Mitigating Diesel Truck Impacts in Environmental Justice Communities

Transportation Planning and Air Quality in Barrio Logan, San Diego, California

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This paper describes a series of sequentially implemented policies to mitigate local diesel truck impacts resulting from goods movement activity at two port facilities and simultaneously to improve traffic operations in the communities of Barrio Logan in San Diego, California, and Old Town in National City, California, both low-income communities of color. The paper provides the first comprehensive documentation of the unique process and solutions that emerged following the collaboration of all major stakeholders. Local impacts in Barrio Logan comprised air pollution, noise, and decreased pedestrian safety, while traffic operations in both communities were affected by congestion on the main freeway access, interchanges with insufficient capacity, and heavily mixed land uses both within and adjacent to the communities. These issues provided the impetus for the mitigation effort, the final implementation of which involved a permanent rerouting of all trucks weighing more than 5 tons to roads external to the community. Previous assessments of the project have described the extent to which mitigation strategies are expected to improve traffic operations or have assumed air quality improvements without carrying out an air quality analysis. A local-scale analysis of diesel particulate matter (DPM) emissions in Barrio Logan is given. The results show that while the mitigation did not result in improved regional air quality, it did significantly improve air quality in the primary affected corridor and resulted in a 99% reduction in DPM emissions and an 87% reduction in diesel truck vehicle miles traveled.

Barrio Logan is a neighborhood of San Diego, California, and is recognized by government agencies as an "environmental justice" community or a "[community] of color and low-income . . . faced with a disproportionate share of unwanted land uses and disparities in environmental protection" (*1*). According to the 2000 U.S. Census (Census Tract 50, San Diego County), 91% of Barrio Logan residents are Hispanic or Latino, and 37% of residents live below the census-defined poverty threshold (*2*). The community's land use patterns mix residential, commercial, industrial, and military uses in close proximity (*1, 3*). The Tenth Avenue Marine Terminal (TAMT), operated by the Unified Port of San Diego (the port), is located adjacent to Barrio Logan and is one of two port facilities in the study area. The National City Marine Terminal (NCMT) is located 4 mi south of TAMT and is adjacent to the Old Town neighborhood in National City, California, which exhibits demographics similar to those of Barrio Logan (*4*). The 2000 U.S. Census (average of Block Group 2 from Census Tract 114 and Block Group 1 from Census Tract 115, San Diego County) indicates that Old Town residents are 85% Hispanic or Latino, with 37% of residents living below the census-defined poverty threshold (*2*). Together, the two marine terminals represent the fifth-largest port in California in terms of total tonnage handled (*5*) and are the most important local generators of diesel truck traffic. The communities, marine terminals, and other key facilities that make up San Diego's "working waterfront" are shown in Figure 1.

While small in comparison with the nearby ports of Long Beach and Los Angeles (the largest and second-largest in California in terms of total tonnage, respectively), maritime shipping at the TAMT and the NCMT has a substantial and growing regional economic impact (*6*). In 2006, 2.8 million tons (2.5 Mt) of foreign cargo and 0.5 million tons (0.4 Mt) of domestic cargo moved through the marine terminals (*5*), representing a 13.6% annual growth rate since fiscal year 2002–2003, with strong growth projected into the future (*6*). The terminals fill a niche not met by California's larger ports, primarily handling noncontainerized goods including automobiles, break bulk fruit, steel, lumber, fertilizer, dry bulk cargoes such as sand and cement, and petroleum products. The port's growth, both current and projected, and the disproportionate impacts that vulnerable communities will experience as a result have spurred great interest in the mitigation of local air quality impacts and in the improvement of local traffic operations.

Specific community concerns have focused on diesel truck impacts generated primarily by the TAMT, including air pollution, noise, and decreased pedestrian safety from both through traffic and parked and idling vehicles on local streets in Barrio Logan. Old Town does not experience the same local truck impacts because of its location in relation to the NCMT and freeway access routes. For this reason, the discussion of community responses and mitigation focuses on Barrio Logan; however, the proposed mitigations ultimately apply to the entire working waterfront and will benefit Old Town residents by virtue of improved traffic operations.

