,571

i. Total Costs

The total regulatory cost to industry for the proposed amendments is the summation of the repair costs relative to BAU repair costs, reporting costs, smoke tester training costs, along with additional citation and PSIP testing costs. Table 27 breaks down the estimated yearly costs of the proposed amendments. The majority of costs are expected to come from the repair or replacement of damaged emission control components to meet the more stringent opacity limits. The repair costs estimated to have occurred in the baseline are represented as a negative number. As described previously, these repair costs represent vehicles that are out of compliance with the existing opacity limits, and would be repaired to the current opacity limits regardless of the proposed amendments. Because these repair costs would already occur in the future baseline scenario, they are subtracted from the overall cost of the proposed amendments.

The amendments are projected to go into effect in September 2018. Costs in 2019 are projected to be higher than in 2018 due to the fact that the proposed amendments would be enforced for only 4 months in 2018. Between the years 2018 and 2025, the proposed amendments to the HDVIP and PSIP are estimated to cost the regulated entities about $218 million, with a maximum annual cost of $102 million in 2019. The cost effectiveness of the proposed amendments is estimated to be about $128 per pound of PM reduced. This was calculated by dividing the direct costs from 2018 through 2025 by the total PM benefits, and excludes indirect costs and any monetized health benefits.

Table 27: Annual Costs for the Proposed Regulatory Amendments

Year	Repair Cost	Reporting Costs	Smoke Tester Training Costs	Baseline Repair Costs	Citation Costs	PSIP Testing Costs	Total Costs
2018	$38,700,085	$0	$0	-$1,027,061	$310,500	$0	$37,983,524
2019	$101,151,458	$0	$1,143,239	-$934,001	$621,000	$764,000	$102,745,696
2020	$9,510,565	$305,600	$0	-$685,242	$310,500	$0	$9,441,423
2021	$14,970,914	$152,800	$0	-$400,580	$155,250	$1,752,000	$16,630,384
2022	$8,761,402	$503,200	$0	-$378,014	$77,625	$0	$8,964,213
2023	$10,888,380	$328,000	$182,332	-$130,422	$54,000	$3,331,835	$14,654,125
2024	$6,312,147	$5,035,800	$0	-$119,112	$54,000	$3,457,115	$14,739,950
2025	$6,340,843	$2,681,900	$0	-$107,769	$54,000	$3,567,229	$12,536,203
Total	**$196,635,794**	**$9,007,300**	**$1,325,571**	**-$3,782,201**	**$1,636,875**	**$12,872,179**	**$217,695,518**

2. Direct Costs on Individuals

There are no direct costs to individuals as a result of the amendments to the HDVIP and PSIP. Any indirect or induced costs on individuals, such as costs being passed on to the consumer, are discussed further in the Macroeconomic Impact section.

3. Direct Costs on Typical Businesses

CARB estimates that the lifetime direct cost to the trucking industry will be about $218 million. The majority of these costs are expected to be incurred by trucking fleets that do business within the state of California. Based on initial staff estimates, about 9 percent of all statewide HD diesel vehicles are currently operating above the proposed opacity limits. The largest direct costs to businesses are costs associated with the repair and replacement of damaged emission control components and PM aftertreatment systems. Estimated repair costs on a per vehicle basis are shown in Table 10 and range from $2,707 to $7,063 per vehicle. These repairs account for about 97 percent of the total regulatory costs.

The cost to a typical business is calculated as the cost to a large 50-vehicle fleet in 2019, the year in which the costs for the proposed amendments are the largest. Some fleets may need to repair more vehicles, whereas other may not need to repair any vehicles. Based on the statewide percentage of vehicles projected to be above the proposed opacity limits and the estimated repair rates in Table 13, staff estimates the average fleet of 50 vehicles will repair a total of 4 vehicles, with 3 repairs occurring in 2019. Staff assumes 2 of these repairs are done on 2007-2009 MY engines and 1 repair is done on a 2010+ MY engine. Staff assumes a fleet of 50 vehicles will do their own PSIP opacity testing and estimates that 3 employees will be sent to the online PSIP smoke tester training course. No reporting costs are assumed for the year 2019 as the deadline to submit reporting results are not until April of 2020 and staff assumes fleets wait until near the deadline to report. Table 28 breaks down the estimated costs of a 50-vehicle fleet for the year 2019. A typical 50-vehicle fleet is projected to accrue about $12,558 in additional costs in 2019 due to the proposed amendments. Costs in other years of proposed amendments are expected to be significantly less.

Table 28: Estimated Costs for the Average 50-Vehicle Fleet in 2019

Repair Costs	Training Costs	Reporting Costs	Total Costs
$12,357	$201	$0	$12,558

4. Direct Costs on Small Businesses

Based on DMV registration data, small businesses, identified as fleets of 3 vehicles or fewer, represent about 87 percent of the fleets in California but only about 35 percent of the total in-state HD vehicle population. Owner operators (one vehicle fleets), a segment of the small business sector, contribute about 20 percent of the total in-state vehicle population. The average cost of vehicle repairs on a per vehicle basis is expected to be the same, ranging from $2,707 to $7,093 based on the MY of the vehicle, regardless of fleet size. Small businesses do not have reporting requirements until 2024, whereas the larger fleets have reporting requirements starting in 2020. Staff assumes there are no differences in repair rates and PSIP compliance rates between small fleets and large fleets. Based on these estimates, about $70 million of the regulatory costs between 2018 and 2025 would be attributed to small businesses.

Staff estimates the total costs for a small business fleet for the year 2019. As with large fleets, many small fleets are projected to be in compliance with the proposed opacity limits and not need any vehicle repairs. For these fleets, there are no additional costs above the BAU in 2019. However, for the purposes of this section, staff will assess the costs of a small fleet that will need a vehicle repair due to the proposed amendments. Staff assesses the costs of a small fleet that needs to repair one of their vehicles equipped with a 2007-2009 MY engine in the year 2019. Staff assumes that small fleets contract out their annual PSIP testing and does not require any smoke tester training classes. Additionally, small fleets will not accrue any reporting costs in the 2019, so the only additional costs above the BAU are repair costs. Based on these assumptions, staff estimates that the proposed amendments will cost a small fleet needing a vehicle repair in 2019 about $3,876.

D. ECONOMIC IMPACTS

1. Methodology for Determining Economic Impacts

REMI, Policy Insight Plus Version 2.1.1 is used to estimate the macroeconomic impacts of the proposed amendments on the California economy. REMI is a structural economic forecasting and policy analysis model that integrates input-output, computable general equilibrium, econometric and economic geography methodologies.

REMI Policy Insight Plus provides year-by-year estimates of the total impacts of the proposed amendments, pursuant to the requirements of SB 617 and the California Department of Finance.[32] CARB uses the REMI single-region, 160-sector model with the

[32] http://www.dof.ca.gov/Forecasting/Economics/Major_Regulations/SB_617_Rulemaking_Documents/documents/Order_of_Adoption-1.pdf

model Reference case adjusted to reflect the Department of Finance conforming forecasts dated June 2017. These forecasts include California population figures, U.S. real GDP forecast, and civilian employment growth numbers.

The proposed amendments are simulated in REMI by adjusting production costs to regulated industries to reflect the change in repair and maintenance costs to fleets operating in California, equipment and training costs for contracted PSIP smoke testers, and increased reporting requirements for the PSIP program. Additionally, the additional staff resources required to monitor and enforce is modeled through changes in REMI's State spending variable. The years of the analysis are 2018 through 2025; these years are used to simulate the proposed amendments through 12 months post full implementation.

