West Oakland Diesel Emissions Inventory and Air Quality Monitoring Study

West Oakland Diesel Truck Emissions Reduction Initiative

By the Pacific Institute

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PACIFIC INSTITUTE

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Introduction

The Pacific Institute has been working with the West Oakland Environmental Indicators Project since 2000. In 2002, Pacific Institute and the 7th Street/McClymonds Corridor Neighborhood Improvement Initiative jointly published *Neighborhood Knowledge for Change: The West Oakland Environmental Indicators Project*,[1] a report that used local residents' knowledge and concerns about environmental justice and health to drive research questions. The 2002 report confirmed many residents' concerns about community health, vulnerability to displacement, air quality, and other concerns. The report made a set of technical information, from scientific, public health and local agencies that was previously not easily available, accessible to West Oakland residents.

The current report is an outcome of that previous process and continues to build on an exciting and effective partnership between community groups, a technical assistance organization and government agencies for promoting policy change and decision-making that will hopefully improve the quality of life and environmental health for all the residents of West Oakland. This process has already led to meaningful and substantive community participation in decision-making and monitoring around the Port of Oakland. Additionally, benefits in environmental quality and cleaner air will ultimately benefit all the residents of Oakland, Alameda County, the San Francisco Bay Area Air Basin and onwards.

One of the questions that residents expressed in *Neighborhood Knowledge for Change* was around air quality, specifically, the contribution of diesel trucks to poor air quality, asthma rates and poor community health. In the process of conducting a review of the available literature on diesel traffic and environmental and health impacts (see Section 1, the Summary of Studies and the Data Gap Analysis), researchers at the Pacific Institute (PI) and members of the West Oakland Environmental Indicators Project (WOEIP) realized two things: diesel trucks were not the only major source of diesel pollution, and that what was being emitted might not be representative of what people are actually breathing. PI and WOEIP used the results from a study conducted and designed by an outside contractor, TIAX LLC, and West Oakland community members (see TIAX 2003), to help understand and develop an emissions estimate for heavy-heavydiesel truck[2] traffic in West Oakland (Section 1) and a total diesel exhaust emissions inventory for West Oakland (Section 2). PI and WOEIP also partnered with the Natural Resources Defense Council to conduct an exploratory study that documents the levels of diesel particulate matter (black soot) in the air in a few people's homes in West Oakland (Section 3).

[1] Pacific Institute and 7th St/McClymonds Corridor Initiative. 2002. Neighborhood Knowledge for Change: The West Oakland Environmental Indicators Project. Oakland, CA. Available for download at www.neip.org

[2] Heavy-Heavy diesel truck (HHDT) refers to diesel trucks over 4.5 tons, as defined in the California Air Resources Board EMFAC2002 model for traffic-related air pollution. These are the only trucks we consider in this report.

Our research shows that diesel truck traffic in West Oakland accounts for at least 125 pounds of diesel particulate matter (DPM) emissions per day in West Oakland, and that total DPM emissions for West Oakland are at least 92.6 tons per year. This is equivalent to almost 7 times the average amount of DPM emitted per person in Alameda County and the San Francisco Bay Area Air Basin, or 95 times the average amount of DPM emitted per square mile per year in California.

We also measured average ambient air quality for 4 weekdays in two homes in West Oakland using an Aethalometer. Average ambient air concentrations of black carbon were 2.1 ug/m^3. Average ambient black carbon levels were also measured for two weekdays in an Oakland home four miles from the West Oakland sites, and found to be 0.37 ug/m^3. Black carbon was then converted to diesel particulate matter (Methods are explained in detail in Section 3). Average ambient DPM concentrations in West Oakland were almost 6 times the ambient DPM levels found in this Oakland home near Lake Merritt. Using the California Air Resources Board's estimate for lifetime excess cancer risk for DPM, we find that the lifetime excess cancer risk for West Oakland might be as high as 1,201 per 1 million people, or over 5 times higher than for the rest of Oakland.

The scaling of our results also showed that while poor air is concentrated in and near sources or attractors of pollution such as the Port of Oakland, poor air quality and diesel pollution is very much a regional and statewide problem that affects all residents of California. Given these findings, we encourage the cooperation of workers, truck drivers, West Oakland residents, the Port of Oakland, federal, state and local environmental and public health agencies, and other concerned organizations to work together to implement these solutions and recommendations in a timely manner. The results can only be a better, cleaner, safer and healthier environment for all people.

1. HHDT DPM emissions estimates for West Oakland

In this section the findings of four studies of air quality in West Oakland are reviewed, and the relevant data on air pollution due to diesel trucks extracted. This report uses measures of diesel particulate matter (DPM). DPM only partially captures the severity of the total health impacts of diesel pollution and in this report is intended to be used as a surrogate for all of the toxins that are present in diesel exhaust.

Existing diesel emissions estimates for West Oakland were reviewed, particularly, Environmental Impact Statements (EISs) and Environmental Impact Reports (EIRs) for the Port of Oakland and a report to the City of Oakland Environmental Services Department. Generally, Port EIRs and EISs did not differentiate diesel particulate matter (DPM) from other sources of particulate matter (PM). In addition, the purposes of the reports were slightly different that our own estimate. Thus, particulate matter and diesel particulate matter emissions estimates in the different studies differ over two orders of magnitude (See Table 1-1).

In reviewing the reports, we found several reasons for calculated differences in particulate matter emissions, including:

- **Geographic range** of impacts/emissions considered (e.g. West Oakland, versus BAAQMD, versus SF Air Basin, versus all possible impacts);
- **Number of truck trips per day** (projected vs. actual);
- **Duration of truck trips per day** (and secondarily, **complexity of calculations**: whether idling, engine temperature, and other factors were included in the calculations);
- **Whether or not on-highway truck trips were counted;**
- **Emissions factors** (g/mi; or g/bhp-hr); these emissions factors were being revised almost annually throughout the years in which these studies were being conducted, and at this point also include idling, speed of travel, county-specific fleet age distributions, estimated from fleet averages, all of which may or may not be similar to that of trucks specifically servicing the Port

Table 1-1. Total DPM emitted per day: Calculated estimates for Heavy-Heavy Diesel Trucks.

