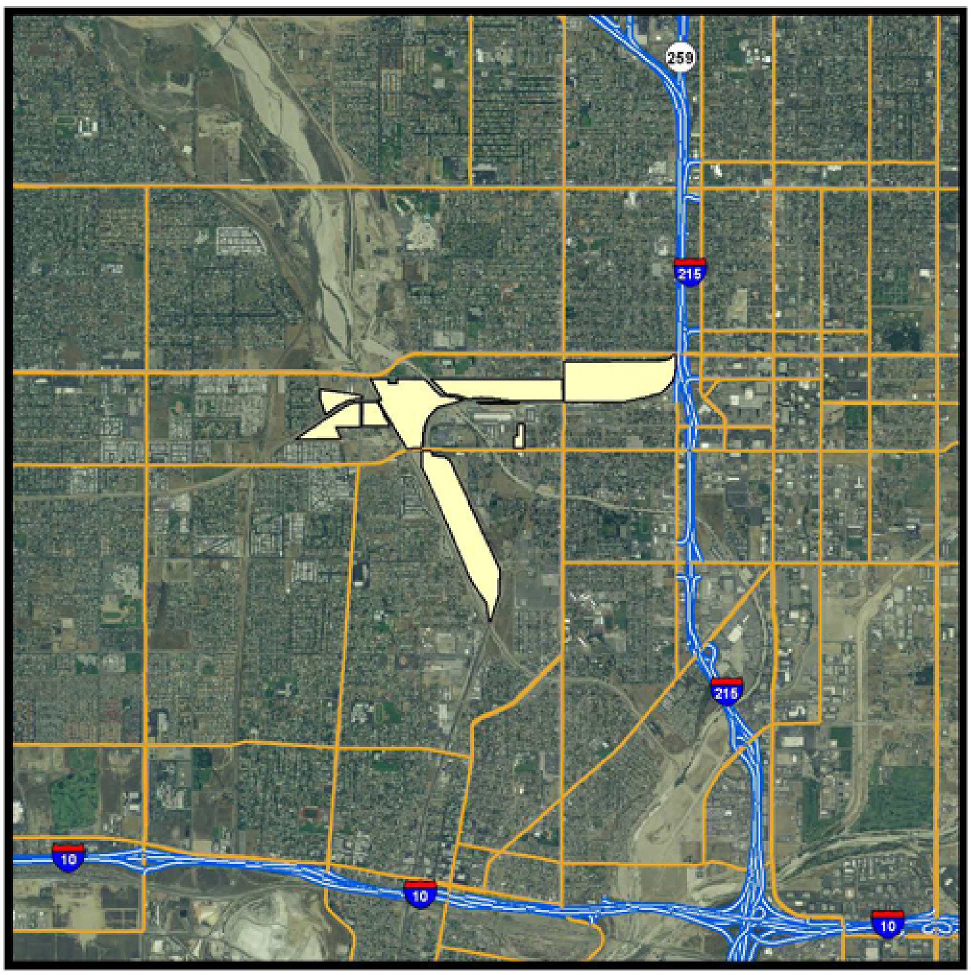
California Environmental Protection Agency

Air Resources Board

Health Risk Assessment for the BNSF Railway San Bernardino Railyard



Stationary Source Division
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California Environmental Protection Agency

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I. INTRODUCTION

The California Air Resources Board (ARB or Board) conducted a health risk assessment (HRA) to evaluate the impacts associated with toxic air contaminants emitted in and around BNSF Railway's (BNSF) San Bernardino Railyard located in San Bernardino, California. The study focused on the railyard property emissions from locomotives, on-road heavy-duty trucks, cargo handling equipment, and off-road equipment used to move bulk cargo. Also evaluated were mobile and stationary sources with significant emissions within a one-mile distance of the railyard. This information was used to evaluate the potential health risks associated with diesel particulate matter (diesel PM) emissions to those living nearby the railyard.

A. Why is ARB concerned about diesel PM emissions?

In 1998, following a ten year scientific assessment process, ARB identified particulate matter from 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 to this action, research has shown that diesel PM contributes to premature death* (ARB, 2002). 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. 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. Population-based studies in hundreds of cities in the U.S. and around the world demonstrate a strong link between elevated PM levels and premature deaths (Pope et al., 1995, 2002, and 2004; Krewski et al., 2000), increased hospitalizations for respiratory and cardiovascular causes, asthma and other lower respiratory symptoms, acute bronchitis, work loss days, and minor restricted activity days (ARB, 2006e).

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

* 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.

health impacts in this railyard health risk assessment study primarily focus on the risks from the diesel PM emissions.

B. Why evaluate diesel PM emissions at the BNSF San Bernardino Railyard?

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

The Agreement requires that health risk assessments (HRAs) be prepared for each of the 17 major or designated railyards in the State. The 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 (ARB, 2006d). The BNSF San Bernardino 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 of a pollutant (concentration in the air) 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: (1) the air pollution emission inventory, (2) the air dispersion modeling and (3) an assessment of associated health risks. The air pollution emission inventory provides an estimate of how the air toxics are generated from different emission sources. The air dispersion modeling incorporates the emission inventory and meteorological data inputs and then uses a computer model to predict the distributions of air toxics in the air. Based on the modeling results, an assessment of the potential health risks from 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[†] (REL) is used to estimate 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 BNSF San Bernardino Railyard diesel PM emissions, on the other hand, are an estimated 22 tons for the year 2005, about 0.3% of the total air basin diesel PM emissions. In 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. The ratio of potential number of cancers per million people can also be interpreted as the incremental likelihood of an individual developing cancer from the continuous exposure, over a lifetime, to the carcinogen. 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

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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.

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.

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.

D. Who prepared the BNSF San Bernardino 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. Using the Guidelines, the railroads developed the emission inventories, based on 2005 activity, and performed the air dispersion modeling for operations that occur within each of the designated railyards.

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. 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 BNSF San Bernardino Railyard operations, emissions, air dispersion modeling, and health risk assessment results. The following chapters present the details of the BNSF San Bernardino Railyard emission inventories, the air dispersion modeling and the detailed health risk assessment. The appendices present the technical supporting documents for the analyses discussed in the main body of the report.

II. SUMMARY

This study estimated the 2005 base-year diesel PM emissions generated from, not only the BNSF San Bernardino Railyard, but also off-site non-railyard emissions sources. Below is a summary of the BNSF San Bernardino Railyard operations, as well as emissions, air dispersion modeling, and health risk assessment results for both on-site railyard and off-site non-railyard sources.

A. General Description of the BNSF San Bernardino Railyard

The BNSF San Bernardino Railyard is located at 1535 West 4th Street in San Bernardino, California, and encompasses about 168 acres. The railyard is located in a commercial and manufacturing area however, several residential areas surround the facility, some of them within 200 feet.

The railyard is divided into two distinct sections referred to as the “A” yard and the “B” yard. The “A” yard is aligned in an East - West direction and is bordered along the north side by West 4th and West 5th street and along the south side by West 3rd Street as well as an adjacent main line. The “B” yard is aligned roughly in a north - south direction (See Figure II-1) and is bordered along the west side by North 8th Street. Additionally, several residential properties border the BNSF San Bernardino railyard on the north and west side and along the south and east side of the “A” yard and the “B” yard.

Facilities within the BNSF San Bernardino Railyard include classification tracks, a gate complex for inbound and outbound intermodal truck traffic, intermodal loading and unloading tracks, an auto conveyance yard and various buildings and facilities supporting railroad and contractor operations.

B. What are the Primary Operations at the BNSF San Bernardino Railyard?

The BNSF San Bernardino Railyard can be separated in to two key operational sections; an intermodal railyard, aligned east to west, known as the “A” yard; and an automotive yard, aligned roughly north to south, known as the “B” yard.

The “A” yard consists of a classification yard, an intermodal area and a refueling area. The main purpose of the “A” yard is to build and configure trains. In order to do this, trailers and containers are hauled in, either by truck or locomotive, and are temporarily stored at the yard before they are loaded onto trains for transport to distant destinations, or loaded onto a chassis for transport by a truck to local destinations.

Activity at the “B” yard is generally very low and consists of the unloading of automobiles on to trucks which pick-up autos for delivery to local destinations. Locomotives may arrive at, or pass through, or depart from the “B” yard as the main line runs through the center of this yard. The “B” yard also has a classification yard where switching activity can occur as trains are configured and built.

Figure II-1: BNSF San Bernardino Railyard and Surrounding Areas

C. What are the diesel PM emissions at and near the BNSF San Bernardino Railyard?

For 2005, the combined diesel PM emissions from the BNSF San Bernardino railyard (on-site emissions) and other significant emission sources within a one-mile distance (off-site emissions) are estimated at about 33 tons per year. The BNSF San Bernardino railyard diesel PM emissions are estimated at about 22 tons per year, which accounts for about 66% of the combined on-site and off-site diesel PM emissions. 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 11 tons per year of diesel PM emissions, or 34% of the combined on-site and off-site diesel PM emissions.

In comparison with other railyards in California, Table II-1 summarizes four major diesel PM source categories within all of the designated railyards subject to the health risk assessments under the 2005 Agreement.

1. Railyard

The BNSF San Bernardino railyard emission sources include, but are not limited to, locomotives, cargo handling equipment, on-road diesel-fueled trucks and other yard vehicles, off-road equipment, transportation refrigeration units (TRUs) and refrigerated railcars (reefer cars). The facility operates 24 hours a day, 365 days a year.

The BNSF San Bernardino Railyard emissions were calculated on a source-specific and facility-wide basis for the 2005 baseline year. 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). The future growth in emissions at the BNSF San Bernardino facility is not incorporated in the HRA emission inventory, but will be included as part of the mitigation emission reduction efforts.

Railyard diesel PM emissions are summarized in Table II-2. Locomotive operations generated about 48% (10.6 tons per year) of the railyard diesel PM emissions, cargo handling equipment generated about 17% (3.7 tons per year), on-road trucks generated about 20% (4.4 tons per year), and off-road equipment, including transport refrigeration units (TRUs) and refrigerated railcars generated about 15% (3.4 tons per year) of the facility-wide emissions.

Diesel PM is not the only toxic air contaminant emitted at the BNSF San Bernardino Railyard. Relatively small amounts of gasoline toxic air contaminants (benzene, isopentane, toluene, etc.) are generated from a gasoline storage tank. The detailed emission inventories for these toxic air contaminants are presented in the *San Bernardino TAC Emissions Inventory* (ENVIRON, 2008a). The total amount of these toxic air contaminant emissions is about 290 pounds per year, compared to 22 tons per year of diesel PM emissions in the railyard.

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

Railyard	Locomotive	Cargo Handling Equipment	On-Road Trucks	Others (Off-Road Equipment, TRUs, Stationary Sources, etc.)	Total+
BNSF Barstow	27.1	0.03	0.04	0.75	27.9
BNSF San Bernardino	10.6	3.7	4.4	3.4	22.0
BNSF San Diego	1.6	N/A	0.007	0.04	1.7
UP ICTF/Dolores	9.8	4.4	7.5	2.0	23.7
UP Colton	16.3	N/A	0.2	0.05	16.5
UP Oakland	3.9	2.0	1.9	3.4	11.2
UP City of Industry	5.9	2.8	2.0	0.3	10.9
UP Roseville*	25.1	N/A	N/A	N/A	25.1
BNSF Hobart	5.9	4.2	10.1	3.7	23.9
UP Commerce	4.9	4.8	2.0	0.4	12.1
UP LATC	3.2	2.7	1.0	0.5	7.3
UP Stockton	6.5	N/A	0.2	0.2	6.9
UP Mira Loma	4.4	N/A	0.2	0.2	4.9
BNSF Richmond	3.3	0.3	0.5	0.6	4.7
BNSF Stockton	3.6	N/A	N/A	0.02	3.6
BNSF Commerce Eastern	0.6	0.4	1.1	1.0	3.1
BNSF Sheila	2.2	N/A	N/A	0.4	2.7
BNSF Watson	1.9	N/A	<0.01	0.04	1.9

* The UP Roseville Health Risk Assessment (ARB, 2004a) was based on 1999-2000 emission estimate, only locomotive diesel PM emissions were reported in that study. The actual emissions were estimated at a range of 22.1 to 25.1 tons per year.
N/A = Not applicable.
+ Numbers do not add precisely due to rounding.

Table II-2: BNSF San Bernardino Railyard and Surrounding Areas Diesel PM Emissions

Diesel PM Emission Sources	San Bernardino Railyard		Off-site Emissions**	
	Tons per Year	Percentage	Tons per Year	Percentage
Locomotives	10.6	48%	-	-
Line Haul Locomotives	*6.1*	*28%*		
Switch Locomotives	*4.1*	*18%*		
Refueling	*0.4*	*2%*		
On-road Trucks and Vehicles	4.4	20%	-	-
Cargo Handling Equipment	3.7	17%	-	-
Off-road Vehicles and Equipment	3.4	15%	-	-
Other Stationary Sources	0.1	< 1%	-	-
Off-site Mobile Sources	-	-	10.6	98%
Off-site Stationary Sources	-	-	0.2	2%
Total+	22.0	100%	11.0	100%

\+ Numbers and percentages do not add precisely due to rounding.
** Emissions within the one-mile boundary (does not include railyard emissions).

Other than diesel PM, benzene, formaldehyde and 1,3-butadiene are the only toxic air contaminants among the top five cancer risk contributors and are estimated at about 60 pounds per year. The potential cancer risks contributed by these toxic air contaminants are found to be considerably lower than the diesel PM emissions at the yard – about a factor of 5,500 less, based on cancer potency weighted factor adjustment. 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 BNSF San Bernardino 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.

ARB staff estimated that off-site non-railyard sources of diesel PM generated about 11.0 tons per year. Significant off-site emission sources are based on two categories: mobile sources and stationary sources. Around the BNSF San Bernardino railyard, off-site diesel PM emissions are dominated by mobile sources which generated about 10.6 tons per year. The majority of the off-site diesel PM emissions are from diesel-fueled heavy heavy-duty trucks traveling on local streets around the railyard and on the I-215 Freeway. This estimate was based on the Southern California Association of Governments (SCAG) Heavy Duty Truck Transportation Demand Model and the EMFAC-2007 (v2.3) model within a one-mile boundary from the railyard. The analysis of off-site mobile sources 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 BNSF San Bernardino 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 the 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.

> ***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.*

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. Diesel PM emissions are estimated from stationary internal combustion engines burning diesel fuel, operating at stationary sources reported in CEIDARS. Within one mile of the BNSF San Bernardino Railyard, the diesel PM emissions from off-site stationary sources are estimated to be about 0.2 tons per year, or about 2% of the total off-site diesel PM emissions.

ARB staff also evaluated other toxic air contaminant emissions around the BNSF San Bernardino Railyard. Within a one-mile distance of the railyard, five 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 were estimated at about 0.11 tons per year. Over 40 toxic air contaminant species are identified among these emissions, in which ammonia, formaldehyde, and naphthalene are three major contributors with emissions estimated at 0.05, 0.04, and 0.02 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 BNSF San Bernardino Railyard, the top five cancer risk contributors (without diesel PM) are estimated at about 0.04 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 (OEHHA) 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 0.002 tons per year, which is substantially less than the diesel PM emissions. Hence, they are not included in this analysis.

ARB staff also estimated the potential cancer risk levels contributed by the use of gasoline in the region of South Coast Air Basin based on 2005 emission inventory, including 1,3-butadiene, benzene, formaldehyde, and acetaldehyde. These four TACs are identified as major contributors associated with the use of gasoline in the air basin. Table II-4 presents the emissions of these toxic air contaminants from gasoline-related sources, weighted by individual cancer potency factors. The potency weighted emissions from these carcinogens from all gasoline related sources are estimated at about 817 tons per year, about 11% of diesel PM emissions in the region. For gasoline-fueled vehicles only, the potency weighted emissions are estimated at about 438 tons per year, or about 6% of diesel PM emissions region wide. The potential cancer risks associated with non-diesel PM toxic air contaminants emitted from off-site gasoline vehicular sources are substantially less than the potential cancer risks associated with diesel PM emissions and are not included in the analysis.

Table II-3: Potency Weighted Estimated Toxic Emissions from Significant Off-Site Stationary Sources Surrounding BNSF San Bernardino 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-Butadiene	0.6	0.55	0.001	**0.0006**
Benzene	0.1	0.09	0.002	**0.0002**
Carbon Tetrachloride	0.15	0.14	-	**-**
Formaldehyde	0.021	0.02	0.04	**0.0008**
Total (non-diesel PM)	**-**	**-**	**0.04**	**0.002**

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	7,746	**7,746**	-	-
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 BNSF San Bernardino 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 United States Environmental Protection Agency (U.S. EPA) recently approved a new state-of-science air dispersion model called AERMOD (**A**merican Meteorological

Society/**E**PA **R**egulatory Model Improvement Committee **MOD**EL). ARB staff used AERMOD in the railyard 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. Based on the AERMOD meteorological data selection criteria, the data from the San Bernardino – East 4th Street Station, operated by the SCAQMD, was selected for the modeling.

> *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, 250 and 500 in a million. Figure II-2 (See Page 15) and Figure II-4 (See Page 20) 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 San Bernardino area, surrounding the BNSF San Bernardino Railyard, to better illustrate the land use (residential, commercial, industrial, or mixed use) of these impacted areas.

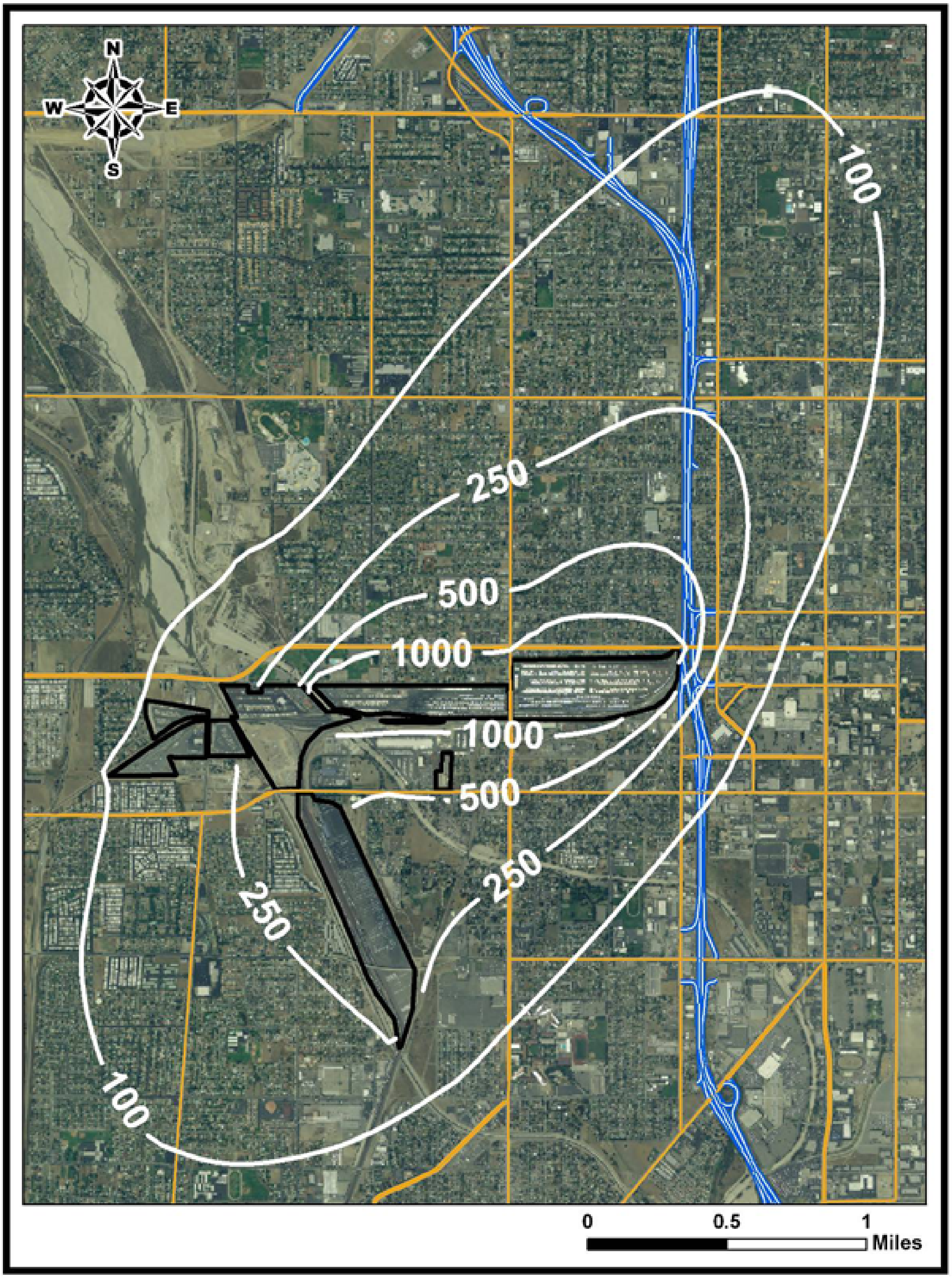
At the BNSF San Bernardino Railyard property boundaries, the estimated cancer risk is generally above 500 in a million. As shown in Figure II-2, within about a half mile of the BNSF San Bernardino Railyard boundaries, the estimated cancer risks lower to about 100 in a million, and within a mile of the railyard boundary the estimated cancer risks are lowered to about 50 in a million. At about two miles from the BNSF San Bernardino Railyard, as Figure II-4 indicates, the estimated cancer risks are about 25 in a million.