2. Inputs of the Assessment

The analysis is separated into five components: vehicle repair costs, smoke testing costs and certification, reporting requirements, additional State and local spending, and monetized health benefits. Costs, as outlined in the cost section previously, are translated into REMI inputs as illustrated in Table 29, and described below:

1. Change in Production Costs
    a. HD vehicle repair costs are represented as production cost increases. DPF and upstream engine component repairs and replacements, as a result of the proposed amendments, result in an increase in operating costs relative to the BAU. These production cost increases are applied to three industries: Truck Transportation, Transit and Ground Passenger Transportation, and Waste Management and Remediation Services, representative of regulated fleets.
    b. Smoke tester training costs are modeled as an increase in production cost to automotive repair facilities, as CCDET training has a small cost per participant.
    c. New reporting requirements are reflected as an increase in production cost to California fleets of 2 or more. These reporting requirements would apply to fleets subject to the repair costs mentioned above.
2. Change in Exogenous Final Demand (changes in the demand faced by industries as an indirect impact of the proposed amendments)
    a. Manufacturers of heavy duty vehicle parts will see an increase in exogenous final demand as a result of the repair costs required for trucks with high opacity levels.
    b. Office administrative resources will see additional demand for services to collect and submit documentation verifying compliance to meet the reporting requirements as described in the changes to the PSIP.
    c. Independent repair shops and repair departments in HD vehicle dealerships will see an increase in demand as a result of the increase in HD vehicle repairs to correct failing DPFs.
    d. Community colleges will see a slight increase in demand for CCDET smoke tester training courses.

    e. Demand will increase for smoke testing equipment, which is represented by the navigational, measuring, electromedical, and control instruments manufacturing industry.
3. State and Local Spending
    a. There are anticipated to be increases in State spending in response to the need for additional staff resources, which includes oversight of reporting requirements and increased enforcement.
    b. Public sector fleets will be subject to the proposed amendments, resulting in increased spending for repairs and reporting.
    c. Staff anticipates an increase in citation revenue resulting from the amendments to the HDVIP program. This revenue is returned in this analysis by simulating additional state spending. Citation revenue increases are outlined in Table 29.
4. Health Benefits
    a. The decrease in acute respiratory, cardiovascular, and asthma related hospital and emergency room visits results in less household spending in the healthcare industry. This decrease in consumer spending allows for an increase in spending in all other consumption categories.

The production cost changes for the industries operating HD fleets in California are calculated by applying the incremental cost of repairs to the population of HD trucks with compromised DPFs, using the methods of estimating the population of vehicles operating above the proposed opacity limits and described in the Direct Costs section above. Population volumes in future years were projected using CARB's EMFAC model, separating public from private fleets, allowing REMI inputs representing these repair costs to be directed to specific industries, including State-owned fleets.

Table 29: REMI Inputs

Primary Industries	Explanation	REMI Category	2018	2019	2020	2021	2022	2023	2024	2025
Truck Transportation	Repair, reporting, and testing costs	Production Cost (2016M$)	$36.53	$96.00	$9.48	$15.95	$8.75	$13.67	$13.91	$8.52
Transit and Ground Passenger Transportation		Production Cost (2016M$)	$1.59	$4.17	$0.41	$0.69	$0.38	$0.59	$0.60	$0.37
Waste Management and Remediation Services		Production Cost (2016M$)	$0.90	$2.36	$0.23	$0.39	$0.21	$0.34	$0.34	$0.21
Motor Vehicle Body and Trailer Manufacturing*	OEM labor opacity testing certification, labor demand for repairs	Production Cost (2016M$)	$0.00	$0.42	$0.00	$0.00	$0.00	$0.07	$0.00	$0.00
Automotive Repair and Maintenance*	Repair labor opacity testing certification, labor demand for repairs	Production Cost (2016M$)	$0.00	$0.72	$0.00	$0.00	$0.00	$0.11	$0.00	$0.00
State Government	Staff Resources, State Fleet Repairs, and Citation Revenue	State Spending (2016M$)	$2.15	$4.74	$1.09	$1.20	$0.85	$1.03	$1.03	$0.95
Local Government	Local Fleet Repairs	Local Spending (2016M$)	$3.85	$10.19	$0.92	$1.65	$0.89	$1.46	$1.47	$1.25
Secondary Industries	**Explanation**	**REMI Category**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Engine, Turbine, and Power Transmission Equipment Manufacturing	Parts sales	Exogenous Final Demand (2016M$)	$10.92	$28.53	$2.68	$4.22	$2.47	$3.07	$1.78	$1.79
Motor Vehicle Body and Trailer Manufacturing	Parts sales & dealership labor	Exogenous Final Demand (2016M$)	$19.25	$50.31	$4.73	$7.45	$4.36	$6.65	$4.42	$3.29
Automotive Repair and Maintenance	Labor	Exogenous Final Demand (2016M$)	$8.53	$22.30	$2.10	$3.30	$1.93	$2.61	$3.57	$1.62

Educational Services	CCDET Certification Course	Exogenous Final Demand (2016M$)	$0.00	$1.14	$0.00	$0.00	$0.00	$0.18	$0.00	$0.00
Office Administrative Services	Bookkeeping	Exogenous Final Demand (2016M$)	$0.00	$0.00	$0.31	$0.15	$0.50	$0.33	$5.04	$2.35
Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	Equipment sales	Exogenous Final Demand (2016M$)	$0.00	$0.76	$0.00	$1.75	$0.00	$0.00	$0.00	$0.00
Health Benefits	**Explanation**	**REMI Category**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Consumer Spending Hospitals	Health benefits savings	Consumer Spending (2016M$)	-$0.04	-$0.14	-$0.13	-$0.11	-$0.11	-$0.03	-$0.03	-$0.03
Consumption Reallocation	Increased consumption resulting from health benefits savings	(2016M$)	$0.04	$0.14	$0.13	$0.11	$0.11	$0.03	$0.03	$0.03

REMI input values are rounded to the nearest $10,000. Values for primary industries are representative of the net of multiple costs, and a positive value indicates an increased cost. Positive values for secondary industries are representative of absolute increases in demand.

***** Industries that incur both direct and indirect impacts as a result of the proposed amendments, making them a candidate for both primary and secondary industries.

3. Assumptions and Limitations of the Model

The estimated economic impacts of the proposed amendments are sensitive to modeling assumptions made by CARB. The list below outlines the key assumptions made in estimating the economic impacts of the proposed amendments in REMI.

