APPENDIX C

Draft Health Risk Assessment for the Union Pacific Railroad Oakland Railyard

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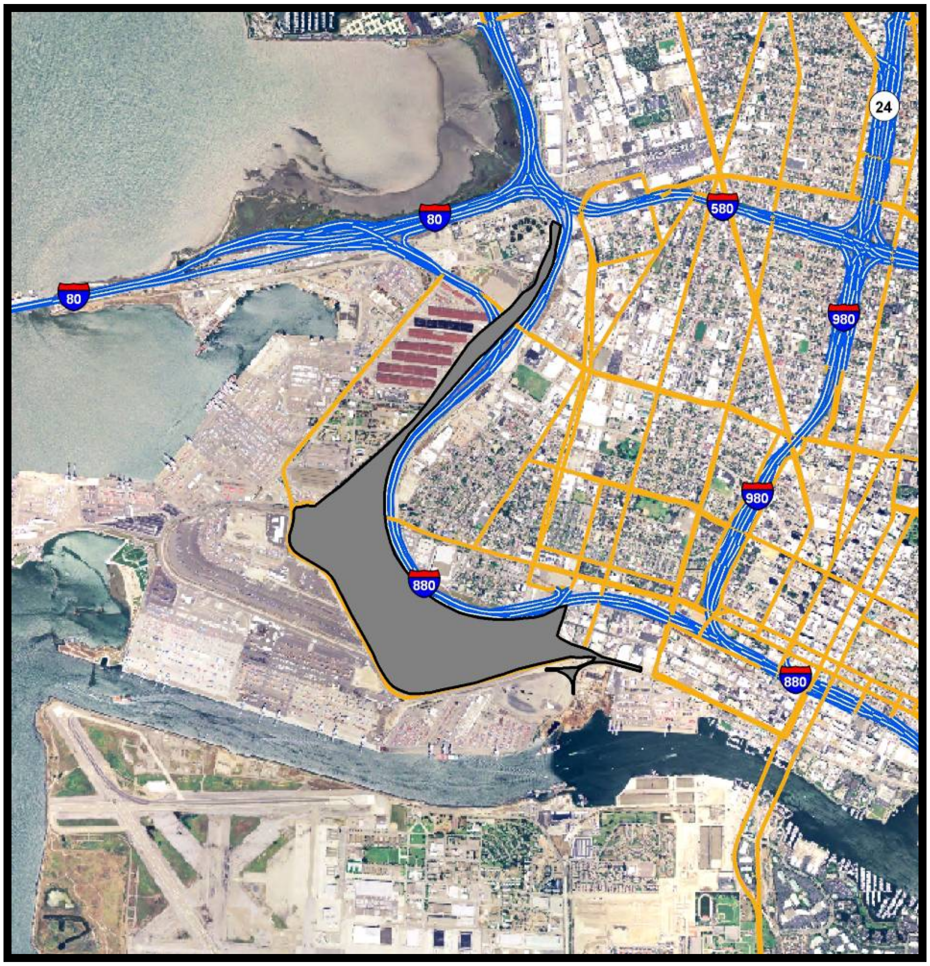
California Environmental Protection Agency

Air Resources Board

Draft Health Risk Assessment for the Union Pacific Railroad Oakland Railyard



Stationary Source Division
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California Environmental Protection Agency

Air Resources Board

Draft Health Risk Assessment for the Union Pacific Railroad Oakland Railyard

Principal Author
Hector Castaneda

Contributing Authors
Stationary Source Division:
Eugene Yang, Ph.D., P.E.
Ambreen Mahmood
Stephen Cutts

Planning and Technical Support Division:
Nicole Dolney
Beth Schwehr
Anthony Servin, P.E.
Stephen Zelinka

Reviewed by

ARB Executive Office:
Michael H. Scheible, Deputy Executive Officer

ARB Stationary Source Division:
Robert D. Fletcher, Chief, Stationary Source Division
Dean C. Simeroth, Chief, Criteria Pollutants Branch
Harold Holmes, Manager, Engineering Evaluation Section

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Union Pacific Railroad:
Lanny Schmid, Jon Germer, Brock Nelson, James Diel, Duffy Exon.

Sierra Research:
Gary Rubenstein, Brenda Douglass, Eric Walther, Ph.D.

Air Quality Management Consulting:
Robert G. Ireson, Ph.D.

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I. INTRODUCTION

The California Air Resources Board (ARB or Board) conducted a health risk assessment study to evaluate the health impacts associated with toxic air contaminants emitted from the Union Pacific Railroad's (UP) railyard located in Oakland, California. The study focused on the railyard property emissions from locomotives, cargo handling equipment, on-road trucks, and off-road vehicles.

A. Why is ARB concerned about diesel PM emissions?

In 1998, ARB identified particulate matter from diesel exhaust (diesel PM) as a toxic air contaminant based on its potential to cause cancer and other adverse health problems, including respiratory illnesses, and increased risk of heart disease. Subsequent research has shown that diesel PM contributes to premature death[*] (ARB, 2002). Exposure to diesel PM is a health hazard, particularly to children, whose lungs are still developing; and the elderly, who may have other serious health problems. In addition, the diesel PM particles are very small. By mass, approximately 94% of these particles are less than 2.5 microns in diameter ($PM_{2.5}$). Because of their tiny size, diesel PM particles are readily respirable and can penetrate deep into the lung and enter the bloodstream, carrying with them an array of toxins. Population-based studies in hundreds of cities in the U.S. and around the world demonstrate a strong link between elevated PM levels and premature deaths (Pope et al., 1995, 2002 and 2004; Krewski et al., 2000), increased hospitalizations for respiratory and cardiovascular causes, asthma and other lower respiratory symptoms, acute bronchitis, work loss days, and minor restricted activity days (ARB, 2006e).

Diesel PM emissions are the dominant toxic air contaminants in and around a railyard facility. Statewide, diesel PM accounts for about 70% of the estimated potential ambient air toxic cancer risks based on an analysis conducted by ARB staff in 2000 (ARB, 2000). That analysis also indicated that residents in the South Coast Air Basin (SCAB) had higher estimates of risk than elsewhere in the State. These findings are consistent with the preliminary findings reported in a recently released draft report entitled the "*Multiple Air Toxics Exposure Study in the South Coast Air Basin (SCAQMD, 2008)".* This study reported that diesel PM emissions have decreased, but these emissions are still the major contributor to air toxics risk in the SCAB, accounting for over 80% of the total risk from air toxics in the region. The higher percentage contribution over the previously reported 70% reflects the fact that there has been a proportionally greater reduction in other air toxics, such as benzene and 1,3-butadiene. Based on scientific research findings and the dominance of diesel PM emissions, the health impacts in this railyard health risk assessment study primarily focus on the risks from the diesel PM emissions.

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[*] Premature Death: as defined by U.S. Centers for Disease Control and Prevention's Years of Potential Life Lost, any life ended before age 75 is considered premature death.

B. Why evaluate diesel PM emissions at the UP Oakland Railyard?

In 2005, the ARB entered into a statewide railroad pollution reduction agreement (Agreement) with Union Pacific Railroad Company (UP) and BNSF Railway Company (BNSF) (ARB, 2005). This Agreement was developed to implement near term measures to reduce diesel PM emissions in and around California railyards by approximately 20 percent.

The Agreement requires that health risk assessments (HRAs) be prepared for each of the 17 major or designated railyards in the State. The UP Oakland Railyard HRA was prepared as part of the 2005 Railroad Agreement. Under the agreement each railyard health risk assessment was prepared pursuant to ARB Guidelines and ARB experience in preparing the UP Roseville Railyard Study in 2004 and the *ARB Health Risk Assessment Guidance for Railyard and Intermodal Facilities* that the ARB staff developed in 2006 (see http://www.arb.ca.gov/railyard/hra/hra.htm) (ARB, 2006d). Under ARB guidelines, the railyard HRAs are to be prepared with the U.S. EPA newly approved air dispersion model AERMOD. AERMOD is a , a facility specific and micro scale level model. The Railyard HRAs are also to include off-site mobile and stationary emissions up to one mile from the railyard boundaries.

In a separate effort, the West Oakland HRA is currently being prepared by ARB and Bay Area Air Quality Management District (BAAQMD) staff and includes three elements for assessment: 1) The Port of Oakland, 2) The UP Oakland Railyard and 3) the West Oakland Community. ARB staff elected to use CALPUFF for the West Oakland HRA because CALPUFF is designed to assess regional air pollution; this is critical when assessing ship emissions from 10 to 30 miles off-shore. As part of the West Oakland HRA, ARB staff is also assessing offsite emissions up to and greater than a mile from the Port of Oakland. This off-site assessment will be equivalent to or exceed the railyard HRA off-site assessments in levels of detail. As a result, the UP Oakland Railyard (AERMOD) HRA will also rely on the West Oakland HRA off-site results. The West Oakland HRA Study is scheduled for release in Spring 2008.

This study is limited to the UP Oakland Railyard and uses only methodologies and modeling consistent with the 2005 Railroad Agreement.

C. What are Health Risk Assessments (HRAs)?

A health risk assessment uses mathematical models to evaluate the health impacts from exposure to certain chemical or toxic air contaminants released from a facility or found in the air. HRAs provide information to estimate potential long term cancer and non-cancer health risks. HRAs do not gather information or health data on specific individuals, but are estimates for the potential health impacts on a population at large.

An HRA consists of three major components: the air pollution emission inventory, the air dispersion modeling, and an assessment of associated health risks. The air pollution emission inventory provides an understanding of how the air toxics are generated and emitted. The air dispersion modeling takes the emission inventory and meteorology data such as temperature and wind speed/direction as its inputs, then uses a computer model to predict the distributions of air toxics in the air. Based on this information, an assessment of the potential health risks of the air toxics to an exposed population is performed. The results are expressed in a number of ways as summarized below.

- For potential cancer health effects, the risk is usually expressed as the number of chances in a population of a million people. The number may be stated as “10 in a million” or “10 chances per million”. The methodology used to estimate the potential cancer risks is consistent with the Tier-1 analysis of *Air Toxics Hot Spots Program Risk Assessment Guidelines* (OEHHA, 2003). A Tier-1 analysis assumes that an individual is exposed to an annual average concentration of a given pollutant continuously for 70 years. The length of time that an individual is exposed to a given air concentration is proportional to the risk. During childhood, the impact from exposure to a given air concentration is greater. Exposure duration of 30 years or 9 years may also be evaluated as supplemental information to present the range of cancer risk based on residency period.

- For non-cancer health effects, a reference exposure level (REL)[†] is used to predict if there will be certain identified adverse health effects, such as lung irritation, liver damage, or birth defects. These adverse health effects may happen after chronic (long-term) or acute (short-term) exposure. To calculate a non-cancer health risk number, the reference exposure level is compared to the concentration that a person is exposed to, and a “hazard index” (HI) is calculated. Typically, the greater the hazard index is above 1.0, the greater the potential for possible adverse health effects. If the hazard index is less than 1.0, then it is an indicator that adverse effects are less likely to happen.

- For premature deaths linked to diesel PM emissions in the San Francisco Bay Area Air Basin, ARB staff estimated about 410 premature deaths per year due to diesel exhaust exposure in 2000 (ARB Research Division, and Lloyd and Cackette, 2001). The total diesel PM emissions from all sources in the San Francisco Bay Air Basin were estimated at about 4,840 tons per year in 2000 and 4,550 tons per year in 2005 (ARB, 2006a). During 2005, the diesel PM emissions from the UP Oakland Railyard was estimated at 11.2 tons, about 0.3 percent of the total estimated air basin diesel PM emissions.

[†] The Reference Exposure Level (REL) for diesel PM is essentially the U.S. EPA Reference Concentration first developed in the early 1990s based on histological changes in the lungs of rats. Since the identification of diesel PM as a Toxic Air Contaminant (TAC), California has evaluated the latest literature on particulate matter health effects to set the Ambient Air Quality Standard. Diesel PM is a component of particulate matter. Health effects from particulate matter in humans include illness and death from cardiovascular and respiratory disease, and exacerbation of asthma and other respiratory illnesses. Additionally, a body of literature has been published, largely after the identification of diesel PM as a TAC and adoption of the REL, which shows that diesel PM can enhance allergic responses in humans and animals. Thus, it should be noted that the REL does not reflect adverse impacts of particulate matter on cardiovascular and respiratory disease and deaths, exacerbation of asthma, and enhancement of allergic response.

The potential cancer risk from a given carcinogen estimated from the health risk assessment is expressed as the incremental number of potential cancer cases that could be developed per million people, assuming the population is exposed to the carcinogen at a constant annual average concentration over a presumed 70-year lifetime. For example, if the cancer risk were estimated to be 100 chances per million, the probability of an individual developing cancer would not be expected to exceed 100 chances in a million. If a population (e.g., one million people) were exposed to the same potential cancer risk (e.g., 100 chances per million), then statistics would predict that no more than 100 of those million people exposed would be likely to develop cancer from a lifetime of exposure (i.e., 70 years) due to diesel PM emissions from a facility.

The health risk assessment is a complex process that is based on current knowledge and a number of assumptions. However, there is a certain extent of uncertainty associated with the process of risk assessment. The uncertainty arises from lack of data in many areas necessitating the use of assumptions. The assumptions used in the assessments are often designed to be conservative on the side of health protection in order to avoid underestimation of risk to the public. As indicated by the Office of Environmental Health Hazard Assessment (OEHHA) Guidelines, the Tier-1 evaluation is useful in comparing risks among a number of facilities and similar sources. Thus, the risk estimates should not be interpreted as a l
affected communities but more as a tool for comparison of the relative risk between one facility and another. In addition, the HRA results are best used to compare potential risks to target levels to determine the level of mitigation needed. They are also an effective tool for determining the impact a particular control strategy will have on reducing risks.

As soon as the HRAs are final, both the ARB and the railroads in cooperation with the BAAQMD (Bay Area Air Quality Management District) staff, local citizens and others will begin a series of meetings to identify and implement measures to reduce emissions from railyard sources.

D. Who prepared the UP Oakland Railyard HRA?

Under the Agreement, ARB worked with the affected local air quality management districts, communities, cities, counties, and the two railroads to develop two guideline documents for performing the health risk assessments. The two documents, entitled *ARB Rail Yard Emissions Inventory Methodology* (ARB, 2006c), and *ARB Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006d), provide guidelines for the identification, modeling, and evaluation of the toxic air contaminants (TACs) from designated railyards throughout California.

Using the guidelines, the railroads and their consultants (i.e., Sierra Research and Air Quality Management Consulting for the UP Oakland Railyard) developed the emission inventories and performed the air dispersion modeling for operations that occurred within each of the designated railyards. The base year of the analysis was 2005.

ARB staff was responsible for reviewing and approving the railroads' submittals, identifying significant sources of emissions near the railyards, modeling the impacts of those sources, and preparing the railyard health risk assessments. ARB staff was also responsible for releasing the draft HRAs to the public for comment and presenting them at community meetings. After reviewing public comments on the draft HRAs, ARB staff will make revisions as necessary and appropriate, and then present the HRAs in final form. Ultimately, the information derived from the railyards HRAs is to be used to help identify the most effective mitigation measures that could be implemented to further reduce railyard emissions and public health risks.

E. How is this report structured?

The next chapter provides a summary of the UP Oakland Railyard operations, emissions, air dispersion modeling, and health risk assessment results. Following the summary, the third chapter presents the details of the UP Oakland Railyard emission inventories. After that, the fourth chapter explains how the air dispersion modeling was conducted, and the fifth chapter provides the detailed health risk assessment for the UP Oakland Railyard. The appendices present the technical supporting documents for the analyses discussed in the main body of the report.

II. SUMMARY

Below is a summary of the UP Oakland Railyard operations, emissions, air dispersion modeling, and health risk assessment results.

A. General Description of the UP Oakland Railyard

The Union Pacific (UP) Oakland Railyard is located at 1408 Middle Harbor Road, Oakland, California, approximately two miles west of downtown Oakland (see Figure II-1). Running along I-880 for about two miles, the UP Oakland Railyard covers a horse shoe-like area and is surrounded by residential, industrial and commercial properties to the north and northeast. The Port of Oakland and its supporting facilities surround the railyard to the south, southwest, and northwest.

Facilities within the railyard include: classification tracks, a gate complex for inbound and outbound intermodal truck traffic, intermodal loading and unloading tracks, a locomotive service track, a locomotive maintenance shop, a freight car repair shop, an on-site wastewater treatment plant, and various buildings and facilities supporting railroad and contractor operations. In addition, there are two warehouse distribution centers operated by Pacific Coast Containers Inc. (PCC) at the UP Oakland Railyard.

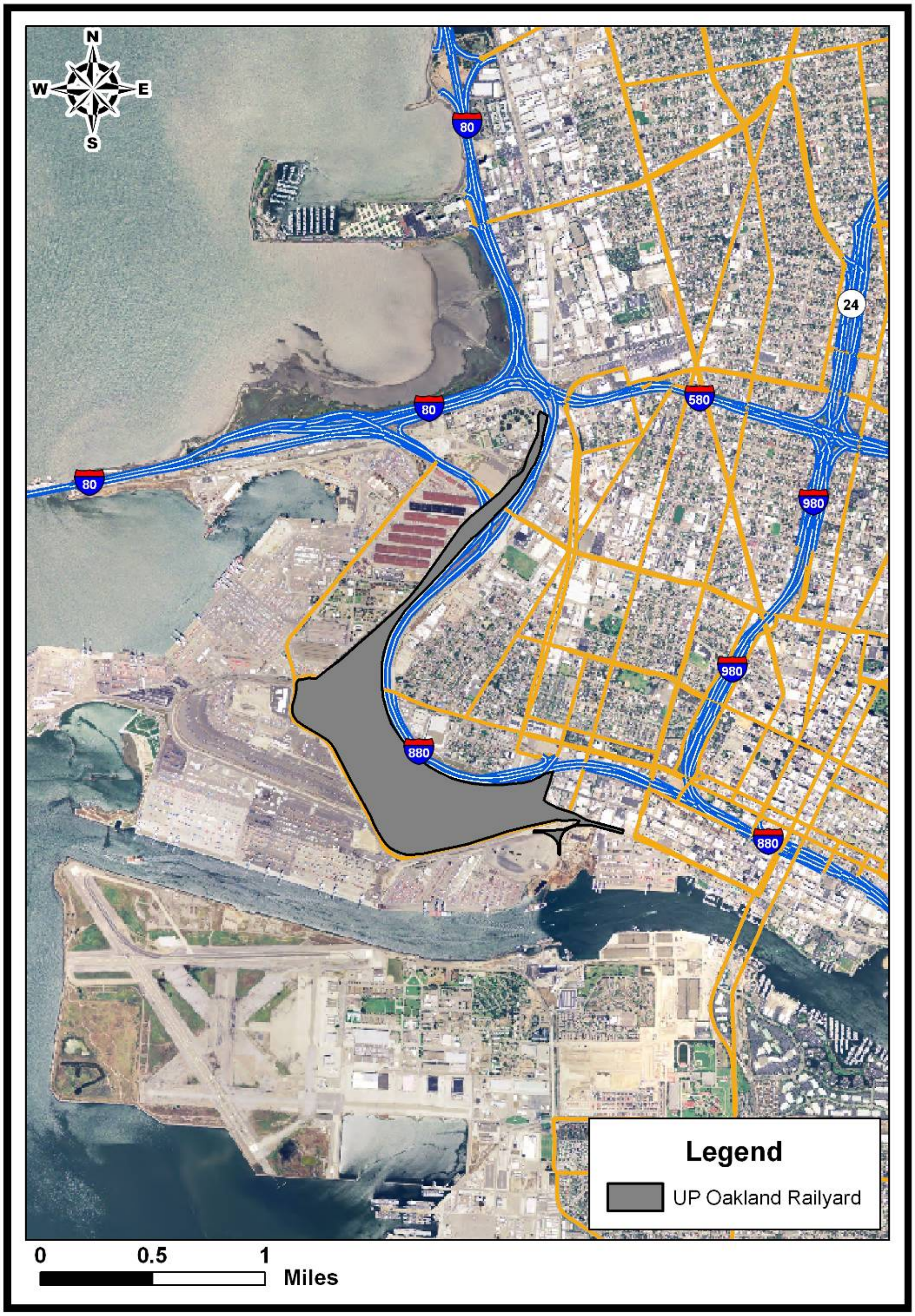
B. What are the primary operations at the UP Oakland Railyard?

The UP Oakland Railyard is a cargo handling facility with a focus on intermodal containers. Activities at the UP Oakland Railyard include receiving inbound trains, switching rail cars, loading and unloading intermodal trains, storing intermodal containers and truck chassis, building and departing outbound trains, and repairing freight cars and intermodal containers/chassis.

An estimated 350,000 containers were processed in 2005. Cargo containers and other freight are received, sorted, and distributed from the facility. Intermodal containers may arrive at the facility by truck to be loaded onto trains for transport to distant destinations, or arrive by train and unloaded onto chassis for transport by truck to local destinations. Cargo containers and chassis are also temporarily stored at the railyard. The railyard also includes facilities for crane and yard hostler maintenance, locomotive service and repair, and on-site wastewater treatment.

Within the railyard, the primary locomotive operations are associated with arriving, departing, and servicing interstate line haul locomotives. Arriving and departing line haul locomotives are fueled in the locomotive service area after arrival, and are sent back into the railyard or to other railyards after service. The service area can also perform periodic and unscheduled maintenance on locomotives if the need arises. Four switch locomotives (i.e., dedicated to moving rail cars within the railyard) also operate within the railyard. Three of the switchers are remote control and operate exclusively in the railyard, while the fourth operates inside as well as outside of the yard, at other facilities.

Figure II-1: UP Oakland Railyard and Surrounding Areas



The switchers are used to move sections of inbound trains to appropriate areas within the railyard (e.g., intermodal rail cars go to the intermodal ramp for unloading and loading), and to move sections of outbound trains to tracks from which they will depart.