OEHHA Guidelines specify that, for health risk assessments, the location of the maximum exposure at the point of maximum impact (PMI) be reported. The PMI is defined as a location or the receptor point with the highest cancer risk level - based on the highest diesel PM concentration estimated from the modeling results outside of the facility - outside of the railyard boundary, with or without residential exposure. The estimated cancer risk at the PMI for BNSF San Bernardino Railyard is about 3,300 chances in a million based on a 70-year exposure duration. The location of PMI is predicted to be along the north side of the west end (i.e., west intermodal area) of the "A" yard fence line (see Figure III-1) on West 4th Street, where the land use is a mix of industrial and residential. The estimated level of the PMI is primarily due to the density of emission sources near the west intermodal area. For the residential area, the potential cancer risk for the maximally exposed individual resident (MEIR) or maximum individual cancer risk (MICR) – which is in close proximity to the PMI – is estimated at about 2,500 chances in a million. The modeling results also show similar cancer risk levels in the north neighboring areas near the east intermodal area of the "A" yard (see Figure III-1).

As indicated by the *Roseville Railyard Study* (ARB, 2004a), the location of the PMI and MICR 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 PMI and MICR. These indications, of the PMI and MICR, should not be interpreted as a literal prediction of disease incidence, but more as a tool for comparison as discussed in the OEHHA guidelines. In addition, the estimated point of maximum impact location and maximum individual cancer risk from the air dispersion model 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 designated 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 II-2: Estimated near-Source Cancer Risk (Chances per Million People) From the BNSF San Bernardino Railyard



OEHHA Guidelines recommend a 70-year lifetime exposure duration to evaluate the potential cancer risks for residents. Shorter exposure durations of 30 years and 9 years 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 OEHHA Guidelines recommend that a 40-year exposure duration be used, assuming workers have a different breathing rate (149 L kg^{-1} day^{-1}) and exposure for an 8-hour workday, five days a week, 245 days a year.

Table II-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 isopleth line with a potential cancer risk level of 10 chances per million 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 are 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.

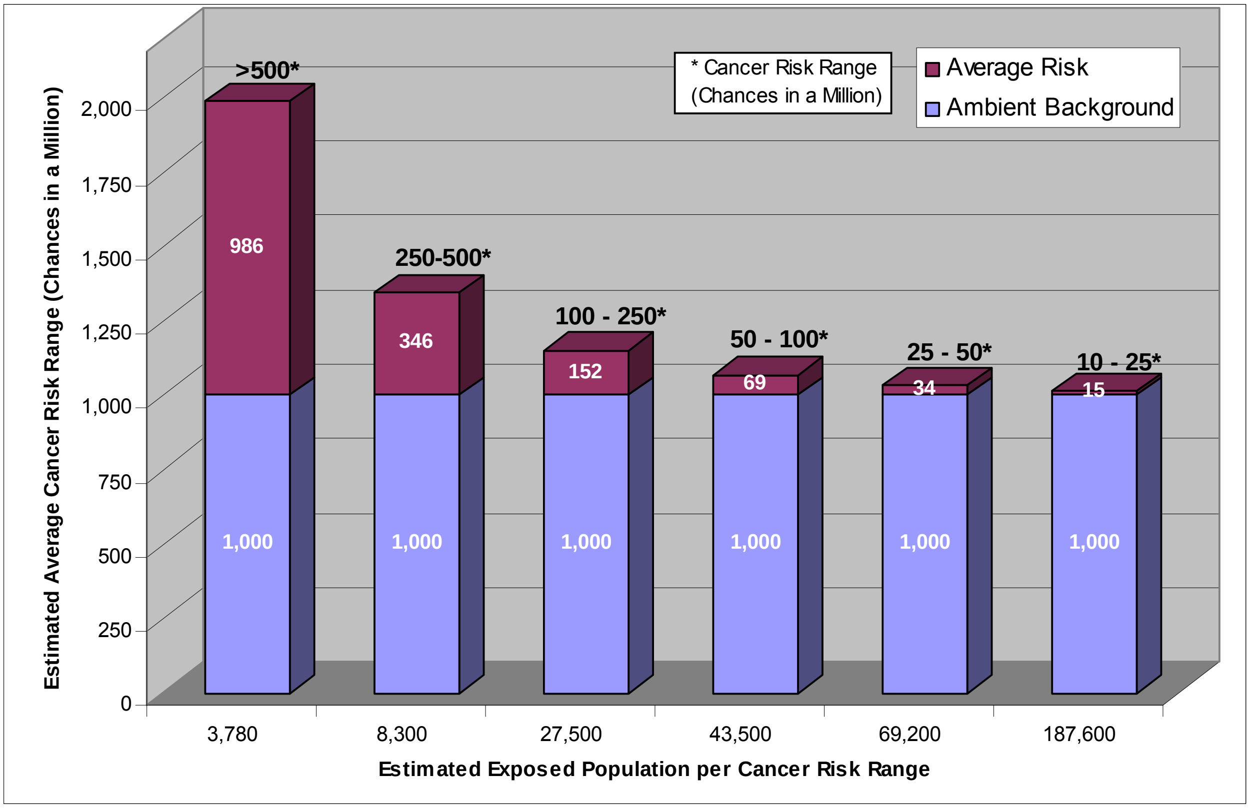
There are many densely populated areas which surround the BNSF San Bernardino Railyard. The area with an estimated risk above 10 chances in a million encompasses approximately 62,000 acres where about 340,000 residents live, based on the 2000 U.S. Census Bureau's data. Table II-6 presents the exposed 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 Cancer Risk (chances per million)	Impacted Area (Acres)	Estimated Population Exposed
> 500	430	3,780
250 – 500	730	8,300
101 - 250	2,430	27,500
51 - 100	4,780	43,500
26 - 50	11,460	69,200
10 - 25	42,050	187,600
> 10	**61,880**	**339,880**

It is important to understand that these risk levels represent the potential cancer risks in addition to the regional background risk from diesel PM emissions. 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 presents a comparison of the estimated average potential cancer risks in various risk ranges associated with the BNSF San Bernardino Railyard diesel PM emissions to the regional background risk level from all air toxic contaminants from the air basin. For example, in the 101 – 250 per million risk range, the average potential cancer risk above the regional background is about 150 in a million. Therefore, residents living in that area would have a potential cancer risk of about 1,150 in a million.

Figure II-3: Comparison of Estimated Potential Cancer Risks from the BNSF San Bernardino Railyard and the Regional Background Risk Levels



E. What are the estimated non-cancer chronic risks near the BNSF San Bernardino Railyard?

The potential non-cancer chronic risk health hazard index levels from the estimated diesel PM emissions from the BNSF San Bernardino Railyard are estimated as hazard indices from 0.05 to 0.3. According to OEHHA Guidelines (OEHHA, 2003), these levels (less than 1.0) indicate that the potential non-cancer chronic public health risks are less likely to happen.

Due to the uncertainties in the toxicological and epidemiological studies, diesel PM as a whole was not assigned a short-term acute 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. Acrolein is a by-product of the combustion or burning process. 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 chemical 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 and hourly model-estimated peak concentrations for short term exposure. 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 non-railyard diesel PM emissions near the BNSF San Bernardino Railyard using the U.S. EPA AERMOD dispersion model. The off-site mobile and stationary diesel PM emission sources, located within a one-mile distance from the railyard, were included in the air dispersion model simulations. Diesel PM off-site emissions, consisted of about 10.6 tons per year from roadways (local streets and I-215) and 0.2 tons per year from stationary sources. The estimated potential cancer risks associated with off-site diesel PM emissions are illustrated in Figure II-5 (See Page 20).

Based on the 2000 U.S. Census Bureau's data, the zone of impact of the estimated potential cancer risks above 10 chances in a million levels associated with off-site diesel PM emissions encompasses approximately 25,000 acres, where about 180,000 residents live. For comparison with the BNSF San Bernardino Railyard health risks, the same level of potential cancer risks (above 10 chances in a million) associated with railyard diesel PM emissions covers about 61,000 acres where approximately 340,000 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 BNSF San Bernardino Railyard

Estimated Cancer Risk (chances per million)	Impacted Area (Acres)	Estimated Population Exposed
> 250	200	600
100 - 250	1,600	14,700
51 – 100	2,600	26,500
26 – 50	4,700	49,700
10 – 25	16,400	89,700
> 10	**25,500**	**181,200**

Figure II-4: Estimated regional cancer risk (chances in a million) from the BNSF San Bernardino Railyard

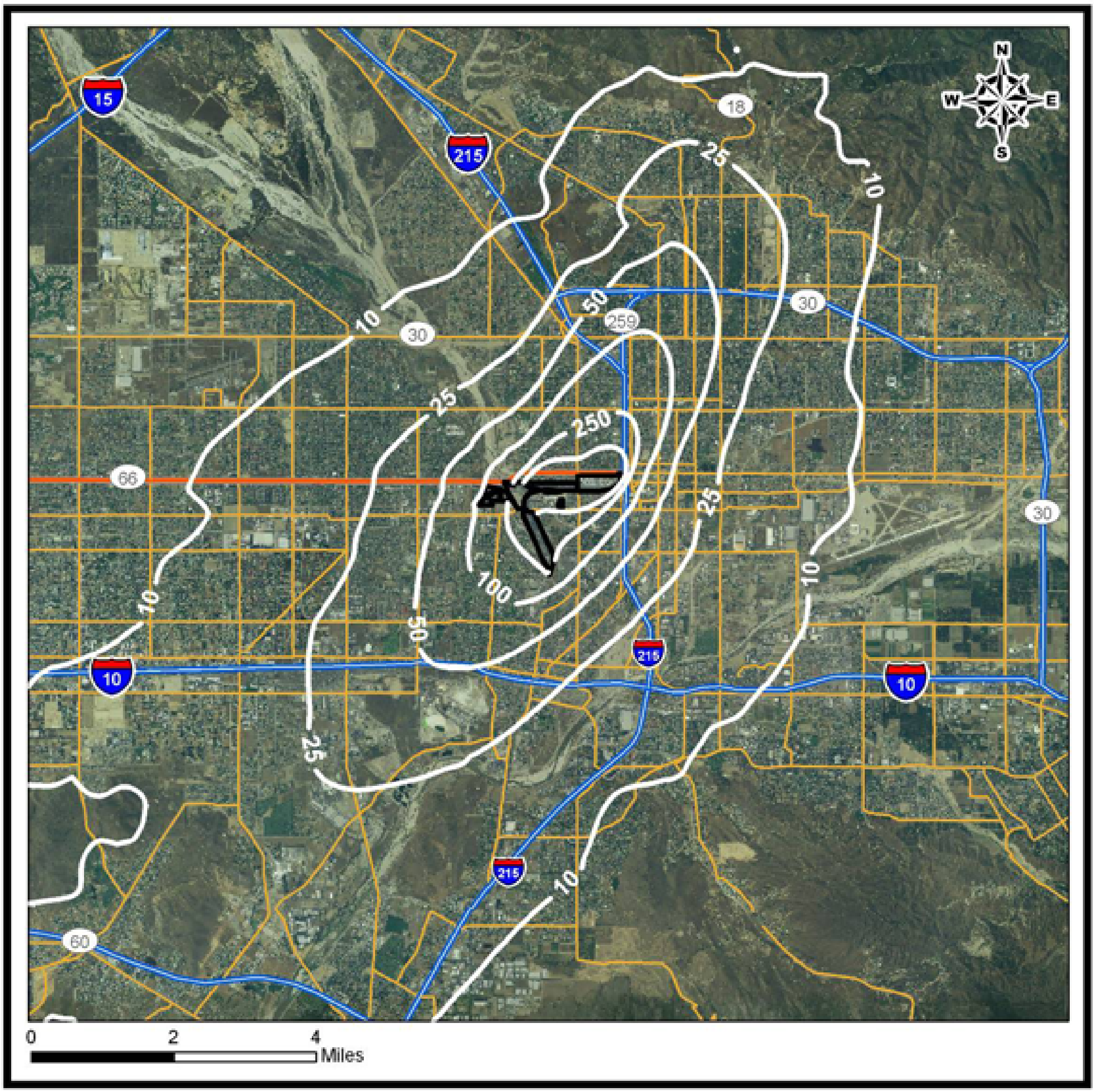
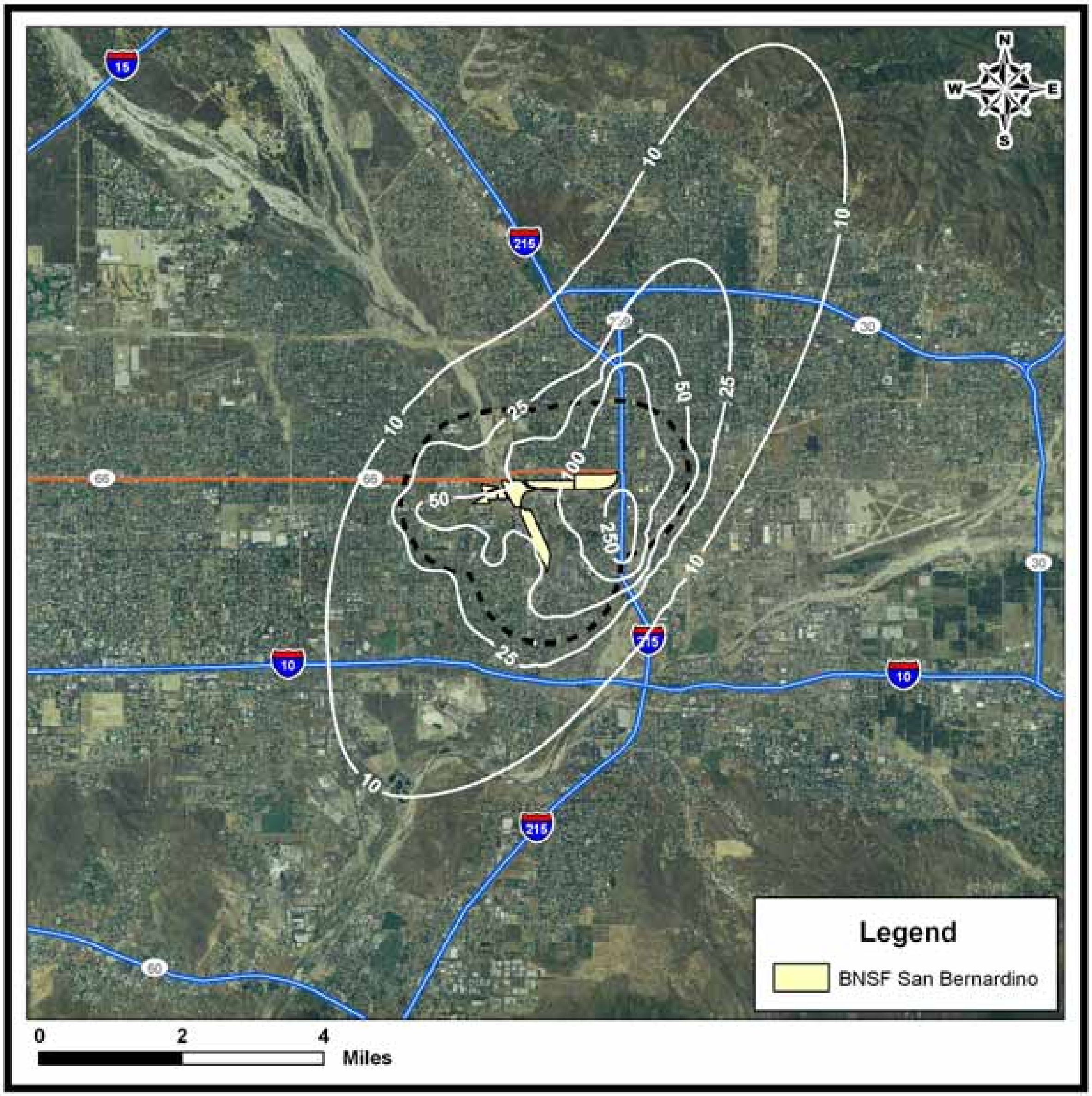


Figure II-5: Estimated Cancer Risks (chances in a million) Associated with the Off-site Non-railyard Diesel PM Emissions within the One-mile Boundary around the BNSF San Bernardino Railyard



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, funding programs, and early replacement of California's line haul and yard locomotive fleets. California's key locomotive and railyard air pollution control measures and strategies are summarized below:

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

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

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

- Identifying and implement future feasible mitigation measures based on the results of the railyard health risk assessments.

ARB Diesel Fuel Regulations Extended to Intrastate Locomotives (2007): This regulation, approved in 2004, requires intrastate locomotives that operate 90 percent of the time in the state to use only California ultra low sulfur (15 parts per million) diesel fuel. CARB diesel's lower aromatics provide, on average, a six percent reduction in NOx and 14 percent reduction in diesel PM emissions as compared to U.S. EPA ultra low sulfur on-road diesel fuel. ARB staff estimates there are about 250 intrastate locomotives currently operating in 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 NO_x. The regulation took effect statewide for intrastate locomotives on January 1, 2007.

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

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

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

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

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

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

U.S. EPA Locomotive Emission Standards: Under the Federal Clean Air Act, U.S. EPA has sole authority to adopt and enforce locomotive emission standards. Under U.S. EPA's rules, this preemption also extends to the remanufacturing of existing locomotives. In April 2007, U.S. EPA released a proposed locomotive rulemaking that would reduce Tier 0 locomotive NOx emissions by 20% and Tier 0-3, remanufacture and new standards, to reduce PM by 50%. The ARB is relying on U.S. EPA to expeditiously require the introduction of the next generation or Tier 4 locomotive emission standards that requires Tier 4 locomotives to be built with diesel particulate filters and selective catalytic reduction. Combined, these exhaust aftertreatment devices are expected to provide up to a 90 percent reduction in NOx and PM emissions beginning in 2015. The final U.S. EPA locomotive regulations were released on March 14, 2008.

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

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

III. BNSF SAN BERNARDINO RAILYARD DIESEL PM EMISSIONS

In this chapter, we provide a summary of the diesel particulate matter (PM) emissions inventory for the BNSF San Bernardino Railyard.