Publication/Study (Year)	PM Calculated (lbs/d)	Reported in PM10 or DPM?
Berths 55-58 (draft) for 2000 (1998)	430.7	PM10
FISCO/Port Vision 2000 – No Action Alternative for 2000 (1997)	3,534.4	PM10
FISCO/Port Vision 2000 – Reduced Harbor Fill Alternative for 2000 (1997)	3,997.6	PM10
Harding ESE for 2000 (2001)	2,119.75	DPM
TIAX for 2002 (2003)	64.0	DPM

In this next section, we describe the estimates of each report, visit their assumptions and using back-of-the-envelope calculations and estimates, see if by attempting to standardize the assumptions, we arrive at a more consistent range of estimates for DPM emissions from Port-related truck traffic. We modified assumptions to be consistent with our stated goal of figuring out sources of DPM emissions in West Oakland, with one line item specifically for Port related diesel truck traffic. In each of the following sections, results and estimates are reported in the units as reported in the original report. However, in Section 2, all estimates are converted to DPM.

Berths 55-58

Full Citation: Port of Oakland and URS Greiner Woodward Cycle. 1998. *Berth 55-58 Project Draft Environmental Impact Report.* SCH No. 97102076. December 11, 1998. Oakland, CA.

Of all the different EIRs examined, this study reported the highest percentage estimate for ship PM emissions. In most other studies, diesel truck emissions dominated the PM and NOx emissions for the Port. Table 1-2 shows the distribution of PM sources in the EIR.

Since 95-98% of heavy-heavy truck traffic servicing the Port of Oakland is due to diesel trucks, all of this is basically DPM. That is, it is assumed that in this case PM = DPM.

Looking specifically at the PM emissions estimates for truck traffic, in pounds per day, and in Appendix Table C1-17 (See Table 1-3 below), where the specific breakdowns occur, we saw that a significant proportion of estimated PM emissions came from the estimates of trucks that are

Table 1-2. Distribution of PM Emissions as reported in the Berths 55-58 Draft EIR.

Source Category	Source		PM Emissions (tons/y)	PM Emissions (lbs/d)
Mobile	Vehicles	Employee	1	3
		Operations	0	0
	Cargo Operations		38	210
	Transport Trucks		46	431
	Train Operations	Line Haul	5	25
		Switching	0	2
Marine	Tugs		3	16
	Ships	Hoteling	12	66
		Maneuvering	35	192
		Cruising	108	590
		Totals	247	1533

Note: The conversions from lb/d to tons/y do not add up, but they used averages of about 210 working days per year (ranged from 208-212). Because of this discrepancy, the values reported for pounds/d figures were used for the rest of this report.

hauling to sources within the Bay Area and long-distance: to other counties, to the Central Valley, and beyond.

In Appendix C of the Berths 55-58 EIR, it turns out that calculations in the Bay Area, based on a weighted average, were estimated at 16 miles distance traveled. Long-haul operations, also based on a weighted average of reported trips, were estimated at 48 miles. Since all this traffic originates in West Oakland, it must travel on the highway through West Oakland at least 4 miles (the average length of the highways bounding West Oakland).

We wanted to know how much the emissions estimates would change if we only tried to count for diesel pollution that was being released *in West Oakland*. For a ballpark estimate, we used 4 miles as an estimator for distance traveled per truck trip in West Oakland. We assumed a proportional correlation between distance traveled and PM emissions generated. In that case, for trucks, the on-site fraction stays the same (3.6 lbs PM/d), the Bay Area fraction may go down by 1/4 (from 190 to 47.3 lbs PM/d), long-distance amount goes to roughly one-twelfth, (from 235 to 19.6 lbs PM/d) and Richmond is negligible in any case, but does stay more or less the same (2.3 lbs PM/d). This will lead to an underestimate because the trucks are dirty when they are not warmed up. Because the Port and West Oakland are major destinations and departure points, the

Table 1-3. Detailed breakdown of PM emissions as calculated in the Berths 55-58 EIR. Shaded cells indicate data taken directly from the report.

			Berths 55-58 (1998) – DRAFT	
Source	Source		PM emissions (lbs/d)	PM Emissions (Tons/y)
Mobile	Vehicles	Employee	1	0.125
		Operations	0	0
	Cargo Operations		38	4.75
	Transport Trucks	*Subtotal*	*430.7*	*53.8375*
		On-site	3.6	0.45
		Bay Area	189.6	23.7
		Long-distance	235.2	29.4
		To Richmond	2.3	0.2875
	Train Operations	Line Haul	5	0.625
		Switching	0	0
Marine	Tugs		3	0.375
	Ships	*Subtotal*	*155*	*19.375*
		Hoteling	12	1.5
		Maneuvering	35	4.375
		Cruising	108	13.5
		Totals	247	31

emissions in these geographic areas will actually be dirtier because of all the stopping and starting, and even this conversion should be taken as a lower bound estimate. **Thus, a conservative estimate for the applicable fraction of the PM estimated in the Berth 55-58 report for DPM emitted by Port-related HHDT truck traffic in West Oakland is 72.8 pounds DPM emitted in West Oakland per day.** Using the 2003 estimate for all projects yields 92.5 pounds DPM per day, and doing a similar scaling for 2010 yields a total of 85.3 pounds per day. The main reason for this is the assumed successful implementation of cleaner emissions standards for trucks, scheduled to take place in 2004 and beyond. See Table 1-8 for a summary of these calculations.

