California Environmental Protection Agency

Air Resources Board

# Health Risk Assessment for the Union Pacific Railroad Los Angeles Transportation Center Railyard


**Stationary Source Division**

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**Principal Author**
Stephen Cutts, P.E.

**Contributing Authors**
Stationary Source Division:
Jing Yuan, Ph.D.
Eugene Yang, Ph.D., P.E.
Hector Castaneda

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

**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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Robert G. Ireson, Ph.D.

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# I. INTRODUCTION

The California Air Resources Board (ARB or Board) conducted a health risk assessment to evaluate the impacts associated with toxic air contaminants emitted in and around Union Pacific Railroad's (UP) Los Angeles Transportation Center (LATC) located in Los Angeles, California. The study focused on the railyard property emissions from locomotives, on-road heavy-duty trucks, cargo handling equipment, and other vehicles and off-road equipment used to move bulk cargo such as forklifts. Also evaluated were mobile and stationary sources with significant emissions within a one-mile distance of the railyard.

## 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 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 contaminant in and around a railyard facility. Diesel PM typically accounts for about 70% of the State's estimated potential ambient air toxic cancer risks. This estimate is based on data from ARB's ambient monitoring network in 2000 (ARB, 2000). These findings are consistent with a study conducted by South Coast Air Quality Management District: *Multiple Air Toxics Exposure Study in the South Coast Air Basin* (SCAQMD, 2000). Based on these scientific research findings, the health impacts in this study primarily focus on the risks from the diesel PM emissions.

* 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 LATC 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%.

The Agreement requires that health risk assessments (HRAs) be prepared for each of the 17 major or designated railyards in the State. The Agreement requires the railyard HRAs to be prepared based on the experience in preparing the UP Roseville Railyard HRA 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). UP LATC Railyard is one of the designated railyards subject to the Agreement and the HRA requirements.

## C. What are Health Risk Assessments (HRAs)?

An exposure assessment is an analysis of the amount (concentration in the air) of a pollutant that a person is exposed to for a specific time period. This information is used in a risk assessment to evaluate the potential for a pollutant to cause cancer or other health effects. An HRA 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 meteorological 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 durations 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[†] 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 is calculated. Typically, the greater the hazard index is above 1, the greater the potential for possible adverse health effects. If the hazard index is less than 1, it is an indicator that adverse effects are less likely to happen.

- For premature deaths linked to diesel PM emissions in the South Coast Air Basin, ARB staff estimated about 1,300 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 South Coast Air Basin are estimated at 7,750 tons for the year 2005 (ARB, 2006a). The UP LATC Railyard diesel PM emissions, on the other hand, are an estimated 7.31 tons[‡] for the year 2005, less than 0.1% of the total air basin diesel PM emissions. For comparison with another major source of diesel PM emissions in South Coast Air Basin, the diesel PM emissions from the Ports of Los Angeles and Long Beach combined are estimated at 1,760 tons per year, resulting in an estimated 29 premature deaths per year (ARB, 2006b).

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) to diesel PM emissions from a facility.

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[†] 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, 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 toxic air contaminant and adoption of the reference exposure level, which shows that diesel PM can enhance allergic responses in humans and animals. Thus, it should be noted that the reference exposure level does not reflect adverse impacts of particulate matter on cardiovascular and respiratory disease and deaths, exacerbation of asthma, and enhancement of allergic response.

[‡] The value in Table II-1 is slightly different due to rounding.

The HRA 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 assessment 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 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 literal prediction of disease incidence in the affected communities, but more as a tool for comparison of the relative risk between one facility and another. Therefore, risk assessment results are best used for comparing 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.

The Office of Environmental Health Hazard Assessment is in the process of updating the current Guidelines. The ARB and the two railroads (UP and BNSF) agreed to evaluate the non-cancer health impacts using an interim methodology. This was used in the *Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, Final Report* (ARB, 2006b) to estimate PM mortality. This will serve as a short-term and interim effort until the Office of Environmental Health Hazard Assessment can complete its update of the Guidelines.

As soon as the HRAs are final, the ARB and the railroads, in cooperation with the SCAQMD staff, local citizens, and others, will begin a series of meetings to identify and implement measures to reduce emissions from railyard sources. Existing effects are detailed in Chapter III, Section C.

## D. Who prepared the UP LATC Railyard HRA?

Under the Agreement, ARB worked with 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 from designated railyards throughout California.

The railroads and their designated consultants (i.e., Sierra Research and Air Quality Management Consulting for the UP LATC Railyard) were responsible for developing the emission inventories and performing the air dispersion modeling for operations that occur within each of the designated railyards. The base year of the analysis is 2005.

ARB staff is responsible for reviewing and approving the railroads' submittals, identifying significant sources of emissions near the railyards and modeling the impacts of those sources, and preparing the railyard health risk assessments. ARB staff is also responsible for releasing the draft HRAs to the public for comment and presenting them at community meetings.  After reviewing public comment on the draft HRAs, ARB staff made revisions as necessary and appropriate, and is now presenting the HRAs in final form.

Ultimately, the information derived from the railyard 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 LATC Railyard operations, emissions, air dispersion modeling, and health risk assessment results.  Following the summary, the third chapter presents the details of the UP LATC 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 LATC Railyard.  The appendices present the technical supporting documents for the analyses discussed in the main body of the report.

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## II. SUMMARY

Below is a summary of the Union Pacific Railroad's (UP) Los Angeles Transportation Center (LATC) Railyard operations, emissions, air dispersion modeling, and health risk assessment results.

### A. General Description of the UP LATC Railyard

The UP LATC Railyard is located at 750 Lamar Street in Los Angeles, California, and encompasses about 120 acres. The railyard is a roughly circular plot of land, with a train arrival and departure strip extending about one mile to the east. The land use surrounding the facility within 1,000 feet is mostly industrial-commercial, with residential areas at the northeast and northwest corners of the facility. Additional residential areas are located approximately 1,500 feet to the south of the facility.

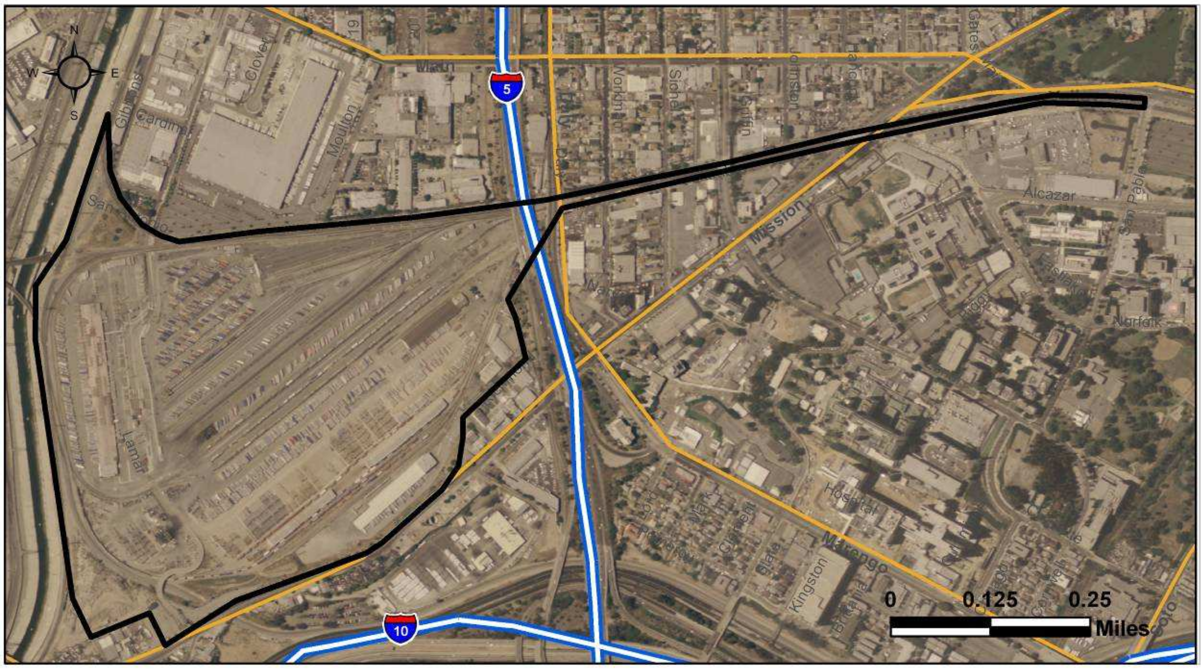
The UP LATC Railyard is located less than a mile northeast of downtown Los Angeles (see Figure II-1). The Los Angeles River borders on the west. There are four major freeways within one mile of the railyard:

- Interstate 10 (I-10), about 500 ft to the south.
- Interstate 5 (I-5), about ¼ mile east of the southernmost part of the railyard.
- Interstate 101 (I-101), about 500 ft to the southwest.
- State Route 110 (SR-110), about a mile to the northwest.

The UP Commerce Railyard is located about seven miles southeast of the UP LATC Railyard, and is evaluated in a separate HRA.

Facilities within the UP LATC Railyard include classification tracks, a gate complex for inbound and outbound intermodal truck traffic, intermodal loading and unloading tracks, and various buildings and facilities supporting railroad and contractor operations.

**Figure II-1: UP LATC Railyard and Surrounding Areas**




## B. What are the Primary Operations at the UP LATC Railyard?

The UP LATC Railyard is an intermodal container facility handling about 250,000 container lifts per year, 5% international and 95% domestic (UP Operating Data, July 2005). Cargo containers 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. Cranes and packers are washed at the railyard: wastewater generated during equipment washing is shipped, by tanker truck, to the UP Commerce Railyard Wastewater Treatment Plant for treatment.

Activities at the UP LATC Railyard include receiving inbound trains, switching cars, loading and unloading intermodal trains, storing intermodal containers and chassis, building and departing outbound trains, and repairing freight cars and intermodal containers/chassis.

A variety of heavy heavy-duty diesel-fueled trucks are used at the railyard to pick up and deliver cargo containers. The heavy heavy-duty diesel-fueled trucks logged approximately 287,000 vehicle miles traveled in 2005, or about 790 vehicle miles traveled average per day. There is also one light heavy-duty diesel-fueled truck used to support railyard activities: it logged about 5,000 vehicle miles traveled in 2005, or about 14 vehicle miles traveled average per day.

## C. What are the diesel PM emissions in and around the UP LATC Railyard?

In 2005, the combined diesel PM emissions from the UP LATC Railyard (on-site emissions) and other significant emission sources within a one-mile distance (off-site emissions) are estimated at about 40.3 tons per year. Off-site sources and activities – not generally related to activities at the railyard – within a one mile distance from the railyard include both mobile and stationary sources, and account for about 33.0 tons per year of diesel PM emissions, or 83% of the combined on-site and off-site diesel PM emissions. The UP LATC Railyard diesel PM emissions are estimated at about 7.31 tons per year, which accounts for about 17% of the combined on-site and off-site diesel PM emissions.

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

**Table II-1: Comparison of Diesel PM Emissions from Eleven Railyards (Tons Per Year)**

| Railyard | Locomotive | Cargo Handling Equipment | On-Road Trucks | Others (Off-Road Equipment, Transport Refrigeration Units, 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 | 0.05 | **1.9** |

* The UP Roseville Health Risk Assessment (ARB, 2004a) was based on 1999-2000 emission estimates. 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.

+ May not add precisely due to rounding.

† An error of cargo handling equipment emissions was found after the modeling was completed. The applicable change in emissions was believed to be de minimis; consequently, the modeling was not re-performed.

### 1. Railyard

The UP LATC Railyard emission sources include, but are not limited to, locomotives, cargo handling equipment, on-road diesel-fueled trucks, other vehicles and off-road equipment, and transport refrigeration units and refrigerated railcars (reefer cars). The facility operates 24 hours a day, 365 days a year. The UP LATC Railyard emissions were calculated on a source-specific and facility-wide basis for the 2005 baseline year. The future growth in emissions at the UP LATC 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 emissions is based on the ARB *Rail Yard Emissions Inventory Methodology* (ARB, 2006c).

Railyard diesel PM emissions are summarized in Table II-2. Locomotive operations are responsible for an estimated 3.19 tons per year, or about 44%, of the UP LATC Railyard diesel PM emissions. The locomotive diesel PM emissions are primarily due to yard operations by switch locomotives, comprising about 2.46 tons per year of diesel PM emissions. Line haul locomotives account for 0.73 tons per year of locomotive diesel PM emissions, with 0.47 tons per year from arriving and departing trains; the balance of locomotive diesel PM emissions due to through trains and various power moves, at about 0.26 tons per year.

The remaining approximately 56% of the UP LATC Railyard diesel PM emissions are generated by a variety of other sources including cargo handling equipment at about 37%, on-road trucks (about 14%), and transport refrigeration units and reefer cars (about 6%).

**Table II-2: UP LATC Railyard and Surrounding Areas**
**Diesel PM Emissions**

| DIESEL PM EMISSION SOURCES | UP LATC Railyard | | Within 1 Mile | |
|---|---|---|---|---|
| | Tons Per Year | Percent[+] of Total | Tons Per Year | Percent of Total |
| LOCOMOTIVES | **3.19** | **44%** | - | - |
| - Switch Locomotives | *2.46* | *34%* | - | - |
| - Line Haul Locomotives | *0.73* | *10%* | - | - |
| - Arriving and Departing Trains | *0.47* | *6%* | - | - |
| - Through Trains and Through Power Moves* | *0.20* | *3%* | - | - |
| - Arriving and Departing Power Moves | *0.06* | *1%* | - | - |
| CARGO HANDLING EQUIPMENT | **2.67**[†] | **37%** | - | - |
| ON-ROAD TRUCKS | **0.99** | **14%** | - | - |
| OTHER (Transport Refrigeration Units and Reefer Cars) | **0.46** | **6%** | - | - |
| OFF-SITE MOBILE SOURCES (e.g., trucks, etc.) | **-** | **-** | **31.7** | **96%** |
| OFF-SITE STATIONARY SOURCES (e.g., refineries, power plants, etc.) | - | - | **1.3** | **4%** |
| **TOTAL** | **7.31** | **100%** | **33.0** | **100%** |

* Power Moves: trains with locomotives, whose objective is to either move locomotives to where they are needed, or to take malfunctioning units to service facilities.

[+] Percentages do not add to 100% due to rounding.

[†] An error of cargo handling equipment emissions was found after the modeling was completed. The applicable change in emissions was believed to be de minimis; consequently, the modeling was not re-performed.

Diesel PM is not the only toxic air contaminant emitted at the UP LATC Railyard. Relatively small amounts of gasoline toxic air contaminants are emitted from a gasoline storage tank. The detailed emission inventories for these toxic air contaminants are presented in the *Toxic Air Contaminant Emissions Inventory and Dispersion Modeling Report for the Los Angeles Transportation Center, Los Angeles, California* (Sierra Research, 2007). The total amount of these toxic air contaminant emissions is about 72 pounds per year, compared to 7.31 tons per year of diesel PM emissions in the railyard.

Other than diesel PM, benzene is the only toxic air contaminant among the top five cancer risk contributors, and is estimated at about 0.6 pounds per year. Calculation of potency weighted estimated toxic emissions for the on-site toxic air contaminants (see a similar analysis for off-site toxic air contaminants in Table II-3) shows a potential cancer risk level of less than a hundred-thousandth of the cancer risk level for diesel PM (0.00003 vs. 7.31 tons per year). Hence, only diesel PM emissions are presented in the on-site emission analysis.

## 2. Surrounding Sources

ARB staff also evaluated significant mobile and stationary sources of diesel PM emissions within a one-mile distance of the UP LATC Railyard. A one-mile distance was chosen because a previous study of diesel PM emissions in the UP Roseville Railyard (ARB, 2004a) indicated that potential cancer risk associated with on-site diesel PM emissions is substantially reduced beyond a one-mile distance from the railyard. Diesel PM emissions from sources operating around the railyard are summarized in Table II-2.

> **Roadway link:** is defined as a discrete section of roadway with unique estimates for the fleet specific population and average speed and is classified as a freeway, ramp, major arterial, minor arterial, collector, or centroid connector.

ARB staff analyzed the significant off-site emission sources based on two categories: mobile and stationary. For the off-site mobile on-road sources, the analysis focused on on-road heavy-duty diesel trucks, as these are the primary source of diesel PM from the on-road vehicle fleet. ARB staff estimated mobile emissions based on roadway specific vehicle activity data and allocated them to individual **roadway links**. All roadway links within a one-mile distance from UP LATC Railyard are included in the analysis. The estimates do not include the diesel PM emissions generated by idling of heavy-duty trucks, and off-road equipment. As the available activity data are limited, individual sources such as truck distribution centers and warehouses are not evaluated individually, but their truck traffic related to these facilities is reflected in the roadway link traffic activities. Because the off-site mobile sources have only focused on the on-road diesel emissions, the exclusion of extended idling and off-road equipment may result in an underestimation of off-site mobile sources emissions.

Emissions from off-site stationary source facilities are identified using the California Emission Inventory Development and Reporting System (CEIDARS) database, which contains information reported by the local air districts for stationary sources within their jurisdiction. The CEIDARS facilities whose locations fell within a one-mile distance of the UP LATC Railyard are selected. Diesel PM emissions are estimated from stationary internal combustion engines burning diesel fuel, operating at stationary sources reported in CEIDARS.

Off-site diesel PM emissions are predominantly generated by mobile sources which, at 31.7 tons per year, provide 80% of the combined on-site and off-site diesel PM emissions. The majority of the off-site diesel PM emissions are from diesel-fueled heavy heavy-duty trucks traveling on I-5, I-10, and I-101 Freeways (trucks are not allowed on SR-110 between the interchange with I-101 and the northern terminus in Pasadena[§]). Stationary sources, at 1.3 tons per year, provide only 3% of the combined on-site and off-site diesel PM emissions.

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[§] http://en.wikipedia.org/wiki/California_State_Highway_110

ARB staff also evaluated other toxic air contaminant emissions around the UP LATC Railyard. Within a one-mile distance of the railyard, 22 stationary toxic air contaminant sources are identified. For the year 2005, the total emissions of toxic air contaminants other than diesel PM emitted from stationary sources within a one-mile distance from the railyard are estimated at about 36.6 tons per year. Over 40 toxic air contaminant species are identified among these emissions, in which ammonia, methylene chloride, and formaldehyde are three major contributors with emissions estimated at 22.5, 5.8, and 1.9 tons per year, respectively.

Not all of these toxic air contaminants are identified as carcinogens. According to ARB's *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (ARB, 2000), diesel PM, 1,3-butadiene, benzene, carbon tetrachloride, and formaldehyde are defined as the top five cancer risk contributors, based on ambient concentrations. These toxic air contaminants account for 95% of the State's estimated potential cancer risk levels. This study also concluded that diesel PM contributes over 70% of the State's estimated potential cancer risk levels, significantly higher than other toxic air contaminants (ARB, 2000). Among the off-site toxic air contaminant emissions for the UP LATC Railyard, the top five cancer risk contributors (without diesel PM) are estimated at about 1.9 tons per year.

The Office of Environmental Health Hazard Assessment has estimated an inhalation **cancer potency factor** for individual chemicals and some chemical mixtures such as whole diesel exhaust. Diesel PM contains many individual cancer-causing chemicals. The individual cancer-causing chemicals are not separately evaluated so as to avoid double counting. The four compounds listed here are given a weighting factor by comparing each compound's cancer potency factor to the diesel PM cancer potency factor. This factor is multiplied by the estimated emissions for that compound, which gives the potency weighted estimated toxic emissions as shown in Table II-3. As can be seen in Table II-3, the potency weighted toxic emissions for these toxic air contaminants are about 0.04 tons per year, which is substantially less than the diesel PM emissions. Hence, they are not included in this analysis.

> **Cancer potency factors** 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 $(mg/kg\text{-}day)^{-1}$.

In addition, ARB staff evaluated the potential cancer risk levels caused by the use of gasoline in the South Coast Air Basin. Table II-4 shows the emissions of four major carcinogenic toxic air contaminants from South Coast Air Basin gasoline sources in 2005 (ARB, 2006a). As indicated in Table II-4, the potency weighted emissions of these four toxic air contaminants from all types of gasoline sources are estimated at about 816 tons per year, or about 11% of diesel PM emissions in the South Coast Air Basin. If only gasoline-powered vehicles are considered, the potency weighted emissions of these four toxic air contaminants are estimated at about 438 tons per year, or about 6% of diesel PM emissions in the Basin. Hence, gasoline-powered vehicular sources are not included in the analysis.

**Table II-3: Potency Weighted Estimated Toxic Emissions from Significant Off-Site Stationary Sources Surrounding UP LATC Railyard**

| Compound | Cancer Potency Factor | Weighted Factor | Estimated Emissions (Tons Per Year) | Potency Weighted Estimated Toxic Emissions (Tons Per Year) |
|---|---|---|---|---|
| Diesel PM | 1.1 | 1 | 1.3 | **1.3** |
| 1,3-Butadiene | 0.6 | 0.55 | 0.01 | **0.005** |
| Benzene | 0.1 | 0.09 | 0.03 | **0.003** |
| Carbon Tetrachloride | 0.15 | 0.14 | 0 | **0** |
| Formaldehyde | 0.021 | 0.02 | 1.87 | **0.037** |
| **Total (non-diesel PM)** | **-** | **-** | **1.91** | **0.045** |

**Table II-4: Emissions of Major Toxic Air Contaminants from Use of Gasoline in the South Coast Air Basin**

| Compound | Toxic Air Contaminant Emissions (Tons Per Year) | | | |
|---|---|---|---|---|
| | From All Sources | Potency Weighted* | From Gasoline Vehicles | Potency Weighted* |
| *Diesel PM* | *7,446* | ***7,446*** | - | - |
| 1,3-Butadiene | 695 | **382** | 420 | **231** |
| Benzene | 3,606 | **325** | 2,026 | **182** |
| Formaldehyde | 4,623 | **92** | 1,069 | **21** |
| Acetaldehyde | 1,743 | **17** | 314 | **3** |
| **Total (non-diesel PM)** | 10,668 | **816** | 3,829 | **438** |

*Based on cancer potency weighted factors.

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

As discussed previously, ARB developed the *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 Office of Environmental

Health Hazard Assessment, and is consistent with the *Roseville Railyard Study* (ARB, 2004a) performed by ARB staff.

The U.S. EPA's newly approved state-of-science air dispersion model AERMOD (**A**merican Meteorological Society / **E**PA **R**egulatory Model Improvement Committee **MOD**EL) is used in the ARB health risk assessments. One of the critical inputs required for the air dispersion modeling is meteorological data, such as wind direction and wind speed. These parameters determine where and how the pollutants will be transported.

Two meteorological stations around the UP LATC Railyard were evaluated: the Downtown Los Angeles – North Main station (operated by SCAQMD) and the Los Angeles International Airport station (operated by the National Weather Service). The Downtown Los Angeles – North Main station was selected because it appeared to be more representative of the railyard conditions.

