Attachment A

Part 1

Environ's Draft Emission Inventory Methodology With ARB Suggested Revisions Noted

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1. INTRODUCTION

The Port of Oakland emission inventory project plan is described in this document. The purpose of this work was to better understand the typical activities, so the Port can better address the impact of the freight movements. The emission inventory project was planned such that the major activity categories listed below could be analyzed in detail.

- Large Ocean-Going Deep Draft Vessels
- Harbor Craft (Dredging, Assist Tugs)
- Cargo Handling Equipment
- Trucking (Container)
- Locomotive

The purpose of the study was to determine the local impacts, so the spatial scope was limited to activities within the nearest freeway interchanges and out into the Bay. While local impact was the primary purpose, the study includes marine vessel activity well out into the ocean because the ship calls could be well characterized.

The Port area under study includes 9 marine terminals and two rail yards and includes rail lines and road traffic to those facilities. The Port area was defined by the boundaries of I-80, I-880, and the Howard Terminals. Within this defined geographic area two significant areas were specifically excluded; the Schnitzer Steel terminal and the former Army Base located between Maritime Street and I-880. The Schnitzer Steel facility is a privately operated facility separate of the Port of Oakland. The former Army Base is little used for warehouse and other similar uses sometimes leased on a monthly basis, and so the emission related activity is difficult to characterize.

The methodology used to estimate emissions is provided in the following sections in the order listed above.

Air Resources Board: General Comments

- The Proposed Environ emission estimation methodologies for a port-wide emission inventory for the Port of Oakland should be consistent with the ARB emission estimation methodologies in the following categories:
  - Ocean Going Vessels, Main and Auxiliary
  - Commercial Harbor Craft
  - Cargo Handling Equipment
  - Locomotive
  - Trucking (Container transport)

- In general, ARB staff has found significant differences between ARB inventories and the proposed Port of Oakland inventory in most of the inventory categories. ARB staff believe that these differences need to be resolved before the final emissions inventory is completed. The differences affect most of the inventory categories in the following areas:
  - Zero Hour Emission Factors
  - Deterioration Rates and deteriorated emission factors
  - Load factors

2. DEEP-DRAFT MARINE VESSELS

Deep Draft Marine Vessel Activity and Inventory

This section documents the emission estimation methods and results for the base year, 2005, for large deep draft vessels calling at Port of Oakland terminals. The emissions study assessment follows the guidance for best practices (ICF, 2005) to prepare a detailed emissions inventory for Port emissions inventory.

The vessels calling at Port of Oakland were overwhelmingly container ships with few calls by roll on/roll off and general cargo vessels as characterized by the Lloyds classification, however all of these would generally be considered container ships that may carry other cargo. One terminal that lies within the boundaries of the Port of Oakland terminals is the privately owned Schnitzer facility, which generally sees bulk carriers calling for scrap steel and calls to that terminal were excluded in this study.

The spatial area contained within this study included transit activity out past the Pilot Buoy to the berths at the Port. Based on discussions with the Marine Exchange (2006), Port of Oakland Wharfingers (2006), Port of Oakland (2006), and SF Bar Pilot (2006), a schematic of the transit activity for ships calling at the Port of Oakland can be described as shown in Table 2-1. These correspond to the schematic link descriptions shown in Figures 2-1 and 2-2. The number of links described here may be more numerous than needed for a basic estimate, however, this provides flexibility if later information demonstrates different speeds along each link segment.

The time in mode and load for propulsion engines was calculated from the vessel speed and distance for each transit mode. Maneuvering mode times were estimated based on typical time for maneuvering vessel as estimated by the SF Bar Pilots. The auxiliary engine time was determined from the time in mode calculated for transit modes and provided by Wharfinger (2006) data for berthing time.

The Bar Pilot (2006) suggested that predominately smaller ships during fair weather and low traffic periods may use an alternative route for movements between the Golden Gate and Bay Bridges by transiting south of the Harding Rock buoy or even south of Alcatraz. But because sufficient data to describe the routes of each vessel transit was not available, the shorter route however was supplied only as an alternative route for this work. The alternative route would serve to shorten the transit link, so the longer default route resulted in higher emissions than using the more direct route. The longer route was used as the default condition because all vessels can always use this route, and the more direct route is limited to certain vessel types and weather conditions.

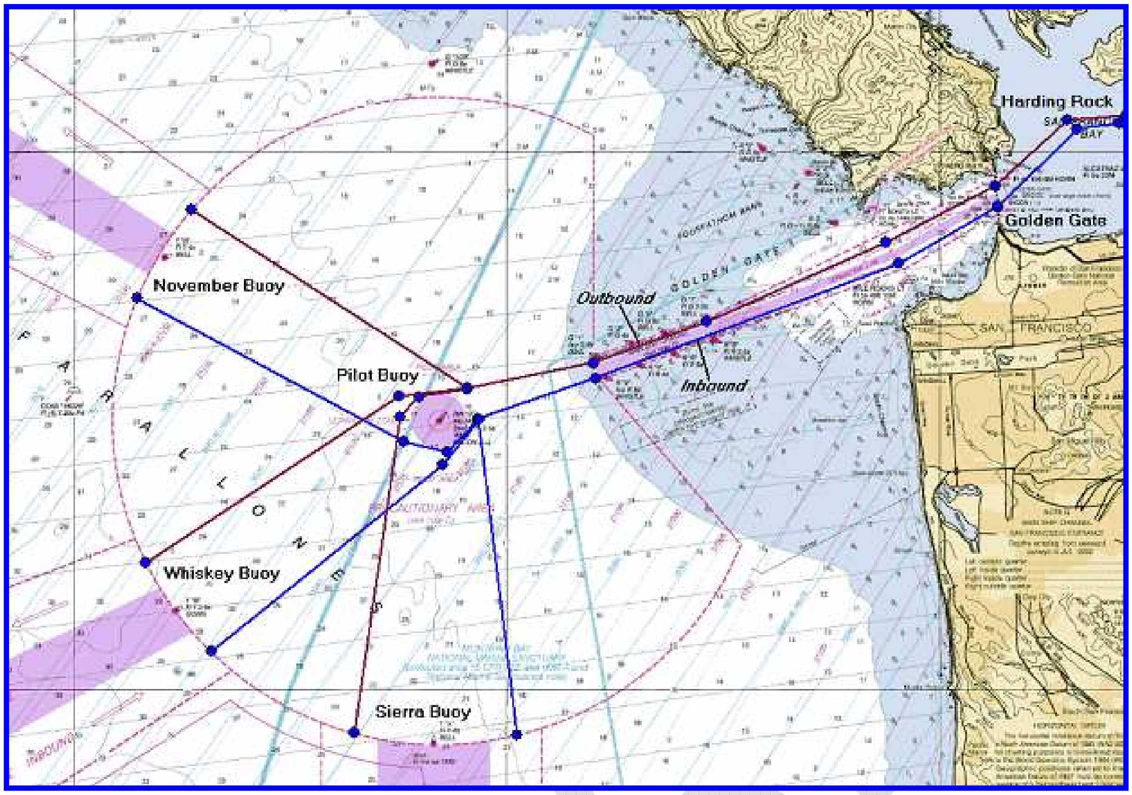

Figure 2-1. Link descriptions outside of the Golden Gate.

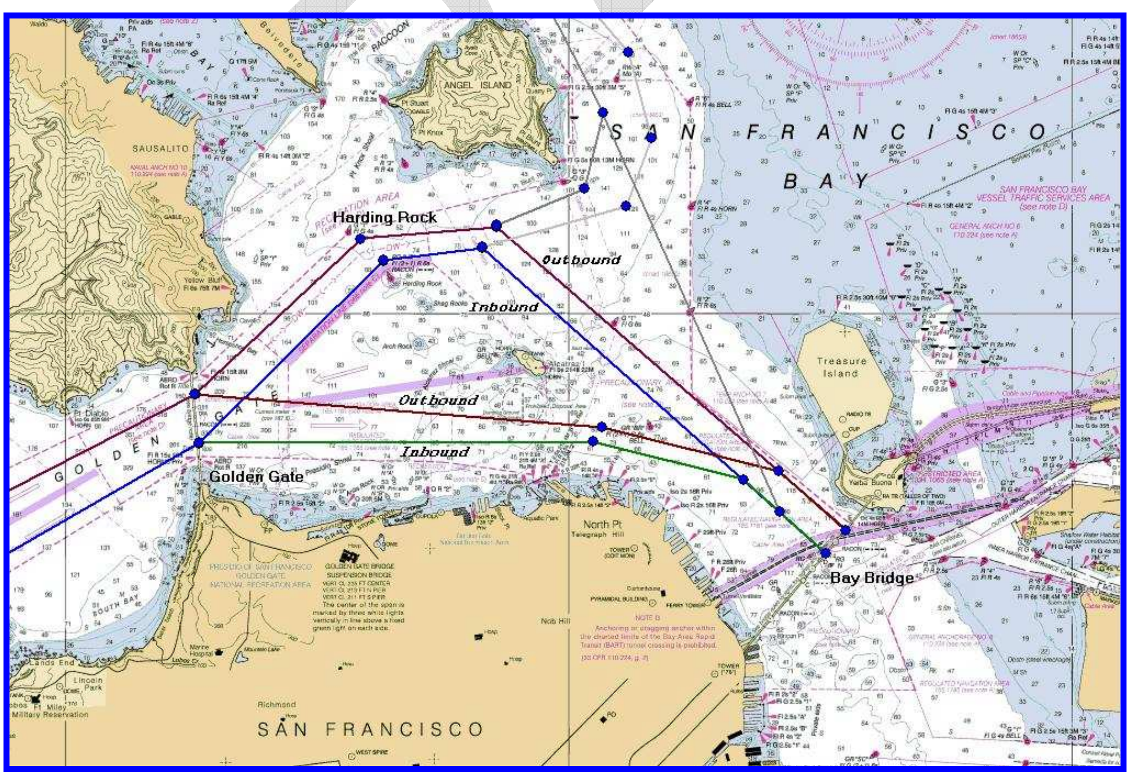

Figure 2-2. Transit link descriptions in San Francisco Bay including a more direct alternative route.

Table 2-1. Transit link descriptions.

Transit into Port				
Direction	**Link Start**	**Link End**	**Distance (nautical miles)**	**Speed (knot)**
In – From Asia or Northern Ports	November Buoy	Pilot Boards	7.2 – 1.7 = 5.5	Cruise
In – From Hawaii	Whiskey Buoy	Pilot Boards	6.5 – 1.7 = 4.8	Cruise
In – From Southern Ports	Sierra Buoy	Pilot Boards	5.9 – 1.7 = 4.2	Cruise
In – All	Pilot Boards	Pilot Buoy	1.7[2]	10
In – All	Pilot Buoy	Golden Gate	10.3	13.5
In – All[1]	Golden Gate[1]	Harding Rock	2.0	13.5
In – All[1]	Harding Rock[1]	Bay Bridge	4.4	13.5
In – All (alternative route) [1]	Golden Gate	Bay Bridge	5.2	13.5
Maneuvering Modes				
Direction	**Link Start**	**Link End**	**Time (hrs)**	**Load**
In/Out – Inner Harbor Terminals (Small Ships)	Bay Bridge	Dock	0.833 / 0.833	2%
In/Out – Inner Harbor Terminals (Large Ships – Turning Basin)	Bay Bridge	Dock	1.42 / 0.833	2%
In/Out – Outer Harbor Terminals (Small Ships)	Bay Bridge	Dock	0.75 / 0.75	2%
In/Out – Outer Harbor Terminals (Large Ships – Turning Basin)	Bay Bridge	Dock	1.33 / 0.75	2%
Shifts (small number of calls have shifts from one terminal to another)	Oakland	Oakland	0.75	2%
Transit Out of Port				
Direction	**Link Start**	**Link End**	**Distance (nautical miles)**	**Speed (knot)**
Out – All[1]	Bay Bridge[1]	Harding Rock	4.7	13.5
Out – All[1]	Harding Rock[1]	Golden Gate	1.8	13.5
Out – All (alternative route) [1]	Bay Bridge[1]	Golden Gate	5.3	13.5
Out – All	Golden Gate	Pilot Buoy	10.4	13.5
Out – All	Pilot Buoy	Pilot Departs	1.7[2]	10
Out – To Asia or Northern Ports	Pilot Departs	November Buoy	6.0 – 1.7 = 4.3	Cruise
Out – To Hawaii	Pilot Departs	Whiskey Buoy	6.8 – 1.7 = 5.1	Cruise
Out – To Southern Ports	Pilot Departs	Sierra Buoy	7.3 – 1.7 = 5.6	Cruise

1. SF Bar Pilot suggested that all ships use the Deep Water Traffic Lane north of the Harding Rock Buoy though some ships under certain conditions may take the more direct route demonstrated with the alternative route.
2. Assumes 10 minutes at slower speed for the pilot to board and depart safely. Distance in this mode was subtracted from the cruise mode. Distances were measured from east of Pilot Buoy.