C. What are the diesel PM emissions from the UP Oakland Railyard?

In 2005, the diesel PM emissions from the UP Oakland Railyard are estimated at about 11.2 tons per year (see Figure II-3).

To provide a perspective on the railyards diesel PM emissions, Table II-1 lists the estimated diesel PM emissions (for the year of 2005) for eighteen railyards. The diesel PM emissions from the UP Oakland Railyard rank sixth among these eighteen railyards.

Table II-1: Comparison of Diesel PM Emissions (tons per year) from Four Major Source Categories within Eighteen Railyards.

Railyard	Locomotive	Cargo Handling Equipment	On-Road Trucks	Others (Off-Road Equipment, TRUs, Stationary Sources, etc.)	Total[§]
UP Roseville*	25.1**	N/A[‡]	N/A[‡]	N/A[‡]	**25.1**
BNSF Hobart	5.9	4.2[†]	10.1	3.7	**23.9**
UP Commerce	4.9	4.8[†]	2.0	0.4	**12.1**
UP LATC	3.2	2.7[†]	1.0	0.5	**7.3**
UP Stockton	6.5	N/A[‡]	0.2	0.2	**6.9**
UP Mira Loma	4.4	N/A[‡]	0.2	0.2	**4.9**
BNSF Richmond	3.3	0.3[†]	0.5	0.6	**4.7**
BNSF Stockton	3.6	N/A[‡]	N/A[‡]	0.02	**3.6**
BNSF Commerce Eastern	0.6	0.4[†]	1.1	1.0	**3.1**
BNSF Sheila	2.2	N/A[‡]	N/A[‡]	0.4	**2.7**
BNSF Watson	1.9	N/A[‡]	<0.01	0.04	**1.9**
UP ICTF/Dolores	9.8	4.4	7.5	2.0	**23.7**
UP Colton	16.3	N/A[‡]	0.2	0.05	**16.5**
UP Oakland	3.9	2.2[†]	1.9	3.4	**11.2**
UP City of Industry	5.9	2.8	2.0	0.3	**10.9**
BNSF Barstow	*To be available in Spring 2008*				**TBD**
BNSF San Bernadino	*To be available in Spring 2008*				**TBD**
BNSF San Diego	*To be available in Spring 2008*				**TBD**

* The UP Roseville Health Risk Assessment (ARB, 2004a) was based on 1999-2000 emission estimate, only locomotive diesel PM emissions were reported in that study.

** The actual emissions were estimated at a range of 22.1 to 25.1 tons per year.

[‡] Not applicable.

[§] Numbers may not add precisely due to rounding.

[†] After the modeling was completed, ARB received updated information on cargo handling equipment emissions. However, the resulting change in emissions was de minimis, so the modeling was not reperformed.

The UP Oakland Railyard emission sources include, but are not limited to, locomotives, on-road diesel-fueled trucks, cargo handling equipment, transport refrigeration units (TRUs) and refrigerated rail cars (reefer cars), and fuel storage tanks. The facility operates 24 hours a day, 365 days a year. The UP Oakland Railyard emissions were calculated on a source-specific and facility-wide basis for the 2005 baseline year. The future growth in emissions at the facility is not incorporated in the HRA emission inventory, but will be included as part of the mitigation emission reduction efforts. The methodology used to calculate the diesel PM and other toxic air contaminant (TAC) emissions is based on the *ARB Rail Yard Emissions Inventory Methodology* (ARB, 2006c).

As indicated by Table II-2, locomotive operations within the railyard are responsible for an estimated 3.9 tons per year of diesel PM emissions (about 35% of the total on-site emissions). Of the emissions from locomotives, yard operations (primarily switch locomotives moving rail cars within the facility), contribute the largest amount of locomotive diesel PM emissions at about 1.9 tons per year. Line haul freight and pass-through trains contribute 1.6 tons per year of the diesel PM emissions and locomotive service and testing activities account for 0.5 tons per year. Cargo handling equipment (CHE) operated within the yard, such as cranes and yard hostlers as well as heavy equipment, emit about 2.2 tons per year of diesel PM, or about 18% of the total on-site emissions. Diesel-fueled trucks and other vehicles contribute about 1.9 tons per year, or about 17% of the total on-site diesel PM emissions. Locomotives, CHE, and diesel-fueled trucks engaging in direct intermodal operations produce about 70% of the railyard diesel PM emissions. The remaining 30% of the diesel PM emissions are generated by a variety of other sources including transport refrigeration units (TRUs), which produce about 2.5 tons per year (22%) diesel PM and refrigerated rail cars, which produce about 0.7 tons per year (about 6%) diesel PM.

Diesel PM emissions from sources in the UP Oakland Railyard are summarized in Table II-2.

Table II-2: UP Oakland Railyard Diesel PM Emissions in 2005

Sources	Diesel PM Emissions (tons per year)	
	Total Diesel PM Emissions	Percent of Total
LOCOMOTIVES	**3.9**	**35%**
Switchers	*1.9*	*17%*
Line Hauls	*1.6*	*14%*
Service/Testing	*0.5*	*4%*
TRUs and Reefer Cars	**3.2**	**29%**
CARGO HANDLING EQUIPMENT†	**2.2**	**20%**
ON-ROAD TRUCKS	**1.9**	**17%**
TOTAL*	**11.2**	**100%**

† After the modeling was completed, ARB received updated information on cargo handling equipment emissions. However, the resulting change in emissions was de minimis, so the modeling was not reperformed.

* Numbers and percentages may not add precisely due to rounding.

Diesel PM is not the only toxic air contaminant (TAC) emitted in the UP Oakland Railyard. Relatively small amounts of gasoline toxic air contaminants (benzene, isopentane, toluene, etc.) are generated from gasoline storage tanks and gasoline-powered vehicles and engines. Some other toxic air contaminants, such as xylene, are emitted from the wastewater treatment plant. The detailed emission inventories for these TACs are presented in the Sierra Research report. The total amount of these toxic air contaminants emissions is about 0.10 tons or 200 pounds per year, compared to the 11.2 tons per year of the diesel PM emissions in the railyard.

Moreover, when adjusted on a cancer potency weighted basis for their toxic potential, these non-diesel PM toxic air contaminants have a potential cancer risk level of less than a thousandth of the cancer risk level for diesel PM. Hence, only diesel PM emissions are presented in the on-site emission analysis.

ARB staff also evaluated the potential cancer risk levels caused by the use of gasoline in the San Francisco Bay Air Basin. Table II-4 shows the emissions of four major carcinogen compounds of gasoline exhausts in San Francisco Bay Air Basin in the year of 2005 (ARB, 2006a). As indicated in Table II-3, the cancer potency weighted emissions of these four toxic air contaminants from all types of gasoline sources are estimated at about 481 tons per year. For gasoline-fueled vehicles only, the potency weighted emissions of these four TACs are estimated at about 253 tons per year, or about 6% of diesel PM emissions in the Basin. The potential cancer risks associated with non-diesel PM toxic air contaminants emitted from gasoline vehicular sources in the San Francisco Bay Air

Cancer potency factors (CPF) are expressed as the 95% upper confidence limit of excess cancer cases occurring in an exposed population assuming continuous lifetime exposure to a substance at a dose of one milligram per kilogram of body weight, and are expressed in units of $(mg/kg\text{-}day)^{-1}$.

Basin are substantially less than the potential cancer risks associated with diesel PM emissions, and are not included in the analysis.

Table II-3: Emissions of Major Toxic Air Contaminants from Gasoline Exhausts in San Francisco Bay Air Basin

Toxic Air Contaminant	Emissions (tons per year)			
	All Sources	Potency Weighted†	Gasoline Vehicular Sources	Potency Weighted*
Diesel PM	4,552	4,552	-	-
1,3-Butadiene	414	228	245	135
Benzene	1,997	180	1,153	104
Formaldehyde	3,208	61	605	12
Acetaldehyde	1,355	12	177	2
Total (other than diesel PM)	6,974	481	2,180	253

*: Based on cancer potency weighting factors.

D. What are the potential cancer risks from the UP Oakland Railyard?

As discussed previously, the ARB developed *Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006d) to help ensure that the methodologies used in each railyard HRA meet the requirements in the ARB / Railroad Statewide Agreement. The railyard HRA follows *The Air Toxics Hot Spots Program Risk Assessment Guidelines* (OEHHA, 2003) published by the OEHHA, and is consistent with the methodologies used for the UP Roseville Railyard Study (ARB, 2004a) performed by ARB staff.

The United States Environmental Protection Agency (U.S. EPA) recently approved a new state-of-science air dispersion model called AERMOD (**A**merican Meteorological Society/**E**PA **R**egulatory Model Improvement Committee **MOD**EL). This model is used in the ARB railyard health risk assessments. One of the critical inputs required for the air dispersion modeling is the meteorology, such as wind direction and wind speed. These parameters determine where and how the pollutants will be transported. Based on the AERMOD meteorological data selection criteria, the data from the Oakland International Airport, operated by National Weather Service, was selected for the modeling.

An **isopleth** is a line drawn on a map through all points of equal value of some measurable quantity; in this case, cancer risk.

The potential cancer risk levels associated with the estimated diesel PM emissions at the UP Oakland Railyard are displayed by using isopleths. For this analysis, ARB staff elected to present the cancer risk isopleths focusing on risk levels of 10, 25, 50, 100, and 250 in a million. Figure II-2 (see page 14) and Figure II-3 (see page 16) present these isopleths. Figure II-2 focuses on the near source risk levels and Figure II-3 focuses on the more regional impacts. In each figure, the risk isopleths are overlaid onto a satellite image of the Oakland area surrounding the UP Oakland Railyard, to better illustrate the land use (residential, commercial, industrial, or mixed use) of these impacted areas.

OEHHA Guidelines specify that, for health risk assessments, the cancer risk for the maximum exposure at the point of maximum impact be reported. The point of maximum impact (PMI), which is defined as a location or the receptor point with the highest cancer risk level outside of the facility boundary, with or without residential exposure, is predicted to be located at the east side of the railyard fence line, next to Interstate 880 (see Figure II-2). This is directly downwind of high emission density areas for the prevailing westerly wind, where about 55% of facility-wide diesel PM emissions are generated (see the emission allocation in Appendix F).

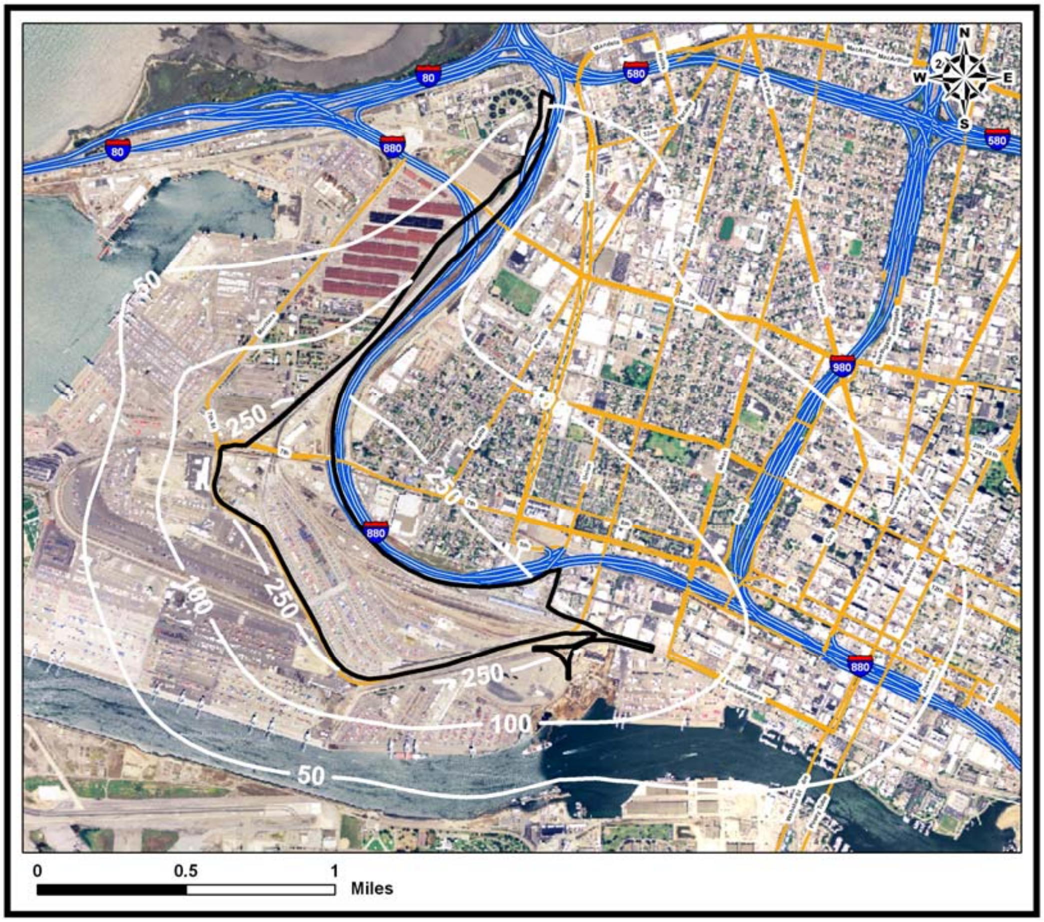
The cancer risk at the PMI is estimated to be about 640 chances in a million. The land use in the vicinity of the PMI is primarily zoned as industrial use. However, there may be residents living in this zoned area. In the residential zoned area, the potential cancer risk of maximally exposed individual resident (MEIR) or maximum individual cancer risk (MICR) is estimated at about 460 chances in a million.

As indicated by Roseville Railyard Study (ARB, 2004a), the location of the PMI may vary depending upon the settings of the model inputs and parameters, such as meteorological data set or emission allocations in the railyard. Therefore, given the estimated emissions, modeling settings, and the assumptions applied to the risk assessment, there are great uncertainties associated with the estimation of point of maximum impact (PMI) and maximum individual cancer risk (MICR). These indications should not be interpreted as a literal prediction of disease incidence but more as a tool for comparison. In addition, the estimated point of maximum impact location and maximum individual cancer risk value may not be replicated by air monitoring.

ARB staff also conducted a comparison of cancer risks estimated at the PMI versus MICR, and the differences of facility-wide diesel PM emissions between the UP and BNSF railyards. The ratios of cancer risks at the PMI or MICR to the diesel PM emissions do not suggest that one railroad's facilities have statistically higher cancer risks than the other railroad's or vice versa. Rather, the differences are primarily due to emission spatial distributions from individual operations among railyards.

As indicated by Figure II-2, the area with the greatest impact has an estimated potential cancer risk of over 250 chances in a million, occurring in an area to the east of the railyard across Interstate 880. The estimated cancer risk is over 100 chances per million within a mile from the east side of railyard property boundaries. At about two miles from the railyard boundaries, the estimated cancer risks decrease to about 50 chances per million.

Figure II-2: Estimated Near-Source Cancer Risks (chances per million people) from the UP Oakland Railyard



As indicated by Figure II-3, the risks further decrease to 25 chances per million within about 3 miles from the railyard. At about 4 miles from the railyard boundaries, the estimated cancer risks drop to about 10 chances per million or lower.

The OEHHA Guidelines recommend a 70-year lifetime exposure duration to evaluate the potential cancer risks for residents. Shorter exposure durations of 30 years and 9 years may also be evaluated for residents and school-age children, respectively, as a supplement. These three exposure durations – 70 years, 30 years, and 9 years – all assume exposure for 24 hours a day, and 7 days a week. It is important to note that children, for physiological as well as behavioral reasons, have higher rates of exposure than adults on a per unit body weight basis (OEHHA, 2003).

To evaluate the potential cancer risks for off-site workers, the OEHHA Guidelines recommend that a 40-year exposure duration be used, assuming workers have a different breathing rate (149 L kg^{-1} day^{-1}) and exposure for an 8-hour workday, five days a week, 245 days a year. Table II-4 shows the equivalent risk levels of 70- and 30-year exposure durations for exposed residents; and 40- and 9-year exposure durations for workers and school-age children, respectively. As Table II-4 shows, the 10 in a million isopleth line in Figure II-3 would become 4 in a million for exposed population with a shorter residency of 30 years, 2.5 in a million for exposed school-age children, and 2 in a million for off-site workers.

To conservatively communicate the risks, ARB staff presents the estimated cancer risk isopleths all based on 70-year resident exposure duration, even for those impacted industrial areas where no resident lives.

Table II-4: Equivalent Potential Cancer Risk Levels for 70-, 40-, 30- and 9-Year Exposure Durations

Exposure Duration (years)	Equivalent Risk Level (Chances in a million)					
70	10	25	50	100	250	500
30	4	11	21	43	107	214
9[*]	2.5	6.3	12.5	25	63	125
40[‡]	2	5	10	20	50	100

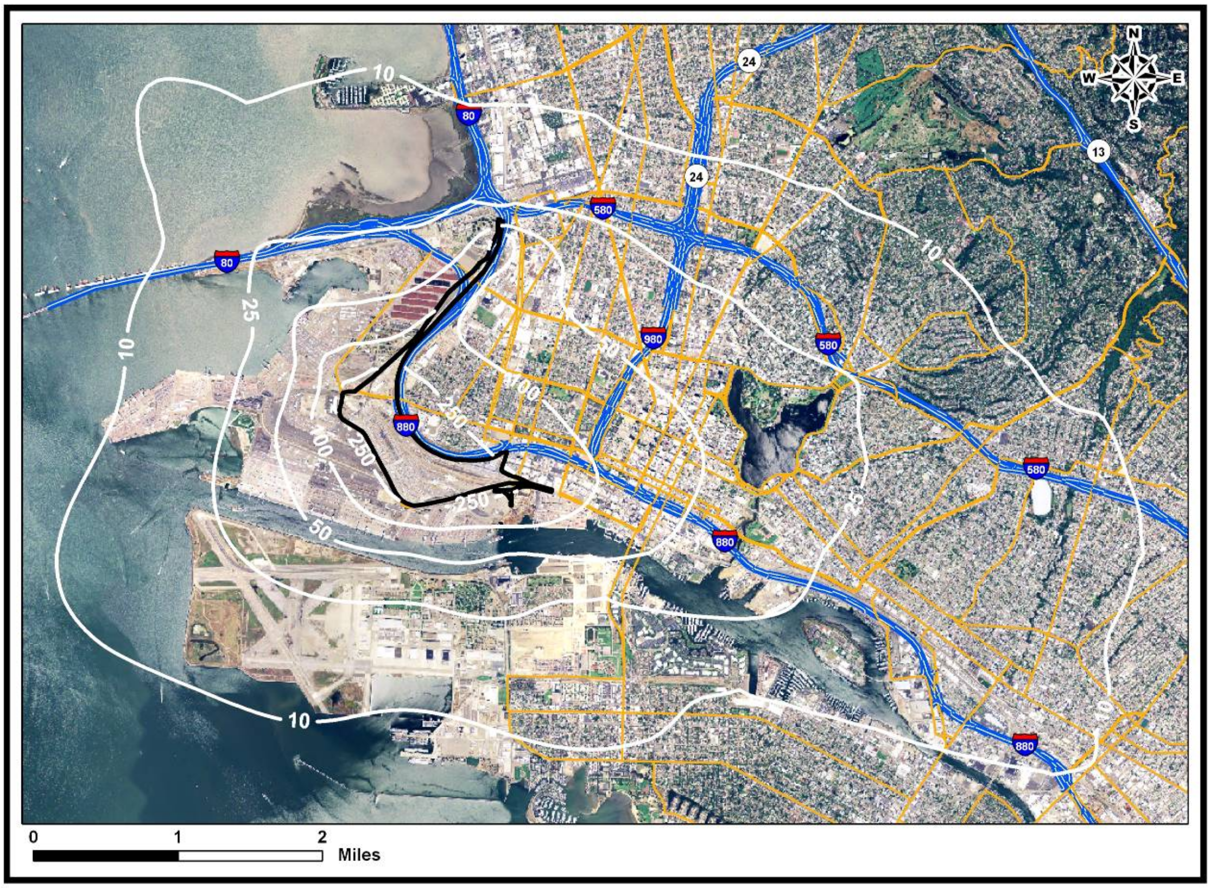
[*] Exposure duration for school-aged children.
[‡] Exposure duration for off-site workers.

The more populated areas near the UP Oakland Railyard are located east of the railyard. Based on the 2000 U.S. Census Bureau's data, the zone of impact of the estimated risks above 10 chances in a million levels encompasses approximately 16,700 acres where about 193,000 residents live. Table II-5 presents the exposed population and area coverage size for various impacted zones of cancer risks.