Similar truck-related traffic impacts have been reported in the vicinity of the Ports of New York and New Jersey (*7*) and Los Angeles and Long Beach (*8*). The health risks of goods movement–related air pollution are well documented and disproportionately distributed (*9*). In Los Angeles County, for example, approximately 70% of excess cancer risk has been associated with diesel particulate matter (DPM) centered on the Ports of Long Beach and Los Angeles (*10*), which

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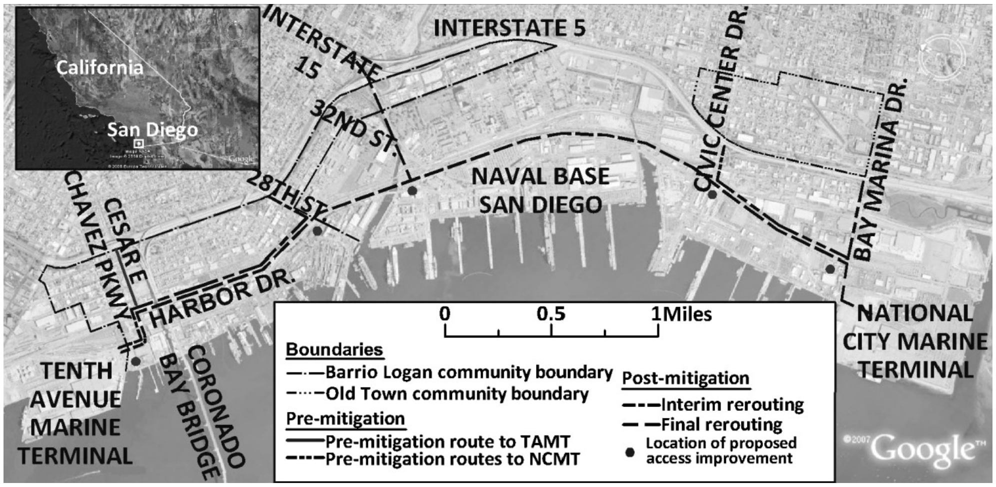

FIGURE 1 San Diego coastal study area—the "working waterfront"—including community boundaries, key facilities, pre- and postmitigation truck routes, and locations of proposed access improvements.

include highly populated areas of mostly low-income and minority citizens (*8*), raising important environmental justice concerns.

This paper documents mitigation efforts that focused on traffic operational improvements and resulted in improved local air quality. It begins by outlining the political and planning process that led to three sequentially implemented traffic operational improvements designed to mitigate local impacts originating from diesel trucks. The final two improvements were expected to smooth and reroute truck traffic in the affected communities. Although air quality benefits are frequently cited in the discussion of the project (*11–13*), no quantitative analysis has yet been completed. The second part of this paper describes an air quality analysis to determine the extent of localized benefits to Barrio Logan and thus the effectiveness of the mitigation strategies. The results show that while emissions were reduced near sensitive receptors, absolute (regional) emissions increased because improvements to local traffic flow did not offset increased truck travel distances. The conclusion poses some questions for regulators about the dilemmas associated with trading off local for regional impacts.

STUDY AREA

The study area is illustrated in Figure 1. The air quality analysis focuses on traffic improvements in Barrio Logan. Its study area is coterminous with that of the Barrio Logan Truck Study (*11*) (BLTS) and is shown in Figure 2. The City of San Diego commissioned the BLTS to forecast level of service changes under truck rerouting scenarios;

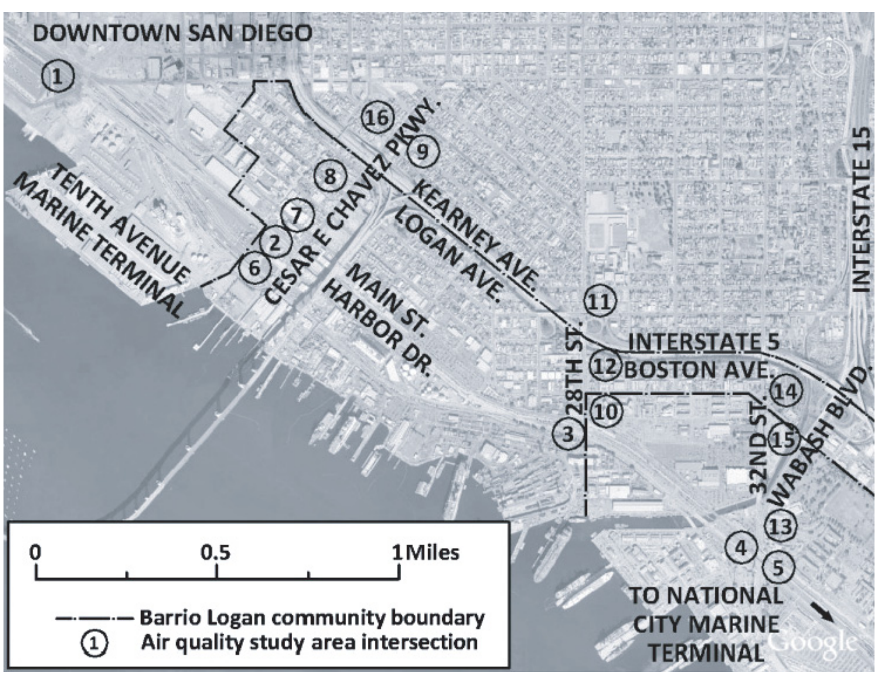

FIGURE 2 Air quality study area.

however, BLTS findings were based on assumptions that differed from the truck rerouting program actually implemented. Notwithstanding these differences, the BLTS's reported 2004 truck traffic counts and intersection delays were used below because they originated from field measurements. The BLTS links were cross-referenced with those from the regional travel demand model maintained by the San Diego Association of Governments (SANDAG). The travel network affected by the mitigation efforts included 26 roadway segments covering 4.4 mi (7.1 km) in Barrio Logan (*14*). Main Street was included in the BLTS but is not represented in the network because its traffic volumes were expected to remain unchanged as a result of the mitigation.