FISCO/Port Vision 2000

Full Citation: Fleet and Industrial Supply Center, Oakland (FISCO) and Port of Oakland, California. 1997. *Disposal and Reuse of Fleet and Industrial Supply Center, Oakland Vision 2000 Maritime Development. Final Environmental Impact Statement / Environmental Impact Report.* SCH # 96062010. US Navy and Port of Oakland Department of Environmental Assessment, San Bruno and Oakland, CA.

Table 1-4 shows the reported sources of PM emissions for the Port of Oakland for this EIR.

Again, as in the Berths 55-58 Report, looking in the Appendices shows how the calculations were derived, and also reveals more detail for the truck PM estimates in particular. For this report, Appendix N, and in particular, Tables N-21 and Table N-45 are re-presented in Table 1-5. Here we've recalculated for the 'No Action Alternative.' Since the Reduced Harbor Fill Alternative PM estimates and the 'No Action Alternative' estimates for 2000 do not differ significantly, and since the purpose of this report is to mainly see how far off the estimates are

Table 1-4. Calculated Mobile PM Sources in the FISCO/Port Vision 2000 EIS/EIR. The report estimates what emissions will be in 2010, including traffic circulation patterns and cleaner trucks. All data is taken directly from the original document. Alternatives 1,2,3 and 4 designate alternatives for 2003. The EIS/EIR recommended 4, the Reduced Harbor Fill alternative, as the most environmentally friendly one.

Mobile Sources of PM 10	**No action**	**1**	**2**	**3**	**4**
	tons/y	tons/y	tons/y	tons/y	tons/y
Autos	127.6	149.2	143.8	157.3	151.7
Trucks	441.8	498.7	490.4	500.7	499.7
Amtrak	3.3	3.3	3.3	3.3	3.3
Freight trains	2.7	3.6	3	3.7	3.7
cargo ships	66.5	103.8	83.6	107.8	106.2
Total	641.8	758.6	724.1	772.8	764.5

Alternatives key
1 = max marine / max rail
2 = min marine / min rail
3 = max marine / min rail
4 = reduced harbor fill

from each other, we did not recalculate for the Reduced Harbor Fill Alternative. Full calculations are presented in Table 1-8. One of the major sources of difference between this study and other studies of PM emissions is that PM from trucks was calculated for exhaust and for entrained emissions. Entrained emissions are the emissions from tire and brake wear, as well as from resuspended road dust, and exhaust emissions factors are 21% of total PM emissions factors.

Assuming a direct proportion between exhaust and entrained road dust, and correcting for distance as in the Berths 55-58 report, yields exhaust estimates of 2.3 pounds per day for in-Port trips, 0.5 pounds per day for Richmond trips, 82.8 pounds DPM for Bay Area trips and 34 pounds per day for long-haul trips. Thus the applicable fraction for comparison to the TIAX report is **119.7 pounds DPM per day in 2010**. For the Reduced Harbor Fill Alternative for 2010, then, the estimate is 153.6 pounds per day of expected DPM emissions from truck traffic servicing the Port of Oakland, in West Oakland. See Table 1-8 for a summary of how these calculations were arrived at and how they compare to the other EIRs in this report.

Both the Berth 55-58 report and this report used PM emissions for trucks based on the EMFAC model that was available at the time, and so the emissions factors from EMFAC7F (0.98 g/mi) to EMFAC7G (0.72 g/mi for travel and 0.04 g/mi for idling, for 1991-1993 model trucks) for HHDT trucks are actually pretty different, as reported by the reports. The EMFAC model was also becoming significantly more complicated over time, as estimates for HHDT trucks were including data from truck traffic regarding times of travel, speeds of travel correlated with time of day, time spent idling, state-wide age-distributions for trucks, and EMFAC 2002 includes county-specific information for age-distribution of trucks. Other factors included in EMFAC

Table 1-5. Detailed PM emissions from the FISCO/Port Vision 2000 EIS/EIR, with recalculation for PM emissions from exhaust only. Estimates are only available for year 2010.

Mobile Sources of PM		**Vision 2000 (1997) -- FINAL -- No Action Alternative**		**Vision 2000 (1997) -- FINAL -- Reduced Harbor Fill**
Source		PM10 Emissions (lbs/d)	Exhaust only (lbs/d)	PM10 Emissions (lbs/d)
Autos		1020.8		1213.6
Transport Trucks	*Subtotals*	*3534.4*		*3997.6*
	On-site	10.9	2.36	118.7
	Bay Area	1577.5	342.02	1737.8
	Long-distance	1943.4	421.36	2141.1
	to Richmond	2.6	0.56	n/a
Train Operations		56		
Ships		532		849.6
	Totals	5087.04		6116

that these reports do not always include are the hot-cold start emissions factors, and local weather patterns, particularly differences in temperature, and also wind direction and speed as varies on a seasonal basis.

Harding ESE

Full Citation: Harding ESE, Inc. 2001. *West Oakland Diesel Particulate Emissions Study, Oakland, California.* Harding ESE Project No. 48168 005, Prepared for the City of Oakland Environmental Services Division. September 24, 2001. Novato, CA.

Table 1-6 shows the reported calculations of sources of DPM emissions in West Oakland. This study was commissioned by the City of Oakland Environmental Services Department, and includes many sources of DPM pollution besides the truck traffic servicing the Port of Oakland.

