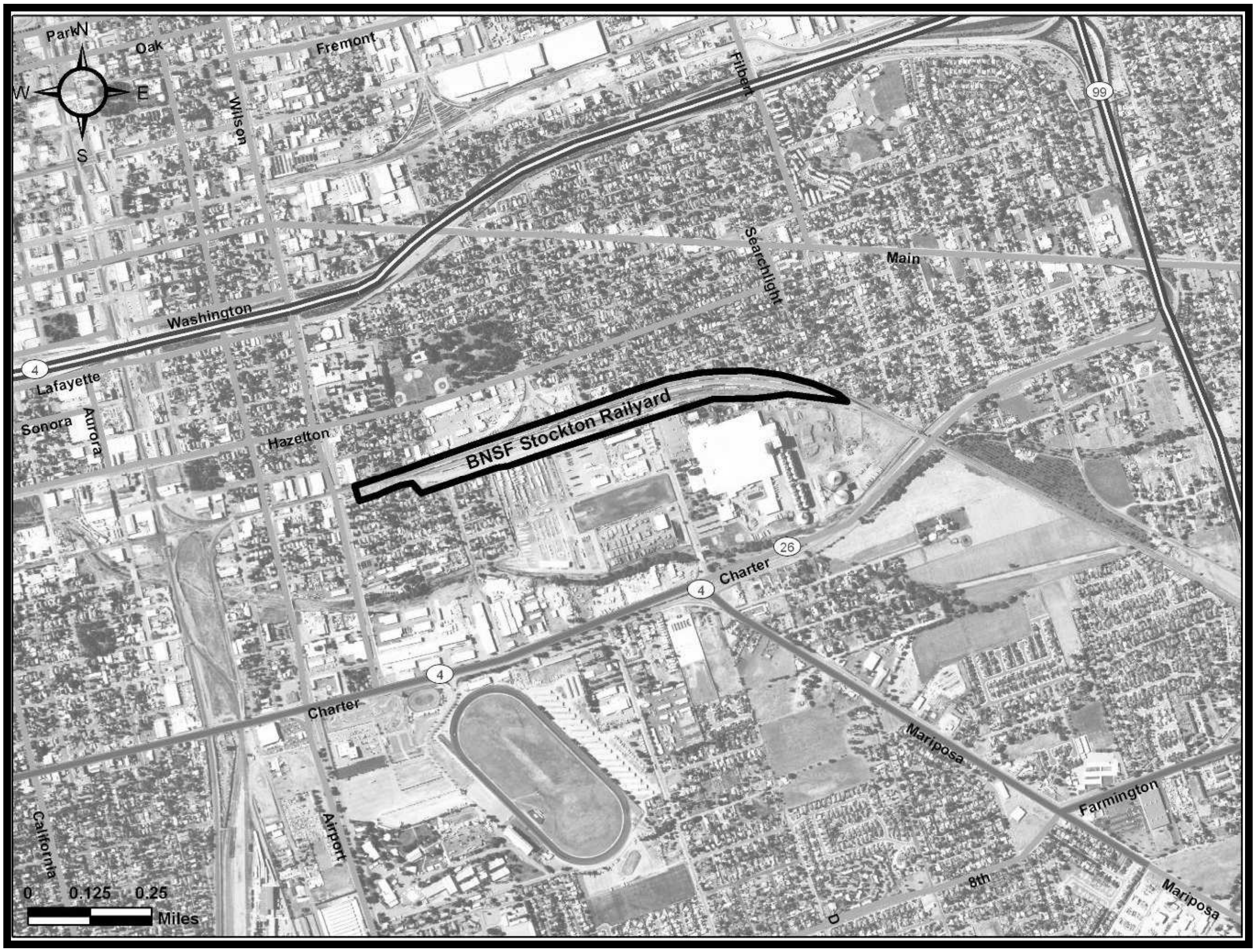
California Environmental Protection Agency

Air Resources Board

Health Risk Assessment for the BNSF Railway Stockton Railyard



Stationary Source Division
Release Date: November 19, 2007

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Principal Author
Chan Pham

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

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

Reviewed by

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

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

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Acknowledgements

Air Resources Board staff extends its appreciation to the representatives of BNSF Railway and their consultants, ENVIRON International Corporation, for preparing the railyard emissions inventory data and spatial allocation of emissions.

BNSF Railway:
Mark Stehly, Michael Stanfill

ENVIRON International Corporation:
David Souten, Dr. Christian Lindhjem, Dr. Till Stoeckenius,
Dr. Douglas Daugherty, Dr. Robert Scofield

San Joaquin Valley Air Pollution Control District:
Leland Villalvazo

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I. INTRODUCTION

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

A. Why is ARB concerned about diesel PM emissions?

In 1998, ARB identified particulate matter from diesel exhaust (diesel PM) as a toxic air contaminant based on its potential to cause cancer and other adverse health problems, including respiratory illnesses, and increased risk of heart disease. Subsequent research has shown that diesel PM contributes to premature death[1] (ARB, 2002). Exposure to diesel PM is a health hazard, particularly to children whose lungs are still developing and the elderly who may have other serious health problems. In addition, the diesel PM particles are very small. Approximately 94 percent of the mass of these particles are less than 2.5 microns in diameter ($PM_{2.5}$). Because of their tiny size, diesel PM particles are readily respirable and can penetrate deep into the lung and enter the bloodstream, carrying with them an array of toxins. Population-based studies in hundreds of cities in the U.S. and around the world demonstrate a strong link between elevated PM levels and premature deaths (Pope et al., 1995, 2002 and 2004; Krewski et al., 2000), increased hospitalizations for respiratory and cardiovascular causes, asthma and other lower respiratory symptoms, acute bronchitis, work loss days, and minor restricted activity days (ARB, 2006e).

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

B. Why evaluate diesel PM emissions at the BNSF Stockton 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). This Agreement was developed to implement near term measures to reduce

[1] 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.

diesel PM emissions, and the potential for elevated cancer risks, in and around California railyards by approximately 20 percent.

The Agreement requires that health risk assessments 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 ARB's 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 (available at http://www.arb.ca.gov/railyard/hra/hra.htm) (ARB, 2006b). The BNSF Stockton Railyard is one of the designated railyards subject to the Agreement and the HRA requirements.

C. What are Health Risk Assessments (HRAs)?

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

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

- For potential cancer health effects, the risk is usually expressed as the number of chances in a population of a million people. The number may be stated as "10 in a million" or "10 chances per million". The methodology used to estimate the potential cancer risks is consistent with the Tier-1 analysis of *Air Toxics Hot Spots Program Risk Assessment Guidelines* (OEHHA, 2003). A Tier-1 analysis assumes that an individual is exposed to an annual average concentration of a given pollutant continuously for 70 years. The length of time that an individual is exposed to a given air concentration is proportional to the risk. Children, however, are impacted more during the childhood period. 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)[2] is used to predict if there will be certain identified adverse health effects, such as lung irritation, liver damage, or birth defects. These adverse health effects may happen after chronic (long-term) or acute (short-term) exposure. To calculate a non-cancer health risk number, the REL is compared to the concentration that a person is exposed to and a "hazard index" (HI) is calculated. Typically, the greater the hazard index is above 1.0, the greater the potential for possible adverse health effects. If the hazard index is less than 1.0, then it is an indicator that adverse effects are less likely to happen.

- For premature deaths linked to diesel PM in the San Joaquin Valley Air Basin (SJV), ARB staff estimated about 160 deaths per year due to diesel exhaust exposure in 2000. In the same year, the total diesel PM emissions from all sources in the SJV Air Basin were about 4,500 tons per year (ARB, 2006a). All locomotives diesel PM emissions were estimated to be about 270 tons per year, or less than 7% of the total diesel PM emissions in the basin. Of the total Air Basin locomotive diesel PM emissions, both the UP and BNSF Stockton railyards combined are about 10 tons per year in 2005.

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

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 assessments are often designed to be conservative on the side of health protection in order to avoid underestimation of risk to the public. As indicated by the OEHHA Guidelines, the Tier-1 evaluation is useful in comparing risks among a number of facilities and similar sources.

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

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. In addition, the HRA results are best used to compare potential risks to target levels to determine the level of mitigation needed. They are also an effective tool for determining the impact a particular control strategy will have on reducing risks.

OEHHA is in the process of updating the current health risk assessment guidelines and the ARB and UP and BNSF agreed to evaluate the non-cancer health impacts using an interim methodology. This was used in the Diesel Particulate Matter Exposure Assessment Study for the Ports of Los Angeles and Long Beach (ARB, 2006d) to estimate PM mortality. This will serve as a short-term and interim effort until OEHHA can complete its update of the Guidelines.

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

D. Who prepared the BNSF Stockton 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 *Rail Yard Emissions Inventory Methodology* (ARB, 2006c), and *Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006d), provide guidelines for the identification, modeling, and evaluation of the toxic air contaminants (TACs) from Designated Railyards throughout California.

Using the guidelines, the railroads and their designated consultants (i.e., ENVIRON Corporation for the BNSF Stockton Railyard) were responsible for developing the emission inventories and performing the air dispersion modeling for operations that occurred within each of the designated railyards. The base year for the analysis was 2005.

ARB staff was responsible for reviewing and approving the railroads' submittals, identifying significant sources of emissions near the railyards, and preparing the railyard health risk assessments. ARB staff is also responsible for releasing the draft HRAs to the public for comment and presenting them at community meetings. After reviewing public comments on the draft HRAs, ARB staff made revisions as necessary and appropriate, and is now releasing the HRAs in the final form. Ultimately, the information derived from the railyards HRAs is to be used to identify potential mitigation measures to further reduce railyard emissions and public health risks.

E. How is this report structured?

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

II. SUMMARY

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

A. General Description of the BNSF Stockton Railyard

The BNSF Stockton Railyard, located at 720 South “B” Street, Stockton, California, is a long narrow, strip of land about 200 yards wide by over one-mile long, and compasses about 100 acres. The railyard is located about two miles south of downtown Stockton (see Figure II-1). Within the boundary there is about 16 miles of rail tracks. The areas surrounding the BNSF Stockton Railyard include commercial properties (north of the railyard) and residential communities (northeast, northwest and southwest of the center of the railyard), and some small businesses and warehouses (south of the railyard).

The BNSF Stockton Railyard is surrounded by three major roadways: State Highway 4 about half mile to the north, State Highway 99 about half mile to the east, and Interstate 5 about less than two miles to the west of the railyard.

The BNSF Stockton Railyard is also located nearly 2 miles northeast of the UP Stockton Railyard (Please note that the UP Stockton Railyard HRA report is being prepared on a similar schedule as the BNSF Stockton Railyard, and both will be presented for public review at about the same time). Both the Stockton Metropolitan Airport and UP Lathrop Intermodal Rail Facility are located about three and six miles, respectively south of the BNSF Stockton railyard. The BNSF Stockton Intermodal Rail Facility is located about 6 miles south and east of the BNSF Stockton railyard. None of the other facilities are part of this study, other than UP and BNSF Stockton Railyards.

B. What are the primary operations at the BNSF Stockton Railyard?

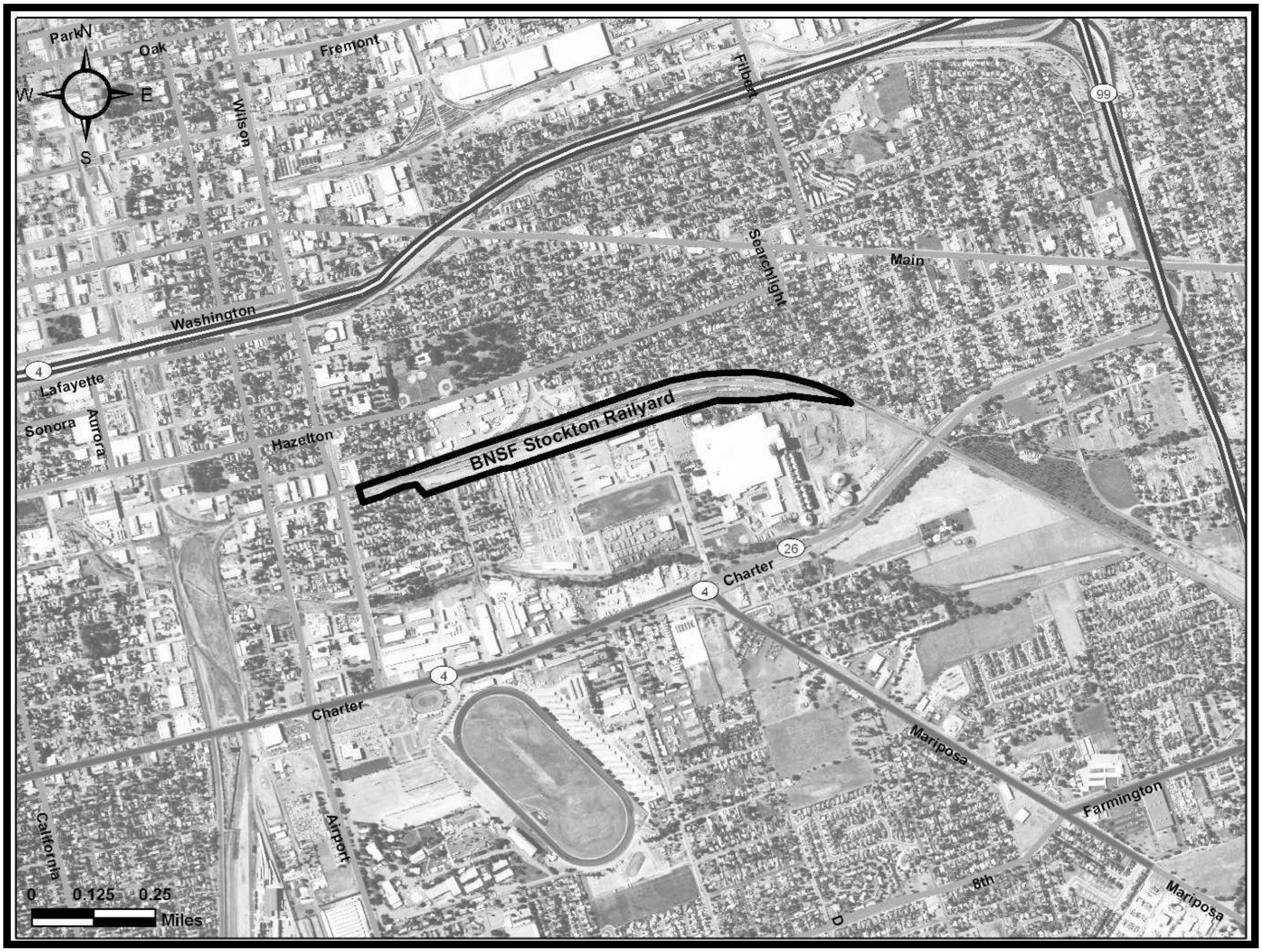
The BNSF Stockton Railyard supports freight train operations on a classification yard on the south of the railyard, and the AMTRAK commuter trains and freight services moving on the adjacent lines located just north of the railyard.