Table II-5: Estimated Impacted Areas and Exposed Population Associated with Different Cancer Risk Levels Estimated for Railyard Diesel PM Emissions

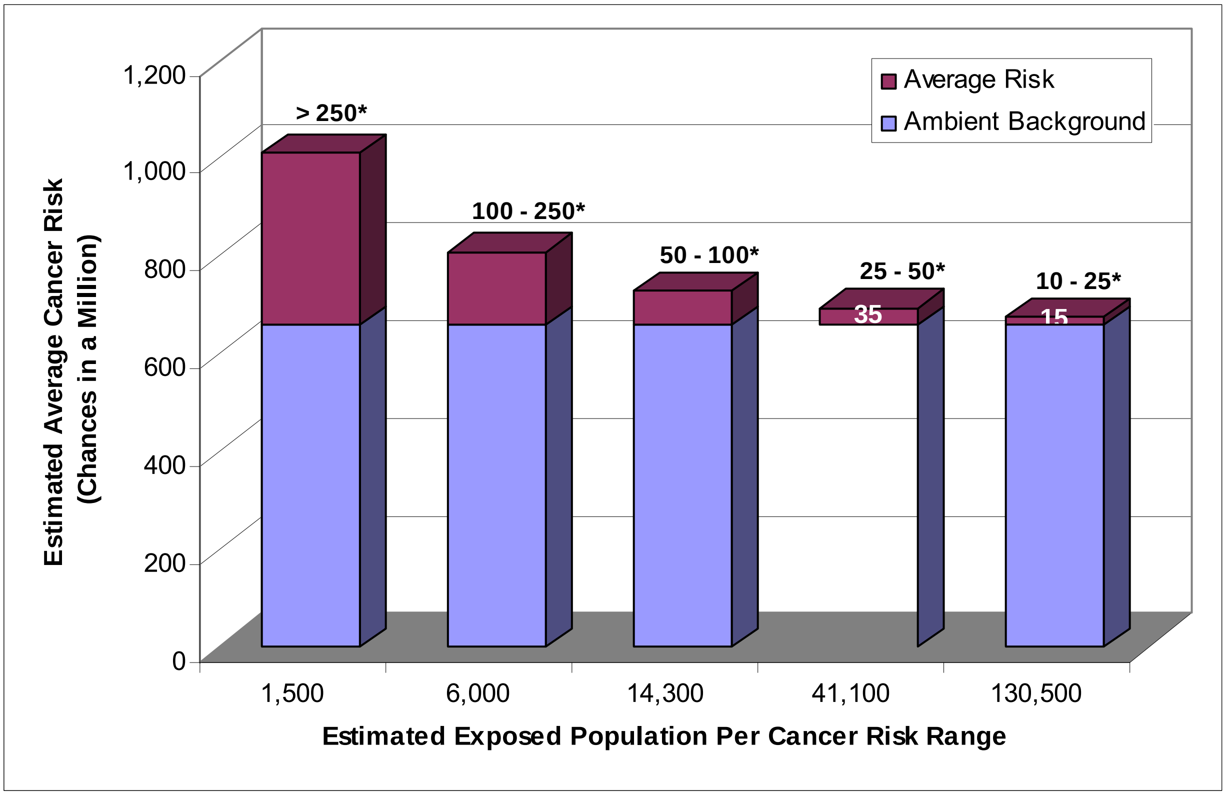
Estimated Cancer Risk (chances per million)	Impacted Area (Acres)	Estimated Population Exposed
>250	130	1,500
101 - 250	800	6,000
51 - 100	1,700	14,300
26 - 50	3,500	41,100
10 - 25	10,600	130,500
> 10	**16,730**	**193,400**

Figure II-3: Estimated Regional Cancer Risks (chances per million people) from the UP Oakland Railyard



It is important to understand that these risk levels represent the predicted risks (due to the UP Oakland Railyard diesel PM emissions) above the existing background risk levels. For the broader San Francisco Bay Air Basin, the estimated regional background risk level is estimated to be about 660 in a million caused by all toxic air pollutants in 2000 (ARB, 2006a). Figure II-4 provides a comparison of the predicted average potential cancer risks in various isopleths to the regional background risk level and estimated exposed population. For example, in the risk range greater than 250 chances in a million, the estimated average potential cancer risk above the regional background is 352 chances per million. When combined with the regional background level of 660 in a million, the potential cancer risk for residents living in that area would be about 1,000 in a million.

Figure II-4: Comparison of Estimated Potential Cancer Risks from the UP Oakland Railyard and the Regional Background Risk Levels



*Cancer Risk Range (Chances in a Million).

E. What are the estimated non-cancer risks near the UP Oakland Railyard?

The potential non-cancer chronic health hazard index from diesel PM emissions from the UP Oakland Railyard is estimated to be less than 0.2. According to OEHHA Guidelines (OEHHA, 2003), these levels (less than 1.0) indicate that the potential non-cancer chronic public health risks are less likely to happen.

Due to the uncertainties in the toxicological and epidemiological studies, diesel PM as a whole was not assigned a short-term acute REL. It is only the specific compounds of diesel exhaust (e.g., acrolein) that independently have potential acute effects (such as irritation of the eyes and respiratory tract), and an assigned acute REL. However, acrolein is a chemically reactive and unstable compound, and easily reacts with a variety of chemical compounds in the atmosphere. Compared to the other compounds in the diesel exhaust, the concentration of acrolein has a much lower chance of reaching a distant off-site receptor. More importantly, given the multitude of activities ongoing at facilities as complex as railyards, there is a much higher level of uncertainty associated with maximum hourly-specific emission data, which is essential to assess acute risk. Therefore, non-cancer acute risk is not addressed quantitatively in this study. From a risk management perspective, ARB staff believes it is reasonable to focus on diesel PM cancer risk because it is the predominant risk driver and the most effective parameter to evaluate risk reduction actions. Moreover, actions to reduce diesel PM will also reduce non-cancer risks.

F. Can study estimates be verified by air monitoring?

Currently, there is no approved specific measurement technique for directly monitoring diesel PM emissions in the ambient air. This does not preclude the use of an ambient monitoring program to measure general air quality trends in a region. Since cancer risk is based on an annual average concentration, a minimum of a year of monitoring data would generally be needed.

G. What activities are underway to reduce diesel PM emissions and public health risks?

The ARB has developed an integrated approach to reduce statewide locomotive and railyard emissions through a combination of voluntary agreements, ARB and U.S. EPA regulations, incentive funding programs, and early replacement of California's line haul and yard locomotive fleets. California's key locomotive and railyard air pollution control measures and strategies are summarized below:

South Coast Locomotive NOx Fleet Average Agreement (1998): Signed in 1998 between ARB and both Union Pacific Railroad (UP) and BNSF Railway (BNSF), it requires the locomotive fleets that operate in the South Coast Air Quality Management District (SCAQMD) to meet, on average, U.S. EPA's Tier 2 locomotive emissions standards by 2010. This measure will provide an estimated 65% reduction in oxides of nitrogen (NOx) and 50% reduction in locomotive particulate matter emissions in the South Coast Air Basin (SCAB) by 2010. This Agreement will provide locomotive fleet benefits in Southern California 20 years earlier than the rest of the country.

Statewide Railroad Agreement (2005): ARB and both UP and BNSF signed a voluntary statewide agreement in 2005 which does not change any federal, state, or local authorities to regulate railroads. The Agreement has resulted in measures that have achieved a 20% reduction in locomotive diesel PM emissions in and around railyards since its adoption in June 2005. The measures in the Agreement include:

- Phasing out of non-essential idling on all locomotives without idle reduction devices (60 minute limit – fully implemented);
- Installing idling reduction devices on 99% of the 450 California-based locomotives by June 30, 2008 (15 minute limit – 95% implemented);
- Identifying and expeditiously repair locomotives with excessive smoke and ensure that at least 99% of the locomotives operating in California pass smoke inspections;
- Requiring all locomotives that fuel in the state use at least 80% federal or California ultra low sulfur (15 parts per million) diesel fuel by January 1, 2007, (fully implemented, six years prior to federal requirement).
- Preparing new health risk assessments for 16 major railyards, based on the UP Roseville Railyard health risk assessment (completed in 2004) and Office of Environmental Health Hazard Assessment (OEHHA) guidelines; (nine of 16 finalized in November 2007); and
- Identifying and implement future feasible mitigation measures based on the results of the railyard health risk assessments.

ARB Diesel Fuel Regulations Extended to Intrastate Locomotives (2007): This regulation, approved in 2004, requires intrastate locomotives that operate 90 percent of the time in the state to use only California ultra low sulfur (15 parts per million) diesel fuel. CARB diesel's lower aromatics provide on average a six percent reduction in NOx and 14 percent reduction in diesel PM emissions as compared to U.S. EPA ultra low sulfur on-road diesel fuel. ARB staff estimates there are about 100 intrastate locomotives currently operating in San Francisco Bay Area Air Basin, and CARB diesel will reduce these locomotive emissions by up to 12 tons per year for diesel PM and 120 tons per year for NO_x. The regulation took effect statewide for intrastate locomotives on January 1, 2007.

ARB Cargo Handling Equipment Regulations (2007): This regulation, approved in 2005, requires the control of emissions from more than 4,000 pieces of mobile cargo handling equipment such as yard trucks and forklifts that operate at ports and intermodal rail yards. Implementation of this regulation will reduce diesel PM emissions by approximately 40% in 2010 and 65% in 2015, and NO_x emissions by approximately 25% in 2010 and 50% in 2015. The regulation, when fully implemented, is expected to cumulatively reduce diesel PM and NO_x emissions from all cargo handling equipment in the State by up to 80 percent by 2020. The regulation took effect on January 1, 2007

Heavy Duty Diesel New Trucks Regulations: ARB and the U.S. EPA both have adopted emission standards for 2007 and subsequent model year heavy-duty diesel engines. These emission standards represent a 90% reduction of NOx emissions, a 72% reduction of non-methane hydrocarbon emissions, and a 90% reduction of PM emissions compared to the 2004 model year emission standards. The ARB adopted similar emission standards and test procedures to reduce emissions from 2007 and subsequent model year heavy-duty diesel engines and vehicles. Statewide, NOx and diesel PM emissions from on-road heavy-duty diesel trucks will be reduced by approximately 50 and 3 tons per day, respectively, in 2010; by 140 and 6 tons per day, respectively, in 2015; and by 210 and 8 tons per day, respectively, in 2020.

ARB Statewide Diesel Truck and Bus Regulation: The ARB is developing a regulation to reduce diesel PM, NO_x and green house gas emissions from on-road heavy-duty diesel-fueled vehicles. This measure will cover long and short haul truck-tractors, construction related trucks, wholesale and retail goods transport trucks, tanker trucks, package and household goods transport trucks, and most other diesel-powered trucks and buses with a gross vehicle weight rating of 14,000 pounds or greater (shuttle buses of all sizes will also be included). The goals of this effort are: (a) by 2014, emissions are to be no higher than a 2007 model year engine with a diesel particulate filter, and (b) by 2021, emissions are to be no higher than a 2010 model year engine. With the implementation of the proposed measure, California's emissions from this sector could be reduced by about 70 percent and NOx emissions by up to 35 percent in 2014. This measure is scheduled for ARB Board consideration in October-2008.

In-Use Port and Railyard Truck Mitigation Strategies: The ARB developed a port truck fleet modernization program that will reduce diesel PM by nearly 86% by 2010, and NOx by nearly 56% by 2014, as compared to the 2007 baseline. There are an estimated 20,000 drayage trucks operating at California's ports and intermodal railyards. These trucks are a significant source of air pollution, with about 3 tons per day of diesel PM and 61 tons per day of NOx in 2007. Drayage trucks also often operate in close proximity to communities. This regulation will result in significant reductions in exposure and potential cancer risks to residents that live near ports, railyards, and the major roadways. The ARB approved the regulation in December 2007.

ARB Tier 4 Off-Road Diesel-Fueled New Engine Emission Standards: In 2004, the ARB and U.S. EPA adopted a fourth phase of emission standards (Tier 4). New off-road engines are now required to meet after treatment-based exhaust standards for particulate matter (PM) and NOx starting in 2011. The Tier 4 standards will achieve over a 90 percent reduction over current levels by 2020, putting off-road heavy duty engines on a virtual emission par with on-road heavy duty engines.

Transport Refrigeration Unit (TRU) Airborne Toxics Control Measure (ATCM): This airborne toxics control measure is applicable to refrigeration systems powered by integral internal combustion engines designed to control the environment of temperature sensitive products that are transported in trucks, trailers, railcars, and shipping containers. Transport refrigeration units may be capable of both cooling and heating. Estimates show that diesel PM emissions for transport refrigeration units and transport refrigeration unit gen-set engines will be reduced by approximately 65% in 2010 and 92% in 2020. California's air quality will also experience benefits from reduced NOx and HC emissions. The transport refrigeration unit airborne toxics control measure is designed to use a phased approach over about 15 years to reduce the diesel PM emissions from in-use transport refrigeration unit and transport refrigeration unit generator set engines that operate in California. The TRU ATCM was approved on February 26, 2004 and became effective on December 10, 2004. Compliance dates for meeting in-use performance standards are phased in, beginning December 31, 2008, and extending out in time from there.

U.S. EPA Locomotive Emission Standards: Under the Federal Clean Air Act, U.S. EPA has sole authority to adopt and enforce locomotive emission standards. Under U.S. EPA’s rules, this preemption also extends to the remanufacturing of existing locomotives. In April 2007, U.S. EPA released a proposed locomotive rulemaking that would reduce Tier 0 locomotive NOx emissions by 20 percent and Tier 0-3, remanufacture and new standards, to reduce PM by 50 percent. The ARB is relying on U.S. EPA to expeditiously require the introduction of the next generation or Tier 4 locomotive emission standards that requires Tier 4 locomotives to be built with diesel particulate filters and selective catalytic reduction. Combined, these exhaust aftertreatment devices are expected to provide up to a 90 percent reduction in NOx and PM emissions beginning in 2015-2017. The final U.S. EPA locomotive regulations are scheduled for approval in early 2008.

ARB Goods Movement Emission Reduction Plan (GMERP): Approved in 2006, this plan forecasts goods movement emissions growth and impacts. It contains a comprehensive list of proposed strategies to reduce emissions from ships, trains, and trucks and to maintain and improve upon air quality. The strategies in the plan, if fully implemented, would reduce locomotive NOx and diesel PM emissions by up to 85% by 2020.

California Yard Locomotive Replacement Program: One locomotive strategy being pursued is to replace California's older yard locomotives that operate in and around railyards statewide. Yard locomotives represent about five percent of the statewide locomotive NOx and diesel PM emissions, but often occur in railyards located in densely populated urban centers. Multiple nonroad engine (gen-set) and electric-hybrid yard locomotives have demonstrated they can reduce NOx and diesel PM emissions by up to 90 percent as compared to existing locomotives. By 2008, UP had deployed 60 gen-set and 12 electric hybrid yard locomotives in southern California. BNSF has been operating four liquefied natural gas (LNG) yard locomotives in downtown Los Angeles since the mid-1990s. UP and BNSF have ordered more gen-set locomotives for use in northern California in 2008.

III. UP OAKLAND RAILYARD DIESEL PM EMISSIONS

This chapter provides a summary of the diesel PM emissions in and around the UP Oakland Railyard.

A. UP Oakland Railyard Diesel PM Emissions Summary

The UP Oakland Railyard activity data and emission inventories were provided by the Union Pacific Railroad and its consultants Sierra Research and Air Quality Management Consulting. The methodology used to calculate the diesel PM and other toxic air contaminant (TAC) emissions is based on *ARB Rail Yard Emissions Inventory Methodology* (ARB, 2006c). Detailed calculation methodologies and resulting emission factors are included in the *Toxic Air Contaminant Emissions Inventory and Dispersion Modeling Report for the Oakland Rail Yard, Oakland, California* (Sierra Research, 2007) submitted by Sierra Research (hereafter Sierra Research Report). For the year 2005, the diesel PM emissions from the UP Oakland Railyard are estimated at about 11.2 tons per year

The UP Oakland Railyard is a cargo handling facility with a focus on intermodal containers, and processed an estimated 350,000 containers in 2005. Cargo containers and other freight are received, sorted, and distributed from the facility. Intermodal containers may arrive at the facility by truck to be loaded onto trains for transport to distant destinations, or arrive by train and unloaded onto chassis for transport by truck to local destinations. Cargo containers and chassis are also temporarily stored at the railyard. The railyard also includes facilities for crane and yard hostler maintenance, locomotive service and repair, and an on-site wastewater treatment plant.

Activities at UP Oakland Railyard include receiving inbound trains, switching rail cars, loading and unloading intermodal trains, building and departing outbound trains, storage of intermodal containers and truck chassis, and repairing freight cars and intermodal containers/chassis. The railyard includes a bypassing main line with freight and passenger train traffic that is not part of the railyard operations.

Facilities within the railyard include: classification tracks, a gate complex for inbound and outbound intermodal truck traffic, intermodal loading and unloading tracks, a locomotive service track, a locomotive maintenance shop, a freight car repair shop, an on-site wastewater treatment plant, and various buildings and facilities supporting railroad and contractor operations. On-site sources were separated into four operation areas based on specific activities to better characterize diesel PM emissions. These areas are summarized in Table III-1 and shown in Figure III-1. The detailed schematic and descriptions of the areas and activities are presented in the Sierra Research Report (Sierra Research, 2007).

Table III-1: UP Oakland Railyard Activities

Area	Description
Main Yard	Most activities occurring here (loading, unloading, cargo handling, etc.)
Maintenance Area	Maintenance and service area for locomotives.
Chassis Stack Areas	Areas to store and stack the chassis
Intermodal Gate	Trucks entering and leaving the Yard

With the data provided by UP and the methodology described in the Sierra Research Report, the diesel PM emissions from railyard sources are estimated to be approximately 11.2 tons per year. The diesel PM emissions from each activity are provided in Table III-2.

Table III-2: Summary of the UP Oakland Railyard Diesel PM Emissions

Sources	**Diesel PM Emissions (tons per year)**	
	Total Diesel PM Emissions	**Percent of Total**
LOCOMOTIVES	**3.9**	**35%**
Switchers	*1.9*	*17%*
Line Hauls	*1.6*	*14%*
Service/Testing	*0.5*	*4%*
TRUs and Reefer Cars	**3.2**	**29%**
CARGO HANDLING EQUIPMENT†	**2.2**	**20%**
ON-ROAD TRUCKS	**1.90**	**17%**
TOTAL	**11.2**	**100%***

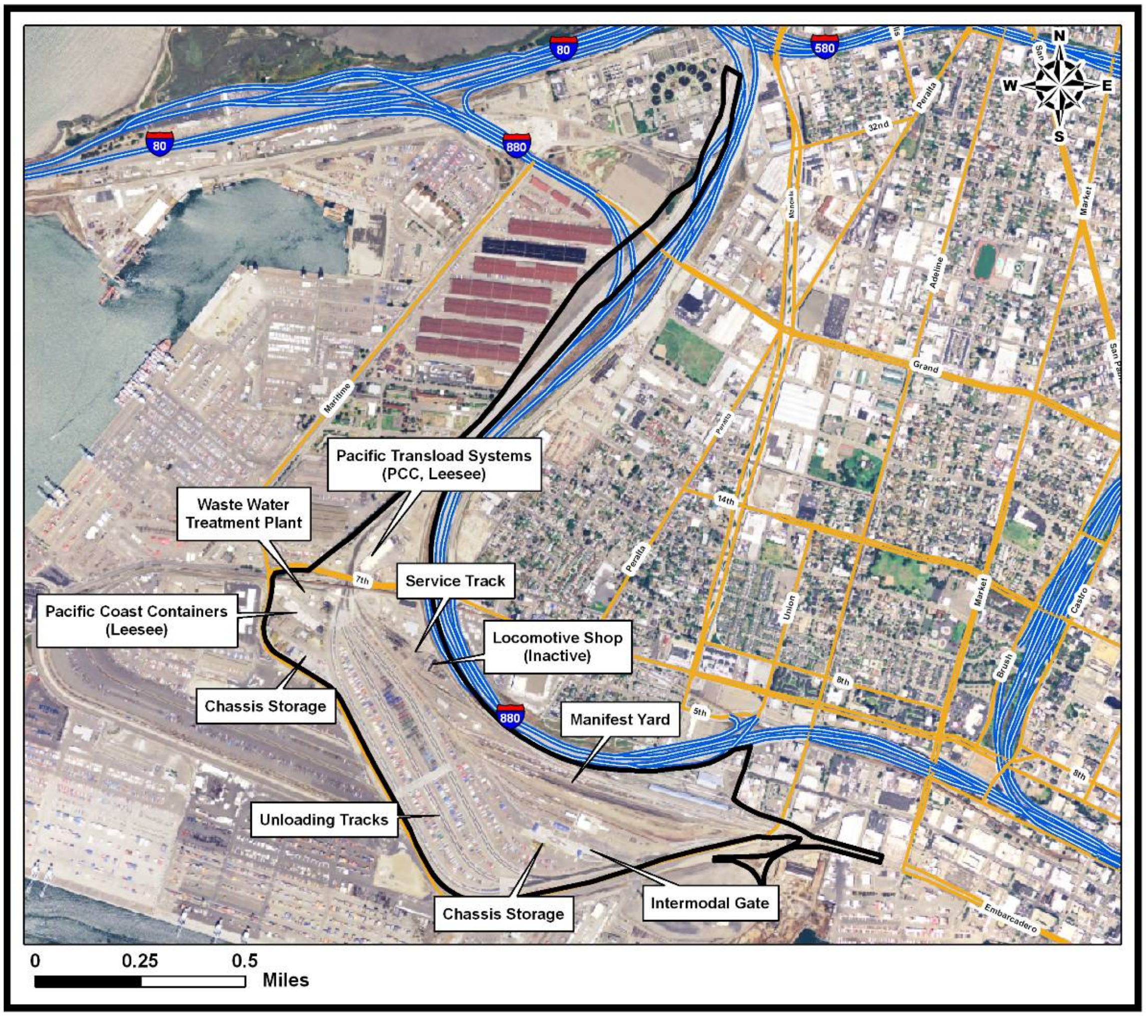
† After the modeling was completed, ARB received updated information on cargo handling equipment emissions. However, the resulting change in emissions was de minimis, so the modeling was not reperformed.

* Numbers and percentages may not add precisely due to rounding.

Diesel PM is not the only toxic air contaminant (TAC) emitted in the UP Oakland Railyard. Relatively small amounts of gasoline toxic air contaminants (benzene, isopentane, toluene, etc.) are generated from gasoline storage tanks and gasoline-powered vehicles and engines. Some other toxic air contaminants, such as xylene, are emitted from the wastewater treatment plant. The detailed emission inventories for these TACs are presented in the Sierra Research report. The total amount of these toxic air contaminants emissions is about 0.10 tons or 200 pounds per year, compared to the 11.2 tons per year of the diesel PM emissions in the railyard.

In addition, when adjusted on a cancer potency weighted basis for their toxic potential, these non-diesel PM toxic air contaminants have a potential cancer risk level of les than a thousandth of the cancer risk level for diesel PM. Hence, only diesel PM emissions are presented in the on-site emission analysis.

Figure III-1: The UP Oakland Railyard Emission Source Locations



1. Locomotives

Locomotives are the largest diesel PM emission source at the UP Oakland Railyard. Locomotives contribute about 3.9 tons per year, or about 35% of the total railyard diesel PM emissions.