For the Harding ESE report, the relevant numbers to consider are the port truck activity numbers which were **1274 pounds per day** of PM, almost all of which is DPM. Their calculation relies on truck trips (9273 per day); diesel engine (assumed to be 500 bhp); time running and diesel PM emissions factors. However, estimates that we recalculated by changing truck trip numbers to reflect observed TEUs yielded estimates from **470 to 1080 pounds per day of DPM emissions for Port-related diesel,** if idling was estimated at a half hour. This calculation includes intra-modal trips. Changing the average time of operations to 15 minutes (0.25 h) halves the DPM calculations, and of course, modeling with lower numbers of daily truck trips also can change truck activity. Table 1-7 shows some of these calculations. In Table 1-7 we also show what happens if instead of using a daily truck count, we used the Port's numbers of 1.707 million TEUs moved in 2002.

A conservative way to deal with the three different numbers from the Harding ESE for truck traffic emissions, while trying to minimize the chance of double-counting truck trips in the three

Table 1-6. The distribution of DPM sources affecting West Oakland, from the Harding ESE (2001) report. Shaded cells represent data directly taken from the report.

Source		DPM (pounds/d)	DPM (pounds/y)
Stationary			
	Boilers		717
	IC Engines		8,437
Subtotal – stationary			*9,154*
Mobile			
	Port Truck Activity	1,274.00	318,500
	Diesel fueled highway trucks	674.13	168,532.5
	Truck related businesses	171.62	42,905
	Port Marine Vessel Activity	187.00	46,750
	Locomotives	55.77	13,942.5
Sub-total – mobile			*590,630*
TOTAL			**599.784**

different estimates, is to take the lower estimate of 470 pounds per day of DPM from Port-related and intramodal truck trips, subtract that from the Diesel-fueled highway truck trips, and then add the local business truck trips. See Table 1-8 for full calculations. **This produces an estimate of 845.8 pounds per day of DPM from trucks in West Oakland.**

Note: Harding ESE numbers should be taken as precise ones, since most are ballpark or back-of-the-envelope calculations that give order of magnitude estimates, but do not include the sort of detailed, age-specific, and other information that some of the other studies do.

TIAX Report

Full Citation: TIAX LLC. 2003. *Container Truck Traffic Assessment and Potential Mitigation Measures for the West Oakland Diesel Truck Emission Reduction Initiative*. Report to the Pacific Institute, prepared September 14, 2003. Technical Report TR-03-176; TIAX LLC Case D5247. Cupertino, CA.

Based on truck counts, the age-distribution of trucks as reported by the Port of Oakland in April 2003, age-specific DPM emissions factors according to EMFAC 2002, and an estimated 2.54 miles traveled per truck trip, the TIAX report estimates that DPM generated by Port-related truck traffic not including highway traffic in West Oakland to be 64 pounds DPM per day (TIAX 2003: Appendix B-4). Of this, 44 pounds are estimated to be from trucks moving on the streets

Table 1-7. Power Analysis for Port Truck Activity (Harding ESE Table 3) -- intramodal and on-road traffic: changing number of average daily truck trips and by changing to total year.

2000 Daily Average truck trips/d[i]	truck diesel engine power (bhp)	average run time (engine) per trip (hrs/trip)	Diesel PM Emission factor (g/bhp=hr)	Total Port Truck Emissions (pounds/d)[ii]
9243	500.00	0.5	0.25	1274.00
7843	500.00	0.5	0.25	1080.61
6831	500.00	0.5	0.25	941.23
8133	500.00	0.5	0.25	1120.64
9243	*500.00*	*0.25*	*0.25*	*636.79*
7843	*500.00*	*0.25*	*0.25*	*540.34*
6831	*500.00*	*0.25*	*0.25*	*470.62*
8133	*500.00*	*0.25*	*0.25*	*560.32*
Million Trips/y				lbs/d
1.707	500.00	0.5	0.25	940.82
1.707	500.00	0.25	0.25	470.41

[i] The 6300 number is the average number of truck trips per day reported by TIAX (2003); the two other numbers – 6830 and 7502 are the numbers calculated fro the Port of Oakland based on average daily truck trips for the Port of Oakland based on actual TEUs moved in July 2003 (and 22 working days), and the 7502 number is based on the Port of Oakland number of total TEUs moved in 2002 (and 250 working days).

[ii] Conversion factor = 2.2046195 lbs/1000g; 250 working d/y; 2000 lbs/(short) ton

and up to 20 pounds per day are estimated to be from idling alone. The idling portion of the estimate itself is significant, as are the field observations of trucks idling inside the Port of Oakland terminal gates, and the observations of long lines waiting to get into the Port terminals. The miles traveled per truck trip are probably low for thinking about West Oakland.
The 64 pounds per day is based on relatively low truck numbers, both in terms of actual number of trucks counted on the particular days, according to the Port of Oakland's estimates of numbers of TEUs moved on July 14, 18 and 20, 2003. These days were low when compared to the total number of TEUs moved in July 2003, and in comparison to the number of TEUs moved on average per day in 2002. It is also well-known that Port TEU traffic increases in October and November of each year. Residents' observations and the Ports numbers corroborate this.

Particular days' TEUs: (from the Port of Oakland)

July 10th:	2232 TEUs Inbound,	4253 TEUs Outbound =	6485 total
July 14th:	2560 Inbound,	4341 Outbound =	6901 total
July 18th:	2385 Inbound,	3747 Outbound =	6132 total

Monthly TEUs:
July 2003 = 172,555 = (Port of Oakland website)

per day: 7502.391 for a 5-d week (23 d)
6390.926 for a 6-d week (27 d)
7843.409 for a 5-d week but not the 4th of July (22d)

Year 2002 (Port of Oakland website)

Year 2002 = 1,707,827 = average 142,318 per month or 250 d = 6831 per day. An estimate of 250 working days is probably high; the Berths 55-58 report used a range from 208-210 working days per year.

Year 2000 = 1,776,922 TEUs

Scaling the TIAX numbers for 2000 instead of the reported numbers of TEUs moved for July 2003 yields an estimate of: **68.3 pounds per day**.