Based on the SF Bar Pilot's (2006) best judgment, the maneuvering time is longer for the Inner Harbor berths and for larger vessels defined here as greater than 750 ft in length. The larger ships require more time to turn and may need to turn only in prescribed areas, such as the Inner Harbor's turning basin shown in Figure 2-3. Therefore, as shown in Table 2-1, the SF Bar Pilot (2006) estimated the maneuvering time for larger ship as longer than that for smaller ships and shorter for the Outer Harbor terminal calls than the Inner Harbor terminal calls because of the shorter distance from the Bay Bridge and more water area available for turning directly at the berth.

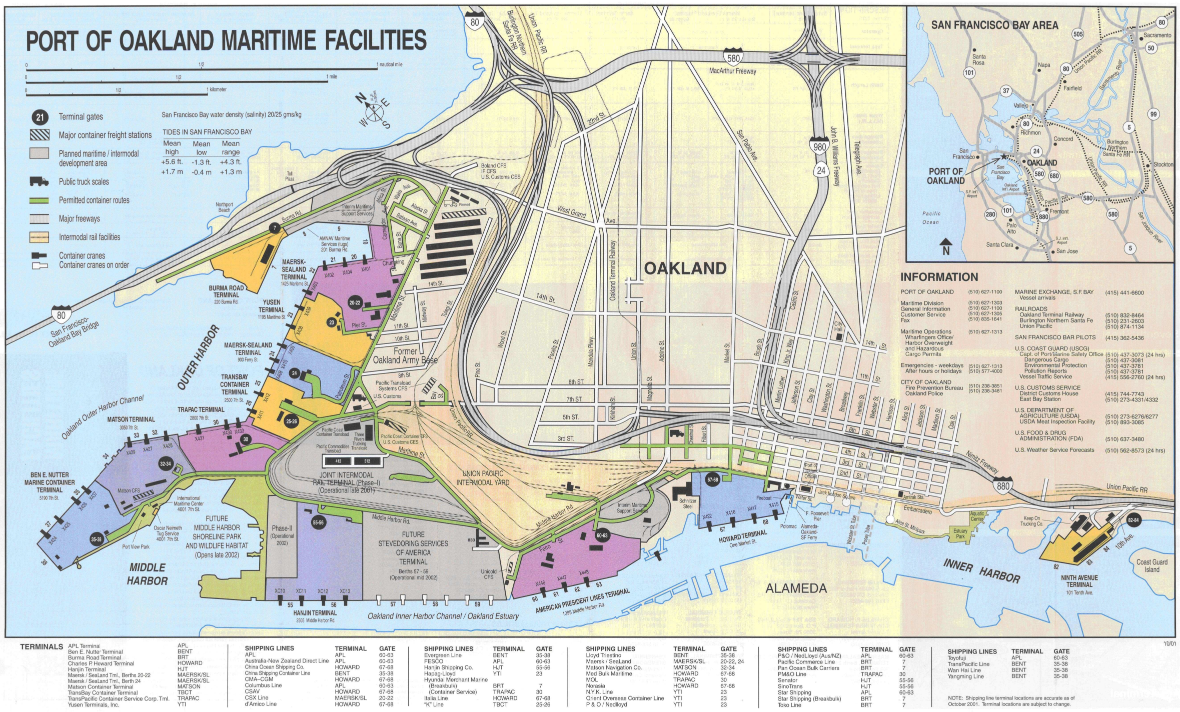

Figure 2-3. Port of Oakland harbor and berths.

ENVIRON determined the activity along each link using the number of vessel movements along each segment using the port calls for 2005. For the most part, it was straightforward to determine the total vessel movements for most segments because each call required transit along set routes described in Table 2-1. A special California State Lands Commission (2006) data source provided the last and next port of call from which the direction (North, West, or South) outside of the pilot buoy was determined. The direction south from the Pilot Buoy is due south whereas the western route is southwest and the northern route is northwest. Based on these general directions, ENVIRON rendered a judgment of the direction to or from the San Francisco Bay as shown in Table 2-2 to determine the link of the cruise modes. The berths where the ship called and the ship length determined the maneuvering mode movements. The purpose of defining these segments was to provide emissions that were accurately spatially allocated and to determine the distance along each link to estimate the time in mode.

Table 2-2. Port direction from the San Francisco Bay.

Port	***Direction***
US northern continental ports including Alaska, Canadian, and all Asian	N
US Hawaiian, Guam, New Zealand, Fiji, Tahiti	W
US Southern continental ports, Mexican, Panama, Chile and other South American, and Caribbean and European through Panama	S

Emissions were determined for each link as shown in the equation below accounting for the engine power, typical load time at that load. The emissions were determined separately for propulsion and auxiliary engines.

Emissions per vessel/mode = (Rated Power) x (Load Factor) x (Time) x (Emission Factor)

Emissions total = Σ{All vessel calls and modes}

The time in each link was determined from the link distance and estimated speed. The load factor also depended upon the vessel's maximum speed and the actual vessel speed in each mode.

Input Data and Use

The basic input data that form the basis for the emissions from large ocean-going vessels include port calls through 2005, vessel installed power and maximum speed, and estimates of load and speed during the operation modes defined.

Port Calls

The Port calls for the Port of Oakland 2005 were provided from two data sources, California State Lands Commission (2006) and the Port of Oakland Wharfingers (2006). The Lands Commission collects port calls and records last and next port of call. The Lands Commission data however uses self-reporting of calls for purposes of tracking ballast and other dumping, and it was not reported promptly, so significant lag occurred between the actual port call and the report for that port call. The Wharfingers data was recorded at the dock and includes the arrival and departure time allowing the hotelling time to be calculated.

The Wharfingers data was viewed as the primary source of port calls and the Lands Commission data used only to provide the next and last port of call information to allocate trips outside of the Pilot Buoy. The data handling procedure to describe the vessel calls is described in more detail in Appendix A.

When the next or last port of call was another Bay Area ports (Carquinez, Sacramento, San Francisco, or Stockton), the transit modes were assumed to be to and from Oakland out past the Pilot Buoy. Vessel transit to other ports was assumed to proceed to or from the route to or from route described for the Port of Oakland. For vessel calls when the next or last port of call was another Bay Area port, the cruise mode route (north, south, or west of the Pilot Buoy) was assumed to be typical of other Port of Oakland calls by that vessel, or, if other calls did not occur with that vessel, the same route out was assumed as the route entering the port.

Propulsion Power and Load

Propulsion power and vessel speed was derived from the Lloyds (2006) Database and data handling procedures are described in Appendix B. The estimates of installed power were then corrected to estimate maximum power using the survey data from the Port of Los Angeles emission inventory study. (Starcrest, 2005)

Vessel Propulsion Power = Lloyds Power / (0.968)

Vessel Maximum Speed = Lloyds Vessel Speed / (0.968)

The load factors for the propulsion power over any given link are determined from the classic Stokes Law cubic relationship of speed and load. The proportional relationship of load to the vessel speed can be expressed as in the following equation where the 100% load factor would correspond to the vessel operating at its maximum speed.

$$\text{Load Factor} \propto (\text{Vessel Speed} / \text{Vessel Maximum Speed})^3$$

From the Port of Los Angeles study (Starcrest, 2005), the cruise speed of the vessel was estimated to be 0.937 of the maximum speed. This calculation of the cruise speed results in a load factor of 0.823.

Auxiliary Power and Load

As described in Appendix C, the auxiliary power was derived from auxiliary generator capacity derived primarily from the Lloyds database supplemented by other available data and estimates. The load factors used to describe the vessel activity were derived from the EPA Best Practices estimates shown in Table 2-3.

Table 2-3. Auxiliary engine load factors (ICF, 2005).

Ship-Type	Cruise	RSZ	Maneuver	Hotel
Auto Carrier	0.13	0.30	0.67	0.24
Bulk Carrier	0.17	0.27	0.45	0.22
Container Ship	0.13	0.25	0.50	0.17
Cruise Ship	0.80	0.80	0.80	0.64
General Cargo	0.17	0.27	0.45	0.22
Miscellaneous	0.17	0.27	0.45	0.22
RORO	0.15	0.30	0.45	0.30
Reefer	0.20	0.34	0.67	0.34
Tanker	0.13	0.27	0.45	0.67

ARB (2005) proposed to use alternative load factors, shown in Table 2-4, which were different than what ICF (2005) reported as derived from Starcrest (2005). Because the ARB document had not been finalized, these load factors were not used in the analysis but are provided as a comparison. Most of the ship calls to the Port of Oakland were from container vessels, so the use of the ARB load factors would affect the emission estimates primarily for reduced speed zone (RSZ) modes (between the Pilot Buoy and the Bay Bridge).

Table 2-4. Auxiliary engine load factors (ARB, 2005). (not used in this study.)

Ship-Type	Cruise	RSZ	Maneuver	Hotel
Auto Carrier	15%	15%	45%	26%
Bulk Carrier	17%	17%	45%	10%
Container Ship	13%	13%	50%	18%
Cruise Ship	80%	80%	64%	16%
General Cargo	-	-	-	-
Miscellaneous	-	-	-	-
RORO	15%	15%	45%	26%
Reefer	15%	15%	45%	32%
Tanker	24%	24%	33%	26%

Emission Factors

The studies related to marine engine emissions that have been used in the Port of LA study (Starcrest) and ARB (2005) include the ENTEC (2002) and IVL (2004) studies written by the same author, David Cooper. The emission data from the ENTEC study were used in the Port of Los Angeles emission inventory report (Starcrest, 2005). The author of the 2002 ENTEC study later published a report that derived average emission rates with supplemented emission data compiled in the ENTEC study for marine engines (IVL, 2004). The emission data used in the IVL (2004) study are summarized in Table 2-5 for engines built prior to the MARPOL (1997) requirements for engine manufactured after January 2000.

Table 2-5. Emission Factors (g/kW-hr).

Engine Type	Fuel Type	BSFC	HC	CO	NOx
Slow Speed	Residual Oil	195	0.3	0.5	18.1
Slow Speed	MGO	195	0.3	0.5	17.0
Medium Speed	Residual Oil	210	0.2	1.1	14.0
Medium Speed	MGO	210	0.2	1.1	13.2
Steam Boiler	Residual Oil	305	0.1	0.2	2.1
Steam Boiler	MGO	305	0.1	0.2	2.0

For this study, the IVL emission factors in Table 2-5 were used except for particulate emissions. The particulate emission factors in the IVL work do not correspond to the expected effect of added sulfur in the fuel, especially comparing the medium and slow speed engine emissions when using higher sulfur fuel. Because fuel sulfur levels are under scrutiny and it will be necessary to estimate the effect of lower fuel sulfur, it was necessary to be able to correct the PM emissions based on the sulfur level in the fuel. The following equation was determined from test data of PM emissions with a change in the fuel sulfur level in an EPA study (EPA, 2002). The PM emissions rates when using low (0.4%) sulfur fuel was taken from IVL (2004), while the adjustment equation to address higher sulfur fuels was derived from the EPA study. The algorithm to estimate PM emission rates at any given fuel sulfur level then is demonstrated in the following equations.

*SPM adj = BSFC * 7.0 * 0.02247 * 0.01 * (soxfuel - soxbas)*

Where

soxbas = 0.4% sulfur in the IVL (2004)

soxfuel = % sulfur in fuel

PM (g/kW-hr) = 0.2 + SPM adj

The sulfur adjustment equation was derived by EPA by estimating that the fuel sulfur partially converts (2.247%) to SO3 (with the remainder emitted as SO2), which rapidly hydrolyzes in the humid exhaust to hydrated sulfuric acid [historically assumed to be in the form of H2SO4:(7)H2O] and condenses on other particulates. Hence, the molecular weight adjustment of 7.0 (ratio of hydrated sulfuric acid to elemental sulfur). The figure 0.01 in the equation is to adjust values in percent (%) to fractional values. The method described in the equations above result in 0.86 and 0.81 g/kW-hr particulate emission rates for medium and slow speed engines burning 2.4% sulfur fuel, close to the PM emission rate averaged for these two engine types in IVL (2004). Recent publicly-available data that come from Fleischer (1998) and Maeda (2004) measured particulate emissions of 0.44 and 1.06 g/kW-hr when run on 1.5% and 2.36% sulfur fuels are consistent with the method for PM and sulfur fuel effects described here.

The SO2 emissions therefore can be calculated from the fuel consumption accounting for the fraction of sulfur that directly converts to particulate as shown in the equation below.