COLLABORATIVE PLANNING PROCESS IN CONTEXT

Sources of Information

Telephone and in-person interviews were conducted with key stakeholders between April 2007 and May 2008 to collect information on the planning process, the results of which had not previously been comprehensively documented. The interviews revealed specific details of the mitigation effort that facilitated the air quality analysis. This effort was separate from the actual planning process and did not affect its outcomes.

Interviewees were identified by using a "snowball" method, under which each respondent was asked to identify others who might have additional knowledge of the project. This led to the rapid identification of a core group of informants who functioned as ongoing sources of information. In total, five telephone interviews were conducted with five stakeholders, and additional in-person interviews were conducted with two of the same individuals. Participants included representatives from the City of San Diego, SANDAG, the port, the California Department of Transportation (Caltrans), and the Environmental Health Coalition (EHC). A number of other individuals, many at the same core agencies, provided specialized knowledge or data. Information was also assembled from public reports, newsletters, and press releases.

Planning Process Results: Reroute Trucks Around Barrio Logan

Before the mitigation effort, trucks traveling to and from the TAMT primarily used Cesar E. Chavez Parkway (Figure 1). The sensitive receptors along this street—residences and schools—were of concern to Barrio Logan residents.

SANDAG conducted the *Central Interstate 5 Corridor Study* (*15*) in 2003. It concluded that the port's operations resulted in frequent congestion on the main freeway access, Interstate 5 (I-5), because of low-capacity interchanges with poor heavy-vehicle access and at-grade trolley and train crossings located at the most direct access and egress routes. SANDAG also investigated several capital projects that would mitigate these impacts, tentatively including them in the April 2003 regional transportation plan (RTP) pending the study of alternative alignments and minimization of community impacts (*16*). The favored and most capital-intensive project involved the construction of a new viaduct from I-5 directly to Harbor Drive, north of the TAMT.

While this plan enjoyed the support of the involved agencies, community residents resisted construction of an additional overhead span in Barrio Logan (*17*). Two structures completed in the 1960s—the Coronado Bay Bridge (1969) and I-5 (1963) (see Figure 1)—have been viewed by residents as unjustly separating the community (*18*). The Coronado Bay Bridge in particular has been a catalyst for activism, beginning with the establishment of Chicano Park on the land under the bridge's supports in the early 1970s (*18*, *19*). Previously promised a community park by the City of San Diego and the State of California, Barrio Logan residents were outraged when the California Highway Patrol began constructing a new substation on the land in April 1970 (*18*). Supporters occupied the site for 12 days, after which the City of San Diego announced that a land exchange was to be negotiated with the state (*19*). Approximately 1 year later, and after substantial negotiations, Chicano Park was established. The community was therefore able to substantiate its opposition to an additional structure by pointing to its previously demonstrated ability to organize against unwelcome projects.

At this point (mid-2003), an impasse existed between the community and port-related and planning stakeholders. The community wanted solutions that would not inequitably burden residents and would remove trucks from Cesar E. Chavez Parkway. The port, its tenants, and the transportation planning agencies sought alternatives that would improve traffic operations. An important event helped to move the process forward. In March 2004, the port formed the Marine Terminal Community Committee (MTCC), a venue for conflict resolution and consensus building among the stakeholders (*20*). The committee successfully applied for a $250,000 Caltrans partnership grant in fiscal year 2005–2006 to study alternative approaches for mitigating local truck impacts. Stakeholders represented on the MTCC included community residents, the City of San Diego, the port, SANDAG, port-related businesses and truckers, local environmental justice organizations, and other community groups. The committee, which was still functioning as of late 2008, provided an ongoing forum for solving problems related to truck volumes, safety, health risks, job opportunities, and related issues (*20*).

The formation of the MTCC formalized a dialogue already under way between the agencies and the community; this dialogue initially resulted in a successful parking-related mitigation. Some parking spaces were changed from parallel to angle; "No Parking" red curbing and signage were added; and enforcement was improved for all parking regulations in the community (*21*). Together, these improvements, completed in February 2004 (*21*), helped reduce or eliminate truck idling in the community.