1. The primary impacted industries are broken into the following categories using the North American Industry Classification System (NAICS):
    a. NAICS 484 (Truck Transportation): This NAICS code is used to represent the majority, roughly 94 percent, of affected fleets that are subject to the proposed amendments. The costs are primarily due to increased repair costs, reporting costs, and additional PSIP testing.
    b. NAICS 485 (Transit and Ground Passenger Transportation): This NAICS code is used to represent a small subset, less than 5 percent, of fleets that are subject to the proposed amendments. These fleets will see increases in repair costs, reporting costs, and additional PSIP testing.
    c. NAICS 562 (Waste Management and Remediation Services): This NAICS code represents the smallest population, roughly 2 percent, of HD fleets that are subject to the proposed amendments.
    d. NAICS 8111 (Automotive Repair and Maintenance): This industry will be required to obtain hands-on smoke tester training (CCDET) for their repair technicians if they plan to offer PSIP testing services.
    e. NAICS 3362 (Motor Vehicle Body and Trailer Manufacturing): This NAICS code is representative of the OEM dealers that perform on-site repairs at dealerships. The primary impact is an increase in costs related to the requirement for OEM repair technicians to obtain hands-on smoke tester training if they plan to offer PSIP testing services.
2. Secondary industries that see an increase in demand for parts manufacturing, educational services, and administrative services are broken down into:
    a. NAICS 3336 (Engine, Turbine, and Power Transmission Equipment Manufacturing): This industry represents the manufacturing of parts that are used to replace and repair malfunctioning DPFs and upstream engine components.
    b. NAICS 3362 (Motor Vehicle Body and Trailer Manufacturing): Similar to NAICS 3336, this industry also provides parts for replacing or repairing DPFs and upstream engine components, but manufactured for specific OEMs. The increase in demand for these parts is considered a secondary impact for this analysis.
    c. NAICS 8111 (Automotive Repair and Maintenance): This NAICS code represents the labor for repairs at independent autobody shops. The increase in demand for repair labor is considered a secondary impact for this analysis.
    d. NAICS 3345 (Navigational, Measuring, Electromedical, and Control Instruments Manufacturing): This NAICS code represents the industry

that manufactures opacity testing equipment, assumed to be in higher demand due to the changes to the PSIP.

   e. NAICS 5611 (Office Administrative Services): This NAICS code represents bookkeeping services that may be contracted due to the proposed reporting requirements.
   f. NAICS 61 (Educational Services): This NAICS code represents community colleges that offer the smoke tester training courses required for PSIP testing.

3. Other impacts not associated with NAICS classification:
   a. State and Local Government Spending: Additional staff resources and public fleet repairs and PSIP testing requirements will increase spending at the state and local level.
   b. Consumer Spending on Hospitals: The estimated reduction in PM from the proposed amendments will result in decreases in acute respiratory and cardiovascular hospitalizations and emergency room visits for asthma. This is modeled as a decrease in consumer spending on hospitals.
   c. Consumption Reallocation: The decrease in consumer spending on hospital visits results in a reallocation of spending to all other consumption categories.

4. Results of the Assessment

a. California Employment Impacts

As illustrated in Table 30 the proposed amendments would have a negligible impact on employment relative to the BAU scenario. The California economy is growing, therefore the changes in employment growth are not declines relative to today, but incremental results from growth forecasts in future years. Some industries experience job growth that is slightly higher than enjoyed under the BAU while other industries take slightly longer to reach anticipated employment levels. The slight slowing of employment is concentrated in directly impacted industries that face direct costs as a result of the proposed amendments. These industries include truck transportation, transit and ground passenger transportation, and waste management and remediation services. The impact to employment for these industries does not exceed one-tenth of one percent relative to the baseline in any one year. Thus, employment in these industries is 99.9% what it would be in absence of the proposed amendments. Industries that see an increase in demand as a result of the proposed amendments see positive employment growth. These industries include parts manufacturing, autobody labor, and office administrative services.

HD fleets are expected to make the most repairs in the first two years of this assessment, which translates into higher demand for parts manufacturing and autobody labor. The first two years of implementation of the proposed amendments also affects the largest population of HD trucks in any single year, and as production costs are reduced over the

subsequent years and incremental parts and labor demand declines, the slowing of employment growth begins to reduce beginning in 2020 as a result of the proposed amendments.

Table 30: Change in Employment Growth

	2018	2019	2020	2021	2022	2023	2024	2025
Change (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change in Jobs	-200	-675	-575	-475	-375	-350	-250	-225
Total Jobs Anticipated under the BAU (Millions)	23.335	23.537	23.727	23.910	24.101	24.294	24.488	24.684

The value in each year is interpreted as the reference year value less the BAU value in that same year. The change in jobs is rounded to the nearest 25, total jobs are rounded to the nearest thousand.

b. California Business Impacts

The proposed amendments are anticipated to have a small impact on growth in final product output, referred to here as output growth, relative to the BAU. As modeled, fleets would have slightly higher operating costs as a result of vehicle repairs, reporting, additional PSIP testing, training, and potential increases in citation costs. Table 31 shows a slight decline in the growth of output for primary industries that operate fleets in California throughout the years of this assessment. Although compliance costs are highest in the first two years of implementation, operating costs for fleets will be slightly higher through 2025.

Secondary industries that manufacture the parts needed for fleets to come into compliance enjoy output growth higher than the BAU throughout all years of the assessment. This is due to the increase in demand for goods and services as a result of the proposed amendments. Other secondary industries that see an increase in demand see a slight slowing of output growth, likely due to the impact of higher operating costs to California fleets that outweigh some benefits to secondary industries. Table 31 shows the impact to the growth in output for industries impacted by the proposed amendments, and represents a minor percentage change from output levels estimated under the BAU scenario.

Table 31: Change in Output Growth Relative to the BAU

		2018	2019	2020	2021	2022	2023	2024	2025
Primary Industries									
Truck Transportation	**Change (%)**	-0.02%	-0.07%	-0.06%	-0.06%	-0.05%	-0.05%	-0.04%	-0.04%
	Change (2016M$)	-$7.6	-$25.6	-$22.0	-$21.3	-$19.1	-$18.4	-$17.9	-$16.3
Transit and Ground Passenger Transportation	**Change (%)**	-0.01%	-0.03%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%
	Change (2016M$)	-$0.8	-$2.3	-$0.6	-$0.7	-$0.5	-$0.6	-$0.5	-$0.4
Waste Management and Remediation Services	**Change (%)**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-$0.1	-$0.4	-$0.3	-$0.3	-$0.3	-$0.2	-$0.2	-$0.2
Motor Vehicle Body and Trailer Manufacturing*	**Change (%)**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	$0.0	-$0.1	-$0.2	-$0.2	-$0.2	-$0.2	-$0.1	-$0.1
Automotive Repair and Maintenance*	**Change (%)**	0.04%	0.10%	0.01%	0.01%	0.01%	0.01%	0.02%	0.01%
	Change (2016M$)	$7.9	$19.9	$1.6	$2.8	$1.6	$2.2	$3.2	$1.4
Secondary Industries									
Engine, Turbine, and Power Transmission Equipment Manufacturing	**Change (%)**	0.09%	0.22%	0.02%	0.03%	0.02%	0.02%	0.01%	0.01%
	Change (2016M$)	$5.6	$14.3	$1.2	$1.9	$1.0	$1.3	$0.7	$0.7
Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	**Change (%)**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-$0.2	-$0.2	-$0.4	$0.6	-$0.2	-$0.2	-$0.2	-$0.1
Educational Services	**Change (%)**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-$0.2	$0.1	-$0.5	-$0.5	-$0.4	-$0.3	-$0.3	-$0.3
Office Administrative Services	**Change (%)**	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.01%
	Change (2016M$)	-$0.1	-$0.2	$0.0	-$0.1	$0.2	$0.1	$3.3	$1.5

The value in each year is interpreted as the reference year value less that BAU value in that same year. The values presented above are rounded to the nearest $100,000. The percentages are rounded to the nearest hundredth.
*Industries that incur both direct and indirect impacts as a result of the proposed amendments, making them a candidate for both primary and secondary industries.

c. Impacts to Investments in California

As modeled, the proposed amendments would produce very small impacts to California private business investment from 2018 to 2025. Table 32 shows a slight decline in annual investments in California, which can be linked to incremental increases in production costs to HD fleets operating in California, restricting potential investments in new capital purchases. As compliance costs decline, slowing of gross domestic private investment growth is anticipated to decline through 2025. The relative changes to growth in private investment, however, are imperceptible from the BAU of the current HDVIP and PSIP programs.

