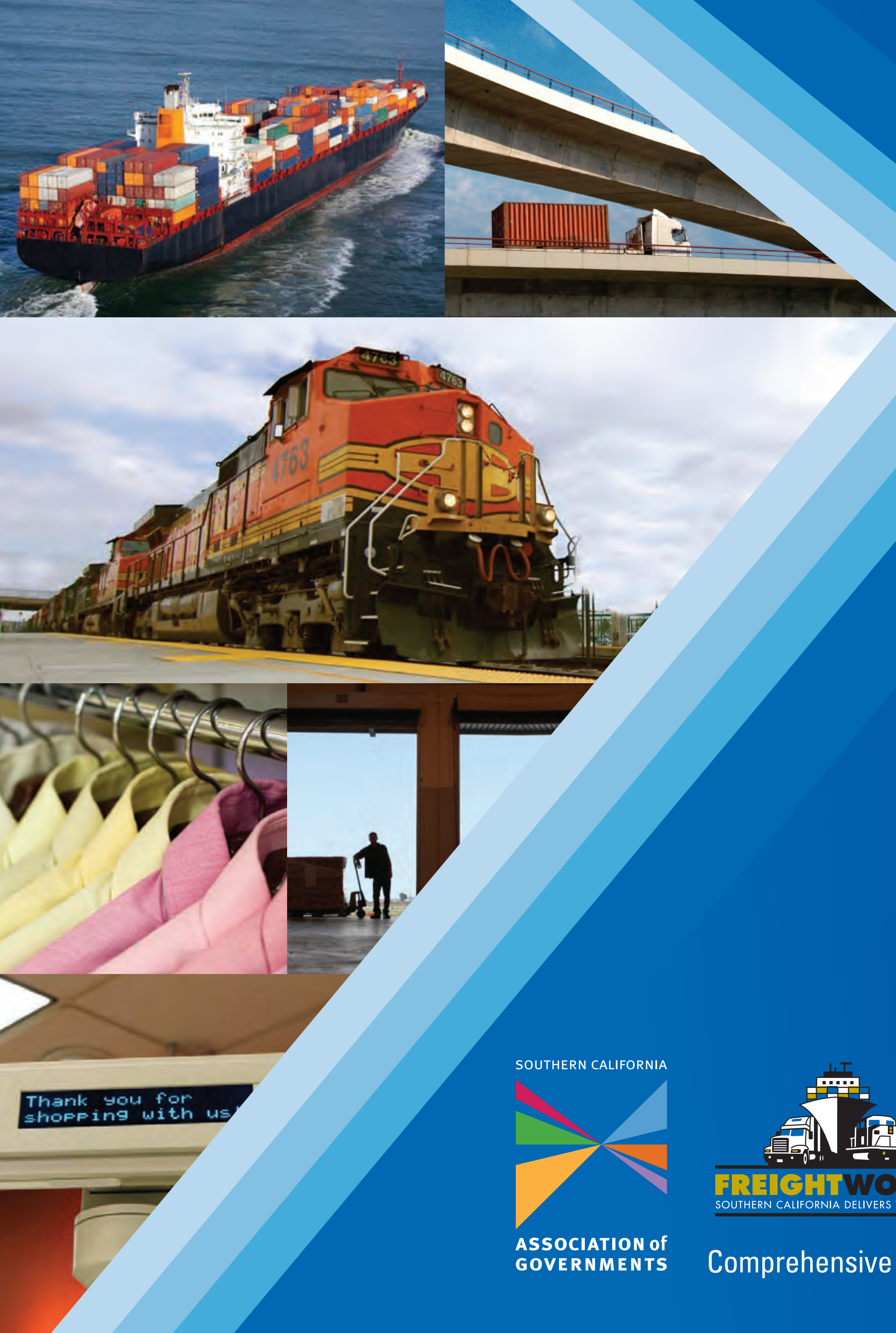

ON THE MOVE

SOUTHERN CALIFORNIA DELIVERS THE GOODS

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SOUTHERN CALIFORNIA DELIVERS THE GOODS

Comprehensive Regional Goods Movement Plan and Implementation Strategy

ON THE MOVE

SOUTHERN CALIFORNIA DELIVERS THE GOODS

Comprehensive Regional Goods Movement Plan
and Implementation Strategy

final
report

prepared for

The Southern California Association of Governments

prepared by

Cambridge Systematics, Inc.

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5 Environmental/ Community Issues and Needs

5.1 Air Quality – The Policy Context and Challenges

In Southern California, goods movement and air quality are inextricably linked. Much of the SCAG region (and nearly all of the urbanized area) does not meet Federal air quality standards. Goods movement is a major source of emissions that contribute to these regional air pollution problems. Goods movement also contributes to localized air pollution "hot spots" that can have adverse human health impacts.

Air quality is regulated under the Federal Clean Air Act. The Clean Air Act requires the U.S. EPA to establish National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. These pollutants include ozone, particulate matter, carbon monoxide, nitrogen dioxide, sulfur dioxide, and lead. The two air pollutants of greatest concern in Southern California are ozone and particulate matter.

Ground-level ozone, often called smog, is formed through chemical reactions between oxides of nitrogen (NO_x) and volatile organic compounds (VOC) in the presence of sunlight. NO_x emissions are formed in the combustion chamber of internal combustion engines due to the high pressures and temperatures. Diesel engines are a major source of NO_x, and thus a major contributor to ozone formation.

Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. Particulate matter is formed during combustion of fossil fuels and also is created when emissions of NO_x or sulfur oxides react with other compounds in the atmosphere to form particles. In addition, road dust and tire and brake wear cause particulate pollution. The size of particles is directly linked to their potential for causing health problems, so particulate matter is often defined as particles less than 10 micrometers in diameter (PM_{10}) or less than 2.5 micrometers in diameter ($PM_{2.5}$); the latter is termed "fine" particulate matter.

The air quality standards set limits to protect public health, including the health of "sensitive" populations such as people with asthma, children, and the elderly. The EPA designates an area as "nonattainment" if it has violated (or contributed to a violation of) the NAAQS.

In 2004, the EPA designated nonattainment areas throughout the country that exceeded the health-based standards for 8-hour ozone. The 8-hour ozone nonattainment areas are classified as Extreme, Severe 15, Serious, Moderate, or Marginal according to the severity of air pollution and time allowed to attain the NAAQS. The South Coast Air Basin is one of two nonattainment areas in the nation designated as "Extreme" (the other is the San Joaquin Valley). The other ozone nonattainment areas in the SCAG region are Ventura County, Western Mohave area, Coachella Valley, and Imperial County; they are designated from Moderate to Severe 15 as shown in Table 5.1. The South Coast Air Basin and a portion of Imperial County also are designated $PM_{2.5}$ nonattainment areas. Because the South Coast Air Basin has the worst air quality problems in the SCAG region and is home to roughly 90 percent of the SCAG region population, it receives the most attention in this section.

Table 5.1 Ozone and $PM_{2.5}$ Nonattainment Areas Within the SCAG Region

Name	Current U.S. EPA Severity Classification	Required Attainment Date
Ozone Nonattainment Areas (8-hour standard)		
South Coast Air Basin	Extreme	2024
Coachella Valley (portion of Riverside County)	Severe 15	2019
Ventura County	Serious	2013
Western Mojave (portion of Los Angeles and San Bernardino Counties)	Moderate	2010
Imperial County	Moderate	2010
$PM_{2.5}$ Nonattainment Areas (2006 standard)		
South Coast Air Basin	N/A	
Imperial County (portion)	N/A	

For state air quality management purposes, the California Air Resources Board (ARB) has divided the State into air basins; air basins within the SCAG region are shown in Figure 5.1.

While not regulated under the NAAQS, goods movement also is a source of hazardous air pollutants, also known as air toxics. Air toxics can cause serious adverse health effects even in low quantities. The U.S. EPA and Federal Highway Administration (FHWA) have identified six priority Mobile Source Air Toxics: acetaldehyde, acrolein, benzene, 1,3-butadiene, diesel particulate matter (DPM), and formaldehyde.

The multiple pollutants and emissions sources make it challenging to solve Southern California's air quality problems. Strategies to address one pollutant or emissions source may not be effective for other pollutants and sources. For example, particulate filters can successfully reduce PM emissions from vehicle exhaust; they do not affect the PM formed by tire and brake wear, the secondary particulates that form in the atmosphere, or NO_x emissions. Some control measures for NO_x will help reduce ozone formation and secondary particulate formation, but not affect direct emissions of diesel PM or tire and brake wear PM. Moreover, the need to reduce CO_2 emissions to address global climate change (discussed below) adds additional complexity to solving these challenges. CO_2 emissions are directly linked to the amount of fuel burned and generally are not affected by traditional engine and exhaust measures for controlling NO_x and PM.