The MTCC's most important action as of late 2008 was the development of a consensus on mitigating impacts from truck flows. Two rerouting measures were identified for sequential implementation:

1. Interim rerouting (completed as of 2007). This was a two-part measure, with the first part redirecting trucks leaving the TAMT to the 28th Street interchange at I-5 by requiring a right turn out of the terminal; it was completed in April 2007. The configuration of the interchange at that time was unable to accommodate trucks heading to the TAMT. This was addressed by the second part, which widened the interchange to facilitate truck access in both directions. Associated improvements included the installation of signage directing trucks weighing more than 5 tons to the 28th Street access and prohibiting them from traveling on residential streets, as well as capacity improvements along surrounding roads that included the addition of turning pockets and traffic signals. All trucks of more than 5 tons, not only those destined for the TAMT, were also prohibited from Cesar E. Chavez Parkway. The second part was completed in August 2007 (*22*).
2. Final rerouting (scheduled for completion by April 2016). Once the final rerouting measure is completed, the 32nd Street interchange

at I-15 will be reconstructed to facilitate its use as the primary goods movement corridor in the area. The plan assumes that all trucks weighing more than 5 tons will use 32nd Street for access (i.e., trucks of more than 5 tons will be prohibited from Cesar E. Chavez Parkway and 28th Street). While the TAMT is the single most important destination for trucks on Cesar E. Chavez Parkway, nonport destinations account for 55% of total trips on that street (*11*), so their inclusion is substantial from the perspective of impact mitigation. Trucks with nonport destinations are performing local deliveries or serving other waterfront industry.

Both the pre- and postmitigation truck routes are shown in Figure 1. The final rerouting was elaborated in the *Freeway Access Study* conducted in October 2007 by Boyle Engineering under the direction of the port (*12*). That study included recommendations for infrastructure improvements to five access points along I-5 in the vicinity of the working waterfront (see Figure 1 for locations) to enhance the attractiveness of the final route by eliminating or reducing rail conflicts, which benefits not only freight access but local circulation as well. The mitigation policies met the objectives of the stakeholders by moving most trucks as far as feasible from Barrio Logan and Old Town, while vastly improving port access.

Previous project assessments focused on the extent to which traffic operations were expected to improve (*11, 12*) or assumed air quality improvements without carrying out a detailed modeling exercise (*13*). A possible explanation for the absence of an air quality analysis is that air quality benefits associated with the project would be highly localized in nature and would not necessarily representing regional-scale emissions reductions. Rerouting shifts the emissions spatially away from more densely populated areas, reducing per capita exposure to diesel truck traffic and thus DPM. In the next section a local-scale analysis of DPM emissions is given.

AIR QUALITY ANALYSIS

To estimate the air quality effects of the improvements, the mitigation measures were separated according to the stage in which they were to be implemented. Lack of data prevented the inclusion of the parking-related mitigation, so the three scenarios studied represented a baseline of no mitigation along with the interim and final rerouting. This analysis considers only the infrastructure in Barrio Logan as of 2004. The access improvements proposed by Boyle Engineering (*12*) to support the final rerouting are not included.

Estimating mobile source pollutant emissions requires data on both activity (e.g., speed and distance traveled) and emissions factors (e.g., g/mi) (*23*), which vary nonlinearly with speed (*24*). A variety of sources were used to prepare the requisite data for this analysis. Truck fractions for 2004 were taken from the BLTS, and the average daily traffic and peak-period hourly traffic volumes (all vehicle types) and capacities were taken from the regional travel demand model for 2003 (the closest year to 2004 for which data were available). These were assumed to be representative of 2004 traffic volumes (*14*). Idling and running exhaust emissions factors for the 2004 truck fleet in San Diego County were obtained by using EMFAC2007 v2.3 (*25*), based on the annual average values for temperature (67°F, 19°C) and relative humidity (62%) in San Diego County.

Two factors supported the use of a 2004 analysis year. First, 2004 was the only year for which detailed truck traffic counts were available. Moving to a different analysis year would have required an assumption that truck demand was constant or an estimation of some future increase over time. Second, the extent to which future-year forecasts included the various mitigation strategies was unclear. For example, the 2020 and 2030 forecasts from the regional travel demand model included links representing the defunct viaduct option rejected from the 2003 RTP. Fixing the analysis year to 2004 ensured a consistent baseline among the various sources of data. That is, the three scenarios all assume constant 2004 traffic volumes and emissions factors. In one case, to illustrate the effect of fleet turnover, emissions factors were allowed to vary by the expected year of implementation, while demand (and thus speeds) was held constant at 2004 levels. The following three subsections describe the data and methods used for the analysis.