For the year 2005, the combined diesel PM emissions from the BNSF San Bernardino Railyard (on-site emissions) and significant non-railyard emission sources within a one-mile distance (off-site emissions) are estimated at 33 tons per year. Estimated off-site diesel PM emissions from mobile and stationary sources account for about 11 tons per year, or about 34% of the total combined on-site and off-site diesel PM emissions. The BNSF San Bernardino Railyard diesel PM emissions are estimated at about 22 tons per year, or about 66% of the total combined on-site and off-site diesel PM emissions.

A. On-Site BNSF San Bernardino Railyard Diesel PM Emissions Summary

The BNSF San Bernardino Railyard activity data and emission inventories were provided by the BNSF Railway Company and its consultant ENVIRON International. This data was used to prepare the railyard emissions inventory. 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 Emission Inventory for the BNSF San Bernardino Railyard* (ENVIRON, 2008a) and *Air Dispersion Modeling Assessment of Air Toxic Emissions from BNSF San Bernardino Railyard* (ENVIRON, 2008b).

The BNSF San Bernardino Railyard is both a domestic container facility and a classification yard for manifest (mixed freight) trains. Activities at the BNSF San Bernardino Railyard include receiving inbound trains, switching cars, loading and unloading intermodal trains, storing containers and chassis, building and departing outbound trains, and repairing freight cars, containers and 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, sources were allocated into three different operational areas based on specific activities. The railyard areas of operations are summarized in Table III-1. The detailed schematic and descriptions of the areas and activities are also presented in the ENVIRON Report.

Table III-1: BNSF San Bernardino Railyard Activities

Area	Description
Classification Yard	Switching, Arriving and Departing Trains, Passing Trains, Passenger Trains, Boxcar/Freight TRUs.
Intermodal Area	Cargo Handling Equipment, On-Road Container Trucks and Fleet Vehicles, Container/Trailer TRUs, Stationary Sources.
Locomotive Refueling Area	Locomotive Refueling

Emission sources at the BNSF San Bernardino Railyard include, but are not limited to, locomotives, on-road trucks and vehicles, cargo handling equipment, transportation refrigeration units (TRUs) and refrigerated railcars. Emissions were calculated on a source-specific and facility-wide basis for the 2005 calendar year. The diesel PM emissions for the BNSF San Bernardino Railyard in 2005, are calculated at about 22 tons per year; these emissions are summarized in Table III-2 by source categories.

Table III-2: Summary of BNSF San Bernardino Railyard Diesel PM Emissions

Sources	Diesel PM Emissions (tons per year)	
	Total Diesel PM Emissions	Percent of Total
Locomotives	10.57	48%
Line Hauls	*6.13*	*28%*
Switchers	*4.06*	*18%*
Refueling	*0.39*	*2%*
On-Road Trucks and Vehicles	4.35	20%
Cargo Handling Equipment	3.65	17%
Off-Road Equipment	3.35	15%
Stationary Sources	0.09	>1%
Total*	22.01	100%*

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

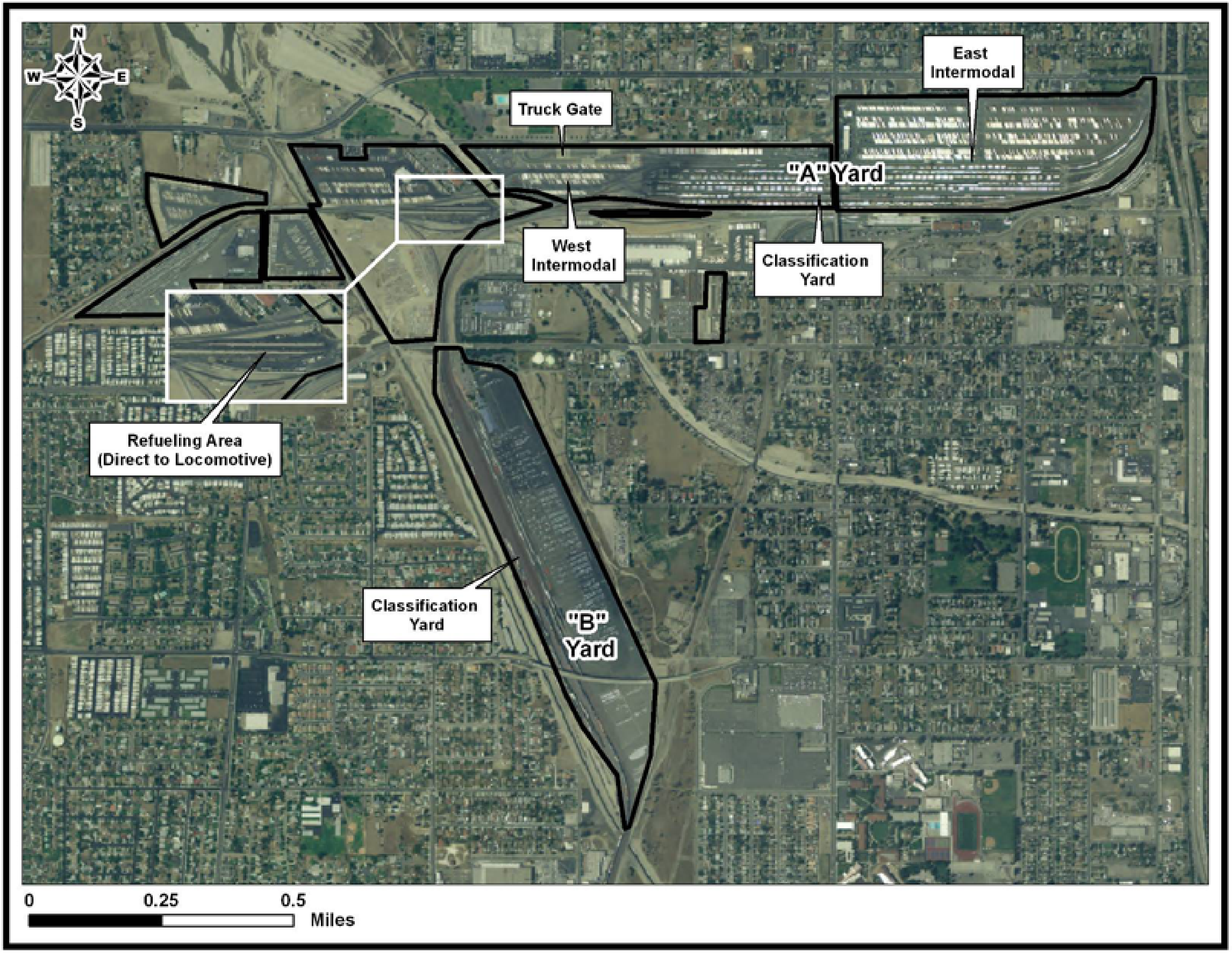
As shown in Table III-2, emissions from locomotives comprise almost half of the total emissions, at 10.6 tons per year. On-site emissions from on-road trucks and vehicles are estimated at about 4.4 tons per year (20% of the facility-wide diesel PM emissions) while cargo handling equipment produces about 17% of the facility-wide emissions, at 3.7 tons per year. Off-road equipment, including TRUs and refrigerated freight railcars (reefer cars), generates about 15% of the total emissions, at 3.4 tons per year.

Diesel PM is not the only toxic air contaminant emitted at the BNSF San Bernardino 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 Emission Inventory for the BNSF San Bernardino Railyard* (ENVIRON, 2008a). The total amount of these toxic air contaminant emissions is about 290 pounds per year, compared to about 22 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 and 1,3-butadiene are the only toxic air contaminants among the top five cancer risk contributors at the BNSF San Bernardino Railyard; they are estimated at about 8.0 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 (0.0004 vs. 22 tons per year). Hence, only diesel PM emissions are presented in the on-site emission analysis.

Figure III-1: BNSF San Bernardino Railyard Diesel PM Emission Source Locations



1. Locomotives

Locomotives are the largest diesel PM emission source at the BNSF San Bernardino Railyard. Locomotives contribute about 10.6 tons per year, or about 48% of the total on-site diesel PM emissions.

Locomotive activities at the BNSF San Bernardino Railyard are divided into three emissions categories: (1) line haul locomotives (i.e., arriving and departing, adjacent freight movements, etc.), (2) switching (i.e., moving railcars within the yard), and (3) refueling. Line haul emissions were further divided into sub-categories to describe the emission modes and spatial allocation, such as locomotive arrivals and departures freight movement, and adjacent commuter rail movement. Temporal emission profiles are estimated for each activity based on hourly locomotive counts. The profiles developed account for hourly and seasonal temporal variations and are reflected in the air dispersion modeling to capture operational variations. Locomotive operations data used to estimate emissions include the number of engines and the typical time in notch setting for those engines.

As shown in Table III-3, the highest percentage of locomotive diesel PM emissions results from line haul locomotives, arriving or departing from, or moving freight past, the railyard, accounting for almost 60% of the total locomotive diesel PM emissions (6.1 tons per year). Switcher locomotives generate an estimated 4.1 tons per year of diesel PM emissions, while adjacent commuter trains and refueling cumulatively generate an estimated 0.5 tons per year.

The ARB has developed an integrated approach to reduce statewide locomotive emissions through a combination of voluntary agreements, ARB and U.S. EPA regulations, incentive funding programs, and early replacement of California's line haul and yard locomotive fleets. In the future, the BNSF San Bernardino Railyard may benefit from these mitigation measures as diesel PM emissions from locomotives are gradually reduced as the locomotive fleets turn over.

The replacement of the switch locomotives in the yard with ultra low emitting switch locomotives could reduce switching emissions by up to 90% and reduce facility-wide emissions by up to 17%. The detailed approach has been discussed in Chapter 2.

Table III-3: Diesel PM Emissions by Locomotive Operations at the BNSF San Bernardino Railyard

Activity	Diesel PM Emissions in 2005	
	Tons Per Year	Percent of Total
Line Haul Locomotives	6.1	58%
Arriving and Departing Trains	*3.7*	*35%*
Adjacent Freight Movement	*2.3*	*22%*
Adjacent Commuter Rail Operations	*0.2*	*1%*
Switcher Locomotives	4.1	38%
Refueling	0.4	4%
Total*	10.6	100%

* Numbers and percentages may not add precisely due to rounding

2. On-road Trucks and Vehicles

On-road trucks contribute about 20% of the total railyard diesel PM emissions at about 4.4 tons per year. As shown in Table III-5, close to 80% of the on-road truck diesel PM emissions come from container trucks, traveling on-site, which were estimated at 3.4 tons per year. About 20% of the on-road truck diesel PM emissions come from container trucks idling on-site, at about 0.9 tons per year. All of the other diesel-fueled trucks traveling and idling on-site, generate about 0.05 tons per year of the diesel PM emissions, about 1% of the total on-road truck diesel PM emissions.

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

In December 2007, the ARB approved a regulation that will modernize port and intermodal railyard drayage trucks. It is estimated that this regulation will reduce diesel PM by nearly 86% by 2010 and NOx by nearly 56% by 2014, as compared to the 2007 baseline, and will result in significant reduction in exposure and potential cancer risks to residents that live near ports, railyards and major roadways.

The ARB is also developing a regulation to reduce diesel PM and NOx by 70% and 35%, respectively. This measure will cover most diesel-powered trucks and buses with a gross vehicle weight rating of 14,000 pounds or greater; it is scheduled for ARB Board consideration in October 2008.

Table III-4: BNSF San Bernardino Railyard On-Road Truck Diesel PM Emissions

Source	Diesel PM Emissions (tons per year)		
	Traveling	Idling	Total
On-site Container Trucks	3.40	0.90	4.30
Fueling Trucks	> 0.01	0.03	0.03
On-road Fleet Vehicles	0.02	-	0.02
TOTAL	3.42	0.93	4.35
Percent of Total On-Road Truck Emissions	79%	21%	100%

3. Cargo Handling Equipment

Cargo handling equipment[‡] (CHE) is the third largest diesel PM emission source at the BNSF San Bernardino Railyard. The diesel PM emissions from cargo handling equipment were estimated at 3.7 tons in year 2005, equivalent to about 17% of the total diesel PM emissions from the BNSF San Bernardino Railyard.

Cargo handling equipment is used to move intermodal freight and containers at the BNSF San Bernardino Railyard. Additionally, cargo handling equipment is used for non-cargo-related activities at the railyard. Four types of equipment were included in CHE inventory: yard hostlers, cranes, forklifts, and container handling equipment.

- Yard hostlers are also known as yard trucks. They are the most common type of cargo handling equipment and are designed to move cargo containers within the railyard.
- 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.
- Fork lifts are used to stack the truck chassis.
- Container handling equipment is used to lift or move containers within the railyard.

The CHE diesel PM emissions in the BNSF San Bernardino Railyard were estimated using the latest version of ARB's OFFROAD model. As indicated in Table III-4, about 57% of the CHE diesel PM emissions were due to the yard hostlers, at about 2.10 tons

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

per year. The RTGs emit about 27% of the total CHE diesel PM emissions (about 1 ton per year). Container handling equipment emits about 15% of the total CHE diesel PM (about 0.6 tons per year). The remaining (less than 1%) of the CHE diesel PM emissions were from fork lifts. Additional details of calculations and estimations are presented in Sierra Research Report.

Table III-5: Cargo Handling Equipment Diesel PM Emissions

Equipment	Diesel PM Emissions	
	Tons per year	**Percent of Total**
Yard Hostlers	2.10	57%
RTGs	0.97	27%
Container Handling Equipment	0.56	15%
Fork Lifts	0.01	< 1%
Total*	3.65	100%

* Numbers and percentages may not add precisely 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. This regulation will provide up to 80% diesel PM control or better from the best available control technology by 2020. The BNSF San Bernardino Railyard has already begun, and will continue to, benefit from this mitigation measure.

4. Off-road Equipment

Off-road equipment is the fourth largest source of diesel PM emissions at the BNSF San Bernardino Railyard; it was estimated at about 3.4 tons per year for 2005. Off-road equipment at the BNSF San Bernardino Railyard includes transportation refrigeration units (TRUs) and track maintenance equipment that operate within the yard.

Emissions from TRUs are based on the number of units in the yard, the hours of operation in the yard and the TRU configuration (either railcar or container). Emissions from track maintenance equipment are based on the amount of track within the railyard.

Transportation refrigeration units (TRUs) and refrigerated railcars (reefer cars) are used to transport perishable and frozen goods. TRUs and reefer cars are not only transferred in and out of the railyard but also temporarily stored at the railyard. As shown in Table III-6, diesel PM emissions from transport refrigeration units and reefer cars are estimated at about 3.3 tons per year, or about 99% of the diesel PM emissions from off-road equipment.

Track maintenance equipment is used to maintain track and produces about 1% of total diesel PM emissions from off-road equipment, at about 0.04 tons per year. The detailed methodology is discussed in the ENVIRON Report.

Table III-6: Diesel PM Emissions of Off-road engines and Equipment at the BNSF San Bernardino Railyard

Equipment Type	Diesel PM Emissions in 2005 (Tons Per Year)	Percent of Total Other Emissions
Transport Refrigeration Units	3.31	99%
Track Maintenance	0.04	1%
Total	3.35	100%

In November 2004, ARB adopted a new regulation: *Airborne Toxic Control Measure (ATCM) for In-Use Diesel-Fueled Transport Refrigeration Units (TRUs), TRU Generator Sets and Facilities where TRUs Operate*. This regulation applies to all TRUs in California, including those coming into California from out-of-state. It requires in-use TRU and TRU 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 TRUs and TRU generator set engines will be reduced by approximately 65% by 2010 and 92% by 2020. Starting in 2009, the BNSF San Bernardino Railyard will benefit from these mitigation measures as diesel PM emissions from TRUs are gradually reduced as their fleets turn over.

5. Stationary Sources

The diesel PM emissions from stationary sources at the BNSF San Bernardino Railyard include a diesel-fueled internal combustion engine that is used as an emergency power generator. The emissions from stationary sources at the BNSF San Bernardino Railyard are estimated at 0.09 tons per year.

6. Other Toxic Air Contaminants

The total volatile organic compound (VOC) emissions generated from various sources were estimated at about 1.0 ton per year in the BNSF San Bernardino Railyard. Among the VOC gases, relatively small amount of toxic air contaminant emissions of benzene, formaldehyde and 1,3-butadiene were identified and estimated at about 0.03 tons or 60 pounds per year. In comparison with the diesel PM emissions generated at the facility, these toxic air contaminants are estimated at about 0.1% of the total estimated diesel PM emissions in the railyard. The potential cancer risks contributed by these toxic air contaminants are found to be considerably lower than the diesel PM emissions - about a factor of 5,500 less, based on cancer potency weighted factor adjustment discussed in Chapter II. Because of the dominance of diesel PM emissions, these gaseous toxic air contaminants are not included in the health impact evaluation in this study.

B. Off-Site Diesel PM Emissions Summary

ARB staff analyzes the significant off-site emission sources based on two categories: mobile and stationary. Figure III-2 presents the one-mile off-site boundary from the BNSF San Bernardino Railyard, where off-site diesel PM emissions are evaluated. The off-site diesel PM emissions are estimated for the sources within a one-mile distance from the boundary of the BNSF San Bernardino Railyard and are predominantly generated by mobile sources, at about
10.6 tons per year; stationary sources contribute about 0.2 tons per year. The off-site mobile and stationary diesel PM emissions total 10.8 tons per year, or about 33% of the combined on-site and off-site diesel PM emissions.

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 BNSF San Bernardino Railyard are included in the analysis. The estimates do not include the diesel PM emissions generated from other modes of operations such as extended idling, starts and off-road equipment outside of the railyard. 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. Because the off-site mobile sources have only focused on the on-road diesel PM emissions, the exclusion of extended idling and off-road equipment may result in an underestimation of off-site mobile source emissions.

> ***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 BNSF San Bernardino Railyard, off-site diesel PM emissions are predominantly generated by mobile sources, which provide around 10.6 tons per year, or 98% of the total off-site diesel PM emissions. The diesel PM emissions for mobile sources are allocated by the roadway links illustrated in Appendix C.

Off-site diesel PM emission from mobile source are estimated based on the local traffic flow, and calculated by different classifications of truck gross vehicle weights, as shown in Table III-7. In 2005, heavy heavy-duty and medium heavy-duty trucks contributed about 87% of the total diesel PM emissions from off-site mobile sources. The two classifications account for about 7.7 and 1.5 tons per year of diesel PM, respectively. The methodology for mobile diesel PM emission estimation is presented in Appendix A.

Table III-7: Off-Site Mobile Source Diesel PM Emissions by Vehicle Type Near the BNSF San Bernardino Railyard

Vehicle Type	Gross Vehicle Weight (Pounds)	Diesel PM Emissions	
		Tons Per Year	Percent of Total
Light Heavy-Duty	8,501 – 14,000	1.4	13%
Medium Heavy-Duty	14,001 – 33,000	1.5	14%
Heavy Heavy-Duty	> 33,000	7.7	73%
Total	**-**	10.6	100%

As shown in Table III-8, about 5.1 tons per year of the off-site diesel PM emissions, 48% of the total, is from diesel-fueled trucks traveling on I-215. The remaining 5.5 tons per year of off-site diesel PM emissions, 52% of the total, is from diesel-fueled trucks traveling on major local streets. It should be noted that I-10 (south of the yard) falls outside the one-mile radius from the yard and was not part of ARB's offsite analysis, however, its emissions are likely to impact the risk levels in the vicinity of they railyard.