Freight operations at the classification yard include locomotive line haul, switching locomotive, moving freight, building and departing outbound trains, performing basic locomotives service and refueling. The site had supported an intermodal function prior to 2003, but was since shutdown and moved to the new BNSF Intermodal Railyard located further southeast. Short line and other trains arrive and depart from this site, which is along a busy mainline route.

The BNSF Stockton Railyard also has the commuter rail operations from AMTRAK moving through on the adjacent main lines. The fleet characteristics and the diesel PM emissions of these operations are also considered as part of this study.

The facilities within the railyard include classification tracks (contains about 12 parallel rail lines), a locomotive service track, a locomotive maintenance shop, a transport refrigeration units (TRUs) on boxcars and on shipping containers, and off-road track maintenance equipment. There are no stationary sources permitted inside the railyard. A fleet of twenty gasoline powered light duty on-road trucks operate within the railyard to support a variety of operational activities.

Figure II-1: BNSF Stockton Railyard and Surrounding Areas



C. What are the diesel PM emissions in and around the BNSF Stockton Railyard?

In 2005, total diesel PM emissions in and around the BNSF Stockton Railyard are estimated to be about 13.6 tons per year. Off-site sources within one-mile generated about 10 tons per day diesel PM emissions (or about 74% of the total) while railyard sources emitted about 3.6 tons per year (or about 26% of the total).

To provide a perspective on the railyards diesel PM emissions, Table II-1 lists the estimated diesel PM emissions (for the year of 2005) for the eleven railyards railyards whose HRAs are completed or planned to be completed at the beginning of 2007. The diesel PM emissions from the BNSF Stockton Railyard rank eighth among these eleven railyards.

Table II-1: Comparison of Diesel PM Emissions from Eleven Railyards (tons per year)

Railyards	Locomotives	Cargo Handling Equipment	On-Road Trucks	Others (Off-Road Equipment, TRUs, Stationary Sources, etc.)	Total ***
UP Roseville*	25.1**	n/a	n/a	n/a	**25.1**
BNSF Hobart	5.9	4.2[†]	10.1	3.7	**23.9**
UP Commerce	4.9	4.8[†]	2.0	0.4	**12.1**
UP LATC	3.2	2.7[†]	1.0	0.5	**7.3**
UP Stockton	6.5	n/a	0.2	0.2	**6.9**
UP Mira Loma	4.4	n/a	0.2	0.2	**4.9**
BNSF Richmond	3.3	0.3	0.5	0.6	**4.7**
BNSF Stockton	3.5	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, 2004) 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 tons per year.*
**** Numbers may not add precisely due to rounding*

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

1. Railyard

BNSF Stockton Railyard emission sources include, but are not limited to locomotives, TRUs, off-road track maintenance equipment, and a fleet of twenty gasoline-powered trucks. The facility operates 24 hours per day, 365 days per year. The railyard emissions were calculated on a source-specific and facility-wide basis for the 2005 baseline year. The future growth in emissions at the BNSF Stockton facility is not incorporated in the HRA emission inventory, but will be included as part of the mitigation emission reduction efforts. The Amtrak commuter locomotives and related operations emissions are also included. Gasoline TAC emissions from the fleet of on-road gasoline-fueled trucks are also calculated. The methodology used to calculate the diesel PM and other toxic air contaminant (TAC) emissions is based on the ARB *Rail Yard Emissions Inventory Methodology* (ARB, 2006c).

Over 34,000 locomotives passed through the BNSF Stockton Railyard via the mainline, in a one-year period between May 1, 2005 and April 1, 2006. Out of that number, about a quarter (or 8,000) arrived and departed from the railyard, about 5,000 from AMTRAK and non-BNSF trains passed through, and the majority (about 21,000) were BNSF freight trains that passed though at the adjacent mainline of the railyard. In comparison, over 46,000 locomotives passed through UP Roseville Railyard during 2000. Out of that number, about one-third (or 15,000) was through trains and the other two-thirds (or 31,000) were part of trains that visited the railyard in 2000.

Within the railyard, as shown in Table II-2, locomotive operations are the dominate emission sources with an estimated 3.6 tons per year (about 99% of the on-site or 26% of total diesel PM emissions). Of the emissions from locomotives, 8 switch locomotives engage in flat switching operations (i.e. moving group of rail cars within the railyard), to contribute about 42% of locomotive diesel PM emissions at about 1.5 tons per year. Line haul freight and arriving-departure trains contribute the largest volume with 1.9 tons per year of locomotive diesel PM emissions (or 53% of locomotive diesel PM). Other locomotive emissions are from basic locomotive service and refueling, and passenger locomotives (about 0.2 tons per year or 5% of locomotive diesel PM). The remaining 1% of the on-site diesel PM emissions are generated by a variety of other sources including transport refrigerator units (TRUs), and off-road track maintenance equipment.

Table II-2: BNSF Stockton Railyard and Surrounding Area
Diesel PM Emissions

DIESEL PM EMISSIONS SOURCES	On-site Tons per Year	Off-site Tons Per Year	Percent of Total
LOCOMOTIVES	**3.6**		26%
- Switch Locomotives (conducting yard operations)	*1.5*		
- Freight & Through Trains	*1.9*		
- Service/Refueling	*<0.1*		
- Amtrak and Others Operations	*<0.1*		
OFF-ROAD EQUIPMENT	**0.02**		<1%
OTHER (TRUs)	**0.002**		
OFF-SITE MOBILE SOURCES		**9.97**	74%
OFF-SITE STATIONARY SOURCES		**0.05**	<1%
TOTAL	**3.6***	**10**	**100%**

* Numbers may not add up due to rounding.

Diesel PM is not the only toxic air contaminant (TAC) emitted in the BNSF Stockton Railyard. Gasoline TACs, such as benzene, are generated from the fleet of gasoline-fueled light duty trucks. However, the total amount of TACs emissions is less than 20 pounds per year (or 0.01 tons per year) (see ENVIRON Report for more details), which is significantly less than the diesel PM emissions in the railyard. In addition, most of these TACs are not identified as carcinogens (OEHHA, 2003). Therefore, these toxic air contaminants have substantially lower levels of potential cancer risks as compared to diesel PM, the predominant emissions at the BNSF Stockton Railyard.

In addition, adjusting these emissions on a cancer potency weighted basis for their toxic potential (see a similar analysis for off-site air toxic contaminants on Table II-3), these non-diesel PM TACs have substantially lower levels of potential cancer risks based on the potency weighted emissions as compared to the diesel PM, the dominant emission at the BNSF Stockton Railyard. Thus, only diesel PM emissions are presented in the on-site emission analysis.

2. Surrounding Sources

ARB staff evaluated significant mobile and stationary sources of diesel PM emissions surrounding BNSF Stockton Railyard. The Health Risk Assessment study for the UP Roseville Railyard (ARB, 2004a) indicated that the potential cancer risks associated with on-site diesel PM emissions is substantially reduced beyond a one-mile distance from the railyard. Therefore, in most of the railyard HRA studies, ARB staff analyzed the significant diesel PM emission sources within a one-mile distance from the railyard property boundary, where on-site emissions have significant health impacts.

ARB staff analyzed the significant off-site emission sources based on two categories: mobile and stationary.

For the off-site mobile sources, the analysis focused on on-road heavy duty diesel trucks, as these are the primary source of diesel PM from the on-road vehicle fleet. ARB staff estimated mobile emissions based on roadway specific vehicle activity data and allocated them to individual roadway links. All roadway links within a one-mile distance from the BNSF Stockton Railyard are included in the analysis. The estimates do not include the diesel PM emissions generated from other modes such as extended idling, starts, tire and break wear, and off-road equipment outside the rail yards. 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 may have been included 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. The CEIDARS facilities whose locations located within the one-mile distance from the railyard boundary are selected and evaluated. Diesel PM emissions are estimated from stationary internal combustion (IC) engines burning diesel fuel, and operating at stationary sources reported in CEIDARS.

Within one mile of the BNSF Stockton railyard, Off-site diesel PM emissions generated by mobile sources contributes about 10 tons per year (or almost 74%) of the total diesel PM emissions in this study (from I-5, Hwy 99, and Hwy 4 vehicle traveling). There is no truck traffic around the railyard except the supporting and servicing on-road trucks identified in Table II-2. The diesel PM emissions of known stationary sources are minimal or about 100 pounds per year (less than 1% of the total).

ARB staff also evaluated other toxic air contaminants (TACs) emissions around the BNSF Stockton Railyard. The total stationary sources emissions of the top TACs other than diesel PM emitted within a one-mile distance from the boundary of the BNSF Stockton Railyard, which included 1,3-butadiene, benzene, acetaldehyde, and formaldehyde, were estimated at 1.8 tons per year. When compared to diesel PM, these TACs have significantly lower levels of potential cancer risks. According to ARB' *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 5 potential cancer risk contributors, based on ambient concentrations. These TACs account for 95% of the State's estimated potential cancer risk levels. This study also concluded that diesel PM contributes over 70% percent of the state's estimated potential cancer risk levels, which are significantly higher than other TACs (ARB, 2000). Among the off-site TACs emissions, within one mile of the BNSF Stockton Railyard, the top 5 cancer risk contributors (without diesel PM) were estimated at about 1.8 tons per year; diesel PM emissions are estimated at about 10 tons per year as shown in Table II-2.

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

The Office of environmental Health Hazard Assessment (OEHHA) has estimated an inhalation cancer potency factor (CPF) 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 from diesel exhaust are not separately evaluated so as to avoid double counting. The four compounds listed here are given a weighing factor by comparing each compound's CPF to the diesel PM CPF. This factor is multiplied by the estimated emissions for that compound, which gives the potency weighted toxic emission as shown in Table II-3. As can be seen in Table II-3, the potency weighted toxic emissions for these TACs are about 0.13 tons per year, which is substantially less than the diesel PM emissions.

In addition, ARB staff evaluated the potential cancer risk levels caused by the use of gasoline in the San Joaquin Valley Air Basin. Table II-4 shows the emissions of four major carcinogen compounds of gasoline exhausts in San Joaquin Valley Air Basin in the year of 2005 (ARB, 2006a). As indicated in Table II-4, the potency weighted emissions of these four toxic air contaminants from all type of gasoline sources are estimated at about 484 tons per year, or about 12% of diesel PM emissions in San Joaquin Valley Air Basin. If only gasoline powered vehicles are considered, the potency weighted emissions of these four TACs are estimated at about 139 tons per year, or about 3% of diesel PM emissions in the Basin. Hence, gasoline-powered vehicular sources are not included in the analysis.

Table II-3: Potency Weighted Toxic Emissions from Significant Off-Site Stationary Sources Surrounding BNSF Stockton Railyard

Compound	Cancer Potency Factor	Weighted Factor	Actual Emission (tons/year)	Potency Weighted Toxic Emission (tons/year)
Diesel PM	1.1	1	10	**10**
1,3-Butadiene	0.6	0.55	n/a	**-**
Benzene	0.1	0.09	1.4	**0.12**
Acetaldehyde	0.15	0.01	0.03	**0.0003**
Formaldehyde	0.021	0.02	0.4	**0.008**
Total (non-diesel PM)	**-**	**-**	**1.8**	**0.13**

Table II-4 Emissions of Major Toxic Air Contaminants from Gasoline Exhausts in San Joaquin Valley Air Basin

Compound	TACs Emissions (tons/year)			
	From All Sources	Potency weighted*	From Gasoline vehicles	Potency weighted*
Diesel PM	*4,015*	***4,015***	-	-
1,3-Butadiene	439	**241**	134	**74**
Benzene	1,820	**164**	629	**57**
Acetaldehyde	1,136	**11**	102	**1**
Formaldehyde	3,383	**68**	346	**7**
Total (non-diesel PM)	6,778	**484**	1,211	**139**

D. What are the potential cancer risks from the BNSF Stockton Railyard?

As discussed previously, the ARB has developed *Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006) to help ensure 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 (OEHHA), and is consistent with the UP Roseville Railyard Study (ARB, 2004a).

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

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

The potential cancer risks levels associated with the estimated diesel PM emissions at the BNSF Stockton Railyard are displayed by using **isopleths.** For this analysis, ARB staff elected to present the cancer risk isopleths focusing on risk levels of 10, 25, 50, 100, 250, and 500 in a million. However, for the BNSF Stockton Railyard, maximum cancer risk level is between 100 and 200 in a million. Therefore, isopleths up to 100 are presented in Figure II-2 and Figure II-3. Figure II-2 focuses on the near source risk levels and Figure II-3 focuses on the more regional impacts. In each figure, the risk isopleths are overlaid onto a satellite image of the Stockton area surrounding the BNSF Stockton Railyard, to better illustrate the land use (residential, commercial, industrial, or mixed use) of these impacted areas.