Table 32: Change in Gross Domestic Private Investment Growth

	2018	2019	2020	2021	2022	2023	2024	2025
Change (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change (2016M$)	-$10.6	-$35.6	-$25.1	-$17.8	-$10.6	-$7.3	-$4.4	-$2.0

The value in each year is interpreted as the reference year value less that BAU value in that same year. The values presented above are rounded to the nearest $100,000.

d. Impacts to Individuals in California

The proposed amendments have no direct impact to California individuals, and produce no noticeable change in personal income growth in any year of the assessment as seen in Table 33. The greatest annual change in personal income is a reduction of $116.6 million relative to the BAU, which does not represent a perceptible change. The change in personal income growth follows in the same pattern as employment, and the growth impacts decline annually after 2019 as a result of decreased output to the primary sectors operating fleets in California as seen in Table 31.

Table 33: Change in Personal Income Growth

	2018	2019	2020	2021	2022	2023	2024	2025
Change (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change (2016M$)	-$39.4	-$116.6	-$39.9	-$41.1	-$31.7	-$34.8	-$30.4	-$25.9
Personal Income Anticipated under the BAU (Trillions)	$2.224	$2.282	$2.338	$2.392	$2.458	$2.506	$2.557	$2.617

The value in each year is interpreted as the reference year value less that BAU value in that same year. The changes in income growth presented above are rounded to the nearest $100,000, while personal income anticipated under the BAU are rounded to the nearest billion.

e. Impacts on Gross State Product

As presented in Table 34, Gross State Product (GSP) growth levels are estimated to be insignificantly less throughout all years of the analysis, likely resulting from the initial repair costs to California fleets which are highest in the first two years of implementation. The analysis estimates that, under the proposed amendments, the California economy grows at a rate indistinguishably less than anticipated levels through 2025. This change

in growth, however, does not represent a discernable change from the GSP projections under BAU.

Over 60 percent of the compliance costs of this regulation occur within the first two years of implementation, which decreases GSP through reductions in the output of regulated fleets. While some industries in California will experience higher demand as a result of the proposed amendments, the increases are outweighed by the impact of higher operating costs to regulated fleets, resulting in a slightly lower GSP overall. CARB interprets the impact of the proposed amendments on GSP as being indiscernible in California's $2.6 trillion economy.[33]

Table 34: Change in Gross State Product Growth

	2018	2019	2020	2021	2022	2023	2024	2025
Change (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change (2016M$)	-$16.7	-$62.3	-$55.2	-$45.8	-$37.5	-$34.3	-$26.4	-$24.7

The value in each year is interpreted as the reference year value less that BAU value in that same year. The values presented above are rounded to the nearest $100,000.

5. Creation or Elimination of Businesses

Due to the proposed amendments, there is anticipated to be growth in industries that support fleets operating in California. Increases in repair costs induce demand for the industries that manufacture parts for HD vehicles and those that provide labor for required repairs. This growth is estimated to increase major economic indicators discussed previously (GSP, personal income, and employment growth), which may expand businesses through the implementation of the proposed amendments. This is supported by the increases in output growth among some secondary industries impacted in this analysis, as outlined in Table 31. This does not necessarily incentivize more businesses to enter the market, but it does strengthen market reliability for these goods and services throughout all years in this analysis. Given the small impact on these industries, however, it is unlikely that there will be any creation or elimination of businesses in California.

6. Incentives for Innovation

The proposed amendments would have similar incentives to innovate as the original regulations. There is still opportunity to improve upon existing HD vehicle emission reduction technology, but staff assumes there will be no directly induced increases in technological innovation as a result of the proposed amendments since the technology that allows compliance has already been online for many years. The proposed amendments do not require a specific technology to be used. If a less costly alternative is developed in the future, the costs could be lower than estimated here.

[33] US Bureau of Economic Analysis, updated May 11, 2017. http://www.dof.ca.gov/Forecasting/Economics/Indicators/Gross_State_Product/

7. Competitive Advantage or Disadvantage

All fleets operating in California are subject to the same proposed opacity limits, regardless of their primary service locations. The proposed amendments, therefore, would not create any competitive disadvantage to fleets located in California, as their competitors would have to comply with the same requirements. This would result in a comparable increase in operating costs for both Californian and non-Californian fleet operators for the HDVIP portion of the proposed amendments. California fleets, however, are subject to the PSIP and face additional reporting requirements. As reporting costs are minor relative to the total costs of the proposed amendments this is not anticipated to result in a competitive disadvantage to California fleets. With only minor additional costs relative to out-of-state fleets, California HD fleet owners are not expected to face competitive disadvantages as an overall result of the proposed amendments.

8. Inclusion of Monetized Health Benefits

As mentioned earlier, monetized health benefits affect two separate variables in the REMI model: Consumer Spending on Hospitals and Consumption Reallocation. These variables provide slightly higher spending power to consumers, as they are expected to spend less on healthcare related costs.

The impact of the monetized cost-savings for avoided acute respiratory and cardiovascular hospitalization and avoided ER department visits on the macroeconomic analysis of the proposed amendments is negligible, as the spread of roughly $0.6 million in cost-savings between 2018 and 2025 does not noticeably change any economic indicators in the model output.

9. Summary and Interpretation of the Results of the Economic Impact Assessment

Regulated fleets see a slight increase in operating costs, but the overall impact to these industries is negligible given the changes in output growth shown in Table 31. The primary industries will make repairs that produce emissions benefits, all while creating demand for goods and services in supporting industries, resulting in increased output and employment in those industries.

As modeled the proposed amendments are unlikely to have significant impacts on the California economy, including the growth of employment, investment, personal income, and production compared to the BAU. All of these economic indicators do no exhibit a significant change when comparing the impact of the proposed amendments to the current HDVIP and PSIP programs.

E. ALTERNATIVES

In addition to the proposed amendments, staff also evaluated alternative modifications to the HDVIP and PSIP regulations. CARB staff and stakeholders discussed potential alternatives during each workshop. Staff combined stakeholder comments into the possible alternatives and evaluated two alternatives to the proposed amendments.

1. Alternative 1: Stricter Opacity Limits than the Proposed Amendments

Alternative 1 proposes a more stringent opacity limit for Non-DPF equipped vehicles than the proposed amendments as shown in Table 35. The reporting and smoke tester training requirements are the same as the proposed amendments. The stricter opacity limit results in a slight increase in the projected percentage of vehicles above the proposed opacity limits upon implementation for Non-DPF equipped vehicles, up to 11 percent compared to 10 percent in the proposed amendments.

Table 35: Proposed Opacity Limits for Alternative 1

2006 Model Year (MY) and older engines without DPFs
20% Opacity Limit
Engines equipped with a DPF
5% Opacity Limit

a. Costs

Alternative 1 would result in increased costs relative to the proposed amendments. Some Non-DPF equipped vehicles with pre-1997 engines would likely not be able to meet the proposed 20 percent opacity limit even if their emission control systems are properly functioning. This means repairs would not be adequate to meet the proposed opacity limit and result in owners needing to purchase new vehicles to replace their old vehicles. Staff estimates about 613 new vehicles would be purchased to replace vehicles that could not meet the 20 percent opacity limit. Staff assumes that 1/3 of these new vehicle purchases occur in 2018 and 2/3 of the new vehicle purchases occur in 2019. Under this scenario, staff assumes that the owner would purchase a 5 year old used vehicle equipped with a 2010+ MY engine to be in compliance with other CARB rules, such as the Truck and Bus Rule, which requires 2010+ MY engines in most California counties by 2023. Staff estimates the cost of this vehicle purchase to be about $40,000 based on used truck websites.[34] Table 36 shows the combined estimated repair and replacement costs for Alternative 1.