The TIAX report also does not include all of the factors that affect DPM burden, such as wind and seasonality, which the EMFAC model and the Harding ESE (2001) study attempt to account for. By running the EMFAC2002 model trying to model only for the burden generated by up to 10,000 heavy-heavy diesel truck trips of 4 miles in West Oakland, the model generated a burden where total PM = PM10 = PM2.5 = 0.02 tons/day, or about 400 pounds per day. While we would use this as the kind of middle-upper limit of the estimate, it is clear that the TIAX report estimate brackets the lower value of DPM emissions related to heavy diesel truck traffic to and from the Port of Oakland.

Conclusion

In conclusion, while reported estimates in four reports for diesel particulate matter emissions from Port-related heavy-heavy (over 4.5 ton) diesel truck traffic originally varied over two order of magnitude, examination of the underlying assumptions showed that a large part of the variation in emissions estimates was due to differences in the geographic area considered, the emissions factors, the complexity of the calculations used and the number of truck trips per day used. This differed depending on the date(s) of the various publications, as some were estimates and projections into the future, while other estimates were based on actual data.

Attempting to standardize the estimates of each of the studies resulted in a range of variation of approximately one order of magnitude: from 72.8 to 845.8 pounds per day of DPM emitted in West Oakland, with estimates from 100-400 pounds DPM emitted per day being the most likely estimates, using conservative and middle-of-the-road assumptions. See Table 1-8 for more details. In the next section, we use these numbers to develop an emissions inventory for West Oakland.

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2. Towards a West Oakland Total DPM Emissions Estimate

Based on a review of these studies, we propose the following important categories to consider for sources of DPM that affect the community of West Oakland:

- Port related truck traffic, particularly Port related heavy-heavy diesel truck (HHDT) traffic
- Heavy-heavy diesel truck traffic related to businesses located in West Oakland.
- Heavy-heavy diesel truck traffic traveling on highways that border or go through West Oakland
- Ships
- Trains (freight and passenger) and cargo operations and terminals

Port-related heavy-heavy diesel truck traffic

Based on the calculations in Part 1 above, we estimate the diesel particulate matter for Port-related truck traffic to be between 72.8 and 845.8 pounds per day in 2000. This is using the absolute most conservative estimates among the various reports and methods. For the purposes of comparison for the rest of the report, **we used a relatively conservative estimate of 125 pounds per day DPM for 2000**.

Diesel truck traffic related to businesses in West Oakland

The Harding ESE report estimates that this contributes **171.6 pounds DPM per day** to West Oakland. We would investigate the DPM emissions factor, to see how it compares to those of EMFAC 2002, and rescale if necessary. Many, but not all, of these businesses could potentially be re-located to a place near or inside the Port of Oakland, if there was space inside the Port, since many of them probably are mostly related to Port business. This would also be a significant reduction of (legal) diesel truck activity in residential areas of West Oakland, which according to the TIAX study was probably on the order of 400 trucks a day.

Diesel truck traffic traveling on highways that border or go through West Oakland

Harding ESE estimates that highway truck traffic on the freeways around West Oakland contribute something like 674 pounds DPM per day. While this is almost certainly double-counting Port-related truck traffic, as detailed above, even subtracting that out leaves a residual of at least 200-450 pounds of DPM per day that is unaccounted for by Port-related traffic that is also traveling on highways. **We used 204 pounds per day DPM emissions for over-the-highway truck traffic that impacted West Oakland**.

Ships

Ship emissions in the Harding ESE need to be revised considerably upward (esp 2.5 → 6 or 7 ships/d), and the Berths 55-58 report includes a much more substantial cruising number than the other EIRs, hence it is so much higher than the other reports. Ships are a huge source of DPM pollution, but cruising offshore is like 6/8 of the estimated 800 pounds per day of DPM that they generate, by any report. See Table 2-1 for revisions of the Harding ESE report.

Table 2-1. Investigating Harding ESE ship emissions numbers.

Harding ESE (2001) Port Marine Vessel Activity – Table 3 – original data

2000 daily average marine ship calls	Marine vessel diesel engine power (bhp)	Average engine run time/call (h)	BSFC (Btu/bhp-hr)	Diesel Consumption (1000gal/call)	Diesel PM emission factor (lbs/1000gal)	Total marine vessel PM emissions (lbs/d)	Total Marine Vessel Emissions (tons/y)
2.5	50000.00	2	7000	5	15.00	**187.00**	**23.38**

Total emissions = # calls/d * diesel consumption per call (based on a 2 hr call) * Diesel PM emissions factor

Diesel consumption (1000 gal) per call = [Marine vessel diesel engine power * average engine run time / call * BSFC]/[diesel fuel heating value (140000 Btu/bal)*1000]

However, we know that 2002 port cargo vessel calls = 1730; working days = 250, so that daily average marine ship calls need to be adjusted upwards:

2000 daily average marine ship calls	Marine vessel diesel engine power (bhp)	Average engine run time/call (h)	BSFC (Btu/bhp-hr)	Diesel Consumption (1000gal/call)	Diesel PM emission factor (lbs/1000gal)	Total marine vessel PM emissions (lbs/d)	Total Marine Vessel Emissions (tons/y)
6.92	50000.00	2	7000	5	15.00	519.00	64.88
6.92	50000.00	2.8	7000	7	15.00	726.60	90.83
6.92	50000.00	3.2	7000	8	15.00	830.40	103.80

Revising the Harding ESE report, which was actually the lowest number for ships, yields general agreement of ship DPM emissions among all the studies, to be between 100 and 500 pounds DPM generated per day. **For the purposes of final comparison we used an estimate of 200 pounds per day.** This estimate probably is a gross underestimate of ship-related DPM emissions because the total time that a ship is operating is actually much higher than 3.2 or 4 hours.