*SO2 (g/kW-hr) = 2 * (Fuel sulfur fraction) * BSFC * (1- 0.02247)*

Considerable uncertainty exists for propulsion engine emissions when applying low load adjustment factors for emissions. For the initial study, the Port of Los Angeles (Starcrest, 2005) low load adjustments shown in Table 2-6 were used.

Table 2-6. Low load adjustment factors (Starcrest, 2004).

Load	HC	CO	NOx	PM	SO2
1%	89.44	20.00	11.47	19.17	1
2%	31.62	10.00	4.63	7.29	1
3%	17.21	6.67	2.92	4.33	1
4%	11.18	5.00	2.21	3.09	1
5%	8.00	4.00	1.83	2.44	1
6%	6.09	3.33	1.60	2.04	1
7%	4.83	2.86	1.45	1.79	1
8%	3.95	2.50	1.35	1.61	1
9%	3.31	2.22	1.27	1.48	1
10%	2.83	2.00	1.22	1.38	1
11%	2.45	1.82	1.17	1.30	1
12%	2.15	1.67	1.14	1.24	1
13%	1.91	1.54	1.11	1.19	1
14%	1.71	1.43	1.08	1.15	1
15%	1.54	1.33	1.06	1.11	1
16%	1.4	1.25	1.05	1.08	1
17%	1.28	1.18	1.03	1.06	1
18%	1.17	1.11	1.02	1.04	1
19%	1.08	1.05	1.01	1.02	1

Starcrest (2005) estimated an average load of 2% for the maneuvering mode. EPA however estimated that the maneuvering mode adjustments should be 5.28 / 7.41 / 1.36 / 1.68 / 1.55 for HC / CO / NOx / PM / CO2 (SO2) respectively. (ENVIRON, 2002) The EPA estimated adjustments were considerably lower than that used in the Port of Los Angeles study and so raises significant uncertainty and deserves further study. The adjustment factors used in the Port of Los Angeles study (Starcrest, 2005) shown in Table 2-6 were derived from an EPA contracted study (EEA, 2000), which used for PM emissions estimates at low load only data from smaller medium speed engines using lower sulfur fuel. So the adjustments as applied to the large propulsion engines using high sulfur fuel in the Port of Los Angeles study is not justified and actual emissions data should be developed to verify proper estimates for the adjustments to increase emissions at lower loads. In particular because the PM emissions are so dependent upon the fuel sulfur conversion to hydrated-sulfate, an adjustment based on data collected with engines using low sulfur fuel would not be appropriate and likely overestimates the emission increase. When the particulate is due primarily to the fuel sulfur, the PM adjustment should correspond to the fuel consumption increase rather than other factors. In addition, because during maneuvering the engine cycles on and off, a 2% average load reflects the relative time in mode under no load (idle emission rates have not been established) and under loads much higher than 2%.

Boiler Emissions

Using the time in mode of the ships for each links, ENVIRON used the 0.0125 tonnes of fuel consumed per hour (ICF, 2005) to estimate total activity for this source. ICF (2005) also provided emission factors for boilers.

Air Resources Board: Revisions to the Marine Vessel Portion

- Provide more detailed clarification of ship types.

- Provide breakdown of number of unique ships by type, ship visits by type, the age of the vessels, registration by country, vessel age, and the percentage or number of vessels based on the number of vessel calls during the year (e.g. % making 1 visit, 2 visits,. 5-10,etc.

- Provide average time in mode and vessel activity.

- Use the ARB load factors for auxiliary engines (except for the reduced speed zone factors which are not available) rather than the load factors developed by Starcrest Consulting Group. The ARB load factors are based on the ARB's Oceangoing Ship Survey, which collected information on over 1000 auxiliary engines used on ships visiting California ports. The Starcrest factors were based on a more limited survey conducted for the Port of Los Angeles.

- Under "Emission Factors," a reference needs to be provided for the 2004 IVL report used as a source for most of the emission factors in the Environ report. In addition, some discussion of the differences in emission factors between the 2004 IVL and the 2002 Entec would be helpful. In particular, we note that some of the 2004 IVL HC emission factors are about half the 2002 Entec values.

- Use the PM emission factors in the ARB's staff report for the ship auxiliary engine regulation, Appendix D.

Table II-2: Main Engine Emission Factors – Transit Mode (g/kW-hr)

Engine Type	Fuel Type	PM	NOx	SO2	HC	CO	CO2
Slow Speed	HFO	1.5	18.1	10.5	0.6	1.4	620
Medium Speed	HFO	1.5	14	11.5	0.5	1.1	677

Table II-4: Auxiliary Engine Emission Factors – Transit, Maneuvering, and Hotelling (g/kW-hr)

Engine Type	Fuel Type	PM	NOx	SO2	HC	CO	CO2
Medium Speed	HFO (2.5%)	1.5	14.7	11.1* ~~12.3~~	0.4	1.1	722
Medium Speed	Marine Distillate (0.5%)	0.38* ~~0.3~~	13.9	2.1	0.4	1.1	690

* Changes referenced in Chapter 7, Table VII-1

- Make clear how emission factors will be adjusted for low load.

- List emission factors used for boiler emissions.

- Due to differences in ARB and Environ recommended emission factors for auxiliary and main engines, a sensitivity analysis will be performed comparing the results from each set of emission factors.

3. HARBOR CRAFT

This section provides emission estimation methodology for harbor craft used to conduct annual maintenance dredging and disposal and vessel assist operations at the Port of Oakland.

Operation and Maintenance Dredging and Disposal

Background & Limitations

O&M dredging removes new material deposited into the Bay by stream and urban runoff as well materials that are redistributed through a process known as shoaling to form shallow areas that can interfere with safe navigation. Dredging at the bulk terminal berths operated by the privately owned and operated Schnitzer Steel facility is not addressed in this analysis.

The Port and the US Army Corps of Engineers (USACE) contract separately for O&M dredging, at the Port's berths and the Federal channel respectively. In normal years, dredging has been conducted by a diesel-powered clamshell dredge, accompanied by a tender, and supported by several boats. Material removed from the bottom is transferred into barges by the dredge. The barges, sometimes referred to as scows, are then pushed by a diesel-powered tug to a disposal or reuse site. After the barge is emptied, the tug returns with the empty barge to pick up a new load. To protect sensitive marine species, O&M dredging is limited to a 4- month "window" that extends from August 1 through November 30 each year.

The base year 2005 was an atypical year for O&M dredging. The year was non-representative in terms of the total volume of material dredged, the equipment used to conduct dredging, and the choice of disposal sites. The Port dredged only 36,580 cubic yards, versus a long-term average of 123,000 cubic yards during the previous five years. (Port-2006) The USACE removed 276,000 cubic yards, versus their 2001-2005 mean of 310,000 cubic yards. (USACE-2006) Because their Federal channel maintenance dredging was being conducted in conjunction with the Port's –50 Foot Deepening Project, the USACE's contractor used an electric cutter head dredge instead of a diesel clam shell dredge. In addition, half the material was disposed of within the Port, at the Middle Harbor Enhancement Area, rather than a remote site. These circumstances greatly reduced O&M dredging emissions in 2005 compared to an average year. In typical years, excavation of O&M dredging material is conducted with a diesel-powered dredge and the material is disposed either at the in-bay Alcatraz site (for the Port's berth sediments) or at the Deep Ocean Disposal Site (DODS) for the USACE channel sediments."

Methodology

Operation & Maintenance Dredging was divided into two activities, dredging and dredge materials transport. Emissions from these activities were summed to form the final total emissions from maintenance dredging.

Dredging equipment included:

- A clamshell dredge with main and auxiliary diesel engines,
- A dredge tender with main and auxiliary diesel engines,

- A workboat and a crew boat each with a single diesel engine and an auxiliary engine.
- A barge or scow into which the dredged material is loaded for disposal or reuse. The barge has no engines.

The equation used to calculate emissions from each of the engines involved in dredging is:

$$Equip_{Emiss} = EF \times Time_{hrs} \times Engine_{bhp} \times LF \times 1/(453.6 \times 2000)$$

Where:

$Equip_{Emiss}$ is the engine's emissions in tons per year,
And
EF is the engine emission factor in grams per brake horsepower-hour
$Time_{hrs}$ is annual operating hours
$Engine_{Bhp}$ is the brake horsepower rating of the engine
LF_{wt} is the time weighted load factor, based on different engine operating modes during a round trip, stated as a ratio of 1, and
$1/(453.6 \times 2000)$ is the conversion of annual grams to annual tons

Materials transport equipment includes:

- A diesel powered tug that pushes the loaded scow or barge to the disposal area, stands by during unloading, and pushes the unloaded barge back to the Port. The tug has two main propulsion engines and one or two auxiliary engines, only one of which is assumed to operate at a time.

The equation used to calculate main propulsion and auxiliary engine emissions from the tug is:

$$Tug_{emiss} = EF \times {}_{Engine\ Bhp} \times Time_{hours} \times LF_{wt} \times Trips \times 1/(453.6 \times 2000)$$

Where:

Tug_{emiss} is tug emissions in tons per year
And
EF is the tug main propulsion or auxiliary engine emission factor in grams per brake horsepower-hour
$Engine_{Bhp}$ is the combined brake horsepower rating of a tug's main propulsion engines, and the brake horsepower rating of the auxiliary engine
Time is the tug operating time per round trip in hours
Trips is the annual number of round trips per tug
LF_{wt} is the time weighted load factor, based on different engine operating modes during a round trip, stated as a ratio of 1, and the load factor for the auxiliary engine stated as a ratio of 1, and
$1/(453.6 \times 2000)$ is the conversion of annual grams to annual tons

Once it reaches the disposal area, a barge or scow is unloaded in one of two ways. Unloading at a Bay or ocean disposal site is accomplished by gravity - that is by opening the bottom of the barge and allowing material to flow out. At beneficial reuse sites like the wetlands restoration project at Montezuma Slough near Collinsville, a dedicated "off-loader" draws the wet material out of the barge and pumps it "upland" for distribution. The unloading process is not included as Port emissions in this inventory. Actually, the Montezuma off-loading process is essentially a zero emissions operation anyway because it uses an electric off-loader. A similar off-loading system is planned for the Hamilton wetlands restoration site in Marin County, which is expected to be a prime disposal area for O&M material in the future. (USACE-2006). However, pollutants generated by tugs making the return trip to the dredging area are considered Port emissions in this analysis.

Input Data and Use

Dredging - Key dredging input data for 2005 included the list of equipment used by the Port, the volume of material removed, the dredge's daily capacity, and the emissions and load factors assumed. The volume of material was collected from the Port and the other information from prior studies. (ICF Kaiser, Weiss & Associates, and CARB Fuels-2004). As noted, the USACE conducted maintenance dredging in conjunction with the –50' Deepening Project, and because that project was conducted by an electric dredging system, it was assumed to be a zero emissions activity in 2005. Input data and assumptions for dredging Port berths are summarized in 3-le 1.

Table 3-1. Operation & Maintenance dredging, key data and variables.

Equipment	Horse power	Load Factor	Capacity	Units	Emission factors in g/bhp-hr					
					NOx	CO	POC	SOx	PM10	PM2.5
Clamshell dredge	1142	0.75	275	cy/hr	9.84	0.82	0.37	0.47	0.54	0.52
Dredge Aux. Engine	160	0.43			7.46	1.27	0.20	0.00	0.17	0.17
Tender	336	0.69			7.46	1.12	0.20	0.00	0.17	0.17
Tender Aux Engine	14	0.43			7.46	1.27	0.20	0.00	0.17	0.17
Crew boat	212	0.43			7.46	1.12	0.20	0.00	0.17	0.17
Crew boat Aux. Engine	54	0.43			7.46	1.27	0.20	0.00	0.17	0.17
Work boat	197	0.43			7.46	1.12	0.20	0.00	0.17	0.17
Work boat Aux. Engine	17	0.43			7.46	1.27	0.20	0.00	0.17	0.17

Note: Horsepower ratings, load and emission factors from "Best Practices in Preparing Port Emissions Inventories", Prepared for EPA by ICF Kaiser for EPA, June 23, 2005, Table 2-15 through 2-18. Load factor and capacity of dredge from "Evaluation of Air Emissions from Dredging Activities at the Port of Oakland for Use in Determining the Least Environmentally Damaging Practical Alternative (LDDPA), Weiss & Associates, August 11, 2003. SO2 and PM10 emission factors corrected as necessary for lower sulfur diesel fuel using data and methods from "Proposed Regulatory Amendments Extending California Standards for Motor Vehicle Diesel Fuel to Diesel Fuel Used in Harbor Craft and Locomotives", Appendix F, October 1, 2004 http://www.arb.ca.gov/regact/carblohc/appf.pdf Conversion factor g/bhp-hr = g/kw-hr/1.341

Transport to Disposal - The USACE has been closely tracking disposal and reuse emissions from the –50' Deepening Project and has collected real world data on tug engine horsepower ratings, barge volumes, travel time to various sites, and tug propulsion engine load factors. (GAIA 2005). The USACE data, information provided by the Port and USACE on the distribution of materials to disposal areas in 2005, and emission factors from the ICF Kaiser report done for EPA and cited above, were used to estimate disposal emissions. Table 3-2 summarizes key input data and assumptions.