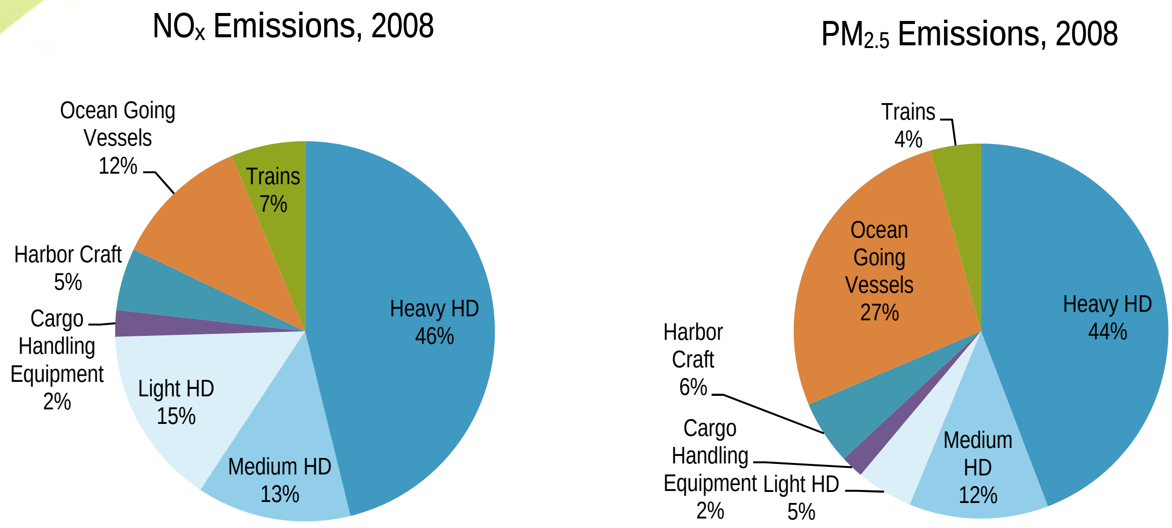
Figure 5.1 Air Basins in the SCAG Region

5.1.1 Current and Future Emissions

Considering emissions from all sources, goods movement currently is responsible for about 47 percent of NO_x emissions in the region and about 18 percent of all $PM_{2.5}$ emissions. (Road dust is the largest single source of $PM_{2.5}$ emissions.)

Figure 5.2 shows the sources of goods movement NO_x and $PM_{2.5}$ emissions in the South Coast Air Basin in 2008. Heavy-duty trucks contribute 75 percent of the NO_x emissions and 61 percent the $PM_{2.5}$ emissions from goods movement. Ocean-going vessels are responsible for 12 percent of NO_x and 27 percent of $PM_{2.5}$ goods movement emissions. Freight trains contribute 7 percent of NO_x and 4 percent of $PM_{2.5}$ goods movement emissions.

Figure 5.2 Goods Movement NO_x and $PM_{2.5}$ Emissions in South Coast Air Basin by Source
2008



Source: South Coast Air Quality Management District.

Note: Heavy-Duty Trucks are classified as Light-Heavy Duty (8,501-14,000 lbs. gross vehicle weight), Medium-Heavy Duty (14,001-33,000 lbs. gross vehicle weight, and Heavy-Heavy Duty (33,001+ lbs. gross vehicle weight).

In the future, emissions from goods movement are expected to drop, primarily as a result of Federal and state emissions regulations. Over the next decade, the introduction of trucks meeting Federal emission standards, accelerated by ARB's Statewide Truck and Bus Rule (described in the following section), will cause a dramatic reduction in heavy-duty vehicle (HDV) emissions. In the South Coast Air Basin, NO_x emissions from HDVs are expected to drop 74 percent between 2008 and 2023, as shown in Table 5.2. By 2023, nearly all trucks will comply with the most stringent existing emissions standards, although emissions are projected to slowly rise after 2023 due to growth in vehicle-miles-traveled (VMT). However, HDV NO_x emissions in 2035 are still projected to be 75 percent below 2008 levels. As with NO_x emission, $PM_{2.5}$ emissions from heavy-duty vehicles are expected to drop dramatically over the next decade, falling 70 percent between 2008 and 2023 and then rising slightly by 2035 due to VMT growth.

Locomotive NO_x emissions are projected to decline more slowly than truck emissions because the introduction of cleaner locomotives will occur more gradually and their benefits will be offset by growth in railroad activity. Between 2008 and 2035, freight locomotive NO_x emissions are projected to decline by 37 percent. Fine particulate emissions from locomotives will drop more rapidly, largely because of the near-term PM benefits of the U.S. EPA locomotive rebuild requirements (discussed in the Locomotive Regulations section), which do not affect NO_x. Compared to 2008, $PM_{2.5}$ emissions from freight locomotives will be 56 percent lower in 2035.

Table 5.2 Baseline Emissions from Heavy-Duty Vehicles and Locomotives in South Coast Air Basin (tons/day)

	NO_x Emissions			$PM_{2.5}$ Emissions		
	2008	2023	2035	2008	2023	2035
Heavy Duty Vehicles						
Light-Heavy Duty	53.4	26.4	13.8	0.70	0.55	0.63
Medium-Heavy Duty	46.1	6.4	6.9	1.71	0.51	0.62
Heavy-Heavy Duty	157.9	33.1	44.7	6.17	1.48	2.12
Total HDV	257.4	65.9	65.4	8.58	2.54	3.37
Change from 2008	–	-74%	-75%	–	-70%	-61%
Locomotives[a]						
Line-Haul	19.1	18.3	12.6	0.52	0.38	0.23
Switcher	2.2	1.1	0.6	0.04	0.03	0.01
Class 2/3	0.5	0.6	0.5	0.01	0.01	0.01
Passenger	4.3	2.1	1.9	0.11	0.04	0.04
Total Locomotive	26.1	22.2	15.6	0.69	0.47	0.29
Total Freight Locomotive	21.8	20.0	13.7	0.6	0.4	0.3
Change from 2008 (Freight)	–	-8%	-37%	–	-26%	-56%

Source: *Heavy duty vehicle emissions from South Coast Air Quality Management District, Draft 2012 Air Quality Management Plan; Locomotive emission based on Draft 2012 Air Quality Management Plan and ICF International analysis.*

[a] *Locomotives generally fall into three broad categories based on their intended use. Switch locomotives, typically less than 2,500 horsepower (hp), are the least powerful locomotives, used in freight yards to assemble and disassemble trains or for short hauls of small trains. Passenger locomotives are powered by engines of approximately 3,000 hp. Line-haul locomotives are the most powerful locomotives and are used to move freight trains over long distances. Class 2/3 refers to small railroad companies, including those that serve the ports and other local facilities.*

Table 5.3 shows similar emissions estimates for the entire six-county SCAG region. The expected future changes in heavy-duty truck and locomotive emissions are similar to those for the South Coast Air Basin.

Table 5.3 Baseline Emissions from Heavy-Duty Vehicles and Locomotives in SCAG Region (tons/day)

	NO_x Emissions			$PM_{2.5}$ Emissions		
	2008	2023	2035	2008	2023	2035
Heavy Duty Vehicles						
Light-Heavy Duty	80.5	42.4	28.2	0.93	0.90	0.99
Medium-Heavy Duty	52.1	7.5	8.1	1.97	0.61	0.76
Heavy-Heavy Duty	226.8	50.2	70.9	9.76	2.53	3.73
Total HDV	359.4	100.1	107.3	12.7	4.0	5.5
Change from 2008	–	-72%	-70%	–	-68%	-57%
Locomotives[a]						
Line-Haul	31.9	30.5	21.0	0.87	0.65	0.39
Switcher	2.2	1.1	0.6	0.04	0.03	0.01
Class 2/3	0.5	0.6	0.5	0.01	0.01	0.01
Passenger	4.3	2.3	1.9	0.11	0.04	0.04
Total Locomotive	39.0	34.5	24.1	1.05	0.73	0.44
Total Freight Locomotive	34.6	32.2	22.1	0.9	0.7	0.4
Change from 2008 (Freight)	–	-7%	-36%	–	-25%	-56%