Trains (freight and passenger) and Cargo operations and terminals

Both estimates for Cargo operations, terminals, and trains are on the lower end of the estimates, when compared to the DPM generated by truck traffic and by ships. Trains estimates run from about 7 pounds per day to up to 53 pounds per day DPM. Cargo operations and terminals, only because they are encouraged to use clean diesel, use a lot of it, but generate less DPM. In general these sources are on the order of 40 pounds per day DPM generated (Berths 55-58; Harding ESE). This is also most likely an underestimate.

Table 2-2. A conservative total estimate for DPM emissions in West Oakland.

Source	Pounds DPM per day
Port-related truck traffic	125
Diesel truck traffic related to businesses in West Oakland	171.6
Over-the-highway diesel truck traffic	204.1
Ships	200
Trains and Cargo Operations	40
Total	*740.7*

Port-related heavy-heavy diesel truck traffic, heavy-heavy diesel truck traffic related to businesses in West Oakland and over-the-highway heavy-heavy diesel truck traffic are all in some sense related to the Port, since many of the businesses in West Oakland are Port-related. Other major sources of diesel truck traffic are the Post Office distribution center. The important thing to note in this instance is that all sources of diesel-truck traffic are roughly of the same magnitude, and that a significant majority – probably on the order of 400 pounds per day, according to EMFAC 2002 - of the diesel-related pollution in West Oakland is still Port-related. This is equivalent to 92.6 tons DPM emitted per year.

Comparisons

We obtained estimated emissions from truck traffic for Alameda County, the San Francisco Bay Area Air Basin and the State of California from the California Air Resources Board Air Quality

Almanac (2002).[3] The Almanac uses calculated emissions for diesel particulate matter pollution based on EMFAC 2002 and population estimates from Census 2000.

We used an estimate of 6.25 square miles for West Oakland, as published in The West Oakland Environmental Indicators Report, *Neighborhood Knowledge for Change* (2002).[4] Population estimates for West Oakland were based on census tracts 4014-4019 and 4021-4027, from Census 2000. In 2000, the population of West Oakland was 19,684 (Alameda County Department of Public Health 2001).[5]

Table 2-3 below shows the comparisons per unit area. Figure 2-1 and 2-3 display graphically the difference between DPM emissions per unit area and per person between West Oakland and other regions.

Table 2-3. Comparisons of DPM emitted per person and per unit area for West Oakland, Alameda County, San Francisco Bay Area Air Basin and the State of California.

Geographic Area	DPM Emissions estimates (tons/y) (2000)	Area (Square miles)	Population (Census 2000)	DPM emitted	
				per person (pounds/y)	per square mile (tons/y)
West Oakland	92.6	6.25	19,684	9.4	14.8
Alameda County	950	730	1,466,900	1.3	1.30
San Francisco Bay Area Air Basin	4,498	5,545	6,705,400	1.3	0.811
State of California	24,509	157,034	34,480,430	1.4	0.156

By these results, West Oakland is undoubtedly disproportionately bearing the brunt of diesel pollution for Alameda County and the San Francisco Bay Area, as well as for the State of California.

To help visualize this, we calculated the number of car equivalents that 125 pounds of truck DPM were equal to. It turns out that, per year, 125 pounds of DPM per day for a 250-day year, would be the equivalent of nearly 250,000 cars! If there about 50 miles of streets in West Oakland, this would be more than enough to cover the streets of West Oakland in cars, 4-wide and three deep! Calculations are displayed in Table 2-4 attached to this document.

[3] Available at http://www.arb.ca.gov/aqd/almanac/almanac02/almanac02.htm
[4] This report is available for download at http://www.neip.org. Land Use section, p. 39.
[5] "West Oakland Community Information Book". http://www.co.alameda.ca.us/publichealth/information/info.htm