Table 3-2. Operation & Maintenance dredging disposal transport, key data and variables.

Variable		Alcatraz	Port Reuse or Disposal	Montezuma	Aux. Engines
One-way Nautical Miles to Reuse/ Disposal Location		6.0	3.8	47.0	
Travel Time (Note 1)					
	Loading	6.8	6.8	8.0	
	Loaded Travel	0.9	0.6	7.1	
	Unloading	0.5	6.8	1.5	
	Unloaded Travel	0.6	0.4	5.1	
	Total Travel Time	8.86	4.6	21.7	
Load Factors					
	Loading (Note 2)	-	-	-	
	Loaded Travel (Note 3)	0.83	0.83	0.83	
	Unloading	-	-	-	
	Unloaded Travel	0.83	0.83	0.83	
Weighted Load Factor		0.15	0.06	0.47	0.43
Average Scow Load (Note 4)		2,720	2,550	2,550	
NOx Emission Factor (g/bhp-hr) (Note 5)		9.84	9.84	9.84	7.46
POC Emission Factor (g/bhp-hr)		0.37	0.37	0.37	0.20
CO Emission Factor (g/bhp-hr)		0.82	0.82	0.82	1.27
SO2 Emission Factor (g/bhp-hr)		0.00	0.00	0.00	0.00
PM10 Emission Factor (g/bhp-hr)		0.42	0.42	0.42	0.17
PM2.5 Emission Factor (g/bhp-hr) (Note 6)		0.41	0.41	0.41	0.17

Overall Note: Unless otherwise specified, information derived from USACE monitoring of dredge disposal emissions, GAIA Constants, 2005-2006

Notes:
1 - Travel times to Hamilton and SFDODS calculated based on average haul speed to Montezuma; travel time to Port reuse based on 5 knot moving speed. Unloading time for SFDODS and Alcatraz assumes bottom dump. GAIA, 2006
2 - Load factor set to zero per discussion at IPR; Port of Oakland (Len Cardoza) indicates that tugs shut down while scow is being loaded and unloaded.
3 - Based on information provided by Mark Guinn at Brusco to Susanne von Rosenberg of GAIA
4 - 85% of bin count shown to allow for bulking, 80% capacity to DODS or Alcatraz due to spill control requirements - GAIA, 2006
5 - Emission factors and load factors from "Best Practices in Preparing Port Emissions Inventories", Prepared for EPA by ICF Kaiser for EPA, June 23, 2005, Tables 2-16 to 2-18, Conversion factor from g/Kw-hr to g/bhp-hr=1.341. SO2 and PM10 emission factors corrected as necessary for lower sulfur diesel fuel using data and methods from "Proposed Regulatory Amendments Extending California Standards for Motor Vehicle Diesel Fuel to Diesel Fuel Used in Harbor Craft and Locomotives", Appendix F, October 1, 2004 http://www.arb.ca.gov/regact/carblohc/appf.pdf
6 - Conversion factor = 0.97; from "Best Practices in Preparing Port Emissions Inventories", p.20

Emissions from transport to disposal are summarized by disposal area and totaled for 2005. Most emissions occurred from the transport of material to Montezuma because of the volume of material and the distance to the site.

Assist Tug Activity and Characteristics

Background

This section describes the emission estimation methods and results for the base year, 2005, for the operation of the tugs that assist container cargo vessels to berth at and depart from the Port of Oakland. The role of the assist tugs is to ensure safe navigation, which is particularly important in windy weather and when vessels turn to reverse direction within the Inner or Outer Harbors. As discussed elsewhere, cargo vessels operating in San Francisco Bay have qualified pilots on board to guide the vessel to and from its destination. In virtually all cases, the pilot requires two tugs to meet each cargo vessel bound for the Port of Oakland in the federal channel near the Bay Bridge and accompany that vessel until it is tied up at its berth. When the vessel is ready to leave, the process is reversed and the tugs accompany the vessel back to the Bay Bridge. This section addresses two types of tug operations, the actual vessel assist operation described above and the tugs' transit from their base to the Bay Bridge.

There are a number of variables that affect actual tug emissions during an assist event. Among the most important are:

- The horsepower ratings of assist tug propulsion engines, which vary from tug to tug by a factor of three or more,
- The time required to complete the assist operation, which vary by a factor of almost two, depending on the length of the trip from the Bay Bridge to berth, whether the vessel was arriving or departing, and the size of the vessel.

Assist tugs are not assigned randomly. Cargo vessels vary greatly in size and maneuverability, and tugs have different power levels, rudders and other equipment. To ensure safe navigation it is important that tugs be properly powered and equipped to handle the vessel it is assisting. The San Francisco Bar Pilots publish a guideline document that sets minimal requirements for tugs based largely on the length and draft of the vessel they will assist. (Bar Pilots Guidelines). Tugs are classified from "A" to "D" based on their minimum Bollard Pull, both ahead and astern. Bollard Pull is a measure of tug efficiency that goes beyond horsepower rating to consider other aspects of tug design, such as whether it is a "tractor tug", has twin or single propellers, the type of rudder, and has thrusters. The Bar Pilot guidelines specify minimum tug assist capabilities for various areas of the Bay, depending on the nature of the assist and local conditions. For the Port of Oakland, vessels are divided into five groups based on their length and draft, and the minimum Class of the two tugs required for each vessel is specified for each vessel size group. As might be expected, larger vessels require larger, more powerful tugs with higher Bollard Pull ratings. Table 3-3 shows this grouping and classification scheme.

Table 3-3. Tug/vessel grouping for the Port of Oakland.

Tug/Vessel Group	Corresponding Vessel Length	Class of Tug 1	Class of Tug 2
1	<550 feet	B or C	B
2	550-750 feet	B or B	B
3	750-900 feet	A or B	B
4	900-1000 feet	A	B
5	>1000 feet	A	B

There is no central process for the assigning tugs to vessels as they arrive at or depart from the Port of Oakland. Agents working for individual shipping lines hire assist tugs for each assist situation. The pilot on board the vessel checks to be sure the tugs that meet each vessel have the required capabilities, but because the Bar Pilots do not keep track of which tugs actually meet and assist each vessel, there is no central record that shows the assist activities of individual tugs operating at the Port of Oakland.

Approach and Methodology

ENVIRON took the following general approach to estimating assist tug emissions during the assist phase of their operation at the Port of Oakland.

- Developed a database for a fleet of the assist tugs representative of those that operated in San Francisco Bay in 2005,
- Grouped assist tugs as to their "class", or capability to assist the vessels of different sizes that call at the Port of Oakland,
- Calculated a mean horsepower rating and emission factor for each assist tug group,
- Sorted all 2005 vessel calls into five categories based on the length of the vessel, and "assigned" two tugs to each vessel call based on their assist tug class,
- Applied to assist tugs the average in-bound and out-bound maneuvering times that were used for vessels elsewhere in this report, that is; the average time required to transit between the Bay Bridge and the berth, for the Inner and Outer Harbors,
- Computed the number of vessel calls in each group, and
- Calculated emissions for each tug group using the formula described below.

The basic equation used to calculate emissions from each group of assist tugs is:

$$Tug\ Group_{Emiss} = EF \times Time_{hrs} \times Engine_{bhp} \times LF \times 1/(453.6/2000)$$

Where:

$Tug\ Group_{Emiss}$ is the tug group emissions in tons per year,
And
EF is the average group main engine and/or auxiliary engine emission factor in grams per brake horsepower-hour for each of the two tugs that assist each vessel
$Time_{hrs}$ is the annual operating hours for the tugs in each group, based on the number of vessel calls and the averaging maneuvering time per call,
$Engine_{Bhp}$ is the average main propulsion and/or auxiliary engine brake horsepower rating of the engines in each tug group
LF_{wt} is the time weighted load factor for the maneuvering phase for the main engine and/or auxiliary engine, taken from the literature, stated as a ratio of 1,
And *1/(453.6/2000)* is the conversion of annual grams to annual tons

Annual emissions from each tug group were added to compute total annual emissions from tug assist operations.

ENVIRON also calculated the emissions from tugs transiting to and from their base of operations to the Bay Bridge meeting location. The tugs in the database are based at various locations inside the Port, in Alameda, and in San Francisco and Richmond. ENVIRON used a similar approach to calculating emissions as that used for assist operations, except that operating time in the transit phase was estimated by dividing the distance from tug mooring locations to the Bay Bridge by an assumed average transit speed, and applying a load factor consistent with higher speed transit operation.

More detail on the key steps in the approach is provided below.

Characterizing the Assist Tug Fleet

In the absence of a central record that identified individual assist tugs and their activities, ENVIRON's challenge was to create a database that would be reasonably representative of the fleet of tugs that actually provided assist activities in 2005. The process began with a list published by the Marine Exchange (2005) of individual tugs that are "certified" to provide escort or assist services. Since certifications expire, and tug operators periodically relocate tugs to other port areas, tug operator websites were checked to ensure that the individual tugs on the list were still operating in San Francisco Bay and were being marketed as providing vessel assist services. Finally, several sources of information were checked to identify the Bollard Pull Classification of each tug and, as a minimum, the horsepower ratings of its main engines. An important source of information on tug engines was a 2002 list of tugs obtained by ENVIRON from GAIA, Inc. The GAIA list contained information on main and auxiliary engines, including their age and engine horsepower ratings. ENVIRON used the GAIA list as a starting point and updated it with information from the San Francisco Bar Pilots, the Bay Area Air Quality Management District (BAAQMD) and tug company websites. The Bar Pilots provided an updated certified list of tugs, the BAAQMD provided updated emissions information for tugs that had main propulsion or auxiliary engines retrofitted or repowered under the Carl Moyer Program since 2002, and the websites provided data on main engines and their horsepower ratings. If information on main engines was not available, a tug was not included in the database.

In the end, ENVIRON assembled a database with descriptive information on about 40 individual San Francisco Bay tugs, a fleet that ENVIRON assumes for purposes of this inventory is reasonably representative of the tugs that provided assist services in 2005. Each tug in the representative fleet has two main propulsion engines with horsepower ratings from 600 to 3600 horsepower each. If the tug's auxiliary engine horsepower rating was identified in the GAIA list or other sources, it was used. Other auxiliary engine horsepower ratings were filled in by assuming default average ratings (Best Practices, 2005). Auxiliary horsepower ratings ranged from 81 to 155 horsepower.

Emission factors for main propulsion and auxiliary engines were assembled from a variety of sources. Where engines were known to be of pre-1990 vintage, emission factors were taken from Carl Moyer Guidelines (2005 Carl Moyer Guidelines, Appendix B, Table B-18). If main propulsion engines had been repowered or retrofitted under the Moyer Program, Tier 1 non-road emission factors were used. If auxiliary engines had been retrofitted or repowered under the Carl Moyer program, Tier 1 or Tier 2 emission factors were used, depending on the year of action. In all other cases, default emission factors were applied (Best Practices, 2005). The emission factors for SO_2 and PM10 were adjusted if necessary to reflect the average sulfur fuel content found in ARB's survey of vessel operators (CARB Fuels-2004).

An average load factor of 0.31 from the literature was used tug propulsion engines during assist operations (Best Practices, 2005). Based on observations and descriptions provided by tug operators, this load factor may overstate the actual load on tug engines during these operations, perhaps significantly. Assist tugs spend most of their time escorting vessels at speeds of 8 knots or less. Under normal wind conditions tugs use higher power surges to slow some vessels as they approach the turning location, assist in making the 180 degree turn needed to reverse course for berthing or departure, positioning a vessel during the last stages of berthing, and to help the vessel separate from the berth on departing. These higher power activities occur for a relatively small portion of the time spent on escort and assist operation. A well-designed and conducted field study would yield a more accurate, Port of Oakland-specific load factor.

Managing Variability in Tug Characteristics and Assist Operations

Because of the variability described earlier in propulsion engine horsepower levels and assist times, and because tugs are assigned in part because of the needs of the actual vessels they are assisting, ENVIRON felt it was important to take these factors into account to provide a more accurate emissions estimate. The classification scheme shown in Table 3-3 and the database of vessel calls and other information used elsewhere in this report to calculate cargo vessel emissions provided an opportunity to allocate tugs more accurately by size and assist time. As noted earlier, ENVIRON used the classification scheme for tugs to group the tugs in the database and determine their average horsepower ratings and emission factors by group. Second, ENVIRON divided vessel calls into five groups based on the length of the vessel. Third, we "assigned" tugs by class to each vessel call group. Fourth, we divided vessel calls into in-bound and outbound legs to and from the Inner and Outer Harbors respectively. Finally, we assumed that each vessel call would have two tugs assisting. Tables 3-4 and 3-5 summarize this process.