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

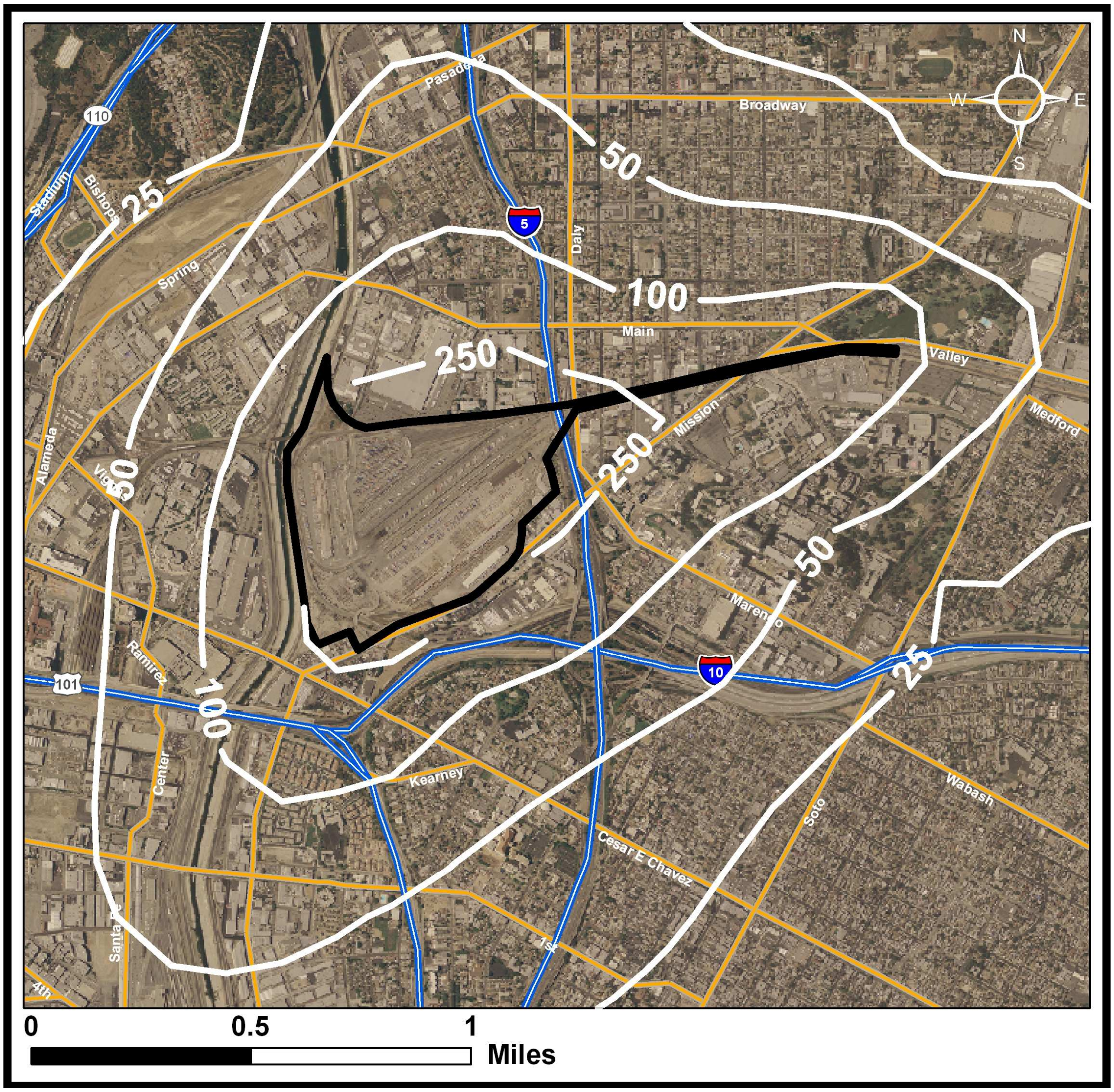
The potential cancer risks associated with the estimated 2005 diesel PM emissions are displayed in **isopleths**. For this analysis, ARB staff elected to present the cancer risk isopleths focusing on risk levels of 10, 25, 50, 100, and 250 in a million. Figure II-2 (See Page 17) and Figure II-4 (See Page 22) present these isopleths: Figure II-2 focuses on the near source risk levels, while Figure II-4 focuses on the more regional impacts. In each figure, the risk isopleths are overlaid onto a satellite image of the Los Angeles area surrounding the UP LATC Railyard, to better illustrate the land use (residential, commercial, industrial, or mixed use) of these impacted areas.

The Office of Environmental Health Hazard Assessment 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 north side of the railyard fenceline, between SR-110 and I-5 (see Figure II-2). The PMI is not downwind of the high emission density areas for the prevailing westerly-southwesterly wind, where yard operations due to switch locomotives and cargo handling equipment generate about 60 percent of facility-wide diesel PM emissions (see the emission allocation in Appendix F). The cancer risk at the PMI is estimated to be about 430 chances in a million. The land use in the vicinity of the point of maximum impact is industrial. 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 250 chances in a million. As indicated by the *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 the point of maximum impact (PMI) location 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 risk than the other railroad's or vice versa. Rather, the differences are primarily due to emission spatial distributions from individual operations among railyards.

At the UP LATC Railyard property boundaries, the estimated cancer risk generally ranges from about 100 to 250 in a million. As shown in Figure II-2, within about a half mile of the UP LATC Railyard boundaries, the estimated cancer risks lowers to 50 in a million, and within a mile of the railyard boundary the estimated cancer risks are lowered to 25 in a million. At about two miles from the UP LATC Railyard, as Figure II-4 indicates, the estimated cancer risks are about 10 in a million.

**Figure II-2: Estimated Near-Source Cancer Risk (Chances per Million People) From the UP LATC Railyard**




The Office of Environmental Health Hazard Assessment 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 are also recommended 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 workers, the Office of Environmental Health Hazard Assessment 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-5 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-5 shows, the 10 in a million isopleth line in Figure II-4 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 a 70-year resident exposure duration, even for those impacted industrial areas where no resident lives.

**Table II-5: Equivalent Potential Cancer Risk Levels for 70-, 40-, 30-, and 9-Year Exposure Durations**

| Exposure Duration (Years) | Equivalent Risk Level (Chance in a Million) | | | | |
|---|---|---|---|---|---|
| 70 | 10 | 25 | 50 | 100 | 250 |
| 30 | 4 | 11 | 21 | 43 | 107 |
| 9‡ | 2.5 | 6.3 | 12.5 | 25 | 62.5 |
| 40* | 2 | 5 | 10 | 20 | 50 |

‡ Exposure duration for school-age children, age 0-9.
* Exposure duration for off-site workers: work schedule of 8 hours a day, 5 days a week, 245 days a year.

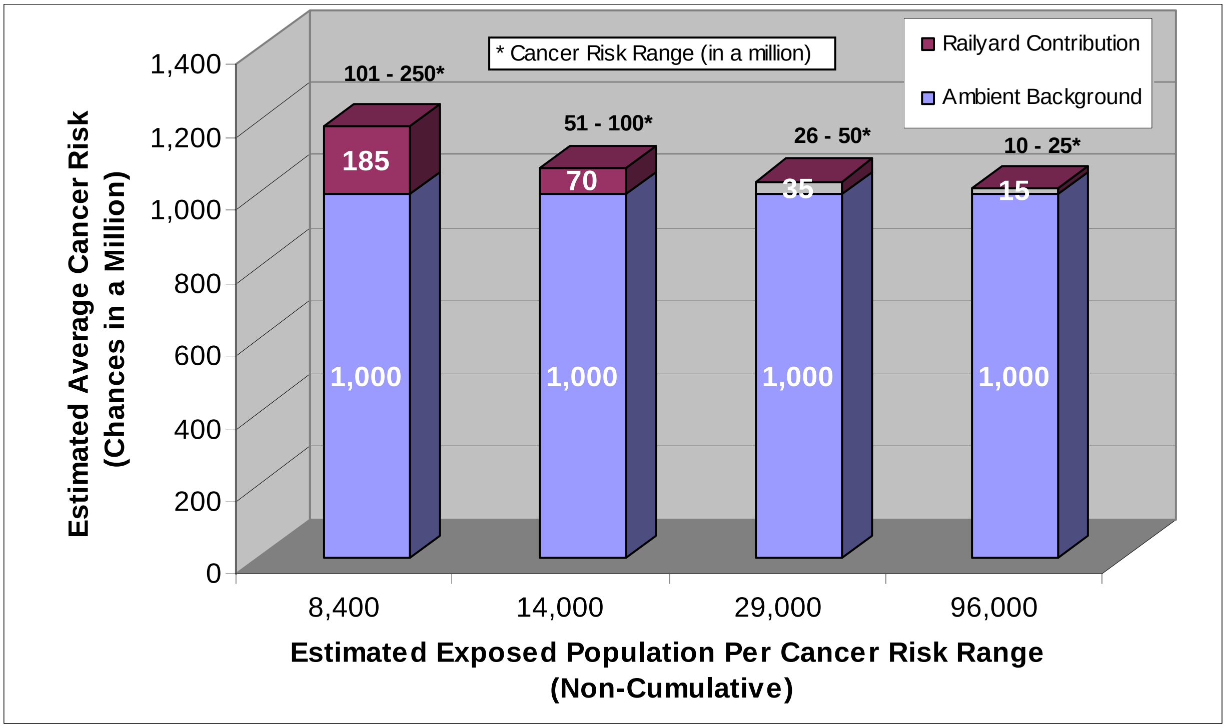
The more populated areas near the UP LATC Railyard are located northwest and northeast of the railyard. Areas located east, south and west are predominantly industrial-commercial. Based on the 2000 U.S. Census Bureau's data, the zone of impact of the estimated risks above 10 chances in a million levels encompasses approximately 9,400 acres where about 147,000 residents live. Table II-6 presents the exposed population and area coverage size for various impacted zones of cancer risks.

**Table II-6: Estimated Impacted Areas and Exposed Population Associated with Different Cancer Risk Levels (Assumes a 70-Year Exposure)**

| Estimated Risk (Per Million) | Estimated Impacted Area (Acres) | Estimated Exposure (Population) |
|---|---|---|
| 10 - 25 | 6,000 | 96,000 |
| 26 - 50 | 2,000 | 29,000 |
| 51 - 100 | 890 | 14,000 |
| 101 - 250 | 550 | 8,400 |

It is important to understand that these risk levels represent the predicted risks (due to the UP LATC Railyard diesel PM emissions) above the existing background risk levels. For the broader South Coast Air Basin, the estimated regional background risk level is estimated to be about 1,000 in a million caused by all toxic air pollutants in 2000 (ARB, 2006a). Figure II-3 provides a comparison of the predicted average potential cancer risks in various isopleths to the regional background risk level from diesel PM emissions. For example, in the 101 – 250 per million risk range, the average potential cancer risk above the regional background is about 185 in a million. Therefore, residents living in that area would have a potential cancer risk of about 1,200 in a million.

**Figure II-3: Comparison of Estimated Potential Cancer Risks from the UP LATC Railyard and the Regional Background Risk Levels**




## E. What are the estimated non-cancer chronic risks near the UP LATC Railyard?

The potential non-cancer chronic risk health hazard index levels from the estimated diesel PM emissions from the UP LATC Railyard are estimated to be about 0.1. According to Office of Environmental Health Hazard Assessment Guidelines (OEHHA, 2003), these levels 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 reference exposure level. 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 reference exposure level. 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 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 are essential for assessing 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. What are the estimated health risks from off-site emissions?

ARB staff evaluated the health impacts from off-site pollution sources near the UP LATC Railyard using the U.S. EPA-approved AERMOD dispersion model. Specifically, off-site mobile and stationary diesel PM emission sources located within a one-mile distance from the railyard were included. Diesel PM off-site emissions used in the off-site modeling runs consisted of 31.7 tons per year from roadways and 1.3 tons per year from stationary facilities, representing emissions for 2005. The estimated potential cancer risks associated with off-site diesel PM emissions are illustrated in Figure II-5 (See Page 23). As indicated in Figure II-5, the zone of impact of estimated cancer risks associated with off-site diesel PM emissions is significantly larger than that of the UP LATC Railyard.

Based on the 2000 U.S. Census Bureau's data, the zone of impact of the estimated potential cancer risks above 100 chances in a million levels associated with off-site diesel PM emissions encompasses approximately 6,600 acres, where about 120,000 residents live. For comparison with the UP LATC Railyard health risks, the same level of potential cancer risks (more than 100 chances in a million) associated with railyard diesel PM emissions covers about 550 acres where approximately 8,400 residents live. Table II-7 presents the exposed population and area coverage size for various impacted zones of cancer risks associated with off-site diesel PM emissions.

**Table II-7: Estimated Impacted Areas and Exposed Population Associated with Different Cancer Risk Levels from Off-Site Emissions Near the UP LATC Railyard**

| Estimated Risk (Per Million) | Estimated Impacted Area (Acres) | Estimated Exposure (Population) |
|---|---|---|
| 10 - 25 | 40,100 | 813,000 |
| 26 - 50 | 13,200 | 271,000 |
| 51 - 100 | 5,400 | 97,000 |
| 101 - 250 | 4,000 | 71,000 |
| 251 - 500 | 2,300 | 43,000 |
| > 500 | 260 | 6,400 |

**Figure II-4: Estimated Regional Cancer Risk (Chances per Million People) From the UP LATC Railyard**

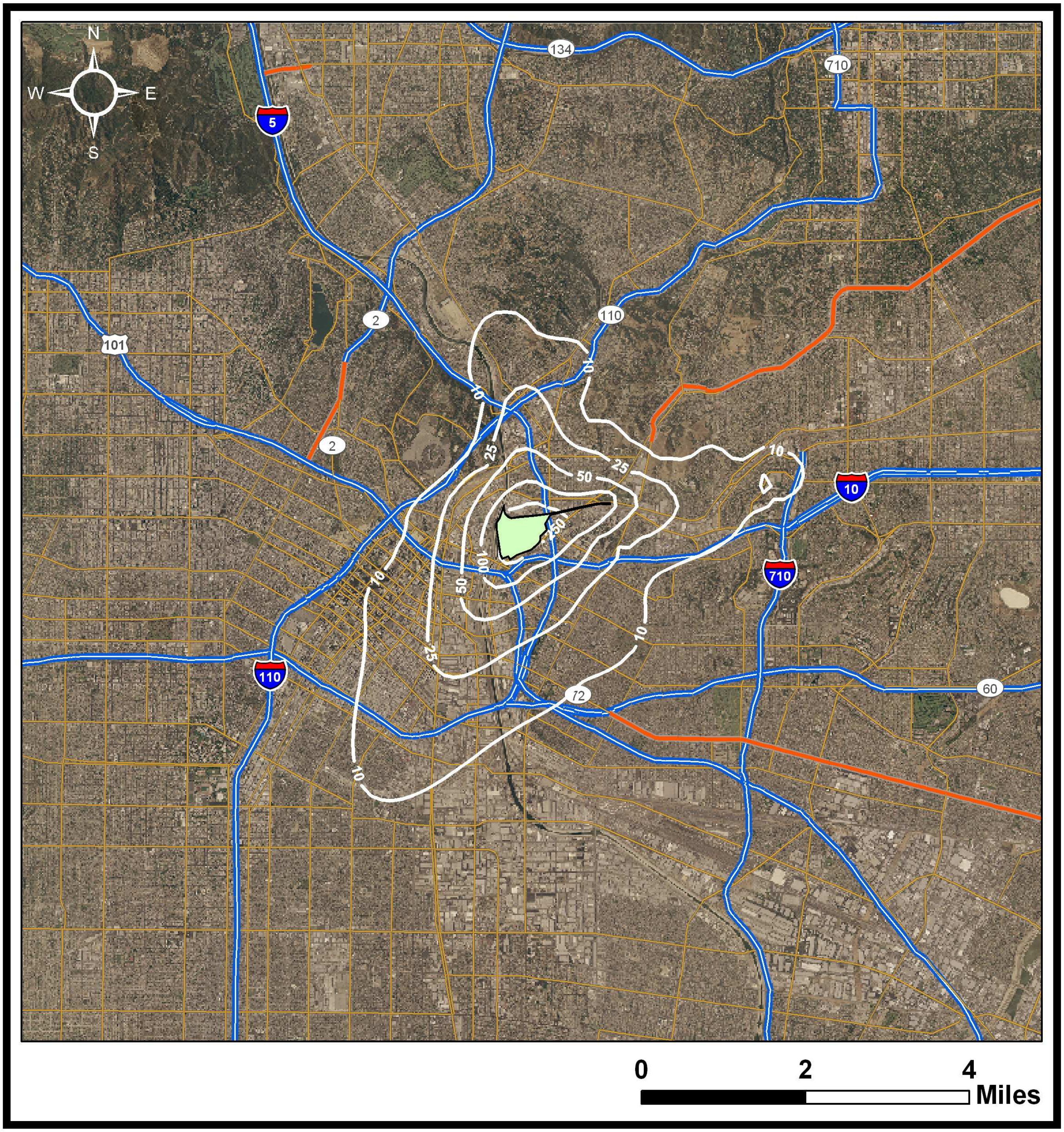
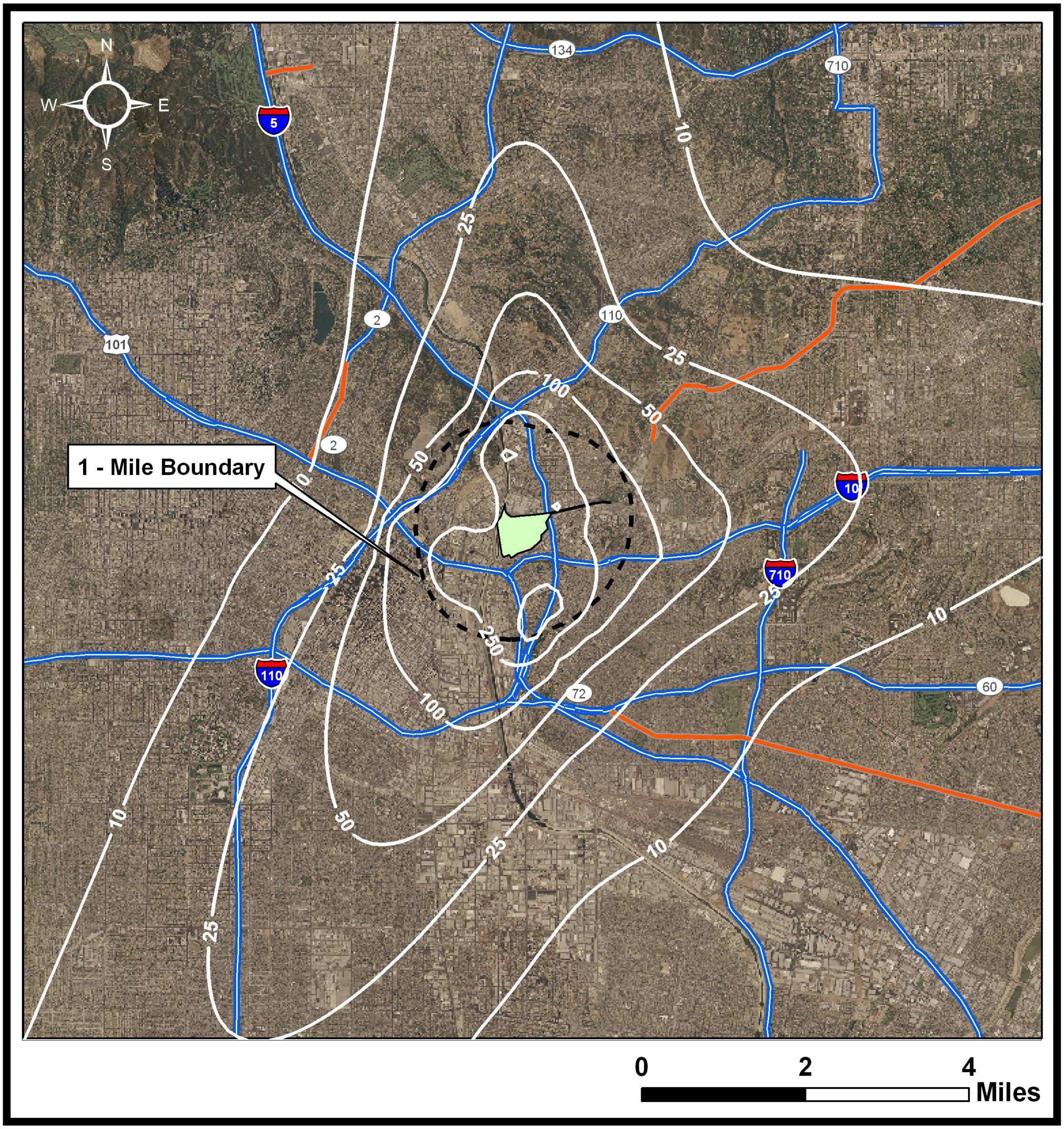


**Figure II-5: Estimated Cancer Risk**
**Near the UP LATC Railyard (Off-Site)**



## G. 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.

## H. 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 railyard 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.

**Statewide Railroad Agreement (2005):** ARB and both UP and BNSF signed a voluntary statewide agreement in 2005. When fully implemented, the Agreement is expected to achieve a 20% reduction in locomotive diesel PM emissions in and around railyards through a required number of short-term and long-term measures. As of January 1, 2007, ARB staff estimates that the Agreement has reduced diesel PM emissions by 15% in and around the UP LATC Railyard.

**ARB Diesel Fuel Regulations Extended to Intrastate Locomotives (2007):** This regulation, approved in 2004, requires intrastate locomotives to use only California ultra low sulfur (15 parts per million) and aromatics diesel fuel. CARB diesel fuel can reduce intrastate locomotive diesel PM emissions and NOx emissions by 14% and 6% on average, respectively. ARB staff estimates there are over 250 intrastate locomotives currently operating in the South Coast Air Basin, and CARB diesel will reduce these locomotive emissions by up to 30 tons per year for diesel PM and 300 tons per year for NOx. 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 statewide. Implementation will reduce diesel PM emissions by approximately 40% in 2010 and 65% in 2015; and NOx emissions by approximately 25% in 2010 and 50% in 2015. The regulation took effect January 1, 2007: when fully implemented, it is expected, cumulatively, to reduce diesel PM and NOx emissions from all cargo handling equipment in the State by up to 80% by 2020. At UP LATC Railyard, this regulation could reduce diesel PM emissions by up to 1.7 tons per year. There are up to eight intermodal railyards in the South Coast Air Basin affected by this regulation.

**On-Road Heavy-Duty Diesel Trucks Regulations:** In January of 2001, the U.S. EPA promulgated a Final Rule to reduce 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 NOx emissions, 72% reduction of non-methane hydrocarbon emissions, and 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 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.

**Transport Refrigeration Unit Air Toxics Control Measure:** This air 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 emission factors for transport refrigeration units and transport refrigeration unit generator 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 emissions and reduced hydrocarbon emissions. The transport refrigeration unit air toxics control measure is designed to use a phased approach over about 15 years to reduce the PM emissions from in-use transport refrigeration units and transport refrigeration unit generator set engines that operate in California. The new rule became effective on December 10, 2004.

**Proposed On-Road In-Use Truck Regulations:** The California Air Resources Board (ARB or the Board) is developing a control measure to reduce diesel PM and NOx emissions from private fleets of on-road heavy-duty diesel-fueled vehicles. This measure includes, but is not limited to, long and short haul truck-tractors, construction related trucks, port hauling trucks, wholesale and retail goods transport trucks, tanker trucks, package and household goods transport trucks, and any other diesel-powered trucks with a gross vehicle weight rating of greater than 14,000 pounds. The proposed goals of the regulations are: (a) by 2014, emissions are to be no higher than a 2004 model year engine with a diesel particulate filter, and (b) by 2020, emissions are to be no higher than a 2007 model year engine.