Figure 2-1. Tons of Diesel Particulate Matter per Square Mile By Region

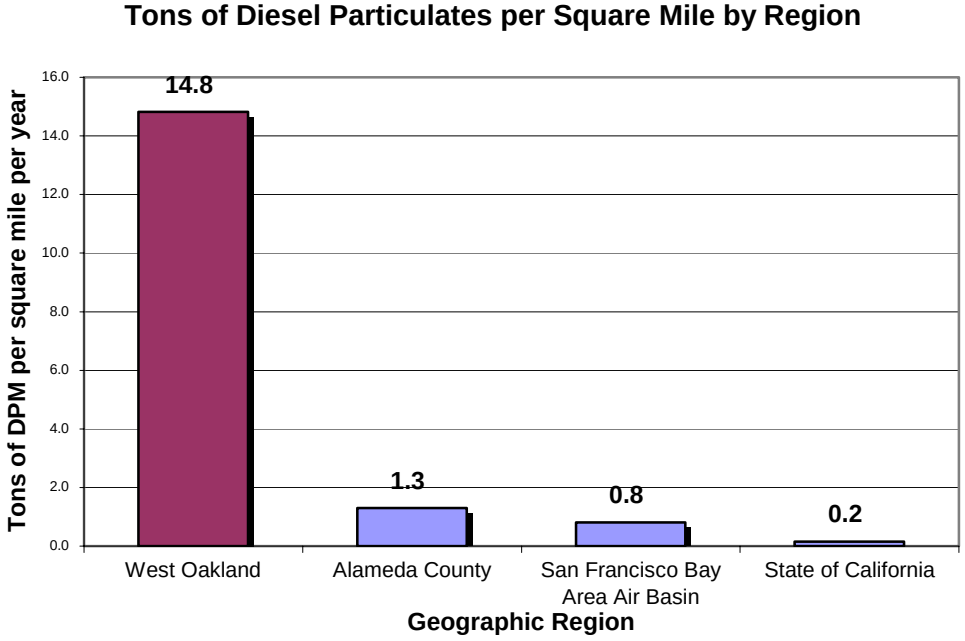


Figure 2-2. Pounds of Diesel Particulate Matter per Person by Region

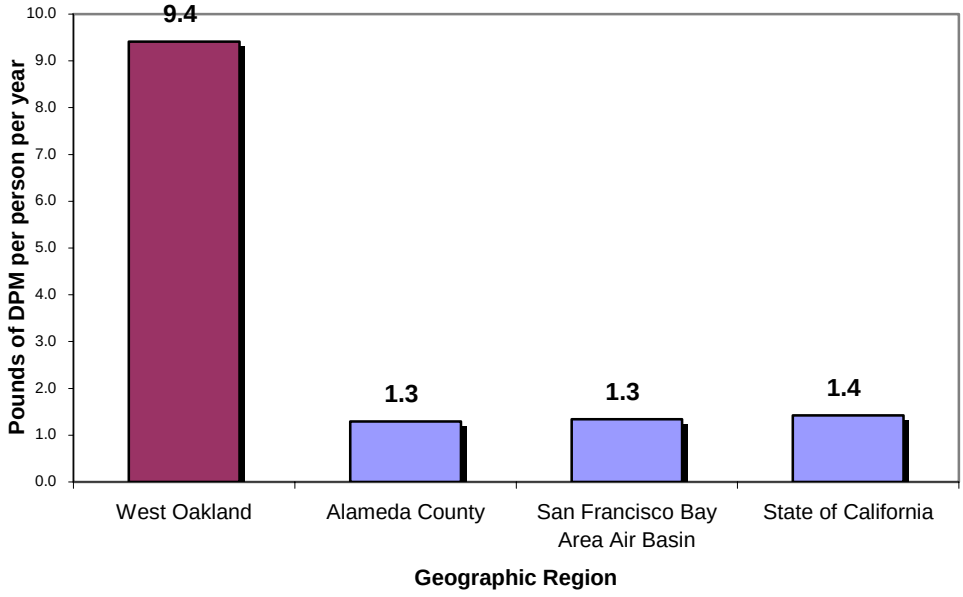
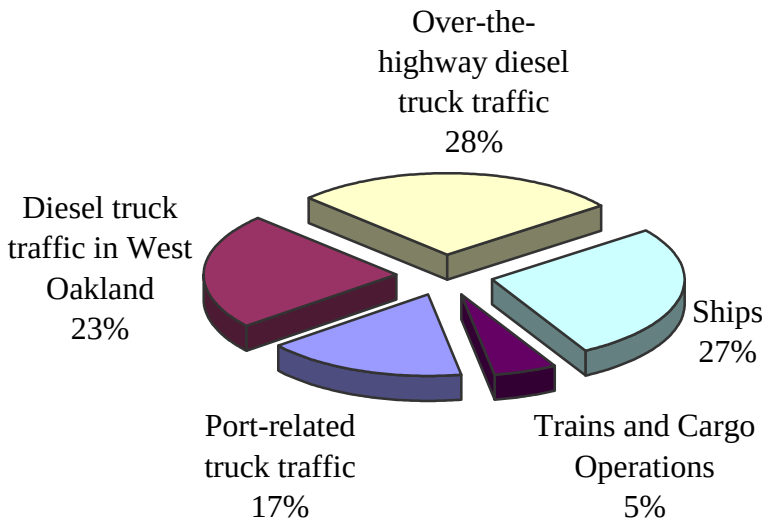


Figure 2-3. Sources of Diesel Pollution in West Oakland



3. Air Quality Monitoring Study

With the generous assistance of Diane Bailey and the Natural Resources Defense Council, we were able to use an Aethalometer AE-2[6] to measure levels of black carbon inside West Oakland residents' homes. Black carbon can be used as a surrogate for diesel particulate matter.

Black carbon levels were measured in two West Oakland homes and a third home in a residential location in another part of Oakland. The Aethalometer was placed for 4 days in two West Oakland locations and 2 days for the Cleveland Street, non-West Oakland location.[7] To avoid the possibility of confounding black carbon measures for diesel with other sources of black carbon, volunteers were instructed to make sure that there was not any smoking or use of incense or candles or any other materials that burned in the vicinity of the air monitor.

The average weekday concentrations of black carbon measured by the Aethalometer were:

2.1 $\mu g/m^3$ of black carbon for two West Oakland locations, and

0.37 $\mu g/m^3$ black carbon for one other Oakland location (Cleveland St), 4 miles from West Oakland. We used this as an estimate for Oakland background.

The concentration of diesel particulate matter can be converted from measured levels of black carbon through the following method detailed in *No Breathing in the Aisles*[8] and in STAPPA/ALAPCO (2000):[9]

Figure 3-1. CONVERSION FROM BLACK CARBON TO DIESEL PM

Black carbon to elemental carbon=1.32[a] (No Breathing in the Aisles citation 136)
Elemental carbon to diesel exhaust particulate=1.56[b]
Amount of Elemental Carbon in the air from diesel sources = 0.67

C_{air} = Concentration in the Air = (BC)(1.32)(1.56)(0.67) $\mu g/m^3$ Diesel PM, (3.1)

where BC = Black Carbon levels measured by the Aethalometer in $\mu g/m^3$.

[a] Babich, P, M. Davey, G. Allen and K. Poutrakis. 2000. Method Comparisons for Particulate nitrate, Elemental Carbon and PM 2.5 Mass in Seven U. S. Cities. *Journal of Air and Waste Management Association* 50: 1095-1104. Cited in Natural Resources Defense Council and Coalition for Clean Air. 2001. No Breathing in the Aisles: Diesel Exhaust Inside Schoolbuses. Los Angeles, CA: Natural Resources Defense Council and Coalition for Clean Air.
[b] STAPPA/ALAPCO, Cancer Risk from Diesel Particulate: National and Metropolitan Area Estimates for the United States, March 15, 2000.