[34] Commercial Truck Trader, www.commericaltrucktrader.com http://www.commercialtrucktrader.com/Heavy-Duty-Conventional--Sleeper-Trucks-For-Sale-In-California/search-results?type=heavy&category=Conventional+-+Sleeper+Truck|2000603&keyword=2012&state=California|CA

Table 36: Annual Repair and Replacement Costs for Alternative 1

Year	Annual Cost
2018	$47,112,785
2019	$118,272,392
2020	$9,509,506
2021	$15,082,986
2022	$8,764,019
2023	$10,854,768
2024	$6,282,735
2025	$6,315,103
Total	$222,194,293

Alternative 1 results in significantly higher costs in 2018 and 2019 due to vehicle replacement costs and slightly higher repair costs in subsequent years due to the stricter opacity limit for Non-DPF equipped vehicles. Incorporating reporting costs, smoke tester training costs, additional PSIP testing costs, additional HDVIP citation costs, and baseline costs, which are the same as in the proposed amendments, the total regulatory cost for Alternative 1 from 2018-2025 is about $243 million, $26 million higher than the proposed amendments.

b. Benefits

Alternative 1 results in slightly more emission benefits than the proposed amendments due to the stricter opacity limits. As seen in Table 37, Alternative 1 is estimated to deliver about 1.7 million pounds of PM emission reductions between 2018 and 2025, with the largest impact in the year 2019. The proposed opacity limits in alternative 1 only result in an additional 18,250 pounds of PM emission benefits relative to the proposed amendments between the years 2018 and 2025. Reductions in premature mortalities, avoided hospitalizations, and avoided ER visits are similar for Alternative 1 and the proposed amendments (Table 38). For example, only 1 additional premature death is prevented under Alternative 1 compared to the proposed amendments.

Table 37: Projected Annual Statewide PM Emission Benefits for Alternative 1

Year	PM tons per day	PM pounds per year
2018	0.177	129,450
2019	0.550	401,500
2020	0.500	365,000
2021	0.414	302,220
2022	0.385	281,050
2023	0.104	75,920
2024	0.107	78,110
2025	0.110	80,300
Total	2.347	1,713,550

Table 38: Regional and Cumulative Statewide Avoided Incidences from 2018 to 2025 for Alternative 1

	Avoided Premature Deaths	Avoided Hospitalizations	Avoided ER Visits
Great Basin Valleys	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Lake County	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Lake Tahoe	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Mojave Desert	2 (1 - 2)	0 (0 - 1)	1 (0 - 1)
Mountain Counties	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
North Central Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
North Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Northeast Plateau	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Sacramento Valley	4 (3 - 5)	1 (0 - 1)	1 (1 - 2)
Salton Sea	2 (1 - 2)	0 (0 - 1)	1 (0 - 1)
San Diego County	5 (4 - 6)	1 (0 - 2)	2 (1 - 3)
San Francisco Bay	9 (7 - 11)	2 (0 - 4)	4 (2 - 5)
San Joaquin Valley	13 (10 - 16)	2 (0 - 4)	5 (3 - 7)
South Central Coast	1 (1 - 1)	0 (0 - 0)	0 (0 - 1)
South Coast	59 (46 - 72)	8 (1 - 20)	25 (16 - 34)
Statewide	85 (66 - 100)	13 (2 - 29)	35 (22 - 49)

*Values in parenthesis represent the 95% confidence interval.

c. Economic Impacts

Alternative 1 would result in an increase of $26 million in operating costs to the primary industries when compared to the proposed amendments over the years of analysis. These costs would directly benefit secondary industries, where demand for HD parts and repairs exceeds the same demand in the proposed amendments scenario. Alternative 1 leads to similar health benefits and cost-savings for individuals as the proposed amendments. The REMI output for the main economic indicators, seen in Table 39, shows a slightly greater impact to GSP, personal income, employment, and private investment, all attributed to the higher operating costs for fleets operating in California, but still negligible given the size of the California economy.

Table 39: Change in Growth of Economic Indicators for Alternative 1 Compared to BAU

		2018	2019	2020	2021	2022	2023	2024	2025
GSP	Change (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-$20.5	-$73.4	-$64.2	-$52.2	-$42.0	-$37.4	-$28.6	-$26.3
Personal Income	Change (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-$48.0	-$136.2	-$45.2	-$45.2	-$34.8	-$37.2	-$32.4	-$27.5
Employment	Change (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change in Jobs	-225	-800	-675	-550	-425	-375	-275	-250
Private Investment	Change (%)	0.00%	-0.01%	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-$13.0	-$41.8	-$29.1	-$19.8	-$11.4	-$7.2	-$3.9	-$1.4

The value in each year is interpreted as the reference year value less the BAU value in that same year. The change in jobs is rounded to the nearest 25, while the dollar values are rounded to the nearest $100,000.

d. Cost-Effectiveness

Alternative 1 results in higher compliance costs and higher emission benefits. A cost effectiveness of $142 per pound of PM is estimated for Alternative 1. This was calculated by dividing the total regulatory cost through 2025 by the total PM benefits. Alternative 1 costs $14 more per pound of PM than the proposed amendments.

e. Reason for Rejecting

Requiring all Non-DPF equipped vehicles to meet a 20 percent opacity limit would force some older vehicles off the road even though they would be operating with engines and emission control systems that are being maintained up to their design specifications. The intent of the proposed amendments is not to force the turnover of older vehicles, it is to ensure emission control and aftertreatment systems are operating as originally designed. By setting a 20 percent opacity limit for all Non-DPF equipped vehicles regardless of engine MY, the proposed HDVIP and PSIP amendments would go beyond what the programs were originally designed for.

2. Alternative 2: Less Stringent Opacity Limits than the Proposed Alternative

Alternative 2 proposes less stringent opacity limit requirements for DPF-equipped vehicles than the proposed amendments as shown in Table 40. The reporting and smoke tester training requirements are identical to the proposed amendments. The less

stringent opacity limit significantly reduces the projected rates of DPF-equipped vehicles with excess opacity emissions, as shown in Table 41.

Table 40: Proposed Opacity Limits for Alternative 2

2006 Model Year (MY) and older engines without DPFs	
Pre-1991	40% Opacity Limit
1991 -1997 MY	30% Opacity Limit
1997-2006 MY	20% Opacity Limit
2007+ MY and any Engines equipped with a DPF	
8% Opacity Limit	

Table 41: Estimated Percentages of Vehicles with Excess Opacity Emissions for Alternative 2

Engine Type	Implementation Year (2018)	Subsequent Years
2010+ MY Engine	1%	0.04%
2007-2009 MY Engine	16%	1.3%
Pre-2007 MY Engines	8%	0.17%
Non-DPF Engines	10%	1%

a. Costs

Alternative 2 would result in significantly lower costs than the proposed amendments. The less stringent opacity limit would lead to reduced repair costs to industry. Table 42 depicts the annual repair costs expected for Alternative 2. Reporting costs, smoke tester training costs, additional PSIP testing costs, additional HDVIP citation costs, and baseline costs are identical to the proposed amendments. The total regulatory cost between 2018 and 2025 is estimated to be about $133 million, approximately $84 million less than the proposed amendments.