Table 3-4. Horsepower and emissions factors for assist tugs by class (emissions factors in gm/bhp-hr).

Tug Class	Combined Engine HP	NOx	POC	CO	SO2	PM10	PM2.5
Mean Propulsion Engine Emissions Factors							
A	4,088	9.13	0.50	0.88	0.01	0.34	0.27
B	3,100	9.63	0.66	0.89	0.01	0.33	0.26
C	2,314	11.58	1.18	0.90	0.01	0.30	0.24
D	1,373	8.53	0.52	0.84	0.01	0.28	0.23
Mean Auxiliary Engine Emissions Factors							
A	121	6.84	1.05	0.36	0.01	0.18	0.18
B	110	8.57	1.33	0.20	0.01	0.25	0.24
C	100	7.20	1.14	0.30	0.01	0.19	0.18
D	110	8.08	1.17	0.31	0.01	0.25	0.24

The engine horsepower and emission factors shown above are the arithmetic means of the tugs in each class, based on the assist tug database.

Table 3-5. 2005 Vessel calls & maneuvering time, sorted by group and destination.

Vessel Size Groups	Vessel Calls	Time to berth (hrs)	Annual Berthing hours	Time to depart (hrs)	Annual Departing hours
Group 1 < 167.6 m (550')	49				
Group 1 Inner Harbor	49	0.83	41	0.83	41
Group 1 Outer Harbor	0	0.75	0	0.75	0
Group 2, 167.6 to 228.6 m (550-750')	386				
Group 2 Inner Harbor	296	0.83	247	0.83	247
Group 2 Outer Harbor	90	0.75	68	0.75	68
Group 3, 228.6 to 274.3 m (750-900')	537				
Group 3 Inner Harbor	214	1.42	304	0.83	178
Group 3 Outer Harbor	323	1.33	430	0.75	242
Group 4, 274.3 to 304 m (900-1000')	878				
Group 4 Inner Harbor	593	1.42	842	0.83	494
Group 4 Outer Harbor	285	1.33	379	0.75	214
Group 5, >304 m (>1000')	66				
Group 5 Inner Harbor	50	1.42	71	0.83	42
Group 5 Outer Harbor	16	1.33	21	0.75	12

Assist Tugs in Transit Operation

Since assist tugs must travel some distance to meet incoming vessels at the Bay Bridge and to return to their bases after assisting departing vessels, emissions from transit operation need to be included to complete the assist tug inventory. The representative tug database described above includes the name and location of tug operators. ENVIRON estimated the distance from each tug operator's base to the Bay Bridge to meet in-bound vessels, and from a central location within the Inner and Outer Harbors respectively to return to their base after assisting. The estimates were reversed to account for the trip back to their base after assisting departing vessels. It was assumed that each tug makes this round trip for each vessel assist assignment, however since tugs may occasionally continue from an assist assignment to another activity, this assumption may slightly overestimate transit mode emissions. The mean distances for each of the three modes were divided by an assumed average speed of 12 miles per hour to estimate average travel times per trip. The travel times were multiplied by the number of vessel calls to estimate total annual transit time for each group. Table 3-6 summarizes transit times.

Table 3-6. Assist tugs transit time (hours per year).

Group	Transit location	Average Distance by Tugs Assisting Group 1 Vessels (miles)	Transit Hours in 2005 [1]
	To Bay Bridge	12.8	52
	Inner harbor to home	13.3	54
1	Outer harbor to home	12.8	-
	To Bay Bridge	12.8	412
	Inner harbor to home	13.3	328
2	Outer harbor to home	12.8	96
	To Bay Bridge	12.8	573
	Inner harbor to home	13.3	237
3	Outer harbor to home	12.8	346
4	To Bay Bridge	12.8	937

Group	Transit location	Average Distance by Tugs Assisting Group 1 Vessels (miles)	Transit Hours in 2005 [1]
	Inner harbor to home	13.3	658
	Outer harbor to home	12.8	305
5	To Bay Bridge	12.8	70
	Inner harbor to home	13.3	55
	Outer harbor to home	12.8	17
Total Hours For All Vessel Groups			
	To Bay Bridge		2,045
	Inner harbor to home		1,334
	Outer harbor to home		764

1. Assumes average transit speed of 12 miles per hour

The same basic equation used for calculating assist emissions was used for transit emissions with two exceptions. First the times shown in Table 3-6 replaced assist times for each group, and second a load factor of 0.80 was used to reflect higher tug speeds.

Air Resources Board: Revisions to the Harbor Craft Portion

- Methodologies need to be consistent with that in ARB's methodology in the proposed Commercial Harbor Craft regulation.
- Current CO emission factor in Table 3-2 is significantly lower than the factors (1.97 or higher) ARB is using.
- The methodology does not account for engine model year, deterioration, or fuel correction factor.
- The Port used tug boat emission factor by class/combined engine HP. The combined engine HP is not clearly defined and the classifications made it impossible to make side-by-side comparison with ARB's emission factors.
- The Port need to clearly state the scope of work and reasons of excluding certain vessel types.
- Dredgers are included in the Port of Oakland harbor craft inventory while it is categorized as portable equipment by ARB and not part of the ARB harbor craft inventory.
- Comparison Tables

Comparison of emission factors for dredging (Table 3-1)

		Load Factor		NOx		PM10	
	HP	Port	ARB	Port	ARB	Port	ARB
Clamshell Dredge	1142	0.75	N/A				
Dredge Aux. Engine	160	0.43	N/A				
Tender	336	0.69	0.45	7.46	5.1-16.52	0.17	0.15-0.70
Tender Aux. Engine	14	0.43	0.43	7.46	4.8-6.9*	0.17	0.32-0.64
Crew boat	212	0.43	0.45	7.46	5.1-16.52	0.17	0.09-0.64
Crew boat Aux. Engine	54	0.43	0.43	7.46	5.2-13	0.17	0.24-0.70
Work boat	197	0.43	0.45	7.46	5.1-16.52	0.17	0.09-0.64
Work boat Aux. Engine	17	0.43	0.43	7.46	4.8-6.9*	0.17	0.32-0.64

* Using factors for Aux engines 25-50 HP

Comparison of load factors for transport to disposal (Table 3-2)

	Alcatraz	Port Reuse of Disposal	Montezuma	Aux. Engines
Port Weighted Load Factor	0.15	0.06	0.47	0.43
ARB Weighted Load Factor	0.5	0.5	0.5	0.43

ARB emission factors are model year and HP specific (pre 2005 model year). Port does not provide engine model year for us to compare.

Comparison of load factors for assist Tug

	Assist Operation	Transit Operation	Aux. Engines
Port Load Factor	0.31	0.8	N/A
ARB Weighted Load Factor	0.5	0.5	0.43

Note: ARB may split tug load into idle and non-idle operation

- A comprehensive list of commercial harbor craft associated with the Port of Oakland is needed. The information provided should include vessel-type, engine type, engine horsepower, annual hours of activity, and available annual fuel use data for each vessel. In addition, the proposed emission estimation methodology does not include the variety of commercial harbor craft the ARB included in its Goods Movement emission inventory. Vessel-types not included in the proposed methodology are commercial, fishing, charter fishing, ferry/excursion, pilot, and "others." The ARB would like to see emission estimates for all types of commercial harbor craft associated with the Port of Oakland or documentation as to why a particular commercial harbor craft vessel type was not included.

- The ARB considers those vessels that support dredging operations as part of the commercial harbor craft emission inventory. The emissions associated with the dredges themselves are considered "portable equipment" emissions and should be designated as such in the report.

- The emission factors provided in Table 3-1 do not match the emission factors set forth in the reference material (example: the emission factor for PM_{10} provided in the proposed methodology is almost half the emission factor provided in the referenced material). Environ needs to provide additional documentation as to the source of the emission factors and the load factor associated with dredges. In addition, the same comment applies to the emission factors set forth in Table 3-4. Those emission factors do not match the emission factors set forth in the referenced source material. Additional information as to how the emission factors were developed should be provided.

- The proposed emission estimation methodology appears to include travel distance (and time) from the Crowley Tug Boat Facility? Do those estimated distances (and times) include the entire trip from the Crowley facility to the Bay Bridge? Another question that needs to be addressed, although only emission sources on Port property are intended for inclusion in this emission estimation method, shouldn't emissions from sources whose primary function is to serve Port activities be included? If 95 percent of all activity associated with the Crowley facility is associated with the Port of Oakland, how can those emissions not be allocated to the Port of Oakland?

- Are the "transit hours in 2005" listed in Table 3-6 one-way or round-trip values? If they're round-trips, what are the vessel load factors associated with each leg of the trip?

4. CARGO HANDLING EQUIPMENT

Cargo Handling Equipment Activity and Inventory

This section documents the emission estimation methods and results for the base year, 2005, for cargo handling equipment (CHE) at Port of Oakland terminals and rail yards. One terminal that lies within the boundaries of the Port of Oakland terminals is the privately owned Schnitzer facility, which has not been included in the CHE inventory.

The approach used to estimate CHE emissions was to determine annual emissions for each piece of equipment by terminal according to engine characteristics (rated power and equipment type) and equipment operation (hours of operation and fuel consumption rates). The equipment population and operation estimates were derived primarily from terminal and rail yard surveys conducted in April 2006 by the Port of Oakland (Appendix D). For other input estimates, the inventory guidance documentation published by ARB (2005) was followed.

CHE emission estimates have been developed in accordance with ARB OFFROAD emission model methodology. For equipment in which on-road engines were used, ARB certifications have been consulted to take into account different emission rates. For equipment with additional emission control devices, control efficiencies derived from the ARB (2006) for those devices have been incorporated into emission estimations.

The basic equation used to calculate emissions from cargo handling equipment is:

$$E_p = EF_{p,t} * (1 - CF) * LF * n * hp * hrs$$

where: E_p = annual emissions of pollutant "p"
EF = emission factor (g/hp-hr)
CF = control factor (% reduction) by pollutant
LF = load factor (average load expressed as a % of rated power)
n = equipment population
hp = rated power (hp)
hrs = hours of activity per year (hr/year)
p - pollutant species (ROG, CO, NOx, PM10, SOx)
t - equipment type

Emission factors depend upon the fuel type, model year, rated power, cumulative hours/age, and retrofit control factor, if applicable. A significant part of the ARB (2005) CHE rule was the incorporation of accelerated fleet turnover or retrofit of in-use equipment. So when comparing the benefit of the ARB program, it was necessary to first determine the current age distribution and retrofit programs in place.

Input Data and Use

Surveys sent out to each terminal at the Port and the two rail yards were returned with detailed information for each piece of CHE which was used as inputs in emissions estimation, including:

1 Equipment Type
2 Engine Type
3 Engine Model Year
4 Engine Retrofit Type/Repower
5 Chassis
6 Chassis Model Year
7 Fuel Type
8 Annual hours of operation
9 Rated horsepower
10 Cumulative hours of operation

CHE were grouped into equipment type categories defined by ARB (2005), and results for the marine terminals are summarized in Table 4-1. As reported by ARB, yard trucks were found to be the most prevalent cargo handling equipment type.

Table 4-1. Equipment population by type (rail yards not included).

Equipment Type	Equipment Type Detail	Population	Percent
Container Handling Equipment	Side Pick	29	5.5%
	Top Pick	79	14.9%
Rubber Tired Gantry (RTG) Cranes		25	4.7%
Forklifts		52	9.8%
Other, General Industrial Equipment		53	10.0%
Tractors/ Loaders/Backhoes		25	4.7%
Yard Trucks		266	50.3%
Total		**529**	

A vast majority of Port of Oakland CHE is diesel powered with some liquefied petroleum gas (LPG) or gasoline powered equipment. All gasoline powered CHE was of 25 rated horsepower or less. Table 4-2 summarizes CHE population by fuel type and shows the number of emission control devices and repowered engines present in the fleet.

Table 4-2. Equipment population by fuel type with emission control device and repower summary data (rail yards not included).

Fuel Type	Total CHE Equipment	Percent of Total	Emission Control Devices or Repower	Population	Percent of Total
Diesel	453	86%	DOC	97	18%
			DPF	2	0%
			Repowered	16	3%
			No control device or repower	338	64%
Gasoline	42	8%	No control device or repower	42	8%
LPG	34	6%	Repowered	22	4%
			No control device or repower	12	2%
Totals	**529**	**100%**		**529**	**100%**

Table 4-3 summarizes the average horsepower and annual use by equipment type and horsepower. Actual annual hours of operation for each piece of equipment were used to estimate emissions however.