Dose inhaled is calculated from the ambient concentration through the following method (Figure 3-2 below) as developed by the California Environmental Protection Agency's Office of Environmental Health Hazards Assessment (2003):[10]

[6] Magee Scientific. Aethalometer specifications located in Appendix I and online at www.mageesci.com
[7] All days were weekdays. Averages were taken on a per day basis. Each daily average concentration does not necessarily represent a full 24-hours of data.
[8] Natural Resources Defense Council and Coalition for Clean Air. 2001. No Breathing in the Aisles: Diesel Exhaust Inside Schoolbuses. Los Angeles, CA: Natural Resources Defense Council and Coalition for Clean Air.
[9] STAPPA/ALAPCO, Cancer Risk from Diesel Particulate: National and Metropolitan Area Estimates for the United States, March 15, 2000.

Figure 3-2. HEALTH RISK ASSESSMENT METHODOLOGY

$$\text{Dose Inhaled} = \frac{(C_{air})(DBR)(A)(EF)(ED)(1x10^{-6})}{AT} \quad (3.2)$$

where

Parameter	Definition	Value
Dose Inhaled	Dose through inhalation (mg/kg/day)	
C_{air}	Concentration in air ($\mu g/m^3$)	(1.38)(BC)
DBR	Daily breathing rate (L/kg body weight-day or L/kg-day)	393 (represents the 95th percentile, or high end[a])
A	Inhalation absorption factor	1 (currently used for all substances included in CARB's Hot Spots program)
EF	Exposure frequency (day/year)	350 days/year
ED	Exposure duration (years)	70 years
AT	Averaging time period over which exposure is averaged, in days	25,550 days (70 years)
1×10^{-6}	Micrograms to milligrams conversion (10^{-3} mg/µg), liters to cubic meters conversion (10^{-3} m^3/l)	

Cancer Risk Potency Factor for diesel PM = 3.0×10^{-4} per $\mu g/m^3$ or 1.1 per mg/kg-day (3.3)

Cancer Risk (chances per million) = Dose Inhaled (mg/kg-day) x Cancer Potency $(mg/kg\text{-}day)^{-1}$ $(1x10^6)$ (3.4)

[a] This risk assessment does not account for the fact that exposure is higher during infant and childhood years due to much higher breathing rates and other factors; therefore, the high end of adult breathing rates was selected. See National Environmental Trust. 2002. Toxic Beginnings: Cancer Risks to Children from California's Air Pollution.

Following these calculations yields the following results for excess cancer risk for West Oakland, presented in Table 3-1.

[10] Cal EPA, Office of Environmental Health Hazard Assessment, Air Toxics Hot Spots Program Risk Assessment Guidelines, August 2003; http://www.oehha.ca.gov/air/hot_spots/pdf/HRAguidefinal.pdf.

Table 3-1. Lifetime Excess Cancer Risk from Diesel Particulate Matter Concentrations in West Oakland as compared to elsewhere in Oakland.

Location	BC (µg/m3)	C_{air}, Diesel PM (µg/m3)	Dose (mg/kg/day)	70 Year (Full Adult Life Span) Risk
West Oakland	2.1	2.90	0.00109	1201 per million or 12 per 10,000
Background Oakland	0.37	0.51	0.00019	212 per million or 2.1 per 10,000

The U.S. Environmental Protection Agency generally regards any lifetime individual cancer risk of greater than 1 in 1 million as too high.[11] Diesel particulate matter concentrations in West Oakland are over one thousand times greater than federal levels for what constitutes significant health risk.

In addition, health risks from diesel particulate matter are not sufficiently captured solely through estimates of lifetime excess cancer risk. Key health effects reported in a California Air Resources Board report, citing the U.S. Environmental Protection Agency, include premature mortality, aggravation of respiratory and cardiovascular disease (as indicated by increased hospital admissions and emergency room visits, school absences, work loss days, and restricted activity days), aggravated asthma, acute respiratory symptoms (including aggravated coughing and difficult or painful breathing), chronic bronchitis, and decreased lung function that can be experienced as shortness of breath.[12]

In conclusion, West Oakland residents have an increased health risk of one extra cancer case for every thousand residents due to diesel particulate pollution exposure over a lifetime. This is almost six times the risk that residents in some other parts of Oakland face from diesel pollution, and well over the acceptable limits of increased risk of mortality, from cancer or other non-cancer health effects. This study confirms community knowledge that West Oakland residents are exposed to extremely high levels of diesel pollution, and that diesel pollution is a local and regional problem with severe adverse health effects.

[11] U.S. EPA, National Air Toxics Assessment. 2003. "Frequently Asked Questions." http://www.epa.gov/ttn/atw/nata/natsafaq.html (Accessed January 13, 2004)

"EPA has made case-specific determinations such as the 1989 Benzene National Emission Standard for Hazardous Air Pollutants (NESHAP) that set up a two part risk-based decision framework. First, it set an upper limit of acceptability of 1 in 10,000 lifetime cancer risk for highly exposed individuals. Second, it set a target of protecting the greatest number of persons possible to an individual lifetime risk level no high than approximately 1 in 1,000,000. In addition, these determinations called for considering other health and risk factors, including the uncertainty in the risk assessment, in making an overall judgment on acceptability"

[12] California Environmental Protection Agency Air Resources Board. 2003. Staff Report: Initial Statement Of Reasons For Proposed Rulemaking. Airborne Toxic Control Measure For In-Use Diesel-Fueled Transport Refrigeration Units (TRU) and TRU Generator Sets, And Facilities Where TRUs Operate. Sacramento, Ca. Stationary Source Division, Emissions Assessment Branch. October 2003.

Appendix 1.
See attached.