Table 42: Annual Repair Cost Estimates for Alternative 2

Year	Annual Cost
2018	$25,191,497
2019	$64,731,729
2020	$4,711,896
2021	$7,840,148
2022	$3,900,925
2023	$3,080,850
2024	$1,542,374
2025	$1,506,647
Total Cost	$112,506,065

b. Benefits

Alternative 2 results in fewer emission benefits than the proposed amendments due to a less stringent opacity limit for DPF-equipped vehicles. As seen in Table 43, Alternative 2 is estimated to deliver about 1 million pounds of PM emission reductions between 2018

and 2025, approximately 40 percent lower than the emission benefits predicted for the proposed amendments. These reduced PM benefits significantly reduce the number of reduced premature deaths, avoided hospitalizations, and avoided ER visits relative to the proposed amendments (Table 44). For example, the proposed amendments would avoid 84 premature deaths between 2018 and 2025, while Alternative 2 would avoid 52 premature deaths.

Table 43: Projected Annual Statewide PM Emission Benefits

Year	PM Tons per day	PM Pounds per Year
2018	0.119	86,870
2019	0.365	266,450
2020	0.322	235,060
2021	0.272	198,560
2022	0.250	182,500
2023	0.046	33,580
2024	0.046	33,580
2025	0.045	32,850
Total	1.465	1,069,450

Table 44: Cumulative Regional and Statewide Avoided Incidences from 2018 to 2025 for Alternative 2

	Avoided Premature Deaths	Avoided Hospitalizations	Avoided ER Visits
Great Basin Valleys	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Lake County	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Lake Tahoe	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Mojave Desert	1 (1 - 1)	0 (0 - 0)	0 (0 - 1)
Mountain Counties	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)
North Central Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
North Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Northeast Plateau	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Sacramento Valley	2 (2 - 3)	0 (0 - 1)	1 (1 - 1)
Salton Sea	1 (1 - 1)	0 (0 - 0)	0 (0 - 1)
San Diego County	3 (2 - 4)	1 (0 - 1)	1 (1 - 2)
San Francisco Bay	5 (4 - 7)	1 (0 - 2)	2 (2 - 3)
San Joaquin Valley	8 (6 - 10)	1 (0 - 2)	3 (2 - 5)
South Central Coast	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
South Coast	37 (28 - 45)	5 (1 - 12)	16 (10 - 21)
Statewide	52 (41 - 64)	8 (1 - 18)	22 (14 - 30)

*Values in parenthesis represent the 95% confidence interval.

c. Economic Impacts

Unlike Alternative 1, Alternative 2 would result in lower operating costs for fleets operating in California when compared to the proposed amendments. Alternative 2 would result in an $84 million reduction in repair and labor costs when compared to the proposed amendments. Primary industries would still see an increase in operating costs relative to the BAU, but the macroeconomic impacts to GSP, personal income, employment, and private investment, are negligible given the size of the California economy. Secondary industries would still enjoy an increase in demand for goods and services, but the impact of the compliance costs for fleets still outweighs the impact of increased demand for HD parts and repair labor. Individuals will experience health benefits resulting in cost savings for hospital and ER visits, but these cost-savings are significantly lower than under the proposed amendments. Still, macroeconomic modeling results are not considerably different from the estimated impacts under the proposed amendments and are presented in Table 45.

Table 45: Change in Growth of Economic Indicators for Alternative 2 Compared to BAU

		2018	2019	2020	2021	2022	2023	2024	2025
GSP	Change (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-$10.5	-$40.3	-$34.9	-$28.3	-$22.5	-$20.1	-$13.7	-$13.2
Personal Income	Change (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-$25.5	-$75.9	-$24.4	-$25.0	-$18.3	-$19.5	-$18.0	-$14.0
Employment	Change (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change in Jobs	-125	-450	-375	-300	-225	-200	-125	-125
Private Investment	Change (%)	0.00%	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-$6.9	-$23.1	-$16.0	-$11.0	-$6.1	-$3.7	-$2.1	-$0.6

The value in each year is interpreted as the reference year value less the BAU value in that same year. The change in jobs is rounded to the nearest 25, while the dollar values are rounded to the nearest $100,000.

d. Cost-Effectiveness

Alternative 2 results in reduced compliance costs and lower emission benefits. A cost effectiveness of $125 per pound of PM is estimated for Alternative 2. This was calculated

by dividing the total regulatory cost through 2025 by the total PM benefits. Alternative 2 costs $3 less per pound of PM than the proposed amendments.

e. Reason for Rejecting

By relaxing the opacity limits, Alternative 2 effectively increases the amount of vehicles on California roadways that will continue to operate with damaged emission control systems. Diesel PM emissions, defined as a toxic air contaminant (TAC), lead to increased health impacts such as increased cancer rates and respiratory issues. It is important to significantly reduce these emissions in an effort to improve human health. Alternative 2 leaves significant PM benefits on the table and does not adequately address the issue of removing harmful PM emissions from the HD vehicle sector.

F. FISCAL IMPACTS

1. Local Government

The proposed amendments are expected to impact local governments statewide that own HD diesel vehicles. HD diesel vehicles owned by local government agencies would be expected to meet the proposed HDVIP and PSIP requirements. This means that local government fleets may incur repair costs, citation costs, reporting costs, and training costs due to the proposed amendments.

Staff estimated the HD vehicle population for local and state governments based on CARB's EMFAC model vehicle populations. Staff assumed solid waste collection vehicles, school buses, and urban buses all belonged to local government agencies. Additionally, staff estimated that the public fleet vehicle population in EMFAC, which comprises of state, county, and city government vehicles, is broken up equally into local and state agency vehicles.

Based on these assumptions, staff estimated that local government agencies own about 10 percent of the statewide HD diesel vehicle population above 14,000 pounds GVWR. Staff estimates the cost to local governments statewide to be about 10 percent of the total regulatory costs, resulting in a cost of about $22 million between the years 2018 and 2025, as shown in Table 46. With the reduction in PM emissions and improvement in overall air quality, it is expected that local governments will benefit from fewer employee sick days and a reduction in public hospital and ER visits.

Currently, the monetary benefits attributed only to local government cannot be separated from the overall cost-savings, however, a portion of total cost-savings will go to local governments. The majority of health benefits occur in the South Coast Air Basin followed by the San Joaquin Valley and San Francisco air basins. These local governments are expected to experience the most cost savings from the proposed amendments. Local governments will also benefit from a greater ability to attain regional air quality goals.

Table 46: Estimated Annual Cost to Local Government Agencies Statewide for the Proposed Amendments

Year	Annual Cost
2018	$3,850,180
2019	$10,189,787
2020	$916,731
2021	$1,647,198
2022	$891,170
2023	$1,457,220
2024	$1,465,798
2025	$1,246,305
Total Cost	**$21,664,389**

2. State Government

Two separate costs may pertain to the state government level: costs for CARB to implement and enforce the proposed regulation and costs to state agencies that own HD diesel vehicles that must be brought into compliance. In addition, state government will experience cost savings from health benefits of the proposed amendments, which are discussed below.