**Proposed In-Use Port and Railyard Truck Mitigation Strategies:** The ARB is proposing a port truck fleet modernization program that will substantially reduce diesel PM and NOx emissions by 2010, with additional reductions by 2020. There are an estimated 12,000 port trucks operating at the 3 major California ports which are a significant source of air pollution, about 7,075 tons per year of NOx and 564 tons per day of diesel PM in 2005, and operate in close proximity to communities. Strategies will include the retrofit or replacement of older trucks with the use of diesel particulate filters and a NOx reduction catalyst system. ARB staff will propose regulatory strategies for ARB Board consideration by the end of 2007 or early 2008.

**ARB Tier 4 Off-Road Diesel-Fueled Emission Standards:** On December 9, 2004, the Board adopted a fourth phase of emission standards (Tier 4) that are nearly identical to those finalized by the U.S. EPA on May 11, 2004, in its Clean Air Nonroad Diesel Rule. As such, engine manufacturers are now required to meet aftertreatment-based exhaust standards for particulate matter (PM) and NOx starting in 2011 that are over 90% lower than current levels, putting off-road engines on a virtual emissions par with on-road heavy-duty diesel engines.

**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. This federal preemption also extends to the remanufacturing of existing locomotives. The ARB has been encouraging the U.S. EPA to expeditiously require the introduction of Tier 4 locomotives built with diesel particulate filters and selective catalytic reduction. U.S. EPA released the Notice of Proposed Rulemaking (NPRM) for locomotives and marine vessels in the Federal Register on April 3, 2007. The NPRM proposed interim reduction in diesel PM emissions for locomotives from 2010-2013, but the final proposed standards would not be applicable to new locomotives until 2017. The final regulations are expected to be approved by early 2008.

**ARB Goods Movement Emission Reduction Plan (GMERP):** Approved in 2006, the GMERP provides goods movement emissions growth estimates and proposed strategies to reduce emissions from ships, trains, and trucks and to maintain and improve upon air quality. Based largely on the strategies discussed, one of the goals of the GMERP is to reduce locomotive NOx and diesel PM emissions by up to 50% by 2015, and by up to 90% by 2020.

**California Yard Locomotive Replacement Program:** One locomotive strategy identified in the GMERP is to replace California's older switcher yard locomotives (about 800) that operate in and around railyards statewide. Government incentive programs (e.g., Carl Moyer Program, California Proposition 1B Bond Measure) may be able to assist in funding replacement of some intrastate locomotives by 2010.

# III. UP LATC RAILYARD DIESEL PM EMISSIONS

In this chapter, we provide a summary of the diesel particulate matter (PM) emissions inventory for the Union Pacific Railroad's (UP) Los Angeles Transportation Center (LATC) Railyard.

For the year 2005, the combined diesel PM emissions from the UP LATC Railyard (on-site emissions) and significant non-railyard emission sources within a one-mile distance (off-site emissions) are estimated at 40.3 tons per year. Estimated off-site diesel PM emissions from mobile and stationary sources account for about 33.0 tons per year, or about 83% of the total combined on-site and off-site diesel PM emissions. The UP LATC Railyard diesel PM emissions are estimated at about 7.31 tons per year, or about 17% of the total combined on-site and off-site diesel PM emissions.

## A. On-Site UP LATC Railyard Diesel PM Emissions Summary

The UP LATC 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 emissions is based on the 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 Los Angeles Transportation Center, Los Angeles, California* (Sierra Research, 2007) submitted by Sierra Research (hereafter Sierra Research Report).

The UP LATC Railyard is an intermodal container facility handling about 250,000 container lifts per year, 5% international and 95% domestic (UP Operating Data, July 2005). Cargo containers 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 UP LATC Railyard. Cranes and packers are washed at the railyard. Wastewater generated during equipment washing is shipped, by tanker truck, to the UP Commerce Railyard Wastewater Treatment Plant for treatment.

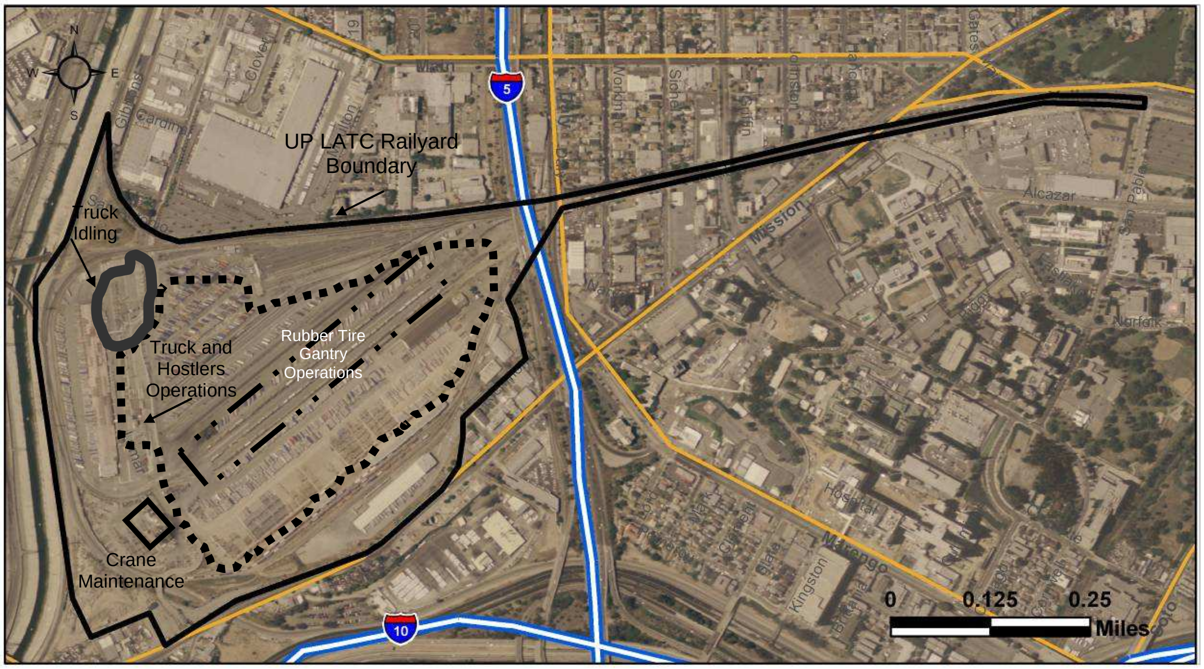
Activities at UP LATC Railyard include receiving inbound trains, switching cars, loading and unloading intermodal trains, storing intermodal containers and chassis, building and departing outbound trains, and repairing freight cars and intermodal containers/chassis. Facilities within the railyard include classification tracks, a gate complex for inbound and outbound intermodal truck traffic, intermodal loading and unloading tracks, and various buildings and facilities supporting railroad and contractor operations.

To characterize diesel PM emissions from on-site sources, they are allocated into five different areas based on specific activities. The railyard areas of operations are summarized in Table III-1, and shown in Figure III-1. The detailed schematic and descriptions of the areas and activities are also presented in the Sierra Research Report.

**Table III-1: UP LATC Railyard Activities**

| Area | Description |
|---|---|
| UP LATC Railyard Boundary | Locomotive idling and traveling |
| Truck and Hostlers Operations | Light heavy-duty and heavy heavy-duty diesel-fueled truck traveling, loading, and unloading |
| Rubber Tire Gantry Operations | Loading and unloading of cargo from trains |
| Crane Maintenance | Maintenance of various types of cranes |
| Truck Idling | Light heavy-duty and heavy heavy-duty diesel-fueled truck idling |

**Figure III-1: UP LATC Railyard Diesel PM Emission Source Locations**



With the data provided by UP and the methodology described in the Sierra Research Report, the diesel PM emissions are calculated for the UP LATC Railyard at about 7.31 tons per year for the year 2005. As shown in Table III-2, emissions from locomotives comprise almost half of the total emissions, at 3.19 tons per year. The next highest percentage is from cargo handling equipment, at 37% (2.67 tons per year). On-road trucks produce about a seventh of the total emissions, at 0.99 tons per year. Transport refrigeration units and refrigerated freight railcars (reefer cars) generate about 6%, at 0.46 tons per year.

**Table III-2: Summary of UP LATC Railyard Diesel PM Emissions**

| Source | Diesel PM Emissions in 2005 | |
|---|---|---|
| | **Tons Per Year** | **Percent of Total[+]** |
| Locomotives | 3.19 | 44% |
| *Switch Locomotives* | *2.46* | *34%* |
| *Line Haul Locomotives* | *0.73* | *10%* |
| *Arriving and Departing Trains* | *0.47* | *6%* |
| *Through Trains and Through Power Moves* | *0.20* | *3%* |
| *Arriving and Departing Power Moves* | *0.06* | *1%* |
| Cargo Handling Equipment | 2.67 | 37% |
| On-Road Trucks** | 0.99 | 14% |
| Other Sources (Transport Refrigeration Units and Reefer Cars) | 0.46 | 6% |
| **Total** | **7.31** | **100%** |

[+]Percentages do not add to 100% due to rounding.
** For further detail on railyard versus off-site on-road truck emissions, see Section C.

Diesel PM is not the only toxic air contaminant emitted in the UP LATC Railyard. Relatively small amounts of gasoline toxic air contaminants are generated from a gasoline storage tank. The detailed emission inventories for these toxic air contaminants are presented in the *Toxic Air Contaminant Emissions Inventory and Dispersion Modeling Report for the Los Angeles Transportation Center, Los Angeles, California* (Sierra Research Report). The total amount of these toxic air contaminant emissions is about 72 pounds per year, compared to 7.31 tons per year of diesel PM emissions in the railyard.

According to ARB's *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (ARB, 2000), diesel PM, 1,3-butadiene, benzene, carbon tetrachloride, and formaldehyde are defined as the top five cancer risk contributors, based on ambient concentrations. These toxic air contaminants account for 95% of the State's estimated potential cancer risk levels. Other than diesel PM, benzene is the only toxic air contaminant among the top five cancer risk contributors, and is estimated at about 0.6 pounds per year. Calculation of potency weighted estimated toxic emissions for the on-site toxic air contaminants (see a similar analysis for off-site toxic air contaminants in Table III-13) shows a potential cancer risk level of less than a hundred-thousandth of the cancer risk level for diesel PM (0.00003 vs. 7.31 tons per year). Hence, only diesel PM emissions are presented in the on-site emission analysis.

### 1. Locomotives

Locomotives are the largest diesel PM emission source at the UP LATC Railyard. Locomotives contribute about 3.19 tons per year, or about 44% of the total railyard diesel PM emissions.

As shown in Table III-3, the highest percentage of locomotive diesel PM emissions results from switch locomotives conducting railyard operations, accounting for more than three-quarters of the total locomotive diesel PM emissions (2.46 tons per year). Line haul locomotives generate 0.73 tons per year of diesel PM emissions, with arriving and departing trains at about 0.47 tons per year, and through trains and various power moves (e.g., moving to other yards for fueling) at about 0.26 tons per year.

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

According to Union Pacific, the UP interstate locomotives were fueled out of state before they entered the California borders. However, data of the detailed diesel deliveries within and outside of California were not available in 2005. When trains arrive at UP railyards, UP estimated a fuel mixture of about 90% CARB-EPA on-road to 10% non-road diesel fuel, based on traveling distance before entering California borders from the last refueling facility outside California. 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: 221 parts per million (ppm) for yard operations, 463 ppm for arriving and departing trains, 1,430 ppm for through trains, and 2,639 ppm for terminating trains.

The locomotive diesel PM emission factors used in this study are based on those of the *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:

> **1). California Fuel.** In 2005, Chevron was UP'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 ppm to 400 ppm, with an average of 221 ppm. The 221 ppm sulfur content is assumed to be representative of California fuel used by UP (Sierra Research Report).
>
> **2). 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 ppm (U.S. EPA, 2004c). The 2,639 ppm sulfur content is assumed to be representative of non-road diesel fuel used by UP for fueling of locomotives outside of California (Sierra Research Report).

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: Diesel PM Emissions by Locomotive Operations at the UP LATC Railyard**

| Activity | Diesel PM Emissions in 2005 | |
|---|---|---|
| | **Tons Per Year** | **Percent of Total** |
| Switch Locomotives | 2.46 | 77% |
| Line Haul Locomotives | 0.73 | 23% |
| *Arriving and Departing Trains* | *0.47* | *15%* |
| *Through Trains and Through Power Moves* | *0.20* | *6%* |
| *Arriving and Departing Power Moves* | *0.06* | *2%* |
| **Total** | **3.19** | **100%** |

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. The detailed approach has been discussed in Chapter 2. Therefore, in the future, the UP LATC Railyard will benefit from these mitigation measures, with diesel PM emissions from locomotives being gradually reduced as the locomotive fleet turns over.

### 2. Cargo Handling Equipment

Cargo handling equipment is the second largest diesel PM emission source at the UP LATC Railyard. The diesel PM emissions from cargo handling equipment was estimated at 2.67 tons in year 2005, equivalent to about 37% of the total diesel PM emissions from the UP LATC Railyard.

Cargo handling equipment is used to load, unload, and move cargo containers at the UP LATC Railyard. Additionally, cargo handling equipment is used for non-cargo-related activities at the railyard, such as locomotive maintenance, handling of parts and company material, derailments, etc. Five types of equipment are included in cargo handling equipment: yard trucks, rubber tire gantry cranes, rough terrain cranes, forklifts, and top picks.

- Yard trucks are also known as yard hostlers. 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 tire gantry 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.
- Rough terrain cranes are mounted on an undercarriage with four rubber tires. They are designed for pick-and-carry operations and for off-road and "rough terrain" applications.
- Forklifts are industry trucks used to hoist and transport materials by means of one or more steel forks inserted under the load.
- Top picks are also known as top handlers. Top picks are another common type of cargo handling equipment. A top pick is a large truck-like vehicle with an overhead beam which locks onto the top of containers in a single stack.

The cargo handling equipment diesel PM emissions in the UP LATC Railyard are estimated using the latest version of ARB OFFROAD model. As indicated in Table III-4, about 78% of cargo handling equipment diesel PM emissions are due to the yard tractors, at about 2.08 tons per year. The ten 2004 model year yard tractors are responsible for 56% of all cargo handling equipment diesel PM emissions. The next highest emission source is the three rubber tire gantry cranes, at about 14% (0.38 tons per year). The three forklifts produce about 5% of total cargo handling equipment diesel PM emissions. The remaining 3% is divided among the rough terrain crane and the two top picks. Additional details of calculations or estimations are presented in the Sierra Research Report.

**Table III-4: Diesel PM Emissions for Cargo Handling Equipment at the UP LATC Railyard**

| Equipment Type | Model Year | Number of Units | Diesel PM in 2005 (Tons Per Year) | Percent of Total Cargo Handling Equipment Emissions* |
|---|---|---|---|---|
| Yard Tractor | 2004 | 10 | 1.49 | 56% |
| Yard Tractor | 2003 | 3 | 0.59 | 22% |
| Rubber Tire Gantry Crane | 1984 | 1 | 0.30 | 11% |
| Rubber Tire Gantry Crane | 2004 | 2 | 0.08 | 3% |
| Rough Terrain Crane | 2003 | 1 | 0.03 | 1% |
| Forklift | 2004 | 1 | 0.07 | 3% |
| Forklift | 1999 | 1 | 0.06 | 2% |
| Forklift | 2000 | 1 | 0.005 | <1% |
| Top Pick | 1990 | 1 | 0.04 | 1% |
| Top Pick | 1998 | 1 | 0.006 | <1% |
| **Total** | | | **2.67** | **100%** |

* Percentages do not add up to 100% due to rounding.

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 NOx emissions by approximately 25% in 2010 and 50% in 2015. The regulation, when fully implemented, is expected to cumulatively reduce diesel PM and NOx emissions from all cargo handling equipment in the State by up to 80% by 2020 (ARB, 2006e). As a result, starting in 2007, the UP LATC Railyard will benefit from these emissions mitigation measures, with diesel PM emissions from cargo handling equipment gradually being reduced as cargo handling equipment fleets turn over. Cargo handling equipment diesel PM emissions at UP LATC Railyard could be reduced by about 2.1 tons per year by 2020, thereby reducing total facility diesel PM emissions by about a quarter.

### 3. On-Road Diesel-Fueled Trucks

On-road trucks contribute about 14% of the total railyard diesel PM emissions, at about 0.99 tons per year. As shown in Table III-5, more than 99% of the on-road truck diesel PM emissions come from heavy heavy-duty trucks. The emissions for the light heavy-duty diesel-fueled trucks are minimal, at 0.001 tons per year. Overall, more on-road truck emissions are due to traveling, outweighing idling emissions by more than two to one. Additional details of calculations or estimations are presented in the Sierra Research Report.

**Table III-5: Diesel PM Emissions for Heavy Heavy-Duty and Light Heavy-Duty On-Road Trucks Within the UP LATC Railyard**

| Source | Diesel PM Emissions in 2005 (Tons Per Year) | | |
|---|---|---|---|
| | Traveling | Idling | Total |
| Light Heavy-Duty[**] Diesel-Fueled Trucks | 0.001 | 0.000 | 0.001 |
| Heavy Heavy-Duty[††] Diesel-Fueled Trucks | 0.70 | 0.29 | 0.99 |
| **Total** | **0.70** | **0.29** | **0.99** |
| **Percent of Total On-Road Truck Emissions** | **71%** | **29%** | **100%** |

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, 72% reduction of non-methane hydrocarbon emissions, and 90% reduction of particulate matter emissions compared to the 2004 model year emission standards. Therefore, starting in 2007, the UP LATC Railyard will benefit from these mitigation measures, with diesel PM emissions from heavy-duty diesel-fueled trucks being gradually reduced as truck fleets turn over.

[**] Light Heavy-Duty: Gross Vehicle Weight Rating: 8,501 to 14,000 lbs
[††] Heavy Heavy-Duty: Gross Vehicle Weight Rating: 33,001 lbs or more

### 4. Transport Refrigeration Units and Reefer Cars

Transport refrigeration units and refrigerated railcars (reefer cars) are used to transport perishable and frozen goods. Transport refrigeration units and reefer cars are transferred in and out of the railyard and are temporarily stored at the railyard. As shown in Table III-6, diesel PM emissions from transport refrigeration units and reefer cars are estimated at 0.46 tons per year, or about 6% of total railyard diesel PM emissions.

The transport refrigeration units produce about 80% of total diesel PM emissions from other sources, at 0.37 tons per year, with the remainder of 0.09 tons per year due to reefer cars. The detailed methodology is discussed in the Sierra Research Report.

**Table III-6: Diesel PM Emissions from Other Sources at the UP LATC Railyard**

| Equipment Type | Diesel PM Emissions in 2005 (Tons Per Year) | Percent of Total Other Emissions |
|---|---|---|
| Transport Refrigeration Units | 0.37 | **80%** |
| Reefer Car | 0.09 | **20%** |
| **Total** | **0.46** | **100%** |

In November 2004, ARB adopted a new regulation*: Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units, Transport Refrigeration Unit Generator Sets and Facilities Where Transport Refrigeration Units Operate*. This regulation applies to all transport refrigeration units in California, including those coming into California from out-of-state. It requires in-use transport refrigeration units and transport refrigeration unit generator 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 transport refrigeration units and transport refrigeration unit generator set engines will be reduced by approximately 65% by 2010 and 92% by 2020. Therefore, starting in 2009, the UP LATC Railyard will benefit from these mitigation measures as diesel PM emissions from transport refrigeration units are gradually reduced as their fleets turn over.

### 5. Other Sources

There were also two diesel fuel storage tanks, an air compressor, and a light tower producing diesel PM emissions at the Yard. However:

- The two diesel fuel tanks are exempt from permitting requirements per South Coast Air Quality Management District (SCAQMD) Rule 219(m).
- The air compressor is rated at 45 horsepower, and the light tower is rated at 10.7 horsepower. Internal combustion engines with a rated capacity of 50 brake horsepower or less are exempt from permitting requirements per SCAQMD Rule 219 (b)(1).

As the diesel fuel storage tanks, air compressor, and light tower are exempt from local air district rules, their emissions will not be included in this inventory nor in the dispersion modeling analysis.

## B. Current Available Diesel Fuel Regulations and Their Benefits to the Railyards

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

The original 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% 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. 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% aromatic standard (or in the case of small refiners, the 20% 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) established separate diesel fuel specifications for on-road diesel fuel and off-road (non-road) diesel fuel. The former 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% 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-8.

### 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. 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 ultimately reduced from current uncontrolled levels of 5,000 ppmw to 15 ppmw. An interim cap of 500 ppmw is contained in the rule: beginning June 1, 2007, refiners are 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 levels of sulfur 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 non-vehicular diesel fuel. Non-road diesel fuel sulfur levels have been recorded as about 3,000 ppmw in-use and aromatics level of about 35% 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 |
| Polynuclear Aromatic Hydrocarbons, 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.

### 5. Diesel Fuels Used by California-Based Locomotives

In November 2004, the ARB Board approved a regulation which extended the CARB diesel fuel requirements to intrastate locomotives (those operating 90% 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 on-road diesel fuels to 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. BNSF locomotives typically fuel at Belen, New Mexico before traveling to Barstow, California and UP locomotives typically fuel at 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 line haul locomotives arrive in California, they typically have about 10% 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 ppm to 400 ppm, with an average of 221 ppm. 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 ppm, 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 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% by volume or an emission equivalent alternative formulation limit. ARB staff estimates that use of CARB diesel provides a 6% reduction in NOx and a 14% 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% 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 oxides of sulfur (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 entered into an agreement in 2005 which included a provision that requires at least 80% 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 on-road 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%, or by about 6.4 tons per day from 2000 levels. Direct diesel PM emissions would be reduced by about 4%, or about 0.6 tons per year in 2010 for engines not equipped with advanced particulate emissions control technologies. U.S. EPA on-road lower sulfur diesel fuel would provide similar levels of sulfur oxide and direct diesel PM 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%, or about 80 tons per year for those engines not currently using CARB diesel, assumed to be about 10% 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 PM 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.

## C. Off-Site Diesel PM Emissions Summary

ARB staff analyzes the significant off-site emission sources based on two categories: mobile and stationary. The off-site emissions are estimated for the sources within a one-mile distance from the boundary of the UP LATC Railyard.

### 1. Mobile Sources

For the off-site mobile sources, the analysis focused on on-road heavy-duty diesel trucks, as they are the primary source of diesel PM from the on-road vehicle fleet. ARB staff estimated mobile emissions based on roadway specific vehicle activity data and allocated them to individual roadway links. All roadway links within a one-mile distance from the UP LATC Railyard are included in the analysis. The estimates do not include the diesel PM emissions generated by idling of heavy-duty trucks. Off-road equipment is not included in the analysis. Individual sources such as local truck distribution centers and warehouses were not evaluated due to insufficient activity data, but their truck traffic related to these facilities is reflected in the **roadway link** traffic activities.

> **Roadway link:** is defined as a discrete section of roadway with unique estimates for the fleet specific population and average speed and is classified as a freeway, ramp, major arterial, minor arterial, collector, or centroid connector.