As shown in Table III-3, the highest percentage of locomotive diesel PM emissions result from switch locomotives conducting railyard operations, accounting for about half of the total locomotive diesel PM emissions (1.88 tons per year). Line haul locomotives generate 1.56 tons per year of diesel PM emissions, with arriving and departing trains at about 0.46 tons per year, and through trains and various power moves (e.g., moving to other yards for fueling) at about 0.47 tons per year. Service and load testing produced about 0.47 tons per year of diesel PM emissions.

Temporal emission profiles were estimated for each activity based on hourly locomotive counts. The profiles developed account for hourly, daily and seasonal temporal variations and are reflected in the air dispersion modeling to capture operational variations.

According to UP, their interstate locomotives were fueled out of state before they entered the California borders. However, data for the detailed diesel deliveries within and outside of California were not available in 2005. Trains arriving and terminating at California railyards (with the exception of local trains) used fuel produced outside of California, and arrive with remaining fuel in their tanks at 10% of capacity. On arrival, locomotives were refueled with California diesel fuel, resulting in a mixture of 90% CARB and 10% non-CARB fuel. This mixture is representative of fuel on departing trains as well as trains undergoing load testing (if conducted at a specific yard). For through trains by-passing UP railyards, an average composition of 50-50 split was applied to account for CARB-EPA and non-California diesel fuel used. Therefore, UP estimated different fuel sulfur levels based on the average fractions of California fuel being used as follows: 221 ppmw for yard operations, 463 ppmw for arriving and departing trains, 1,430 ppmw for through trains, and 2,639 ppmw for terminating trains.

The locomotive diesel PM emission factors used in this study are based on those of UP Roseville Railyard Study (ARB, 2004a), and have been adjusted according to 2005 fuel sulfur levels provided by UP. The adjustment factors are linear in sulfur content, allowing emission rates for a specific mixture of California and non-road fuels to be calculated as a weighted average of the emission rates for each of the fuels. Adjustment factors were developed and used to prepare tables of emission factors for two different fuel sulfur levels:

- California Fuel. In 2005, Chevron was Union Pacific Railroad’s principal supplier of diesel fuel in California. Chevron’s California refineries produced only one grade of low sulfur diesel for both CARB diesel and U.S. EPA on-road diesel fuels in 2005. Quarterly average sulfur content for these refineries ranged from 59 ppmw to 400 ppmw, with an average of 221 ppmw. The 221 ppmw sulfur content is assumed to be representative of California fuel used by UP (Sierra Research, 2007).
- Non-Road Fuel. In the U.S. EPA’s 2004 regulatory impact analysis in support of regulation on non-road diesel engines, the estimated 49-state average fuel sulfur content is 2,639 ppmw (U.S. EPA, 2004c). The 2,639 ppmw sulfur content is assumed to be representative of non-road diesel fuel used by UP for fueling of locomotives outside of California (Sierra Research, 2007).

The benefit of the diesel fuel regulations is presented in detail in Section B.

The results are shown in two tables in Appendix D. Table III-3 presents the summary of diesel PM emissions from locomotive operation activities.

Table III-3: Locomotive Diesel PM Emissions

Activity	Diesel PM Emissions	
	Tons per year	Percent of Total
Switching	**1.88**	**48%**
Line Haul	**1.56**	**40%**
Intermodal Trains	*0.62*	*16%*
Through Trains and Power Moves	*0.47*	*12%*
Other Trains	*0.46*	*12%*
Service/Maintenance	**0.48**	**12%**
TOTAL*	**3.91**	**100%**

* Numbers may not add precisely due to rounding.

The ARB has developed an integrated approach to reduce statewide locomotive emissions through a combination of voluntary agreements, ARB and U.S. EPA regulations, incentive funding programs, and early replacement of California's line haul and yard locomotive fleets. In the future, the UP Oakland Railyard may benefit from these mitigation measures as diesel PM emissions from locomotives are gradually reduced as the locomotive fleets turn over. The replacement of the four switch locomotives in the yard with ultra low emitting switch locomotives could reduce switching emissions by up to 90% and reduce facility-wide emissions by up to 15%. The detailed approach has been discussed in Chapter 2.

2. TRUs and Reefer Cars

Transport refrigeration units (TRUs) and refrigerated rail cars (reefer cars) are used to transport perishable and frozen goods. TRUs and reefer cars are transferred in and out of the railyard and are temporarily stored at the railyard. Diesel PM emissions from TRUs and reefer cars are the second largest source of diesel PM at the UP Oakland Railyard. They were estimated at 3.2 tons per year, or about 29% of railyard diesel PM emissions. The detailed methodology is discussed in the Sierra Research Report.

In November 2004, ARB adopted a new regulation: *Airborne Toxic Control Measure (ATCM) for In-Use Diesel-Fueled Transport Refrigeration Units (TRUs), TRU Generator Sets and Facilities where TRUs Operate*. This regulation applies to all TRUs in California, including those coming into California from out-of-state. It requires in-use TRU and TRU gen-set engines to meet specific diesel PM emissions that vary by horsepower range and engine model year, starting December 31, 2008 for engine model years 2001 or older. ARB staff estimates that diesel PM emissions for TRUs and TRU gen-set engines will be reduced by approximately 65% by 2010 and 92% by 2020. This measure is designed to use a phased approach over about 15 years. Starting in 2009, the UP Oakland Railyard will benefit from these mitigation measures as diesel PM emissions from TRUs are steadily reduced as their fleets turn over.

Table III-4: TRU Diesel PM Emissions

Equipment	Diesel PM Emissions	
	Tons per year	Percent of Total
TRU	**2.47**	**78%**
Railcar	**0.68**	**22%**
TOTAL*	**3.15**	**100%**

* Numbers and percentages may not add precisely due to rounding.

3. Cargo Handling Equipment

Cargo handling equipment[*] (CHE) is the third largest diesel PM emission source at the UP Oakland Railyard. The diesel PM emissions from cargo handling equipment was estimated at 2.2 tons in year 2005, equivalent to about 20% of the total diesel PM emissions from the UP Oakland Railyard.

Cargo handling equipment is used to move intermodal freight and containers at the UP Oakland Railyard. Additionally, cargo handling equipment is used for non-cargo-related activities at the railyard. Five types of equipment were included in CHE: yard hostlers, rubber-tired gantries (RTG), chassis stackers, and heavy equipment (forklifts, cranes, backhoes, a trackmobile and a man lift).

- Yard hostlers are also known as yard trucks. It is the most common type of cargo handling equipment. A yard hostler is very similar to an on-road truck tractor, but is designed to move cargo containers within the railyard.
- Rubber-tired gantry (RTG) cranes are very large cargo container handlers that have lifting equipment mounted on a cross-beam supported on vertical legs which run on rubber tires.
- Chassis stackers are used to stack the truck chassis.
- Heavy equipment is used for locomotive maintenance, handling of parts and company material, derailments, etc.

The CHE diesel PM emissions in the UP Oakland Railyard were estimated using the latest version of ARB OFFROAD model. As indicated in Table III-5, about 72% of the CHE diesel PM emissions were due to the yard hostlers, at about 1.59 tons per year. The RTGs emit about 16% of the total CHE diesel PM emissions (0.35 tons per year). Heavy equipment emits about 9% of the total CHE diesel PM (0.20 tons per year). The remaining 3% of the CHE diesel PM emissions was divided among the chassis stackers and cranes. Additional details of calculations and estimations are presented in Sierra Research Report.

In December 2005, ARB adopted a new regulation for cargo handling equipment to reduce diesel PM and NOx emissions beginning in 2007. Implementation of this regulation will reduce diesel PM emissions by approximately 40% in 2010 and 65% in 2015, and NO_x emissions by approximately 25% in 2010 and 50% in 2015. The regulation, when fully implemented, is expected to cumulatively reduce diesel PM and NO_x emissions from all cargo handling equipment in the State by up to 80 percent by

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[*] According to Title 13, Section 2479 of the California Code of Regulations, *Cargo Handling Equipment* means any off-road, self-propelled vehicle or equipment used at a port or intermodal rail yard to lift or move container, bulk, or liquid cargo carried by ship, train, or another vehicle, or used to perform maintenance and repair activities that are routinely scheduled or that are due to predictable process upsets. Equipment includes, but is not limited to, mobile cranes, rubber-tired gantry cranes, yard trucks, top handlers, side handlers, reach stackers, forklifts, loaders, sweepers, aerial lifts, excavators, and dozers.

2020. Therefore, starting in 2007, the UP Oakland Railyard will benefit from these mitigation measures.

Table III-5: Cargo Handling Equipment Diesel PM Emissions

Equipment	Diesel PM Emissions	
	Tons per year	Percent of Total
Yard Hostlers	**1.59**	**72%**
RTGs	**0.35**	**16%**
Heavy Equipment	**0.20**	**9%**
Chassis Stackers	**0.05**	**2%**
Cranes	**0.004**	**<1%**
TOTAL*	**2.2**	**100%**

* Numbers and percentages may not add precisely due to rounding.

4. On-Road Diesel-Fueled Trucks

On-road trucks contribute about 17% of the total railyard diesel PM emissions at about 1.90 tons per year. As shown in Table III-6, 99% of the on-road truck diesel PM emissions come from heavy heavy-duty[*] (HHD) trucks, which were estimated as 1.88 tons per year. All of the other diesel-fueled trucks generate less than 0.01 tons per year of the diesel PM emissions. About two-thirds of the HHD truck diesel PM emissions were from traveling within the railyard, versus idling.

An ARB regulation to modernize port and intermodal railyard drayage trucks is estimated to reduced diesel PM emissions by 86% by 2010, and NO_x by 56% by 2014, as compared to the 2007 baseline.

In January 2001, the U.S. EPA promulgated a Final Rule for emission standards for 2007 and subsequent model year heavy-duty diesel engines (66 FR 5002, January 18, 2001). These emission standards represent a 90% reduction of oxides of nitrogen emissions, a 72% reduction of non-methane hydrocarbon emissions, and a 90% reduction of particulate matter emissions compared to the 2004 model year emission standards. Starting in 2007, the UP Oakland Railyard will benefit from these mitigation measures as diesel PM emissions from heavy-duty diesel fueled trucks are gradually reduced as the truck fleets turn over.

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[*] HHD: Gross Vehicle Weight Rating: 33,001 lbs or more.

Table III-6: UP Oakland Railyard On-Road Truck Diesel PM Emissions

Source	Diesel PM Emissions (tons per year)		
	Traveling	Idling	Total
HDD Diesel-Fueled Truck	**1.19***	**0.68***	**1.87***
Other Diesel-Fueled Trucks	**0.006**	**0.002**	**0.008**
TOTAL	**1.20***	**0.68***	**1.88***
Percent of Total On-Road Truck Emissions	**64%**	**36%**	**100%**

* Numbers may not add precisely due to rounding.

5. Other Toxic Air Contaminants Emissions

A small amount of toxic air contaminant (TAC) emissions were identified and estimated at about 0.1 tons or about 200 pounds per year in the UP Oakland railyard. These TACs include benzene, chloroform, and methyl chloride. In comparison to the diesel PM emissions generated at the facility, these TACs are at less than 1%. Based on cancer potency weighted factor adjustment discussed in Chapter II, the potential cancer risks contributed by these toxic air contaminants are found to be considerably lower than the potential cancer risks contributed by diesel PM. Because of the dominance of diesel PM emissions, these gaseous toxic air contaminants are not included in the health impact evaluation in this study.

B. Current Applicable Diesel Fuel Regulations and their Benefits to the Railyards

1. California Air Resources Board (CARB) Diesel Fuel Specifications

The initial California diesel fuel specifications were approved by the Board in 1988 and limited sulfur and aromatic contents. The requirements for "CARB diesel," which became applicable in October 1993, consisted of two basic elements:

- A limit of 500 parts per million by weight (ppmw) on sulfur content to reduce emissions of both sulfur dioxide and directly emitted PM.
- A limit on aromatic hydrocarbon content of 10% by volume for large refiners and 20 percent for small refiners to reduce emissions of both PM and NOx.

At a July 2003 hearing, the Board approved changes to the California diesel fuel regulations that, among other things, lowered the maximum allowable sulfur levels in California diesel fuel to 15 ppmw beginning in June 2006. Thus, ARB's specifications for sulfur and aromatic hydrocarbons are shown in Table III-7.

Table III-7: California Diesel Fuel Standards

Implementation Date	Maximum Sulfur Level (ppmw)	Aromatics Level (% by volume)	Cetane Index
1993	500	10	N/A
2006	15	10	N/A

The regulation limiting aromatic hydrocarbons also includes a provision that enables producers and importers to comply with the regulation by qualifying a set of alternative specifications of their own choosing. The alternative formulation must be shown, through emissions testing, to provide emission benefits equivalent to that obtained with a 10 percent aromatic standard (or in the case of small refiners, the 20 percent standard). Most refiners have taken advantage of the regulation's flexibility to produce alternative diesel formulations that provide the required emission reduction benefits at a lower cost.

2. U.S. EPA On-Road Diesel Fuel Specifications

The United States Environmental Protection Agency (U.S. EPA) has also established separate diesel fuel specifications for on-road diesel fuel and off-road (nonroad) diesel fuel. The initial U.S. EPA diesel fuel standards were applicable in October 1993. The U.S. EPA regulations prohibited the sale or supply of diesel fuel for use in on-road motor vehicles, unless the diesel fuel had a sulfur content no greater than 500 ppmw. In addition, the regulation required on-road motor-vehicle diesel fuel to have a cetane index of at least 40 or have an aromatic hydrocarbon content of no greater than 35 percent by volume (vol. %). On-road motor-vehicle diesel fuel sold or supplied in the United States, except in Alaska, must comply with these requirements. Diesel fuel, not intended for on-road motor-vehicle use, must contain dye solvent red 164.

On January 18, 2001, the U.S. EPA published a final rule which specified that, beginning June 1, 2006, refiners must begin producing highway diesel fuel that meets a maximum sulfur standard of 15 ppmw for all diesel-fueled on-road vehicles. The current U.S. EPA on-road diesel fuel standard is shown in Table III-7.

3. U.S. EPA Non-Road Diesel Fuel Specifications

Until recently, fuel supplied to outside of California was allowed a sulfur content of up to 5,000 ppmw (parts per million by weight). However, in 2004, the U.S. EPA published a strengthened rule for the control of emissions from non-road diesel engines and fuel. The U.S. EPA rulemaking requires that sulfur levels for non-road diesel fuel be reduced from current uncontrolled levels of 5,000 ppmw ultimately to 15 ppmw, though an interim cap of 500 ppmw is contained in the rule. Beginning June 1, 2007, refiners were required to produce non-road, locomotive, and marine diesel fuel that meets a maximum sulfur level of 500 ppmw. This does not include diesel fuel for stationary sources. In 2010, non-road diesel fuel will be required to meet the 15 ppmw standard except for locomotives and marine vessels. In 2012, non-road diesel fuel used in locomotives and marine applications must meet the 15 ppmw standard. The non-road diesel fuel standards are shown in Table III-8.

Table III-8: U.S. EPA Diesel Fuel Standards

Applicability	Implementation Date	Maximum Sulfur Level (ppmw)	Aromatics Maximum (% by volume)	Cetane Index (Minimum)
On-Road	2006	15	35	40
Non-road *	1993	5,000	35	40
Non-road *	2007	500	35	40
Non-road, *excluding loco/marine* *	2010	15	35	40
Non-road, *loco/marine* *	2012	15	35	40

* Non-road diesel fuels must comply with ASTM No. 2 diesel fuel specifications for aromatics and cetane.

4. What are the Current Properties of In-Use Diesel Fuel?

Table III-9 shows average values for in-use sulfur levels and four other properties for motor vehicle diesel fuel sold in California after the California and Federal diesel fuel regulations became effective in 1993. The corresponding national averages are shown for the same properties for on-road diesel fuel only since the U.S. EPA sulfur standard does not apply to off-road or nonvehicular diesel fuel. Nonroad diesel fuel sulfur levels have been recorded as about 3,000 ppmw in-use and aromatics level of about 35 percent by volume in-use.

Table III-9: Average 1999 Properties of Reformulated Diesel Fuel

Property	California	U.S.[1]
Sulfur, ppmw	10[2]	10 [2]
Aromatics, vol.%	19	35
Cetane No.	50	45
PNA[3], wt.%	3	NA
Nitrogen, ppmw	150	110

1 U.S. EPA, December 2000
2 Based on margin to comply with 15 ppmw sulfur standards in June 2006
3 Polynuclear aromatics

5. Diesel Fuels Used by California-Based Locomotives

The ARB Board approved a regulation in November 2004 which extended the CARB diesel fuel requirements to intrastate locomotives (those operating 90 percent or more of the time in California) effective on January 1, 2007. UP and BNSF agreed in the 2005 railroad Agreement to dispense only CARB diesel or U.S. EPA onroad diesel fuels to a minimum of 80% of interstate locomotives that fuel in California beginning on January 1, 2007.

Line haul locomotives have a range of about 800 to 1,200 miles between fuelings. UP locomotives typically refuel at Rawlins, Wyoming or Salt Lake City, Utah before traveling to Roseville in northern California or Colton in southern California. These major out-of-state railroad facilities have the option to use Federal non-road diesel fuels for the refueling of line haul locomotives. When these out-of-state linehaul locomotives arrive in California they typically have about 10 percent remaining volume of diesel fuel relative to their tank capacity.

UP surveyed each of the California fueling centers, and major interstate fueling centers to California, to estimate the average diesel fuel properties for locomotives for the railyard health risk assessments. In 2005, Chevron was Union Pacific Railroad’s principal supplier of diesel fuel. Chevron’s California refineries produced only one grade (“low sulfur diesel” or LSD) in 2005. Quarterly average sulfur content for these refineries ranged from 59 ppmw to 400 ppmw, with an average of 221 ppmw. This value is assumed to be representative of California fuel used by UPRR. Non-California Diesel fuel for 2005 is estimated to have a sulfur content of 2,639 ppmw, based on the estimated 49-state average fuel sulfur content used by the U.S. Environmental Protection Agency in its 2004 regulatory impact analysis.

The U.S. EPA on-road and CARB on and off-road diesel ultra low sulfur specifications (15 ppmw) went into effect on June 1, 2006. The CARB diesel fuel requirements for intrastate locomotives went into effect on January 1, 2007. The U.S. EPA non-road diesel fuel sulfur limit dropped from 5,000 ppmw to 500 ppmw on June 1, 2007. In 2012, the non-road diesel fuel limits for use in locomotives and marine vessels will drop from 500 ppmw to 15 ppmw.

The NOx emission benefits associated with the use of CARB diesel compared to U.S. EPA on-road and non-road diesel fuels are due to the CARB aromatic hydrocarbon limit of 10 percent by volume or an emission equivalent alternative formulation limit. ARB staff estimates that use of CARB diesel provides a 6 percent reduction in NOx and a 14 percent reduction in particulate emissions compared with the use of U.S. EPA on-road and non-road diesel fuels. In addition, CARB diesel fuel will provide over a 95 percent reduction in fuel sulfur levels in 2007 compared to U.S. EPA non-road diesel fuel. This reduction in diesel fuel sulfur levels will provide SOx emission reductions, and additional PM emission reductions by reducing indirect (secondary formation) PM emissions formed from SOx.

In addition, the ARB, UP and BNSF Railroads entered into an agreement in 2005 which requires at least 80 percent of the interstate locomotives must be fueled with either CARB diesel or U.S. EPA on-road ultra low sulfur diesel fuel by January 1, 2007. Both the CARB diesel fuel regulation for intrastate locomotives and the 2005 Railroad Agreement for interstate locomotives require the use of ultra low sulfur diesel fuel in 2007, five years earlier than the U.S. EPA non-road diesel fuel regulations for locomotives in 2012.

6. What are the Potential Overall Benefits from the Use of Lower Sulfur Diesel Fuels?

Both the U.S. EPA and CARB diesel fuels had sulfur levels lowered from 500 ppmw to 15 ppmw on June 1, 2006. Under the prior sulfur specification of 500 ppmw, CARB diesel fuel in-use sulfur levels averaged around 140 ppmw versus U.S. EPA on-road sulfur levels of about 350 ppmw. With the 2006 implementation of the 15 ppmw sulfur levels, in-use levels for both CARB diesel and U.S. EPA onroad now average about 10 ppmw.

Sulfur oxides and particulate sulfate are emitted in direct proportion to the sulfur content of diesel fuel. Reducing the sulfur content of diesel fuel from the California’s statewide average of 140 ppmw to less than 10 ppmw would reduce sulfur oxide emissions by about 90 percent or by about 6.4 tons per day from 2000 levels. Direct diesel particulate matter emissions would be reduced by about 4 percent, or about 0.6 tons per year in 2010 for engines not equipped with advanced particulate emissions control technologies. U.S. EPA onroad lower sulfur diesel fuel would provide similar levels of sulfur oxide and direct diesel particulate matter emission reductions.

The emissions reductions would be obtained with low sulfur diesel used in mobile on-road and off-road engines, portable engines, and those stationary engines required by district regulations to use CARB diesel. In addition, NOx emissions would be reduced by 7 percent or about 80 tons per year for those engines not currently using CARB diesel, assumed to be about 10 percent of the stationary engine inventory and including off-road mobile sources such as interstate locomotives.

The lower sulfur diesel makes much more significant emissions reductions possible by enabling the effective use of advanced emission control technologies on new and retrofitted diesel engines. With these new technologies, emissions of diesel particulate matter and NOx can be reduced by up to 90 percent. Significant reductions of non-methane hydrocarbons and carbon monoxide can also be achieved with these control devices.

IV. AIR DISPERSION MODELING FOR THE UP OAKLAND RAILYARD

In this chapter, ARB staff presents the air dispersion modeling performed to estimate the transport and dispersion of diesel PM emissions resulting from the sources in and around the UP Oakland Railyard. A description of the air quality modeling parameters is listed, including air dispersion model selection, emission source characterizations, meteorological data, model receptor network, and building wake effects. ARB staff also describes model input preparation and output presentation.