Traffic Volumes

An illustration of the rerouting procedure is shown in Table 1, which provides the directional average daily traffic volumes for 2004 under three scenarios: baseline, interim, and final. Percentage changes from the baseline to the rerouting scenarios are also shown. To calculate the changes, links on which truck traffic was to be prohibited were identified. The sum of the truck fraction exceeding 5 tons on each of those was multiplied by the average daily volume to obtain the absolute volume of rerouted vehicles. Average daily volumes on the prohibited links were reduced by subtracting the number of rerouted vehicles, and the displaced volumes were simply added to the new routes.

The effects of the rerouting are clear—average daily traffic volumes on Cesar E. Chavez Parkway on all links north of Harbor Drive and south of Logan Avenue decrease by between 10% and 11% in both directions under both rerouting scenarios. These declines are entirely due to removing all trucks of more than 5 tons from those links. Similar reductions are observed along Kearney Avenue.

Emissions Factors

EMFAC2007 provides emissions factors for four types of heavy trucks specified by weight [two classes for light-heavy duty as well as medium- and heavy-heavy duty (LHDT, MHDT, and HHDT, respectively)]. However, the truck traffic counts for 2004 from the BLTS were categorized by the FHWA classification Scheme F (*26*), which does not use weight categories but is instead based on axle counts and spacing. Weight ranges within each class are known to vary widely (*27*). The BLTS data provided a project-specific distribution of heavy (FHWA Class 6 and above) and total (FHWA Class 5 and above) trucks. Since Class 6 and above emissions factors are much higher than those for Class 5, the BLTS distribution was preserved by mapping the Scheme F categories into weight classes by using data from Miller et al. (*27*), who discretized the Environmental Protection Agency's MOBILE6 heavy-duty truck classes by Scheme F category.

FHWA Vehicle Class	*Description*	*Weight class (lb)*	*EMFAC Vehicle Class*
5	Light-heavy-duty	8,501–10,000	LHDT1
5	Light-heavy-duty	10,001–14,000	LHDT2
5	Medium-heavy-duty	14,001–33,000	MHDT
6–13	Heavy-heavy-duty	33,001–60,000	HHDT

FHWA Class 6 and above maps to the EMFAC HHDT class one-to-one. The EMFAC default truck distribution by vehicle miles traveled (VMT) for San Diego County was used to determine the

TABLE 1 Baseline, Interim, and Final Directional Average Daily Traffic Volumes, 2004, All Vehicle Types

		Northbound–Eastbound			Southbound–Westbound		
ID[a]	Road (in bold) and Segment	Baseline Absolute	Interim[b] %	Final[b] %	Baseline Absolute	Interim[b] %	Final[b] %
	Harbor Dr.						
1	West of 8th Ave.	7,000	0	0	8,200	0	0
2	West of Cesar E. Chavez Pkwy.	7,900	1	1	5,800	2	2
3	West of 28th St.	6,200	15	15	4,700	15	15
4	West of 32nd St.	10,000	1	7	8,900	0	9
5	East of 32nd St.	9,100	1	1	10,600	0	0
	Cesar E. Chavez Pkwy.						
6	South of Harbor Dr.	1,700	0	0	1,600	0	0
7	North of Harbor Dr.	4,900	–10	–10	4,200	–10	–10
8	South of Logan Ave.[c]	8,500	–11	–11	6,800	–11	–11
9	North of Kearney Ave.	4,600	–6	–6	3,600	–6	–6
	28th St.						
10	North of Harbor Dr.	7,500	12[d]	–3[e]	8,900	8[f]	–3[e]
11	North of National Ave.	5,000	0	–4[e]	4,600	0	–4[e]
	Boston Ave.						
12	East of 28th St.	7,600	6	–5	800	0	0
	32nd St.						
13	North of Harbor Dr.[g]	10,300	0	11	10,200	0	9
	Main St.						
14	West of 32nd St.	6,100	0	0	6,600	0	0
	Wabash Blvd.						
15	North of 32nd St.[g]	6,600	0	17	4,900	0	20
	Kearney Ave.						
16	West of Cesar E. Chavez Pkwy.	[h]	[h]	[h]	3,700	–10	–10

[a]The number in this column corresponds to the intersection number shown in Figure 2.
[b]Percent changes in traffic volumes following implementation of mitigation, relative to the baseline volumes.
[c]The basis for the interim rerouted volumes because any trucks located north of Harbor Drive heading in either direction would likely have been counted south of Logan Avenue.
[d]Twelve percent increase in average daily traffic northbound on 28th Street equal to the rerouted volume north of Logan Avenue (900 vehicles per day).
[e]Under the final phase rerouting, traffic is eliminated from 28th Street.
[f]Eight percent increase in average daily traffic southbound on 28th Street equal to the rerouted volume south of Logan Avenue (720 vehicles per day).
[g]Primary links carrying the final rerouted trucks to I-15.
[h]Kearney Ave. is a one-way street.