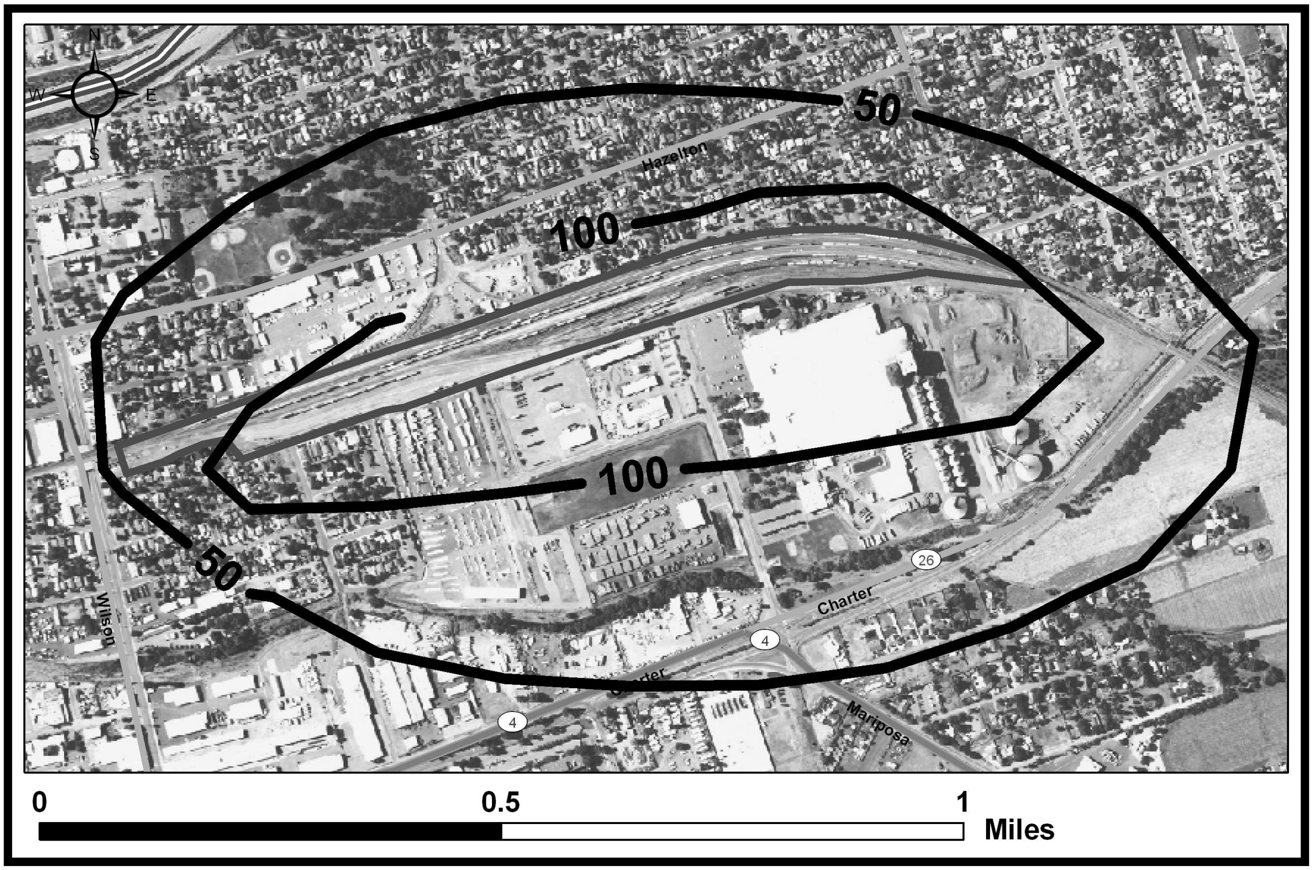
The OEHHA Guidelines require that for health risk assessments, the cancer risk for the maximum exposure at the point of maximum impact should be reported. The point of maximum impact (PMI), which is defined as a location or the receptor point with the highest cancer risk level outside of the facility boundary, with or without residential exposure, is predicted to be located directly south of the railyard boundary, directly downwind of high emission density areas for the prevailing northwesterly wind, where about 95 percent of facility-wide diesel PM emissions were generated (see the emission allocation in Appendix E). The cancer risk at the PMI is estimated to be 195 chances in a million. The land use in the vicinity is former intermodal railyard (currently open land). However, there may be residents living in this zoned area. In the residential zoned area the potential cancer risk of maximally exposed individual resident (MEIR) or maximum individual cancer risk (MICR) is estimated at about 120 chances in a million. As indicated by Roseville Railyard Study (ARB, 2004a), the location of the point of maximum impact may vary depending upon the settings of the model inputs and parameters, such as meteorological data set or emission allocations in the railyard. Therefore, given the estimated emissions, modeling settings, and the assumptions applied to the risk assessment, there are great uncertainties associated with the estimation of point of maximum impact (PMI) and maximum individual cancer risk

(MICR). These indications should not be interpreted as a literal prediction of disease incidence but more as a tool for comparison. In addition, the estimated point of maximum impact and maximum individual cancer risk may not be replicated by air monitoring.

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

As shown in Figure II-2, at locations within 300 yards of the BNSF Stockton Railyard boundary, the estimated cancer risks are about 100 chances in a million. At about a half mile from the BNSF Stockton Railyard boundaries, the estimated cancer risk drop down to about 50 in a million. As shown in Figure II-3, within a mile of the railyard boundary the estimated cancer risks are ranged from 50 to 25 chances in a million. Further away, at about two miles from the BNSF Stockton Railyard, the estimated cancer risks are about 10 in a million.

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



OEHHA Guidelines recommend a 70-year lifetime exposure duration to evaluate the potential cancer risks for residents. Shorter exposure duration of 30-year and 9-year are also recommended for residents and school-age children, respectively, as a supplement. These three exposure durations – 70-year, 30-year, and 9-year – are assume to be exposed 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. The 10 in a million isopleth line in Figure II-4 would become 4 in a million for exposed population with a shorter residency of 30 years, 2.4 in a million for exposed school-age children, and 2 in a million for off-site workers.

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

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

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

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

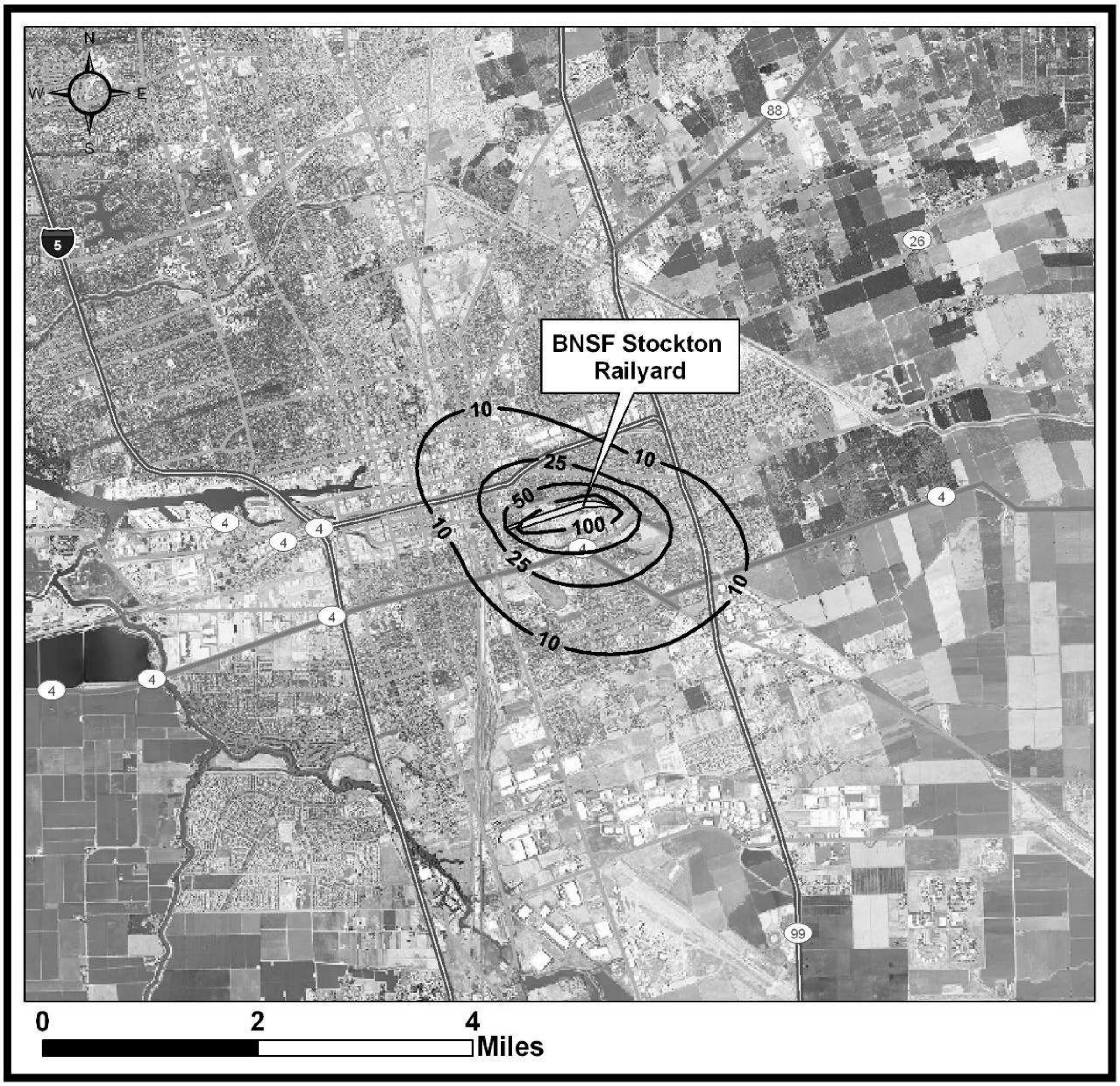
The more populated areas near the BNSF Stockton Railyard are located west, northwest, north and northeast of the railyard. The nearest residential areas in the south are about a half mile from the railyard. Based on the 2000 Census data, the zone of impact of the estimated risks above 10 chances in a million levels encompasses approximately 3,300 acres where about 23,000 residents live. Over the course of an average year, the prevailing wind patterns around the BNSF Stockton Railyard move from the west toward the south to southeast directions, where much of the areas are open lands. These prevailing wind patterns significantly reduce the potential cancer risks associated with the BNSF Stockton Railyard diesel PM emissions by significantly reducing population exposure to those emissions. 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 Caused by Railyard Diesel PM Emissions (Assumes a 70-year Exposure)

Estimated Risk (chances /mil)	Impacted Area (Acres)	Estimated Population Exposed*
10 - 25	2,300	17,000
25 - 50	600	3,800
50 - 100	300	2,000
>100	50	500

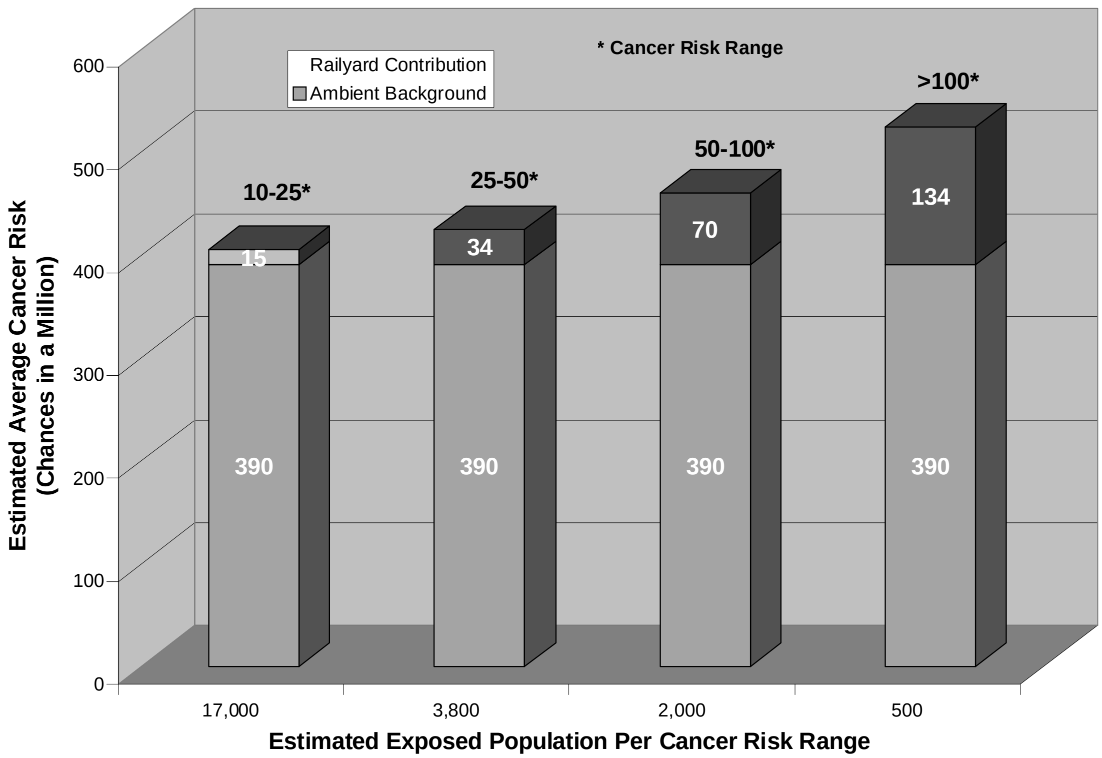
**Based on Census Data 2000*

Figure II-3: Estimated Cancer Risk from Diesel PM Emissions from the BNSF Stockton Railyard



It is important to understand that these risk levels represent the predicted risks (due to the BNSF Stockton Railyard diesel PM emissions) above the existing background risk levels. For the broader San Joaquin Valleys Air Basin, the estimated regional background risk level is estimated to be 390 in a million caused by diesel PM and about 590 in a million caused by all toxic air pollutants in the year of 2000 (ARB, 2006a). Figure II-5 provides a comparison of the predicted average potential cancer risks in various isopleths to the regional background risk level from diesel PM emissions. For example, in the risk range greater than 100, the average potential cancer risk above the regional background of 390 is 134. Residents living in that area would have a potential cancer risk at over 500 in a million.

Figure II-4: Comparison of Estimated Potential Cancer Risks from the BNSF Stockton Railyard to the Regional Background Risk Levels



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

The potential non-cancer chronic health hazard index from diesel PM emissions from the BNSF Stockton Railyard are estimated to be less than 0.1. According to OEHHA Guidelines (OEHHA, 2003), these levels indicate that the potential non-cancer chronic public health risks are less likely to happen.

Due to the uncertainties in the toxicological and epidemiological studies, diesel PM as a whole was not assigned a short-term acute REL. It is only specific gaseous constituents of diesel exhaust (e.g., acrolein) that independently have potential acute effects (such as irritation of the eyes and respiratory tract), and an assigned acute REL. However, acrolein is a chemically reactive and unstable compound, and easily reacts with a variety of chemical compounds in the atmosphere. Compared to the other compounds in the diesel exhaust, the concentration of acrolein has a much lower chance of reaching a distant off-site receptor. More importantly, given the multitude of activities ongoing at facilities as complex as railyards, there is a much higher level of uncertainty associated with maximum hourly-specific emission data, which is essential to assess acute risk. Therefore, non-cancer acute risk is not addressed quantitatively in this study.

F. What are the estimated health risks from off-site emissions?

ARB staff evaluated the health impacts from off-site pollution sources near the BNSF Stockton railyard facility 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 boundary were included. Diesel PM off-site emissions used in the off-site modeling runs consisted of ten tons per year from roadways and 0.05 tons per year from stationary facilities, representing emissions for 2005. The estimated potential cancer risks and non-cancer chronic health hazard index associated with off-site diesel PM emissions are illustrated in Figure II-5. As indicated in Figure II-5, the zone of impacts of estimated cancer risks associated with off-site diesel PM emissions is significantly larger than that of the BNSF Stockton Railyard. This result is expected because the diesel PM emissions from the significant off-site sources are equivalent to three times the BNSF Stockton Railyard diesel PM emissions.