Table III-8: Off-Site Mobile Source Diesel PM Emissions near the BNSF San Bernardino Railyard

Sources	Diesel PM Emissions	
	Tons Per Year	Percent of Total
I-215 Freeway	5.1	48%
Local Streets	5.5	52%
Total	10.6	100%

Figure III-2: One Mile Boundary for Off-Site Analysis

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 BNSF San Bernardino Railyard are selected. Diesel PM emissions are estimated from stationary internal combustion engines burning diesel fuel, operating at stationary sources reported in CEIDARS.

Within one mile of the BNSF San Bernardino Railyard boundary, the diesel PM emissions from off-site stationary sources are about 330 pounds per year, or about 2% of the total off-site diesel PM emissions.

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

3. Non-Diesel Toxic Air Contaminants

ARB staff also evaluated other toxic air contaminant emissions around the BNSF San Bernardino Railyard. Within a one-mile distance of the railyard, 5 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 were estimated at about 0.11 tons per year. Over 40 toxic air contaminant species are identified among these emissions, in which ammonia, formaldehyde, and naphthalene are three major contributors with emissions estimated at 0.05, 0.04, and 0.02 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 BNSF San Bernardino Railyard, the top five cancer risk contributors (without diesel PM) are estimated at about 0.04 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 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-9. As can be seen, the potency weighted toxic emissions for these toxic air contaminants are less than 0.01 tons per year, which is substantially less than the diesel PM emissions. Hence, they are not included in the analysis.

Table III-9: Potency Weighted Estimated Toxic Emissions from Significant Off-Site Stationary Sources Surrounding BNSF San Bernardino 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-Butadiene	0.6	0.55	0.001	**0.0006**
Benzene	0.1	0.09	0.002	**0.0002**
Carbon Tetrachloride	0.15	0.14	-	**-**
Formaldehyde	0.021	0.02	0.04	**0.0008**
Total (non-diesel PM)	**-**	**-**	**0.04**	**0.002**

ARB staff also evaluated the potential cancer risk levels caused by the use of gasoline in the South Coast Air Basin. Table III-10 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-10, 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-10: 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	7,746	**7,746**	-	-
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.

C. 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-11.

Table III-11: 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) has also 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. %). All 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-12.

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 were required to produce non-road, locomotive, and marine diesel fuel that meets a maximum sulfur level of 500 ppmw. This does not include diesel fuel for stationary sources. In 2010, non-road diesel fuel will be required to meet the 15 ppmw standard except for locomotives and marine vessels. In 2012, non-road diesel fuel used in locomotives and marine applications must meet the 15 ppmw standard. The non-road diesel fuel standards are shown in Table III-12.

Table III-12: 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-13 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-13: 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 a minimum of 80% 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; UP locomotives typically fuel at Rawlins, Wyoming or Salt Lake City, Utah before traveling to Roseville in northern California or Colton in southern California. These major out-of-state railroad facilities have the option to use Federal non-road diesel fuels for the refueling of line haul locomotives. When these out-of-state line haul locomotives arrive in California, they typically have about 10% remaining volume of diesel fuel relative to their tank capacity.

According to BNSF, their interstate locomotives were fueled out of state before they entered the California borders. BNSF estimated a fuel mixture of about 50% CARB-EPA on-road to 50% non-road diesel fuel, based on the refueling data (see the *Toxic Air Contaminant Emission Inventory for the BNSF San Bernardino Railyard*, ENVIRON, 2008a). This approach overestimated non-road (i.e., non CARB-EPA diesel fuel) fuel usage, since it disregarded the consumption of out-of-state fuel before arriving in California. This was, therefore, a conservative assumption. A more realistic operating scenario would be a fuel mixture of about 75% CARB-EPA on-road to 25% non-road diesel fuel, which would account for substantial volumes of non-road diesel fuel being consumed before arriving in California. By assuming a mixture of 50% CARB-EPA on-road to 50% non-road diesel fuel, BNSF estimated a sulfur content of about 1,050 ppmw. The locomotive diesel PM emission factors used in this study are presented in Appendix D.

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 matter 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 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.

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IV. AIR DISPERSION MODELING OF BNSF SAN BERNARDINO 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 BNSF San Bernardino 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 or other air quality models are often used to simulate atmospheric processes on different scale applications where the spatial scale ranges from the tens of meters to the tens of kilometers, or to hundreds of kilometers over large scale domains. Selection of air dispersion models usually depends on a number of factors, such as characteristics of emission sources, the type of terrain at the emission source locations, and the scale of source-receptor relationships. For the BNSF San Bernardino Railyard, the U.S. EPA's AERMOD (**A**merican Meteorological Society/**E**PA **R**egulatory **MOD**el) is used for air dispersion modeling work.

AERMOD is the model preferred by the *US EPA Guideline for Air Quality Methods (*40 CFR Part 51, Appendix W*)* (US EPA, 2005) for micro-scale applications. The AERMOD model was developed as replacement for its predecessor, the U.S. EPA Industrial Sources Complex (ISC) air dispersion model, to improve the accuracy of model estimations. This replacement was made in November 2005, and AERMOD has become a U.S. EPA regulatory dispersion model after a one-year transition period.

The AERMOD model is a steady-state plume model that incorporates 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. In the stable boundary layer, it assumes the distribution of pollutant concentrations to be normal (or bell-shaped, or Gaussian) in both the vertical and the horizontal directions. In the **mixing layer** (or the convective boundary layer) near ground surface, the horizontal distribution of a plume mass is also assumed to be normal, but the vertical mass distribution is described with a bi-normal probability density function. In addition, the AERMOD model treats "plume lofting," whereby a portion of plume mass, released from a buoyant source, rises to and remains near the top of the boundary layer before becoming mixed into the mixing layer. For sources in both the convective boundary layer and the stable boundary layer, the AERMOD model treats the enhancement of lateral dispersion resulting from plume meander.

> ***Mixing Layer**: A type of atmospheric boundary layer characterized by vigorous turbulence tending to stir and uniformly mix.*

B. Source Characterization and Parameters

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

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

For the stationary locomotives, the locations of individual locomotive emission sources used for the model inputs were determined based on the detailed locomotive distribution and activity information provided by BNSF. The emissions from all other stationary sources (gasoline storage tank, soil vapor extraction systems and a generator) are simulated as a series of point sources.

C. Meteorological Data

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

These meteorological variables are important to describe the air dispersion in the atmosphere. The wind speed determines how rapidly the pollutant emissions are diluted and influences the rise of emission plume in the air, thus affecting downwind concentrations of pollutants. Under low wind conditions the plume's initial buoyancy and inertia will cause the emissions to go higher into the air than during high wind conditions. Wind direction determines where pollutants will be transported. Atmospheric stability determines the rate of mixing in the atmosphere and is typically characterized by the atmospheric vertical temperature profile. 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 model also incorporates upper air sounding data, cloud ceiling height and cloud coverage, which will determine the mixing height in the atmosphere.

The meteorological data used in the model are selected on the basis of representativeness from available meteorological stations. 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 BNSF San Bernardino Railyard, the candidate meteorological stations for assessment were the Fontana and San Bernardino – East 4th Street (operated by SCAQMD) and the Riverside Airport and March Air Force Base station (operated by the National Weather Service/National Climatic Data Center). The San Bernardino – East 4th station was selected because it appeared to be more representative of the railyard conditions. The upper air sounding data were chosen from the San Diego-Miramar NAS stations because it was not available from the San Bernardino – East 4th meteorological station. Detailed meteorological data selection is discussed in the air dispersion modeling report (ENVIRON 2008b).

Although the meteorological data collected at the East 4th street station is more representative, the presence of elevated terrain nearby the BNSF San Bernardino Railyard in several directions introduces some degree of uncertainty as to the expected direction of prevailing airflows at distant areas from the railyard.

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. Surface meteorological data was collected from the San Bernardino – East 4th monitoring station. The selected meteorological data includes two-year recorded surface parameters from 2005 to 2006 due to a limitation of data quality and the algorithm used for data post process for some yearly data sets. ARB staff investigated the selected meteorological data set and concluded the representativeness of data was sufficient for the air dispersion modeling at the BNSF San Bernardino Railyard and its surrounding areas. The cloud cover and pressure data was collected, for 2005 and 2006, from the March Air Force Base meteorological station because it was not available from the San Bernardino – East 4th meteorological station for these years.

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 UP, 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) meteorological data sets 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 F). Therefore, whether five-year or one-year meteorological data are used, the modeling results show similar estimated exposures and potential cancer risks surrounding the railyard facility.

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

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 southwest. The detailed procedures for meteorological data preparation and quality control are described in the modeling report (ENVIRON, 2008b).

Figure IV-1: Wind Rose Plot for BNSF San Bernardino Railyard

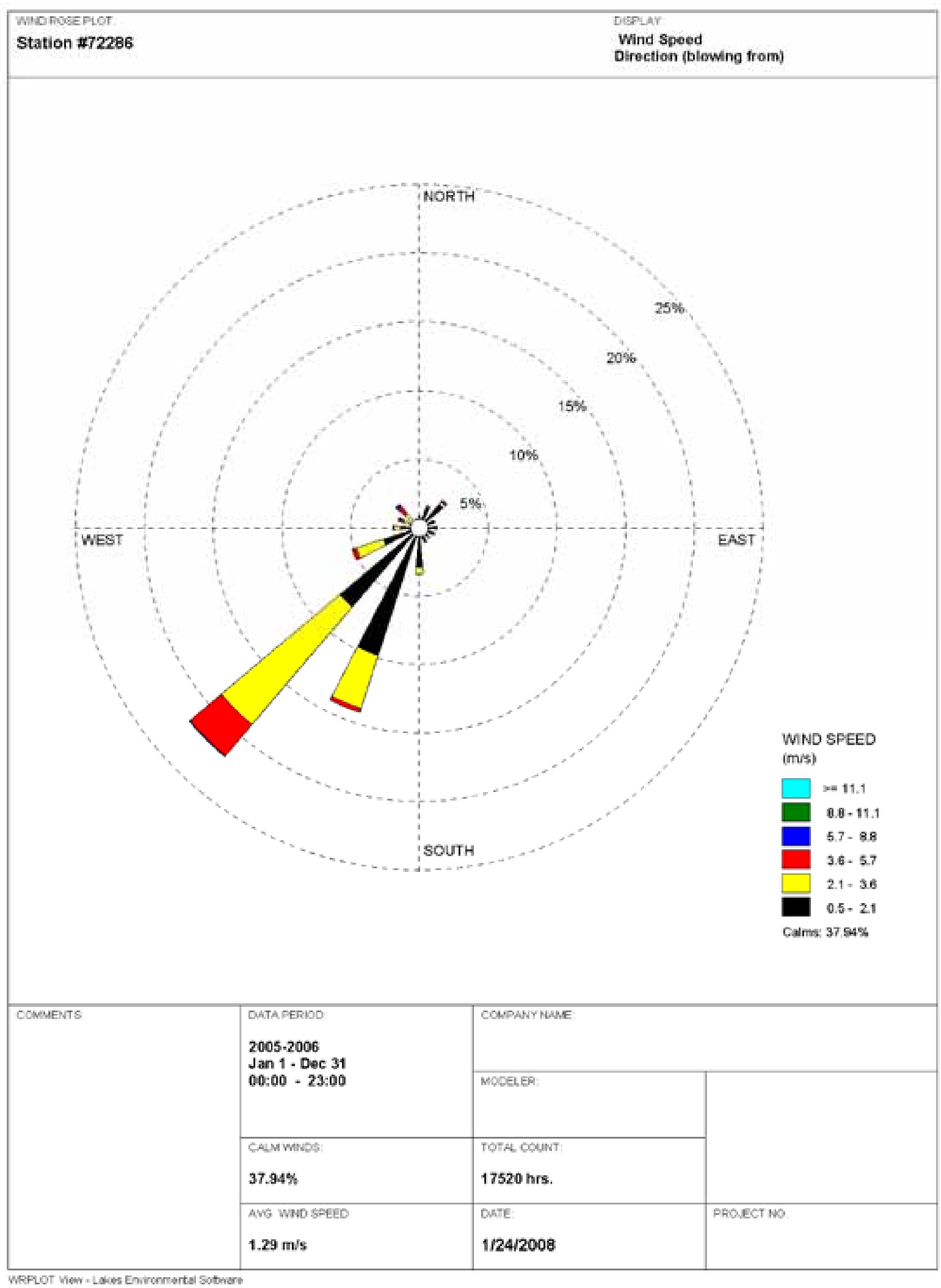
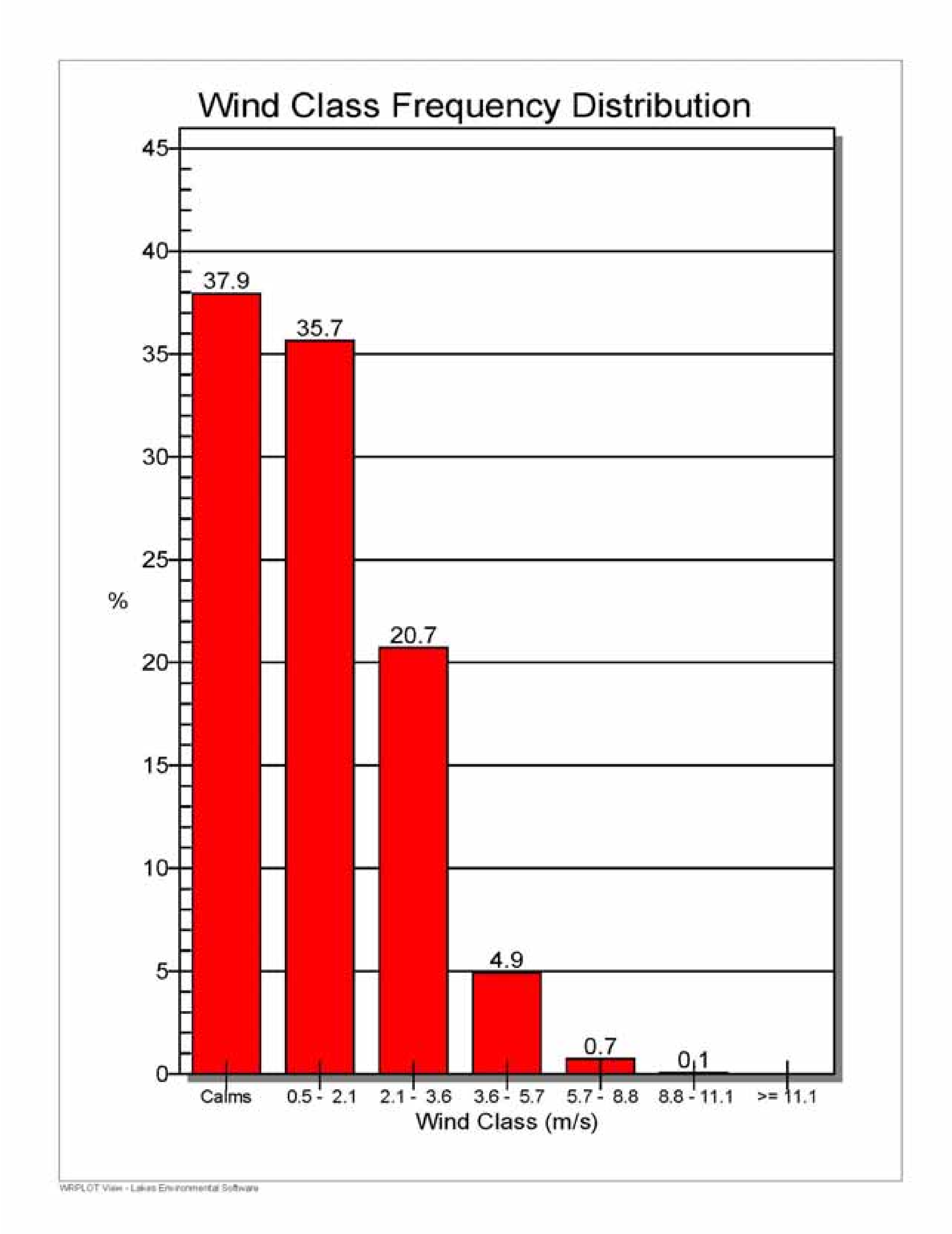


Figure IV-2: Wind Class Frequency Distribution for BNSF San Bernardino Railyard



D. Model Receptors

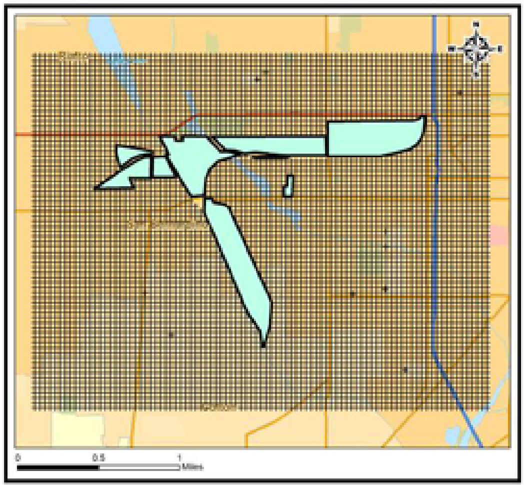
Model receptors are the defined discrete locations where concentrations are estimated by the dispersion model. A Cartesian grid receptor network is used in this study, in which an array of points is identified by their x (east-west) and y (north-south) coordinates. This receptor network is capable of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

According to the *ARB Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006d), the modeling domain is defined as a 20 km by 20 km (km: kilometers) region, which covers the railyard in the center of the domain and extends to the surrounding areas. To better capture the different concentration gradients surrounding the BNSF San Bernardino railyard, 3 receptor grid networks were used: A fine receptor grid with a receptor spacing of 50 meters extending out to a distance of 250 meters from the railyard; a medium receptor grid with a receptor spacing of 250 meters was used for receptor distances up to 1,500 meters of the fence line; and a coarse grid, with a receptor spacing of 500 meters, was used throughout the rest of the modeling domain. (ENVIRON, 2008b)

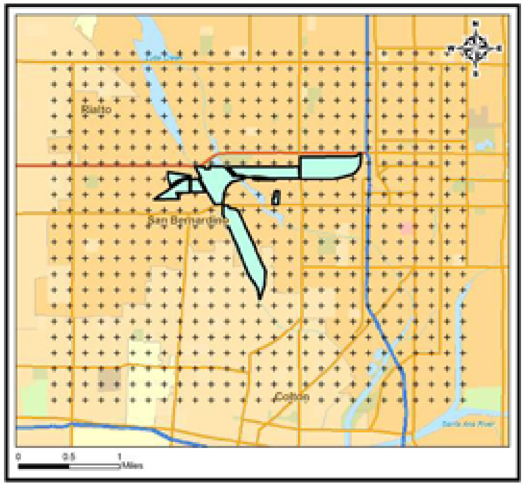
Figure IV-3 shows the fine, medium and coarse grid receptor networks used in air dispersion modeling for the BNSF San Bernardino Railyard.

Figure IV-3: Fine (a), Medium (b) and Coarse (c) Grid Receptor Networks Air Dispersion Modeling for BNSF San Bernardino Railyard

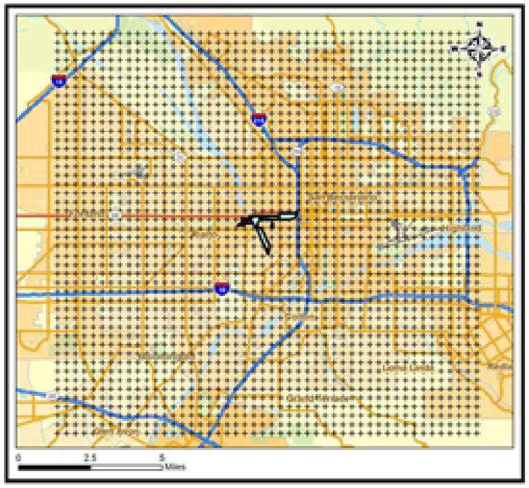
(a)



(b)



(c)



E. Building Wake Effects

One of the characterizations in the air dispersion model is the mixing process of air pollutants due to the air flow caused by the surrounding environment. The spacing and placement of emission sources relative to surrounding building or structures can have such an effect on the pollutant plume in the air. If pollutant emissions are released at or below the "Good Engineering Practice" (GEP) 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. To do so, "direction-specific" building dimensions for each emission point need to be input. The direction-specific building dimensions represent the building width perpendicular to the wind direction along with the building height, and are estimated by a model built-in module called The Building Profile Input Program – Plume Rise Model Enhancements, which accounts 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, 2008b). This sensitivity analysis also indicated that, at receptor distances close to the sources (i.e., within 100 meters), building downwash may have a large impact on the modeled concentrations. However, at distances further away from the sources (i.e., 400 to 700 meters), receptor concentrations from model predictions with and without building downwash were similar (ENVIRON, 2008b).