A. Air Dispersion Model Selection

Air dispersion models are often used to simulate atmospheric processes for applications where the spatial scale is in the tens of meters to tens of kilometers. Selection of air dispersion models depends on many factors, such as characteristics of emission sources (point, area, volume, or line), the type of terrain (flat or complex) at the emission source locations, and source-receptor relationships. For the UP Oakland Railyard, ARB staff selected the U.S. EPA's newly approved air dispersion model AERMOD to estimate the impacts associated with diesel PM emissions in and around the railyard. AERMOD represents for American Meteorological Society / Environmental Protection Agency Regulatory Model Improvement Committee (**AER**MIC) **MOD**EL. It is a state-of-science air dispersion model and is a replacement for its predecessor, the U.S. EPA Industrial Sources Complex (ISC) air dispersion model.

AERMOD has become a U.S. EPA regulatory dispersion model specified by the *U.S. EPA Guideline for Air Quality Methods (*40 CFR Part 51, Appendix W*)* (U.S. EPA, 2005). AERMOD is also the recommended model in the *ARB Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006d).

AERMOD is a steady-state plume model that incorporates current concepts about air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain. These approaches have been designed to be physically realistic and relatively simple to implement.

B. Source Characterization and Parameters

The emission sources from the locomotives and other diesel PM sources at the UP Oakland Railyard are characterized source types, required by the ARB Guidelines (ARB, 2006e). Emission sources were treated as either point or volume sources in the dispersion modeling. Point source treatment includes calculated plume rise based on source stack dimensions and exhaust parameters, and hour-by-hour meteorological conditions; volume source treatment includes user-specified release height and initial horizontal and vertical dispersion. Larger stationary emission sources (e.g., idling locomotives and cranes where present) were treated as a series of point sources within their areas of operation. Spacing between sources was selected based on the magnitude of emissions and the proximity to off-site receptors. Smaller and moving sources (e.g., idling and moving trucks, and moving locomotives) were treated as a series of volume sources. Source spacing and initial dispersion coefficients for volume sources were also selected based on the magnitude of the emissions and the proximity to off-site receptors.

The emission rates for individual locomotives are a function of locomotive makes, notch setting, activity time, duration, and operating location. Emission source parameters for locomotive model classifications at the yard, including emission source height, diameter, exhaust temperature, and exhaust velocity. While the BNSF assumed more specific temperatures and stack heights from their switchers and line haul locomotives fleets, the UP used data from the *Roseville Railyard Study* (ARB, 2004a) based on the most prevalent locomotive model of switchers and line hauls to parameterize locomotive emission settings. In total, the assumptions on the locomotive emission parameters are slightly different between UP and BNSF; however, both are within reasonable ranges according to their activities, and the slight differences in stack height have an insignificant impact on predicted air concentrations, within two percent, based on a sensitivity analysis conducted by ARB staff.

For the stationary locomotives, the locations of individual locomotive emission sources used for the model inputs were determined based on the detailed locomotive distribution and activity information provided by UP. The emissions from all other stationary sources (storage tanks, sand tower, waste water treatment plant, etc.) and portable sources (welders, steam cleaners, air compressors, etc.) are simulated as a series of point sources.

C. Meteorological Data

In order to run AERMOD, the following hourly surface meteorological data are required: wind speed, wind direction, ambient temperature, and opaque cloud cover. In addition, the daily upper air sounding data need to be provided (U.S. EPA, 2004b).

These meteorological variables are important to describe the air dispersion in the atmosphere. The wind speed determines how rapidly the pollutant emissions are diluted and influences the rise of emission plume in the air, thus affecting downwind concentrations of pollutants. Wind direction determines where pollutants will be transported. The difference of ambient temperature and the emission releasing temperature from sources determines the initial buoyancy of emissions. In general, the greater the temperature difference, the higher the plume rise. The opaque cloud cover and upper air sounding data are used in calculations to determine other important dispersion parameters. These include atmospheric stability (a measure of turbulence and the rate at which pollutants disperse laterally and vertically) and mixing height (the vertical depth of the atmosphere within which dispersion occurs). The greater the mixing height is, the larger the volume of atmosphere is available to dilute the pollutant concentration.

The meteorological data used in the model are selected on the basis of representativeness. Representativeness is determined primarily on whether the wind speed/direction distributions and atmospheric stability estimates generated through the use of a particular meteorological station (or set of stations) are expected to mimic those actually occurring at a location where such data are not available.

Typically, the key factors for determining representativeness are the proximity of the meteorological station and the presence or absence of nearby terrain features that might alter airflow patterns. The area surrounding the UP Oakland Railyard is generally flat and would not be expected to exhibit significant variations in wind patterns within relatively short distances. The dominant terrain features/water bodies that may influence wind patterns in this part of the San Francisco Bay Air Basin include the hills to the east and northeast and the Pacific Ocean further to the west.

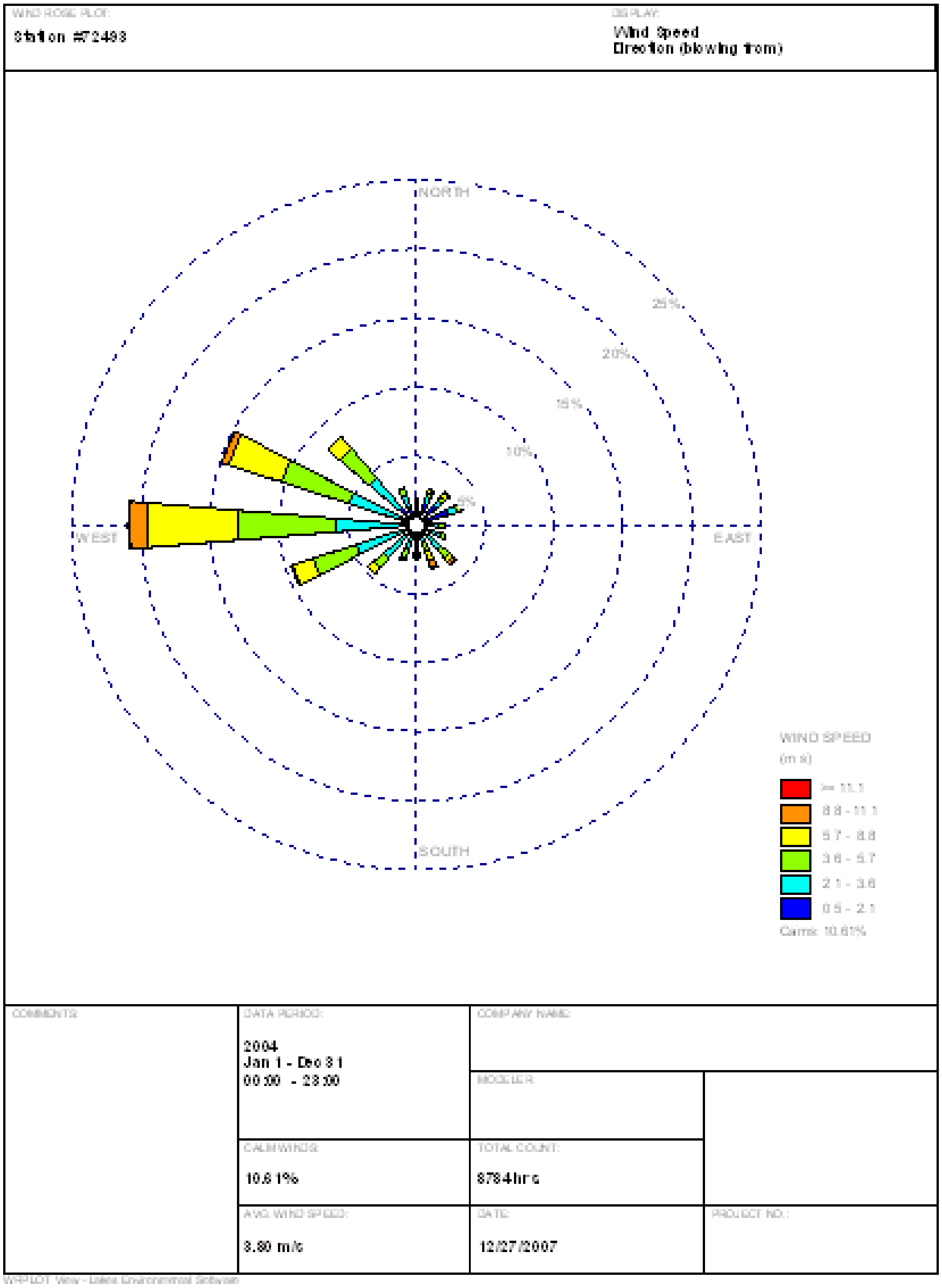
Based on the AERMOD meteorological data selection criteria, the data from the Oakland International Airport (7.5 miles from the UP Oakland Railyard), operated by National Weather Service, were selected for the air dispersion modeling. Meteorological data for a ten-year period, 1996 to 2005, from Oakland International Airport station, were collected and used in AERMET (US EPA, 2004) processing for model inputs.

According to ARB railyard health risk assessment guidelines (ARB, 2006d), 5 years of meteorological data are recommended to be used in the air toxic health risk assessment. For this study, one year (2004) of meteorological data from the Oakland International Airport was processed (Sierra Research, 2007). UP's consultant, Sierra Research, did a sensitivity analysis and found that year-to-year variability would not cause significant differences in the modeled health impacts. Therefore, the meteorological data from 2004 were selected for UP Oakland Railyard air dispersion modeling because the 2004 data set had adequate completeness and quality, and it was the most recent year available. Surface parameters supplied to the model were specified for the area surrounding the surface meteorological monitoring site as recommended by AERMOD and ARB Guidelines (ARB, 2006d). According to the sensitivity analyses conducted by BNSF, the impacts on the diesel PM air concentration predictions by using the long-term (i.e., five-year) vs. short-term (i.e., one-year) are found to be insignificant. This is consistent with the findings from a sensitivity analysis from one of the UP railyards conducted by ARB staff (see Appendix G). Therefore, whether five-year or one-year meteorological data are used, the modeling results show similar estimated exposures and potential cancer risks surrounding the railyard facility.

Wind rose: a rose-like shape plot that depicts wind speed and direction patterns to illustrate prevailing wind

Figure IV-1 presents the wind rose and Figure IV-2 provides the wind class frequency distributions for the meteorological data used in UP Oakland Railyard air dispersion modeling. The yearly average wind speed is 8.80 meters per second. The prevailing wind over the modeling domain blows from west to east.

Figure IV-1: Wind Rose Plot for Oakland International Airport in 2004



WIND ROSE PLOT:
Station #72493

DISPLAY:
Wind Speed
Direction (blowing from)

COMMENTS:

DATA PERIOD:
2004
Jan 1 - Dec 31
00:00 - 23:00

COMPANY NAME:

MODELER:

CALM WINDS:
10.61%

TOTAL COUNT:
8784 hrs

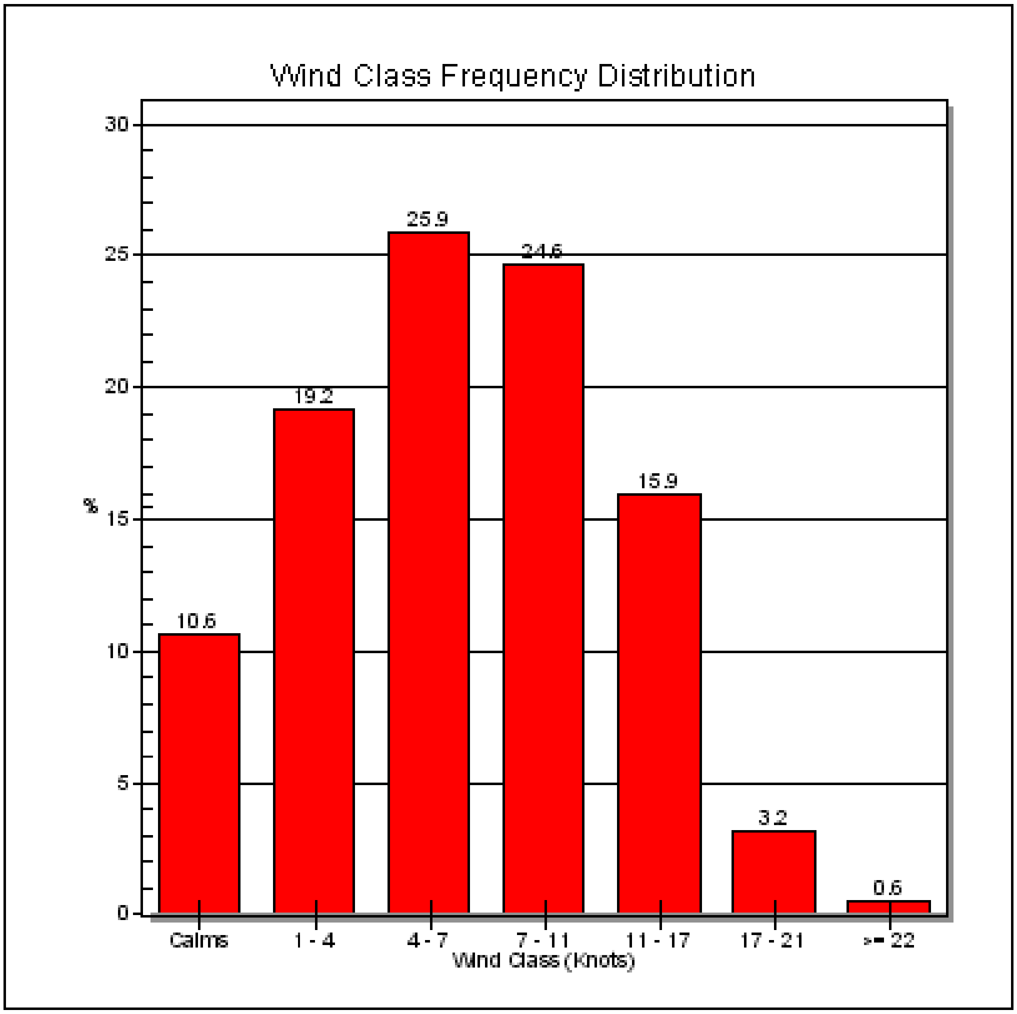
AVG. WIND SPEED:
3.80 m/s

DATE:
12/27/2007

PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure IV-2: Wind Class Frequency Distribution Plot for Oakland International Airport Data in 2004



The detailed procedures of meteorological data preparation and quality control are described in Sierra Research Report.

D. Model Receptors

Model receptors are the locations where the model provides concentrations. A Cartesian grid receptor network is used in this study, in which an array of points is identified by their x (east-west) and y (north-south) coordinates. This receptor network is capable of identifying the emission sources within the railyard with respect to the receptors in the nearby residential areas.

According to the *ARB Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006d), the modeling domain is defined as a 20 km by 20 km (km: kilometers) region, which covers the railyard in the center of the domain and extends to the surrounding areas. To better capture the different concentration gradients surrounding the railyard area, 4 receptor grid networks were used: A fine receptor grid, with a receptor spacing of 50 meters, surrounding the UP Oakland Railyard, was used for modeling within 300 m of the fence line; a medium-fine receptor grid, with a receptor spacing of 100 meters, was used for receptor distances between 300 meters and 600 meters of the fence line; a medium grid, with a receptor spacing of 200 meters, was used for receptor distances between 600 meters and 1,000 meters of the fence line; and a coarse grid with a receptor spacing of 500 meters was used throughout the rest of the modeling domain.

Figure IV-3 shows the fine, medium fine, and medium grid receptor networks and Figure IV-4 illustrates the coarse grid receptor networks used in air dispersion modeling for the UP Oakland Railyard.

Figure IV-3: Fine, Medium Fine and Medium Grid Receptor Networks Used in Air Dispersion Modeling for UP Oakland Railyard

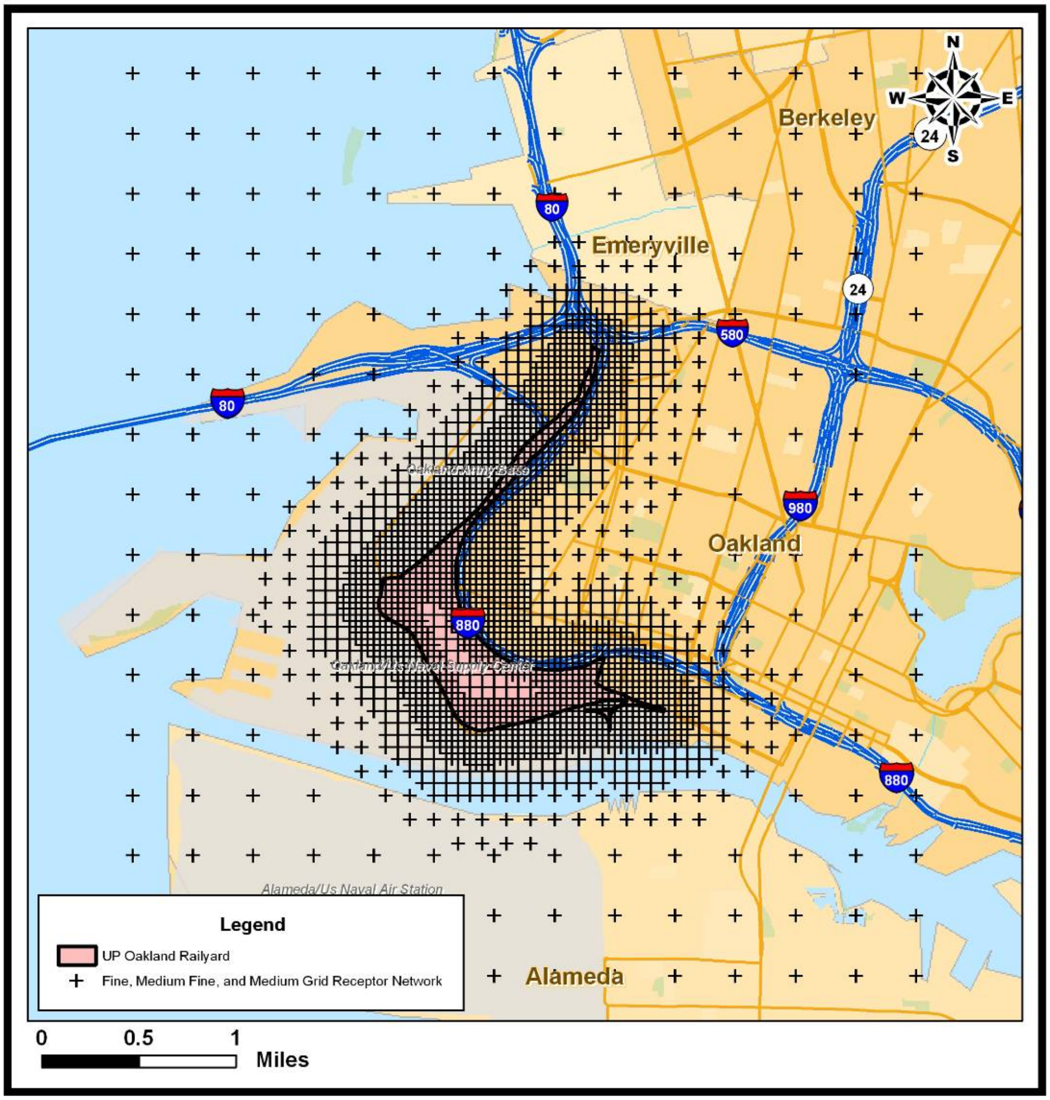
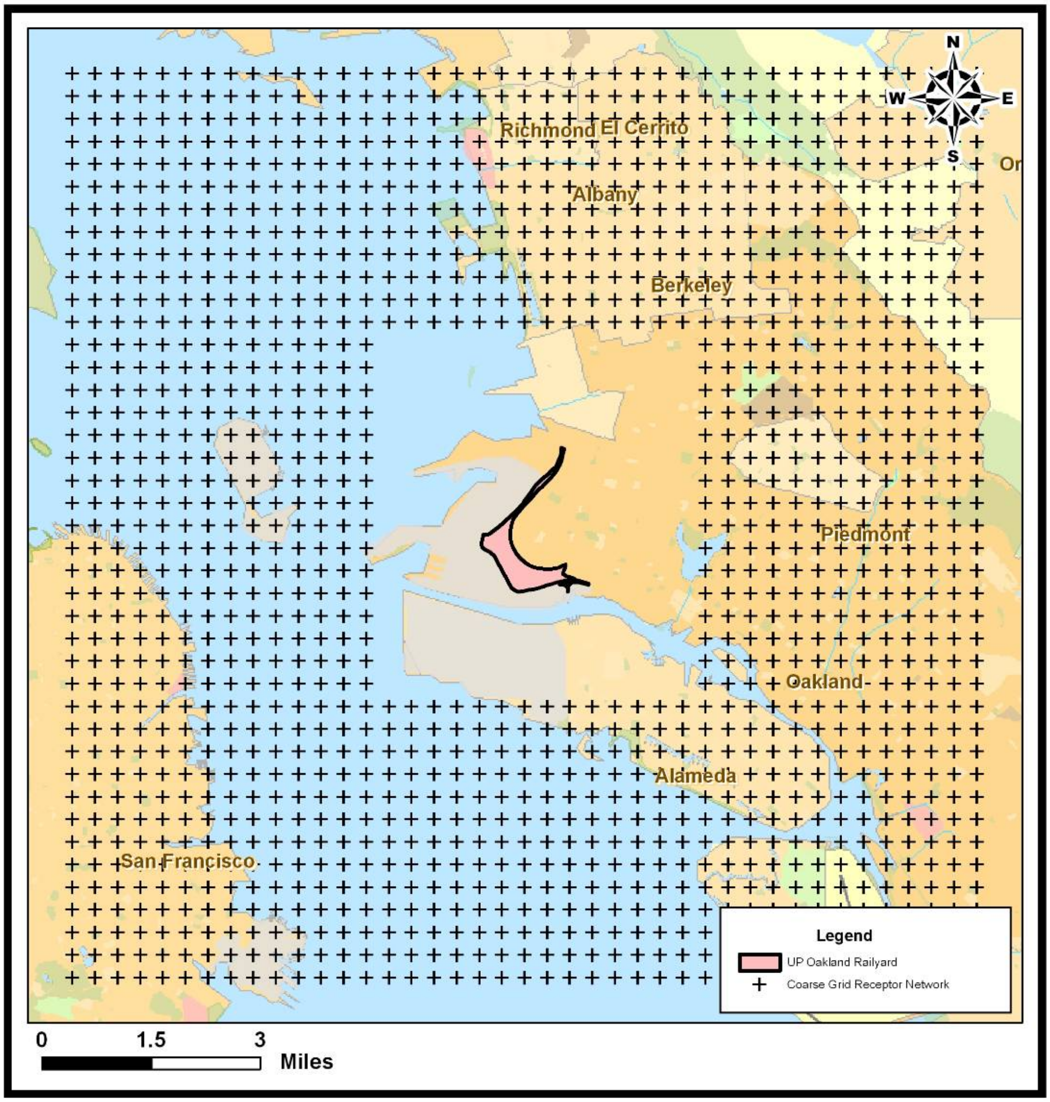


Figure IV-4: Coarse Grid Receptor Networks
Used in Air Dispersion Modeling for UP Oakland Railyard



E. Building Wake Effects

If pollutant emissions are released at or below the “Good Engineering Practice” height as defined by U.S. EPA Guidance (U.S. EPA, 2004a), the plume dispersion may be affected by surrounding facility buildings and structures. The aerodynamic wakes and eddies produced by the buildings or structures may cause pollutant emissions to be mixed more rapidly to the ground, causing elevated ground level concentrations. The AERMOD model has the option--Plume Rise Model Enhancements-- to account for potential building-induced aerodynamic downwash effects. Although UP included building wake effects in their modeling analyses, BNSF conducted a sensitivity analysis and found that the building wake effect has an insignificant impact on the diesel PM air concentrations of the railyard (ENVIRON, 2006b). Detailed treatment of building wake effects is documented in the air dispersion modeling report by the Sierra Research, Inc.