Within a one-mile distance from the UP LATC Railyard, off-site diesel PM emissions are predominantly generated by mobile sources, which provide around 31.7 tons per year, or 96% of the total off-site diesel PM emissions. As shown in Table III-10, about 23.2 tons per year of the off-site diesel PM emissions, 73% of the total, is from diesel-fueled trucks traveling on three of the four major freeways within one mile of the UP LATC Railyard: I-5, I-10, and I-101. Trucks are not allowed on the fourth major freeway, SR-110, between the interchange with I-101 and its northern terminus in

Pasadena[‡‡]. The remaining 8.5 tons per year of off-site diesel PM emissions, 27% of the total, is from diesel-fueled trucks traveling on local streets.

The diesel PM off-site mobile source emissions are estimated based on the local traffic flow, and calculated by different classifications of truck gross vehicle weights, as shown in Table III-11. In 2005, the total diesel PM emissions was estimated at about 31.7 tons per year with 99% from heavy heavy-duty and medium heavy-duty trucks. The two classifications account for about 26.2 and 5.1 tons per year, respectively. The methodology for mobile diesel PM emission estimation is presented in Appendix A.

**Table III-10: Off-Site Mobile Source Diesel PM Emissions by Freeway Near the UP LATC Railyard**

| Sources | Diesel PM Emissions | |
|---|---|---|
| | Tons Per Year | Percent of Total |
| I-10 Freeway | 2.7 | 8% |
| SR-110 Freeway | 0 | 0% |
| I-5 Freeway | 13.3 | 42% |
| I-101 Freeway | 7.2 | 23% |
| Local Streets | 8.5 | 27% |
| **TOTAL** | **31.7** | **100%** |

**Table III-11: Off-Site Mobile Source Diesel PM Emissions by Vehicle Type Near the UP LATC Railyard**

| Vehicle Type | Gross Vehicle Weight (Pounds) | Diesel PM Emissions | |
|---|---|---|---|
| | | Tons Per Year | Percent of Total |
| Light Heavy-Duty | 8,501 – 14,000 | 0.4 | 1% |
| Medium Heavy-Duty | 14,001 – 33,000 | 5.1 | 16% |
| Heavy Heavy-Duty | > 33,000 | 26.2 | 83% |
| | **TOTAL** | **31.7** | **100%** |

‡‡ http://en.wikipedia.org/wiki/California_State_Highway_110

ARB staff also estimated the diesel PM emissions by heavy heavy-duty trucks traveling between the UP LATC Railyard gate and the major freeway (I-5). These emissions, estimated at about 0.18 tons per year, are not part of railyard diesel PM emissions, but contribute about 0.5% of the total off-site diesel PM emissions. The detailed methodology and calculations are presented in Appendix E.

### 2. Stationary Sources

Emissions from off-site stationary source facilities are identified using the California Emission Inventory Development and Reporting System (CEIDARS) database, which contains information reported by the local air districts for stationary sources within their jurisdiction. The CEIDARS facilities whose locations fell within a one-mile distance of the UP LATC Railyard are selected. Diesel PM emissions are estimated from stationary internal combustion engines burning diesel fuel, operating at stationary sources reported in CEIDARS.

As shown in Table III-12, within one mile of the UP LATC Railyard boundary, the diesel PM emissions from off-site stationary sources are about 1.3 tons per year, or about 4% of the total off-site diesel PM emissions. About 77% of the stationary source diesel PM emissions are from one source, the City of Los Angeles Department of General Services.

**Table III-12: Diesel PM Emissions for Off-Site Stationary Sources Near the UP LATC Railyard**

| Sources | Diesel PM Emissions | |
|---|---|---|
| | Tons Per Year | Percent of Total |
| City of Los Angeles – Department of General Services | 1.0 | 77% |
| LAC – USC Medical Center | 0.2 | 15% |
| Los Angeles County Sheriff's Department | 0.1 | 8% |
| **Total** | **1.3** | **100%** |

### 3. Non-Diesel PM Toxic Air Contaminants

ARB staff also evaluated other toxic air contaminant emissions around the UP LATC Railyard. Within a one-mile distance of the railyard, 22 stationary toxic air contaminant sources were identified. For the year 2005, the total emissions of toxic air contaminants other than diesel PM emitted from stationary sources within a one-mile distance from the railyard are estimated at about 36.6 tons per year. Over 40 toxic air contaminant species are identified among these emissions, in which ammonia, methylene chloride, and formaldehyde are three major contributors with emissions estimated at 22.5, 5.8, and 1.9 tons per year, respectively.

Not all of these toxic air contaminants are identified as carcinogens. According to ARB's *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (ARB, 2000), diesel PM, 1,3-butadiene, benzene, carbon tetrachloride, and formaldehyde are defined as the top five cancer risk contributors, based on ambient concentrations. These toxic air contaminants account for 95% of the State's estimated potential cancer risk levels. This study also concluded that diesel PM contributes over 70% of the State's estimated potential cancer risk levels, significantly higher than other toxic air contaminants (ARB, 2000). Among the off-site toxic air contaminant emissions for the UP LATC Railyard, the top five cancer risk contributors (without diesel PM) are estimated at about 1.9 tons per year.

The Office of Environmental Health Hazard Assessment has estimated an inhalation **cancer potency factor** for individual chemicals and some chemical mixtures such as whole diesel exhaust. Diesel PM contains many individual cancer-causing chemicals. The individual cancer-causing chemicals are not separately evaluated so as to avoid double counting. The four compounds listed here are given a weighting factor by comparing each compound's cancer potency factor to the diesel PM cancer potency factor. This factor is multiplied by the estimated emissions for that compound, which gives the potency weighted estimated toxic emissions as shown in Table III-13. As can be seen, the potency weighted toxic emissions for these toxic air contaminants are about 0.04 tons per year, which is substantially less than the diesel PM emissions. Hence, they are not included in the analysis.

**Cancer potency factors** 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 $(mg/kg\text{-}day)^{-1}$.

**Table III-13: Potency Weighted Estimated Toxic Emissions from Significant Off-Site Stationary Sources Surrounding UP LATC Railyard**

| Compound | Cancer Potency Factor | Weighted Factor | Estimated Emissions (Tons Per Year) | Potency Weighted Estimated Toxic Emissions (Tons Per Year) |
|---|---|---|---|---|
| Diesel PM | 1.1 | 1 | 1.3 | **1.3** |
| 1,3-Butadiene | 0.6 | 0.55 | 0.01 | **0.005** |
| Benzene | 0.1 | 0.09 | 0.03 | **0.003** |
| Carbon Tetrachloride | 0.15 | 0.14 | 0 | **0** |
| Formaldehyde | 0.021 | 0.02 | 1.87 | **0.037** |
| **Total (non-diesel PM)** | **-** | **-** | **1.91** | **0.045** |

The detailed methodology of off-site stationary source emissions is presented in Appendix B.

In addition, ARB staff evaluated the potential cancer risk levels caused by the use of gasoline in the South Coast Air Basin. Table III-14 shows the emissions of four major carcinogenic toxic air contaminants from South Coast Air Basin gasoline sources in 2005 (ARB, 2006a). As indicated in Table III-14, the potency weighted emissions of these four toxic air contaminants from all types of gasoline sources are estimated at about 816 tons per year, or about 11% of diesel PM emissions in the South Coast Air Basin. If only gasoline-powered vehicles are considered, the potency weighted emissions of these four toxic air contaminants are estimated at about 438 tons per year, or about 6% of diesel PM emissions in the Basin. Hence, gasoline-powered vehicular sources are not included in the analysis.

**Table III-14: Emissions of Major Toxic Air Contaminants from Use of Gasoline in the South Coast Air Basin**

| Compound | Toxic Air Contaminant Emissions (Tons Per Year) | | | |
|---|---|---|---|---|
| | From All Sources | Potency Weighted* | From Gasoline Vehicles | Potency Weighted* |
| *Diesel PM* | *7,446* | ***7,446*** | - | - |
| 1,3-Butadiene | 695 | **382** | 420 | **231** |
| Benzene | 3,606 | **325** | 2,026 | **182** |
| Formaldehyde | 4,623 | **92** | 1,069 | **21** |
| Acetaldehyde | 1,743 | **17** | 314 | **3** |
| **Total (non-diesel PM)** | 10,668 | **816** | 3,829 | **438** |

*Based on cancer potency weighted factors.

## IV. AIR DISPERSION MODELING FOR THE UP LATC 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 Union Pacific Railroad's (UP) Los Angeles Transportation Center (LATC) 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 the 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 LATC 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 Source Complex 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 mobile sources at the UP LATC Railyard are characterized as either a point source or a volume source depending on whether they are stationary or moving. When a mobile source is stationary, such as when it is idling or undergoing load testing, the emissions are simulated as a series of point sources. Model parameters for point sources include emission source height, diameter, exhaust temperature, exhaust exit velocity, and emission rate. The locomotive exhaust temperatures and stack heights vary by locomotive makes, models, notch settings and operation time. BNSF assumed more specific temperatures and stack heights from their switchers and line haul locomotives fleets. 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 UP and BNSF assumptions on the locomotive emission parameters are slightly different; however, both are within reasonable ranges according to their activities. The slight differences in stack height have an insignificant impact on predicted air concentrations, within 2 percent, based on a sensitivity analysis conducted by ARB staff.

When a mobile source is traveling, the emissions are simulated as a series of volume sources to mimic the initial lateral dispersion of emissions by the exhaust stack's movement through the atmosphere. Key model parameters for volume sources include emission rate (strength), source release height, and initial lateral and vertical dimensions of volumes.

The emissions from all stationary sources and portable sources are simulated as a series of point sources.

The emission rates for individual locomotives are a function of locomotive type, notch setting, activity time, duration, and operating location. Emission source parameters for all locomotive model classifications at the railyard include emission source height, diameter, exhaust temperature, and exhaust velocity. Detailed information on the emission source parameters is presented in the Sierra Research Report. Because the stationary locomotives were not uniformly distributed throughout the railyard, 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 Union Pacific Railroad.

## 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 proximity of the meteorological station and the presence or absence of nearby terrain features that might alter airflow patterns.

For the UP LATC Railyard, the candidate meteorological stations for assessment were the Downtown Los Angeles – North Main station (operated by SCAQMD) and the Los Angeles International Airport station (operated by the National Weather Service). The Downtown Los Angeles – North Main station was selected because it appeared to be more representative of the railyard conditions. Missing data were replaced by data from the Los Angeles International Airport.

The upper air sounding data were chosen from the San Diego-Miramar NAS stations. Detailed meteorological data selection is discussed in the Sierra Research Report.

The presence of elevated terrain nearby the UP LATC Railyard in several directions introduces some uncertainty as to the expected direction of prevailing airflows (and resulting areas of higher concentrations).

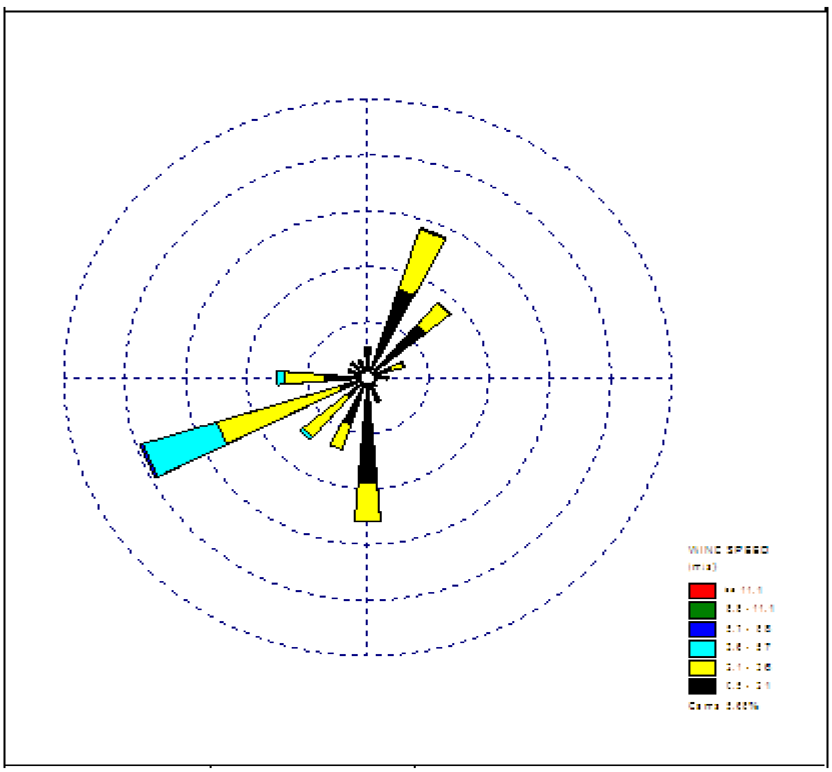
According to ARB railyard health risk assessment guidelines (ARB, 2006d), five years of meteorological data are recommended to be used in the air toxic health risk assessment. Four years of meteorological data from the Downtown Los Angeles – North Main monitoring station (2002 to 2005) were processed to assure that an adequate number of years of acceptable data completeness and quality would be available for AERMOD modeling (Sierra Research Report). The consultant for UP performed 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 2002 were selected for railyard dispersion modeling because they had a greater completeness than the 2003 to 2005 data.

Surface parameters supplied to the model were specified for the area surrounding the surface meteorological monitoring site as recommended by AERMOD and the ARB *Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (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.

The wind field for modeling work is summarized in the wind rose plot is shown in Figure IV-1. The prevailing wind over the modeling domain is from the west-southwest.

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

**Figure IV-1: Wind Rose for UP LATC Railyard**



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

## D. Model Receptors

Model receptors are the locations where concentrations are estimated by the model. In this study, a Cartesian grid receptor network is used, 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 x 20 km (km: kilometers) region, which covers the railyard in the center of the domain and extends to the surrounding areas. To better characterize different dispersive levels of concentrations from the railyard, four different modeling grid structures were defined. The *ARB Guidance* requires coarse and fine modeling receptor grids, in which the Cartesian receptor networks used in model simulations include a fine grid with spacing of 50 meters surrounding the UP LATC Railyard for modeling within 300 meters of the fence line, and a coarse receptor grid with spacing of 500 meters throughout the rest of the modeling domain. Two medium-fine grids with spacing of 100 meters and 200 meters are used for receptors between fine and coarse grid networks.

Figure IV-2 shows the fine and medium grid receptor networks, and Figure IV-3 shows the coarse grid receptor networks, used in air dispersion modeling for the UP LATC Railyard.

**Figure IV-2: Fine and Medium Grid Receptor Networks**
**Air Dispersion Modeling for UP LATC Railyard**

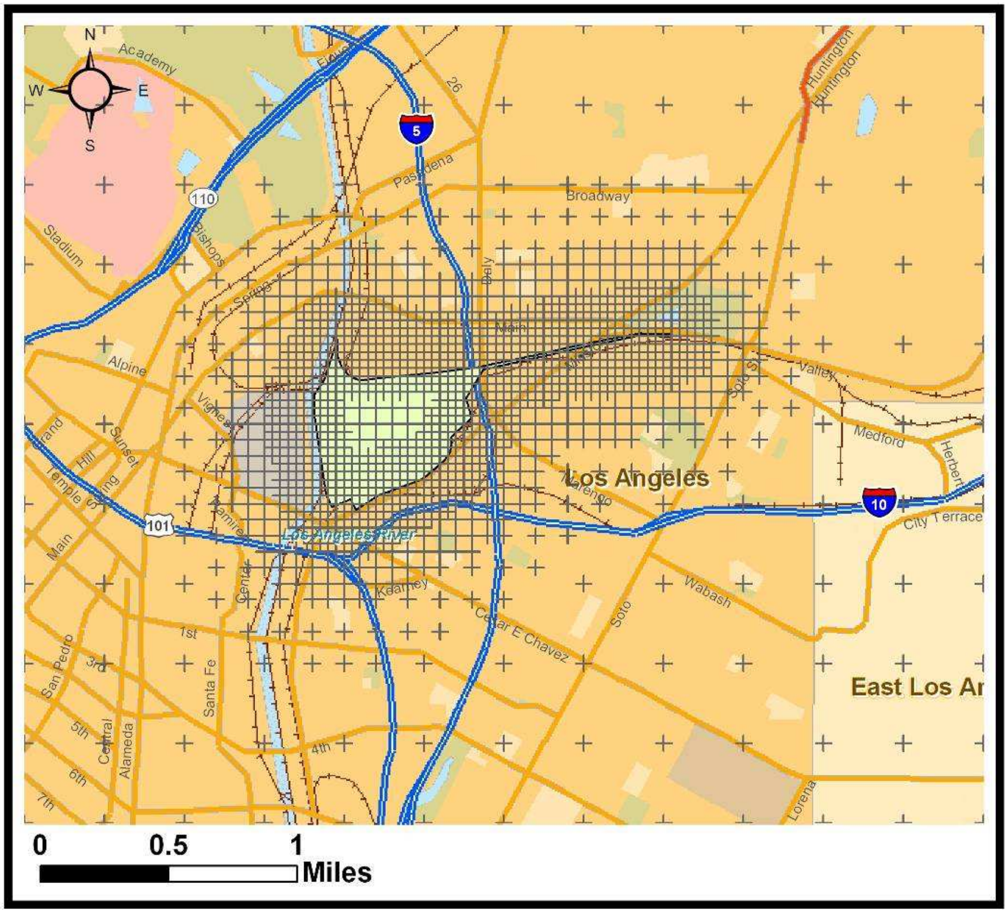
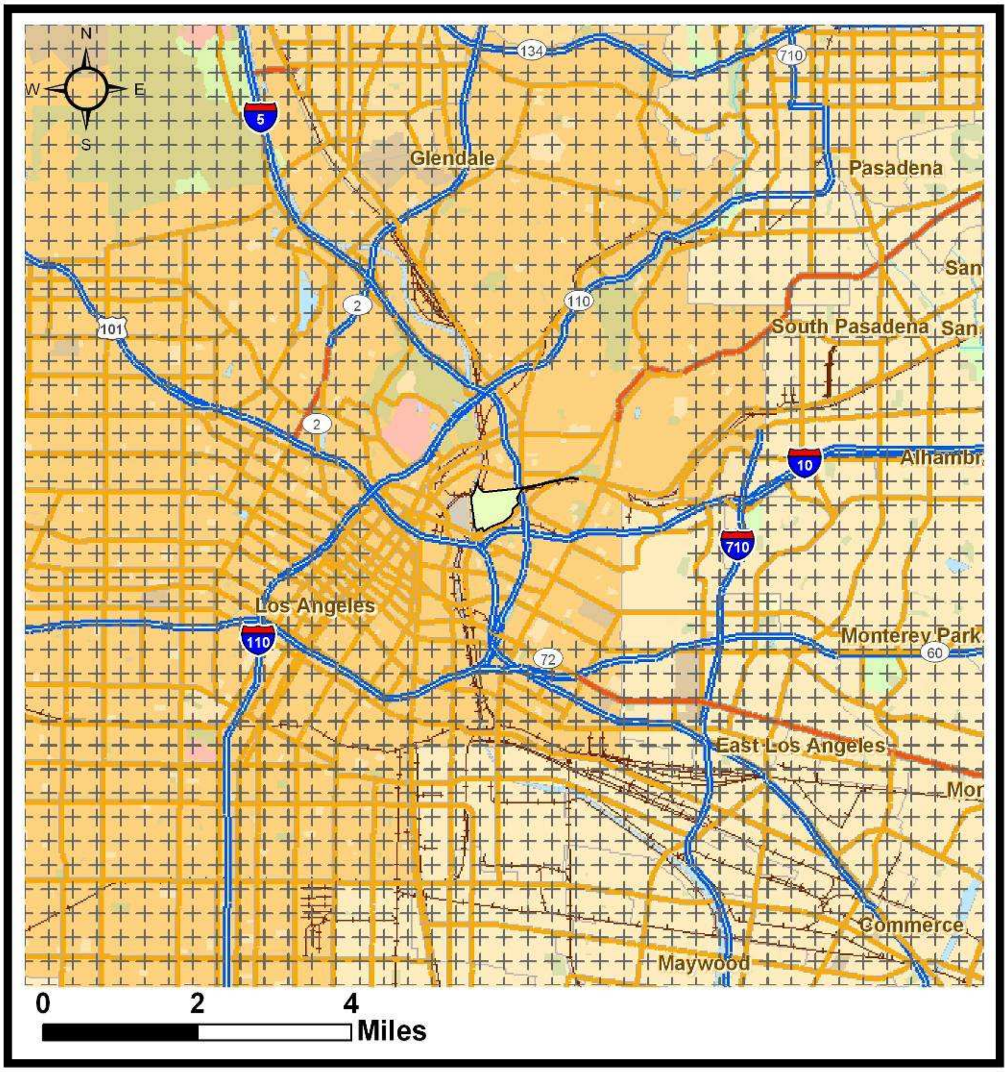


**Figure IV-3: Coarse Grid Receptor Networks**
**Air Dispersion Modeling for UP LATC Railyard**




### E. Building Wake Effects

If pollutant emissions are released at or below the “Good Engineering Practice” height as defined by 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 *Plume Rise Model Enhancements* option 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, 2006). Detailed treatment of building wake effects is documented in the air dispersion modeling report by the Sierra Research, Inc.

## F. Model Inputs

AERMOD requires four types of basic implementation inputs: control, source, meteorological, and receptor. Control inputs are required to specify the global model options for the model run. 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 AERMOD are documented in the user's guide of AERMOD (U.S. EPA, 2004b). The model input files for this study are provided in the Sierra Research Report.

# V. HEALTH RISK ASSESSMENT OF THE UP LATC RAILYARD

In this chapter, we discuss how we characterize potential cancer and non-cancer risks associated with exposure to toxic air contaminants, especially diesel PM, emitted within and surrounding the UP LATC Railyard. In addition, the detailed health risk assessment results are presented, and the associated uncertainties are discussed qualitatively.

## A. ARB Railyard Health Risk Assessment Guidelines

The UP LATC Railyard Health Risk Assessment (HRA) follows *The Air Toxics Hot Spots Program Risk Assessment Guidelines* published by the Office of Environmental Health Hazard Assessment, and is consistent with the *Roseville Railyard Study* (ARB, 2004a) performed by ARB staff. The Office of Environmental Health Hazard Assessment 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 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.

> **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 65$^{th}$ percentile breathing rate is a value such that the breathing rates from 65% of population are less or equal to it.

The HRA is based on the yard specific emission inventory and air dispersion modeling predictions. The Office of Environmental Health Hazard Assessment 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 65$^{th}$ percentile and 95$^{th}$ percentile from the distributions identified in the Office of Environmental Health Hazard Assessment Guidelines (OEHHA, 2000). In 2004, ARB recommended the interim use of the 80$^{th}$ percentile value (the midpoint value of the 65$^{th}$ and 95$^{th}$ 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 80$^{th}$ percentile corresponds to a breathing rate of 302 liters / kilogram-day

(302 L / kg-day) from the probability distribution function. As indicated by the Office of Environmental Health Hazard Assessment Guidelines, the Tier-1 evaluation is useful in comparing risks among a number of facilities and similar sources.

The ARB has also developed the *Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006d) to help ensure that the air dispersion modeling and health risk assessment performed for each railyard meet the Office of Environmental Health Hazard Assessment Guidelines.

## 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. 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 emitted from the UP LATC Railyard. Relatively small amounts of gasoline toxic air contaminants are emitted from a gasoline storage tank. The total amount of these toxic air contaminant emissions is about 72 pounds per year, compared to 7.31 tons per year of diesel PM emissions in the railyard.