distribution of FHWA Class 5 trucks. Finally, a weighted average emissions factor at the link level (g DPM/diesel truck VMT) was calculated (Equation 1):

$$\mathrm{EF}_l = \sum_{i=1}^{4} \mathrm{EF}_i \times \mathrm{vmtTF}_{i,l} \quad (1)$$

where

EF_l = weighted average emissions factor on link l (g DPM/diesel truck VMT),
i = EMFAC vehicle class (1 = LHDT1, 2 = LHDT2, 3 = MHDT, 4 = HHDT),
EF_i = DPM emissions factor of each vehicle class at the link travel speed (g/mi), and
$\mathrm{vmtTF}_{i,l}$ = travel fraction by VMT of class i relative to all four truck classes on link l.

Speeds

The average daily volumes in Table 1 are useful from a planning perspective because the City of San Diego's *Traffic Impact Study Manual* (*28*) defines its project level of service criteria based on change in that volume. The determination of travel speeds, however, required the use of hourly flows and was complicated by the study area being punctuated by signalized intersections. Idling and running exhaust emissions were separated, and midblock travel speeds were calculated without considering intersection delay.

Idling delay in seconds was determined from the BLTS for each study intersection and was assumed to remain constant between the base case and mitigation scenarios. Although this assumption is not strictly true, because the interim rerouting included the addition of several traffic signals, idling emissions were determined to be an order of magnitude less than running emissions. Therefore, this assumption will not substantially alter the final results.

Running speeds were calculated with a speed postprocessing (SPP) method as described by Bai et al. (*29*). SPP uses volume data from travel demand models combined with a speed–volume function. An appropriate speed postprocessor for modeling speeds on arterials without considering the influence of signalized intersections is that proposed by Dowling and Skabardonis (*30*), which does not distinguish between freeway and arterial segments. On the assumption that no queues form because of oversaturation, the midlink travel speed was obtained by using Equation 2:

$$u = \frac{u_0}{1 + \left(\frac{v}{c}\right)^{10}} \quad (2)$$

where

u = postprocessed speed,
u_0 = free-flow speed (approximated by the posted speed limit), and
v/c = volume-to-capacity ratio at midlink given for the peak-period flows (covering 1 h).

Volume was determined for the rerouting scenario by applying the percentage changes from Table 1 to the a.m. and p.m. peak-period volumes from the regional travel demand model to obtain changes in vehicles per hour. Because traffic is not uniformly spread throughout the day, the rerouted peak-period volumes were checked for consistency by using the same procedure applied to the average daily volumes. Capacity was taken from the regional travel demand model for the roadway segment. On the assumption that the calculated speed remained constant over the entire traveling roadway segment, DPM emissions were estimated.

Emissions Results

Figure 3 shows 24-h DPM emissions for each of the key streets in the study area—Cesar E. Chavez Parkway, 28th Street, and 32nd Street—and the total emissions on all study links. As previously noted, the first four sets of bars use 2004 emissions factors, traffic volumes, and speeds. The last set uses year-specific emissions factors (corresponding to the implementation year), while holding volumes and speeds constant at the 2004 level. The 24-h volume is simply scaled up from the a.m. and p.m. peak-period emissions based on 9% of diesel truck VMT occurring during those two peak hours, using the EMFAC default temporal traffic distribution for San Diego County. To the extent that speeds are lower during peak periods than during the rest of the day, modeled and actual emissions differ. Analysis results showed that free-flow speeds were not substantially different from the peak-period speeds along the vast majority of links, validating the use of a scaling factor.

The results for streets along which truck traffic is prohibited are dramatic. Daily DPM emissions drop by 99% on Cesar E. Chavez Parkway under the interim and final rerouting. In addition, diesel truck VMT is reduced by 87% along the same street (not shown). Clearly, to the extent that the rerouting is enforced, a substantial benefit will be derived by residents of Cesar E. Chavez Parkway, indicating that a primary community goal concerning truck traffic will have been addressed.

However, total DPM emissions on all study links grow by 90% between the baseline and the final rerouting based on constant 2004 emissions factors, because of the increased, rerouted truck travel distance. This growth is also a function of the number of links included in the analysis. Had all links in San Diego been analyzed, the increase in DPM emissions would have been substantially reduced because traffic would have been unchanged on many links. Indeed, although the results show an increase in study area DPM, total San Diego County emissions of DPM in 2004 were approximately 4.2 tons/day (3.8 Mg/day) (*31*). Because the differences in total emissions shown in Figure 3 are on the order of thousands of grams per day (1,000 g equals 2.2 lb), the increase in county-level emissions caused by the rerouting is small. However, it is clear that improvements in community-wide travel speeds did not offset emissions increases from increased truck mileage.