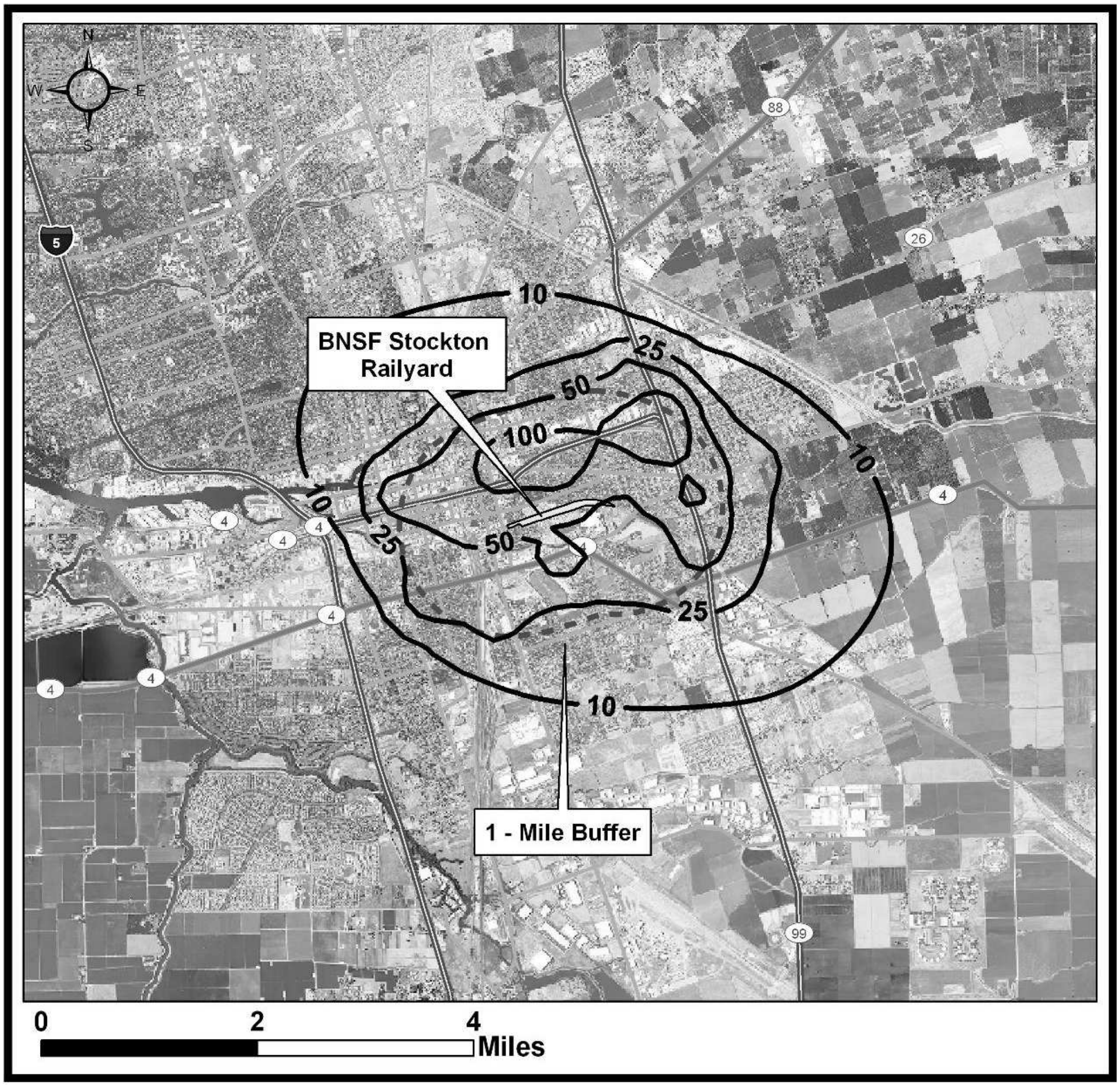
Based on the 2000 U.S. Census Bureau's data, the zone of impact of the estimated potential cancer risks over 10 chances in a million levels associated with off-site diesel PM emissions encompasses approximately 11,000 acres where about 82,000 residents live. For comparison with the on-site health risks, the same level of potential cancer risks (10 chances in a million) associated with railyard diesel PM emissions covers about 3,300 acres where approximately 23,000 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: Impacted Areas and Exposed Population Estimated for the Off-Site Diesel PM Emissions

Estimated Cancer Risk (chances per million)	Estimated Impacted Area (Acres)	Estimated Population Exposed
10 - 25	5,400	37,500
25 - 50	2,500	21,500
50 - 100	1,800	18,000
>100	600	5,000

**** Approximate estimates due to partial of these isopleths exceed the air dispersion model domain.***

Figure II-5: Estimated Potential Cancer Risk Levels (Chances per Million) Associated with the Off-Site Diesel PM Emissions



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 United States environmental Protection Agency (U.S. EPA) regulations, incentive funding programs, and early replacement of California's line haul and yard locomotive fleets. California's key locomotive and railyard air pollution control measures and strategies are summarized below:

California Accelerated Phase-In of New Locomotives Agreement (1998): Signed in 1998 between ARB and both UP and 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 locomotive NOx and 50% reduction in PM in the South Coast Air Basin. It will also provide a spill-over benefit to the rest of the state as cleaner locomotives designated for South Coast travel through other parts of the state. ARB staff estimated that the Agreement could provide the San Joaquin Valley (SJV) Air Basin with a spill-over benefit for NOx and diesel PM emissions of about 15% by 2010.

Statewide Railroad Agreement (2005): ARB and both UP and BNSF signed a voluntary statewide agreement in 2005. When fully implemented, the Agreement is expected to achieve a 20% reduction in locomotive diesel PM emissions in and around railyards through a required number of short-term and long-term measures. In the Stockton area, there are two designated railyards with one from each BNSF and UP and a number of other railyards that will benefit in the SJV Air Basin. As of January 1, 2007, ARB staff estimates that the Agreement has reduced diesel PM emissions in and around railyards by more than 15%.

ARB Diesel Fuel Regulations Extended to Intrastate Locomotives (2007): This regulation, approved in 2004, requires intrastate locomotives to use only California ultra low sulfur (15 parts per million) diesel fuel. CARB diesel fuel can reduce intrastate locomotive diesel PM 14% and NOx emissions by 6%, on average respectively. ARB staff estimates there are 270 intrastate locomotives currently operating in SJV Air Basin. The regulation took effect on January 1, 2007.

ARB Cargo Handling Equipment Regulations (2007): This regulation, approved in 2005, requires the control of emissions from more than 4,000 pieces of mobile cargo handling equipment statewide. Implementation of this regulation will reduce diesel PM emissions by approximately 40% in 2010 and 65% in 2015, and NO_x emissions by approximately 25% in 2010 and 50% in 2015. The regulation, when fully implemented, is expected to cumulatively reduce diesel PM and NO_x emissions from all cargo handling equipment in the State by up to 80 percent by 2020.

On-Road Heavy Duty Diesel Trucks Regulations: In January of 2001, the U.S. EPA promulgated a Final Rule to reduce emission standards for 2007 and subsequent model year heavy-duty diesel engines (66 FR 5002, January 18, 2001). These emission standards represent a 90% reduction of NO_x emissions, 72% reduction of non-methane hydrocarbon emissions, and 90 percent 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. This stringent emission standards will reduce NO_x and diesel PM emissions statewide from on-road heavy diesel trucks by approximately 50 and 3 tons per day, respectively, in 2010; by 140 and 6 tons per day, respectively, in 2015; and by 210 and 8 tons per day, respectively, in 2020.

Transport Refrigeration Unit (TRU) Air Toxics Control Measure (ATCM): This air toxics control measure is applicable to refrigeration systems powered by integral internal combustion engines designed to control the environment of temperature sensitive products that are transported in trucks, trailers, railcars, and shipping containers. Transport refrigeration units may be capable of both cooling and heating. Estimates show that diesel PM emission factors for transport refrigeration units and transport refrigeration unit Gen-set engines will be reduced by approximately 65 percent in 2010 and 92 percent in 2020. California's air quality will also experience benefits from reduced NOx emissions and reduced HC emissions. The transport refrigeration unit air toxics control measure is designed to use a phased approach over about 15 years to reduce the PM emissions from in-use transport refrigeration unit and transport refrigeration unit generator set engines that operate in California. The new rule became effective on December 10, 2004.

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

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

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

U.S. EPA Locomotive Emission Standards: Under the Federal 1990 Clean Air Act, U.S. EPA has sole authority to adopt and enforce locomotive emission standards. This federal preemption also extends to the remanufacturing of existing locomotives. The ARB has been encouraging the U.S. EPA to expeditiously require the introduction of Tier 4 locomotives built with diesel particulate filters and selective catalytic reduction. U.S. EPA released the notice of proposed regulation rulemaking (NPRM) for locomotives and marine vessels in the Federal Register on April 3, 2007. The NPRM proposed interim reduction in diesel PM emissions for locomotives from 2010-2013, but the final proposed standards would not be applicable to new locomotives until 2017. The final regulations are expected to be approved by early 2008.

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

California Yard Locomotive Replacement Program: One locomotive strategy identified in the GMERP mentioned above is to replace California’s older switcher yard locomotives (currently about 800) that operate in and around railyards statewide. There are Government Incentives programs (e.g., Carl Moyer Program, California proposition 1b Bond Measure) that may be able to assist in funding the replacement of some intrastate locomotives by 2010.

III. BNSF STOCKTON RAILYARD DIESEL PM EMISSIONS

This chapter provides a summary of the diesel PM emissions in and around the BNSF Stockton Railyard.

For the year 2005, the combined diesel PM emissions from the BNSF Stockton Railyard (on-site emissions) and significant non-railyard emission sources within a one-mile distance from the boundary (off-site emissions) are estimated at about 13.5 tons per year:

- Off-site mobile sources diesel PM emissions are about 10 tons per year, or about 74% of the total diesel PM emissions.
- Off-site stationary sources contribute less than 100 pounds per year of diesel PM emissions.
- On-site diesel PM emissions are estimated at about 3.6 tons per year, which accounts for about 26% of the total diesel PM emissions.

A. BNSF Stockton Railyard Diesel PM Emissions Summary

The BNSF Stockton Railyard activity data and emission inventories were provided by the BNSF Railway and its consultants ENVIRON International Incorporation. The methodology used to calculate the diesel PM and other toxic air contaminant (TAC) emissions is based on ARB *Rail Yard Emissions Inventory Methodology* (ARB, 2006c). Detailed calculation methodologies and resulting emission factors are included in the *BNSF Stockton Railyard TAC Emission Inventory* (ENVIRON, 2006a) *Air Dispersion Modeling Assessment of Air Toxic Emissions From BNSF Stockton Rail Yard* (ENVIRON, 2006b) submitted by ENVIRON.

Activities at the BNSF Stockton Railyard include engine-on locomotive activity within the service facility, the classification yard switching engines, train arrival and departure, passing freight, and passenger rail. Refueling activity also occurs at the BNSF Stockton. Non-BNSF freight movements and Amtrak commuter train movements also takes place at the BNSF Stockton Railyard.

On-site sources were separated into five operation areas based on specific activities to better characterize diesel PM emissions. These areas are summarized in Table III-1and shown in Figure III-1. The detailed schematic and descriptions of the areas and activities are presented in the ENVIRON Report (ENVIRON, 2006).

Table III-1: BNSF Stockton Railyard Activities

Area	Description
Mechanic Shop	Locomotive basic service and refueling
TRUs	Transport Refrigeration Units on shipping containers or on boxcars
Amtrak Adjacent Lines	AMTRAK Commuter Trains passing
Other Sources (Track Maintenance Equipment)	Equipment to maintain the 16-mile track inside the railyard

Using the data provided by BNSF, and the methodology described in ENVIRON report, the diesel PM emissions calculated for the railyard from on-site sources is approximately 3.5 tons per year. The diesel PM emissions ascribed to each on-site activity are provided in Table III.2.

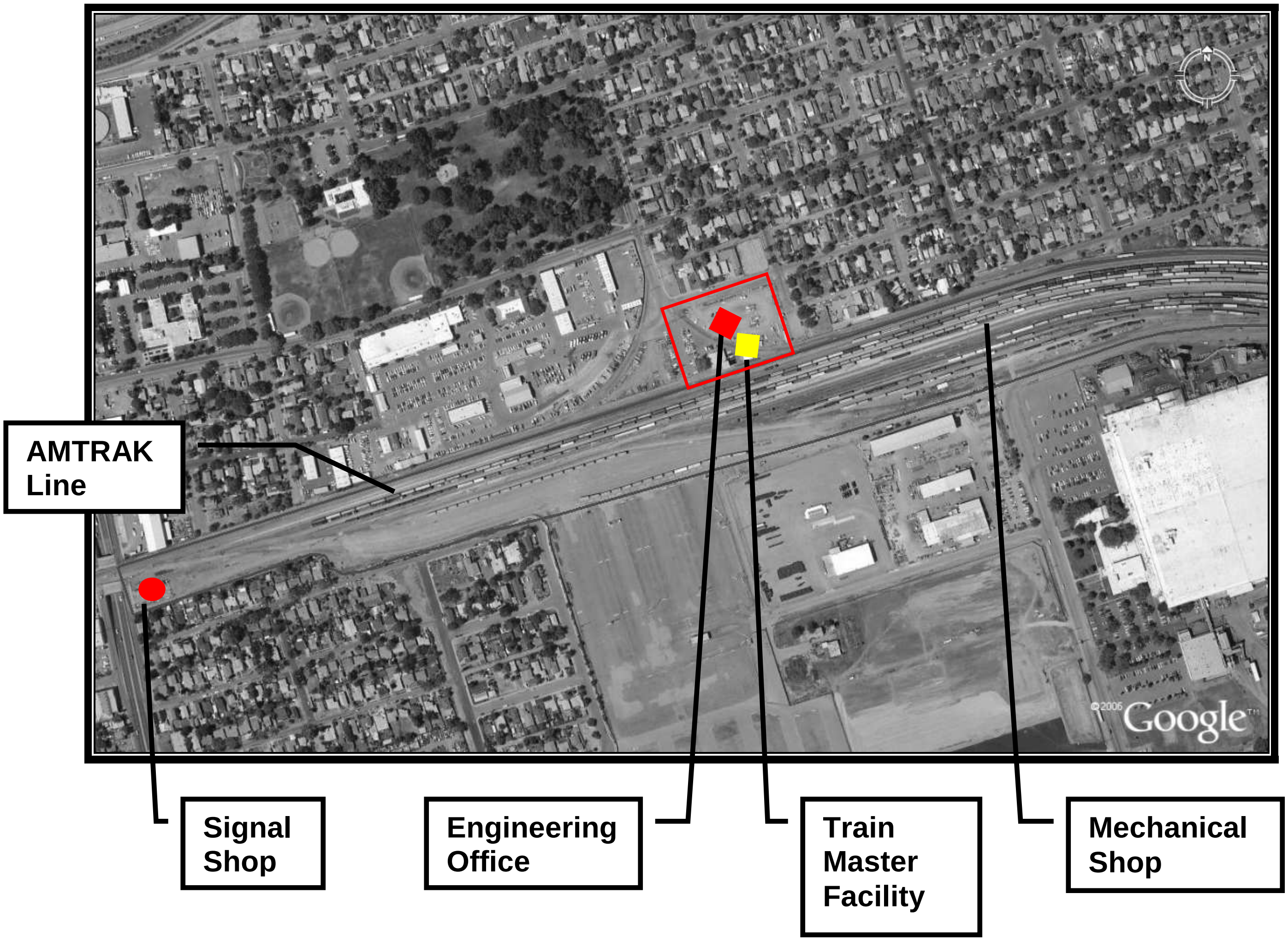
Table III-2: Diesel PM Emissions by Activity BNSF Stockton Railyard in 2005

Sources	Total Diesel PM Emissions	Percent of Total
Locomotives	3.6	99%
- Switchers	*1.5*	*42%*
- Line Haul	*1.9*	*53%*
- AMTRAK and others	*0.1*	*<3%*
- Service and Refueling	*<0.1*	*<2%*
Off-road Equipment	0.02	<1%
Other (TRUs)	0.002	<0.1%
TOTAL	**3.6***	**100%**

*Numbers may not add up because of rounding.