Other than diesel PM, benzene is the only toxic air contaminant among the top five cancer risk contributors, and is estimated at about 0.6 pounds per year. Calculation of potency weighted estimated toxic emissions for the on-site toxic air contaminants (see a similar analysis for off-site toxic air contaminants in Table V-1) shows a potential cancer risk level of less than a hundred-thousandth of the cancer risk level for diesel PM (0.00003 vs. 7.31 tons per year). Hence, only diesel PM emissions are presented in the on-site emission analysis. Detailed emission inventories and analysis are provided in Sierra Research Report.

ARB staff also evaluated other toxic air contaminant emissions around the UP LATC Railyard. Within a one-mile distance of the railyard, 22 stationary toxic air contaminant sources were identified. For the year 2005, the total emissions of toxic air contaminants other than diesel PM emitted from stationary sources within a one-mile distance from the railyard are estimated at about 36.6 tons per year. Over 40 toxic air contaminant species are identified among these emissions, in which ammonia, methylene chloride, and formaldehyde are three major contributors with emissions estimated at 22.5, 5.8, and 1.9 tons per year, respectively.

Not all of these toxic air contaminants are identified as carcinogens. According to ARB's *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (ARB, 2000), diesel PM, 1,3-butadiene, benzene, carbon tetrachloride, and formaldehyde are defined as the top five cancer risk contributors, based on ambient concentrations. These toxic air contaminants account for 95% of the State's estimated potential cancer risk levels. This study also concluded that diesel PM contributes over 70% of the State's estimated potential cancer risk levels, significantly higher than other toxic air contaminants (ARB, 2000). Among the off-site toxic air contaminant emissions for the UP LATC Railyard, the top five cancer risk contributors (without diesel PM) are estimated at about 1.9 tons per year.

**Cancer potency factors** 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 $(mg/kg\text{-}day)^{-1}$.

The Office of Environmental Health Hazard Assessment has estimated an inhalation **cancer potency factor** for individual chemicals and some chemical mixtures such as whole diesel exhaust. Diesel PM contains many individual cancer-causing chemicals. The individual cancer-causing chemicals are not separately evaluated so as to avoid double counting. The four compounds listed here – 1,3-butadiene, benzene, carbon tetrachloride, and formaldehyde – are given a weighting factor by comparing each compound's cancer potency factor to the diesel PM cancer potency factor. This factor is multiplied by the estimated emissions for that compound, which gives the potency weighted estimated toxic emissions as shown in Table V-1. As can be seen, the potency weighted estimated toxic emissions for these toxic air contaminants are about 0.04 tons per year, substantially less than the diesel PM emissions and, therefore, not included in this report. Detailed results and analysis are presented in the Sierra Research Report and Appendix B. Hence, the health impacts in this study primarily focus on the risks from the diesel PM emissions.

**Table V-1: Potency Weighted Estimated Toxic Emissions from Significant Off-Site Stationary Sources Surrounding UP LATC Railyard**

| Compound | Cancer Potency Factor | Weighted Factor | Estimated Emissions (Tons Per Year) | Potency Weighted Estimated Toxic Emissions (Tons Per Year) |
|---|---|---|---|---|
| Diesel PM | 1.1 | 1 | 1.3 | **1.3** |
| 1,3-Butadiene | 0.6 | 0.55 | 0.01 | **0.005** |
| Benzene | 0.1 | 0.09 | 0.03 | **0.003** |
| Carbon Tetrachloride | 0.15 | 0.14 | 0 | **0** |
| Formaldehyde | 0.021 | 0.02 | 1.87 | **0.037** |
| **Total (non-diesel PM)** | **-** | **-** | **1.91** | **0.045** |

In addition, ARB staff evaluated the potential cancer risk levels caused by the use of gasoline in the South Coast Air Basin. Table V-2 shows the emissions of four major carcinogenic toxic air contaminants from South Coast Air Basin gasoline sources in 2005 (ARB, 2006a). As indicated in Table V-2, the potency weighted emissions of these four toxic air contaminants from all types of gasoline sources are estimated at about 816 tons per year, or about 11% of diesel PM emissions in the South Coast Air Basin. If only gasoline-powered vehicles are considered, the potency weighted emissions of these four toxic air contaminants are estimated at about 438 tons per year, or about 6% of diesel PM emissions in the Basin. Hence, gasoline-powered vehicular sources are not included in the analysis.

**Table V-2: Emissions of Major Toxic Air Contaminants from Use of Gasoline in the South Coast Air Basin**

| Compound | Toxic Air Contaminant Emissions (Tons Per Year) | | | |
|---|---|---|---|---|
| | From All Sources | Potency Weighted* | From Gasoline Vehicles | Potency Weighted* |
| *Diesel PM* | *7,446* | ***7,446*** | - | - |
| 1,3-Butadiene | 695 | **382** | 420 | **231** |
| Benzene | 3,606 | **325** | 2,026 | **182** |
| Formaldehyde | 4,623 | **92** | 1,069 | **21** |
| Acetaldehyde | 1,743 | **17** | 314 | **3** |
| **Total (non-diesel PM)** | 10,668 | **816** | 3,829 | **438** |

*Based on cancer potency weighted factors.

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. 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 cancer potency factor for assessing cancer risk is described in the Office of Environmental Health Hazard Assessment Guidelines (OEHHA, 2003). The potential cancer risk is estimated by multiplying the inhalation dose by the cancer potency factor of diesel PM, i.e., $1.1(mg/kg\text{-}day)^{-1}$.

## 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 the risk level above the risk due to 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) Potential Cancer Risk*

The potential cancer risks levels associated with the estimated diesel PM emissions at the UP LATC Railyard are displayed by **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. Both Figure V-1 and Figure V-2 present these isopleths. Figure V-1 focuses on the near source risk levels and Figure V-2 illustrates the more regional impacts. In each figure, the risk isopleths are overlaid onto a satellite image of the Los Angeles area surrounding the UP LATC Railyard, to better illustrate the land use (residential, commercial, industrial, or mixed use) of these impacted areas.

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

The Office of Environmental Health Hazard Assessment 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, was estimated to be located on the north side of the railyard fenceline, between SR-110 and I-5 (see Figure V-1). The PMI is not downwind of the high emission density areas for the prevailing westerly-southwesterly wind, where yard operations due to switch locomotives and cargo handling equipment generate about 60 percent of facility-wide diesel PM emissions (see the emission allocation in Appendix F). The cancer risk at the PMI is estimated to be about 430 chances in a million. The land use in the vicinity of the point of maximum impact is industrial use. 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 250 chances in a million. As indicated by the *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 risk than the other railroad's or vice versa. Rather, the differences are primarily due to emission spatial distributions from individual operations among railyards.

Figure V-2 shows the risk isopleths superimposed on a map that covers part of City of Los Angeles, where the railyard is located. In this scenario, the modeling condition (i.e., 80$^{th}$ percentile breathing rate) represents 80% confidence that the cancer risk associated with exposure to diesel PM from on-site emissions at the Yard will not exceed this level. In the upwind direction, the risk contour of 100 in a million is about 100 yards from the railyard boundary. In the downwind direction, the risk contour of 100 in a million is about 1300 yards from the railyard boundary. The area with predicted cancer risk levels in excess of 100 in a million is estimated to be about 1.8 mi by 0.9 mi. The potential risk of 100 in a million in the predominant wind direction can extend 0.7 miles from the Yard boundary for the 80$^{th}$ percentile breathing rates. The area with predicted cancer risk level in excess of 10 in a million is about 6 mi by 3 mi.

It is important to understand that these risk levels represent the predicted risks (due to the UP LATC Railyard diesel PM emissions) above the existing background risk levels. For the broader South Coast Air Basin, the estimated regional background risk level is estimated to be about 720 in a million caused by diesel PM and about 1,000 in a million caused by all toxic air pollutants in the year of 2000 (ARB, 2006a).

**Figure V-1: Estimated Near-Source Cancer Risk (Chances per Million People) From the UP LATC Railyard**

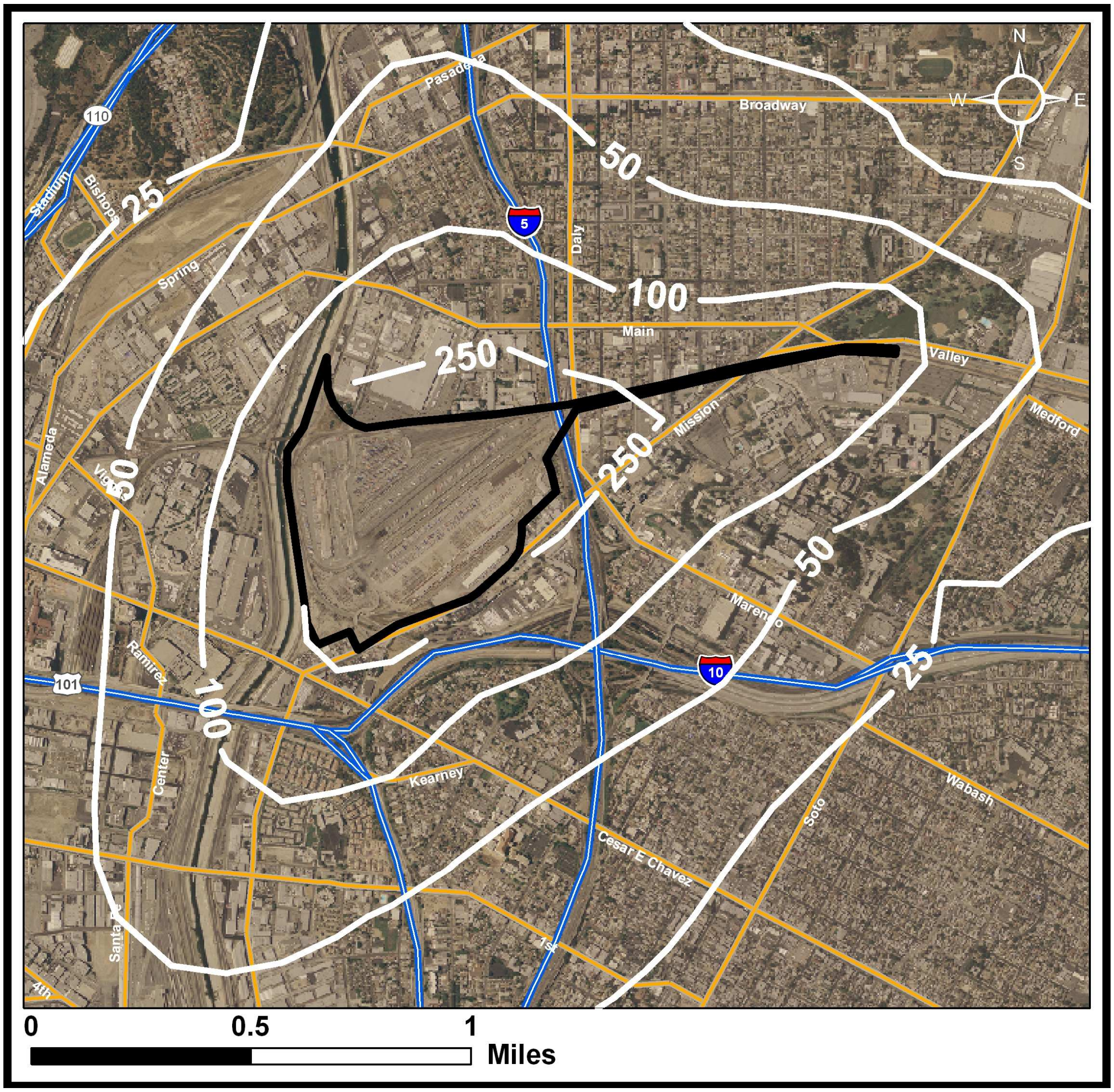
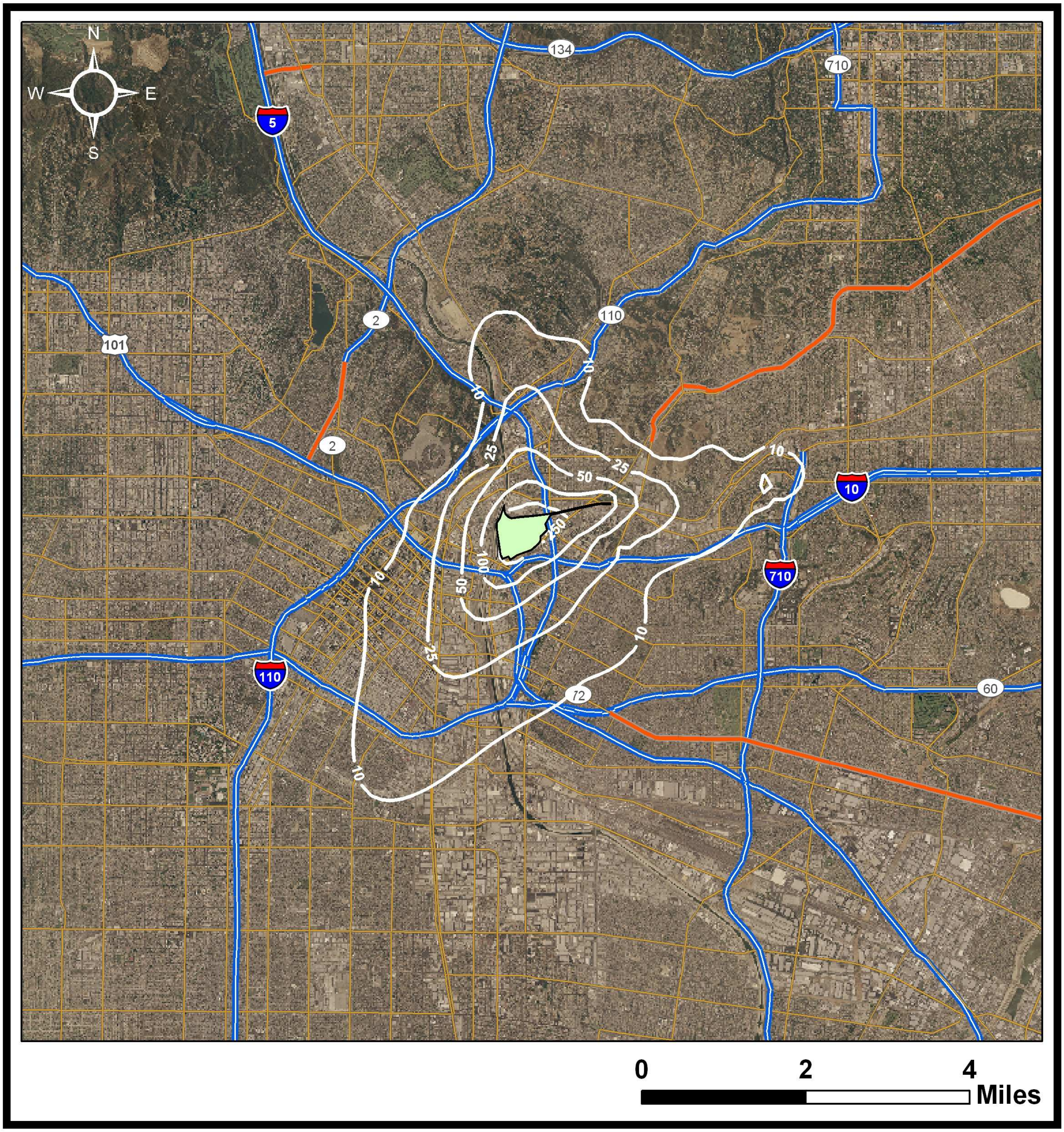


**Figure V-2: Estimated Regional Cancer Risk (Chances per Million People) From the UP LATC Railyard**



The Office of Environmental Health Hazard Assessment 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 are also recommended 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 workers, the Office of Environmental Health Hazard Assessment 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 V-3 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 a 70-year resident exposure duration, even for those impacted industrial areas where no resident lives.

**Table V-3: Equivalent Potential Cancer Risk Levels for 70-, 40-, 30-, and 9-Year Exposure Durations**

| **Exposure Duration (Years)** | **Equivalent Risk Level (Chance in a Million)** | | | | |
|---|---|---|---|---|---|
| 70 | 10 | 25 | 50 | 100 | 250 |
| 30 | 4 | 11 | 21 | 43 | 107 |
| 9[‡] | 2.5 | 6.3 | 12.5 | 25 | 62.5 |
| 40[*] | 2 | 5 | 10 | 20 | 50 |

[‡] Exposure duration for school-age children, age 0-9.
[*] Exposure duration for off-site workers: work schedule of 8 hours a day, 5 days a week, 245 days a year.

The more populated areas near the UP LATC Railyard are located northwest and northeast of the railyard. Areas located east, south and west are predominantly industrial-commercial. 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 9,400 acres where about 147,000 residents live. Table V-4 presents the exposed population and area coverage size for various impacted zones of cancer risks.

**Table V-4: Estimated Impacted Areas and Exposed Population Associated with Different Cancer Risk Levels**

| Estimated Risk (Per Million) | Estimated Impacted Area (Acres) | Estimated Exposure (Population) |
|---|---|---|
| 10 - 25 | 6,000 | 96,000 |
| 26 - 50 | 2,000 | 29,000 |
| 51 - 100 | 890 | 14,000 |
| 101 - 250 | 550 | 8,400 |

*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 Office of Environmental Health Hazard Assessment Guidelines (OEHHA, 2003), dose-response information for non-carcinogens is presented in the form of reference exposure levels. The Office of Environmental Health Hazard Assessment has developed chronic reference exposure levels for assessing non-cancer health impacts from long-term exposure.

A chronic reference exposure level 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 reference exposure levels is fundamentally the same as that used by U.S. EPA in developing the inhalation reference concentrations and oral reference doses. Chronic reference exposure levels are frequently calculated by dividing the no observed adverse effect level or lowest observed adverse effect levels 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, the Office of Environmental Health Hazard Assessment has determined a chronic reference exposure level of 5 $\mu g/m^3$, with the respiratory system as the hazard index target (OEHHA, 2003).

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

The significance of exceeding the reference exposure level 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).

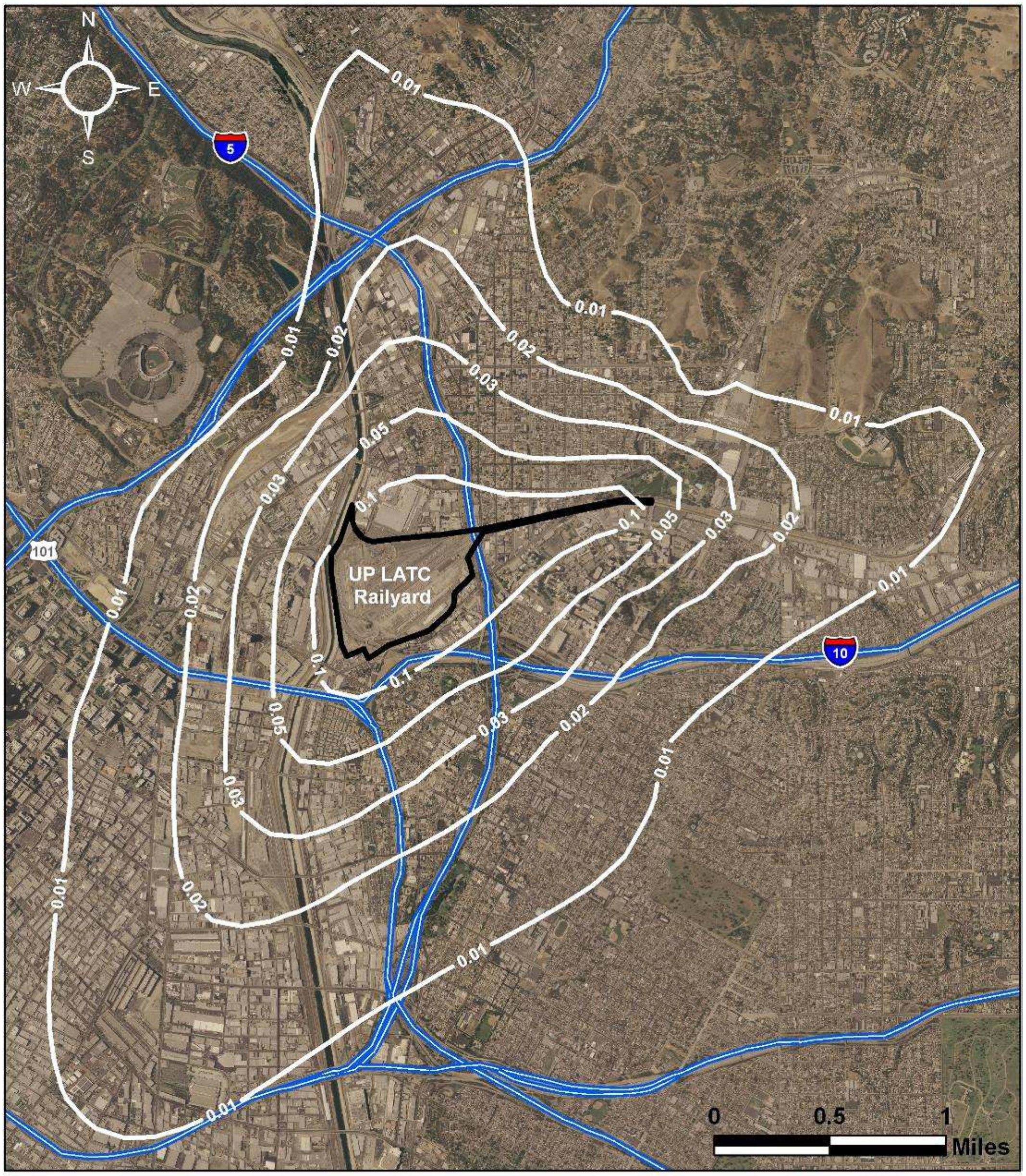
It is important to note that reference exposure level for diesel PM is essentially the U.S. EPA Reference Concentration first developed in the early 1990s based on histological changes in the lungs of rats. Since the identification of diesel PM as a toxic air contaminant, California has evaluated the 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 toxic air contaminant and adoption of the reference exposure level, which shows that diesel PM can enhance allergic responses in humans and animals. Thus, it should be noted that the reference exposure level 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 is then calculated by taking the annual average diesel PM concentration, and dividing by the chronic reference exposure level of 5 $\mu g/m^3$. A hazard index value of 1 or greater indicates an exceedance of the chronic reference exposure level.

As part of this study, ARB staff conducted an analysis of the potential non-cancer health impacts associated with exposures to the model-predicted levels of directly emitted diesel PM from on-site sources within the modeling domain. The hazard index values are calculated, and then plotted as a series of isopleths in Figure V-3. As can be seen, the hazard index is ~ 0.1 at the railyard boundary, and <0.1 around the vicinity of the railyard. According to the Office of Environmental Health Hazard Assessment 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 estimated non-cancer chronic risks by health hazard index isopleths that range from 0.01 to 0.1 around the yard facility. The zone of impact where non-cancer chronic health hazard indices range from 0.01 to 0.1 is an estimated area of 5,200 acres.

**Figure V-3: Estimated Non-Cancer Chronic Risk Health Hazard Index From the UP LATC Railyard**




*c) Potential Non-Cancer Acute Risk*

According to the Office of Environmental Health Hazard Assessment Guidelines, an acute reference exposure level 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 reference exposure level. 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 reference exposure level. 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. Moreover, actions to reduce diesel PM will also reduce non-cancer risks.