CARB estimates 3.5 additional staff will be needed due to the increased staff workload demands of the CARB reporting database and to effectively enforce the proposed changes. 1.5 Air Pollution Specialist (APS) positions are needed to accommodate the increased reporting database workload and 2 additional Field Representatives (FR) are needed to help increase CARB's enforcement presence throughout the state. The annual cost for 1 APS is estimated to be $187,763 and the annual cost for a FR is estimated to be $133,266.

The extra field representatives consist of one additional enforcement inspection team that can be sent out in the field to monitor for compliance. With this extra inspection team, CARB can increase its presence in the state and slightly increase the number of roadside tests performed each year. With the extra inspection team, staff anticipates that roadside enforcement can inspect up to 3.5 percent of statewide vehicles per year. Today, roadside inspections only inspect about 3 percent of the statewide fleet. Staff anticipates the need for the added staff beginning in the 2018 fiscal year. The cost for the additional staff is approximately $548,177 annually. HDVIP citation revenue is not expected to be able to cover the full cost of additional staff. An estimated $1.6 million from 2018-2025 is expected to come from citation revenue. The remaining funds needed for additional staff is projected to be absorbed through the Air Pollution Control Fund.

State agencies that own HD diesel vehicles may see increased costs to bring some of their vehicles into compliance. Using the methodology described in the local government fiscal section, staff estimates that state agencies account for about 3.5 percent of the HD diesel vehicle population throughout the state. Based on this, state agencies are projected

to incur about $8 million in repair costs to comply with the proposed amendments between the years 2018-2025 (Table 47). Combined with citation revenue and the cost of additional staff for CARB, state government agencies are projected to incur additional costs of about $11 million from 2018-2025. As citation costs are revenue generators for the state, these costs are listed as negatives in Table 47.

Table 47: Estimated Additional Annual Statewide Costs of State Agencies for the Proposed Amendments

Year	Annual Repair Costs	Citation Revenue	CARB Staffing Costs	Total State Agency Costs
2018	$1,387,766	-$310,500	$548,177	$1,625,443
2019	$3,672,825	-$621,000	$548,177	$3,600,002
2020	$330,428	-$310,500	$548,177	$568,105
2021	$593,719	-$155,250	$548,177	$986,646
2022	$321,215	-$77,625	$548,177	$791,767
2023	$525,243	-$54,000	$548,177	$1,019,420
2024	$528,335	-$54,000	$548,177	$1,022,512
2025	$449,220	-$54,000	$548,177	$943,397
Total Cost	$7,808,751	-$1,455,300	$4,385,416	$10,738,867

State government will likely generate additional cost savings through reduced hospital visits at state run hospitals and reduced sick days for state employees. The projected changes in hospital visits will also affect general fund costs through changes in state Medi-Cal expenditures. Medi-Cal, California's version of Medicaid, provides health coverage for children and adults with limited resources and is funded both by federal and State funds. A potential method to estimate the changes in general fund costs is multiplying the change in hospital expenditures by the Medi-Cal's share of California's hospital care expenditures and by the State's share of Medi-Cal spending. Specifically,

$$\Delta General\ Fund\ Costs = \Delta Hosptial\ Expenditures \times \left(\frac{M}{C}\right) \times S$$

where M is the value of Medi-Cal hospital care spending in California (including both State and federal funds), C is the total value of hospital care expenditures in California, and S is the state share of Medi-Cal spending. This approach assumes that hospitalizations and ER visits due to respiratory conditions and asthma will fall under the expenditure classification of hospital care as categorized by the Centers for Medicare and Medicaid Services. In addition, this methodology assumes that individuals utilizing hospital care due to asthma or respiratory conditions are no more or no less likely to be insured through Medi-Cal than individuals in the general population. Finally, the methodology assumes that the state share of Medi-Cal spending on hospital care is the same as the share of state spending on Medi-Cal as a whole.

These assumptions may not hold true in all cases. For example, populations with low socioeconomic status can be more susceptible to air pollution and are more likely to use Medi-Cal. Therefore, there may be a disproportionate cost-savings to Medi-Cal from the

proposed amendments. There is insufficient information about the distribution of health impacts and year to year budget details to confirm this possibility, so a more general assumption described above is used.

Data on hospital care spending in California is available from the Centers for Medicare and Medicaid Services, Office of the Actuary, National Health Statistics Group. From 2010 through 2014 (the most recent year with reported data), the ratio of Medi-Cal expenditures on hospital care to total expenditures on hospital care has increased from 19.6 to 23.1 percent, an average annual growth rate of 4.8 percent.[35] Extrapolating this out to 2016 would imply a ratio of 25.4 percent.

In 2014, the state share of Medi-Cal expenditures was 43.6 percent.[36] This percentage has increased in the past few years, in part due to the Affordable Care Act (ACA) optional expansion and the federal medical assistance percentages assigned to the ACA optional expansion population.[37] In 2016, the state share of Medi-Cal expenditures was 35.9 percent.[38] This share may increase over the next several years as the federal medical assistance percentages assigned to the ACA optional expansion population declines.

Using the values of the state share of Medi-Cal expenditures from 2014 to 2016, and the observed and forecasted ratio of Medi-Cal expenditures to total expenditures on hospital care, the data suggests that 8.2 to 11.6 percent of the cost savings for hospital care from the proposed amendments could go to the State General Fund. The magnitude of cost savings from the proposed amendments, however, is small compared to total State spending on medical care.

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[35]Centers for Medicare & Medicaid Services (2017). *Health Expenditures by State of Provider*. Retrieved (7/11/2017) at https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsStateHealthAccountsProvider.html

[36] https://www.medicaid.gov/medicaid/financing-and-reimbursement/state-expenditure-reporting/expenditure-reports/index.html

[37] http://www.lao.ca.gov/Publications/Report/3612#Governor.2019s_Budget_Caseload_Projections

[38] Federal and State Share of Medicaid Spending | The Henry J. Kaiser Family Foundation. http://www.kff.org/medicaid/state-indicator/federalstate-share-of-spending/?currentTimeframe=0&selectedRows=%7B%22states%22:%7B%22california%22:%7B%7D%7D%7D&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D#notes

APPENDIX A: HEALTH MODELING METHODOLOGY

To estimate the change in health outcomes from changes in emissions due to the proposed amendments, CARB uses the incidents-per-ton (IPT) methodology.[39] This methodology quantifies the health benefits of primary and secondary PM2.5 reductions due to regulatory controls. Primary PM2.5 is emitted directly from the source, for example, the black particles in diesel exhaust. Secondary PM2.5 is formed in the atmosphere as a result of chemical reactions. NOx emissions are converted by atmospheric processes to secondary ammonium nitrate PM2.5. Therefore, NOx emission reductions from the proposed amendments will result in a reduction in PM2.5 exposure.

This methodology is similar to the methodology developed by the U.S. EPA for health benefit estimations,[40] but uses California air basin specific relationships between emissions and air quality. The basis of the IPT methodology is the approximately linear relationship which holds between changes in emissions and estimated changes in health outcomes. Therefore, health outcomes are approximately proportional to emissions, and changes in health outcomes from the proposed amendments can be estimated by multiplying changes in emissions by a reference incidence factor, known as the IPT factor.