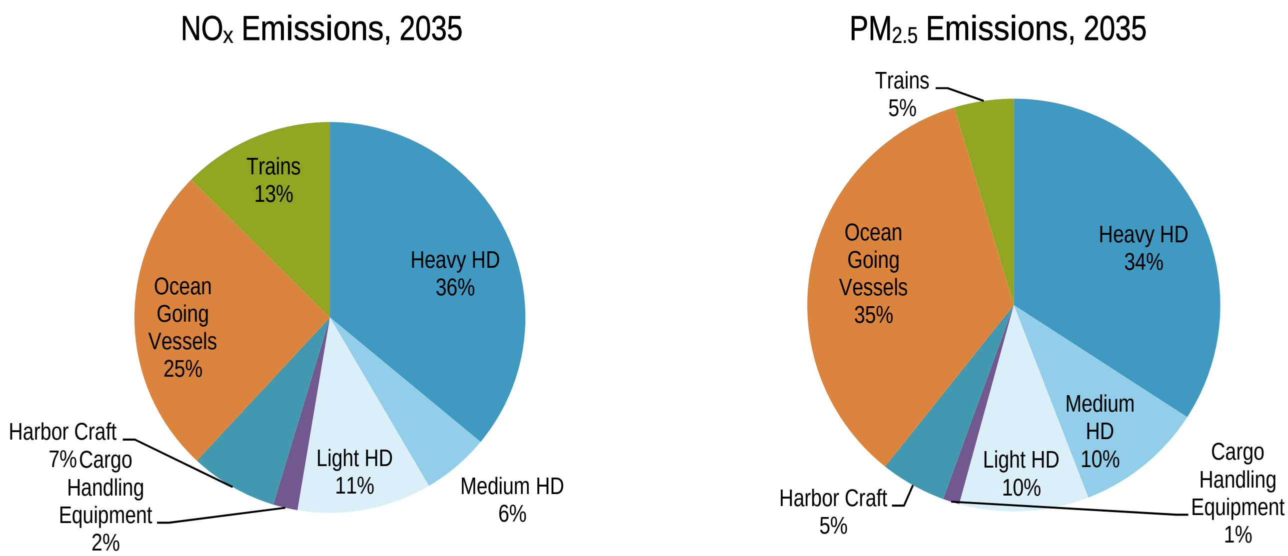
Source: *Heavy duty vehicle emissions from SCAG analysis using EMFAC2011; Locomotive emission based on South Coast Air Quality Management District, Draft 2012 Air Quality Management Plan and ICF International analysis.*

[a] *Locomotives generally fall into three broad categories based on their intended use. Switch locomotives, typically less than 2,500 horsepower (hp), are the least powerful locomotives, used in freight yards to assemble and disassemble trains or for short hauls of small trains. Passenger locomotives are powered by engines of approximately 3,000 hp. Line-haul locomotives are the most powerful locomotives and are used to move freight trains over long distances. Class 2/3 refers to small railroad companies, including those that serve the ports and other local facilities.*

In the future, the goods movement sector will account for a slightly smaller share of total emissions in Southern California, as goods movement emissions will decline more rapidly than other sources. By 2035, goods movement will make up about 44 percent of regional NO_x and 9 percent of $PM_{2.5}$ emissions.

Considering only goods movement sources, because of the large drop in NO_x emissions from heavy duty trucks, trucks will be responsible for a smaller share of goods movement NO_x emissions in 2035 than presently, as shown in Figure 5.3. The contribution by ships will increase significantly, from 12 percent in 2008 to 25 percent in 2035. The shares of goods movement $PM_{2.5}$ emissions by mode will not change significantly, as $PM_{2.5}$ emissions from all sources will decline at roughly the same rate.

Figure 5.3 Goods Movement NO_x and $PM_{2.5}$ Emissions in South Coast Air Basin by Source
2035



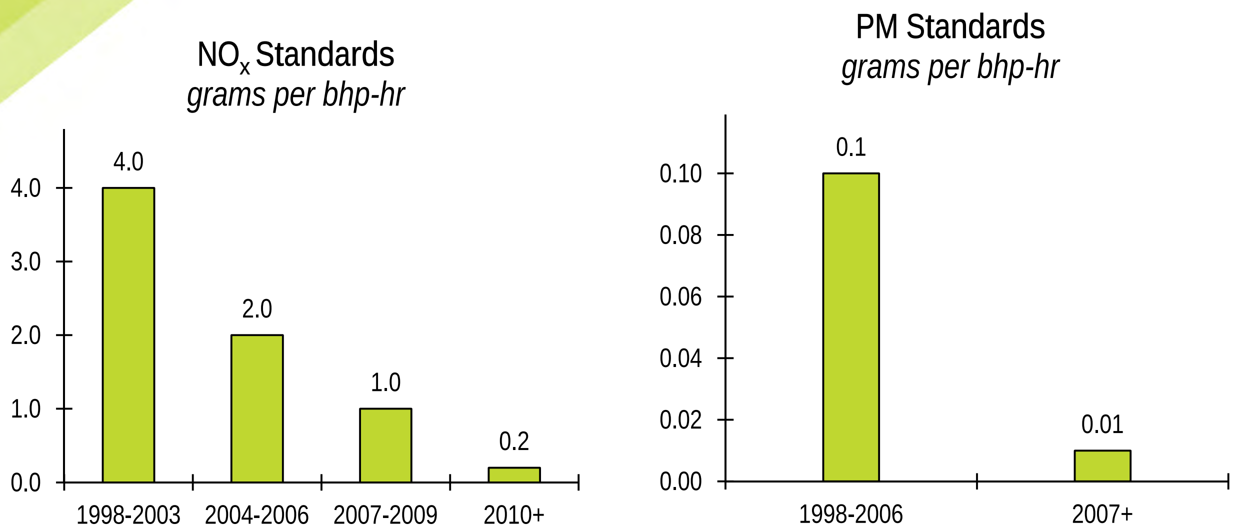
Source South Coast Air Quality Management District.

As noted above, Federal and state regulations are expected to cause a decline in goods movement emissions in coming years. While there are many regulations affecting emissions from trucks, trains, and ships, a handful of key regulations will have the greatest impacts. These regulations are summarized below.

5.1.2 Truck Regulations

All new trucks must meet emission standards set by the U.S. EPA. The current standards applicable to heavy-duty trucks (i.e., those with a gross vehicle weight greater than 8,500 pounds) took effect fully for model year 2010 and new trucks. These standards reflect a 90 percent or greater reduction in emissions as compared to the standards in effect for model years 2006 and earlier. Figure 5.4 illustrates these emissions standards, which are expressed in grams of pollutant per brake horsepower-hour. ARB also has the authority to regulate emissions from new motor vehicles sold in California. ARB's emissions standards for new heavy-duty vehicles have been identical to the U.S. EPA standards for more than a decade.

Figure 5.4 Heavy Duty Truck Emission Standards by Model Year



Turnover of the truck fleet is slow, so the U.S. EPA emission standards for new trucks would normally take several decades to have full effect. In California, however, the introduction of low emission trucks is being accelerated by state regulation. In 2008, ARB approved the statewide in-use Truck and Bus Rule, the most far-reaching diesel emission regulation in the State's history. Unlike EPA emissions standards, the ARB rule applies to existing vehicles already on the road. The rule targets most in-use trucks in the State over 14,000 pounds GVWR (i.e., medium-heavy duty and heavy-heavy duty trucks). The regulation calls for the phase-in of best available control technology (BACT) for PM and NO_x between 2011 and 2023. There are special provisions that can delay the clean-up requirements (e.g., for small fleet owners and owners of agricultural vehicles); however, by 2023 all medium-heavy and heavy-heavy duty diesel vehicles must have a 2010 model year engine or equivalent – far sooner than would occur under natural turnover rates.[1] Depending on their age and condition, trucks and engines that do not meet these standards are likely to be either scrapped or sold to fleets that do not operate in California. Table 5.4 shows the implementation schedule.

[1] See http://www.arb.ca.gov/msprog/onrdiesel/onrdiesel.htm for more details.