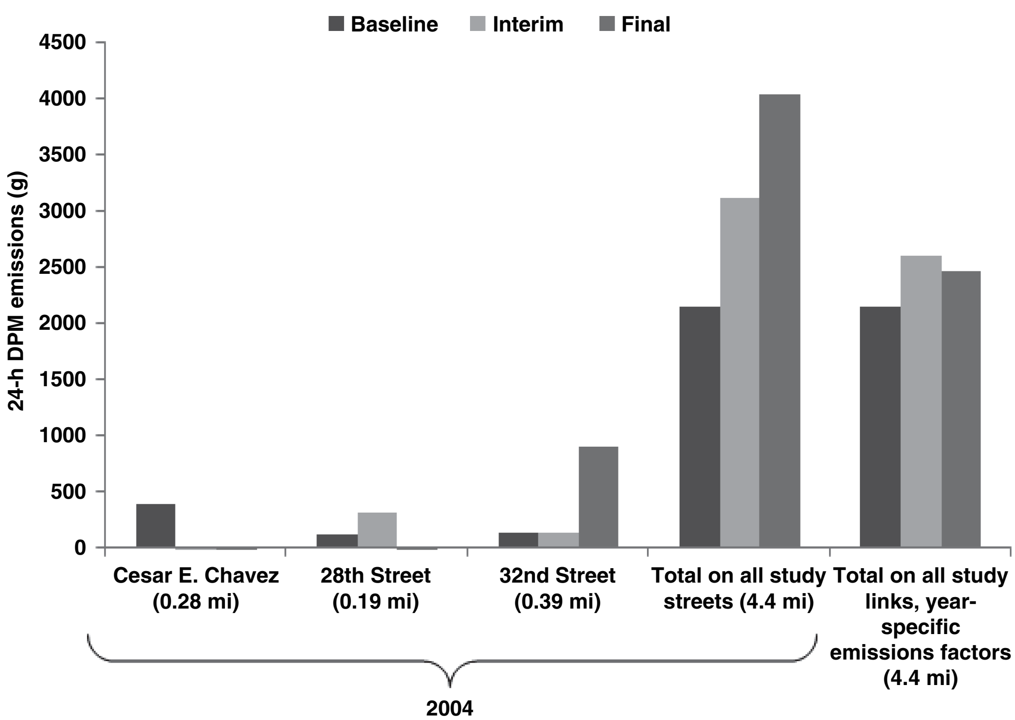

FIGURE 3 DPM emissions on key streets and all study links. (Total segment lengths are shown in parentheses. The first four sets of bars represent 2004 emissions factors, truck volumes, and speeds. The last set of bars models fleet turnover by varying emissions factors as follows: baseline = 2004, interim = 2007, final = 2016. Volumes and speeds are still assumed constant at 2004 levels in this case.)

These results indicate that the regional air quality benefits anticipated in previous assessments of the mitigation (*12, 13*) are unlikely to materialize. However, the effect of fleet turnover is substantial over the entire period of implementation. On the basis of year-specific emissions factors, the increase in absolute emissions from the baseline to final rerouting is held to just 15%.

While Figure 3 shows absolute emissions, Figure 4 shows an emissions rate—DPM emissions normalized by the street length. This metric is useful in quantifying the relative intensity of segments as sources of DPM. Segments with higher volumes of diesel traffic and segments that have travel speeds associated with higher emissions factors will be more intense emissions sources on a per mile basis (i.e., independent of the overall road length). The normalized emissions (Figure 4) can be compared on a more equal footing than the absolute emissions, although both metrics are important. Differences will remain because of the difference in travel speeds on each segment as well as minor variations in the relative distributions of truck types. Results are shown for the key streets. Emissions factors, truck volumes, and speeds are assumed constant at 2004 levels.

As might be expected, the primary rerouted link becomes a stronger source of DPM as the rerouting progresses. That is, 28th Street in the interim rerouting contains all of its own truck traffic as well as that from Cesar E. Chavez Parkway, which was the primary link in the baseline case. Similarly, 32nd Street in the final rerouting contains all of its own traffic as well as that from 28th Street and Cesar E. Chavez Parkway. The normalized DPM emissions increase by 20% from the baseline on Cesar E. Chavez Parkway to the interim on 28th Street and by 40% from the interim on 28th Street to the final on 32nd Street, as increasing numbers of trucks are rerouted. In contrast, Figure 3 shows a decline in absolute emissions from the baseline conditions on Cesar E. Chavez Parkway (386 g/day) to the interim rerouting on 28th Street (321 g/day).

These results indicate that individuals residing adjacent to these links will experience worse air quality as the mitigation proceeds. However, because 32nd Street does not contain sensitive receptors (as opposed to Cesar E. Chavez Parkway and 28th Street), increasing its emissions intensity under the final rerouting represents a net benefit. Thus, while the rerouting project increased total (regional) emissions, it achieved its goals of reducing the effects where it mattered most to Barrio Logan residents, along Cesar E. Chavez Parkway.