Diesel PM is not the only toxic air contaminant (TAC) emitted in the BNSF Stockton Railyard. Relatively small amounts of gasoline TACs, such as benzene, is generated from the fleet of twenty gasoline-fueled light duty trucks. However, the total amount of TACs emissions is less than 20 pounds per year (see Table II-4 and ENVIRON Report for more details), which is significantly less than the diesel PM emissions in the railyard. In addition, adjusting these emissions on a cancer potency weighted basis for their toxic potential (see a similar analysis for off-site air toxic contaminants on Table II-3), these non-diesel PM toxic air contaminants have much less of the potency weighted emissions as compared to diesel PM. Hence, only diesel PM emissions are presented in the on-site emission analysis.

Figure III-1: Diesel PM Source Locations at the BNSF Stockton Railyard



1. ***Locomotives***

Locomotives are the largest diesel PM emission sources at the BNSF Stockton Railyard. Locomotives contribute about 3.6 tons per year or about 99% of the total railyard diesel PM emissions. As shown in Table III.3, the highest percentage of locomotive diesel PM emissions results from freight trains. At about 1.7 tons per year, freight trains represent 53% of the total locomotives diesel PM emissions within the railyard. A significant part of the diesel PM emissions are also generated by switch locomotives, accounting for 42% of the total locomotives diesel PM emissions (1.5 tons per year). The other sources of locomotives diesel PM emissions are due to basic locomotive service, at about 0.1 tons per year, or about 3% of the locomotive diesel PM emissions, the remaining 2% or 0.1 tons per year of locomotives diesel PM emissions are due to AMTRAK and non-BNSF train operations.

According to BNSF, the BNSF 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

Stockton Railyard TAC Emission Inventory, ENVIRON, 2006a).   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 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 is presented in Appendix D.

The ARB has developed an integrated approach to reduce statewide locomotive emissions through a combination of voluntary agreements, ARB and U.S. EPA regulations, incentive funding programs, and early replacement of California's line haul and yard locomotive fleets. The detailed approach has been discussed in Chapter II. Therefore, in the future, the BNSF Stockton Railyard will benefit from these mitigation measures since diesel PM emissions from locomotives are gradually reduced as the locomotive fleets turnover.

Table III-3: Diesel PM Emissions by Locomotive Activity
BNSF Stockton Railyard in 2005

Activity	Diesel PM Emissions	
	Tons per year	%
Freight Trains	1.9	53%
Yard Operations (Conducted by switch locomotives)	1.5	42%
Basic Locomotive Service	<0.1	<3%
AMTRAK and non-BNSF trains	<0.1	<2%
TOTAL	**3.6***	**100%**

*****Numbers may not add up due to rounding.

2. LHD On-Road Gasoline-fueled Trucks

There are no diesel PM emissions from on-road gasoline-fueled light-heavy duty (LHD)[3] trucks operating within the railyard. The TACs emissions from these trucks are estimated at about 100 pounds per year and are identified in the ARB web site: http://www.arb.ca.gov/railyard/hra/hra.htm.

[3] LHD: Gross Vehicle Weight Rating: 8501-14001 lbs

3. Off-Road Equipment

There are diesel PM emissions from a variety of off-road track maintenance equipment to maintain the 16-mile track inside the railyard. The track maintenance equipment includes air compressors, cranes, loaders, backhoes, tractors, trenchers. As shown in table III-4, diesel PM emissions from off-road equipment are estimated at 0.02 tons per year, less than one percent of the total railyard diesel PM emissions.

In January of 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 percent reduction of oxides of nitrogen emissions, 72 percent reduction of non-methane hydrocarbon emissions, and 90 percent reduction of particulate matter emissions compared to the 2004 model year emission standards. Starting in 2007, the BNSF Stockton Railyard will benefit from these mitigation measures as diesel PM emissions from heavy-duty diesel fueled trucks are gradually reduced as the truck fleets turnover.

Table III-4: Diesel PM Emissions from Track Maintenance Equipment

Equipment Type/ID	Make / Model	Fuel Types	Diesel PM Emissions (tons per year)	Percent of Total Emissions
Variety of Equipment	Unknown	Diesel	0.02	<1%
TOTAL			**0.02**	**100%**

4. Others (TRUs)

Diesel PM emissions from TRUs, either on the boxcars or on shipping containers, are insignificant as shown in Table III.5. The details of on-site time and the yearly visits are identified in the ARB web site: http://www.arb.ca.gov/railyard/hra/hra.htm.

Table III-5: Diesel PM Emissions for TRUs
BNSF Stockton Railyard

Equipment Type	Diesel PM Emissions (tons per year)
On Boxcars	<0.001
On Containers	<0.001

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. Therefore starting in 2009, the BNSF Stockton Railyard will benefit from these mitigation measures as diesel PM emissions from TRUs are gradually reduced as their fleets turnover.

B. Current Applicable Diesel Fuel Regulations and Their Benefits to the California 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 volume percent for large refiners and 20 percent for small refiners to reduce emissions of both PM and NOx.

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

Table III-6: California Diesel Fuel Standards

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

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

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

The United States environmental Protection Agency (U.S. EPA) 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 sulfur content no greater than 500 ppmw. In addition, the regulation required on-road motor-vehicle diesel fuel to have a cetane index of at least 40 or have an aromatic hydrocarbon content of no greater than 35 percent by volume (vol. %). On-road motor-vehicle diesel fuel sold or supplied in the United States, except in Alaska, must comply with these requirements. Diesel fuel, not intended for on-road motor-vehicle use, must contain dye solvent red 164.

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

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

Until recently, fuel supplied to outside of California was allowed a sulfur content of up to 5,000 ppmw (parts per million by weight). However, in 2004, the U.S. EPA published a strengthened rule for the control of emissions from non-road diesel engines and fuel. The U.S. EPA rulemaking requires that sulfur levels for non-road diesel fuel be reduced from current uncontrolled levels of 5,000 ppmw ultimately to 15 ppmw, though an interim cap of 500 ppmw is contained in the rule. Beginning June 1, 2007, refiners are required to produce non-road, locomotive and marine diesel fuel that meets a maximum sulfur level of 500 ppmw. This does not include diesel fuel for stationary sources. In 2010, non-road diesel fuel will be required to meet the 15 ppmw standard except for locomotives and marine vessels. In 2012, non-road diesel fuel used in locomotives and marine applications must meet the 15 ppmw standard. The non-road diesel fuel standards are shown above in Table III-7.

Table III-7: U.S. 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-8 shows average values for 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 percent by volume in-use.

Table III-8: Average 1999 Properties of Reformulated Diesel Fuel

Property	California	U.S.[(1)]
Sulfur, ppmw	10[(2)]	10 [(2)]
Aromatics, vol.%	19	35
Cetane No.	50	45
PNA, 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

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

Line haul locomotives have a range of about 800 to 1,200 miles between fuelings. BNSF locomotives typically refuel at Belen, New Mexico before traveling to Barstow, California and UP locomotives typically refuel at Salt Lake City, Utah before traveling to Roseville in northern California or Colton in southern California. These major out-of-state railroad facilities have the option to use Federal non-road diesel fuels for the refueling of line haul locomotives.

UP and BNSF surveyed each of the California fueling centers, and major interstate fueling centers to California, to estimate the average diesel fuel properties for locomotives for the railyard health risk assessments. Diesel fuel sulfur levels were estimated to be an average of 1,050 ppmw based on the mixture of CARB, U.S. EPA on-road, and non-road diesel fuel consumed by locomotives in California in 2005. ARB staff believes this is a conservative estimate for the types of diesel fuels and sulfur levels consumed by locomotives in California.

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 will drop from 5,000 ppmw to 500 ppmw on June 1, 2007. In 2012, the non-road diesel fuel limits for used in locomotives and marines will drop from 500 ppmw to 15 ppmw.

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

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

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

Both the U.S. EPA and CARB diesel fuels had sulfur levels lowered from 500 ppmw to 15 ppmw on June 1, 2006. Under the prior sulfur specification of 500 ppmw, CARB diesel fuel in-use sulfur levels averaged around 140 ppmw versus U.S. EPA on-road sulfur levels of about 350 ppmw. With the 2006 implementation of the 15 ppmw sulfur levels, in-use levels for both CARB diesel and U.S. EPA 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 percent or by about 6.4 tons per day from 2000 levels. Direct diesel particulate matter emissions would be reduced by about 4 percent, or about 0.6 tons per year in 2010 for engines not equipped with advanced particulate emissions control technologies. U.S. EPA on-road lower sulfur diesel fuel would provide similar levels of sulfur oxide and direct diesel particulate matter emission reductions.

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

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

C. Off-Site Diesel PM Emissions Summary

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

1. Mobile Sources

> ***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*.

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 railyard boundary are included in the analysis. The estimates do not include the diesel PM emissions generated from other modes such as extended idling, starts, tire and break wear, and off-road equipment outside the rail yards. 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 emissions, the exclusion of extended idling and off-road equipment may result in an underestimation of off-site mobile sources emissions.

The BNSF Stockton Railyard is located between three main freeways (I-5, HW 4, and HW 99), with the diesel PM emissions generated mostly by commercial trucks, which is estimated at about 10 tons per year. The sources of emissions are categorized in Table III.9 (by diesel trucks categories) and Table III.10 (by freeways).

Table III-9: Diesel PM Emissions for Off-site Mobile Sources – By Diesel Trucks Categories

Sources	Diesel PM Emissions	
	Tons per year	Percent of Total
Light Heavy Duty diesel trucks	<0.1	<1%
Medium Heavy Duty diesel trucks	0.9	10%
Heavy Heavy Duty diesel trucks	9.0	90%
TOTAL	**10**	**100%**

Table III-10: Diesel PM Emissions for Off-site Mobile Sources – By Freeways

Sources	Diesel PM Emissions	
	Tons per year	Percent of Total
Interstate 5	4.3	43%
Highway 4	3.3	33%
Others (local streets)	2.4	24%
TOTAL	**10**	**100%**

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 identify two facilities within the one-mile distance from the BNSF Stockton Railyard. Within 1-mile from the railyard boundary, the diesel PM emissions from stationary or industrial sources is insignificant at about 0.05 tons per year. For other TACs, the emissions level is about 1.8 ton per year, which is also minimal.

Table III-11: Diesel PM Emissions for Off-site Stationary Sources

Sources	Diesel PM Emissions	
	Tons per year	Percent of Total
R&B Protective Coatings, Inc.	0.031	69%
Diamond Walnut Growers, Inc.	0.014	31%
Total	**0.045**	**100%**

ARB staff also evaluated other toxic air contaminant (TACs) emissions around the BNSF Stockton Railyard. According to ARB' *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (ARB, 2000), diesel PM, 1,3-butadiene, benzene, carbon tetrachloride, formaldehyde are defined as the top 5 cancer risk contributors, which account for 95% of the state's estimated potential cancer risk levels (ARB, 2000). This study also concluded that diesel PM contributes over 70% percent of the state's estimated potential cancer risk levels, which is significantly higher than other TACs (ARB, 2000). Among the off-site TACs emissions, the top 5 cancer risk contributors other than diesel PM were estimated at about 1.8 tons per year.

The Office of environmental Health Hazard Assessment (OEHHA) has calculated an inhalation cancer potency factor (CPF) for each hazardous compound. The four compounds listed here are given a weighing factor by comparing each compound's CPF to the diesel PM CPF. This factor is multiplied by the estimated actual emissions for that compound, which gives the potency weighted toxic emission as shown in Table III-10.

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

***Cancer potency factors (CPF)** are expressed as the 95% upper confidence limit of excess cancer chances 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-day)$^{-1}$.*

Table III-12: Potency Weighted Toxic Emissions from Significant Off-Site Stationary Sources Surrounding BNSF Stockton Railyard

Compound	Cancer Potency Factor	Weighted Factor	Actual Emission (tons/year)	Potency Weighted Toxic Emission (tons/year)
Diesel PM	1.1	1	10	**10**
1,3-Butadiene	0.6	0.55	n/a	**-**
Benzene	0.1	0.09	1.4	**0.12**
Acetaldehyde	0.15	0.01	0.03	**0.0003**
Formaldehyde	0.021	0.02	0.4	**0.008**
Total (non-diesel PM)	**-**	**-**	**1.8**	**0.13**

In addition, ARB staff evaluated the potential cancer risk levels caused by gasoline exhausts in the San Joaquin Valley Air Basin. Table III-13 shows the emissions of four major carcinogen compounds of gasoline exhausts in San Joaquin Valley Air Basin in the year of 2005 (ARB, 2006a). As indicated in Table III-13, the potency weighted emissions of these four toxic air contaminants from all type of gasoline sources are estimated at about 480 tons per year, or about 12% of diesel PM emissions in San Joaquin Valley Air Basin. If only gasoline powered vehicles are considered, the potency weighted emissions of these four TACs are estimated at about 149 tons per year, or about 4% of diesel PM emissions in the Basin. Therefore, the potential cancer risk levels caused by non-diesel PM TACs emitted from off-site gasoline powered vehicular sources are substantially less than that of diesel PM and are not included in the analysis.