### 2. *Risk Characterization Associated with Off-Site Emissions*

ARB staff evaluated the impacts from off-site pollution sources near the UP LATC Railyard using the U.S. EPA-approved AERMOD dispersion model. Specifically, off-site mobile and stationary diesel PM emission sources located within a one-mile distance from the railyard were included. Diesel PM off-site emissions used in the off-site modeling runs consisted of about 31.7 tons per year from roadways and 1.3 tons per year from stationary facilities, representing emissions for 2005. The diesel PM emissions from the UP LATC Railyard are not analyzed in the off-site air dispersion modeling. The same meteorological data and coarse receptor grid system used for on-site air dispersion modeling was used for the off-site modeling runs. The estimated potential cancer risks and non-cancer chronic health hazard index associated with off-site diesel PM emissions are illustrated in Figure V-4 and Figure V-5. As indicated in Figure V-4, the zone of impacts of estimated cancer risks associated with off-site diesel PM emissions is significantly larger than that for the on-site diesel PM emissions.

Based on the 2000 U.S. Census Bureau’s data, the zone of impact of the estimated potential cancer risks above 100 chances in a million levels associated with off-site diesel PM emissions encompasses approximately 6,600 acres where about 120,000 residents live. For comparison with the UP LATC Railyard health risks, the same level of potential cancer risks (more than 100 chances in a million) associated with railyard diesel PM emissions covers about 550 acres where approximately 8,400 residents live.

Table V-5 presents the exposed population and area coverage size for various impacted zones of cancer risks associated with off-site diesel PM emissions.

**Table V-5: Estimated Impacted Areas and Exposed Population Associated with Different Cancer Risk Levels from Off-Site Emissions Near the UP LATC Railyard**

| Estimated Risk (Per Million) | Estimated Impacted Area (Acres) | Estimated Exposure (Population) |
|---|---|---|
| 10 - 25 | 40,100 | 813,000 |
| 26 - 50 | 13,200 | 271,000 |
| 51 - 100 | 5,400 | 97,000 |
| 101 - 250 | 4,000 | 71,000 |
| 251 - 500 | 2,300 | 43,000 |
| > 500 | 260 | 6,400 |

Detailed calculations and methodologies used in off-site air dispersion modeling are presented in Appendix C.

**Figure V-4: Estimated Cancer Risk near the UP LATC Railyard (Off-Site)**

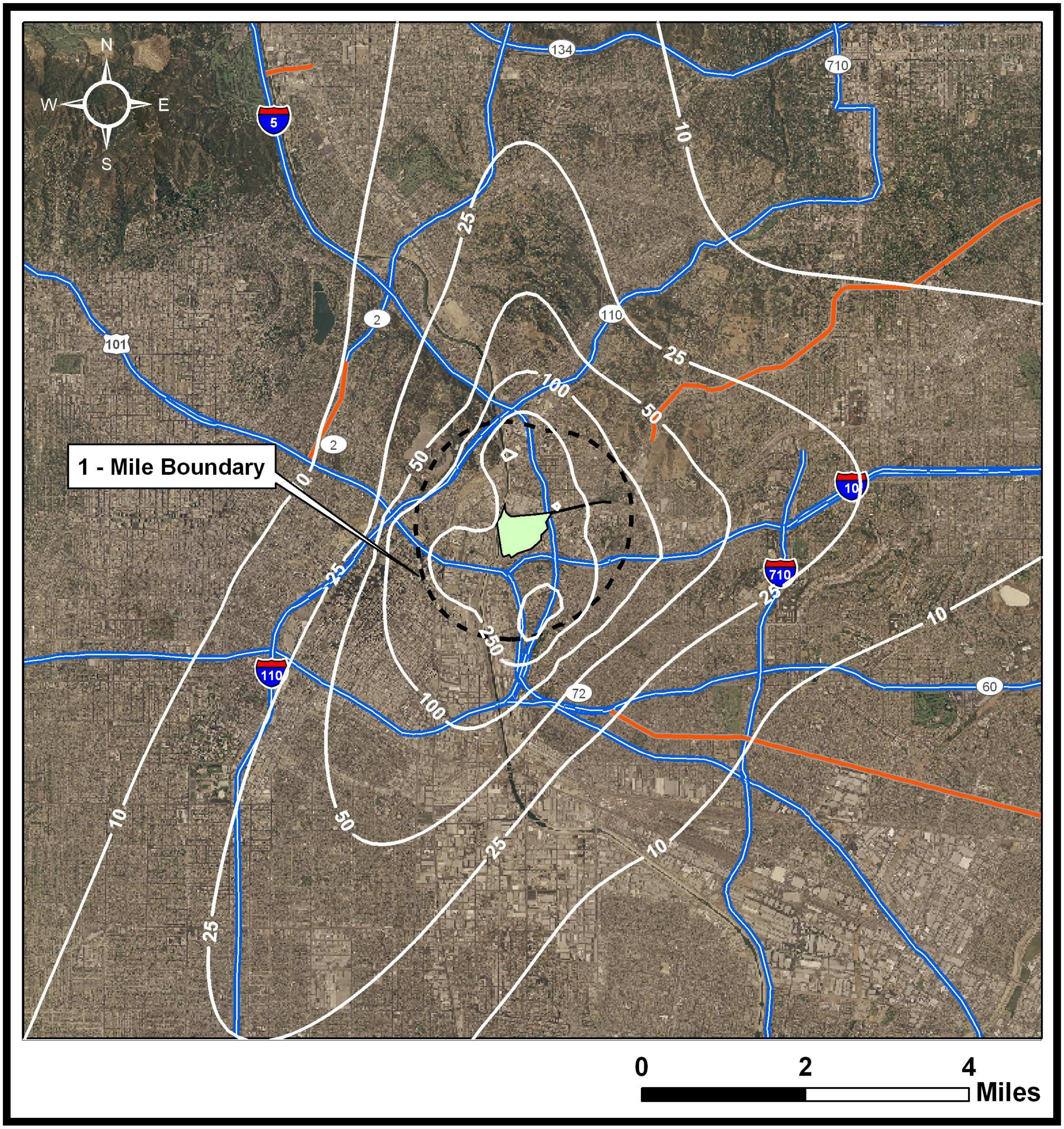
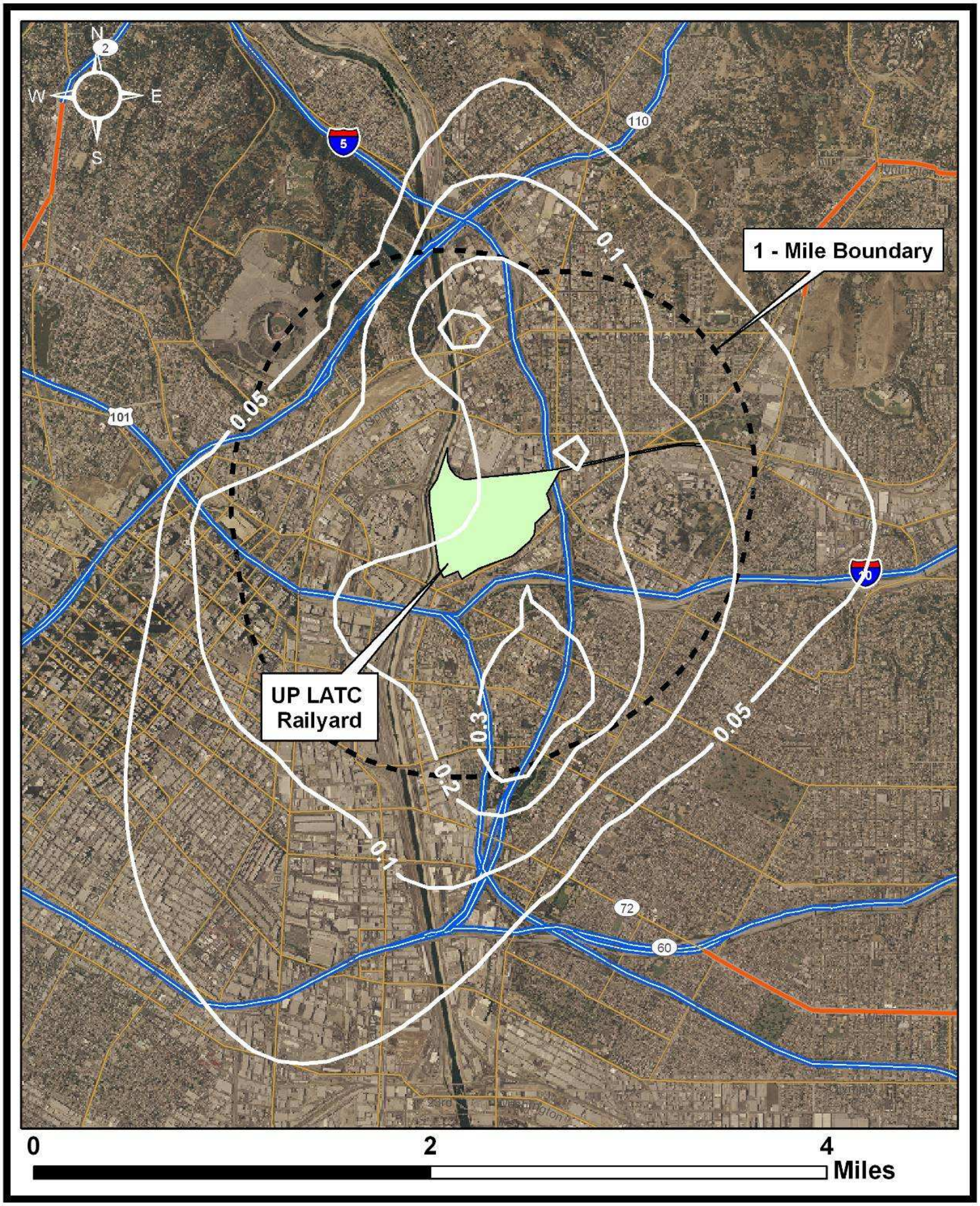


**Figure V-5: Estimated Non-Cancer Chronic Risk Levels From Off-Site Emissions Near the UP LATC Railyard**



### 3. *Risks to Sensitive Receptors*

Individuals may be more sensitive to toxic exposures than the general population. These sensitive populations are identified as school-age children and seniors. The sensitive receptors include schools, hospitals, day-care centers and elder care facilities. There are 55 sensitive receptors within a one-mile distance of the UP LATC Railyard, including 26 schools, 19 child care centers, nine hospitals / medical centers, and one nursing home. The cancer risks for these sensitive receptors are subjective to 40- or 9-year (school-age children) exposure assessment according to the Office of Environmental Health Hazard Assessment Guidelines. Table V-6 summarizes the estimated cancer risk levels associated with diesel PM emission from the UP LATC Railyard for 70-, 40-, and 9-year exposure duration.

**Table V-6: Estimated Number of Sensitive Receptors in Various Levels of Cancer Risks Associated with On-Site Diesel PM Emissions**

| Estimated Cancer Risk (Chance in a Million) | 70-Year Exposure | 40-Year Exposure | 9-Year Exposure |
|---|---|---|---|
| > 100 | 8 | 0 | 0 |
| 51 – 100 | 16 | 0 | 0 |
| 26 – 50 | 8 | 3 | 2 |
| 11 – 25 | 22 | 20 | 14 |
| 0 - 10 | 1 | 32 | 39 |

## D. Uncertainties 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 usually 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.[§§]

For locomotive sources at the UP LATC 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

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[§§] The railyard HRAs have been performed using a methodology in accordance with the ARB *Health Risk Assessment Guidance for Railyards and Intermodal Facilities* (ARB, 2006d) and the Office of Environmental Health Hazard Assessment Guidelines (OEHHA, 2003), and consistent with previous health risk analyses conducted by ARB. As is similar for any model with estimations, the primary barriers of an HRA to the determination of 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 the scope of the current HRAs, given the condition and lack of probability data. The Tier-1 approach used in the HRAs is consistent with the previous health risk analyses performed by ARB, the *Roseville Railyard Study* (ARB, 2004a) and the *Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach, Final Report* (ARB, 2006b). By recognizing associated uncertainties or variability, the HRAs have qualitatively discussed the limitations 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 with uncertainty analyses can lead to misinterpretation of HRA findings.

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 cannot distinguish when an engine is on or off during periods when the locomotive is in the idling 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, 2004a) developed representative diesel PM emission factors for locomotives in different duty cycles. To reduce the possible variability of the locomotive population and the uncertainty from assumptions, the emission factors are updated in the study to cover a wide range of locomotive fleet in the State (see Appendix D). The fuel usage in the locomotives in 2005 is calculated from UP's annual fuel consumption database. These critical updates for locomotive emission inventory have established the most representative locomotive emission factors for the study.

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 a 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 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. 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 intraspecies 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, whose hematological, nervous, endocrine, and immune systems are still developing and who may be more sensitive to the effects of carcinogens, 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 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 identified diesel PM as a toxic air contaminant (ARB, 1998), the panel members endorsed a range of inhalation cancer potency factors [$1.3 \times 10^{-4}$ to $2.4 \times 10^{-3}$ $(\mu g/m^3)^{-1}$] and a risk factor of $3 \times 10^{-4}$ $(\mu g/m^3)^{-1}$, 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 the Office of Environmental Health Hazard Assessment 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. The Office of Environmental Health Hazard Assessment 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 is the 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 for 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 $80^{th}$ 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

## METHODOLOGY FOR ESTIMATING OFF-SITE DIESEL PM MOBILE SOURCE EMISSIONS

## INTRODUCTION

This assessment includes on-road mobile emissions from all heavy-duty diesel truck running exhaust as it is the primary source of diesel particulate emissions within the on-road vehicle fleet. Traditionally, on-road mobile emission inventories are generated at the county scale using California's emission factor model EMFAC and then allocated to large grid cells using the Direct Travel Impact Model. To enhance the spatial resolution, ARB staff estimated emissions based on roadway specific vehicle activity data and allocated them to individual roadway links. All roadway links within a 2-mile buffer of the combined Commerce yards and all links within a 1-mile buffer of all other yards are included in this assessment. This inventory does not include emissions generated by idling of heavy-duty trucks or any off-road equipment outside the railyards.

As more work has been done to understand transportation modeling and forecasting, access to local scale vehicle activity data has increased. For example, the various Metropolitan Planning Organizations (MPOs) are mandated by the Federal government to maintain a regional transportation plan and a regional transportation improvement plan. These reports assess the impact the travel growth and assess various transportation improvement plans[***]. Planning is based on travel activity results from Transportation Demand Models that forecast traffic volumes and other characteristics of the transportation system. Currently, more than a dozen MPOs as well as the California Department of Transportation (Caltrans) maintain transportation demand models. Through a system of mathematical equations, Transportation Demand Models estimate vehicle population and activity estimates such as speed and vehicle miles traveled based on data about population, employment, surveys, income, roadway and transit networks, and transportation costs. The activity is then assigned a spatial and temporal distribution by allocating them to roadway links and time periods. A roadway link is defined as a discrete section of roadway with unique estimates for the fleet specific population and average speed and is classified as a freeway, ramp, major arterial, minor arterial, collector, or centroid connector. Link-based emission inventory development utilizes these enhanced spatial data and fleet and pollutant specific emission factors to estimate emissions at the neighborhood scale.

## METHODOLOGY

Estimating emissions from on-road mobile sources outside the railyards was broken into four main processes and described below. The first step involves gathering vehicle activity data specific to each link on the roadway network. Each link contains 24 hours worth of activity data including vehicle miles traveled, vehicle type, and speed. The activity is then apportioned to the various heavy-duty diesel truck types (Table 1) where speed-specific vehicle miles traveled is then matched to an emission factor from EMFAC to estimate total emissions from each vehicle type for each hour of the day. The working draft of EMFAC, rather than EMFAC2007, was used for this assessment because at the time this project was underway EMFAC2007 was not completed. The

[***] Southern California Association of Governments Transportation Modeling, http://www.scag.ca.gov/modeling/ (Accessed January 2007).

working draft of EMFAC, however, contains nearly all the revisions in EMFAC2007 that would affect these calculations.

**Table A-1: Heavy-Duty Truck Categories**

| Class | Description | Weight (GVW) | Abbreviation | Technology Group |
|---|---|---|---|---|
| **T4** | **Light Heavy-Duty Diesel Trucks** | **8,501-10,000** | **LHDDT1** | **DIESEL** |
| **T5** | **Light Heavy-Duty Diesel Trucks** | **10,001-14,000** | **LHDDT2** | **DIESEL** |
| **T6** | **Medium Heavy-Duty Diesel Trucks** | **14,001-33,000** | **MHDDT** | **DIESEL** |
| **T7** | **Heavy Heavy-Duty Diesel Trucks** | **33,001+** | **HHDDT** | **DIESEL** |

**Step 1: Obtain Link-Specific Activity Data**

The link specific activity data for heavy-duty trucks necessary to estimate emissions are speed and vehicle miles traveled, where vehicle miles traveled is a product of vehicle volume (population) and link length. Link activity for Ventura, Los Angeles, Orange, and more than 90% of Riverside and San Bernardino counties are provided by the Southern California Association of Governments' Heavy-Duty Truck Transportation Demand Model. Heavy-duty truck activity is modeled using truck specific data, commodity flows and goods movement data. The Southern California Association of Governments, however, is the only MPO with a heavy-duty truck model. The remaining counties under the railyard study are covered by the Integrated Transportation Network developed by Alpine Geophysics[†††]. The Integrated Transportation Network was developed by stitching together MPO transportation networks and the Caltrans statewide transportation network. Link specific truck activity from the Integrated Transportation Network is estimated as a fraction of the total traffic on the links and is based on the fraction of trucks within each county as it is estimated in EMFAC.

The product of truck volume and link length is referred to as vehicle miles traveled (VMT) and has units of miles. Transportation demand models provide total VMT for each link without further classification into the various heavy-duty truck weight and fuel type classifications. Therefore, in order to assess the emissions only from heavy-duty diesel trucks, the total heavy-duty truck VMT is multiplied by the fraction of trucks that are diesel. Once the total diesel VMT is calculated, the heavy-duty truck diesel VMT is multiplied by the fraction of trucks that make up the four weight classifications. The fuel and weight fractions are specific to each county and are derived from total VMT for each weight and fuel class in EMFAC for each county. The data are then compiled into an activity matrix (Table 2) composed of a link identification code, hour of the day, speed,

[†††] Wilkinson, James (Alpine Geophysics); et al. "Development of the California Integrated Transportation Network (ITN)," Alpine Geophysics – Atmospheric and Hydrologic Sciences, La Honda, CA (2004). http://www.arb.ca.gov/airways/CCOS/docs/III3_0402_Jun06_fr.pdf

light heavy-duty diesel 1 truck (LHDDT1) VMT, light heavy-duty diesel 2 truck (LHDDT2) VMT, medium heavy-duty diesel truck (MHDDT) VMT, and heavy heavy-duty diesel truck (HHDDT) VMT.

**Table A-2: Activity Matrix Example**

| LINKID | Hour | Speed (mph) | LHDDT1 VMT (miles) | LHDDT2 VMT (miles) | MHDDT VMT (miles) | HHDDT VMT (miles) |
|---|---|---|---|---|---|---|
| 49761 | 12 | 45 | 0.37 | 0.48 | 3.17 | 5.51 |
| 49761 | 3 | 45 | 0.14 | 0.18 | 1.16 | 2.00 |
| 49761 | 3 | 35 | 0.16 | 0.21 | 1.37 | 2.38 |
| 50234 | 4 | 55 | 0.19 | 0.26 | 1.68 | 2.92 |

**Step 2: Derive Gram per Mile Emission Factors**

The second step of the emission inventory process involves developing emission factors for all source categories for a specified time period, emission type, and pollutant. Running exhaust emission factors based on vehicle type, fuel type, and speed were developed from the Emfac mode of EMFAC. These are composite emission factors based on the model year distribution for each county and provided in units of grams of emissions per mile traveled. Finally, a matrix of emission factors by speed and vehicle type was assembled for each county for light heavy-duty diesel trucks 1 and 2 (LHDDT1 and LHDDT2), medium heavy-duty diesel trucks (MHDDT) and heavy heavy-duty diesel trucks (HHDDT). The following is an example of such a matrix (Table 3):

**Table A-3: Emission Factor Matrix Example**

| | Diesel PM Emission Factors (g/mile) | | | |
|---|---|---|---|---|
| Speed (mph) | LHD1 DSL | LHD2 DSL | MHD DSL | HHD DSL |
| 12 | 0.101 | 0.145 | 0.631 | 2.371 |
| 20 | 0.072 | 0.105 | 0.455 | 1.277 |
| 45 | 0.037 | 0.054 | 0.235 | 0.728 |
| 60 | 0.033 | 0.047 | 0.206 | 1.095 |

**Step 3: Calculate Emissions**

Diesel particulate matter (PM) emission factors are provided as grams per mile specific to each speed and heavy-duty truck type (see table above). To estimate emissions, the activity for each diesel heavy-duty truck type was matched to the corresponding emission factor (EF). For example, a 0.25 mile long link at 3 am in the morning has 8 heavy heavy-duty diesel trucks (HHDDTs) traveling at 45 miles per hour. This equates to a VMT of 2.00 miles (8 trucks*0.25 miles). EMFAC has provided a gram per mile emission factor for HHDDT traveling at 45 mph in Los Angeles County as 0.728 grams diesel PM / mile. In order to estimate total emissions from HHDDTs on that link during that hour of the day the following calculation is made:

$$TotalEmissions(grams) = EF \cdot (Volume \cdot LinkLength) = EF \cdot VMT$$

$$TotalEmissions(grams) = EF \cdot VMT = 0.728 \frac{grams}{mile} \cdot 2.00 miles = 1.45 grams$$

The steps outlined above and in Steps 1 and 2 can be represented with this single equation that provides an emissions total for each link for each hour of the day.

$$Emissions = VMT_{link} \cdot \sum_{i,j} Fraction_{i,j} \cdot EF_{i,j}$$

where

- Emissions – the total emissions in grams for each link
- i = represents the individual diesel heavy-duty truck types (LHDDT1, LHDDT2 – light heavy-duty diesel trucks 1 and 2; MHDDT – medium heavy-duty diesel truck; and HHDDT – heavy heavy-duty diesel truck)
- j – represent the hours of the day (hours 1-24)
- $VMT_{Link}$ - total VMT for that link for all heavy-duty trucks (gasoline and diesel)
- Fraction = the fraction of the VMT that is attributable to each diesel heavy-duty truck type The fraction is estimated based on VMT estimates in EMFAC: Example: $VMT_{MHDDT}/VMT_{\text{all heavy-duty trucks (gasoline \& diesel)}}$
- EF = the heavy-duty diesel truck emission factors. The emission factor is vehicle type and speed specific and is thus matched according to the link specific activity parameters.

From this expression, diesel particulate matter emissions are provided for each link and for each hour of the day. Finally, emissions are summed for all links for all hours of the day to provide a total daily emission inventory.

### Step 4: QA/QC – Quality Assurance/Quality Control

To assure that the total emissions were calculated correctly, the total emissions (grams) were divided by the total diesel VMT to estimate a composite diesel gram per mile emission factor. This back-calculated emission factor was checked against emission factors in EMFAC. In addition, where possible, heavy-duty truck gate counts provided for the railyards were checked against traffic volumes on the links residing by the gates.

## LIMITATIONS AND CAVEATS

ARB staff made several important assumptions in developing this inventory. While these assumptions are correct at the county level, they may be incorrect for the particular areas modeled in this assessment. For example, the county specific default model year distribution within EMFAC, and vehicle type VMT fractions were assumed to be applicable for all links within the domain modeled.  While this may be accurate at a county level, it may not reflect link specific model year distributions or vehicle makeup.  Furthermore, these data and activity information used are several years old and may not reflect the latest data available from the MPOs.