F. Model Inputs

One of the basic inputs to AERMOD is the runstream setup file which contains the selected modeling options, as well as source location and parameter data, receptor locations, meteorological data file specifications, and output options. Another type of basic type of input data needed to run the model is the meteorological data. AERMOD requires two types of meteorological data files. One consists of surface scalar parameters, and the other file consists of vertical profiles of meteorological data. For applications involving elevated terrain effects, the receptor and terrain data will need to be processed by the terrain preprocessing program before input to the AERMOD model.

Source inputs require source identification and source type. Each source type requires specific parameters to define the source. For example, the required details for a point source are emission rate, release height, emission source diameter, exhaust exit temperature, and exhaust exit velocity. The requirements and the format of input files to the AERMOD are documented in the user's guide of AERMOD (US EPA, 2004a).

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V. HEALTH RISK ASSESSMENT OF THE BNSF SAN BERNARDINO RAILYARD

This chapter describes the ARB's guidelines on health risk assessment and characterization of potential cancer and non-cancer risks associated with exposure to toxic air contaminants, especially diesel PM emissions from the sources within and surrounding the BNSF San Bernardino Railyard, followed by a discussion of uncertainties with respect to the components of health risk assessment.

A. ARB Railyard Health Risk Assessment Guidelines

The railyard 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 OEHHA guidelines outline a tiered approach to risk assessment, providing risk assessors with flexibility and allowing for consideration of site-specific differences:

- Tier 1: a standard point-estimate approach that uses a combination of the average and high-end point-estimates.
- Tier 2: utilizes site-specific information for 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 65th 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 railyard specific emission inventory and air dispersion modeling predictions. The OEHHA guidelines recommend that all health hazard risk assessments adopt a Tier-1 evaluation for the Hot Spots Program, even if other approaches are also presented. Two point-estimates of breathing rates in Tier-1 methodology are used for 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 the 65th percentile and the 95th percentile, from the distributions identified in the OEHHA guidelines (OEHHA, 2000). In 2004, ARB recommended the interim use of the 80th percentile value (the midpoint value of the 65th and 95th percentile breathing rates referred as an estimate of central tendency) as the minimum value for risk management decisions at residential receptors for the breathing intake (ARB, 2004b). The 80th percentile corresponds to a breathing rate of 302 liters / kilogram-day (302 L / kg-day) from the probability distribution function. As indicated by the OEHHA Guidelines, the Tier-1 evaluation is useful in comparing risks among a number of facilities and similar sources.

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 OEHHA 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, 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. In addition, 40- and 9-year exposure assessments were conducted for off-site workers and school-aged children, respectively. Children have a greater risk than adults because they have greater exposure on a per unit body weight basis in addition to other factors.

Diesel PM is not the only toxic air contaminant emitted at the BNSF San Bernardino Railyard. Relatively small amounts of gasoline toxic air contaminants (benzene, isopentane, toluene, etc.) are generated from gasoline-fueled engines and a gasoline storage tank. The detailed emission inventories for these toxic air contaminants are presented in the *Toxic Air Contaminant Emission Inventory for the BNSF San Bernardino Railyard* (ENVIRON, 2008a). The total amount of these toxic air contaminant emissions is about one ton per year, as compared to the 22 tons per year of diesel PM emissions in the railyard. As described in Chapter III, the cancer potency weighted emissions of these TACs are about a factor 5,500 less than the diesel PM emissions at the railyard. ARB staff also evaluated the health impacts of the diesel PM emissions and other TACs from off-site stationary and mobile sources around the BNSF San Bernardino Railyard.

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

C. Risk Characterization

Risk characterization is defined as the process of obtaining a quantitative estimate of risk. The 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 and difficult to quantify. 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. Additional details on the risk characterization are provided in the Toxic Hot Spot Program Risk Assessment Guidelines (OEHHA, 2003), and discussed in Section D.

To characterize the risk from the diesel PM emissions, three Cartesian receptor networks are used for the coverage of the BNSF San Bernardino Railyard and its surrounding areas, including (1) a fine receptor grid with a receptor spacing of 50 meters extending out to a distance of 250 meters from the railyard, (2) a medium receptor grid with a receptor spacing of 250 meters extending out to a distance of 1,500 meters from the railyard and (3) a coarse grid, with a receptor spacing of 500 meters, extending throughout the rest of the modeling domain. These receptor grid networks are graphically presented in Figure IV-3a, IV-3b and IV-3c. The risk levels are presented as two-dimensional isopleths (or contours). These isopleths are used to display the risk plume ranges and gradient (or risk changes with distance) in all wind directions.

In the following sections, the cancer risk levels and non-cancer chronic risk levels resulting from on-site and off-site diesel PM emissions will be presented, followed by a discussion of non-cancer acute risk assessment.

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

a) Potential Cancer Risk

> *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 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, 250 and 500 in a million. Figure V-1 (See Page 62) and Figure V-2 (See Page 63) present these isopleths: Figure V-1 focuses on the near source risk levels, while Figure V-2 focuses on the more regional impacts.

Figure V-1 shows the isopleths of estimated potential cancer risk from on-site railyard diesel PM emissions based on the 80th percentile breathing rate approach and a 70-year exposure duration. The estimated cancer risk is generally above 500 in a million around the area near railyard property boundaries, assuming a 70-year exposure duration. Within about a mile of the BNSF San Bernardino Railyard boundaries, the estimated cancer risks lowers to about 100 in a million, and within two miles of the railyard boundary the estimated cancer risks are lowered to about 50 in a million. At about four miles from the BNSF San Bernardino Railyard, the estimated cancer risks are about 25 in a million.

There are many densely populated areas which surround the BNSF San Bernardino Railyard. Table V-1 shows the estimated area coverage and exposed population for different cancer risk ranges estimated from modeling results. Based on the 2000 U.S. Census Bureau's data, the area with an estimated risk greater than 10 in a million encompasses approximately 61,800 acres where about 340,000 residents live.

OEHHA Guidelines specify that, for health risk assessments, the location of the maximum exposure at the point of maximum impact (PMI) be reported. The PMI is defined as a location or the receptor point with the highest cancer risk level - based on the highest diesel PM concentration estimated from the modeling results outside of the facility - outside of the railyard boundary, with or without residential exposure. The estimated cancer risk at the PMI for BNSF San Bernardino Railyard is about 3,300 chances in a million based on a 70-year exposure duration. The location of PMI is predicted to be along the north side of the west end (i.e., west intermodal area) of the "A" yard fence line (see Figure III-1) on West 4th Street, where the land use is a mix of industrial and residential. The estimated level of the PMI is primarily due to the density of emission sources near the west intermodal area where arriving and departing locomotives, switch locomotives, cargo handling equipment and trucks - generate about 65% of facility-wide diesel PM emissions (see the emission allocation in Appendix E).

The potential cancer risk for the maximally exposed individual resident (MEIR) or maximum individual cancer risk (MICR) – which is in close proximity to the PMI – is estimated at about 2,500 chances in a million. The modeling results also show similar cancer risk levels in the north neighboring areas near the east intermodal area of the "A" yard (see Figure III-1).

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.

Table V-1: Estimated Impacted Areas and Exposed Population Associated with Different Cancer Risk Levels

Estimated Cancer Risk (chances per million)	Impacted Area (Acres)	Estimated Population Exposed
> 500	430	3,780
250 – 500	730	8,300
101 - 250	2,430	27,500
51 - 100	4,780	43,500
26 - 50	11,460	69,200
10 - 25	42,050	187,600
> 10	**61,880**	**339,880**

OEHHA Guidelines recommend a 70-year lifetime exposure duration to evaluate the potential cancer risks for residents. Shorter exposure durations of 30 years and 9 years 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.

Figure V-1: Estimated Near-Source Cancer Risk (Chances per Million People) From the BNSF San Bernardino Railyard

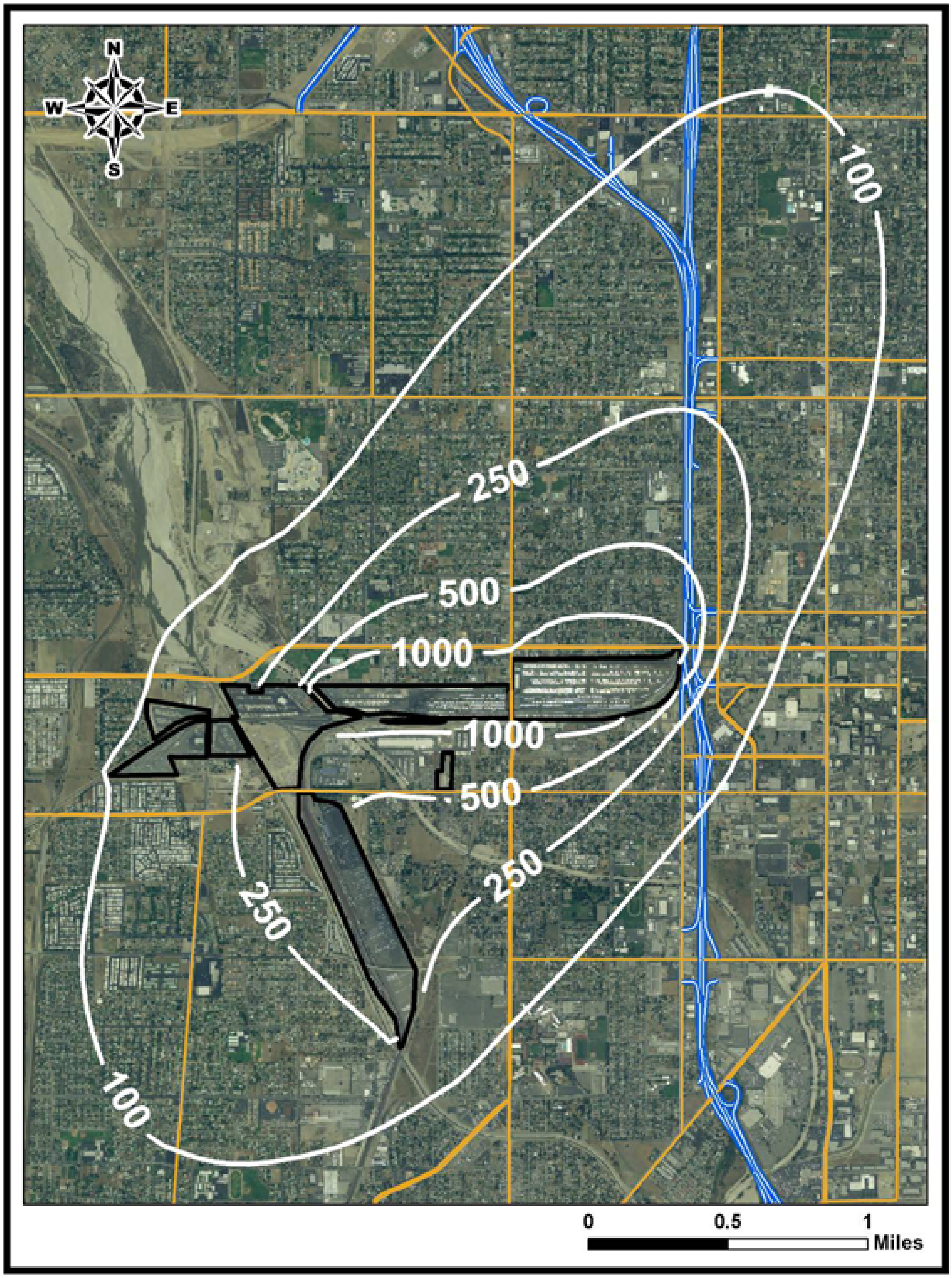


Figure V-2: Estimated Regional Cancer Risk (Chances per Million People) From the BNSF San Bernardino Railyard

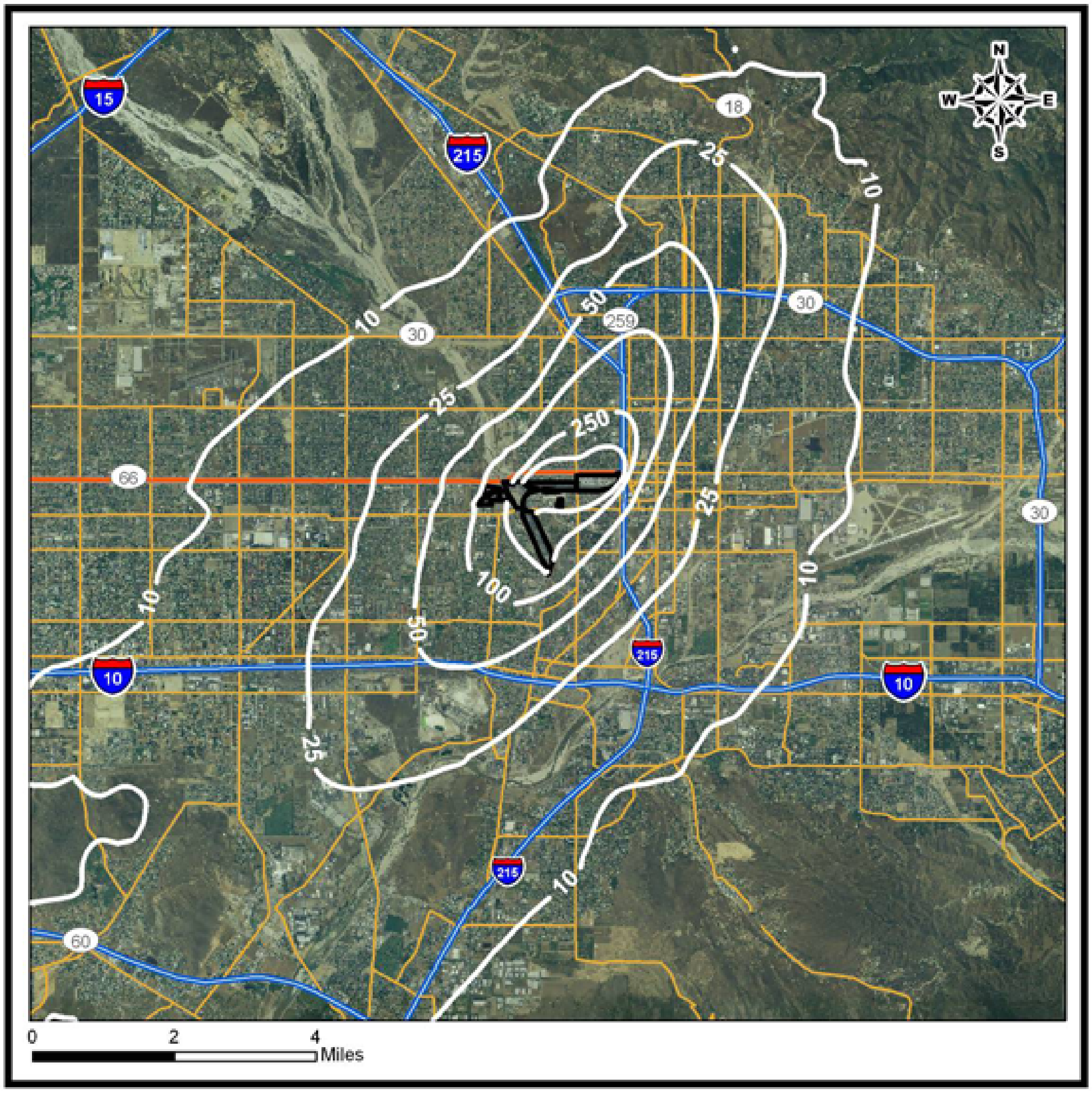


Table V-2 shows the equivalent risk levels of 70- and 30-year exposure durations for exposed residents; and 40- and 9-year exposure durations for workers and school-age children, respectively. As Table V-2 shows, the 10 in a million isopleth line in Figure V-2 would become 4 in a million for exposed 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-2: 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.

ARB staff also evaluated other toxic air contaminants, other than diesel PM, generated at the BNSF San Bernardino Railyard. A relatively small amount of toxic air contaminant emissions of benzene, formaldehyde and 1,3-butadiene were identified and estimated at about 0.03 tons or 60 pounds per year. Using cancer potency weighted factors adjustment discussed in Chapter II, the potential cancer risks contributed by these toxic air contaminants is found to be considerably lower - by about a factor of 5,500 - than the diesel PM emissions at the BNSF San Bernardino Railyard. Hence only diesel PM emissions are presented in the on-site emission analysis

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 referred to a dose-response assessment. According to the OEHHA Guidelines, dose-response information for non-carcinogens is presented in the form of reference exposure levels. OEHHA 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. 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 (RfCs) and oral Reference Doses (RfDs). Chronic reference exposure levels are frequently calculated by dividing the no observed adverse effect level (NOAEL) or lowest observed adverse effect levels (LOAEL) in human or animal studies by uncertainty factors. A substantial number of epidemiologic studies have found a strong association between exposure to ambient particulate matter and adverse health effects. For diesel PM, OEHHA has determined a chronic reference exposure level of 5 $\mu g/m^3$, with the respiratory system, as a target of the reference exposure level.

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. In addition, there is a possibility that a reference exposure level may not be protective of certain small, unusually sensitive human subpopulations. Such subpopulations can be difficult to identify because of their small numbers, lack of knowledge about toxic mechanisms, and other factors. It may be useful to consult OEHHA staff when a reference exposure level is exceeded.

As described previously, reference exposure level for diesel PM is essentially the U.S. EPA reference concentration (RfC) 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 in the air. 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 REL, 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, and some adverse health impacts would be expected.