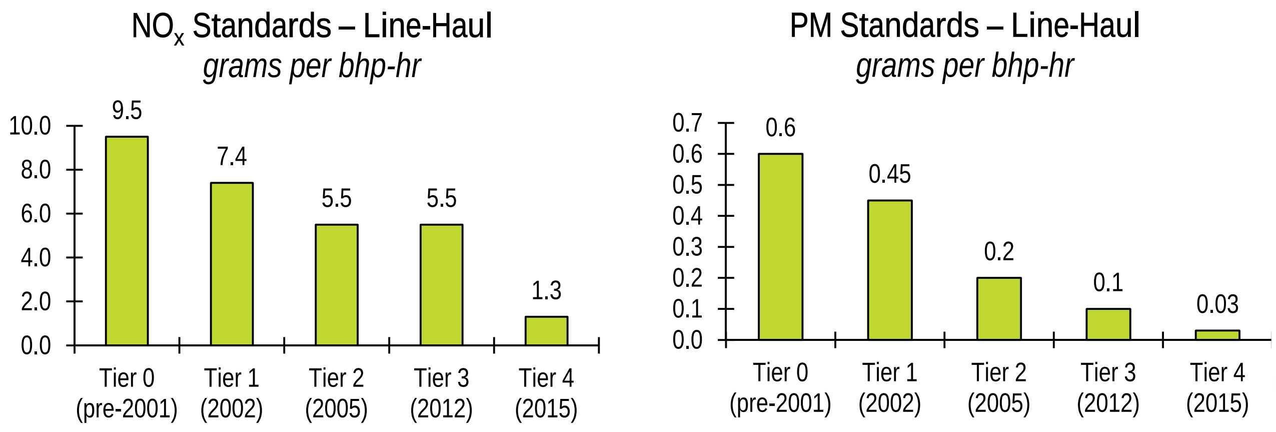
Table 5.4 Implementation Schedule for State Truck and Bus Rule

Lighter Trucks (14,000-26,000 Pounds GVW)		Heavier Trucks (Over 26,000 Pounds GVW)	
Engine Year	Replacement Date	Engine Year	Requirements
1995 and older	January 1, 2015	Pre-1994	No requirements until 2015, then 2010 engine
1996	January 1, 2016	1994-1995	No requirements until 2016, then 2010 engine
1997	January 1, 2017	1996-1999	PM filter from 2012 to 2010, then 2010 engine
1998	January 1, 2018	2000-2004	PM filter from 2012 to 2010, then 2010 engine
1999	January 1, 2019	2005-2006	PM filter from 2012 to 2010, then 2010 engine
2003 and older	January 1, 2020	2007-2009	No requirements until 2023, then 2010 engine
2004-2006	January 1, 2021	2010	Meets final requirements
2007-2009	January 1, 2023		

5.1.3 Locomotive Regulations

Like trucks, Federal emission standards apply to locomotives. In 1998, and amended in 2008, the U.S. EPA created several tier standards for locomotive engines. The standards apply to all newly manufactured and remanufactured locomotives used in line-haul, passenger, and switcher service within the United States. An exception applies to locomotives originally manufactured before 1973, which are not subject to emissions standards. For new locomotives, the Tier 2 standards took effect beginning in 2005. Tier 3 and Tier 4 standards take effect beginning in 2012 and 2015, respectively. The reduction required under Tier 4 emission standards are akin to the 2007/2010 heavy-duty truck standards and will likely necessitate the use of after-treatment technologies (e.g., diesel particulate filters and selective catalytic reduction) by locomotive manufacturers. Tier 3 locomotives are now available; Tier 4 locomotives are not likely to be available before 2015.

Figure 5.5 Emission Standards for Line-Haul Locomotives



In 1998, ARB developed a Memorandum of Understanding (MOU) with the two Class I railroads that operate in California, Union Pacific (UP) and Burlington Northern Santa Fe (BNSF). The MOU includes provisions for early introduction of clean locomotives, with requirements for a locomotive fleet average in the South Coast Air Basin equivalent to EPA's Tier 2 locomotive standard by 2010. The railroads have complied with this requirement.

ARB also signed a 2005 agreement with UP and BNSF that requires the railroads to significantly reduce diesel emissions in and around rail yards in California. Among the most important elements of the agreement include: 1) a statewide idling-reduction program; 2) health risk assessments for all major rail yards; 3) community and air district involvement in the preparation of risk assessments, enforcement of agreement provisions, and the evaluation and development of measures to further reduce impacts on local communities.

In 2010, ARB proposed further binding voluntary commitments to reduce diesel PM emissions at four rail yards: BNSF San Bernardino, BNSF Hobart, UP Commerce, and UP ICTF/Dolores. The agreement would set a maximum level of emissions starting in 2011 that could not be exceeded, regardless of the level of growth that occurs at the rail yards. Compared to the 2005 baseline, this agreement would require a 65-75 percent reduction in diesel PM emissions by 2015 and an 85 percent reduction by 2020. ARB currently is considering revisions to the 2010 commitments. These revisions would establish enforceable emission caps and other requirements, tracking mechanisms, and deadlines to further reduce harmful diesel PM through 2020.The revisions would not change the diesel PM emission caps for each rail yard.

5.1.4 Other Significant Regulations and Programs

Ocean Going Vessels At-Berth Auxiliary Engine Regulation. In 2007 ARB adopted regulations to reduce emissions from ocean going vehicles (OGV) while in port. The OGV At-Berth Regulation targets emissions from auxiliary OGV engines and mandates emissions reductions through the use of shore power or other control technologies to achieve the same level of reductions. The regulations apply to container ships, refrigerated cargo (reefer) ships, and cruise ships. The compliance thresholds for this regulation increase gradually between 2010 and 2020 to ease the retrofit burdens on fleet operators and terminals. Starting January 2010, all vessels with shore power capability must use shore power if it is available at berth. Starting in 2014, 50 percent of a ship fleet's port visits must use shore power, increasing to 70 percent in 2017 and 80 percent in 2020. As of the end of 2011, the Port of Los Angeles has 12 berths electrified, with 12 more to be done by 2014. Port of Long Beach had 4 berths electrified by the end of 2011, with another 20 berths scheduled to be electrified by 2014. Shore power currently is being supplied to approximately 30 percent of container ships at the Port of Los Angeles and 12 percent at the Port of Long Beach.

OGV Low-Sulfur Fuel Regulation. In 2008 ARB adopted regulations to limit emissions from OGVs within 24 nautical miles of the California coastline. These regulations require ship operators to switch from heavy fuel oil to marine distillate fuels when within California waters. In the first phase, which went into effect July 2009, OGVs must operate on marine gas oil with less than 1.5 percent sulfur or marine diesel oil with less than 0.5 percent sulfur. Starting January 2012 the Phase 2 standards call for ships to operate on marine gas oil or marine diesel oil with less than 0.1 percent sulfur. As a result of this regulation, PM emissions from OGVs along the California coastline are expected to fall dramatically. Under the Phase 2 standards, $PM_{2.5}$ emissions will be 83 percent lower than baseline levels. The regulation will have small NO_x benefits.

San Pedro Bay Ports Clean Air Action Plan (CAAP). In 2006, the Ports of Los Angeles and Long Beach enacted the Clean Air Action Plan to identify opportunities to reduce air pollution from port activities. The goal of the CAAP, renewed and updated in 2010, is to reduce NO_x emissions by 22 percent, SO_x by 93 percent, and diesel particulate matter (DPM) by 72 percent relative to 2005 emissions. In addition, the update adds a "health-risk reduction standard" with the aim to reduce DPM in neighboring residential communities by 85 percent by year 2020. The CAAP includes provisions for reducing emissions from all sources within the port or engaged in port activities, including heavy-duty vehicles (Clean Trucks Program), ocean-going vessels, cargo handling equipment, harbor craft, locomotives, and construction activities.

The emissions regulations described above for trucks, locomotives, and ships will go a long way toward reducing the environmental footprint of the goods movement sector. In 2035, NO_x and PM emissions from all Southern California goods movement will be less than half what it was in 2005. Yet the emission reductions will still not be sufficient to meet regional air quality standards, and air pollution "hot spots" will persist in locations of intensive goods movement activity. Advanced technologies will be needed to further reduce emissions from goods movement.

5.1.5 Low Emission Technologies for Trucks

To achieve significant emission reductions from heavy-duty trucks beyond those required under current emission standards will require deployment of advanced technologies that currently are not used on most trucks sold today. Four promising technologies are: advanced natural gas engines, hybrid-electric trucks, plug-in hybrid-electric trucks, and battery electric trucks. While these technologies are commercially available today in some capacity, their production volumes are small and they currently may be suitable only for niche applications.

- Advanced Natural Gas Technologies – Originally deployed in niche applications, heavy-duty natural gas vehicles (NGV) have the performance characteristics to be applied in a number of goods movement applications. The potential for heavy-duty NGVs in the regional-haul market is highlighted by the 700 natural gas trucks deployed at the San Pedro Bay Ports since 2009 as part of the Clean Trucks Program. As part of funding from the American Recovery and Reinvestment Act (ARRA) of 2009 approximately $150 million was awarded for 18 projects involving compressed natural gas (CNG) or liquefied natural gas (LNG), several of which are in the SCAG region. Local projects include drayage truck and LNG corridor initiatives operated by SCAQMD, and LNG truck deployment project operated by SANBAG.[2]

- Hybrid Truck Technologies – Hybrid trucks, including electric hybrids and hydraulic hybrids in various configurations, are a nascent but growing sector of the truck manufacturing industry. The market for hybrid trucks (and buses) has been accelerated significantly with the implementation of the Hybrid Truck and Bus Voucher Incentive Project (HVIP) in California, administered by ARB. The HVIP helped deploy more than 650 vehicles in the first year of the program (nearly 20 percent of the estimated hybrid truck population) with approximately $19 million in awards. While hybrid electric vehicles are considered viable for all goods movement applications, hydraulic hybrids are best suited to stop-and-start applications such as refuse haulers or delivery trucks.