F. Model Implementation Inputs

AERMOD requires four types of basic implementation inputs: control, source, meteorological, and receptor. Control inputs are required to specify the overall job control options for the model run, such as dispersion option, pollutant species, averaging time, etc. Source inputs require source identification and source type (point or volume). Each source type requires specific parameters to define the source. The required inputs for a point source are emission rate, release height, emission source diameter, exhaust exit temperature, and exhaust exit velocity.

Meteorological and receptor inputs have been discussed in Sections C and D. The requirements and the format of input files to the AERMOD are documented in the user's guide of AERMOD (U.S. EPA, 2004b). The model input files for this study is provided in Sierra Research Report.

V. HEALTH RISK ASSESSMENT OF THE UP OAKLAND RAILYARD

This chapter discusses how to characterize potential cancer and non-cancer risks associated with exposure to toxic air contaminants (TACs), especially diesel PM, emitted from the UP Oakland Railyard. In addition, the detailed health risk assessment (HRA) results are presented and the associated uncertainties are discussed qualitatively.

A. Health Risk Assessment Guidelines

The railyard HRA follows *The Air Toxics Hot Spots Program Risk Assessment Guidelines* published by OEHHA, and is consistent with the methodologies used for the UP Roseville Railyard Study (ARB, 2004a). The OEHHA Guidelines outline a tiered approach to risk assessment, providing risk assessors with flexibility and allowing for consideration of site-specific differences:

- Tier 1: a standard point-estimate approach that uses a combination of the average and high-end point-estimates.
- Tier 2: utilizes site-specific information for a risk assessment when site-specific information is available and is more representative than the Tier 1 point-estimates.
- Tier 3: a stochastic approach for exposure assessment when the data distribution is available.
- Tier 4: also a stochastic approach, but allows for utilization of site-specific data distribution.

The Health Risk Assessment is based on the yard specific emission inventory and air dispersion modeling predictions. The OEHHA Guidelines recommend that all health hazard risk assessments adopt a Tier-1 evaluation for the Hot Spots Program, even if other approaches are also presented. Two point-estimates of breathing rates in Tier-1 methodology are used in this HRA, one representing an average and the other representing a high-end value based on the probability distribution of breathing rate. The average and high-end of point-estimates are defined as 65th percentile and 95th percentile from the distributions identified in the OEHHA Guidelines (OEHHA, 2000). In 2004, ARB recommended the interim use of the 80th percentile value (the midpoint value of the 65th and 95th percentile breathing rates referred as an estimate of central tendency) as the minimum value for risk management decisions at residential receptors for the breathing intake (ARB, 2004b). The 80th percentile corresponds to a breathing rate of 302 Liters/Kilogram-day (302 L/Kg-day) from the probability distribution function. As indicated by the OEHHA Guidelines, the Tier-1 evaluation is useful in comparing risks among a number of facilities and similar sources.

Percentile: Any one of the points dividing a distribution of values into parts each of which contain 1/100 of the values. For example, the 65th percentile breathing rate is a value such that the breathing rates from 65 percent of population are less or equal to it.

The ARB has also developed *Health Risk Assessment Guidance for Railyard and Intermodal Facilities* to help ensure that the air dispersion modeling and HRA performed for each railyard meet the OEHHA guidelines. The risk assessment adopted in this study assumes that the receptors (or an individual) will be exposed to the same toxic levels for 24 hours per day for 70 years. If a receptor is exposed for a shorter period of time to a given ambient concentration of diesel PM, the cancer risk will proportionately become less.

B. Exposure Assessment

Exposure assessment is a comprehensive process that integrates and evaluates many variables. Three process components have been identified to have significant impacts on the results of a health risk assessment – emissions, meteorological conditions, and exposure duration of nearby residents. The emissions have a linear effect on the risk levels, given meteorological conditions and defined exposure duration. Meteorological conditions can also have a critical impact on the resultant ambient concentration of a toxic pollutant, with higher concentrations found along the predominant wind direction and under calm wind conditions. An individual's proximity to the emission plume, how long he or she breathes the emissions (exposure duration), and the individual's breathing rate play key roles in determining potential risk. In general, the longer the exposure time for an individual, the greater the estimated potential risk for the individual. The risk assessment adopted in this study generally assumes that the receptors will be exposed to the same toxic levels for 24 hours per day for 70 years. If a receptor is exposed for a shorter period of time to a given pollutant concentration of diesel PM, the cancer risk will proportionately decrease. Children have a greater risk than adults because they have greater exposure on a per unit body weight basis and also because of other factors.

Diesel PM is not the only toxic air contaminant (TAC) emitted from the UP Oakland Railyard. A relatively small amount of gasoline toxic air contaminants is generated from gasoline storage tanks and gasoline-powered vehicles and engines, including benzene, isopentane, toluene, etc. Some other toxic air contaminants, such as xylene, are emitted from the wastewater treatment plant. The total amount of these toxic air contaminants emissions is about 0.10 tons or 200 pounds per year, compared to the 11.2 tons per year of the diesel PM emissions in the railyard. In addition, adjusting these emissions on a cancer potency weighted basis for their toxic potential, these non-diesel PM toxic air contaminants have less than a thousandth of the potency weighted emissions as compared to diesel PM. Hence, only diesel PM emissions are presented in the on-site emission analysis.

The relationship between a given level of exposure to diesel PM and the cancer risk is estimated by using the diesel PM cancer potency factor (CPF). A description of how the diesel cancer potency factor was derived can be found in the document entitled *Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant* (ARB, 1998); and a shorter description can be found in the *Air Toxics Hot Spot Program Risk Assessment Guidelines, Part II, Technical Support Document for Describing Available Cancer Potency Factors* (OEHHA, 2002). The use of the diesel PM CPF for assessing cancer risk is described in the OEHHA Guidelines (OEHHA, 2003). The potential cancer risk is estimated by multiplying the inhalation dose by the CPF of diesel PM, i.e., 1.1(mg/kg-day)$^{-1}$.

C. Risk Characterization

Risk characterization is defined as the process of obtaining a quantitative estimate of risk. The risk characterization process integrates the results of air dispersion modeling and relevant toxicity data (e.g., diesel PM cancer potential factor) to estimate potential cancer or non-cancer health effects associated with air contaminant exposure.

Exposures to pollutants that were originally emitted into the air can also occur in different pathways as a result of breathing, dermal contact, ingestion of contaminated produce, and ingestion of fish that have taken up contaminants from water bodies. These exposures can all contribute to an individual's health risk. However, diesel PM risk is evaluated by the inhalation pathway only in this study because the risk contributions by other pathways of exposure are insignificant relative to the inhalation pathway. It should be noted that the background or ambient diesel PM concentrations are not incorporated into the risk quantification in this study. Therefore, the estimated potential health risk in the study should be viewed as risk level above the risk due to the background impacts.

Because the risk characterization is an integrated process from a series of procedures, the overall associated uncertainties are also linked to the uncertainty from each procedural component. Additional details and associated uncertainty on the risk characterization are provided in the Toxic Hot Spot Program Risk Assessment Guidelines (OEHHA, 2003), and discussed in Section D.

In the following sections, the predicted cancer and non-cancer risk levels resulting from on-site and off-site emissions are presented.

1. *Risk Characterization Associated with On-Site Emissions*

a) Cancer Risk

The potential cancer risks levels associated with the estimated diesel PM emissions at the UP Oakland Railyard are displayed by using isopleths, based on the 80th percentile breathing rate and 70-year exposure duration for residents**.** In this study, ARB staff elected to present the cancer risk isopleths focusing on risk levels of 10, 25, 50, 100, and 250 in a million. Figure V-1 (see page 51) and Figure V-2 (see page 52) present these isopleths. Figure V-1 focuses on the near source risk levels, and Figure V-2 focuses on the more regional impacts. In each figure, the risk isopleths are overlaid onto a satellite image of the Oakland area surrounding the UP Oakland Railyard, to better illustrate the land use (residential, commercial, industrial, or mixed use) of these impacted areas.

The OEHHA Guidelines specify that, for health risk assessments, the cancer risk for the maximum exposure at the point of maximum impact be reported. The point of maximum impact (PMI), which is defined as a location or the receptor point with the highest cancer risk level outside of the facility boundary, with or without residential exposure, is predicted to be located at the east side of the railyard fence line, next to Interstate 880. This is directly downwind of high emission density areas for the prevailing westerly wind, where yard operations, locomotive service, locomotive testing, TRU and cargo handling operations generate about 55% percent of facility-wide diesel PM emissions (see the emission allocation in Appendix B). The cancer risk at the PMI is estimated to be about 640 chances in a million. The land use in the vicinity of the PMI is primarily zoned as industrial use. However, there may be residents living in this zoned area. In the residential zoned area, the potential cancer risk of maximally exposed individual resident (MEIR) or maximum individual cancer risk (MICR) is estimated at about 460 chances in a million. As indicated by Roseville Railyard Study (ARB, 2004a), the location of the PMI may vary depending upon the settings of the model inputs and parameters, such as meteorological data set or emission allocations in the railyard. Therefore, given the estimated emissions, modeling settings, and the assumptions applied to the risk assessment, there are great uncertainties associated with the estimation of point of maximum impact (PMI) and maximum individual cancer risk (MICR). These indications should not be interpreted as a literal prediction of disease incidence, but more as a tool for comparison. Moreover, the estimated point of maximum impact location and maximum individual cancer risk value may not be replicated by air monitoring.

ARB staff also conducted a comparison of cancer risks estimated at the PMI versus MICR, and the differences of facility-wide diesel PM emissions between the UP and BNSF railyards. The ratios of cancer risks at the PMI or MICR to the diesel PM emissions do not suggest that one railroad's facilities have statistically higher cancer risks than the other railroad's or vice versa. Rather, the differences are primarily due to the spatial distributions of emissions from individual operations among railyards.

As indicated by Figure V-1, the area with the greatest impact has an estimated potential cancer risk of over 250 chances in a million, occurring in an area to the east of the railyard across Interstate 880. Within a mile from the east side of the railyard property boundaries the estimated cancer risk is over 100 chances per million. At about two miles from the railyard boundaries, the estimated cancer risks decrease to about 50 chances per million. As indicated by Figure V-2, the risks further decrease to 25 chances per million within about 3 miles from the railyard. At about 4 miles from the railyard boundaries, the estimated cancer risks drop to about 10 chances per million or lower.

It is important to understand that these risk levels represent the predicted risks (due to the UP Oakland Railyard diesel PM emissions) above the existing background risk levels. For the broader San Francisco Bay Air Basin, the estimated regional background risk level is estimated to be about 660 in a million caused by all toxic air pollutants in 2000 (ARB, 2006a).

The OEHHA Guidelines recommend a 70-year lifetime exposure duration to evaluate the potential cancer risks for residents. Shorter exposure durations of 30 years and 9 years may also be evaluated for residents and school-age children, respectively, as a supplement. These three exposure durations – 70 years, 30 years, and 9 years – all assume exposure for 24 hours a day, and 7 days a week. It is important to note that children, for physiological as well as behavioral reasons, have higher rates of exposure than adults on a per unit body weight basis (OEHHA, 2003).

To evaluate the potential cancer risks for off-site workers, the OEHHA Guidelines recommend that a 40-year exposure duration be used, assuming workers have a different breathing rate (149 Liters/Kilogram-day) and exposure for an 8-hour workday, five days a week, 245 days a year.

Table V-1 shows the equivalent risk levels of 70- and 30-year exposure durations for exposed residents; and 40- and 9-year exposure durations for workers and school-age children, respectively. As Table V-3 shows, the 10 in a million isopleth line in Figure V-2 would become 4 in a million for exposed population with a shorter residency of 30 years, 2.5 in a million for exposed school-age children, and 2 in a million for off-site workers.

To conservatively communicate the risks, ARB staff presents the estimated cancer risk isopleths all based on 70-year resident exposure duration, even for those impacted industrial areas where no resident lives.

Table V-1: Equivalent Potential Cancer Risk Levels for 70-, 40-, 30- and 9-Year Exposure Durations

Exposure Duration (years)	Equivalent Risk Level (Chances in a million)					
70	10	25	50	100	250	500
30	4	11	21	43	107	214
9*	2.5	6.3	12.5	25	63	125
40‡	2	5	10	20	50	100

* Exposure duration for school-aged children.
‡ Exposure duration for off-site workers.

The more populated areas near the UP Oakland Railyard are located east of the railyard. Based on the 2000 U.S. Census Bureau's data, the zone of impact of the estimated risks above 10 chances in a million levels encompasses approximately 16,700 acres where about 193,000 residents live. Table V-2 presents the exposed population and area coverage size for various impacted zones of cancer risks.

Table V-2: Estimated Impacted Areas and Exposed Population Associated with Different Cancer Risk Levels Estimated for Railyard Diesel PM Emissions

Estimated Cancer Risk (chances per million)	Impacted Area (Acres)	Estimated Population Exposed
>250	130	1,500
101 - 250	800	6,000
51 - 100	1,700	14,300
26 - 50	3,500	41,100
10 - 25	10,600	130,500
> 10	**16,730**	**193,400**

Figure V-1: Estimated Near-Source Cancer Risks (chances per million people) from the UP Oakland Railyard

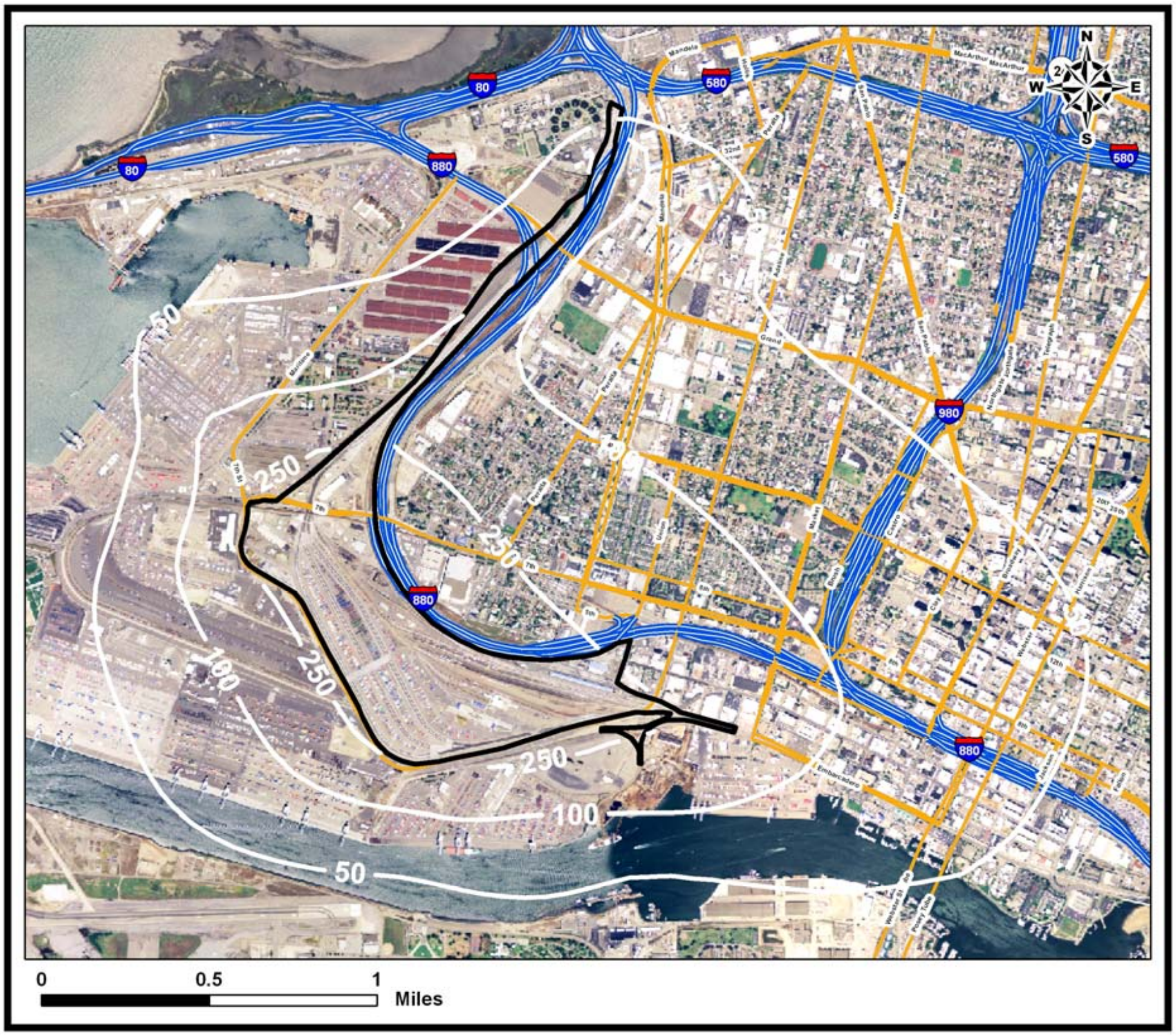
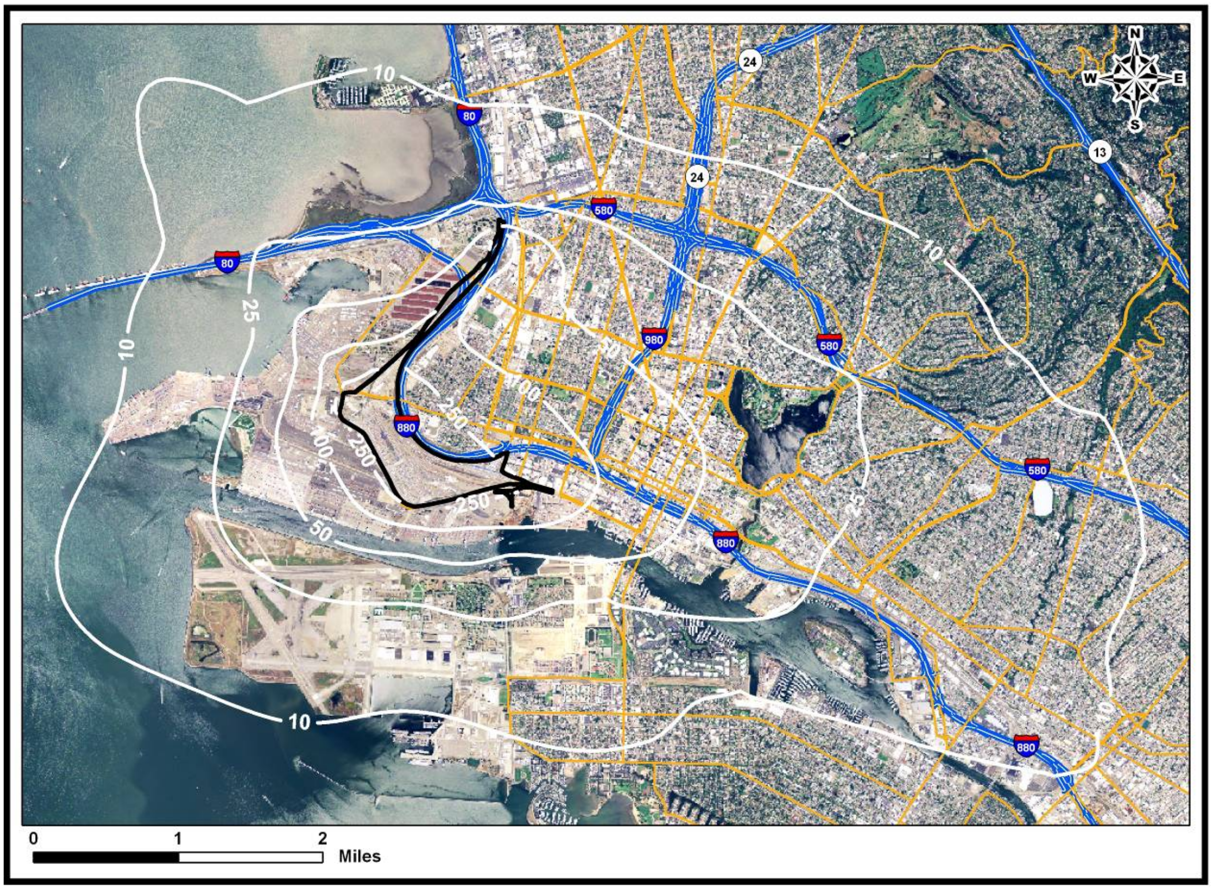


Figure V-2: Estimated Regional Cancer Risks (chances per million people) from the UP Oakland Railyard



b) Potential Non-Cancer Chronic Risk

The quantitative relationship between the amount of exposure to a substance and the incidence or occurrence of an adverse health impact is called the dose-response assessment. According to the OEHHA Guidelines (OEHHA, 2003), dose-response information for non-carcinogens is presented in the form of Reference Exposure Levels (RELs). OEHHA has developed chronic RELs for assessing non-cancer health impacts from long-term exposure.