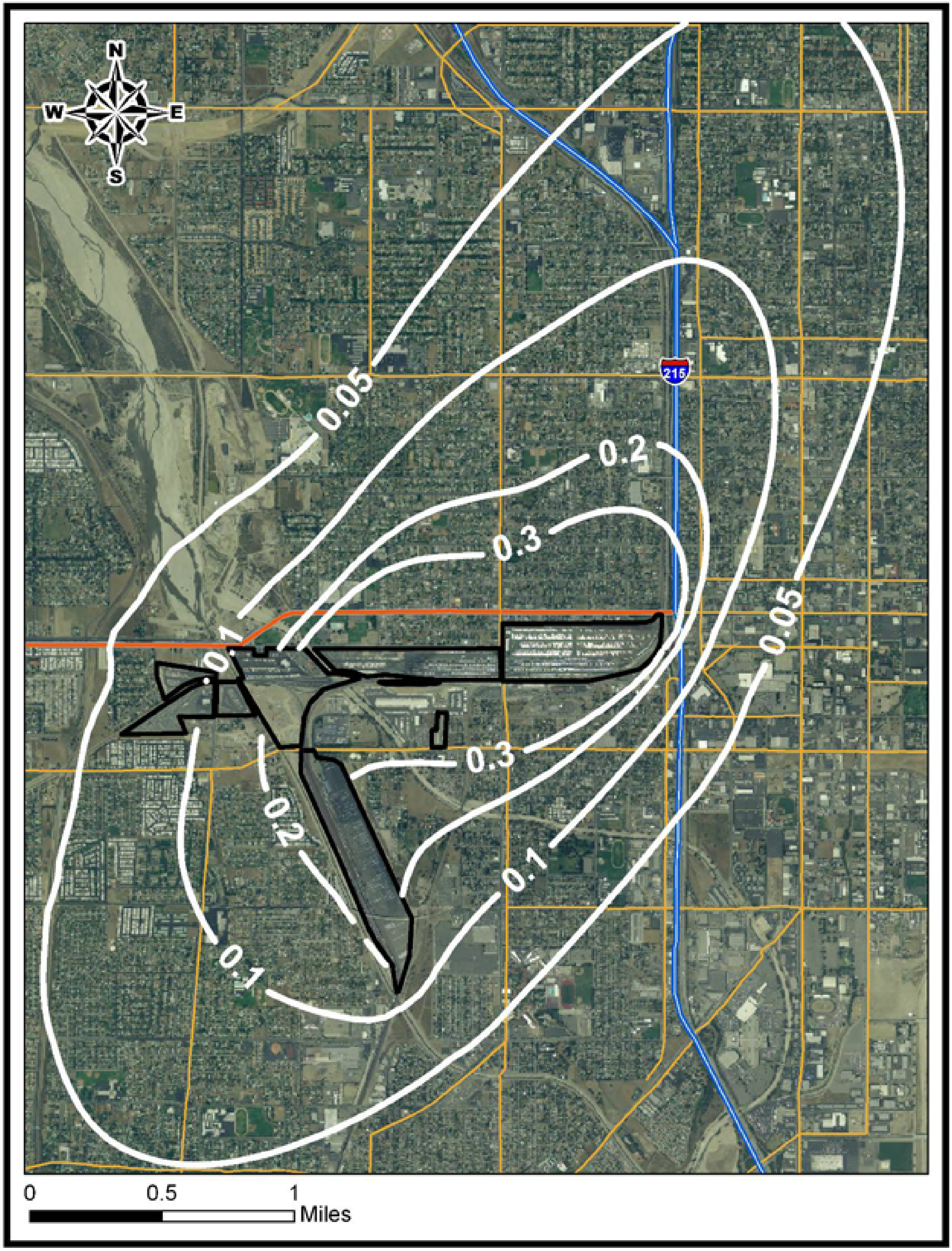
***Hazard Index**: The ratio of the potential exposure to the substance and the level at which no adverse effects are expected*.

As part of this study, ARB staff conducted an analysis of the potential non-cancer health impacts associated with exposures to the model-predicted ambient levels of directly emitted diesel PM from on-site sources within the modeling domain. The potential non-cancer chronic health risks due to the diesel PM emissions at the BNSF San Bernardino Railyard range from 0.05, at about one to one and half miles from the railyard, to 0.3 near the BNSF San Bernardino Railyard.

According to the OEHHA Guidelines (OEHHA, 2003), these levels (less than 1.0) indicate that the potential non-cancer chronic public health risks from diesel PM are less likely to occur. Due to the northwesterly prevailing wind, the coverage extends over populated areas on the west of the railyard, the average chronic risk levels are much lower than 1.0. However, according to the OEHHA Guidelines (OEHHA, 2003), the estimated hazard indices indicate that the potential non-cancer chronic health risks are less likely to occur.

Figure V-3 presents the spatial distribution of estimated non-cancer chronic risks by health hazard index isopleths that range from 0.05 to 0.3 around the yard facility. The zone of impact where non-cancer chronic health hazard indices are above 0.05 is an estimated area of 4,700 acres.

Figure V-3: Estimated Non-Cancer Chronic Risk Health Hazard Index From the BNSF San Bernardino Railyard



c) Potential Non-Cancer Acute Risk

According to the OEHHA 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 a given 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 the diesel PM 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. Acrolein is a by-product of combustion of fossil fuel. In addition, acrolein has been largely used as a chemical intermediate in the manufacture of adhesives. It also has been found in other different sources, such as fires, water treatment ponds, and tobacco smoke. 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 chemical compounds in the diesel exhaust, the concentration of acrolein has a much lower chance of reaching a distant off-site receptor. Given the multitude of activities ongoing at facilities as complex as railyards, there is a much higher level of uncertainty associated with hourly-specific emission data and hourly model-estimated peak concentrations for short-term exposure, which are essential to assess the 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. Further, 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 BNSF San Bernardino 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 11.0 tons per year from roadways and 0.2 tons per year from stationary facilities, representing emissions for 2005. The diesel PM emissions from the BNSF San Bernardino 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.

Based on the 2000 U.S. Census Bureau's data, the zone of impact of the estimated potential cancer risks above 10 chances in a million levels associated with off-site diesel PM emissions encompasses approximately 25,000 acres, where about 180,000 residents live. For comparison with the BNSF San Bernardino Railyard health risks, the same level of potential cancer risks (above 10 chances in a million) associated with railyard diesel PM emissions covers about 61,000 acres where approximately 340,000 residents live. Table V-3 presents the exposed population and area coverage size for various impacted zones of cancer risks associated with off-site diesel PM emissions.

Table V-3: Estimated Impacted Areas and Exposed Population Associated with Different Cancer Risk Levels from Off-Site Emissions Near the BNSF San Bernardino Railyard

Estimated Cancer Risk (chances per million)	Impacted Area (Acres)	Estimated Population Exposed
> 250	200	600
100 - 250	1,600	14,700
51 – 100	2,600	26,500
26 – 50	4,700	49,700
10 – 25	16,400	89,700
> 10	**25,500**	**181,200**

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

ARB staff evaluated other toxic air contaminants emissions around the BNSF San Bernardino Railyard. Among the toxic air contaminants other than diesel PM from stationary sources, benzene was identified to be a dominant cancer risk contributor and estimated at about 0.04 tons per year. According to the cancer potency factors estimated by the OEHHA Guidelines, 1,3-butadiene, carbon tetrachloride, benzene, 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 actual emissions for that compound, which gives the cancer potency weighted toxic emission as presented in Table V-4. As shown in the Table, the potency weighted toxic air contaminant emissions from stationary sources are estimated at less than 0.01 tons per year. Based on the estimated emissions, the potential cancer risks from these non-diesel toxic air contaminants are considerably lower when they are compared to the diesel PM emissions.

Table V-4: Potency Weighted Estimated Toxic Emissions from Significant Off-Site Stationary Sources Surrounding BNSF San Bernardino 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-Butadiene	0.6	0.55	0.001	**0.0006**
Benzene	0.1	0.09	0.002	**0.0002**
Carbon Tetrachloride	0.15	0.14	-	**-**
Formaldehyde	0.021	0.02	0.04	**0.0008**
Total (non-diesel PM)	**-**	**-**	**0.04**	**0.002**

ARB staff also estimated the potential cancer risk levels contributed by the use of gasoline in the South Coast Air Basin based on 2005 emission inventory. Table V-5 presents the emissions of major toxic air contaminants weighted by individual cancer potency factor. The cancer potency weighted emissions of these carcinogens from all gasoline related sources in the Air Basin are estimated at about 481 tons per year for the major risk contributors, 1,3-butadiene, benzene, formaldehyde and acetaldehyde. For gasoline-fueled vehicles only, the cancer potency weighted emissions are estimated at about 253 tons per year, or about 6% of diesel PM emissions basin wide. The potential cancer risks associated with non-diesel PM toxic air contaminants emitted from

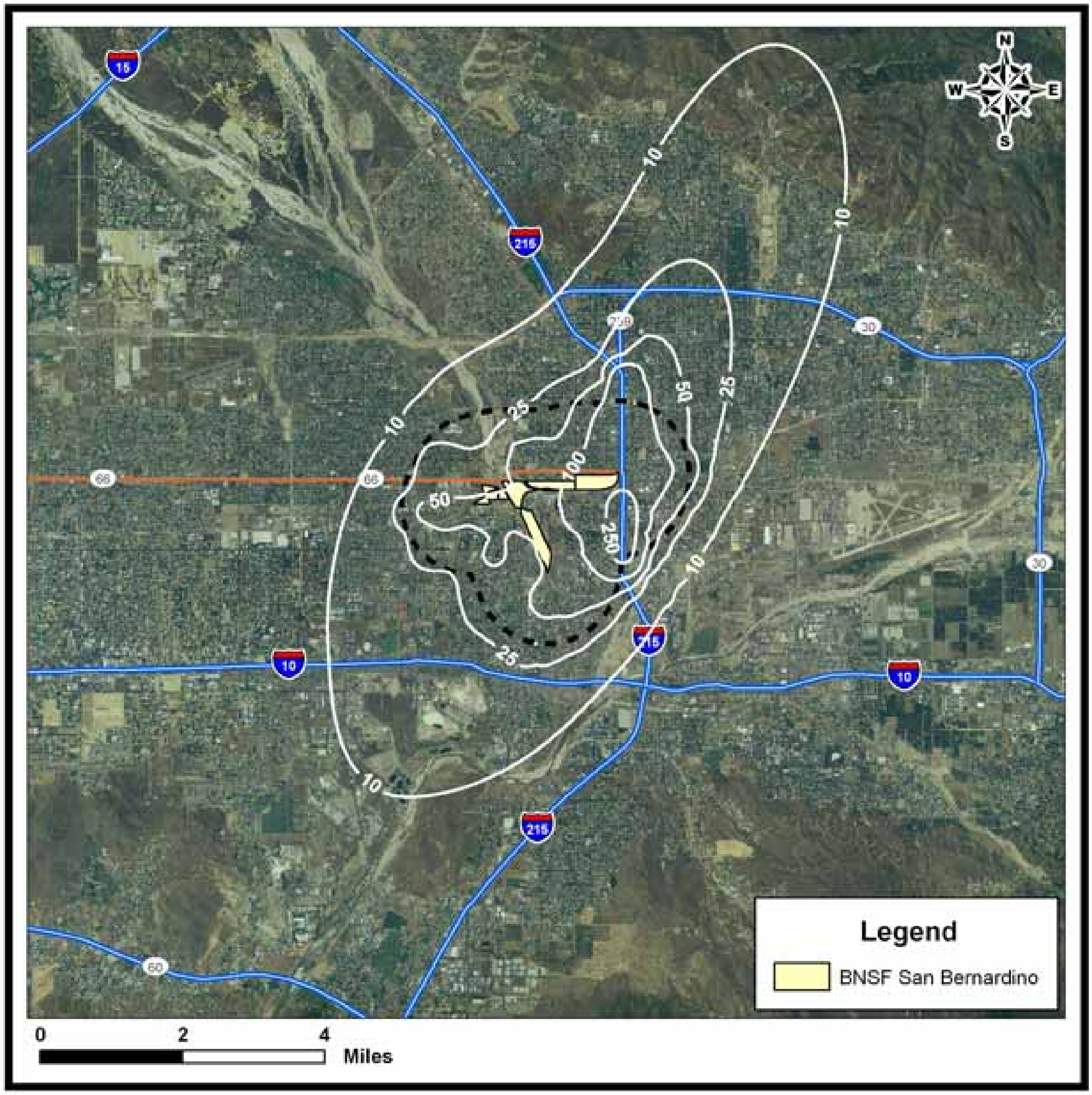
Table V-5: Emissions of Major Toxic Air Contaminants from Use of Gasoline in the South Coast Air Basin

Compound	Toxic Air Contaminant Emissions (Tons Per Year)			
	From All Sources	Potency Weighted*	From Gasoline Vehicles	Potency Weighted*
Diesel PM	7,746	**7,746**	-	-
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.

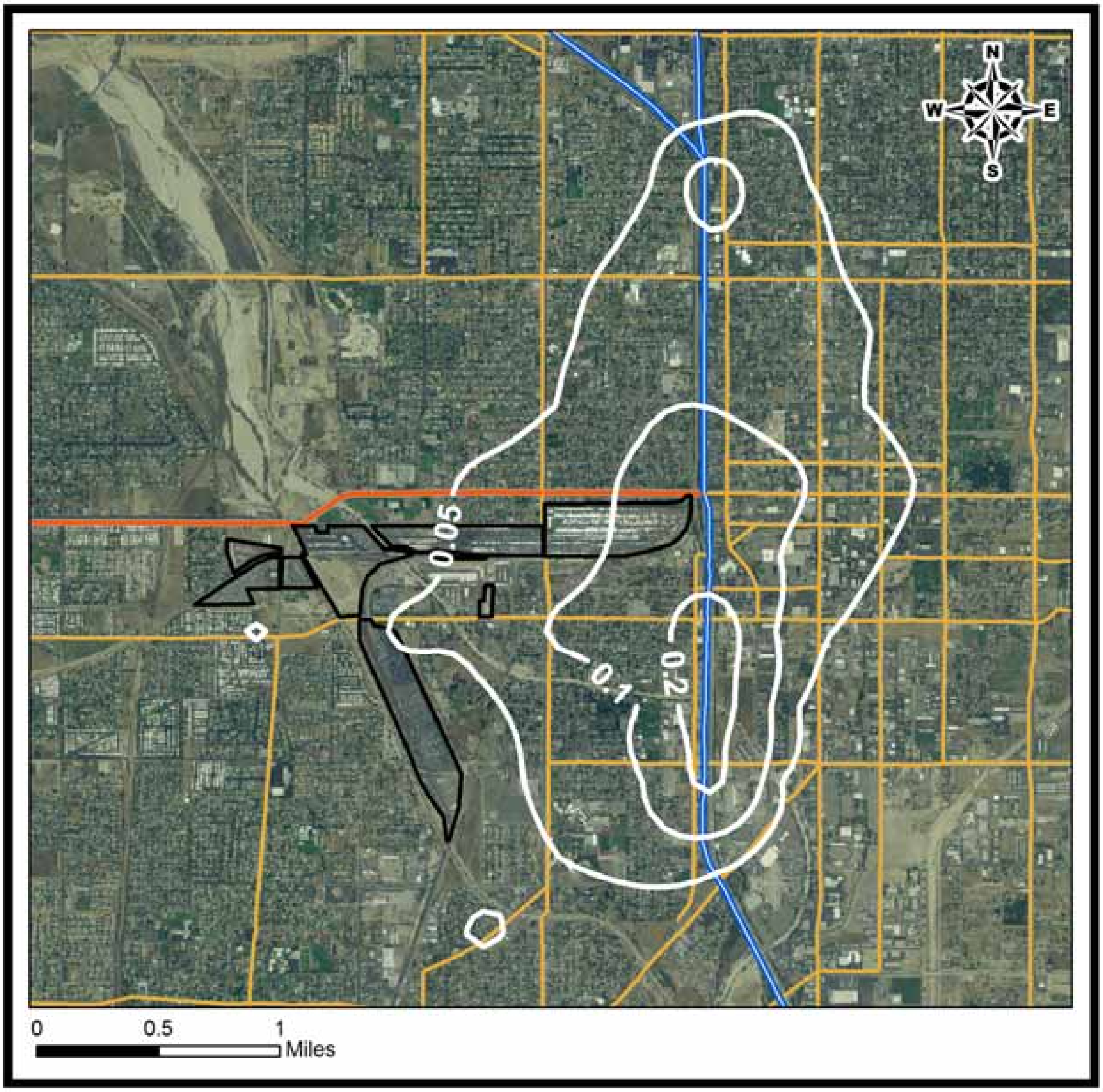
off-site gasoline vehicular sources are substantially less than the potential cancer risks associated with diesel PM emissions. Because of the risk dominance from diesel PM emissions, these air toxic contaminants are not included in the analysis of this study.

Figure V-4: Estimated Cancer Risk From Off-Site Emissions Near the BNSF San Bernardino Railyard



The estimated non-cancer chronic risks (indicated as hazard indices), from the off-site diesel PM emissions, range from about 0.05 to 0.2. The level of 0.1 to 0.2 are located generally near the major off-site diesel PM emission sources, such as I-215. All estimated hazard indices in the modeling domain area are less than 1.0; therefore, the results may suggest that the potential non-cancer chronic health risks be less likely to occur according to the OEHHA Guidelines (OEHHA, 2003).

Figure V-5: Estimated Non-Cancer Chronic Risk Levels From Off-Site Emissions Near the BNSF San Bernardino Railyard



3. *Risks to Sensitive Receptors*

Some individuals may be more sensitive to toxic exposures than the general population. These sensitive populations are identified as school-age children and seniors. The sensitive receptors include schools, hospitals, day-care centers and elder care facilities. There are 41 sensitive receptors within a one-mile distance of the BNSF San Bernardino Railyard, including 15 schools, 19 child care centers and 7 hospitals/medical centers. Table V-6 summarizes the numbers of sensitive receptors identified in different levels of estimated cancer risks based on 70-year exposure duration. The potential non-cancer chronic health risks at these sensitive receptors are found to be less than the hazard index of 1.0, and are less likely to occur.

Table V-6: Numbers of sensitive receptors within one-mile radius identified in different levels of estimated cancer risks (based on a 70-year exposure duration) associated with on-site railyard diesel PM emissions.

Estimated Cancer Risk (chances in a million)	Number of Sensitive Receptors
> 500	1
250 - 500	4
100 - 250	14
50 - 100	10
25 - 50	12
10 - 25	0
> 10	41

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 an 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*

Emissions are usually estimated by consideration of the operational activities and fuel consumption associated with emission factors based on source tests. There are some uncertainties with the emission estimates. These 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 BNSF San Bernardino 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 BNSF's electronic monitoring of locomotives entering and leaving the railyard. However, the monitoring under certain circumstances may produce duplicate readings that can result in overestimates of locomotive activity. In addition to recorded activity data, surveys and communications with facility personnel, and correlations from other existing data (e.g., from the *Roseville Railyard Study* (ARB, 2004a)), all were used to verify the emission estimations in the emission inventory.

Uncertainties also exist in estimates of the engine time in mode. Idling is typically the most significant operational mode, but locomotive event recorder data 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 BNSF's annual fuel consumption database.

[§] 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.

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 intra-species 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 [1.3×10^{-4} to 2.4×10^{-3} $(\mu g/m^3)^{-1}$] and a risk factor of 3×10^{-4} $(\mu g/m^3)^{-1}$, as a reasonable estimate of the unit risk. From the unit risk factor an inhalation cancer potency factor of 1.1 $(mg/kg\text{-}day)^{-1}$ can be calculated, which is used in the study. There are many epidemiological studies that support the finding that diesel exhaust exposure elevates relative risk for lung cancer. However, the quantification of each uncertainty applied in the estimate of cancer potency is very difficult and can be itself uncertain.

This study adopts the standard Tier 1 approach recommended by 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 80th 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 (DTIM). To enhance the spatial resolution we have estimated emissions based on roadway specific vehicle activity data and allocated them to individual roadway links. All roadway links within a 1-mile buffer of the BNSF San Bernardino Railyard were included in this assessment.

As more and 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 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 (TDMs) 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, TDMs estimate vehicle population and activity estimates such as speed and vehicle miles traveled (VMT) 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

The methodology for estimating emissions from on-road mobile sources outside the rail yards 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 A-1) where speed-specific VMT is then matched to an emission factor from EMFAC-2007 (v2.3) to estimate total emissions from each vehicle type for each hour of the day.

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 (VMT), where VMT 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 (SCAG)[**] Heavy Duty Truck Transportation Demand Model. Heavy duty truck activity is modeled using truck specific data, commodity flows and goods movement data. SCAG, however, is the only MPO with a heavy duty truck model. The remaining counties under the rail yard study are covered by the Integrated Transportation Network (ITN) 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 ITN 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 is then compiled into an activity matrix (Table A-2) composed of a link identification code, hour of the day, speed, 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. Due to difficulty in determining weight fractions on all

[**] SCAG Transportation Modeling, http://www.scag.ca.gov/modeling/ [accessed January 2007].
[††] 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

roadways, the county average was used. However, because railyards are commonly located in industrial areas one would expect higher diesel truck fractions near the railyards. Thus, the diesel PM emissions near the railyards are also expected to be relatively higher than other areas.