Table 4-3. Average horsepower and hours of operation by equipment type and horsepower range (rail yards not included).

ARB General Equipment Type Designation	Other Details	Horsepower Range	Number of Equipment	Average Horsepower	Average Annual Operation (hrs)
Container Handling Equipment	Side Pick	120	2	120	416
		175	9	164	1,373
		250	13	215	1,838
		500	5	287	366
	Top Pick	250	10	242	1,116
		500	69	303	1,860
RTG and other Cranes		250	4	225	492
		500	3	375	2,340
		750	8	546	462
		>750	10	1000	2,600
Forklifts		50	3	47	1000
		120	25	77	811
		175	15	173	1,053
		250	8	202	431
		500	1	270	1,040
Other, General Industrial Equipment		15	21	10	500
		25	21	20	500
		50	1	40	1,040
		175	1	150	52
		500	7	327	69
		750	2	648	850
Tractors/ Loaders/Backhoes		175	21	174	593
		250	4	177	600
Yard Trucks		175	74	172	1,764
		250	192	204	1,703
Total		---	529	---	---

Emission Factors

Because the ARB's OFFROAD emissions computer model is not publicly available, emission factors were taken from a number of different ARB sources describing the OFFROAD model to account for varied engine types and controls of each piece of CHE. Appendix E shows emission factor tables by fuel type.

<u>Diesel Powered CHE (Off-road engine)</u>

Emission factors and deterioration rates for diesel powered CHE with off-road engines were taken from ARB OFFROAD model emission factors (ARB, 2000). Emission factors were estimated for diesel powered CHE, in accordance with ARB (2005), according to the following equation:

EF = ZH + DR * chr

DR = (ZH * DF) / UL

where:
EF = Emission Factor
ZH = zero hour emission factor
DR = Deterioration Rate (g/hp-hr)
chr = cumulative hours on the piece of equipment (hr)
DF = deterioration factor (percent increase/percent useful life consumed)
UL = useful life (hrs)

Zero hour emission factors and deterioration factors were obtained from ARB mailout 99-32 (ARB, 2000). Cumulative hours were taken from returned CHE surveys. In cases where cumulative hours were not available for a piece of CHE, cumulative hours were estimated as annual use multiplied by the years of operation for the given piece of equipment through 2005. If useful life was specified in the returned survey, the survey value was used. If not specified, average useful life values from ARB (2005) were used.

Diesel Powered CHE (On-road engine)

CHE onroad diesel engine emission factors were taken from ARB certification standards found online at (http://www.arb.ca.gov/msprog/cert.htm). Deterioration factors were not used for onroad equipment.

Diesel Powered CHE with Control Devices

Diesel emission control devices were accounted for by applying a control factor to the emission factor by piece of equipment. Emission control device efficiencies were taken from ARB (2006) verified control factor estimates.

LPG Powered CHE

Emission factors for LPG engines were taken from Carl Moyer Program Guidance (ARB, 2006) for ROG, NOx, and PM10 while CO emission factors were taken from ARB mailout 98-27 (ARB, 1998). Default deterioration factors were used from ARB 98-27 for CO, but were not included in Carl Moyer program guidance and therefore not applied for ROG, NOx, and PM.

Gasoline Powered CHE

For gasoline powered CHE, emission factors and deterioration factors were taken from ARB mailout 98-04 (ARB, 1998a).

Fuel Correction Factor

Per ARB guidance (ARB, 2000), emission factors for NOx and PM off-road diesel CHE have been adjusted with fuel correction factors. These factors are dimensionless multipliers that have been applied to off-road diesel CHE emission factors. Appendix E shows fuel correction factors.

Load Factor

The load factor is an estimate of the average in-use load for equipment expressed as a percentage or fraction of the rated power of the engine in the equipment. The load factor accounts for idle and loaded operations by average the overall load during engine-on operations. The load factor can be determined from instrumented data, but the typical method to determine the load factor uses the fuel consumption per piece of equipment compared to the fuel consumption at the rated power. The Port of Oakland survey used fuel consumption per piece of equipment to estimate the load factor for various types of cargo handling equipment. The load factor inputs were derived from ARB (2005) and compared with the Port of Oakland surveyed load factors shown in Table 4-4.

Table 4-4. Load factor by diesel equipment type (ARB 2005 and this work).

Equipment Type	ARB Default Engine Load Factor	Port of Oakland Surveyed Load Factor
RTG Cranes	43%	33%
Excavators	57%	---
Forklifts	30%	34%
Container Handling Equipment	59%	17%
Other, General Industrial Equipment	51%	24%
Sweeper/Scrubbers	68%	---
Tractors/Loaders/Backhoes	55%	---
Yard Trucks	65%	27%

Fuel consumption survey results were collected by the Port of Oakland and used to estimate the average load factor. Fuel consumption records were available for about 35% of all Port of Oakland CHE identified in CHE surveys. ENVIRON calculated the load factor by comparing the actual fuel consumption with the maximum fuel consumption (fuel consumption at the rated power) to estimate the average load factor as shown in the equation below. The maximum fuel consumption rate was estimated using the brake specific fuel consumption (BSFC) rates that ARB (2000) had provided specific fuel consumption rates in two forms, in the referenced documentation for OFFROAD and inferred from draft OFFROAD emission factor input files. The two files conflict in the magnitude of the BSFC estimated. The alternative specific fuel consumption was determined through a carbon balance of ARB (2000) emission factors provided to ENVIRON as a file and include CO2 emission rates, and its use yielded high load factors because the BSFC was lower than the written documentation. These two specific fuel consumption estimates allowed for the calculation of Port specific CHE load factors according to the following equations. The reported average load factor in Table 4-4 was determined using the ARB (2000) official mailout version of the BSFC.

LF = FC / MFC / 7.1 lb/gal

MFC = hp * BSFC

where: LF = Load factor
FC = actual fuel consumption (gal/hr)
MFC = maximum fuel consumption (lb/hr)
hp = rated horsepower
BSFC = brake specific fuel consumption (lb/hp-hr)

As shown in Figure 4-1, ARB (2005) load factor estimates generally over estimate the load factors for equipment operating at the Port. Only forklifts were found to operate at higher average loads. The ARB load factor estimates were within the uncertainty range for diesel powered RTG cranes and forklifts. In cases where ARB (2005) load factors were shown to overestimate actual Port CHE load factors, emissions estimates could be high. The port-specific load factors were used in emissions calculations.

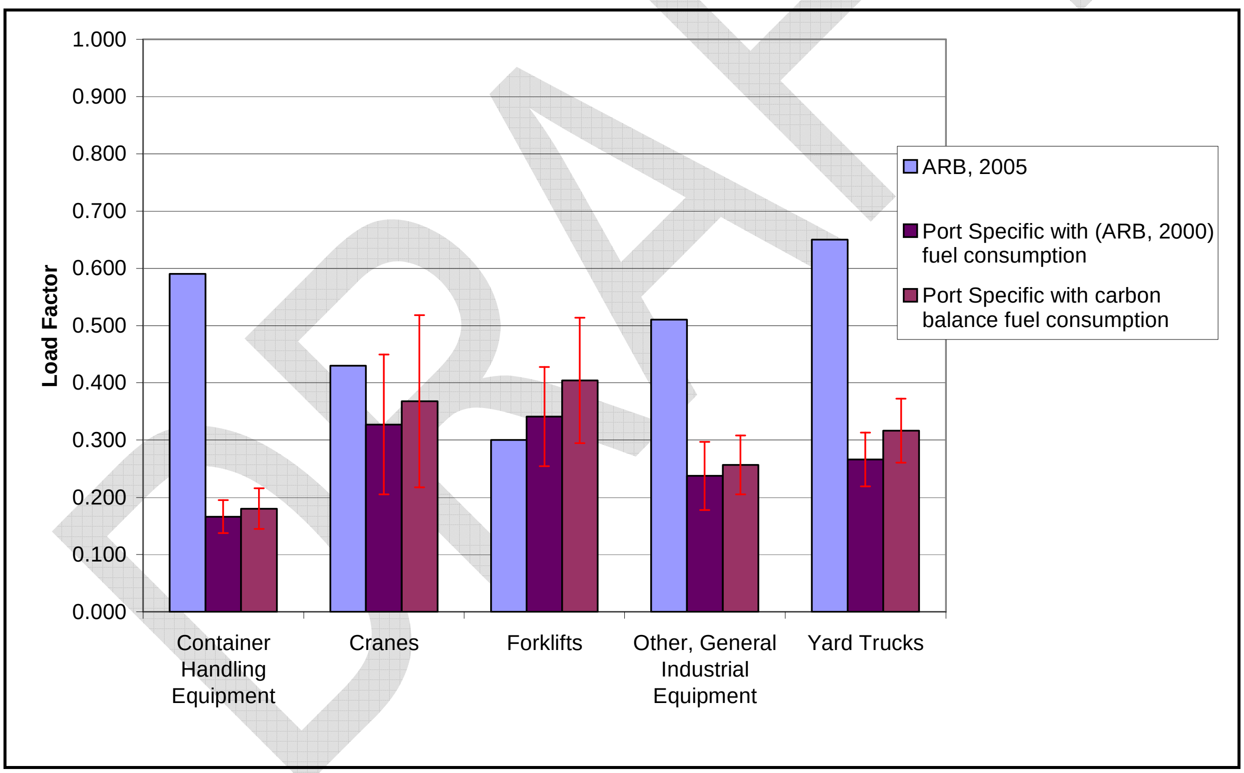

Figure 4-1. Comparison of ARB (2005) load factors and Port of Oakland specific load factors by equipment type based on ARB (2000) fuel consumption and carbon balance fuel consumption estimates. Load factor ranges for Port specific load factors represent 95% confidence intervals.

Specific gasoline and LPG engine load factors were sought; however the data was not sufficient to justify alternative load factors to the default load factors for LPG and gasoline CHE.

Air Resources Board: Revisions to the Cargo Handling Equipment Portion

- Under "Emission Factors," Diesel Powered CHE (On-road engine), p. 4-4,the definition of deterioration factor (DF) is different from how ARB used the DF in the *"Regulation for Mobile Cargo Handling Equipment at Ports and Intermodal Rail Yards".* The DF should be defined as the % increase in emissions over the useful life, not *"(percent increase/percent useful life consumed)".* Staff did not use the DF in the Offroad model, but used the percent change in emission rate over the useful life that is in the Offroad model and changed the definition of useful life to suit the applicable equipment. Then, the deterioration rate (DR) is equal to the zero hour emission factor times DR per the useful life. An example would be a model year 2000 yard truck (300 hp engine) with a useful life of 12 years operating 1500 hours per year on average over the useful life and the vehicle has accumulated 6000 hours so far. The zero hour (ZH) PM emission rate is 0.15 g/bhp-hr and the percent increase over the useful life (DF) is 67%, therefore the DR equals (0.15 g/bhp-hr * 0.67) = 0.10 g/bhp-hr. The new emission factor (EF) equals ZH plus DR * (accumulated hours/useful lifer) which is EF= 0.15 + 0.10*(6000/(12*1500)) = 0.18 g/bhp-hr.

  EF=ZH +DR(chr/UL)*
  *DR= ZH*DF*
  chr= cumulative hours on the piece of equipment

- Under "Emission Factors," Diesel Powered CHE (On-road engine), p. 4-4, states, "Deterioration factors were not used for onroad equipment". Why? The same deterioration factors should be used for both the offroad and onroad engines used in the same application.

- Under "Load Factor," p. 4-5, the suggested new load factors are not acceptable without more information. The methodology in determining these new load factors depends on many variables and especially depends on the accuracy of the survey information, both fuel consumption and hours of operation. Also, the BSFC is different at different loads and for different engines.

- To ensure the methodology used at Port of Oakland is consistent with that at rail yard, the Port need to supply ARB with activity data, and ARB will do the calculation and provide the inventory. Defaults for useful life, load factors, and deterioration rate will be used in the calculations unless site-specific data are provided and sufficient documentation is available to support the revised assumptions.

- Due to differences between ARB and Environ recommended CHE load factors, a sensitivity analysis will be performed comparing the emission results using each set of load factors.

5. TRUCK FREIGHT ACTIVITY

The Port of Oakland operations create a demand for truck trips to and from marine terminals to take containers to other locations. Trucks arrive at the Port terminals primarily via freeway interchanges or rail yards, and leave through the same exits of the general port areas or make round trips to the rail yards. Even if trucks arrive via surface streets, the trips can be defined at the primary freeway interchanges. The study site was therefore defined to include truck routes to each of three freeway interchanges and two rail yards.