Travel demand model results are checked by comparing actual traffic counts on links where the majority of vehicle travel takes place.  Therefore, there will be greater uncertainty associated with activity from minor arterials, collectors, and centroid connectors than from higher volume freeways.  Data based strictly on actual traffic counts for each street would provide better activity estimates, but unfortunately very little data is available for such an analysis.  Furthermore, while links representing freeways are accurately allocated spatially, the allocation of neighborhood streets and other minor roads are not as well represented.

The emissions inventory developed for this study only included diesel particulate matter emissions from running exhaust as it is the primary diesel source from on-road mobile sources.  Emissions from other modes such as idling, starts, and tire and break wear were excluded.

# APPENDIX B

# METHODOLOGY FOR ESTIMATING OFF-SITE DIESEL PM STATIONARY SOURCE EMISSIONS

Emissions from off-site stationary source facilities were identified using the California Emission Inventory Development and Reporting System (CEIDARS) database, which contains information reported by the local air districts for stationary sources within their jurisdiction.

Geographic information system (GIS) mapping tools were used to create a one-mile buffer zone outside the property boundary footprint reported for each railyard.
The CEIDARS facilities whose latitude/longitude coordinates fell within the one-mile buffer zone were selected.

The reported criteria pollutants in CEIDARS include carbon monoxide, nitrogen oxides, sulfur oxides, total organic gases, and particulate matter (PM). The reported toxic pollutants include the substances and facilities covered by the Air Toxics "Hot Spots" (AB 2588) program. Diesel exhaust particulate matter (diesel PM) was estimated from stationary internal combustion engines burning diesel fuel, operating at stationary sources reported in CEIDARS. Diesel PM emissions were derived from the reported criteria pollutant PM that is ten microns or less in diameter (criteria pollutant $PM_{10}$) emitted from these engines. In a few cases, diesel exhaust PM was reported explicitly under the "Hot Spots" reporting provisions as a toxic pollutant, but generally the criteria pollutant $PM_{10}$ reported at diesel internal combustion engines was more comprehensive than the toxics inventory, and was, therefore, the primary source of data regarding diesel PM emissions.

The CEIDARS emissions represent annual average emission totals from routine operations at stationary sources. For the current analysis, the annual emissions were converted to grams per second, as required for modeling inputs for cancer and chronic non-cancer risk evaluation, by assuming uniform temporal operation during the year. (The available, reported emission data for acute, maximum hourly operations were insufficient to support estimation of acute, maximum hour exposures).

The CEIDARS 2004 database year was used to provide the most recent data available for stationary sources. Data for emissions, location coordinates, and stack/release characteristics were taken from data reported by the local air districts in the 2004 CEIDARS database wherever available. However, because microscale modeling requires extensive information at the detailed device and stack level that has not been routinely reported, historically, by many air districts, much of the stack/release information is not in CEIDARS. Gaps in the reported data were addressed in the following ways. Where latitude/longitude coordinates were not reported for the stack/release locations, prior year databases were first searched for valid coordinates, which provided some additional data. If no other data were available, then the coordinates reported for the overall facility were applied to the stack locations. Where parameters were not complete for the stack/release characteristics (i.e., height, diameter, gas temperature and velocity), prior year databases were first searched for valid data. If no reported parameters were available, then U.S. EPA stack defaults from the Emissions Modeling System for Hazardous Air Pollutants (EMS-HAP) program were assigned. The U.S. EPA stack defaults are assigned based on the Source Classification Code (SCC) or Standard Industrial Classification (SIC) code of the operation. If an applicable U.S. EPA default was not available, then a final generic default was applied. To ensure that the microscale modeling results would be health-protective, the generic release parameters assumed relatively low height and buoyancy. Two generic defaults were used. First, if the emitting process was identifiable as a vent or other fugitive-type release, the default parameters assigned were a height of five feet, diameter of two feet, temperature of 100 degrees Fahrenheit, and velocity of 25 feet per second. For all remaining unspecified and unassigned releases, the final generic default parameters assigned were a height of twenty feet, diameter of two feet, temperature of 100 degrees Fahrenheit, and velocity of 25 feet per second. All English units used in the CEIDARS database were converted to metric units for use in the microscale modeling input files.

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# APPENDIX C

## IMPACTS FROM OFF-SITE DIESEL PM EMISSION SOURCES

Impacts from off-site pollution sources near the UP LATC Railyard facility were modeled using the USEPA-approved AERMOD dispersion model. Specifically, off-site mobile and stationary diesel PM emission sources located out to a distance of one mile from the perimeter of the UP LATC Railyard were included. Other emission sources that were located immediately beyond the one-mile zone from the facility, such as a high-volume freeway, have the potential to impact receptors in the modeling grid, but were not considered.

To facilitate modeling of these off-site emission sources, the information summarized in Table 1 was provided by external sources.

**Table 1: Data Provided by Others for Off-Site Emission Source Modeling**

| Type of Data | Description | Data Source |
|---|---|---|
| Emission Estimates | Off-site diesel PM emissions for 2005<br>Mobile Sources: 31.7 TPY diesel PM<br>Stationary Sources: 1.3 TPY diesel PM | PTSD/MSAB |
| Receptor Grid | 41x41 Cartesian grid covering 400 $km^2$ with uniform spacing of 500 meters. Grid origin: (377500, 3759500) in UTM Zone 11. | Sierra Research |
| Meteorological Data | AERMET-Processed data for 2002<br>*Surface*: Los Angeles North and LAX<br>*Upper Air*: San Diego Miramar | Sierra Research |
| Surface Data | Albedo: *Not provided**<br>Bowen Ratio: *Not provided**<br>Surface Roughness: *Not provided** | Sierra Research |

*Surface parameters were defined by the consultants during the AERMET meteorological pre-processing. However, only the AERMET model-ready output files, which do not contain these parameters, were provided by Sierra Research.

The spatial and temporal emissions provided for these sources were converted into the appropriate AERMOD ready files. The off-site emissions were modeled using the same coarse receptor grid and meteorological data used by the consultants for their railyard model runs, as indicated in the table above.

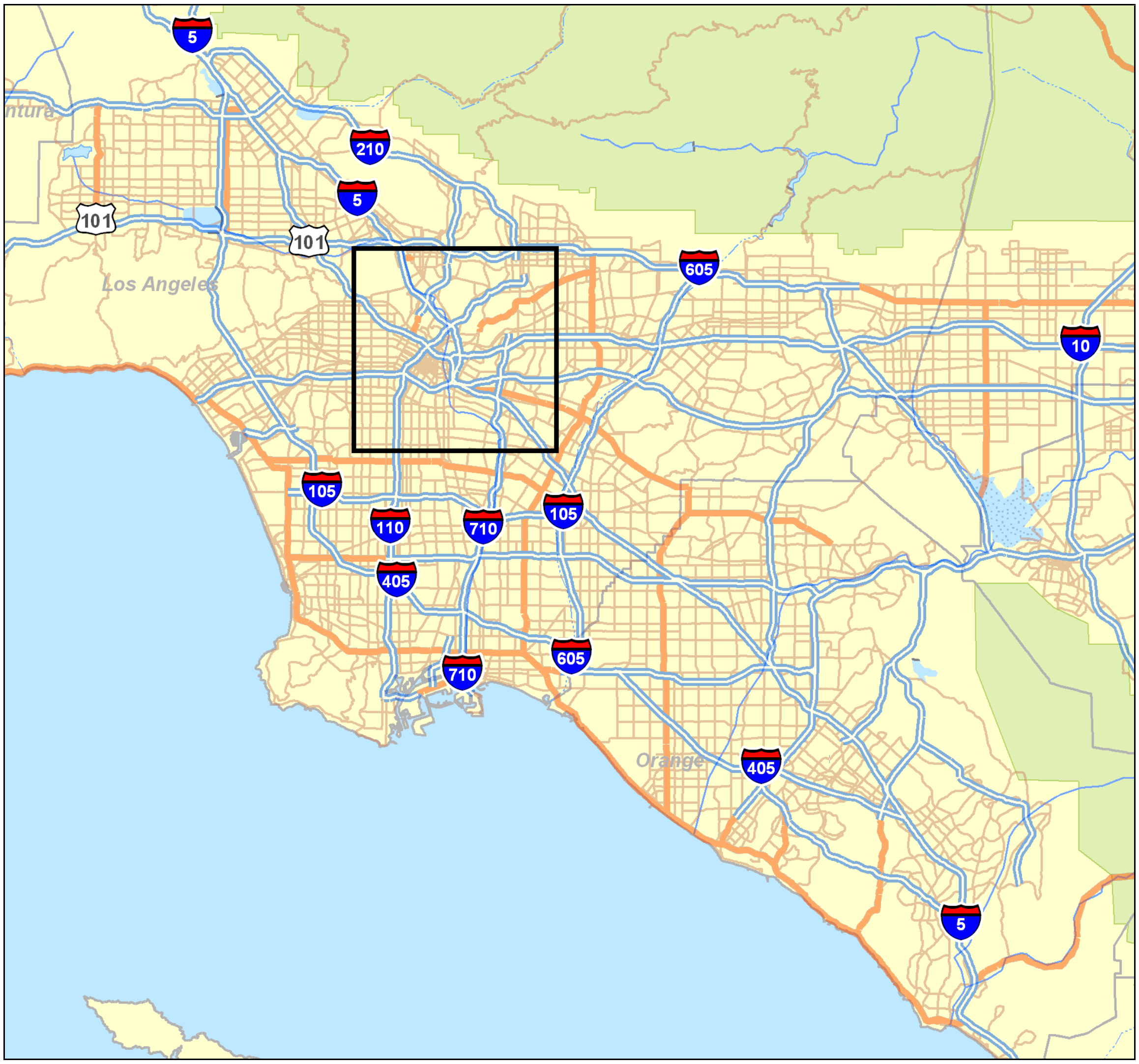


Figure 1: Region surrounding the UP LATC Railyard facility with the modeling domain indicated by the black outline.

Figure 1 illustrates the region surrounding the UP LATC Railyard modeling domain. The domain has dimensions 20 km x 20 km and contains a grid of 1681 receptors with a 500 meter uniform grid spacing.

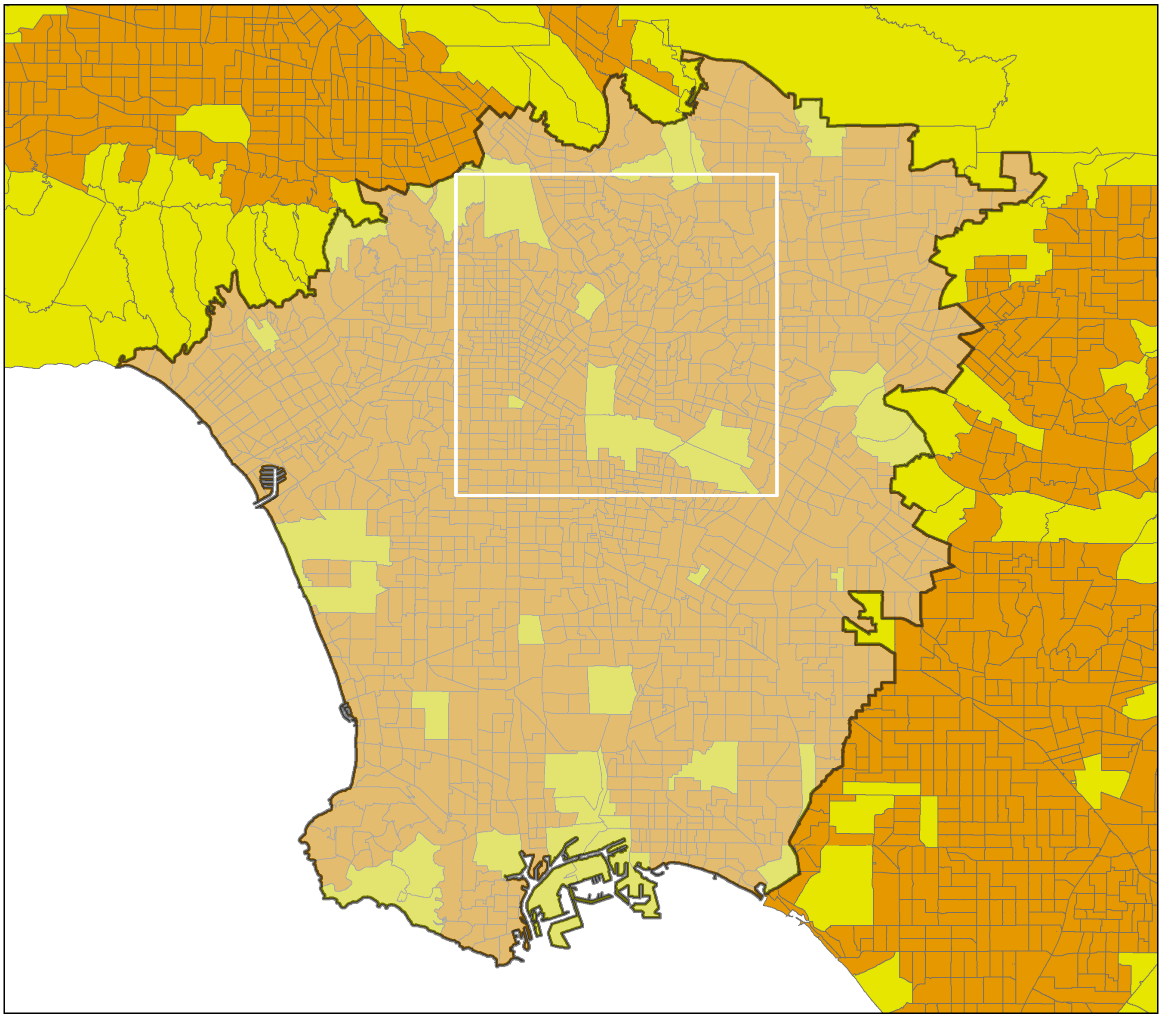

Figure 2: UP LATC Railyard Urban Population: Orange denotes areas with at least 750 people/km$^2$. The highlighted region is the contiguous urban area used for modeling purposes.

AERMOD requires an estimate of the urban population for urban source modeling. The urban population parameter was determined by estimating the area of continuous urban features as defined by the model guidelines (AERMOD Implementation Guide September 27, 2005). According to the guidelines, areas with a population of at least 750 people per square kilometer are considered urban. The UP LATC Railyard model domain is in a region with considerable urbanization. The continuous urban area selected can be seen in Figure 2. The population in this selected area is 6,476,185.

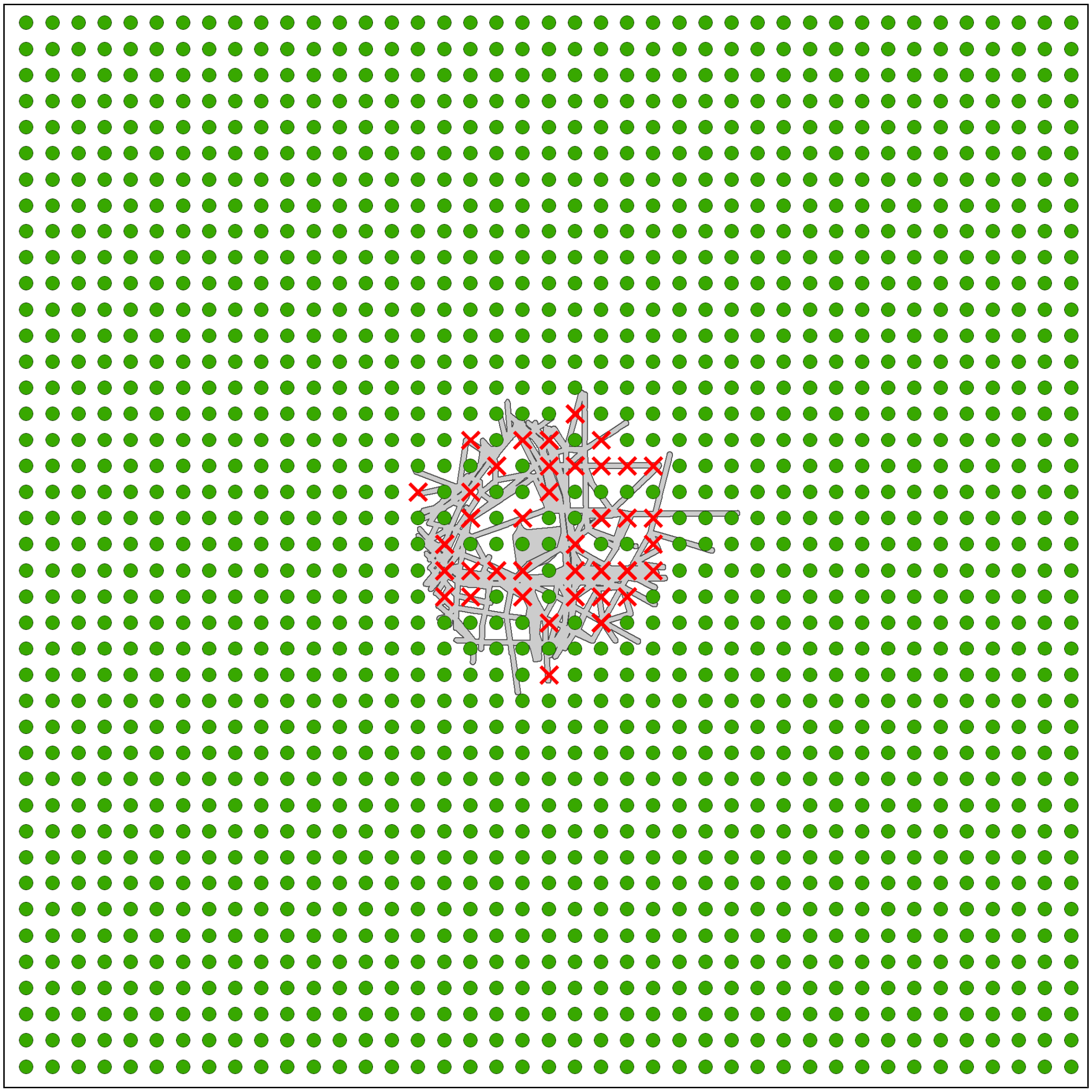

Figure 3: UP LATC Railyard receptor network including off-site sources and rail facility

The off-site stationary and on-road emission sources used in the UP LATC Railyard model runs are plotted along with the receptor network in Figure 3. These sources do not represent all stationary and roadway sources within the domain, but rather a subset made up of those roadways and facilities within one mile of the perimeter of the railyard facility. Diesel PM off-site emissions used in the off-site modeling runs consisted of 31.7 tons per year from roadways and 1.3 tons per year from stationary facilities, representing emissions for 2005. Roadway emissions were simulated as AERMOD area sources with an aspect ratio of no greater than 100 to 1, with a width of 7.3 meters and a release height of 4.15 meters.

As indicated above, Figure 3 illustrates a 20 km x 20 km gridded receptor field with uniform 500 meter spacing of receptors that are plotted as "●". Because a uniform grid sometimes places receptors on a roadway, those within 35 meters of a roadway were omitted. The basis for this is that these receptors are likely to fall on the roadway surface, versus a dwelling or workplace, and have high model-estimated concentrations, which could skew average concentration isopleths. Locations where receptors were removed are displayed as an “**x**” in Figure 3. After removal, 1642 of the original 1681 receptors remained.

The same meteorological data used by Sierra Research was used for the off-site modeling runs. The data were compiled by Sierra Research from the nearby Los Angeles North (34.067°N, 118.225°W) and Los Angeles International Airport (33.938°N, 118.406°W) stations. Upper air data for the same t ime period was obtained from the San Diego Miramar upper air station (32.833°N, 117. 117°W). The model runs used one year of meteorological data from 2002.

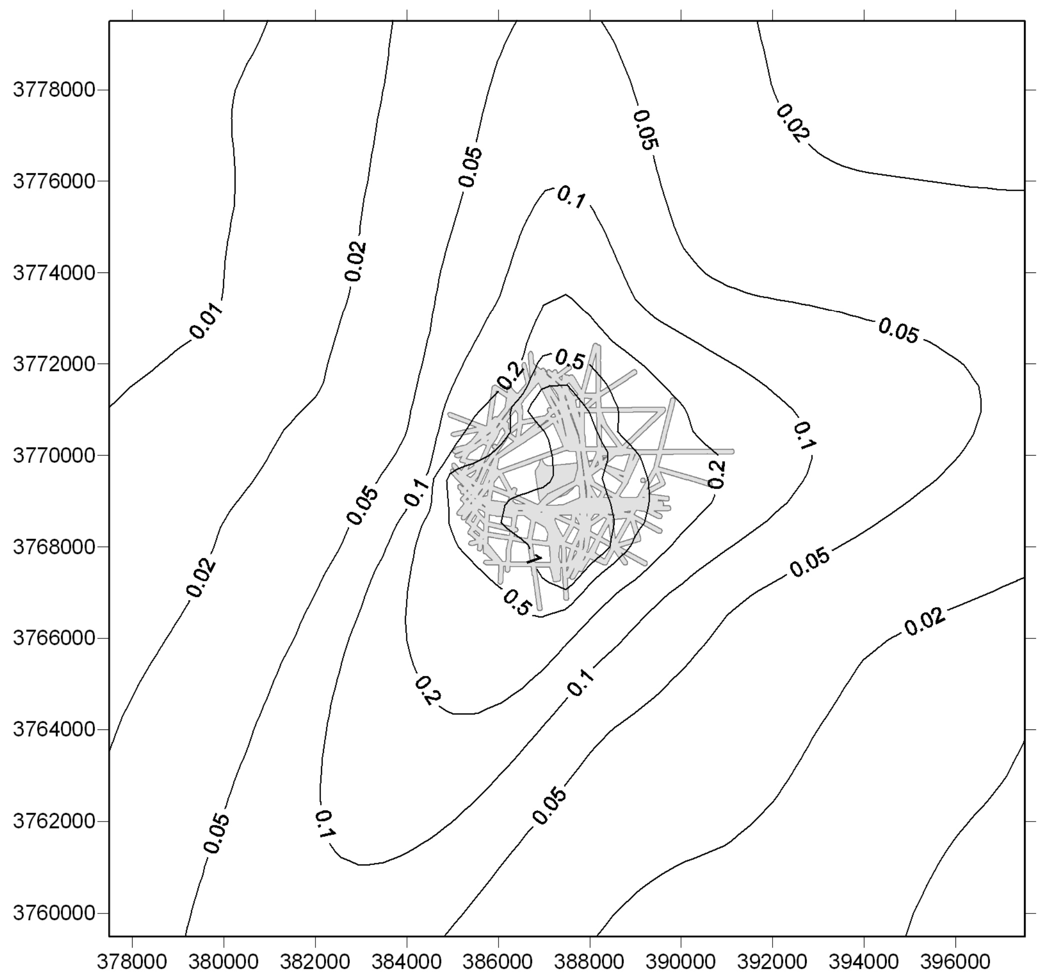


Figure 4: UP LATC Railyard off-site sources and railyard with modeled annual average concentrations from off-site sources in µg/m$^3$

Figure 4 shows annual average diesel PM concentrations from the off-site emissions. Highest values occur near major freeways; the five highest concentrations at a receptor and their locations are provided in Table 2.

| X | Y | Mobile | Stationary | Total (Off-site) |
|---|---|---|---|---|
| 387500 | 3767500 | 1.937 | 0.011 | 1.948 |
| 388000 | 3768000 | 1.765 | 0.014 | 1.780 |
| 387000 | 3771000 | 0.720 | 1.055 | 1.775 |
| 388000 | 3770000 | 1.618 | 0.030 | 1.648 |
| 387500 | 3769000 | 1.505 | 0.022 | 1.527 |

Table 2: UP LATC Railyard maximum annual concentrations in $\mu g/m^3$

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# APPENDIX D

## TABLES OF LOCOMOTIVE DIESEL PM EMISSION FACTORS

| Locomotive Diesel PM Emission Factors (g/hr)<br>Adjusted for Fuel Sulfur Content of 221 ppm | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 ppm | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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.