Table A-2 Activity matrix example

LINK I. D.	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. Emission factors are based on test cycles that reflect typical driving patterns, and non-extended idling is included.

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 A-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 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 DPM/mile. In order to estimate total emissions from HHDDTs on that link during that hour of the day the following calculation is made:

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

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

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 rail yards were checked against traffic volumes on the links residing by the gates.

LIMITATIONS AND CAVEATS

We have made several important assumptions in developing this inventory. While these assumptions are appropriate at the county level they may be less appropriate 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. In the vicinity of significant heavy heavy-duty truck trip generators, it is reasonable to expect that surrounding links will also have higher heavy heavy-duty truck fractions. In these cases, using EMFAC county vehicle mix fractions may underestimate the total diesel particulate emissions from on-road heavy duty trucks. In this inventory, EMFAC county defaults were employed as there is insufficient data available to assess the vehicle mix fractions surrounding the railyards.

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. 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 off-road equipment, extended idling, starts, and off-road equipment outside the rail yards were excluded. Vehicle activity from distribution centers, rail yards and ports, however, are included as they are captured on the roadway network by the travel demand models.

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

SUMMARY OF AIR DISPERSION MODELING RESULTS FROM OFF-SITE DIESEL PM EMISSIONS

Impacts from off-site pollution sources near the BNSF San Bernardino railyard facility were modeled using the USEPA-approved AERMOD dispersion model version 07026. Specifically, off-site mobile and stationary diesel PM (DPM) emission sources located out to a distance of one mile from the perimeter of the BNSF San Bernardino rail yard were included.

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

Table C-1. Data Provided by Others for Off-Site Emission Source Modeling.

Type of Data	**Description**	**Data Source**
Emission Estimates	Off-site DPM emissions for 2005 Mobile Sources: 10.7 TPY DPM Stationary Sources: 0.2 TPY DPM	PTSD/MSAB
Receptor Grid	48x46 Cartesian grid covering 528.75 km^2 with uniform spacing of 500 meters. Grid origin: (458650, 3761800) in UTM Zone 11.	ENVIRON
Meteorological Data	AERMET-Processed data for 2005-2006 *Surface*: San Bernardino-4th St. and March AFB *Upper Air*: San Diego Miramar	ENVIRON
Surface Data	Albedo: 0.14 to 0.18 Bowen Ratio: 0.88 to 3.96 Surface Roughness: 0.81 to 0.98	ENVIRON

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 rail yard model runs, as indicated in the table above.

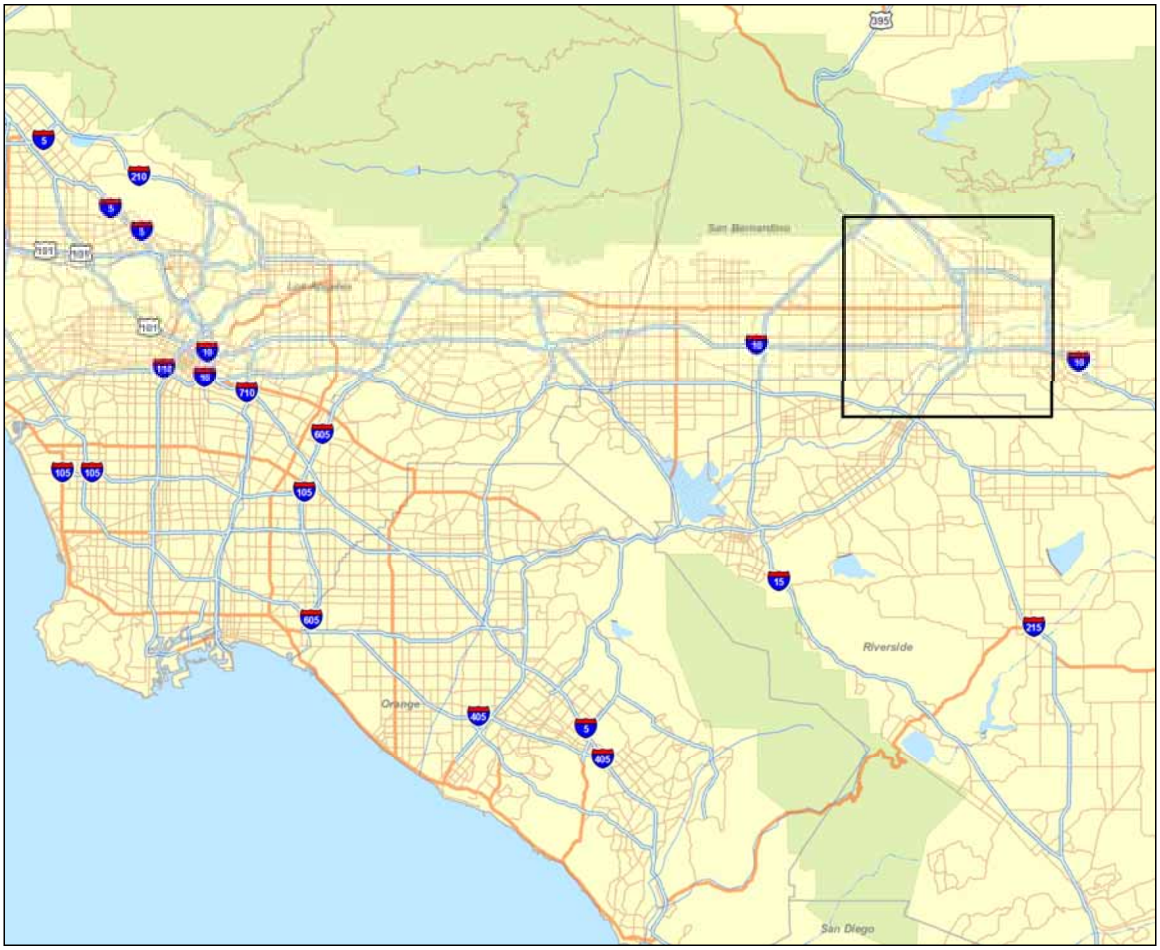

Figure C-1: Region surrounding the BNSF San Bernardino rail facility with the modeling domain indicated by the black outline.

Figure C-1 illustrates the region surrounding the BNSF San Bernardino modeling domain. The domain has dimensions 23.5 km x 22.5 km and contains a grid of 2208 receptors with a 500 meter uniform grid spacing.

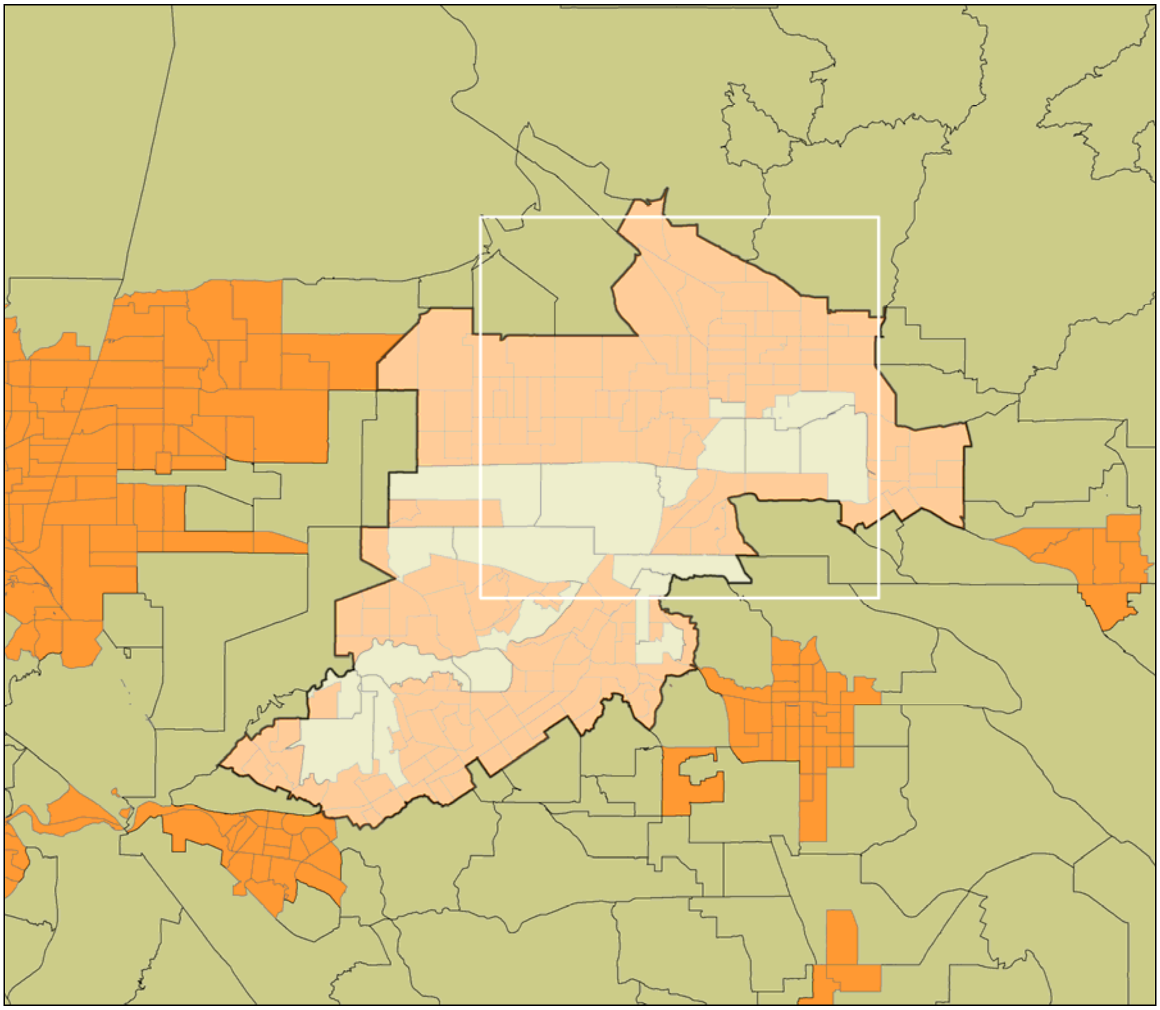

Figure C-2: BNSF San Bernardino Urban Population: Orange denotes areas with at least 750 people/km^2. The highlighted region is the contiguous urban area used for modeling purposes.

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 BNSF San Bernardino model domain is in a region with considerable urbanization. The continuous urban area selected can be seen in Figure C-2. The population in this selected area is 999,687.

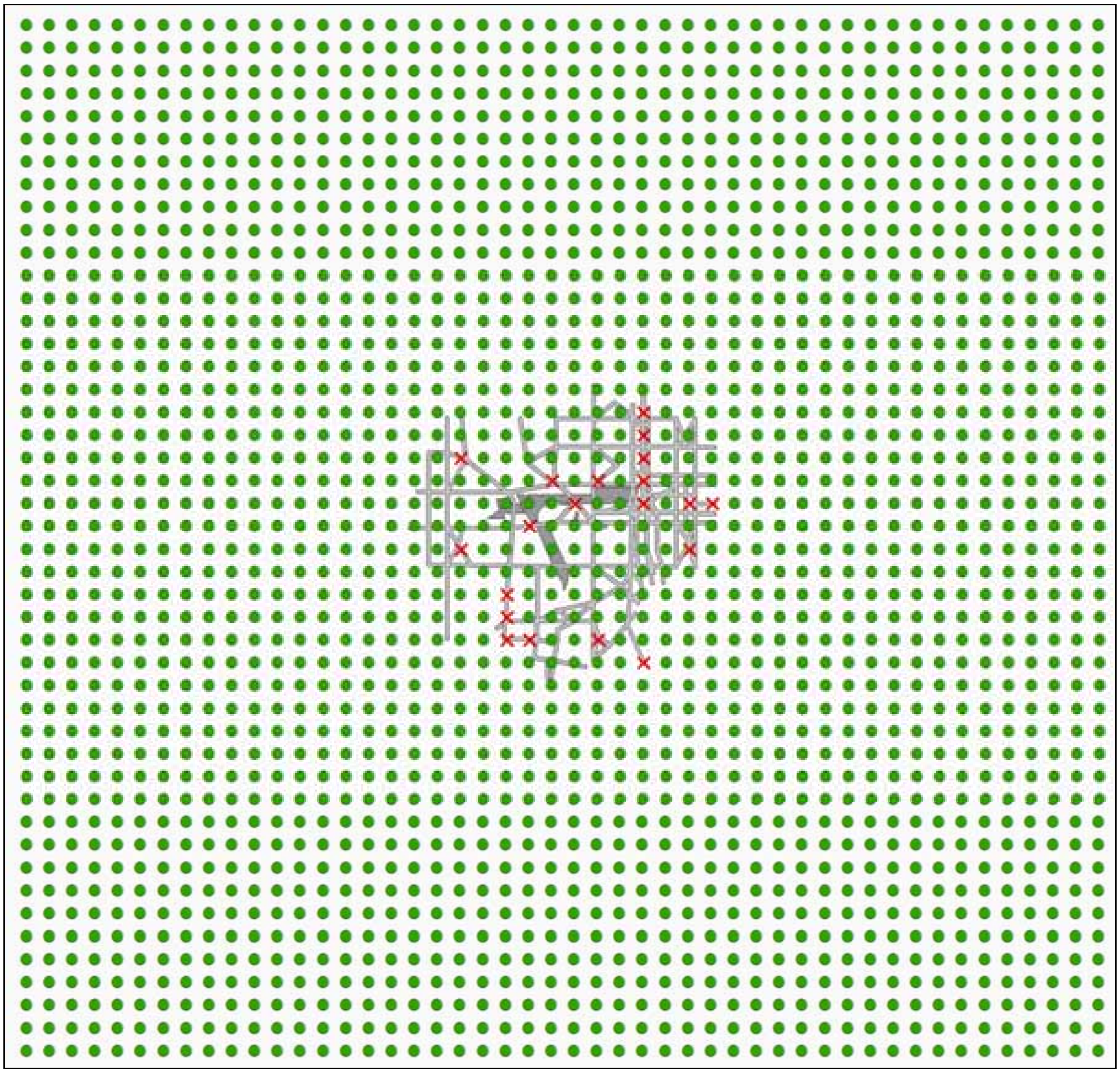

Figure C-3: BNSF San Bernardino receptor network including off-site sources and rail facility

The off-site stationary and on-road emission sources used in the BNSF San Bernardino model runs are plotted along with the receptor network in Figure C-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 rail yard facility. Diesel PM off-site emissions used in the off-site modeling runs consisted of 10.7 tons per year from roadways and 0.2 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 23.5 km x 22.5 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 C-3. After removal, 2188 of the original 2208 receptors remained.

The same meteorological data used by ENVIRON were used for the off-site modeling runs. The data were compiled by ENVIRON from the nearby 4th Street Station (34.11°N, 117.27°W) and March Air Force Base (32.82°N, 117.12°W). Upper air data for the same time period were obtained from the San Diego Miramar upper air station (32.83°N, 117.12°W). The model runs used two years of meteorological data from 2005 through 2006.

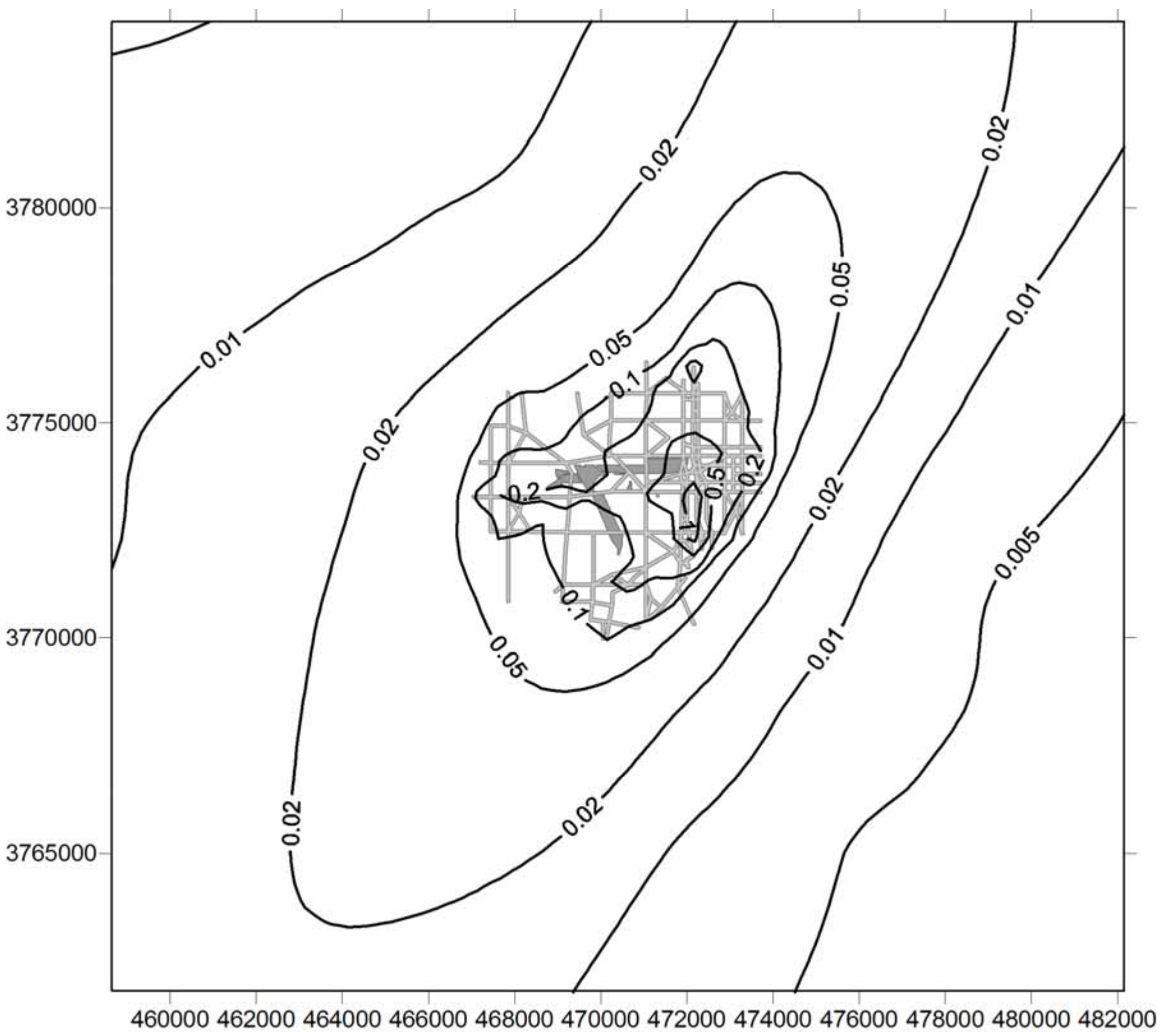

Figure C-4: BNSF San Bernardino off-site sources and rail yard with modeled annual average concentrations from off-site sources in ug/m^3

Figure C-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 C-2.