Table III-13: Emissions of Major Toxic Air Contaminants from Gasoline Exhausts in the San Joaquin Air Basin

Compound	TACs Emissions (tons/year)			
	From All Sources	Potency Weighted*	From Gasoline vehicles	Potency Weighted*
Diesel PM	*4,015*	***4,015***	-	-
1,3-Butadiene	439	**241**	134	**74**
Benzene	1,820	**164**	629	**57**
Formaldehyde	3,383	**64**	346	**7**
Acetaldehyde	1,136	**11**	102	**1**
Total (non-diesel PM)	6,778	**480**	1,211	**139**

* *Based on cancer potency weighted factors.*

IV. AIR DISPERSION MODELING FOR THE BNSF STOCKTON 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 Stockton Railyard. A description of the air quality modeling parameters is listed, including air dispersion model selection, emission source characterizations, meteorological data, model receptor network, and building wake effects. ARB staff also describes model input preparation and output presentation.

A. Air Dispersion Model Selection

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

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

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

B. Source Characterization and Parameters

The emission sources from the locomotives and other mobile sources at the BNSF Stockton Railyard are characterized as either a point source or a volume source depending on whether they are stationary or moving. When a mobile source is stationary, such as when it is idling or undergoing load testing, the emissions are simulated as a series of point sources. Model parameters for point sources include emission source height, diameter, exhaust temperature, exhaust exit velocity, and emission rate. The locomotive exhaust temperatures and stack heights vary by locomotive makes, models, notch settings and operation time. While the BNSF assumed more specific temperatures and stack heights from their switchers and line haul locomotives fleets, the UP used data from the Roseville Railyard Study (ARB, 2004) 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 2 percent, based on a sensitivity analysis conducted by ARB staff.

According to the BNSF, some locomotives at the Hobart Railyard had been equipped with AESS (automatic engine start-stop) or SmartStart device (by ZTR Control System) in 2005[4]. However, the BNSF used a more conservative approach that did not incorporate the benefits of using the devices in the locomotive emissions estimation. ARB staff believes that the BNSF's approach is more protective in terms of health impacts.

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

The emissions from all stationary sources (storage tanks, sand tower, waste water treatment plant, etc.) and portable sources (welders, steam cleaners, air compressors, etc.) are simulated as a series of point sources.

The emission rates for individual locomotives are a function of locomotive type, notch setting, activity time, duration, and operating location. Emission source parameters for all locomotive model classifications at the railyard include emission source height, diameter, exhaust temperature, and exhaust velocity. Detailed information on the emission source parameters is presented in Sierra Research Report. Because the stationary locomotives were not uniformly distributed throughout the railyard, the locations of individual locomotive emission sources used for the model inputs were determined based on the detailed locomotive distribution and activity information provided by BNSF Railway.

C. Meteorological Data

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

These meteorological variables are important to describe the air dispersion in the atmosphere. The wind speed determines how rapidly the pollutant emissions are diluted and influences the rise of emission plume in the air, thus affecting downwind concentrations of pollutants. Wind direction determines where pollutants will be transported. The difference of ambient temperature and the emission releasing temperature from sources determines the initial buoyancy of emissions. In general, the greater the temperature difference, the higher the plume rise. The opaque cloud cover

[4] Staff communication between the ARB, BNSF, and ENVIRON, September, 2007.

and upper air sounding data are used in calculations to determine other important dispersion parameters. These include atmospheric stability (a measure of turbulence and the rate at which pollutants disperse laterally and vertically) and mixing height (the vertical depth of the atmosphere within which dispersion occurs). The greater the mixing height is, the larger the volume of atmosphere is available to dilute the pollutant concentration.

The meteorological data used in the model are selected on the basis of representativeness. Representativeness is determined primarily on whether the wind speed/direction distributions and atmospheric stability estimates generated through the use of a particular meteorological station (or set of stations) are expected to mimic those actually occurring at a location where such data are not available. Typically, the key factors for determining representativeness are proximity of the meteorological station and the presence or absence of nearby terrain features that might alter airflow patterns.

For the BNSF Stockton Railyard, surface meteorology data from the near by Stockton Metropolitan Airport (located about 3 miles south of the railyard) for the five years 2000 and 2002 to 2005 is selected. In addition, the daily upper air sounding data from Oakland Metropolitan station for the years 2000 and 2002 to 2005 were used in the modeling process. No other meteorological data was available in the area.

In this study, to ensure consistency between the UP and BNSF air dispersion modeling analyses for railyards in the Stockton area, the meteorological data used for BNSF Stockton Railyard was also the same as that selected by UP and its consultant Sierra Research for the UP Stockton Railyard nearby (Sierra Research, 2006). The area surrounding the BNSF Stockton Railyard is generally flat and would not be expected to exhibit significant variations in wind patterns within relatively short distances. Hourly wind speed and direction data, and temperature and cloud cover data from the Stockton Metropolitan Airport were selected to be used in the AERMOD.

According to ARB railyard HRA guidelines (ARB, 2006d), 5 years of the meteorological data are recommended to be used in the air toxic health risk assessment. However, for this study, due to the availability of the data, five years, but non-continuous, of meteorological data from the Stockton Metropolitan Airport were processed: 2000 and 2002 - 2005. In addition, the daily upper air sounding data from Oakland Metropolitan station for the years 2000 and 2002 to 2005 were used in the modeling process. The BNSF's consultant performed a sensitivity analysis and found that year-to-year variability would not cause significant differences in the modeled health impacts. Therefore, the meteorological data from 2005 were selected for BNSF Stockton Railyard air dispersion modeling because it had adequate completeness and quality, and were the most recent year available. Surface parameters supplied to the model were specified for the area surrounding the surface meteorological monitoring site as recommended by AERMOD and ARB Guidelines (ARB, 2006b). According to the sensitivity analyses conducted by BNSF, the impacts on the diesel PM air concentration predictions by using the long-term (i.e., five-year) vs.

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

short-term (i.e., one-year) are found to be insignificant. This is consistent with the findings from a sensitivity analysis from one of UP railyards conducted by ARB staff (see Appendix G). Therefore, whether five-year or one-year meteorological data are used, the modeling results show similar estimated exposures and potential cancer risks surrounding the railyard facility

The wind field for modeling work is summarized in the windrose plot is shown in Figure IV-1. The yearly average wind speed is about 2.9 meter per second. The prevailing wind over the modeling domain blows from northwest to southeast where downwind area is an open land.

Figure IV-1: Windrose Plot for the BNSF Stockton Rail Yard

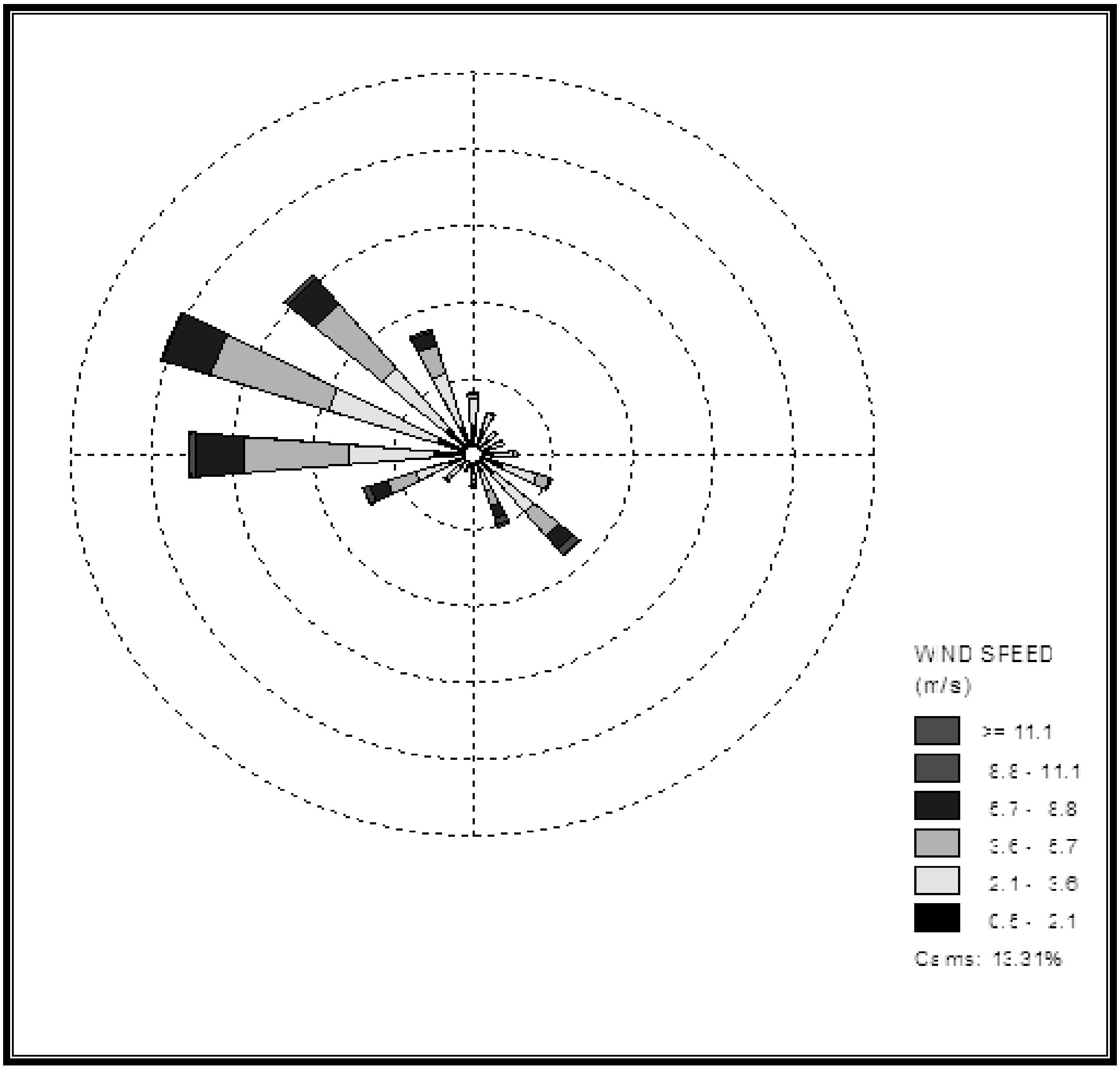


Figure IV-2: Wind Class Frequency Distribution of Stockton Metropolitan Airport in 2005

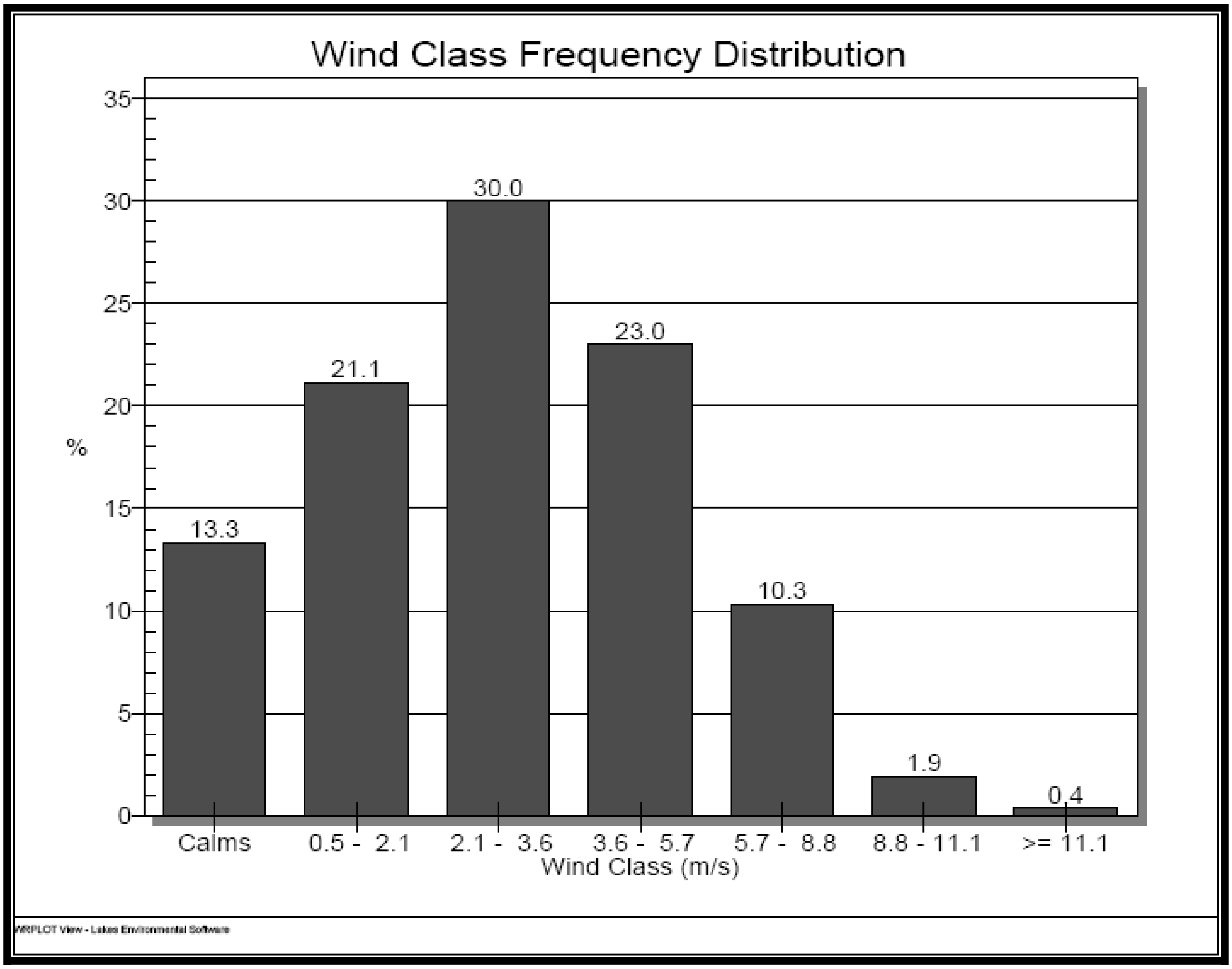


Figure IV-2 shows frequency of wind class (wind speed) in 2005 of the nearby Stockton Metropolitan Airport where the meteorology data ware collected. The detailed procedures for meteorological data preparation and the quality control procedures followed are described in ENVIRON Report.