A chronic REL is a concentration level, expressed in units of micrograms per cubic meter ($\mu g/m^3$) for inhalation exposure, at or below which no adverse health effects are anticipated following long-term exposure. Long-term exposure for these purposes has been defined as 12% of a lifetime, or about eight years for humans (OEHHA, 2003).

The methodology for developing chronic RELs is fundamentally the same as that used by U.S. EPA in developing the inhalation Reference Concentrations (RfCs) and oral Reference Doses (RfDs). Chronic RELs are frequently calculated by dividing the no observed adverse effect level (NOAEL) or lowest observed adverse effect levels (LOAEL) in human or animal studies by uncertainty factors (OEHHA, 2003).

A substantial number of epidemiologic studies have found a strong association between exposure to ambient particulate matter and adverse health effects. For diesel PM, OEHHA has determined a chronic REL at 5 µg/m^3, with the respiratory system as the hazard index target (OEHHA, 2003).

It should be emphasized that exceeding the chronic REL does not necessarily indicate that an adverse health impact will occur. However, levels of exposure above the REL have an increasing but undefined probability of resulting in an adverse health impact, particularly in sensitive individuals (e.g., the very young, the elderly, pregnant women, and those with acute or chronic illnesses).

The significance of exceeding the REL is dependent on the seriousness of the health endpoint, the strength and interpretation of the health studies, the magnitude of combined safety factors, and other considerations (OEHHA, 2003).

As described previously, the reference exposure level for diesel PM is essentially the U.S. EPA Reference Concentration first developed in the early 1990s based on histological changes in the lungs of rats. Since the identification of diesel PM as a Toxic Air Contaminant (TAC), California has evaluated the latest literature on particulate matter health effects to set the Ambient Air Quality Standard. Diesel PM is a component of particulate matter. Health effects from particulate matter in humans include illness and death from cardiovascular and respiratory disease, and exacerbation of asthma and other respiratory illnesses. Additionally, a body of literature has been published, largely after the identification of diesel PM as a TAC and adoption of the REL, which shows that diesel PM can enhance allergic responses in humans and animals. Thus, it should be noted that the REL does not reflect adverse impacts of particulate matter on cardiovascular and respiratory disease and deaths, exacerbation of asthma, and enhancement of allergic response.

The hazard index (HI) is calculated by taking the annual average diesel PM concentration, and dividing by the chronic REL of 5 µg/m^3. An HI value of 1 or greater indicates an exceedance of the chronic REL, and some adverse health impact would be expected.

***Hazard Index**: The ratio of the potential exposure to the substance and the level at which no adverse effects are t d*

As part of this study, ARB staff conducted an analysis of the potential non-cancer chronic health impacts associated with exposures to the model-predicted levels of directly emitted diesel PM from on-site sources. The HI values were calculated, and then plotted as a series of isopleths in Figure V-3 (see page 53). As can be seen, the potential non-cancer chronic health hazard index from diesel PM emissions at the UP Oakland Railyard are estimated to be less than 0.4 at the railyard boundary. According to OEHHA Guidelines (OEHHA, 2003), these levels indicate that the potential non-cancer chronic public health risks are less likely to happen.

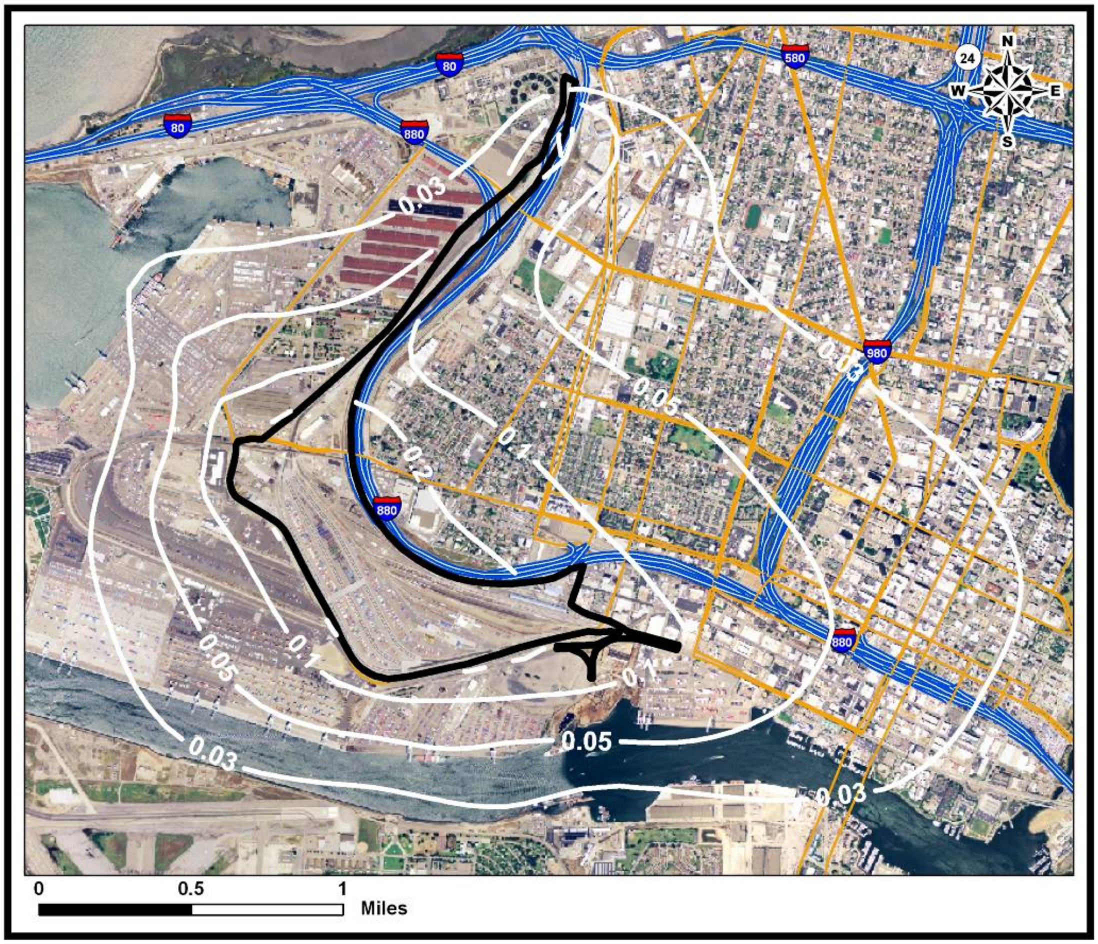
Figure V-3 presents the spatial distribution of non-cancer chronic risks by health hazard index isopleths that range from 0.2 to 0.03 around the yard facility. The zone of impact where non-cancer chronic health hazard indexes are over 0.03 is an estimated area of 2,800 acres.

c) Potential Non-Cancer Acute Risk

According to the OEHHA guidelines, an acute reference exposure level (REL) is an exposure that is not likely to cause adverse health effects in a human population, including sensitive subgroups, exposed to that concentration for the specified exposure duration (generally one hour) on an intermittent basis. Non-cancer acute risk characterization involves calculating the maximum potential health impacts, based on short-term acute exposure and reference exposure levels. Non-cancer acute impacts for a single pollutant are estimated by calculating a hazard index.

Due to the uncertainties in the toxicological and epidemiological studies, diesel PM as a whole was not assigned a short-term acute REL. It is only specific compounds of diesel exhaust (e.g., acrolein) that independently have potential acute effects (such as irritation of the eyes and respiratory tract), and an assigned acute REL. However, acrolein is primarily used as a chemical intermediate in the manufacture of adhesives and paper. It has also been found as a byproduct of any burning process, such as fire, and tobacco smoke. Acrolein is a chemically reactive and unstable compound, and easily reacts with a variety of chemical compounds in the atmosphere. Compared to the other compounds in the diesel exhaust, the concentration of acrolein has a much lower chance of reaching a distant off-site receptor. More importantly, given the multitude of activities ongoing at facilities as complex as railyards, there are much higher levels of uncertainties associated with hourly-specific emission data and hourly model-estimated peak concentrations for short term exposure, which are essential to assess acute risk. Therefore, non-cancer acute risk is not addressed quantitatively in this study. From a risk management perspective, ARB staff believes it is reasonable to focus on diesel PM cancer risk because it is the predominant risk driver and the most effective parameter to evaluate risk reduction actions. Furthermore, actions to reduce diesel PM will also reduce non-cancer risks.

Figure V-3: Estimated Non-Cancer Chronic Risk Health Hazard Index from the UP Oakland Railyard



2. *Risks to Sensitive Receptors*

Some individuals may be more sensitive to toxic exposures than the general population. These sensitive populations are identified as school-age children and seniors. Sensitive receptors include schools, hospitals, day-care centers and elder care facilities. There are 33 sensitive receptors around the UP Oakland Railyard within a distance of one mile, including 14 schools, and 19 child care centers. Table V-3 shows the number of sensitive receptors in various levels of cancer risks associated with diesel PM emission from the UP Oakland Railyard, based on 70-year residential exposure duration.

Table V-3: Estimated Number of Sensitive Receptors in Various Levels of Cancer Risks associated with On-Site Diesel PM Emissions

Estimated Cancer Risk (chances per million)	Number of Sensitive Receptors
> 100	**11**
50 – 100	**12**
25 – 50	**7**
10 – 25	**3**
> 10	**33**

D. Uncertainty and Limitations

Risk assessment is a complex procedure which requires the integration of many variables and assumptions. The estimated diesel PM concentrations and risk levels produced by a risk assessment are based on several assumptions, many of which are designed to be health protective so that potential risks to individual are not underestimated.

As described previously, the health risk assessment consists of three components: (1) emission inventory, (2) air dispersion modeling, and (3) risk assessment. Each component has a certain degree of uncertainty associated with its estimation and prediction due to the assumptions made. Therefore, there are uncertainties and limitations with the results.

The following subsections describe the specific sources of uncertainties in each component. In combination, these various factors may result in potential uncertainties in the location and magnitude of predicted concentrations, as well as the potential health effects actually associated with a particular level of exposure.

1. *Emission Inventory*

The emission rate often is considered to be proportional to the type and magnitude of the activity at a source, e.g., the operation. Ideally, emissions from a source can be calculated on the basis of measured concentrations of the pollutant in the sources and emission strengths, e.g., a continuous emission monitor. This approach can be very costly and time consuming and is not often used for the emission estimation. Instead, emissions are usually estimated by the operation activities or fuel consumption and associated emission factors, based on source tests.

The uncertainties of emission estimates may be attributed to many factors such as a lack of information for variability of locomotive engine type, throttle setting, level of maintenance, operation time, and emission factor estimates. Quantifying individual uncertainties is a complex process and may in itself introduce unpredictable uncertainties[1].

For locomotive sources at the UP Oakland Railyard, the activity rates include primarily the number of engines in operation and the time spent in different power settings. The methodology used for the locomotive emissions is based on these facility-specific activity data. The number of engines operating in the facility is generally well-tallied by UP's electronic monitoring of locomotives entering and leaving the railyard. However, the monitoring under certain circumstances may produce duplicate readings that can result in overestimates of locomotive activity. In addition to recorded activity data, surveys and communications with facility personnel, and correlations from other existing data, (e.g., from the Roseville Railyard Study (ARB, 2004a)), all were used to verify the emission estimations in the emission inventory.

Uncertainties also exist in estimates of the engine time in mode. Idling is typically the most significant operational mode, but locomotive event recorder data could not distinguish when an engine is on or off during periods when the locomotive is in the idle notch. As a result, a professional judgment is applied to distinguish between these two modes. While the current operations may not be precisely known, control measures already being implemented are expected to result in reduced activity levels and lower emissions than are estimated here for future years.

As discussed previously, emission factors are often used for emission estimates according to different operating cycles. The Roseville Railyard Study (ARB, 2004) developed representative diesel PM emission factors for locomotives in different duty cycles. To reduce the possible variability of locomotive population and the uncertainty from assumptions, the emission factors were updated in the study to cover a wide range of locomotive fleet in the State (see Appendix D). These critical updates for locomotive emission inventory have established the most representative locomotive emission factors for the study.

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Guidelines, and consistent with previous health risk analyses conducted by ARB. Similar to any model with estimations, the primary barriers of an HRA to determine objective probabilities are lack of adequate scientific understanding and more precise levels of data. Subjective probabilities are also not always available.

Tier-1 methodology is a conservative point approach but suitable for current HRA's scope, given the condition and lack of probability data. Tier-1 approach used in the HRAs is consistent with previous health risk analyses performed by ARB, "*The Roseville Railyard Study* (ARB, 2004)" and "*Diesel PM Exposure Assessment Study for the Ports of Los Angeles and Long Beach* (ARB, 2006b)". By recognizing associated uncertainties or variability, the HRAs have qualitatively discussed the limitation and caveats of possible underestimation and overestimation in emission inventory and modeling predictions because of assumptions and simplifications. The discussion provides an additional reference for HRA results even though quantitative uncertainty bounds are unavailable. Most importantly, it is not practical to characterize and quantify the uncertainty of estimated health risks without the support of robust scientific data and actual probability distribution functions of model variables. An attempt to incorporate subjective judgments on uncertainty analyses can lead to misinterpretation of HRA findings.

For non-locomotive emissions, uncertainty associated with vehicles and equipment at the railyard facility also exists because the duty cycles (i.e., engine load demanded) are less well characterized. Default estimates of the duty cycle parameters may not accurately reflect the typical duty demanded from these vehicles and equipment at any particular site. In addition, national and state regulations have targeted these sources for emission reductions. Implementation of these rules and fleet turnover to newer engines meeting more strict standards should significantly reduce emissions at these rail sites in future years. However, the effects of these regulations have not been incorporated in the emission estimates, so estimated emissions are greater than those expected for future years at the same activity level.

2. *Air Dispersion Modeling*

An air dispersion model is derived from atmospheric diffusion theory with assumptions or, alternatively, by solution of the atmospheric-diffusion equation assuming simplified forms of effective diffusivity. Within the limits of the simplifications involved in its derivation, the model-associated uncertainties are vulnerably propagated into its downstream applications.

Model uncertainty may stem from data gaps that are filled by the use of assumptions. Uncertainty is often considered as a measure of the incompleteness of one's knowledge or information about a variate whose true value could be established if a perfect measurement is available. The structure of mathematical models employed to represent scenarios and phenomena of interest is often a key source of model uncertainty, due to the fact that models are often only a simplified representation of a real-world system, such as the limitation of model formulation, the parameterization of complex processes, and the approximation of numerical calculations. These uncertainties are inherent and exclusively caused by the model's inability to represent a complex aerodynamic process. An air dispersion model usually uses simplified atmospheric conditions to simulate pollutant transport in the air, and these conditions become inputs to the models (e.g., the use of non site-specific meteorological data, uniform wind speed over the simulating domain, use of surface parameters for the meteorological station as opposed to the railyard, substitution of missing meteorological data, and simplified emission source representation). There are also other physical dynamics in the transport process, such as the small-scale turbulent flow in the air, which are not characterized by the air dispersion models. As a result of the simplified representation of real-world physics, deviations in pollutant concentrations predicted by the models may occur due to the introduced uncertainty sources.

The other type of uncertainty is referred as reducible uncertainty, a result of uncertainties associated with input parameters of the known conditions, which include source characteristics and meteorological inputs. However, the uncertainties in air dispersion models have been improved over the years because of better representations in the model structure. In 2006, the U.S. EPA modeling guidance was updated to replace the Industrial Source Complex model with AERMOD as a recommended regulatory air dispersion model for determining single source and source complex. Many updated formulations have been incorporated into the model structure from its predecessor, ISCST3, for better predictions from the air dispersion process.

Nevertheless, quantifying overall uncertainty of model predictions is infeasible due to the associated uncertainties described above, and is beyond the scope of this study.

3. *Risk Assessment*

The toxicity of toxic air contaminants is often established by available epidemiological studies, or, where data from humans are not available, the use of data from animal studies. The diesel PM cancer potency factor is based on long-term study of railyard workers exposed to diesel exhaust at concentrations approximately ten times typical ambient exposures (OEHHA, 2003). The differences within human populations usually cannot be easily quantified and incorporated into risk assessments. The differences within human populations usually cannot be easily quantified and incorporated into risk assessments. Factors including metabolism, target site sensitivity, diet, immunological responses, and genetics may influence the response to toxicants. In addition, the human population is much more diverse both genetically and culturally (e.g., lifestyle, diet) than inbred experimental animals. The variability among humans is expected to be much greater than in laboratory animals. Adjustment for tumors at multiple sites induced by some carcinogens could result in a higher potency. Other uncertainties arise (1) in the assumptions underlying the dose-response model used, and (2) in extrapolating from large experimental doses, where, for example, other toxic effects may compromise the assessment of carcinogenic potential due to much smaller environmental doses. Also, only single tumor sites induced by a substance are usually considered. When epidemiological data are used to generate a carcinogenic potency, less uncertainty is involved in the extrapolation from workplace exposures to environmental exposures. However, children, a subpopulation whose hematological, nervous, endocrine, and immune systems are still developing and who may be more sensitive to the effects of carcinogens on their developing systems, are not included in the worker population and risk estimates based on occupational epidemiological data are more uncertain for children than adults.

Human exposures to diesel PM are often based on limited availability of data and are mostly derived based on estimates of emissions and duration of exposure. Different epidemiological studies also suggest somewhat different levels of risk. When the Scientific Review Panel (SRP) identified diesel PM as a toxic air contaminant (ARB, 1998), the panel members endorsed a range of inhalation cancer potency factors (1.3×10^{-4} to 2.4×10^{-3} $(\mu g/m^3)^{-1}$) and a risk factor of 3×10^{-4} $(\mu g/m^3)^{-1}$, as a reasonable estimate of the unit risk. From the unit risk factor an inhalation cancer potency factor of 1.1 $(mg/kg\text{-}day)^{-1}$ can be calculated, which is used in the study. There are many epidemiological studies that support the finding that diesel exhaust exposure elevates relative risk for lung cancer. However, the quantification of each uncertainty applied in the estimate of cancer potency is very difficult and can be itself uncertain

This study adopts the standard Tier 1 approach recommended by OEHHA for exposure and risk assessment. A Tier 1 approach is an end-point estimate methodology without the consideration of site-specific data distributions. It also assumes that an individual is exposed to an annual average concentration of a pollutant continuously for a specific time period. OEHHA recommends the lifetime 70-year exposure duration with a 24-

hour per day exposure be used for determining residential cancer risks. This will ensure a person residing in the vicinity of a facility for a lifetime will be included in the evaluation of risk posed by the facility. Lifetime 70-year exposure is a conservative estimate, but it is a historical benchmark for comparing facility impacts on receptors and for evaluating the effectiveness of air pollution control measures.

Although it is not likely that most people will reside at a single residence for 70 years, it is common that people will spend their entire lives in a major urban area. While residing in urban areas, it is very possible to be exposed to the emissions of another facility at the next residence. In order to help ensure that people do not accumulate an excess unacceptable cancer risk from cumulative exposure to stationary facilities at multiple residences, the 70-year exposure duration is used for risk management decisions. However, if a facility is notifying the public regarding health risk, it is a useful indication for a person who has resided in his or her current residence less than 70 years to know that the calculated estimate of his or her cancer risk is less than that calculated for a 70-year risk (OEHHA, 2003). It is important that the risk estimates generated in this study not be interpreted as the expected rates of disease in the exposed population, but rather as estimates of potential risk. Risk assessment is best viewed as a comparative tool rather than a literal prediction of diesel incidence in a community.

Moreover, since the Tier-1 methodology is used in the study for the health risk assessment, the results have been limited to deterministic estimates based on conservative inputs. For example, an 80 percentile breathing rate approach is used to represent a 70-year lifetime inhalation that tends toward the high end for the general population. Moreover, the results based on the Tier-1 estimates do not provide an indication of the magnitude of uncertainty surrounding the quantities estimated, nor an insight into the key sources of underlying uncertainty.