- Plug-In Hybrid Technology – Plug-in hybrid technology advances the configuration of hybrid electric vehicles. In the case of plug-in technology, however, the battery is generally larger and the user can plug the vehicle in to draw energy from the grid. Initiatives from the California Energy Commission are funding projects to implement PHEV trucks in the pick-up and heavy-duty sectors. Plug-in hybrid electric vehicles are suitable for all goods movement applications. Due to operational requirements and battery technology, the most appropriate markets in the near term will be in the smaller heavy-duty vehicles (e.g., Class 3-5). If the cost and weight of batteries are reduced, then plug-in hybrid electric vehicles will transition to heavier vehicle classes (e.g., Class 6-8).

- Battery Electric Trucks – Battery electric vehicles replace the entire engine and drive train of a conventional vehicle with an electric motor and generator, powered by a battery pack. Battery electric trucks could run entirely on battery packs that are charged when the vehicle is plugged into the grid and via regenerative braking, or possibly using an on-board hydrogen fuel cell. In other options, these trucks could receive power from an external power source in the roadway, such as an overhead catenary system or through electromagnetic induction from a contact-less power system embedded in the roadway. Electric vehicles have a number of advantageous characteristics, including smoother operation due to the electric motor; lower maintenance costs due to fewer moving parts than a conventional combustion engine vehicle; potential for reduced operating costs depending on the price of electricity and the displaced fuel; and zero tailpipe emissions and reduced greenhouse gas emissions on a lifecycle basis. Currently, manufacturers such as Navistar are offering battery-electric trucks in the Class 3 LHDT and off-road yard hostler categories. Battery electric trucks are expected to improve as battery technology develops further.

More information on the emissions benefits and costs of these technology options is included in Sections 6.9 and 6.10.

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[2] For more information on these awards, see http://www.westcoastcorridors.org/projects_CC.html.

5.1.6 Low Emission Technologies for Locomotives[3]

New locomotive technologies include cleaner-burning locomotive engines, locomotives powered by multiple smaller engines (GenSets), and locomotive and infrastructure upgraded to new fuels, notably electrification. Benefits can be derived by replacing older units with cleaner units or remanufacturing older units to the standards of new locomotives. Technologies include:

- Tier 4 Line-Haul Locomotives – Beginning in 2015, new locomotives will be required to meet Tier 4 emissions standards, which reduce NO_x emissions by 76 percent and PM emissions by 70 percent compared to current Tier 3 standards. These locomotives, which rely on exhaust after treatment technologies and engine improvements to achieve the more stringent standards, currently are under development but not yet deployed. The U.S. EPA projects that by 2023, 34 percent of the nationwide Class I line-haul fleet will be Tier 4.

- Electrified Line-Haul Locomotives and Infrastructure – Railroad electrification would enable freight trains to be moved using electric rather than diesel locomotives, resulting in potentially large reductions in Southern California locomotive emissions. There are several technology options for electrification, including straight-electric locomotives with overhead catenary, dual-mode locomotives with overhead catenary, and a linear synchronous motor (LSM) system. Other technologies also are in development with the potential to replace diesel engines. Electrification would reduce locomotive emissions in two ways: first, by changing the power source to a cleaner-burning fuel, that is, switching from diesel fuel for a conventional locomotive to natural gas electrical generation; second, by shifting the location of the emissions to the power plant, which may or may not be located within the South Coast Air Basin. Chapter 6 provides a more detailed discussion of the status of rail electrification technologies, their relative strengths and weaknesses, and a detailed analysis of their potential applicability to the rail system in Southern California.

- Tier 4 Single-Engine-Locomotive Switchers – Switcher locomotives are often Tier 0 and pre-Tier 0 units that have been retired from line-haul operation. Rail yard emissions can be reduced by replacing these high-emission locomotives with Tier 4 switcher locomotives that rely on clean engines and exhaust after treatment to meet the most stringent EPA standards. Tier 4 switchers are scheduled to be introduced between 2015 and 2017. The costs of Tier 4 single-engine switcher locomotives have not been clearly established. The U.S. EPA estimates the cost of Tier 4 line-haul locomotives at $3 million each. While switcher locomotives have smaller engines and less power than line-hauls, the costs of each loco type are assumed to be comparable.

- GenSet Switchers – UP and BNSF currently operate 61 GenSet switchers within the South Coast Air Basin. GenSets are powered by a bank of three nonroad engines typically found in off-road heavy-duty equipment such as construction, mining, and cargo handling equipment. The U.S. EPA regulates nonroad engine emissions using a Tier structure more stringent than locomotive engine standards. Further, GenSets can achieve efficient operation at low loads by idling one or more engines, while single-engine locomotives are much less efficient at low speeds.

- Battery-Electric Locomotives – New technologies are being explored that would incorporate batteries into the design of a diesel-electric locomotive or use a battery "tender car" that would be connected to the locomotives to provide power to their electric motors. Batteries could be charged from electricity produced by the on-board diesel engines, or through regenerative breaking. While these technologies are not commercially available today, they appear to have good potential for technological feasibility.

[3] Two technical memoranda are provided in the appendices to this report which contain additional detail on low-emission locomotive options, Task 8.3 Analysis of Freight Rail Electrification in the SCAG Region (April, 2012), Cambridge Systematics and SCAG and Task 10.2 Evaluation of Environmental Mitigation Strategies (April, ,2012), ICF International and SCAG.

Climate Change Policy and GHG Emissions

The California legislature has enacted several policy tools to reduce the state's greenhouse gas (GHG) emissions. Foremost amongst these is the Global Warming Solutions Act of 2006 (AB 32), which establishes programs to reduce California's GHG emissions to 1990 levels by 2020. In developing a Scoping Plan to meet these goals, ARB has identified a suite of reduction measures targeted at transportation, energy, industry, agriculture, and other sectors. Specific to goods movement, measures include provisions for high-efficiency freight trucks.

The Low Carbon Fuel Standard (LCFS) was enacted by executive order S-1-07 and requires at least a 10 percent reduction of the carbon intensity of transportation fuels by 2020. The LCFS is identified as an early action item by ARB in AB 32. The standard is applied to fuels on a lifecycle basis, which includes upstream emissions from production, refining, transportation, and in-use (i.e., tailpipe) emissions.

Lastly, the Sustainable Communities and Climate Protection Act of 2008 (SB 375) creates a framework in which local agencies develop GHG mitigation plans to meet regional emissions targets. These "Sustainable Communities Strategy" plans focus broadly on transportation, land-use, and community development issues. However, SB 375 has little impact on goods movement, as it primarily targets emissions from passenger cars.

The major GHGs from transportation sources are carbon dioxide (CO_2), methane (CH4), and nitrous oxides (N_2O), with CO_2 accounting for roughly 95 percent of the global warming impact. The truck and locomotive emission regulations described above will have little effect on GHG emissions. Therefore, in contrast to NO_x and $PM_{2.5}$, CO_2 emissions from trucks and locomotives are projected to rise steadily in the future under a business-as-usual scenario. The technologies used by manufacturers to comply with NO_x and PM emission standards, such as diesel particulate filters and selective catalytic reduction, do not affect CO_2 emissions. Truck CO_2 emissions are projected to increase 57 percent by 2035, while locomotive CO_2 emissions will more than double. Note that Federal fuel economy and CO_2 emissions standards for heavy-duty trucks have just been established for the first time and will result in as much as a 20 percent reduction in GHG emissions per truck. The effects of these new standards on GHG emissions by vehicle type and calendar year are not clear at this point and therefore have not been incorporated into baseline estimates.

In spite of commitments to reducing GHG emissions both in California and around the world, emissions already have reached a level that will trigger irreversible changes to the climate. Although scientists are still working to forecast the localized effects of this global change, many of the resulting impacts stand to affect Southern California's goods movement. For example, sea levels are projected to rise by 31 to 69 inches by 2100 relative to the year 2000, depending on the rate of warming and speed at which glaciers melt.[4] Highway and rail assets located in coastal areas will be more susceptible to flooding, and may be permanently inundated in the long-term future. Goods movement by marine transport also may face changes in navigation, for example, around waterway bridges with reduced clearance given the rise in sea level and around channels with restricted accessibility given changes in sedimentation. Sea level rise also will increase the impacts of storm surge on coastal infrastructure, which could interrupt services that the goods movement sector depends on.