Table C-2: BNSF San Bernardino maximum annual concentrations in ug/m^3

X	Y	Mobile	Stationary	Total Off-site
472150	3773300	1.359	0.009	1.368
472150	3772800	1.246	0.007	1.252
472150	3772300	1.146	0.004	1.150
472150	3776300	0.672	0.002	0.674
471650	3773300	0.601	0.044	0.644

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APPENDIX D

TABLES OF LOCOMOTIVE DIESEL PM EMISSION FACTORS

Locomotive Diesel PM Emission Factors (g/hr) 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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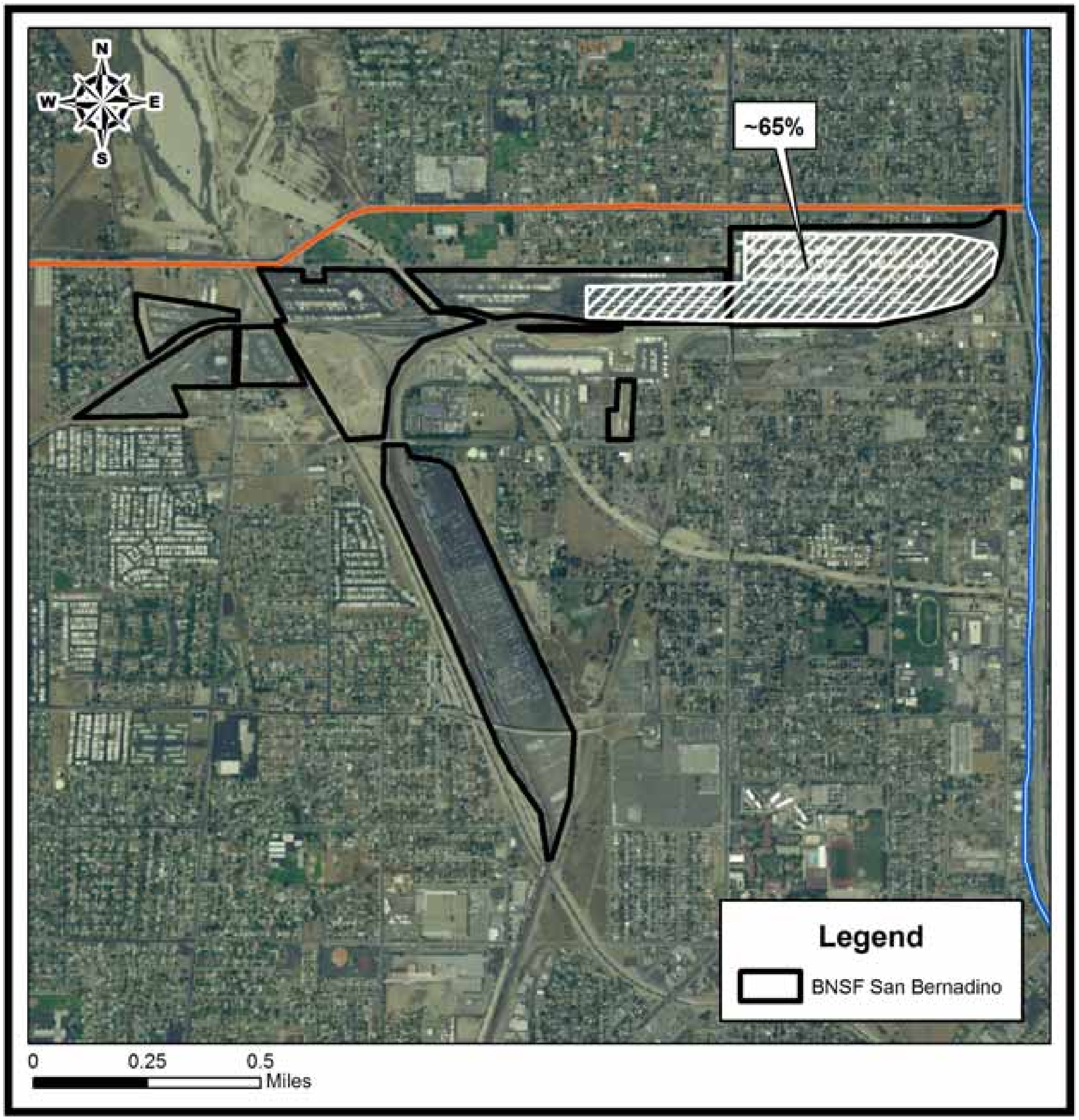
APPENDIX E

SPATIAL ALLOCATIONS OF MAJOR DIESEL PM EMISSION SOURCES AT BNSF SAN BERNARDINO RAILYARD

Facility-wide Diesel PM Emissions at BNSF San Bernardino Railyard



Note: According to the emission inventory, about 65% of the facility-wide emissions at the BNSF San Bernardino Railyard occur in the “A” yard, as show in the figure. The activity includes yard operations due to switch locomotives and cargo handling equipment, as well as pass through and arriving and departing trains accounting for about 14 tons per year of diesel PM emissions.

Figure E-1: Spatial Allocation of Locomotive Diesel PM Emissions at BNSF San Bernardino Railyard

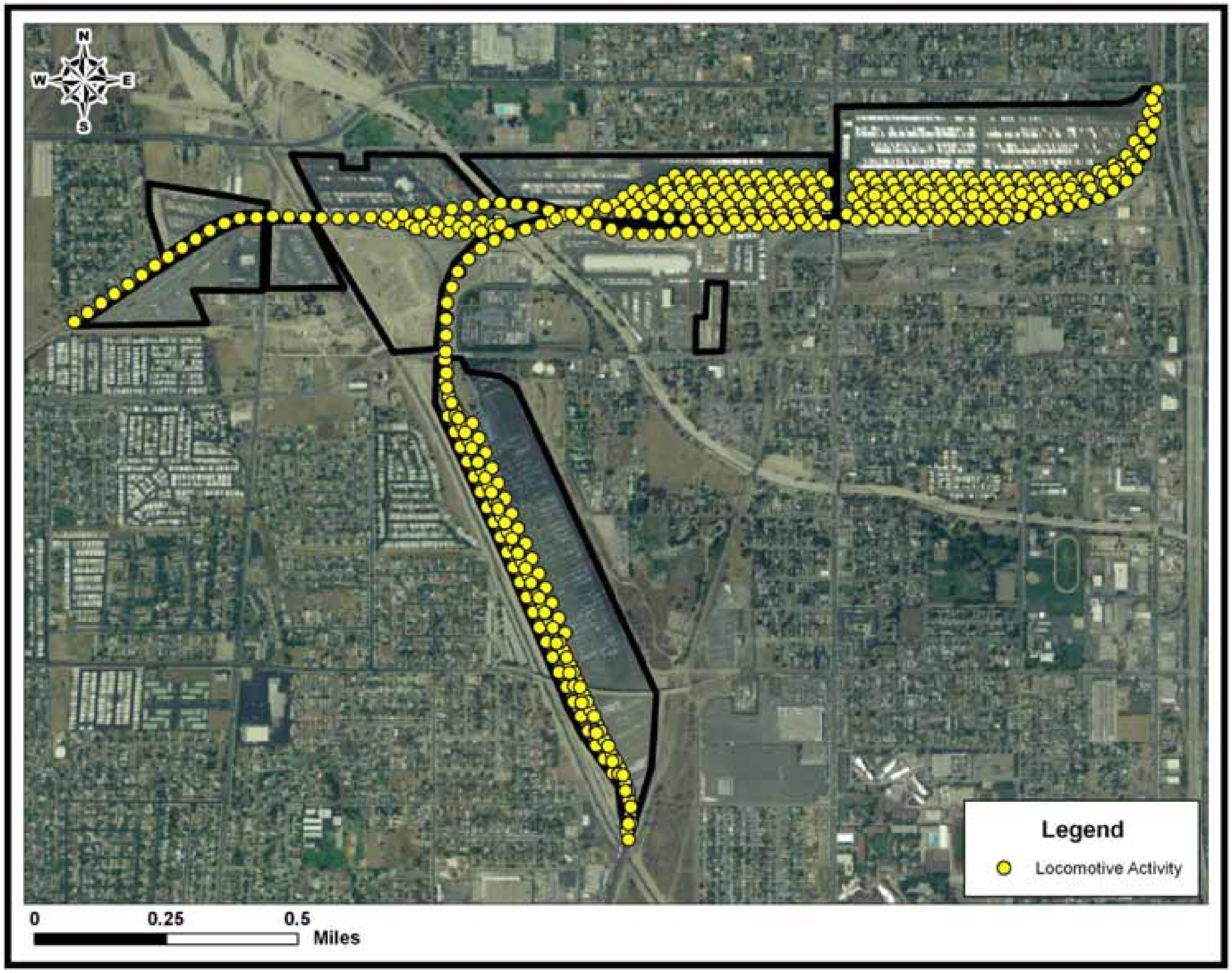


Figure E-2: Spatial Allocation of Cargo Handling Equipment Diesel PM Emissions at BNSF San Bernardino Railyard

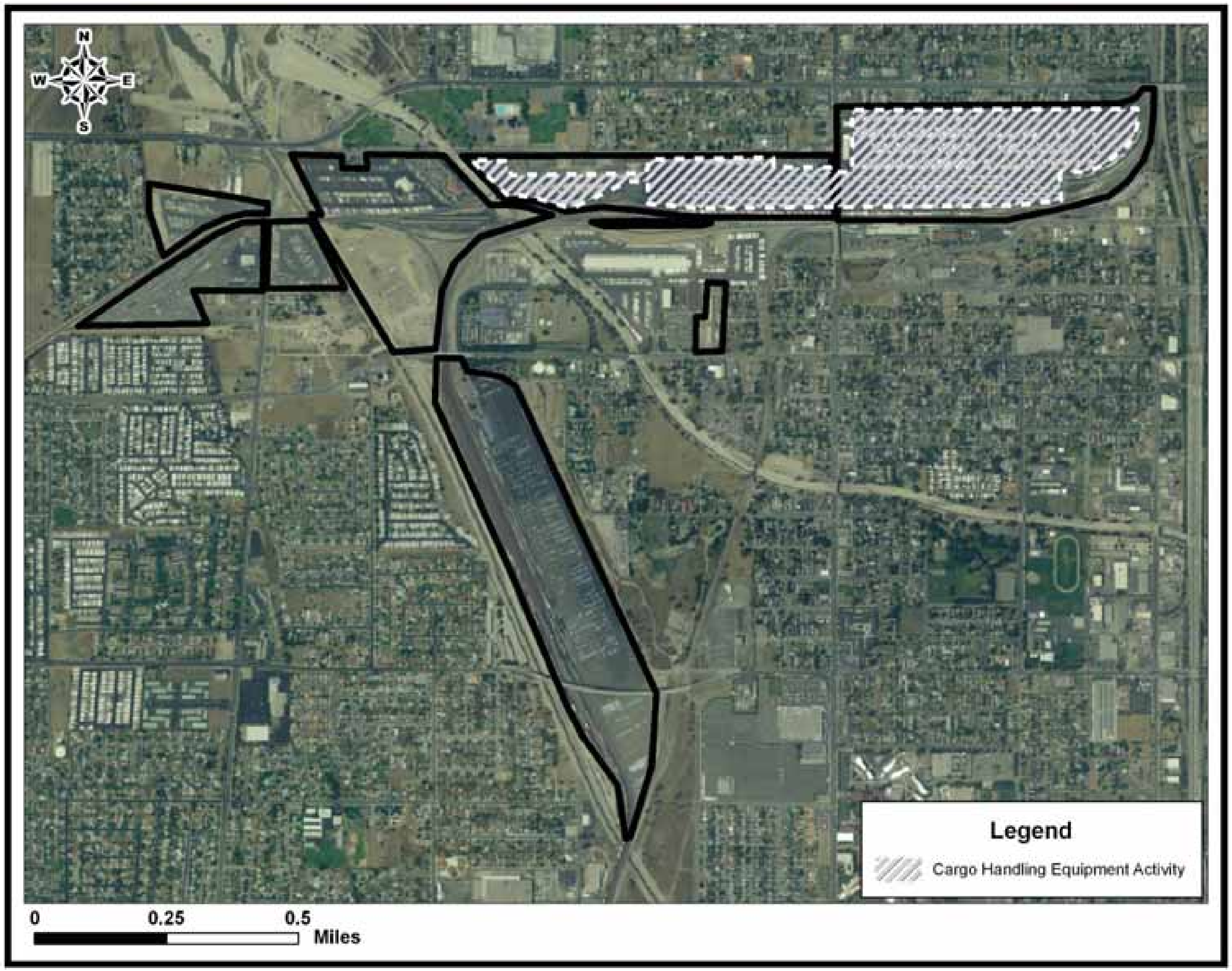
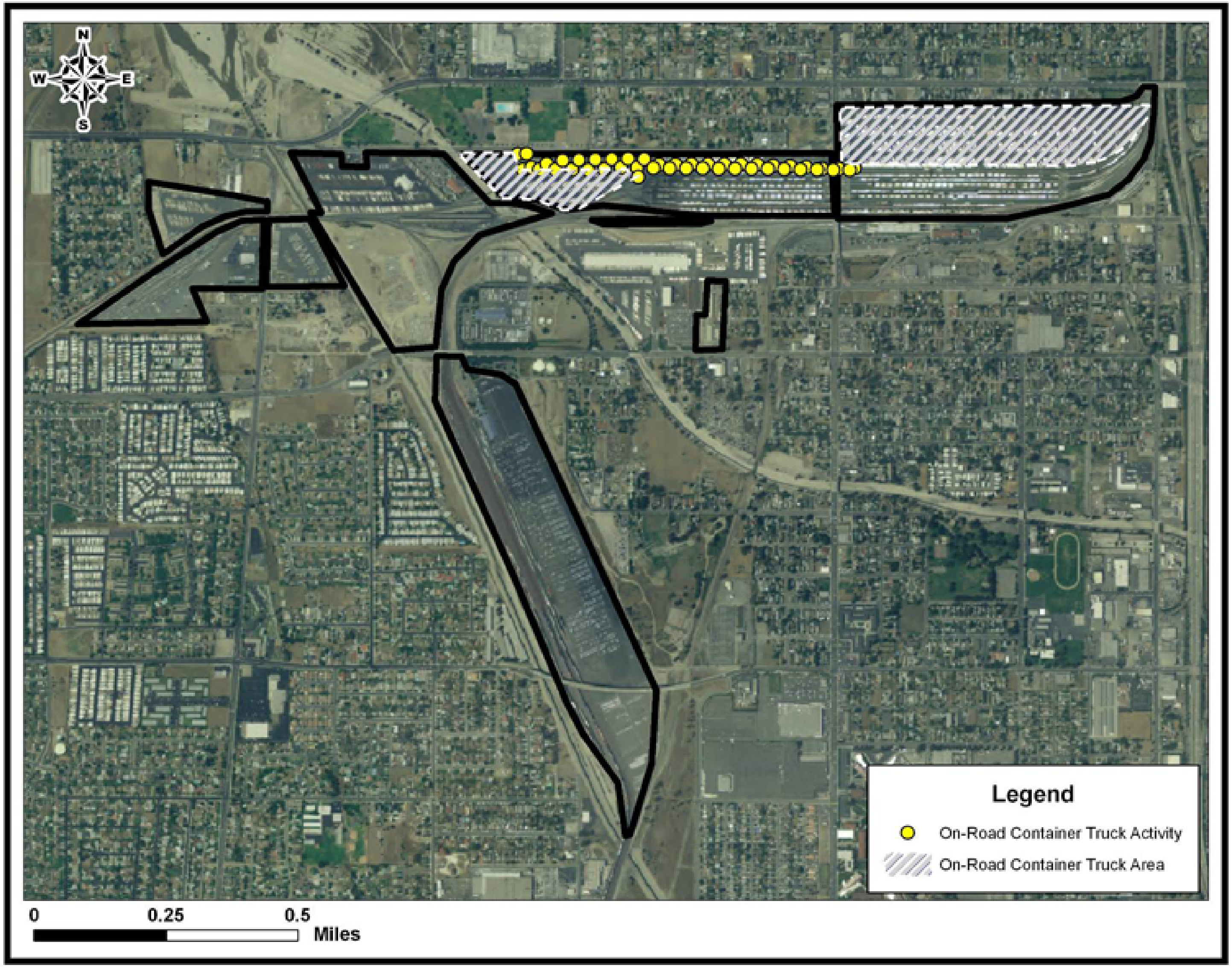


Figure E-3: Spatial Allocation of On-Road Container Truck Diesel PM Emissions at BNSF San Bernardino Railyard



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APPENDIX F

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

Figure F-1: 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.

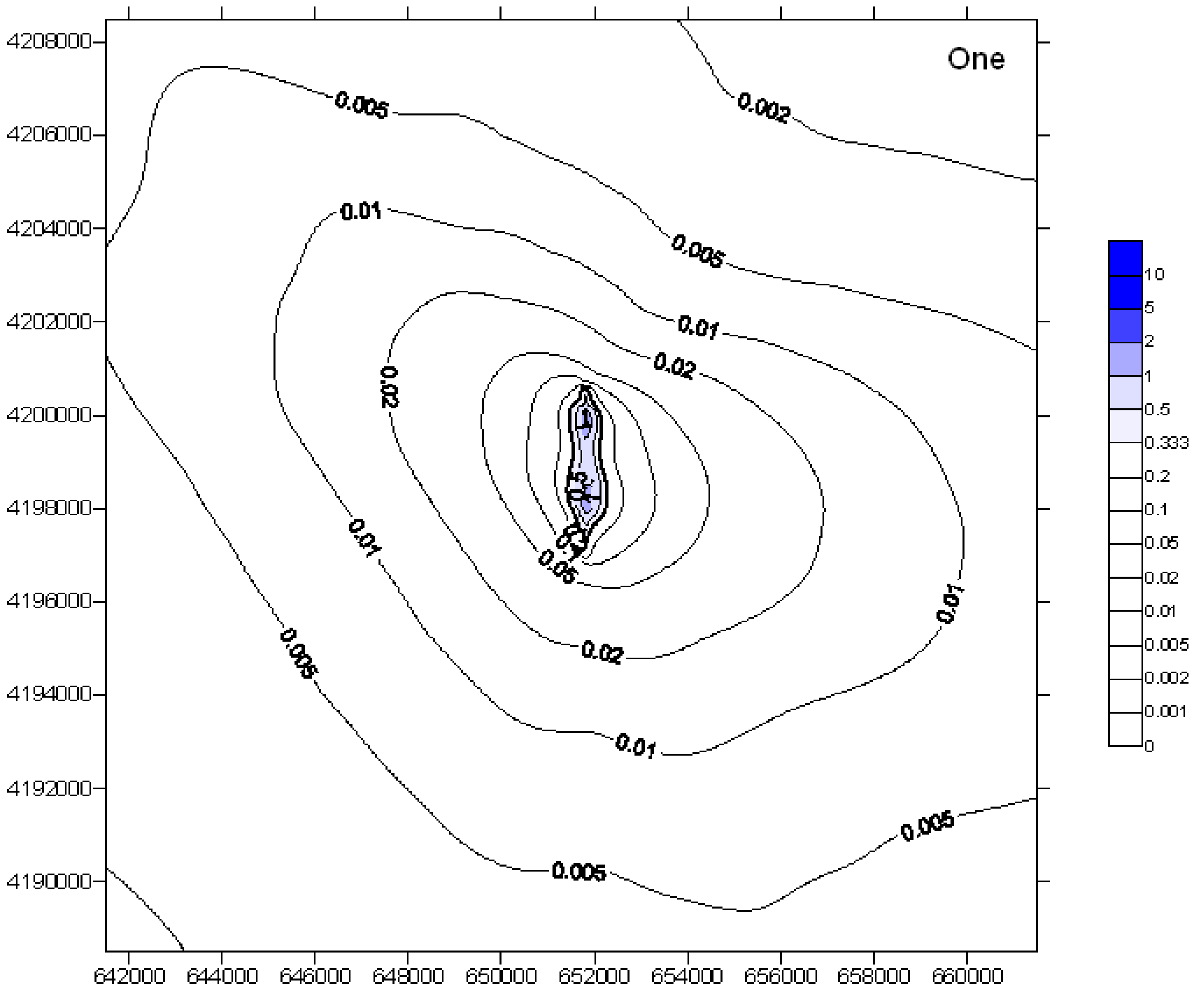

Figure F-2: AERMOD's Simulated Diesel PM Concentrations (due to On-site and Off-site Diesel PM Emissions) around UP Stockton Railyard Using Five-year Meteorological Data.