Limitations of Analysis

Several limitations of the analysis should be noted. First, it conservatively assumes that truck travel demand is held constant at the 2004 volumes. That is, if the mitigation improves local air quality with 2004 volumes, then any volume increase under the mitigation framework will only increase the localized benefits. However, the increases in localized benefits will almost certainly be accompanied by decreases in regional air quality. In addition, infrastructure in the study area is likely to change by 2016 to include at least the access improvements indicated in Figure 1. These were not considered in this analysis but will further improve traffic operations in the study area; however, emissions will decrease as a result only to the extent that additional goods movement demand is not induced.

SUMMARY AND CONCLUSIONS

Expected growth in goods movement, both internationally (*28*) and domestically (*5*), has motivated interest in the mitigation of future truck, rail, and ship emissions associated with freight delivery. A particular concern has been the potential impacts on residential areas proximate to port facilities. This case study explored the impacts of an operational strategy deployed near a Southern California port facility that reduces emissions near sensitive receptors: residential areas along heavily traveled truck routes (along the premitigation and interim routes in Figure 1). However, to achieve the spatial displacement of emissions away from residential areas, the strategy increased truck travel and absolute (regional) emissions (along the final route in Figure 1).

This final point raises pertinent philosophical questions about the ethics of trading off local for regional impacts. Other situations may arise where local impact mitigation results in increased regional emissions. Since the national ambient air quality standards are measured in terms of regional average concentrations, the increase may or may not be problematic, depending on nonattainment status. However, this calls an exclusive focus on the regional level into question, especially since the cumulative local health impacts on vulnerable populations resulting from goods movement are likely to be severe (*8, 9*). The following are among other questions: Who benefits from

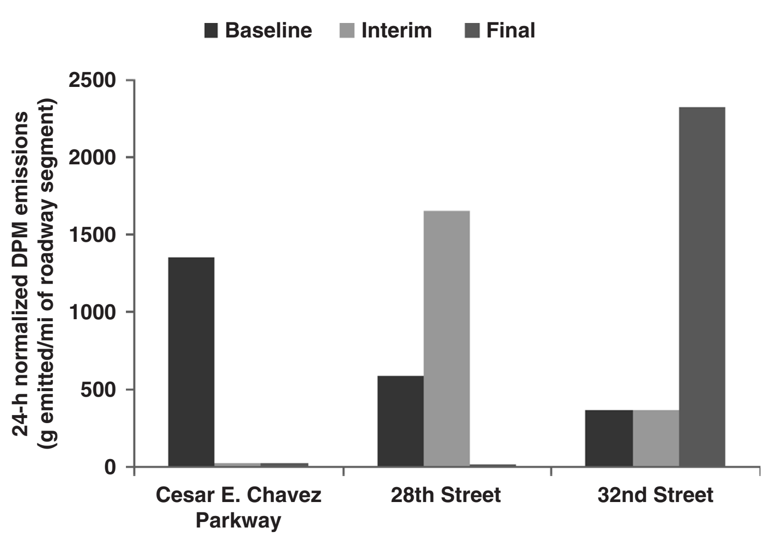

FIGURE 4 Normalized DPM emissions on key segments independent of street length, 2004.

and who pays for goods movement activities? Is it fair to distribute the impacts among a larger population to mitigate locally? Are widely dispersed impacts necessary to facilitate growth and more equitably distribute the full costs of goods movement? Regulators in areas affected by goods movement will have to struggle with these questions as the magnitude of trade increases. Additional insights are as follows:

- Local diesel truck impacts on sensitive communities may be mitigated by simply rerouting, as opposed to constructing new infrastructure. This need not compromise transport operational efficiency but may not result in a regional air quality benefit. Solutions could be as simple as a ramp upgrade and the associated traffic improvements along with the cost of signage and paint. The suitability of such an approach obviously depends on existing site conditions and the nature of community concerns, but under most meteorological conditions, the area within 150 m of the road is where heavy exposure to traffic-related pollution is most likely to occur (*32*). If trucks can be rerouted to avoid traveling in areas adjacent to residential and other sensitive uses, associated adverse impacts can be minimized, even if the new route results in somewhat higher regional emissions.
- Community-led processes can be effective when communication channels among citizens, industry, government, and other regulators are open. The potential for their use should be explored further. Solutions for Barrio Logan were determined outside the traditional transportation planning process by using a collaborative approach facilitated by the inclusive nature of MTCC. Stakeholder interviews indicated that the mitigation plan was effective in the sense that it represented an improvement over the RTP and resulted in consensus. Similar approaches have led to successful outcomes in other cases (*33, 34*), and their generalizability should be studied in future work.

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