Warming will likely impair the integrity and accessibility of transportation infrastructure and the service of vehicle fleets, hindering the movement of goods. In California, temperature is projected to increase 1.8°F to 5.4°F by the mid-21st century, and by 3.6°F to 9°F by end of century.[5] Higher temperatures can soften road pavement or cause it to buckle; trains may need to reduce speed on steel rails to prevent buckling at higher temperatures, and roads and rails may require more frequent maintenance. Heat waves are expected to become as much as 20 times more frequent by the end of the 21st century than at the end of the 20th century. During prolonged periods of high temperatures, overheating and tire deterioration are

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4 Caltrans Climate Change Workgroup (2011). Guidance on Incorporating Sea Level Rise. California Department of Transportation. Available at: http://www.dot.ca.gov/hq/tpp/offices/orip/Updated_Climate_Change/Documents/Sea_Level_Guidance_May2011.pdf.

5 Cayan, D., M. Tyree, M. Dettinger, H. Hidalgo, T. Das, E. Maurer, P. Bromirski, N. Graham, and R. Flick (2009). *Climate Change Scenarios and Sea Level Rise Estimates for the California 2009 Climate Change Scenarios Assessment*. A paper from the California Climate Change Center. August 2009. CEC-500-2009-104-F.

likely to increase the frequency of vehicle breakdowns. More frequent heat waves may also pose worker health risks and interfere with construction activities.

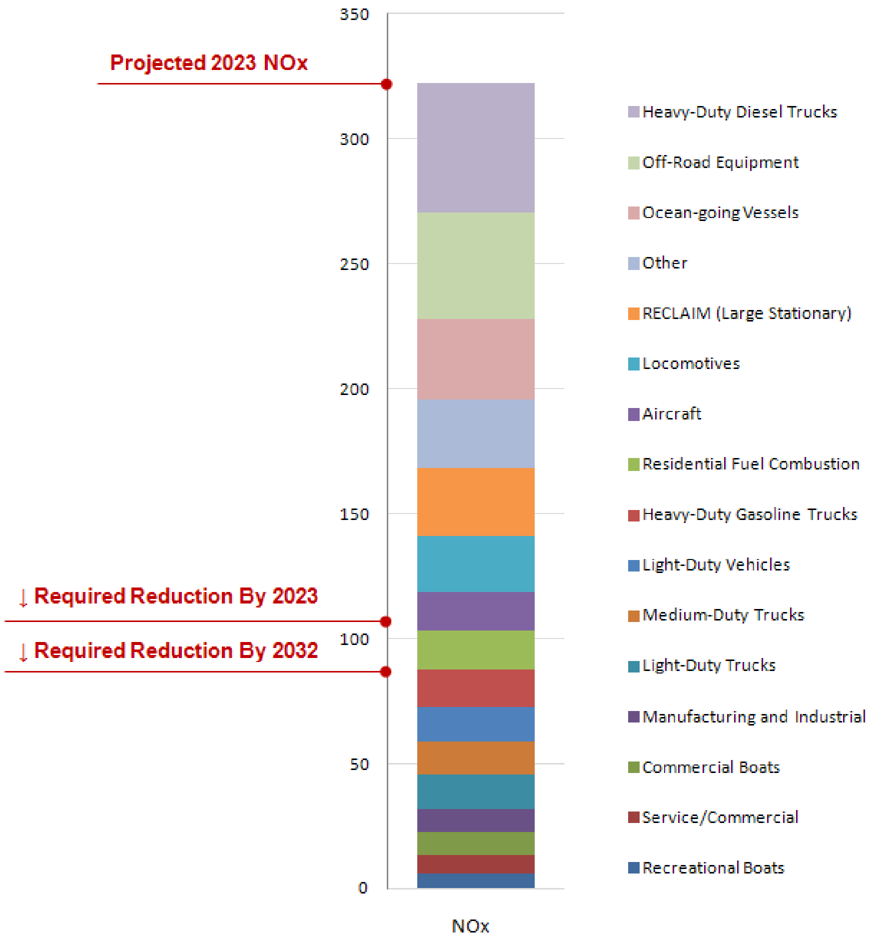
California is projected to face variable and highly uncertain precipitation in the future, which will likely result in both heavy rainfall events and droughts. Projections from climate models disagree on whether California will become wetter or drier under future changes in climate, but they generally predict that dry periods in between precipitation will become longer.[6] Droughts are likely to increase the risk of forest fires, causing closures of roads and rail and damages to transportation infrastructure. When they occur, heavy rainfall events are likely to cause flooding of roadways and railways, and in some cases, erosion or mudslides.

5.1.7 Gap Between Projected Emissions and Air Quality Attainment Goals

As discussed above, the NO_x and PM emission reductions that will accrue due to Federal and state regulations are significant. But they are not likely to be sufficient to meet regional air quality goals as stipulated in the Federal Clean Air Act. Preliminary estimates by South Coast Air Quality Management District (SCAQMD) suggest that the region's 2023 NO_x carrying capacity is approximately 120 tons per day (tpd) to meet the current Federal ozone standard. The two projected largest sources of NO_x emissions, heavy-duty vehicles and off-road equipment, are expected to emit more than 100 tpd together in 2023. When combined with ships and locomotives (more than 50 tpd together) and other sources such as aircraft and stationary engines, SCAQMD projects that 2023 NO_x emissions will far exceed the region's carrying capacity in 2023 without additional control measures.

[6] Cayan, D., M. Tyree, M. Dettinger, H. Hidalgo, T. Das, E. Maurer, P. Bromirski, N. Graham, and R. Flick (2009). *Climate Change Scenarios and Sea Level Rise Estimates for the California 2009 Climate Change Scenarios Assessment*. A paper from the California Climate Change Center. August 2009. CEC-500-2009-104-F.

Figure 5.6 **NO_x Reduction Targets and Projected Regional Totals** ***2023***[7]



Source *South Coast Air Quality Management District.*

5.2 Health Impacts

Air pollution contributes to serious adverse health effects and environmental effects. As discussed above, NO_x reacts with volatile organic compounds (VOC) to form ground-level ozone, commonly known as smog. Ground-level ozone can trigger a variety of health problems, including aggravated asthma, reduced lung capacity, and increased susceptibility to respiratory illnesses like pneumonia and bronchitis. People with respiratory problems are most vulnerable, but even healthy people who are active outdoors can be affected when ozone levels are high.

Many scientific studies have linked breathing PM to a series of significant health problems, including aggravated asthma, difficult breathing, chronic bronchitis, myocardial infarction (heart attacks), and premature death. Increases in particulate matter levels are associated with increased hospital admissions and emergency room visits for people with heart and lung

[7] Figure shows preliminary estimates of baseline NOX emissions in 2023 with benefit of adopted emission standards and programs, and emission reductions needed to attain 80 ppb and 75 ppb National Ambient Air Quality Standards for ozone (attainment required in 2023 and 2032, respectively).

disease, and increased work and school absenteeism. The size of particles is directly linked to their potential for causing health problems. Small particles pose the greatest problems because they can get deep into the lungs, and some may even get into the bloodstream.

Diesel particulate matter is of particular concern because it is widely believed to be a human carcinogen when inhaled. In addition to the U.S. EPA, a number of other agencies have identified the serious health effects of diesel exhaust.[8] SCAQMD's Multiple Air Toxics Exposure Study III (MATES-III) study found that 70 percent of the air pollution inhalation cancer risk in the region was caused by diesel particulate matter, most of which comes from goods movement sources.

5.3 Non-Air Environmental and Community Impacts

While air quality is the most significant environmental concern associated with goods movement, other impacts can also influence the health and quality of life of individuals near goods movement operations. These include noise impacts, vibration, light and other visual impacts, and land use impacts.

5.3.1 Noise Impacts

Excess noise can affect quality of life. Persistent excess noise can take a toll on mental health and cognitive functioning. At high levels, noise can become a more significant health risk. Hearing damage can occur when individuals are exposed to noise levels of 80 decibels (dB), which is approximately the noise level of heavy truck traffic.

Goods movement has significant noise impacts within the region. The primary sources are trucks, including freeway and idling, and locomotives, including line-haul and rail yards. Heavy trucks produce more sound than medium trucks and automobiles. Table 5.6 equates noise from heavy trucks to medium trucks and autos in terms of equivalent vehicles. For example, one heavy truck traveling at 35 mph produces a sound level equivalent to 19.1 automobiles. As speed increases, tire/pavement noise becomes predominant, which reduces the difference in noise level between trucks and automobiles. The sound produced by one truck traveling at 65 mph is equivalent to the sound of 8.9 automobiles.