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APPENDIX A
TABLES OF LOCOMOTIVE DIESEL PM EMISSION FACTORS

Locomotive Diesel PM Emission Factors (g/hr)
Adjusted for Fuel Sulfur Content of 221 ppmw

Model Group	Tier	Throttle Setting										Source[1]
		Idle	DB	N1	N2	N3	N4	N5	N6	N7	N8	
Switchers	N	31.0	56.0	23.0	76.0	129.2	140.6	173.3	272.7	315.6	409.1	EPA RSD[1]
GP-3x	N	38.0	72.0	31.0	110.0	174.1	187.5	230.2	369.1	423.5	555.1	EPA RSD[1]
GP-4x	N	47.9	80.0	35.7	134.3	211.9	228.6	289.7	488.5	584.2	749.9	EPA RSD[1]
GP-50	N	26.0	64.1	51.3	142.5	282.3	275.2	339.6	587.7	663.5	847.2	EPA RSD[1]
GP-60	N	48.6	98.5	48.7	131.7	266.3	264.8	323.5	571.6	680.2	859.8	EPA RSD[1]
GP-60	0	21.1	25.4	37.6	75.5	224.1	311.5	446.4	641.6	1029.9	1205.1	SwRI[2] (KCS733)
SD-7x	N	24.0	4.8	41.0	65.7	146.8	215.0	276.8	331.8	434.7	538.0	SwRI[3]
SD-7x	0	14.8	15.1	36.8	61.1	215.7	335.9	388.6	766.8	932.1	1009.6	GM EMD[4]
SD-7x	1	29.2	31.8	37.1	66.2	205.3	261.7	376.5	631.4	716.4	774.0	SwRI[5] (NS2630)
SD-7x	2	55.4	59.5	38.3	134.2	254.4	265.7	289.0	488.2	614.7	643.0	SwRI[5] (UP8353)
SD-90	0	61.1	108.5	50.1	99.1	239.5	374.7	484.1	291.5	236.1	852.4	GM EMD[4]
Dash 7	N	65.0	180.5	108.2	121.2	306.9	292.4	297.5	255.3	249.0	307.7	EPA RSD[1]
Dash 8	0	37.0	147.5	86.0	133.1	248.7	261.6	294.1	318.5	347.1	450.7	GE[4]
Dash 9	N	32.1	53.9	54.2	108.1	187.7	258.0	332.5	373.2	359.5	517.0	SwRI 2000
Dash 9	0	33.8	50.7	56.1	117.4	195.7	235.4	552.7	489.3	449.6	415.1	Average of GE & SwRI[6]
Dash 9	1	16.9	88.4	62.1	140.2	259.5	342.2	380.4	443.5	402.7	570.0	SwRI[2] (CSXT595)
Dash 9	2	7.7	42.0	69.3	145.8	259.8	325.7	363.6	356.7	379.7	445.1	SwRI[2] (BNSF 7736)
C60-A	0	71.0	83.9	68.6	78.6	237.2	208.9	247.7	265.5	168.6	265.7	GE[4] (UP7555)

Notes:

1. EPA Regulatory Support Document, *Locomotive Emissions Regulation, Appendix B*, 12/17/1997, as tabulated by ARB and ENVIRON.
2. Base emission rates provided by ENVIRON as part of the BNSF analyses for the Railyard MOU (Personal communication from Chris Lindhjem to R. Ireson, 2006) based on data produced in the AAR/SwRI Exhaust Plume Study (Personal communication from Steve Fritz to C. Lindhjem, 2006).
3. SwRI final report *Emissions Measurements – Locomotives* by Steve Fritz, August 1995.
4. Manufacturers' emissions test data as tabulated by ARB.
5. Base SD-70 emission rates taken from data produced in the AAR/SwRI Exhaust Plume Study (Personal communication from Steve Fritz to R. Ireson, 2006).
6. Average of manufacturer's emissions test data as tabulated by ARB and data from the AAR/SwRI Exhaust Plume Study, tabulated and calculated by ENVIRON.

Locomotive Diesel PM Emission Factors (g/hr)
Adjusted for Fuel Sulfur Content of 2,639 ppmw

Model Group	Tier	Throttle Setting										Source[1]
		Idle	DB	N1	N2	N3	N4	N5	N6	N7	N8	
Switchers	N	31.0	56.0	23.0	76.0	136.9	156.6	197.4	303.4	341.2	442.9	EPA RSD[1]
GP-3x	N	38.0	72.0	31.0	110.0	184.5	208.8	262.2	410.8	457.9	601.1	EPA RSD[1]
GP-4x	N	47.9	80.0	35.7	134.3	224.5	254.6	330.0	543.7	631.6	812.1	EPA RSD[1]
GP-50	N	26.0	64.1	51.3	142.5	299.0	306.5	386.9	653.9	717.3	917.4	EPA RSD[1]
GP-60	N	48.6	98.5	48.7	131.7	282.1	294.9	368.5	636.1	735.4	931.0	EPA RSD[1]
GP-60	0	21.1	25.4	37.6	75.5	237.4	346.9	508.5	714.0	1113.4	1304.9	SwRI[2] (KCS733)
SD-7x	N	24.0	4.8	41.0	65.7	155.5	239.4	315.4	369.2	469.9	582.6	SwRI[3]
SD-7x	0	14.8	15.1	36.8	61.1	228.5	374.1	442.7	853.3	1007.8	1093.2	GM EMD[4]
SD-7x	1	29.2	31.8	37.1	66.2	217.5	291.5	428.9	702.6	774.5	838.1	SwRI[5] (NS2630)
SD-7x	2	55.4	59.5	38.3	134.2	269.4	295.9	329.2	543.3	664.6	696.2	SwRI[5] (UP8353)
SD-90	0	61.1	108.5	50.1	99.1	253.7	417.3	551.5	324.4	255.3	923.1	GM EMD[4]
Dash 7	N	65.0	180.5	108.2	121.2	352.7	323.1	327.1	293.7	325.3	405.4	EPA RSD[1]
Dash 8	0	37.0	147.5	86.0	133.1	285.9	289.1	323.3	366.4	453.5	593.8	GE[4]
Dash 9	N	32.1	53.9	54.2	108.1	215.7	285.1	365.6	429.3	469.7	681.2	SwRI 2000
Dash 9	0	33.8	50.7	56.1	117.4	224.9	260.1	607.7	562.9	587.4	546.9	Average of GE & SwRI[6]
Dash 9	1	16.9	88.4	62.1	140.2	298.2	378.1	418.3	510.2	526.2	751.1	SwRI[2] (CSXT595)
Dash 9	2	7.7	42.0	69.3	145.8	298.5	359.9	399.8	410.4	496.1	586.4	SwRI[2] (BNSF 7736)
C60-A	0	71.0	83.9	68.6	78.6	272.6	230.8	272.3	305.4	220.3	350.1	GE[4] (UP7555)

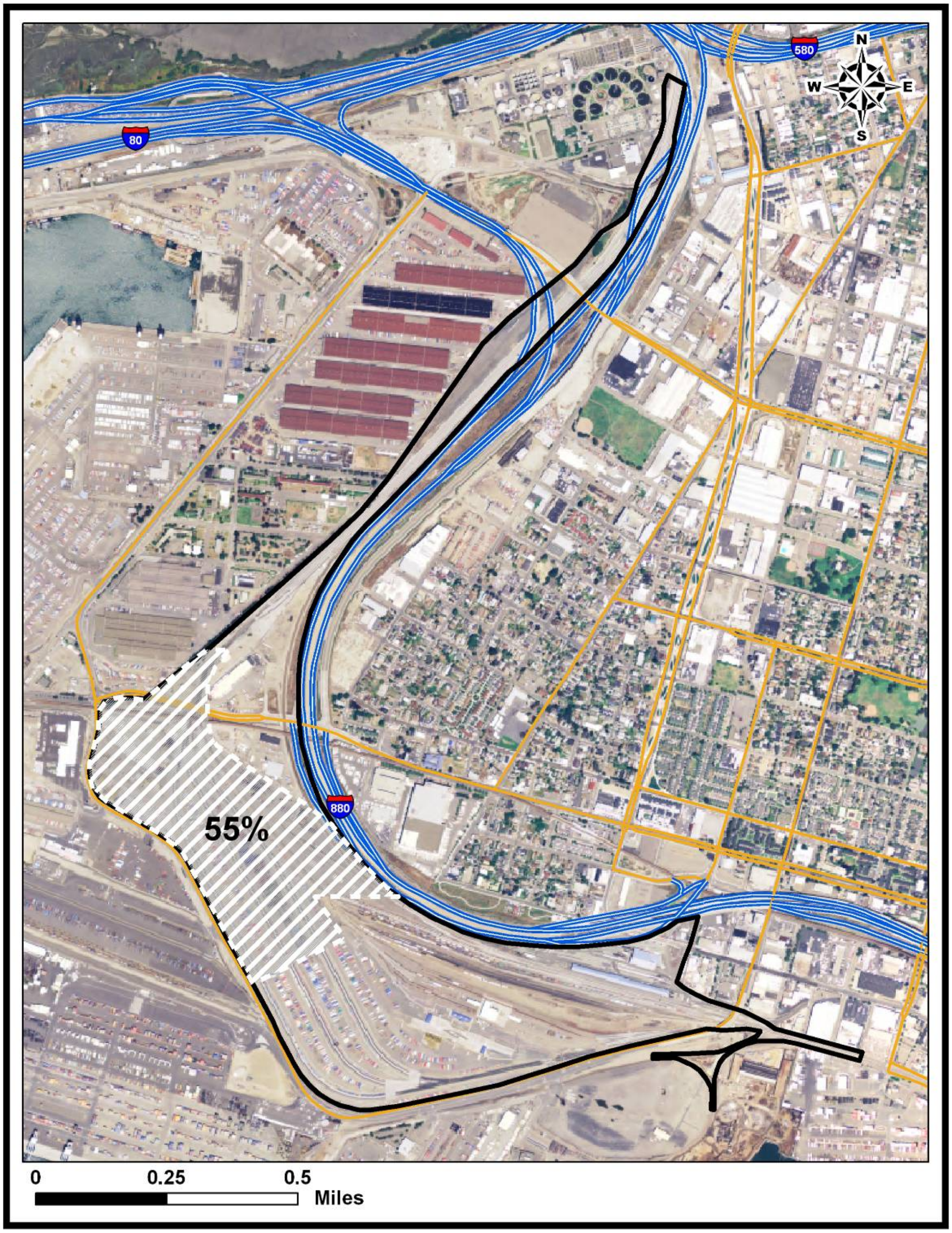
Notes:

1. EPA Regulatory Support Document, *Locomotive Emissions Regulation, Appendix B*, 12/17/1997, as tabulated by ARB and ENVIRON.
2. Base emission rates provided by ENVIRON as part of the BNSF analyses for the Railyard MOU (Personal communication from Chris Lindhjem to R. Ireson, 2006) based on data produced in the AAR/SwRI Exhaust Plume Study (Personal communication from Steve Fritz to C. Lindhjem, 2006).
3. SwRI final report *Emissions Measurements – Locomotives* by Steve Fritz, August 1995.
4. Manufacturers' emissions test data as tabulated by ARB.
5. Base SD-70 emission rates taken from data produced in the AAR/SwRI Exhaust Plume Study (Personal communication from Steve Fritz to R. Ireson, 2006).
6. Average of manufacturer's emissions test data as tabulated by ARB and data from the AAR/SwRI Exhaust Plume Study, tabulated and calculated by ENVIRON.

APPENDIX B

SPATIAL ALLOCATIONS OF MAJOR DIESEL PM EMISSION SOURCES AT THE UP OAKLAND RAILYARD

Figure 5. The UP Oakland Railyard shown with the shaded area accounting for about 45 percentof facility-wide diesel PM emissions.



Note: The emissions at the UP Oakland Railyard are primarily comprised of activity from Cargo Handling Equipment, Locomotives (switching, testing and idling) and TRU's. About to 55% of the emission activity occurs within the highlighted area which encompasses facilities for yard operations, locomotive service, locomotive testing, TRU and cargo handling operations.

Figure 6. Spatial allocation of locomotive emissions at UP Oakland Railyard.

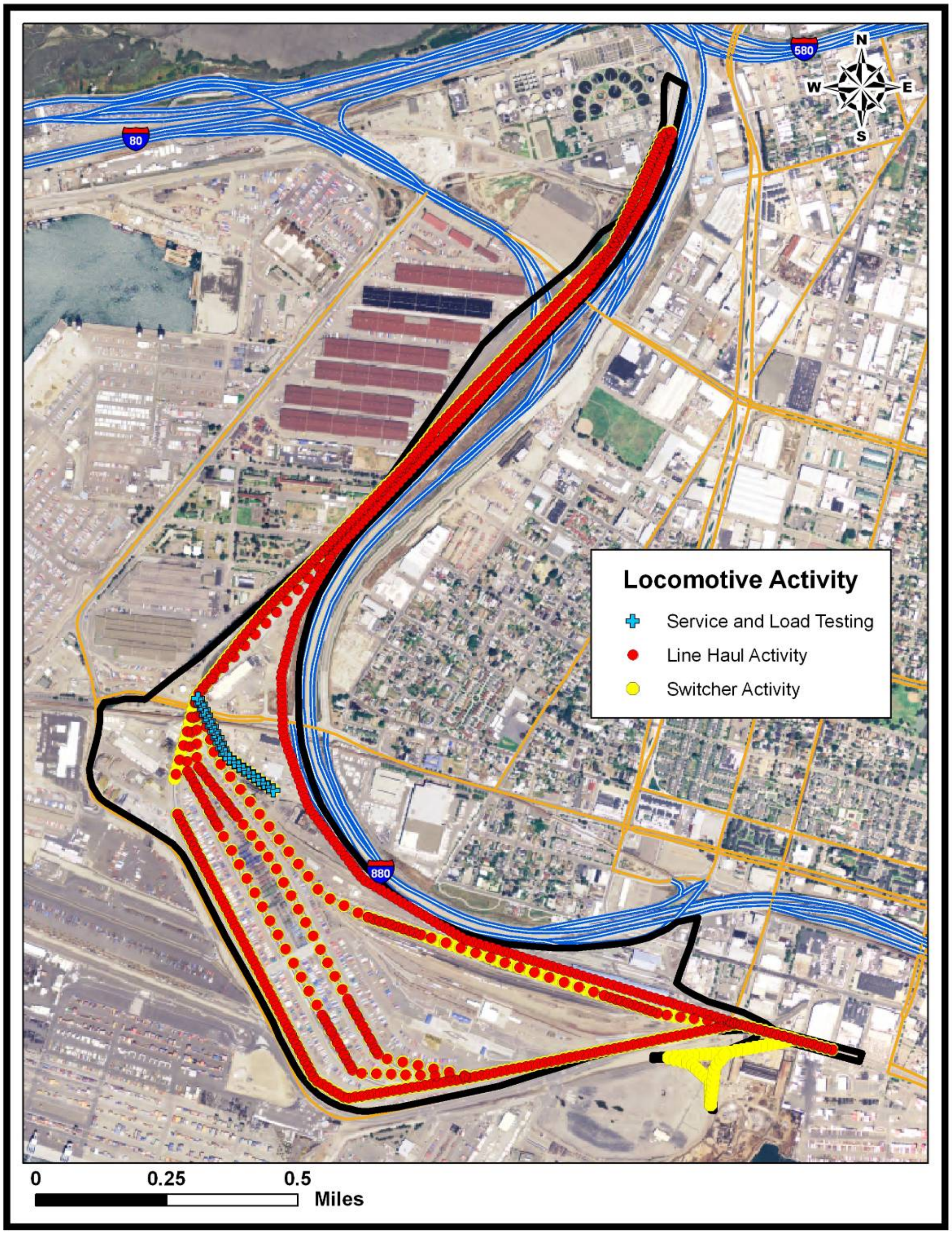
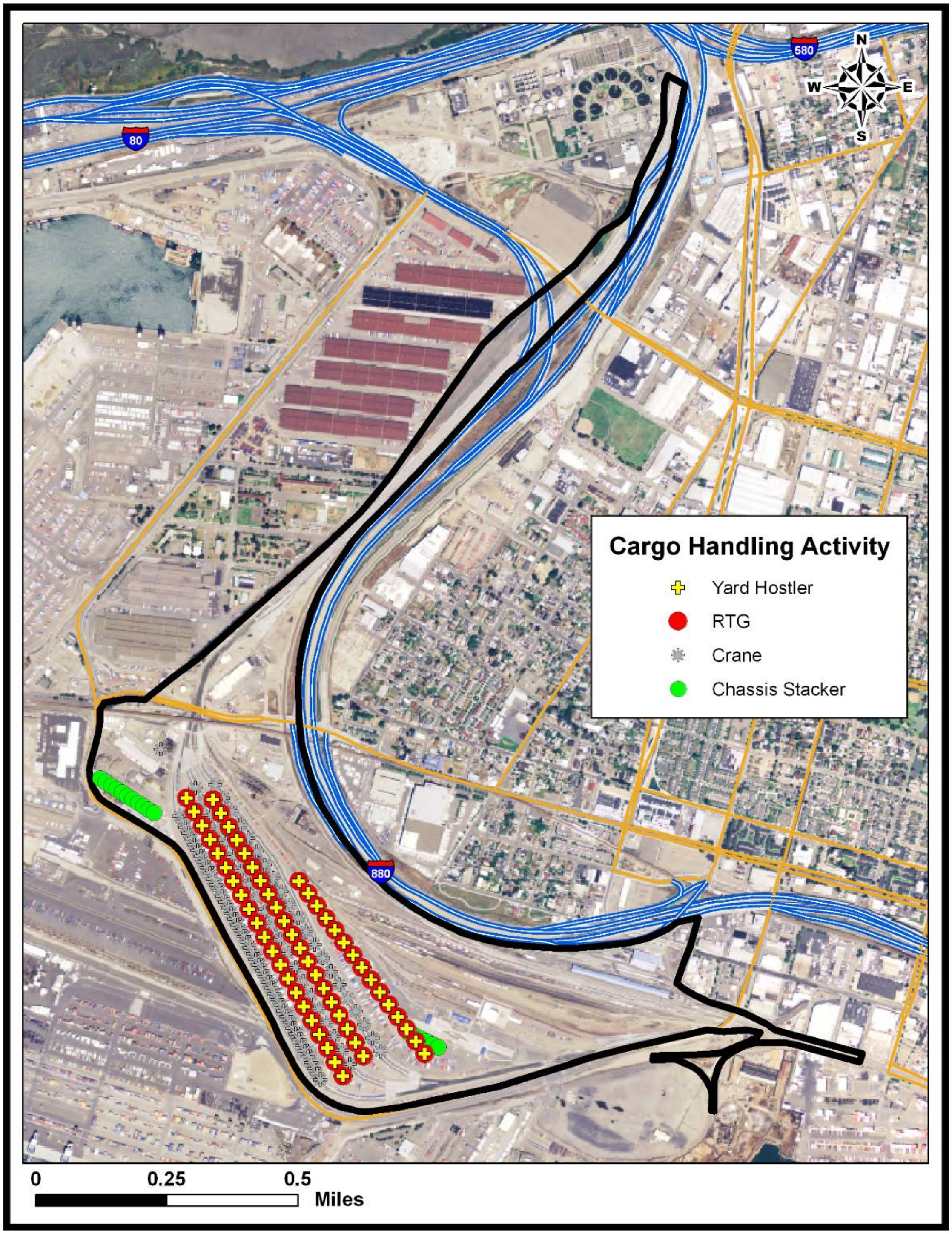


Figure 7. Spatial allocation of diesel PM emissions of cargo handling operation at the UP Oakland Railyard.



APPENDIX C

AERMOD MODEL SENSITIVITY ANALYSIS OF METEOROLOGICAL DATA (ONE- VS. FIVE-YEAR DATA)

Figure 8. AERMOD's Simulated Diesel PM Concentrations (due to On-site and Off-site Diesel PM Emissions) around UP Stockton Railyard Using One-year Meteorological Data..

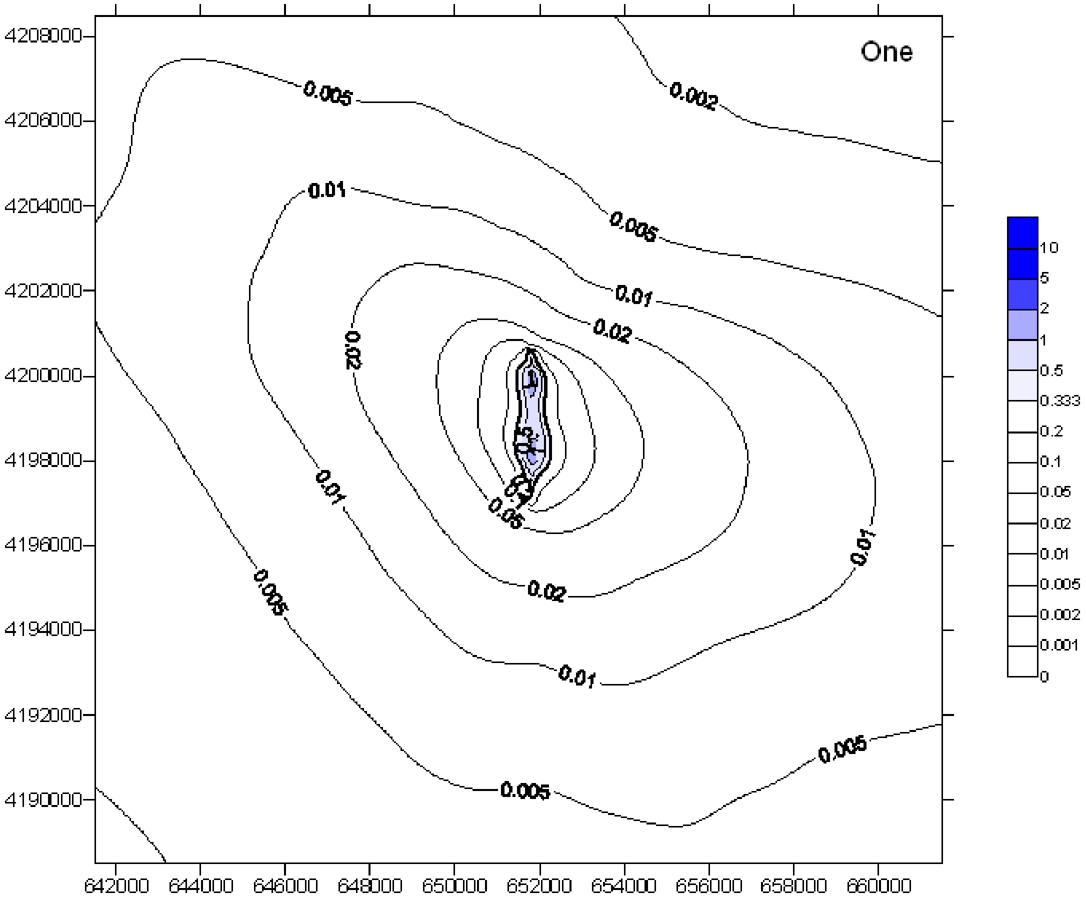


Figure 9. AERMOD's Simulated Diesel PM Concentrations (due to On-site and Off-site Diesel PM Emissions) around UP Stockton Railyard Using Five-year Meteorological Data.