D. Model Receptors

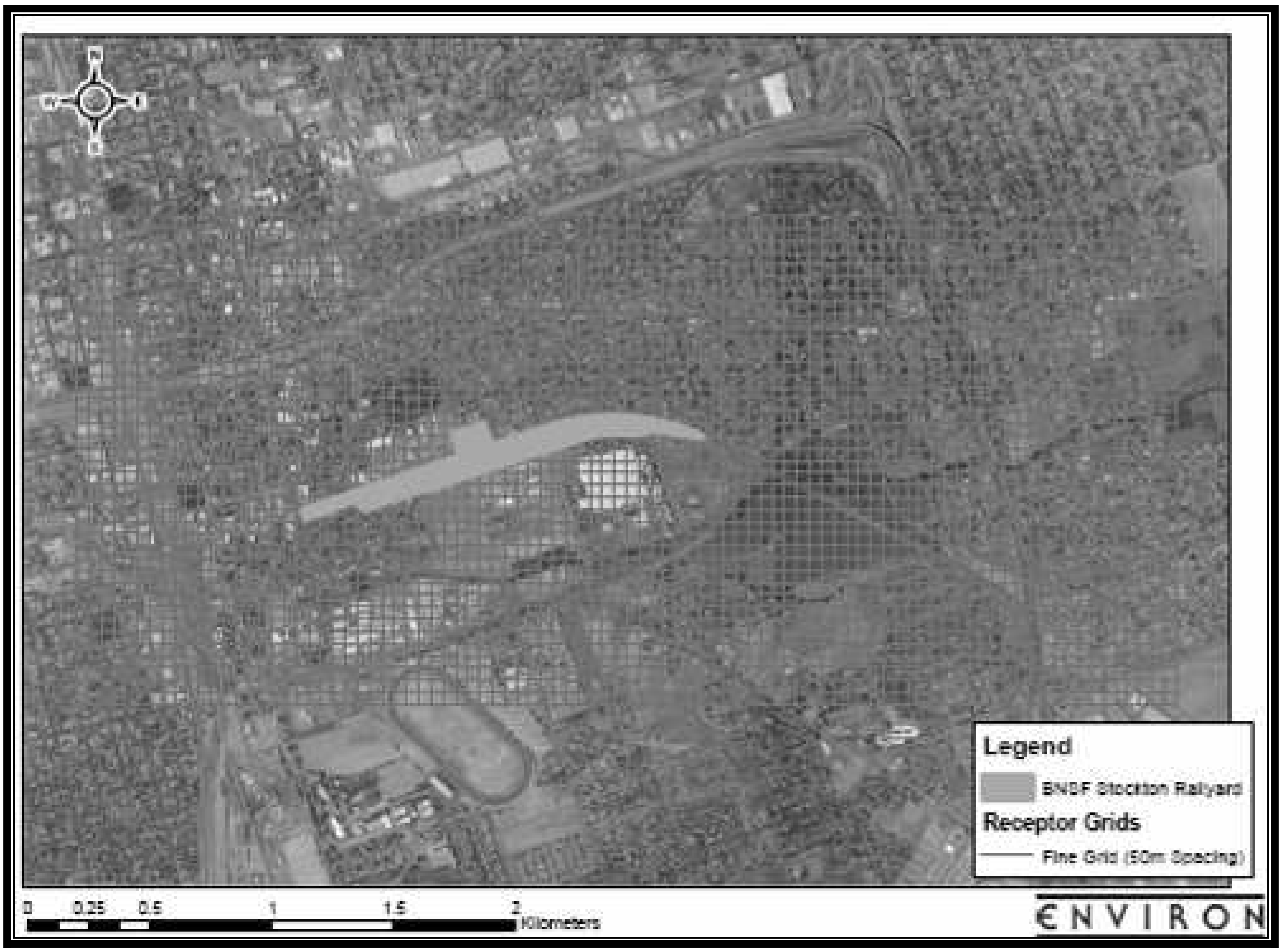
Model receptors are the locations where the model provides concentrations. A Cartesian grid receptor network is used in this study where an array of points are identified by their x (east-west) and y (north-south) coordinates. This receptor network is capable of identifying the emission sources within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

According to the *ARB Railyard Health Risk Assessment Guidance for Railyard and Intermodal Facilities* (ARB, 2006b), the modeling domain is defined as 20 x 20 km (km: kilometers) region, which covers the railyard and the surrounding areas. To better characterize different dispersive levels of concentrations from the railyard, different modeling grid structures were defined:

- A fine grid receptor network within 750 m (m: meter) of the facility boundary with receptor spacing of 50 m apart.
- A medium grid receptor network between 1500 m with receptor spacing of 250 m apart.
- A coarse receptor network between 9500 m with receptor spacing of 500 m apart.

Figure IV-3 shows the fine, medium grid receptor networks for cancer risk modeling.

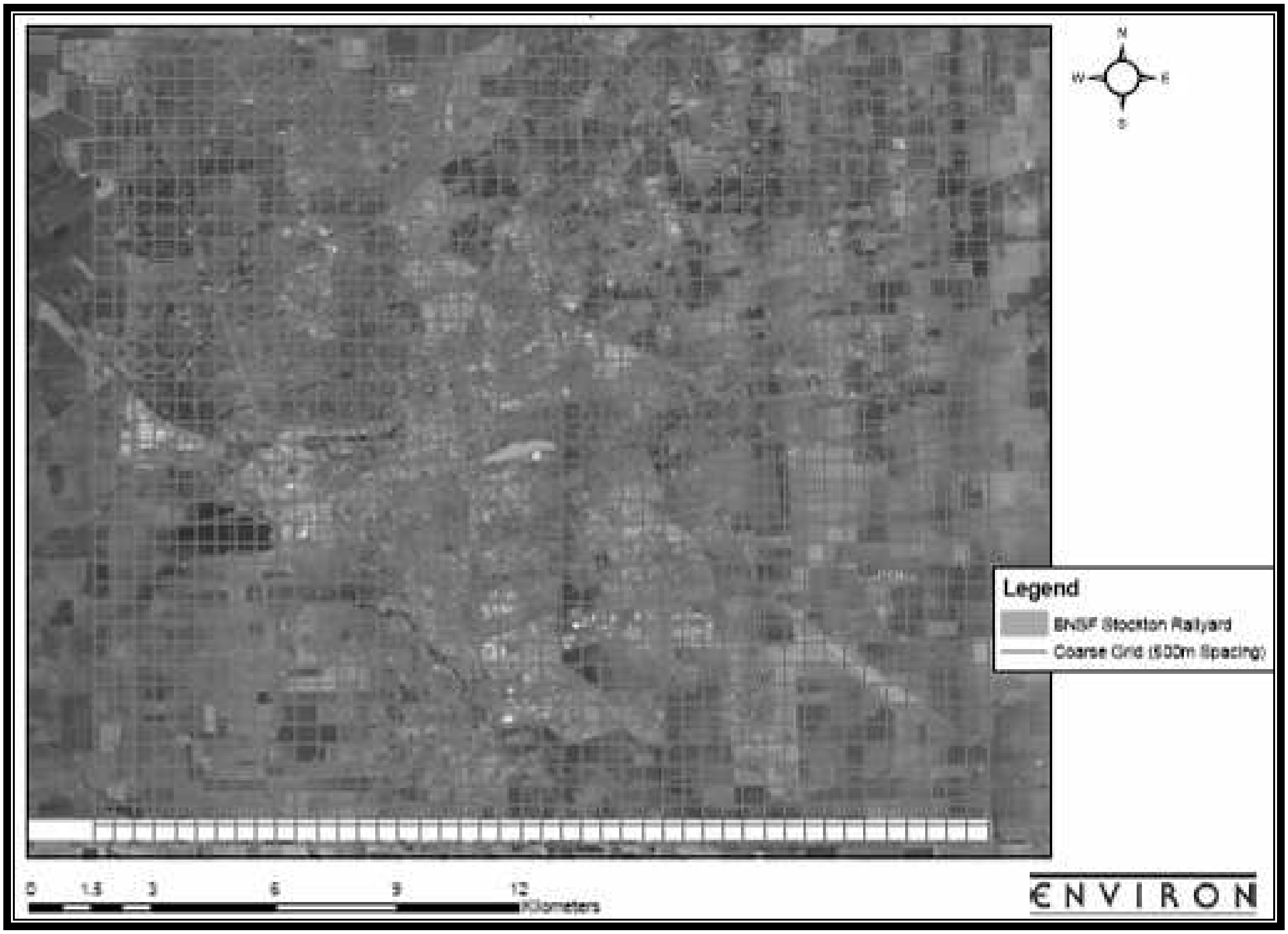
Figure IV-3: Fine Grid Receptor Networks Cancer Risk Modeling
BNSF Stockton Railyard



Sources: ENVIRON International Corporation.

Figure IV-4 shows the coarse grid receptor networks for cancer risk modeling.

Figure IV-4: Coarse Grid Receptor Networks
Cancer Risk Modeling BNSF Stockton Railyard



Source: ENVIRON International Corporation.

E. Building Wake Effects

If pollutant emissions are released at or below the “Good Engineering Practice” height as defined by EPA Guidance (U.S. EPA, 1985), the plume dispersion may be affected by surrounding facility buildings and structures. The aerodynamic wakes and eddies produced by the buildings or structures may cause pollutant emissions to be mixed more rapidly to the ground, causing elevated ground level concentrations. The AERMOD model has the option (called Plume Rise Model Enhancements) to account for potential building-induced aerodynamic downwash effects. Although all BNSF railyards included building wake effects in their modeling analyses, BNSF conducted a sensitivity analysis and found that the building wake effect has an insignificant impact on the diesel PM air concentrations of the railyard (ENVIRON, 2006b). In this study, the building downwash effects were considered. Detailed treatments of building downwash effects can be found from the ENVIRON Report.

F. Model Implementation Inputs

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

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

V. HEALTH RISK ASSESSMENT OF THE BNSF STOCKTON RAILYARD

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

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 (OEHHA), and is consistent with UP Roseville Railyard Study. The OEHHA guidelines outline a tiered approach to risk assessment, providing risk assessors with flexibility and allowing for consideration of site-specific differences:

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

> ***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 percetile breathing rate is a value such that the breathing rates from 65 percent of population are less or equal to it.*

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

The ARB has also developed *Health Risk Assessment Guidance for Railyard and Intermodal Facilities* to help ensure that the air dispersion modeling and HRA performed for each railyard meet the OEHHA guidelines.

B. Exposure Assessment

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

Diesel PM is not the only toxic air contaminant (TAC) emitted from the BNSF Stockton Railyard. A relatively small amount of gasoline TACs is generated from gasoline storage tanks and gasoline-powered vehicles and engines (for BNSF Stockton Railyard, TACs are mainly from the twenty gasoline-powered trucks), including benzene, isopentane, toluene, etc. Some other toxic air contaminants, such as xylene, are emitted from the wastewater treatment plant. The total amount of these toxic air contaminants emissions is about 1 pounds per year, compared to the 7 tons per year of the diesel PM emissions in the railyard. In addition, adjusting these emissions on cancer potency weighted basis for their toxic potential, these non-diesel PM toxic air contaminants have less than a thousandth of the potency weighted emissions as compared to diesel PM. Hence, only diesel PM emissions are presented in the on-site emission analysis.

ARB staff also evaluated other toxic air contaminant (TACs) emissions around the BNSF Stockton Railyard. There are two main stationary toxic air contaminant sources identified within the one-mile distance from the boundaries of the BNSF Stockton Railyard. The total emissions of toxic air contaminants, other than diesel PM emitted from these stationary sources, were estimated at about 1.8 tons per year. Not all of these toxic air contaminants are identified as carcinogens. According to ARB' *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 5 potential cancer risk contributors, based on ambient concentrations. These TACs account for 95% of the State's estimated potential cancer risk levels. This study also concluded that diesel PM contributes over 70% percent of the state's estimated potential cancer risk levels, which are significantly higher than other TACs (ARB, 2000). Among the off-site TACs emissions, the top 10 cancer risk contributors (without diesel PM) were estimated at about 1.8 tons per year.

The OEHHA has estimated an inhalation cancer potency factor (CPF) 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 from diesel exhaust are not separately evaluated so as to avoid double counting. The four compounds listed here are given a weighing factor by comparing each compound's CPF to the diesel PM CPF. This factor is multiplied by the estimated emissions for that compound, which gives the potency weighted toxic emission as shown in Table V-1. As can be seen, the potency weighted toxic emissions for these TACs are about 0.13 tons per year, or about 260 pounds per year, which are substantially less than diesel PM emissions and are not included in the report. Detailed results and analysis are presented in Appendix B. As such, the health impacts in this study primarily focus on the risks from the diesel PM emissions.

Table V-1: Potency Weighted Toxic Emissions from Significant Off-Site Stationary Sources Surrounding BNSF Stockton Railyard

Compound	Cancer Potency Factor	Weighted Factor	Actual Emission (tons/year)	Potency Weighted Toxic Emission (tons/year)
Diesel PM	1.1	1	10	**10**
1,3-Butadiene	0.6	0.55	N/A	**-**
Benzene	0.1	0.09	1.4	**0.12**
Acetaldehyde	0.15	0.01	0.03	**0.0003**
Formaldehyde	0.021	0.021	0.4	**0.008**
Total (non-diesel PM)	**-**	**-**	**1.8**	**0.13**

In addition, ARB staff evaluated the potential cancer risk levels caused by gasoline exhausts in the San Joaquin Air Basin. Table V-2 shows the emissions of four major carcinogen compounds of gasoline exhausts in San Joaquin Air Basin in the year of 2005 (ARB, 2006a). As indicated in Table V-2, the potency weighted emissions of these four toxic air contaminants from all types of gasoline sources are estimated at about 480 tons per year, or about 12% of diesel PM emissions San Joaquin Air Basin. If only gasoline-powered vehicles are considered, the potency weighted emissions of these four toxic air contaminants are estimated at about 139 tons per year, or about 4% of diesel PM emissions in the Basin. Therefore, the potential cancer risk levels caused by non-diesel PM toxic air contaminants emitted from off-site gasoline-powered vehicular sources are substantially less than the potential cancer risk levels associated with diesel PM, and are not included in the analysis.