Table 5.6 Number of Equivalent Automobiles a Function of Vehicle Type and Speed

	Number of Automobiles that Would Produce an Equivalent Noise Level as:	
Speed (mph)	1 Heavy Truck	1 Medium Truck
35	19.1	7.1
40	15.1	5.8
45	12.9	5.0
50	11.5	4.5
55	10.4	4.1
60	9.6	3.7
65	8.9	3.5
70	8.3	3.2

Source: Based on TNM Noise Emission Levels, Caltrans 2009.

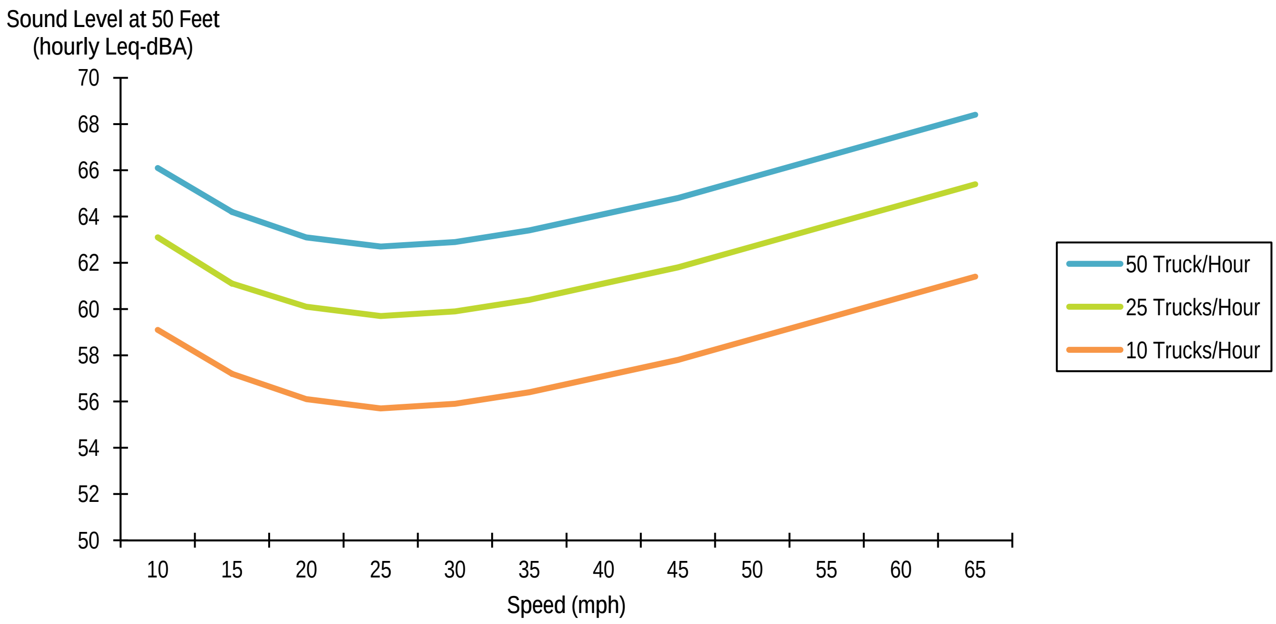
[8] These agencies include the National Institute for Occupational Safety and Health, the International Agency for Research on Cancer, the World Health Organization, California EPA, and the U.S. Department of Health and Human Services.

The extent to which truck movement can affect noise sensitive land uses is a function of many factors, including:

- The distance from the truck movement to the sensitive use, the number of trucks, and the speed of trucks;
- The context – the effect of trucks is more pronounced in a quiet rural setting versus a noisy urban setting; and
- The time of day – people are more sensitive to noise during nighttime hours.

Figure 5.6 shows the noise level generated by heavy trucks traveling at various speeds. This illustrates that, above 25 mph, higher trucks speeds cause higher noise levels. The figure also illustrates how an increase in truck volume will increase noise levels.

Figure 5.7 Truck Noise Levels as a Function of Speed

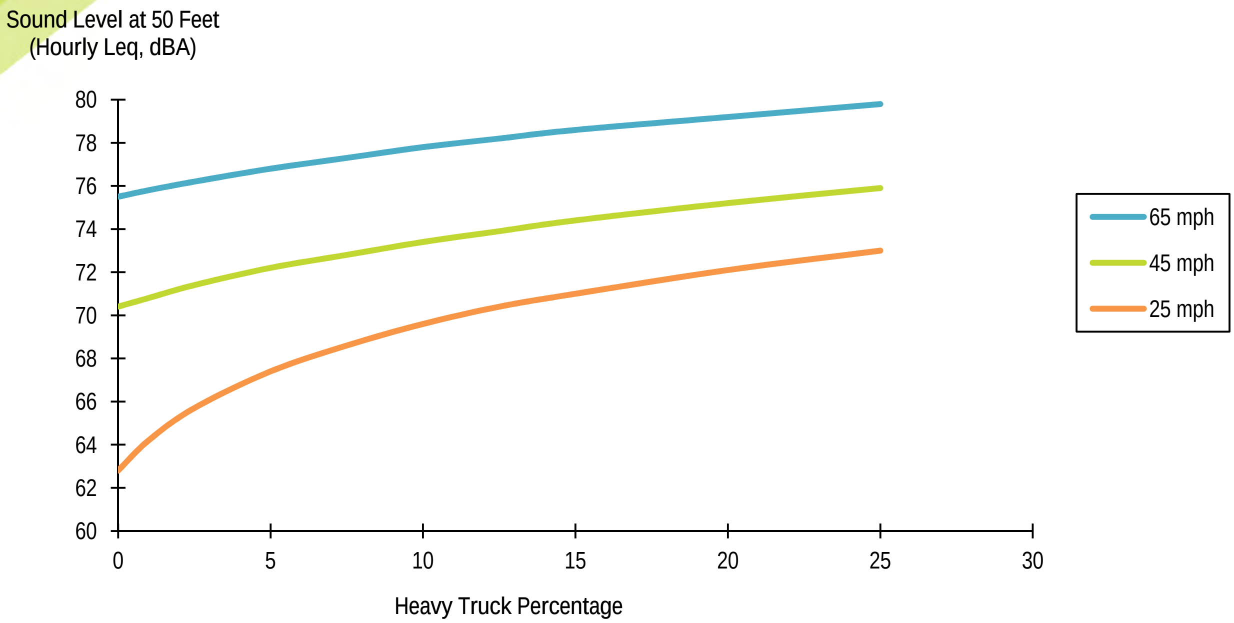


Source: Calculation using FHWA's Traffic Noise Model (TNM) version 2.5.

Assuming that absorptive ground such as grass is located between the roadway and a receiver, the rate of sound attenuation is about 4.5 dBA per doubling of distance. For example, Figure 5.6 indicates that the sound level of 50 trucks per hour traveling at 40 mph is 64 dBA at 50 feet. The sound level at 100 feet would be 59.5 dBA and the sound level at 200 feet would be 55 dBA.

Figure 5.7 shows how the percentage of heavy trucks influences overall traffic noise levels on a roadway with 2,000 vehicles per hour. Noise levels were calculated using FHWA's Traffic Noise Model (TNM) Version 2.5. As discussed above, the difference between the noise levels generated by automobiles and trucks is more pronounced at slower speeds. This is reflected in Figure 5.7, where the percentage of trucks has a greater influence on overall noise levels when traffic is traveling at slower speeds.

Figure 5.8 Effect of Heavy Truck Percentage on Traffic Noise Level



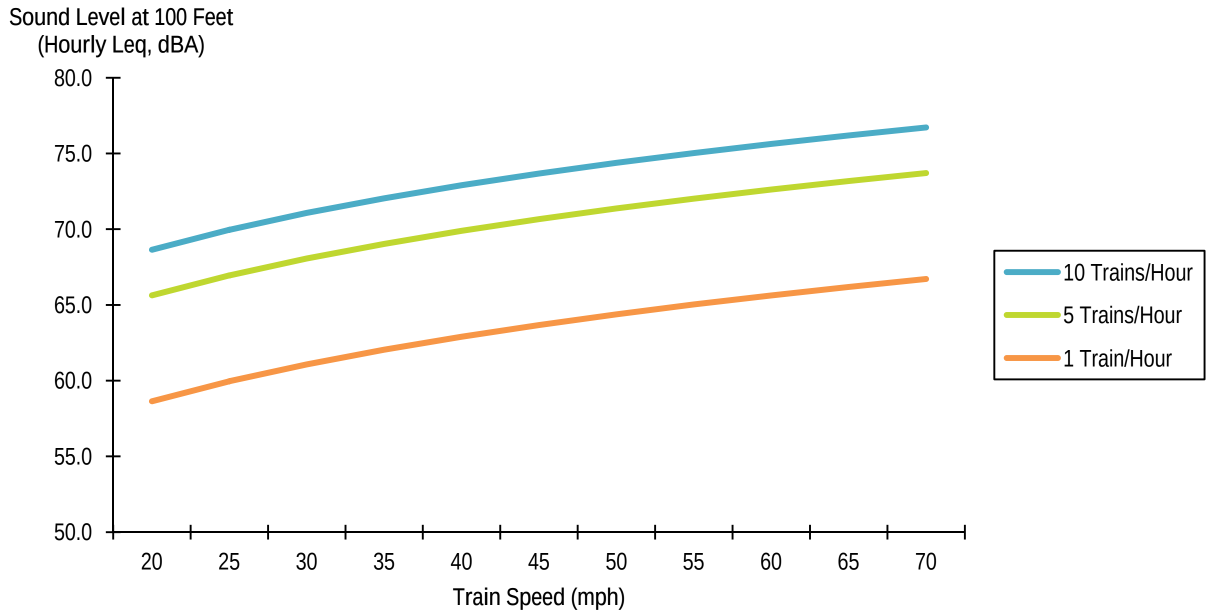
Source: Calculation using FHWA's Traffic Noise Model (TNM) version 2.5.