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# APPENDIX E

## METHODOLOGY FOR ESTIMATING DIESEL PM EMISSIONS FROM THE HEAVY HEAVY-DUTY TRUCKS TRAVELING BETWEEN THE RAILYARDS AND MAJOR FREEWAYS

**Introduction:**

Diesel-fueled heavy heavy-duty trucks (weight > 33,000 pounds) traveling between the railyards and major freeways generate a certain amount of diesel PM emissions, which contribute to the off-site diesel PM emissions. Using the same methodology in estimating the off-site heavy heavy-duty truck diesel PM emissions, ARB staff estimated the diesel PM emissions of heavy heavy-duty trucks traveling between the railyard gates and the freeways. The estimate of the diesel PM emissions from heavy heavy-duty diesel trucks can be performed based on average speed on the local streets, distances traveled locally from gate to freeway, truck count at the railyard gate, and the EMFAC model.

This analysis is conducted for the railyards whose diesel-fueled heavy heavy-duty trucks are a major contributor to the diesel PM emissions. At some railyards, heavy heavy-duty trucks also are idling or queuing outside of the railyards. Such activities are not included in this analysis due to limited availability of activity data.

**Methodology:**

Estimating diesel PM emissions from heavy heavy-duty diesel trucks can be performed by the following steps:

- Assume average speed of truck travel from gate to freeway.
- Select the most frequently traveled freeway for each railyard.
- For each railyard, measure the distance from the gate to the most frequently traveled freeway.
- Use the working draft of the EMFAC model to obtain the emission factor.
- Calculate the heavy heavy-duty diesel PM emissions.

**Step 1: Assume average speed of truck travel from gate to freeway.**

The speed of heavy heavy-duty trucks traveling on local streets ranges from 5 mph (at the railyard gate) to 35 mph (at the freeway entrance) depending on the time of travel, traffic conditions, etc. ARB staff assumes these speeds average about 20 mph.

**Step 2: Select the most frequently traveled freeway for each railyard.**

This step is based on the assumption that the truck traffic is more heavily concentrated on one freeway than the others. In accordance with the judgment of the railyard operators, ARB staff chose the most frequently traveled freeway for each railyard, as shown in Table 1.

**Table 1: Most Frequently Traveled Freeway for Each Railyard**

| Railyard | County | Most Frequently Traveled Freeway | Roundtrip Distance from Gate to Freeway (Miles) |
|---|---|---|---|
| UP Commerce | Los Angeles | I-710 | 2.6 |
| BNSF Hobart | Los Angeles | I-710 | 2.6 |
| BNSF Commerce/Eastern | Los Angeles | I-5 | 2.1 |
| UP LATC | Los Angeles | I-5 | 0.7 |
| UP Mira Loma | Los Angeles | SR-60 | 2.2 |
| BNSF Richmond | Contra Costa | I-580 | 1.74 |

**Step 3: For each railyard, measure the distance from the gate to the most frequently traveled freeway.**

The traveling distance on surface streets from the railyard gate to the entrance/exit ramp of the most frequently traveled freeway is estimated using the Google Earth Pro mapping tools. The results are presented in Table 1 for each railyard.

**Step 4: Use the working draft of the EMFAC model to obtain the emission factor.**

The working draft of EMFAC (V2.23.7), rather than EMFAC 2007, was used in the analysis as described in Appendix A. Emission factors based on vehicle type (in this case heavy heavy-duty diesel trucks), fuel type, and speed were developed by EMFAC. These are composite emission factors based on the model year distribution for each county as identified in Table 1, and are calculated in grams of emissions per mile traveled. The heavy heavy-duty emission factor matrices for Los Angeles County and Contra Costa County are shown in Table 2 and Table 3, respectively.

**Table 2: Heavy Heavy-Duty Emission Factor Matrix for Los Angeles County**

| Speed (Miles Per Hour) | Heavy Heavy-Duty Diesel Emission Factor (Grams Per Mile) |
|---|---|
| 12 | 2.371 |
| **20** | **1.277** |
| 45 | 0.728 |
| 60 | 1.095 |

**Table 3: Heavy Heavy-Duty Emission Factor Matrix for Contra Costa County**

| Speed (Miles Per Hour) | Heavy Heavy-Duty Diesel Emission Factor (Grams Per Mile) |
|---|---|
| 18 | 1.315 |
| **20** | **1.176** |
| 35 | 0.712 |
| 60 | 1.009 |

**Step 5: Calculate the heavy heavy-duty diesel PM emissions**

The calculation of diesel PM emissions can be expressed by the following equation:

*Total Emission (grams) = EF X (Volume X Distance Traveled)*

EF represents diesel PM emission factor. The volume (i.e., truck count) at the railyard gates was provided by the railyard activity data.

The emissions inventory developed by this methodology only included diesel PM emissions from running exhaust, as it is the primary diesel source from on-road mobile sources. Emissions from other modes such as idling, starting, and tire and brake wear were excluded due to limited availability of detailed data.

The estimated heavy heavy-duty diesel PM emissions for travel from the railyard gate to the most frequently traveled freeway are presented in Table 4 for each of the railyards.

**Table 4: Estimated Heavy Heavy-Duty Diesel PM Emissions from Gate to Freeway****

| Railyard | Route | Distance (Miles) | | Truck Trips Per Day | Diesel PM | |
|---|---|---|---|---|---|---|
| | | One Way | Round Trip | | Grams Per Day*** | Tons Per Year |
| **BNSF Hobart** | *Gate to I-710** | 1.3 | 2.6 | 3533 | 11730 | 4.72 |
| **UP Commerce** | *Gate to I-710** | 1.3 | 2.6 | 1026 | 3406 | 1.37 |
| **UP Mira Loma** | *Gate to SR-60** | 1.1 | 2.2 | 321 | 901 | 0.36 |
| **BNSF Commerce/Eastern** | *Gate to I-5** | 1.05 | 2.1 | 557 | 1495 | 0.60 |
| **UP LATC** | *Gate to I-5** | 0.35 | 0.7 | 512 | 457 | 0.18 |
| **BNSF Richmond** | *Gate to I-580** | 0.87 | 1.74 | 153 | 314 | 0.13 |
| | **Total** | | | | | **7.36** |

Notes: * Assumed all trucks take this route

** Assumed all trucks' speeds are 20 mph from gate to freeway

*** Heavy Heavy-Duty Emission Factors at 20 mph: 1.277 g/mi for LA County and 1.176 g/mi for Contra Costa County

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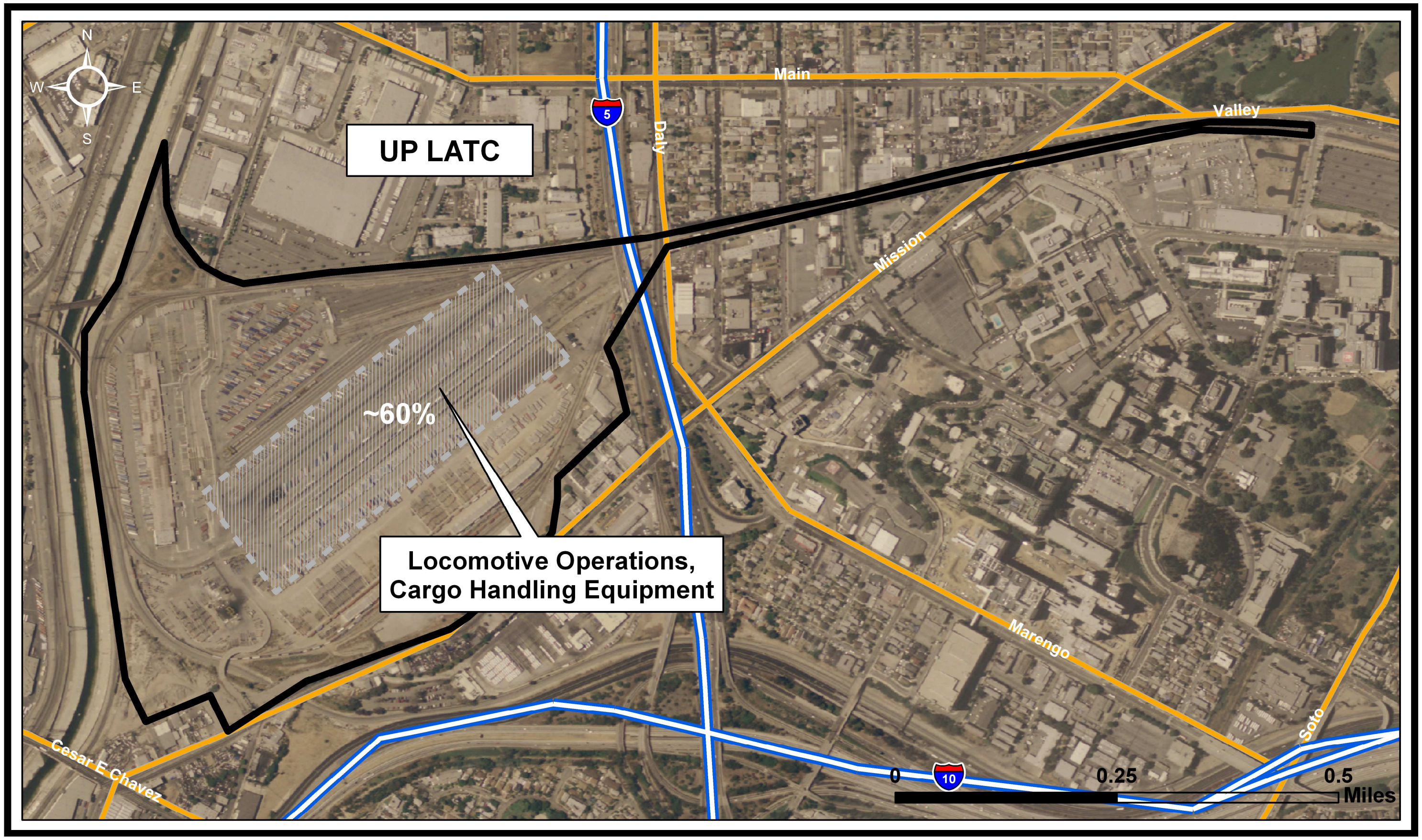
## APPENDIX F

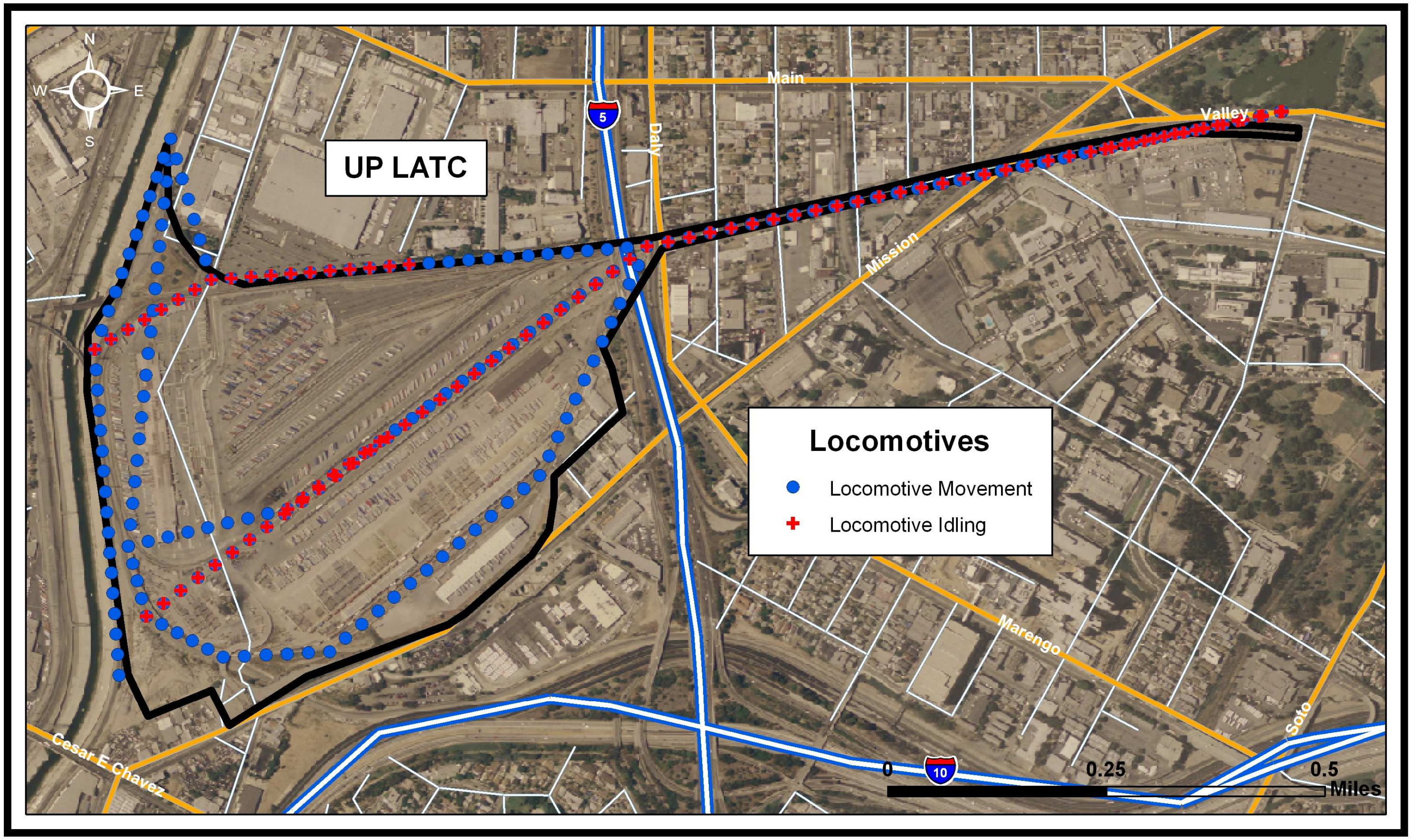
## SPATIAL ALLOCATIONS OF MAJOR DIESEL PM EMISSION SOURCES AT UP LATC RAILYARD

## Facility-wide Diesel PM Emissions at UP LATC Railyard

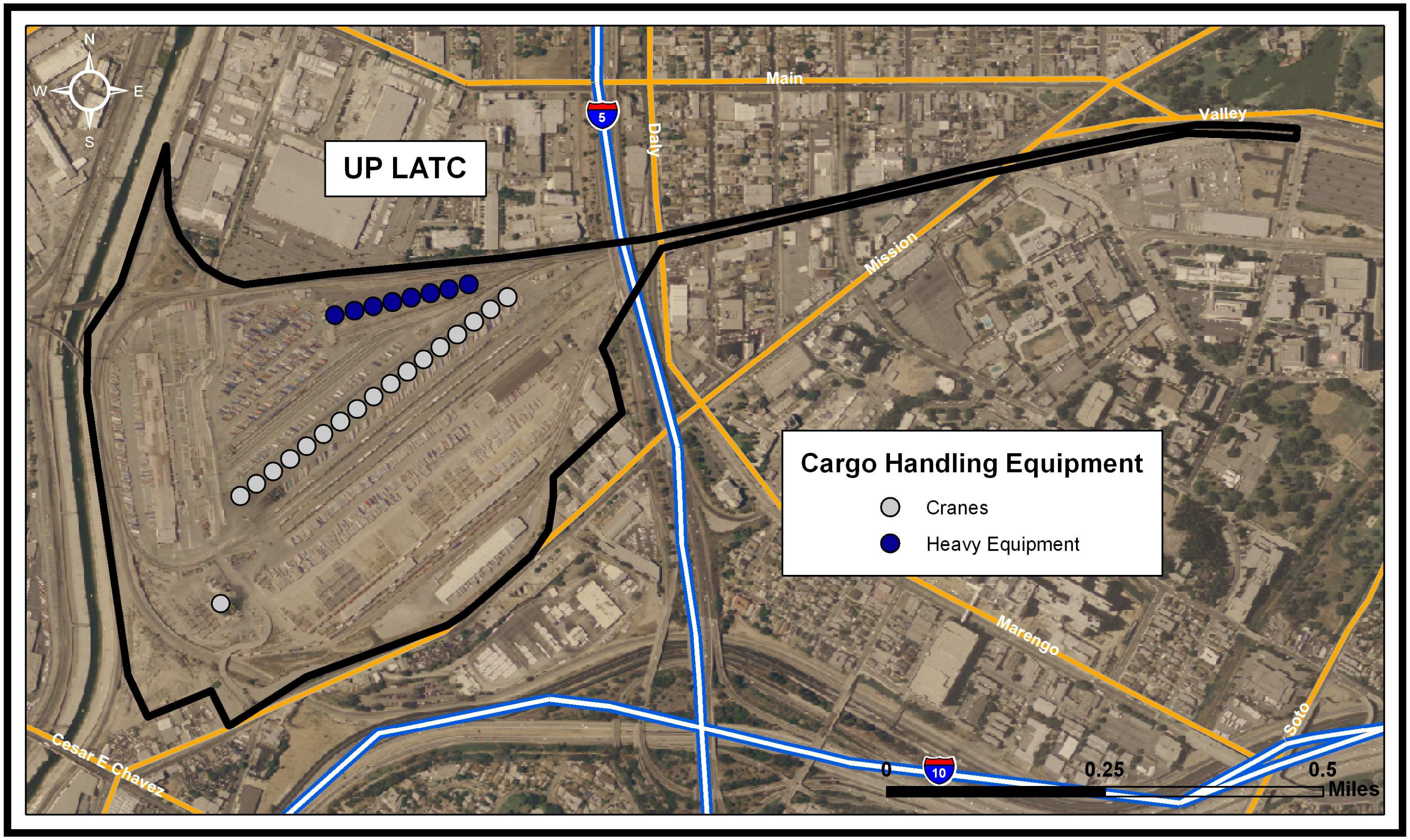



Note: According to the emission inventory, about 60% of the facility-wide emissions at the UP LATC Railyard occur in the central part of the railyard, as show in the figure. The activity includes yard operation due to switch locomotives and cargo handling equipment, accounting for about 4 tons per year of diesel PM emissions.

## Spatial Allocation of Locomotive Diesel PM Emissions at UP LATC Railyard



## Spatial Allocation of Cargo Handling Equipment Diesel PM Emissions at UP LATC Railyard




About 60% of the emissions at the UP LATC Railyard are from switch locomotives and cargo handling equipment. Yard emissions due to switchers account for 2.46 tons per year of diesel PM while activity by cargo handling equipment accounts for 2.67 tons per year. Cargo handling activities occur in high frequency in the areas indicated.

# APPENDIX G

## AERMOD MODEL SENSITIVITY ANALYSIS OF METEOROLOGICAL DATA (ONE-YEAR 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**

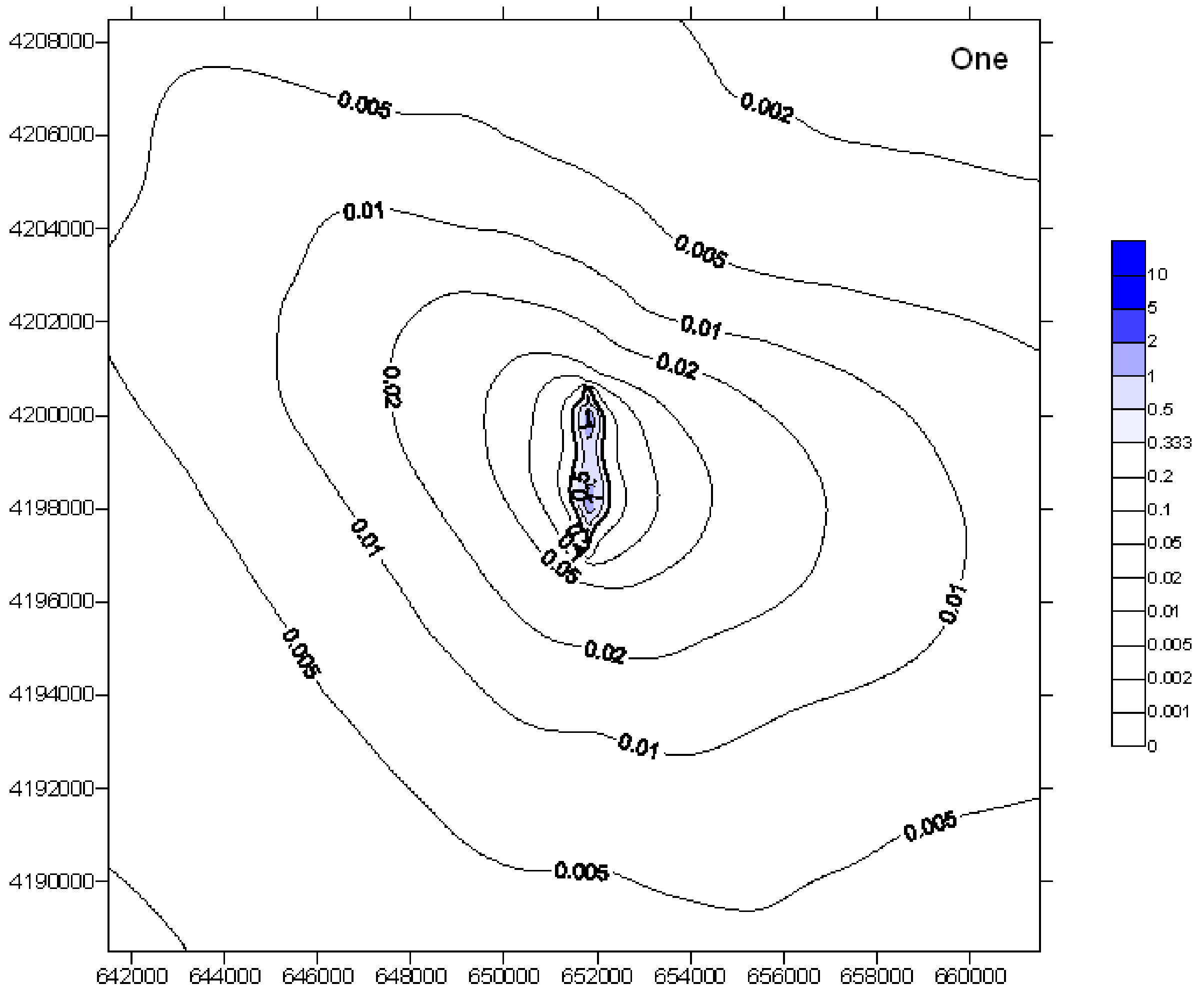


**Figure 9. AERMOD's Simulated Diesel PM Concentrations (Due to On-site and Off-site Diesel PM Emissions) Around UP Stockton Railyard Using Five-year Meteorological Data**