It was beyond the scope to develop specific travel demand models or collect specific activity data including determining truck fleet characteristics, routes of individual trucks trips, ultimate destination of each truck trip, temporal profiles, or other similar estimates. The purpose of this study was to identify the basic annual activity demands and general spatial allocation.

This section documents the emission estimation methods and results for the base year, 2005, for large truck trips to and from Port of Oakland terminals and rail yards. The general approach used to estimate truck emissions was to determine truck travel by estimating truck trips to and from the marine terminals and trips, the trip mileage, and average trip speed. The basic emission estimates

$$E_p = n_{Truck\ Trip} * Miles_{Trip} * EF$$

where: E_p = emissions of pollutant “p”
n = number of trips
Miles = trip mileage
EF = emission factor (g/mile) is speed dependent
(Requires trips to be defined by mileage and speed)

Input activity data used to develop the emission estimates was derived from several disparate sources. Truck trips were determined for each terminal and rail yard and applied to one of various routes to and from the port area.

1. Truck trips
   a) Marine terminal (to and from freeway; to and from rail yard)Rail yards (to and from freeway; to and from marine terminal)
2. Trip mileage (routes)
   a) Outside terminals and rail yards
   b) Within terminal and rail yards
3. Idle time
   a) Outside terminals and rail yards queues
   b) Within terminal and rail yards
4. Emission factor
   a) Age distribution
   b) Average trip speed
   c) Idle emission rate

Trip Counts

To estimate the truck trips, the Port of Oakland conducted an in-depth survey with the terminal operators to determine the gates counts by configuration of each cab (tractor) at the entrance and exit to accurately determine the number of truck trips to the terminals. The survey asked for the gate counts at the entrance and exits of the terminals by the configuration of the truck as shown below.

Truck Configuration

Cab (tractor) and Chassis (trailer) with Container
Cab (tractor) with bare chassis (trailer without container)
Cab only (also called a bobtail)

One concern might arise if the terminals could only provide the truck counts only for the loaded trucks or the cab and chassis configuration. It has been reported that truck counts at gates do not include Cab only (bobtail) movements. If the survey conducted provided insufficient results to accurately count of truck (tractor) trips, a special study investigated methods to provide an accurate measure from which to determine actual truck trips through the marine terminals. The estimate would be either the bobtail fraction entering or leaving the terminals or the fraction of trucks that deliver and receive loads in one trip as shown schematically in Figure 1, by sampling either the bobtail and cab (tractor) and chassis (trailer) counts at the terminal under consideration or the loaded containers counted at both the entrance and exit of the terminal.

Most or all container facilities, either marine terminals or rail yards, keep accurate counts of loaded truck entrances and exits at their gates. However, some terminals may not record unloaded truck entrances and exits. Port officials indicate that trucks entering unloaded and exiting unloaded is a rare or nonexistent event. But some trucks will make trips that are loaded on both the entrance and exit and so could be counted twice. Therefore, while accurate basic gate count data may exist for these loaded trips, that data would not be sufficient to estimate the number of truck trips. The truck trip activity is described schematically in Figure 5-1.

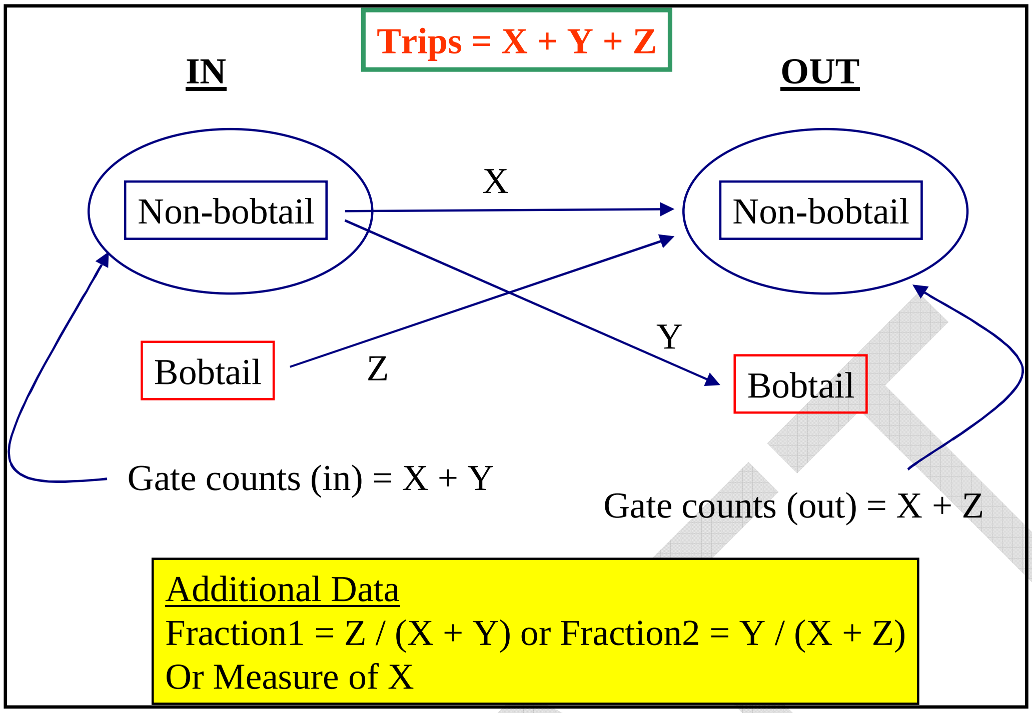

Figure 5-1. Schematic of the gate count methodology.

Therefore, it could be necessary to generate an additional estimate in order to determine an unbiased estimate of truck trips through the terminals and rail yards. Estimates of the fraction of bobtail entrances range from 30 – 40% for incoming trips (CCS, 2003). However this estimate results in a 'Fraction1' in Figure 5-1 of 0.43 to 0.67 and so is imprecise for purposes of estimating activity.

Trip Definition

Under the scope of this study, the truck trips will originate from one of the freeway interchanges or result from round trips between the rail yards and marine terminals. The number of possible routes that a truck trip could take is numerous, and the basic route types are outlined below. It was beyond the scope of this project to identify accurate estimates for each of the possible routes or trip types so a simplified method was used to estimate the truck trips so that vehicle miles traveled (VMT) and average speed of the trips could be determined.

Trip Types

1. Freeway to marine terminal and back to freeway
2. Freeway to marine terminal to rail yard and to freeway
3. Freeway to rail yard to marine terminal and to freeway
4. Freeway to rail yard to marine terminal to rail yard to freeway
5. Rail yard to marine terminal to rail yard round trip
6. Freeway to rail yard to freeway (considered to be unrelated to Port travel demand)

To simplify the analysis, the truck trips to and from rail yards to the freeway (trip type #6) without a trip to the marine terminal were subtracted from the total trips at the rail yards because that was activity unrelated to the Port operations. (This trip type is expected to occur with the UP rail yard facility where some of the freight never moves through the Port of Oakland marine terminals.) The remaining trips at the rail yards, estimated from gate counts or other input data, were assumed to be round trips to marine terminals (trip type #5). This assumes that truck travel directly to rail yards from the freeway (truck trip #3) and onto a marine terminal prior to exiting the study area approximately equals the truck travel that arrives directly to a marine terminal and exits to the freeway via a rail yard (truck trip #2), or both types of trips are an insignificantly small fraction of the total travel. The method also assumes that more complex trip types (#2, #3, and #4) are identical to a combination of a marine-freeway trip (trip type #1) and a round trip between the marine terminal and rail yard (trip type #5). In this manner, all activity is accounted though it may lack specificity in terms of modes or routes taken. Further and extensive surveys would be necessary to determine the truck trips more precisely, and given the changing nature of goods movements these surveys may not provide a robust measure of future activity.

Algebraically the trip calculation is shown in the equations below.

Trip Type #1 = Sum(Marine Terminal Trips) – Sum(Port:Rail Trips)

Trip Type #5 = Sum(Port:Rail Trips) = Sum(Rail Trips) – Sum(Rail:Freeway Trips:Trip Type #6)

The truck trips through the two rail yards were subtracted from the total inner and outer harbor terminals to determine the fraction of trips directly from or to the freeway interchanges and the fraction making round trips to the rail yards. This trip fraction was applied to the trip counts at each marine terminal to estimate the different routes of travel.

The truck trips to the freeway interchanges were modeled as routing to one of three freeway interchanges. According to surveys conducted at the Port (CCS, 2003), 57% of trucker use the 7th Street, 41% use the Grand/Maritime, and 14% use Adeline/Market. Because this fraction totals greater than 100% (likely because different routes were used for different trips or into and out of the Port), the estimate of truck travel was prorated to 51.0%, 37.5%, and 12.5% for 7th Street, Grand/Maritime, and Adeline/Market. The freeway marine terminal trips were then distributed to these three routes accordingly for each terminal. Terminals closer to one interchange could preferentially use that interchange and reduce the overall mileage, however estimates of the preferred routes for each terminal were not available for this study.

The truck trips for on-road vehicles that transport containers to and from the port could go to either of the two rail yards or any of the freeway interchanges. Therefore trips were defined to and from each freeway interchange and each rail yard. Figure 5-2 shows the links from each terminal and rail yard within the freeway boundary of the general port area. Dowling Associates, Inc. estimated travel distances and average trip speeds for each of the 33 defined road links and the methods and estimates are described in Appendix F.

Onroad Traffic Map of Port of Oakland Maritime Operations
Oakland, CA

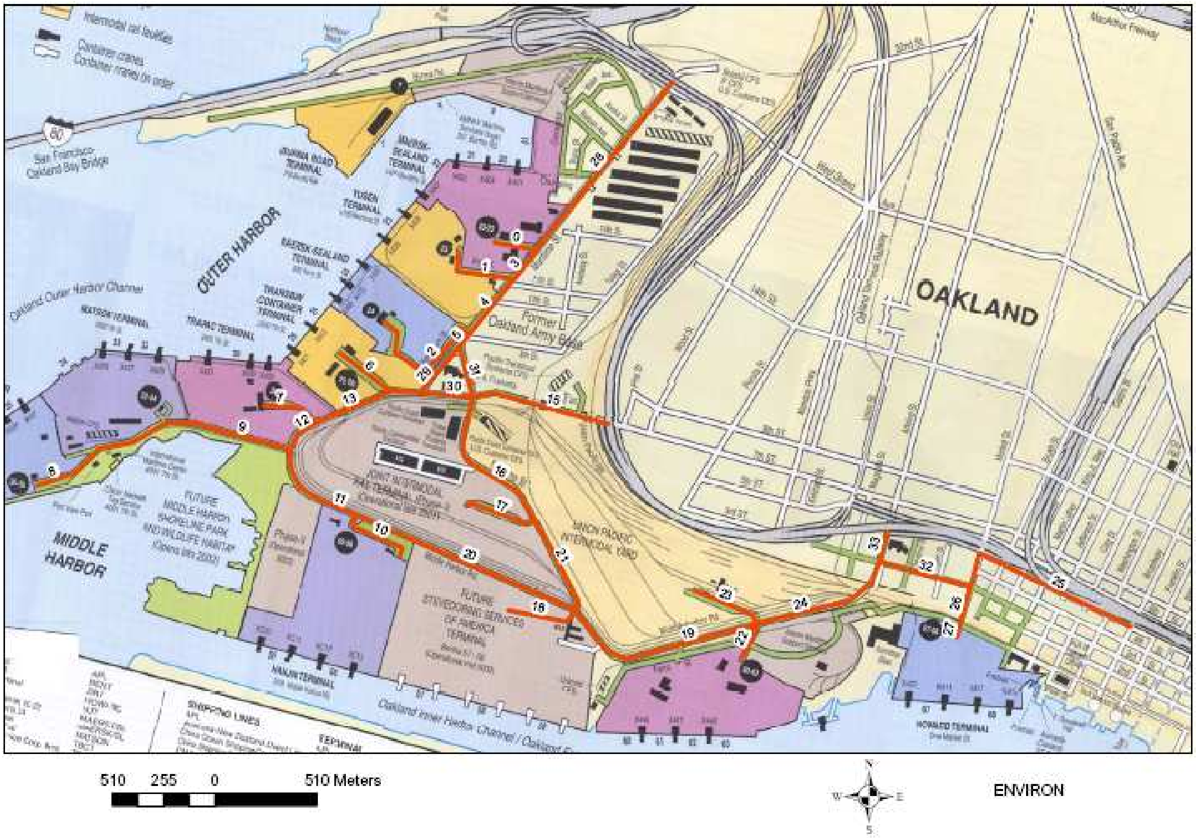

Figure 5-2. On-road links within the Port of Oakland.

The trips were defined by summing the road links to or from the terminals to the rail yards and freeway interchanges. This provides both the mileage and average speed for each truck trip as are shown in Table 5-1.