IPT factors were derived for a reference scenario by identifying the health incidence associated with a PM2.5 source in an air basin, and dividing by the emissions of that PM2.5 source, as in the following equation. This reference scenario is based on 2009 through 2011 average data used in IPT factor development, and is not the same as the regulatory BAU. Separate IPT factors were developed for each health endpoint, air basin, and for primary PM2.5 and NOx emissions.

$$IPT\ Factor = \frac{Reference\ Incidence\ (\#\ cases)}{Reference\ Emissions\ (tons)}$$

A change in health outcomes from the proposed amendments can then be calculated by multiplying the emission change in a given year by the IPT Factor. Since the total incidence of health outcomes is also proportional to population, the change in health outcomes are additionally scaled by the ratio of the population in a given year to the population in the reference year, which is the 2009 through 2011 average. The equation used to estimate health outcomes is:

$$Health\ Outcome_Y = [Emission\ Change_Y(tons)] * \left[IPT\ Factor\ (\frac{incidents}{ton})\right] * \left[\frac{Population_Y}{Population_R}\right]$$

[39] Air Resources Board (ARB), 2010. Initial Statement of Reasons, Appendix J, Regulation to Reduce Emissions of Diesel Particulate Matter, Oxides of Nitrogen and Other Criteria Pollutants from In-Use Heavy-Duty Diesel-Fueled Vehicles.

[40] Neal Fann, Kirk R. Baker, Charles M. Fulcher, Characterizing the PM-related health benefits of emission reductions for 17 industrial, area and mobile emission sectors across the U.S., Environment International, Volume 49, 2012, Pages 141-151, ISSN 0160-4120, http://dx.doi.org/10.1016/j.envint.2012.08.017.

where, Y is a given year for which the proposed amendments lead to a change in PM2.5 emissions, and R is the reference case. The change in health outcomes is calculated for each health endpoint, air basin, year, and for both primary PM2.5 and NOx emissions. A further description of the methodology, assumptions, and uncertainty follows.

IPT Factors

A detailed description of the methodology used to calculate premature mortality from PM2.5 has been published, and is similar to that used to determine IPT factors.[41] IPT factors for other health endpoints are calculated using similar methodology. Calculating IPT factors requires reference incidence rates, population data, ambient concentrations of PM2.5, and a concentration-response function (CRF) relating changes in PM2.5 exposure to changes in health incidence.[42] The underlying analysis was performed at the census tract level, then aggregated to air basin and statewide results.

Reference incidence rates are the number of cases of death or illness in the exposed population. Incidence rates vary according to age; for instance, an older person is more likely to die or be hospitalized because of heart disease or stroke than a child or young adult. Age-specific incidence rates were taken from the Centers for Disease Control and Prevention Wonder database.[43] The CARB methodology divides the population into five-year age brackets up to ages 80-84, and an 85+ age bracket. Thus this analysis reflects differences in vulnerability between different age groups.

Population exposure to PM2.5 was estimated from monitored or modeled concentrations of PM2.5. Consistent with U.S. EPA practice, CARB uses the software program BenMap, which uses input exposure data and CRF to calculate estimated mortality.

Following recent U.S. EPA practice, CRF for death from heart disease and stroke are taken from a study by Krewski et al.,[44] for hospital admissions for heart and lung disease from a study by Bell et al.,[45] and for asthma emergency room visits from a study by Ito et al.[46] Change in cardiopulmonary mortality were not quantified when the concentration

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[41] Air Resources Board, 2010. Estimate of Premature Deaths Associated with Fine Particle Pollution (PM2.5) in California Using a U.S. Environmental Protection Agency Methodology. https://www.arb.ca.gov/research/health/pm-mort/pm-report_2010.pdf

[42] Air Resources Board, 2010. Initial Statement of Reasons, Appendix J, Regulation to Reduce Emissions of Diesel Particulate Matter, Oxides of Nitrogen and Other Criteria Pollutants from In-Use Heavy-Duty Diesel-Fueled Vehicles. https://www.arb.ca.gov/regact/2010/truckbus10/correctedappj.pdf

[43] Centers for Disease Control and Prevention. Wonder Database. https://wonder.cdc.gov/

[44] Krewski et al. (2009) Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality. Health Effects Institute Research Report 140. https://ephtracking.cdc.gov/docs/RR140-Krewski.pdf.

[45] Bell et al. (2008) Seasonal and Regional Short-term Effects of Fine Particles on Hospital Admissions in 202 US Counties, 1999–2005. Am J Epidemiol. 168(11): 1301–1310. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2732959/.

[46] Ito et al. (2007) Characterization of PM2.5, gaseous pollutants, and meteorological interactions in the context of time-series health effects models. J Expo Sci Environ Epidemiol. Vol. 17 Suppl 2: S45-60. http://www.nature.com/jes/journal/v17/n2s/full/7500627a.html.

were below 5.8 μg/m^3, because the Krewski et al. study did not examine impacts below that concentration.

The IPT factors were originally developed for use with on-road diesel PM emissions, but are also applied to PM from portable diesel equipment. This assumes that the emission patterns for PM from portable diesel equipment are similar to those for PM from on-road diesel vehicles. That is, a ton of PM2.5 emitted from portable equipment is expected to result in the same PM2.5 exposure and health effects as a ton of PM2.5 emitted from on-road diesel vehicles.

Population Scaling

Population was estimated by taking 2010 Census data for total population by age bracket and projecting to 2026 using total county population projections from the California Department of Finance (DOF). This accounts for overall population growth in a county but does not reflect shifts in the spatial distribution of the population such as new housing developments built on previously undeveloped land.

The original population estimation analysis was performed in 2014. Though this is not the most recent data available from DOF, the population discrepancy between the data used in this analysis and the July 2017 DOF forecast[47] is less than two percent in a given year, and is randomly distributed among years (i.e., sometimes higher and sometimes lower). This uncertainty is much lower than the uncertainty for estimating either emissions changes or health outcomes, so does not meaningfully contribute to error in this analysis.

Uncertainty

This health benefit analysis relies on multiple data sources and assumptions that contain significant inherent uncertainty. The reference case used to develop IPT factors reconstructs ambient concentrations of both primary PM2.5 and secondary ammonium nitrate formed in the atmosphere from NOx emissions to estimate population exposure. These datasets were constructed from California's ambient monitoring networks, which have limited spatial and temporal coverage. Atmospheric concentrations of PM vary dramatically both spatially and temporally depending on the emission behavior of local sources, the local meteorological conditions, and topographical features. Extrapolating atmospheric concentrations between air quality monitors adds uncertainty to the underlying methodology.

CRF functions are also used to develop IPT factors, and are based on the best available scientific literature, but are difficult to measure and contain inherent uncertainty. These CRF functions do not have sufficient detail to account for all sensitive populations, specifically populations with low socioeconomic status.

Another important source of uncertainty are projected emission inventories under the baseline and proposed amendments. Projecting emission inventories relies on CARB

[47] California Department of Finance, 2017. P-1: State Population Projections (2010-2060) – Total Population by County. http://www.dof.ca.gov/Forecasting/Demographics/Projections/

expert judgment of likely future equipment technology changes and business behavior both in the absence of (i.e., baseline) and presence of the proposed amendments. CARB worked closely with stakeholders to identify the likely response from business both with and without the proposed amendments. Still, unforeseen events could occur that dramatically change future emissions. In addition, the spatial distribution of future emission reductions as a result of the proposed amendments contributes high uncertainty. Health outcomes at the air basin level are presented in this analysis, but represent higher uncertainty than the statewide analysis. It is not possible to accurately constrain the error in projected emission inventories due to lack of information about future conditions.

Some of the uncertainty described above is accounted for in the health outcome calculation, as represented by the 95 percent confidence intervals. Importantly, error associated with projected emission inventories is not included in these confidence intervals. The error associated with the projected emission inventories could contribute significant additional error.