Similar to traffic on a highway, trains traveling on a track are considered to be a line source (i.e., from a linear rather than stationary location)[9] and sound attenuates at a rate of about 4.5 dB per doubling of distance. Figure 5.8 shows the noise level at 100 feet from the track produced by a freight train with two locomotives and 2,000 feet of cars. Noise levels were calculated using the Federal Railroad Administration's (FRA) Chicago Regional Environmental and Transportation Efficiency (CREATE) train noise model.[10]

[9] The source of the noise is assumed to be a line, as opposed to a single point.

[10] CREATE stands for Chicago Region Environmental and Transportation Efficiency Program. FRA developed a noise model for this program that has broad applicability.

Figure 5.9 Freight Train Noise Levels (FRA 2006)



Train horns are also a source of noise associated with trains. The extent to which trains and train yard activity can affect noise sensitive land uses is a function of many factors including:

- The distance from the trains or yard to the sensitive use, the number of trains, and the speed of trains;
- The context – the effect of trains is more pronounced in a quiet rural setting versus a noisy urban setting; and
- The time of day – people are more sensitive to noise during nighttime hours.

The data presented above indicates that there is potential for noise impacts to occur near train tracks and train yards. Strategies to mitigate noise impacts are discussed in Section 6.10.

5.3.2 Vibration Impacts

Ground vibration is an oscillatory motion of the soil particles with respect to the equilibrium position. Because trucks are supported on spring suspension and pneumatic tires, ground vibration is rarely an issue with truck movement. Exceptions to this occur when there is a significant discontinuity in the roadway surface. In this situation, a truck hitting the discontinuity can generate a ground vibration pulse that may be perceptible at nearby residences.

In contrast to trucks, moving freight trains can be a significant source of ground vibration. Although trains are supported on spring suspension, the high axle loads and steel-to-steel contact between the wheels and rails can result in significant energy being imparted into the ground. The speed of the train and the condition of the wheels and track are significant factors in the ground vibration that is generated. Freight trains can cause ground vibration that exceeds the 75 VdB impact threshold for infrequent events (less than 70 events per day) for residences within about 150 feet of a track.

Vibration generated by trucks and trains attenuates over distance similar to how sound attenuates with increasing distance from the source. In general, it is rare that transportation-related ground vibration results in building damage, and transportation-related vibration is not likely to cause adverse health effects. Strategies to mitigate vibration impacts are discussed in Section 6.10.

5.3.3 Light and Other Visual Impacts

A goods movement facility can have negative visual, or aesthetic, impacts if it degrades the existing scenic qualities or visual character of a site (e.g., if new infrastructure affects a scenic vista or blocks views of valued resources, such as trees, rock outcroppings, and historic buildings). These types of impacts are usually limited to rural areas or cases in which a new highway is being constructed. New railroad lines could have similar impacts. Freight trains with double-stacked container cars can reach a height of up to 20 feet, reducing views of scenic vistas.

Goods movement terminals, such as rail yards or distribution centers, can have visual impacts because of containers stacked on-site. Unlike ports and rail yards, which are limited to a select few locations, warehouses and distribution centers are scattered throughout Southern California (see Section 3.6), some in close proximity to residential areas. As a result, many communities may be affected by the visual impacts of these goods movement facilities. Truck routes, rail yards, and other goods movement facilities may also have aesthetic impacts when they create substantial light or glare, which could adversely affect day or nighttime views in the area.

The degree of aesthetic impact depends on the characteristics of the scenic landscape enjoyed by the adjacent community before construction, and the change after construction. A freeway project might have little aesthetic impact if it is built level with the terrain with appropriate landscaping, or it could have significant aesthetic impact if it is built with an elevated roadway or overpasses and lacks appropriate mitigation measures. There are, however, a number of mitigation strategies that can be applied to elevated roadways and overpasses and significant progress in developing these techniques have occurred in recent urban design. Strategies to reduce visual impacts are discussed in Section 6.10.

5.3.4 Land Use Issues

Encroachment is a broad term used to describe the conflicts caused when different land uses (such as a factory and a new housing development) are brought into close contact, and suffer negative impacts from each other's operations. Encroachment is a growing issue in the SCAG region, as increasing population and industrial activity both seek room to expand in an already densely populated urban region. In the SCAG region, encroachment has led to impacts to industry, SCAG residents, and the natural environment.

In certain areas, encroachment has brought incompatible land uses into close contact with each other. This means that residents may experience negative impacts of goods movement, such as air, noise, and light pollution impacts discussed above, as well as traffic and safety impacts. Given its wide distribution across the SCAG region, the expected growth in warehouse development, in particular, has the potential to lead to incompatible land uses and negative community impacts (see Section 4.6).

Encroachment can also limit the ability of vital industries and goods movement facilities to expand. For example, all four urban air carrier airports in Los Angeles and Orange Counties – LAX, Bob Hope, Long Beach, and John Wayne – are highly constrained and have little room to expand. This is due in part to encroachment by surrounding communities and to legal agreements and ordinances. The collective acreage of these four airports amounts to 5,540 acres, which is less than 17 percent of the 34,000 acres of Denver International and less than the 7,700 acres of Chicago O'Hare. When new or expanded goods movement facilities are proposed for areas of the region that already are developed, they must be designed in a context sensitive manner, employing multiple strategies to minimize air emissions, noise, and visual impacts.

Encroachment can also drive the conversion of goods movement land towards higher-value uses (such as residential). This is especially prevalent at the outer edges of the SCAG region, as population continues to expand. While this can minimize land use conflicts, the retreat of freight land uses from population centers could hinder economic development by reducing economic activity and weakening the region's economic diversity. It could also mean that goods movement sector jobs are pushed farther from potential workers for those jobs.

5.4 Summary of Critical Environmental Goals and Challenges

In summary, this section highlights both recent environmental progress and continuing environmental challenges for SCAG's goods movement system. Air quality has historically been the most pressing environmental issue for goods movement, contributing substantially to ozone and particulate matter air pollution problems that are among the nation's worst. Together, government regulation and industry investment are resulting in dramatic reductions in air emission from trucks, locomotives, ships, and cargo handling equipment. For example, the SCAG region heavy-duty truck NO_x and PM emissions in 2035 will be 50-70 percent lower than today, despite steady growth in VMT. NO_x and PM emissions from freight locomotives will be 20-60 percent lower than today.

Yet the need to protect public health and attain air quality standards demands even greater emissions reductions than those projected for the region. Federal air quality standards for ozone and particulate matter have been getting more stringent. Scientists have gained a better understanding of the adverse health effects of air pollution, particularly diesel particulate matter, which has focused attention on locations of intensive goods movement activity such as ports, rail yards, warehouses, and highways.

The threat of global climate change adds another challenge for goods movement. Many of the measures that were used in the past to control NO_x and PM emissions have little or no effect on CO_2, the most important greenhouse gas. By 2035, truck CO_2 emissions are projected to be 57 percent higher than today and freight train CO_2 emissions will more than double.

Other environmental effects of goods movement – noise, vibration, visual impacts – are expected to persist as freight activity grows in a densely populated metro area. While the impacts of incompatible land uses can potentially be avoided in locations of new development on the urban edge, new or expanded goods movement facilities in developed area will need to rely on a variety of strategies to minimize conflicts.

Solving the complex and interrelated environmental issues surrounding goods movement will require new approaches and advanced technologies. It will require that new highway and rail projects incorporate sophisticated environmental mitigation strategies, and that the public agencies and freight industry work cooperatively to build and operate a goods movement system that is both efficient and clean. Section 6 discusses how each element of the Regional Goods Movement Plan addresses the environmental concerns raised in this section.