Table 5-1. Description of potential truck travel.

Trip ID	*Terminals*	Trip Beginning/ End	Road Link Segments	Total Length (feet)	Average Speed (mph)
T1	Berths 20-22	West Grand	0, 28	1,298	29
T2	Berths 20-22	7th	0, 3, 4, 5, 31, 15	1,786	28
T3	Berths 20-22	Adeline	0, 3, 4, 5, 31, 16, 21, 19, 24, 33	4,295	30
T4	Berths 20-22	BNSF	0, 3, 4, 5, 31, 16, 17	2,251	25
T5	Berths 20-22	Union Pacific	0, 3, 4, 5, 31, 16, 21, 19, 23	3,775	28
T6	Berth 23	West Grand	1,3,28	1,649	29
T7	Berth 23	7th	1,4,5,31,15	1,756	27
T8	Berth 23	Adeline	1,4,5,31,16,21,19,24,33	4,265	29
T9	Berth 23	BNSF	1,4,5,31,16,17	2,220	24
T10	Berth 23	Union Pacific	1,4,5,31,16,21,19,23	3,745	27
T11	Berth 24	West Grand	2,4,3,28	2,321	28
T12	Berth 24	7th	2,5,31,15	1,751	23
T13	Berth 24	Adeline	2,5,31,16,21,19,24,33	4,260	27
T14	Berth 24	BNSF	2,5,31,16,17	2,215	21
T15	Berth 24	Union Pacific	2,5,31,16,21,19,23	3,740	25
T16	Berths 25-26	West Grand	6,14,29,5,4,3,28	2,455	29
T17	Berths 25-26	7th	6,14,30,15	1,431	26
T18	Berths 25-26	Adeline	6,14,30,16,21,19,24,33	3,939	29
T19	Berths 25-26	BNSF	6, 14,30,16,17	1,895	23
T20	Berths 25-26	Union Pacific	6,14,30,16,21,19,23	3,420	27
T21	Berth 30	West Grand	7,13,14,29,5,4,3,28	2,828	28
T22	Berth 30	7th	7,13,14,30,15	1,803	25
T23	Berth 30	Adeline	7,12,11,20,19,24,33	4,106	31
T24	Berth 30	BNSF	7,12,11,20,21,17	3,063	28
T25	Berth 30	Union Pacific	7,12,11,20,19,23	3,587	29
T26	Berths 33-35	West Grand	8,9,12,13,14,29,5,4,3,28	4,111	33
T27	Berths 33-35	7th	8,9,12,13,14,30,15	3,087	32
T28	Berths 33-35	Adeline	8,9,11,20,19,24,33	5,001	35
T29	Berths 33-35	BNSF	8,9,11,20,21,17	3,959	34
T30	Berths 33-35	Union Pacific	8,9,11,20,19,23	4,482	34
T31	Berths 55-56	West Grand	10,11,12,13,14,29,5,4,3,28	3,632	29
T32	Berths 55-56	7th	10,11,12,13,14,30,15	2,608	27
T33	Berths 55-56	Adeline	10,20,19,24,33	3,481	30
T34	Berths 55-56	BNSF	10,11,12,13,14,30,16,17	3,073	24
T35	Berths 55-56	Union Pacific	10,20,19,23	2,962	27
T36	Berths 57-59	West Grand	18,21,16,31,5,4,3,28	3,614	30
T37	Berths 57-59	7th	18,21,16,15	2,364	27
T38	Berths 57-59	Adeline	18,19,24,33	2,282	26
T39	Berths 57-59	BNSF	18,21,17	1,239	20
T40	Berths 57-59	Union Pacific	18,19,23	1,762	22
T41	Berths 60-63	West Grand	22,19,21,16,31,5,4,3,28	4,456	31
T42	Berths 60-63	7th	22,19,21,16,15	3,206	29
T43	Berths 60-63	Adeline	22,24,33	1,077	26
T44	Berths 60-63	BNSF	22,19,21,17	2,082	24
T45	Berths 60-63	Union Pacific	22,23	557	17
T46	Berths 67-68	West Grand	27,26,32,24,19,21,16,31,5,4,3,28	5,774	31
T47	Berths 67-68	7th	27,26,32,24,19,21,16,15	4,524	29
T48	Berths 67-68	Adeline	27,26,32,33	930	24
T49	Berths 67-68	BNSF	27,26,32,24,19,21,17	3,399	26
T50	Berths 67-68	Union Pacific	27,26,32,24,23	1,875	24

To determine the distance and speed for truck trips on terminal grounds within the fence line, the Port of Oakland is conducting a survey of the terminal operators to estimate the travel distance and average speed for trucks moving within the terminal and estimates of idle time while on the terminal property. Some terminal operators may also provide average queuing time at their gate entrances, and so the survey is also asking for that information as well.

Emission Factors

Figure 5-3 shows a sample of the emission factors (at one average trip speed) by model year of truck for heavy heavy-duty trucks primarily ferrying containers to the port or rail terminals. It is evident that the age distribution of the fleet of vehicles will affect the emissions of the truck fleet serving the Port terminals because older model year trucks have higher emissions.

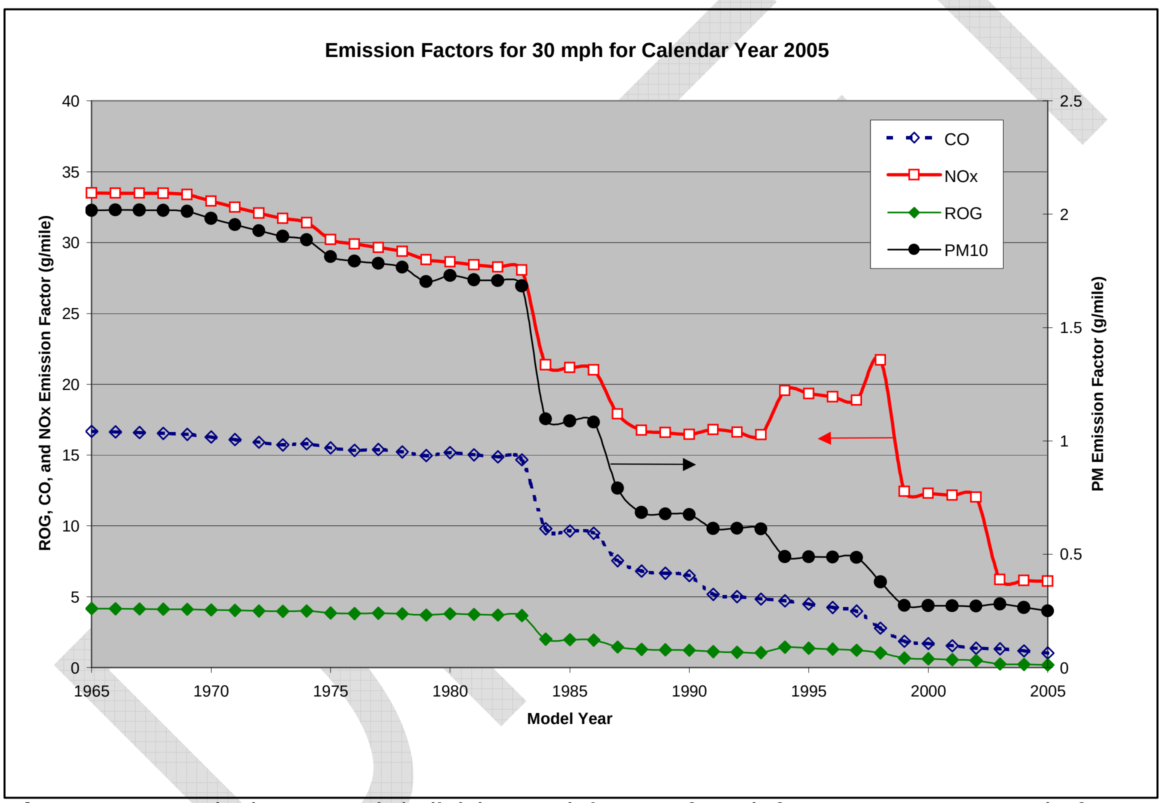

Figure 5-3. Emission rates (g/mile) by model year of truck for an average speed of 30 mph.

Because of the influence of the age distribution, the Port of Long Beach and Los Angeles commissioned a study of the truck fleet age distribution. (Starcrest, 2005) This age distribution is compared in Figure 5-4 with the default age distribution of heavy heavy-duty vehicles projected by EMFAC/BURDEN for the Bay Area using either the population or the VMT-weighted population by age of vehicle.

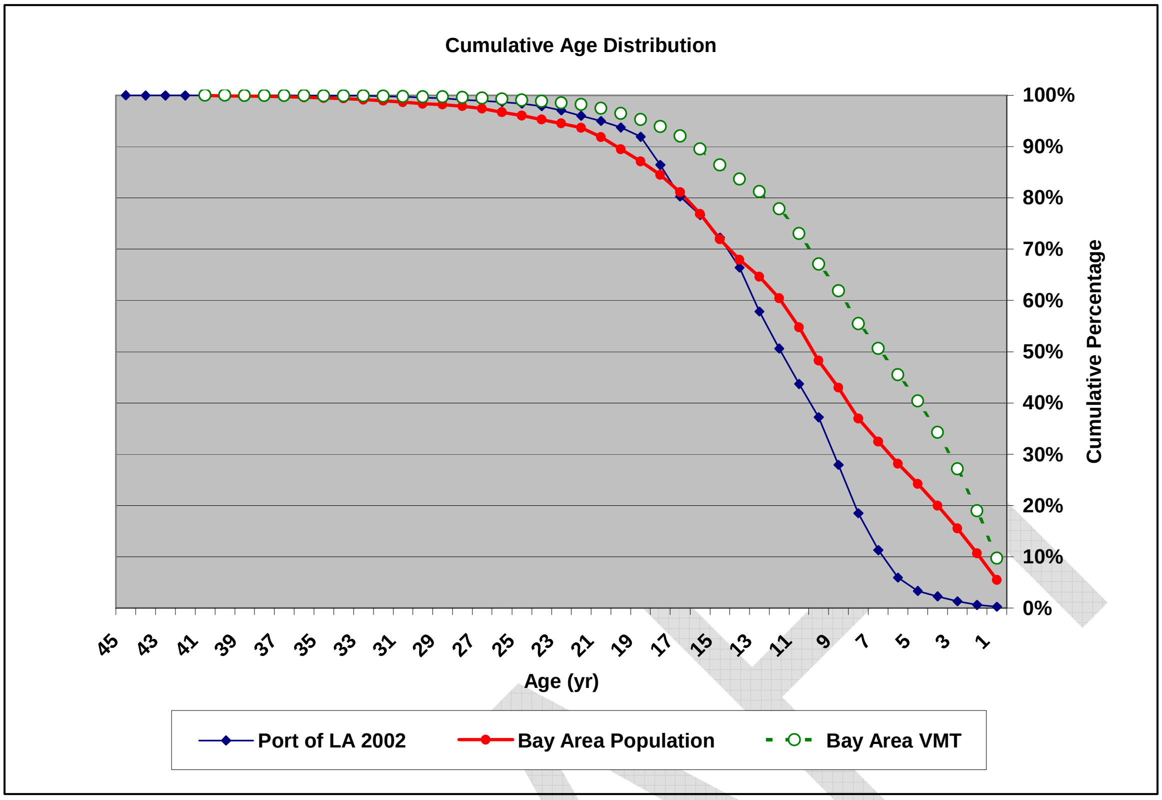

Figure 5-4. Age distribution of truck fleet.

The Port of Oakland is considering a special study to determine the age distribution of the trucks entering the Port area. However in lieu of a specific age distribution at the Port terminals, the Alameda population average age distribution for the Port trucks was used for this study. The population age distribution is typically based on the local registration population of trucks in the area. The population distribution was used and assumes that any truck has an equal opportunity to make a trip to the Port. The South Coast truck population and port operations may be significantly different than in Oakland, so that age distribution was not considered indicative of the local fleet.

Air Resources Board: Revisions to the Truck Portion

- The inventory study was defined to include truck routes to each of three freeway interchanges and two rail yards. The methodologies are similar to that of POLA/LB.
- Data sources: Trip counts – gate counts conducted by the Port; % of truck trips to different route – survey conducted at the Port in 2003.
- Length and average speed for each trip (50 total, with various start/end combination) is based on observations (distance and speed) of 33 defined road links conducted in Feb. 2006.
- The Port needs to use the most current working draft provided by ARB on August 18, 2006.
- Without the survey data on age distribution of truck fleet serving Port of Oakland, the Alameda population average age distribution projected by EMFAC/BURDEN were used. This approach has a potential bias and may not represent the port truck age distribution in the POAK. Therefore, the potential bias by applying the population average age distribution should be addressed.