Table V-2: Emissions of Major Toxic Air Contaminants from Gasoline Exhausts in the San Joaquin Air Basin

Compound	TACs Emissions (tons/year)			
	From All Sources	Potency Weighted*	From Gasoline vehicles	Potency Weighted*
Diesel PM	*4,015*	***4,015***	-	-
1,3-Butadiene	439	**241**	134	**74**
Benzene	1,820	**164**	629	**57**
Formaldehyde	3,383	**64**	346	**7**
Acetaldehyde	1,136	**11**	102	**1**
Total (non-diesel PM)	6,778	**480**	1,211	**139**

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

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

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

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

1. Risk Characterization Associated with On-Site Emissions

a) Cancer Risk

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

The potential cancer risks levels associated with the estimated diesel PM emissions at the BNSF Stockton Railyard are displayed by using isopleths, based on the 80th percentile breathing rate and 70-year exposure duration for residents**.** In this study, ARB staff elected to present the cancer risk isopleths focusing on risk levels of 10, 25, 50, 100, 250, and 500 in a million. Figure V-1 and Figure V-2 present these isopleths.
Figure V-1 focuses on the near source risk levels and Figure V-2 focuses on the more regional impacts. In each figure, the risk isopleths are overlaid onto a satellite image of the Stockton area surrounding the BNSF Stockton Railyard, to better illustrate the land use (residential, commercial, industrial, or mixed use) of these impacted areas.

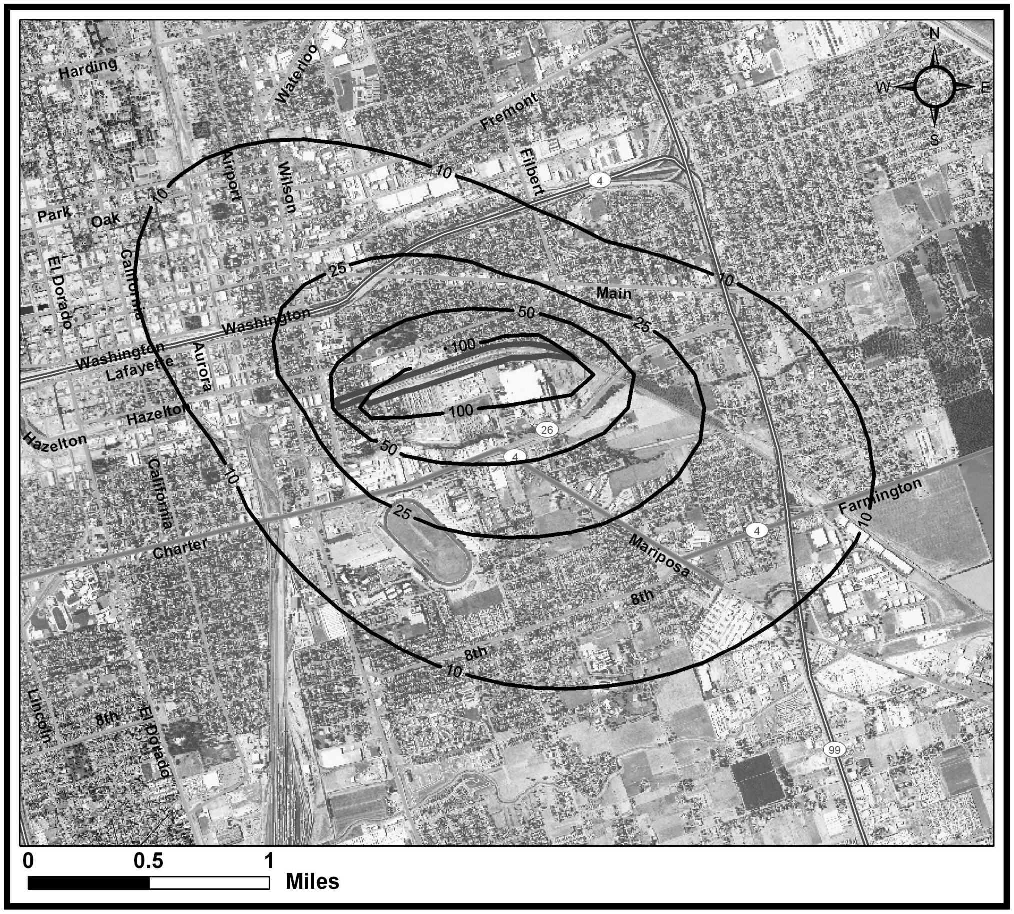
The OEHHA Guidelines require that, for health risk assessments, the cancer risk for the maximum exposure at the point of maximum impact should be reported. The point of maximum impact (PMI), which is defined as a location or the receptor point with the highest cancer risk level outside of the facility boundary, with or without residential exposure, is predicted to be located directly south of the railyard boundary, directly downwind of high emission density areas for the prevailing northwesterly wind, where about 95 percent of facility-wide diesel PM emissions were generated (see the emission allocation in Appendix E). The cancer risk at the PMI is estimated to be 195 chances in a million. The land use in the vicinity is former intermodal railyard (currently open land). However, there may be residents living in this zoned area. In the residential zoned area the potential cancer risk of maximally exposed individual resident (MEIR) or maximum individual cancer risk (MICR) is estimated at about 120 chances in a million. As indicated by Roseville Railyard Study (ARB, 2004a), the location of the point of maximum impact may vary depending upon the settings of the model inputs and parameters, such as meteorological data set or emission allocations in the railyard. Therefore, given the estimated emissions, modeling settings, and the assumptions applied to the risk assessment, there are great uncertainties associated with the estimation of point of maximum impact (PMI) and maximum individual cancer risk (MICR). These indications should not be interpreted as a literal prediction of disease incidence but more as a tool for comparison. In addition, the estimated point of maximum impact and maximum individual cancer risk may not be replicated by air monitoring.

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

Therefore, given the estimated emissions, the modeling settings, and the assumptions applied to the risk assessment, the point of maximum impact location and maximum individual cancer risk is uncertain and should not be interpreted as a literal prediction disease incidence but more as a tool for comparison. The estimated point of maximum impact location and maximum individual cancer risk value may not be replicated by air monitoring.

As shown in Figure V-1, the area with the greatest impact has an estimated potential of 100 in a million is about 200 yards from the railyard boundary in the upwind direction,. In the downwind direction, the risk contour of 100 in a million is about 400 yards from the boundary. The risks further decrease to 50 in a million within about 1 mile from the railyard then to 25 in a million at approximately a 2-mile distance from the railyard boundary. At about 4 miles from the railyard boundaries, the estimated cancer risks are at 10 in a million or lower.

Figure V-1: Diesel PM Risks from BNSF Stockton Railyard Activities



It is important to understand that these risk levels represent the predicted risks (due to the BNSF Stockton Railyard diesel PM emissions) above the existing background risk levels. For the broader San Joaquin Valley Air Basin, the estimated regional background risk level is estimated to be 390 in a million caused by diesel PM and 590 in a million caused by all toxic air pollutants in the year of 2000 (ARB, 2006a).

The OEHHA Guidelines recommend a 70-year lifetime exposure duration to evaluate the potential cancer risks for residents. Shorter exposure duration of 30-year and 9-year are also recommended for residents and school-aged children, as a supplement. These exposure durations are all based on the exposures of 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 to be used, assuming workers have different breathing rates (149 Liters/Kilogram-day) for an 8-hour workday, with adjustments of five days a week and 245 days a year.

Table V-2 shows the equivalent risk levels of 70-, 30-year exposure durations for exposed residents, and 40-, 9-year exposure durations for workers and school-aged children, respectively. Using Table II-5, the 10 in a million isopleth line in Figures II-4 would become 4 in a million for exposed population with a shorter residency of 30-year, 2.4 in a million for children at the age range of 0-9, and 2 in a million for off-site workers.

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

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

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

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

The more populated areas near the BNSF Stockton Railyard are located north and southeast of the railyard. Based on the 2000 U.S. Census Bureau's data, the zone of impact of the estimated risks above 10 chances in a million levels encompasses approximately 3,300 acres where about 23,000 residents live. Table V-4 presents the exposed population and area coverage size for various impacted zones of cancer risks.

Table V-4: Estimated Impacted Areas and Exposed Population associated with Different Cancer Risk Levels Caused by Railyard Diesel PM Emissions

Estimated Risk (chances per million)	Impacted Area (Acres)	Estimated Population Exposed
10 - 25	2,300	17,000
25 - 50	600	3,800
50 - 100	300	2,000
>100	50	300

b) Non-Cancer Chronic Risk

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

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

The methodology for developing chronic reference exposure levels is fundamentally the same as that used by U.S. EPA in developing the inhalation Reference Concentrations (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 (OEHHA 2003).

A substantial number of epidemiologic studies have found a strong association between exposure to ambient particulate matter and adverse health effects (CARB, 2002).
For diesel PM, OEHHA has determined a chronic REL of 5 µg/m^3, with the respiratory system as the hazard index target (OEHHA 2003).

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

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

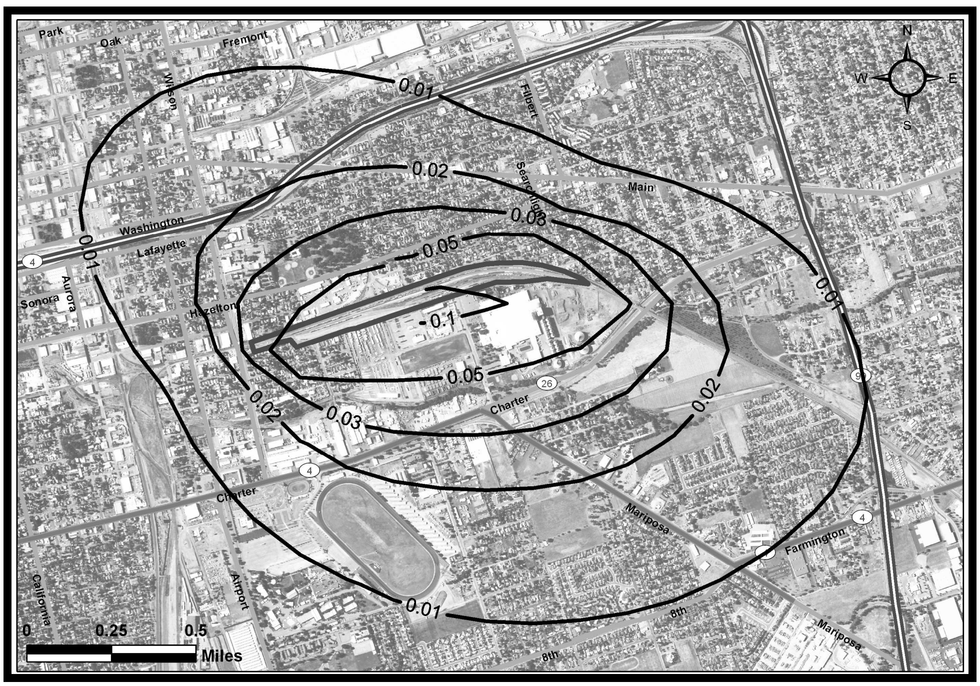
It is important to note that Reference Exposure Level (REL) for diesel PM is essentially the U.S. EPA Reference Concentration first developed in the early 1990s based on histological changes in the lungs of rats. Since the identification of diesel PM as a Toxic Air Contaminant (TAC), California has evaluated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

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

As part of this study, ARB staff conducted an analysis of the potential non-cancer health impacts associated with exposures to the model-predicted levels of directly emitted diesel PM from on-site sources. The HI values were calculated, and then plotted as a series of isopleths in Figure V-2. As can be seen, HI is small (< 0.1) at the BNSF Stockton Railyard and insignificant (<0.01) around vicinity of the railyard. According to OEHHA Guidelines (OEHHA, 2003), these levels indicate that the potential non-cancer chronic public health risks are less likely to happen.

Figure V-2 presents the spatial distribution of non-cancer chronic risks by health hazard index isopleths that range from 0.01 to 0.1 around the yard facility. The zone of impact where non-cancer chronic health hazard indexes are over 0.01 is an estimated area of 6,000 acres.

Figure V-2: Estimated Non-Cancer Chronic Risk Health Hazard Index from the BNSF Stockton Railyard (On-site)



c) Non-Cancer Acute Risk

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

Due to the uncertainties in the toxicological and epidemiological studies, diesel PM as a whole was not assigned a short-term acute REL. It is only specific compounds of diesel exhaust (e.g., acrolein) that independently have potential acute effects (such as irritation of the eyes and respiratory tract), and an assigned acute REL. However, acrolein is primarily used as a chemical intermediate in the manufacture of adhesives and paper. It has also been found as a byproduct of any burning process, such as fire, and tobacco smoke. Acrolein is a chemically reactive and unstable compound, and easily reacts with a variety of chemical compounds in the atmosphere. Compared to the other compounds in the diesel exhaust, the concentration of acrolein has a much lower chance of reaching a distant off-site receptor. More importantly, given the multitude of activities ongoing at facilities as complex as railyards, there are much higher levels of uncertainties associated with hourly-specific emission data and estimated maximum concentrations, which are essential to assess acute risk. Therefore, non-cancer acute risk is not addressed quantitatively in this study. From a risk management perspective, ARB staff believes it is reasonable to focus on diesel PM cancer risk because it is the predominant risk driver and the most effective parameter to evaluate risk reduction actions. 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 Stockton Railyard facility 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 boundary of the BNSF Stockton Railyard was included. Diesel PM off-site emissions used in the off-site modeling runs consisted of about 10 tons per year from roadways and 0.05 tons per year (or about 100 pounds) from stationary facilities, representing emissions for 2005. The diesel PM emissions from the BNSF Stockton 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-3 and Figure V-4. As indicated in Figure V-3, the zone of impacts of estimated cancer risks associated with off-site diesel PM emissions is significantly larger than that of the BNSF Stockton Railyard. This result is expected because the diesel PM emissions from the significant off-site sources are equivalent to 3 times of the BNSF Stockton Railyard diesel PM emissions. Figure V-4 illustrates that the non-caner chronic health risks associated with off-site diesel PM emissions are insignificant.

Based on the 2000 U.S. Census Bureau’s data, the zone of impact of the estimated potential cancer risks over 10 chances in a million levels associated with off-site diesel PM emissions encompasses approximately 11,000 acres where about 82,000 residents live. For comparison with the on-site health risks, the same level of potential cancer risks (10 chances in a million) associated with railyard diesel PM emissions covers about 3,300 acres where approximately 24,000 residents live. Detailed calculations and methodologies used in off-site air dispersion modeling are presented in Appendix C.

Table V-5: Estimated Impacted Areas and Exposed Population associated with Different Cancer Risk Levels Caused by Off-Site Diesel PM Emissions

Estimated Cancer Risk (chances per million)	Estimated Impacted Area (Acres)	Estimated Population Exposed
10 - 25	5,400	37,500
25 - 50	2,500	21,500
50 - 100	1,800	18,000
>100	600	5,000

Figure V-3: Potential Cancer Risk Levels Associated with Off-Site Diesel PM Emission Sources Surrounding the BNSF Stockton Railyard in 2005

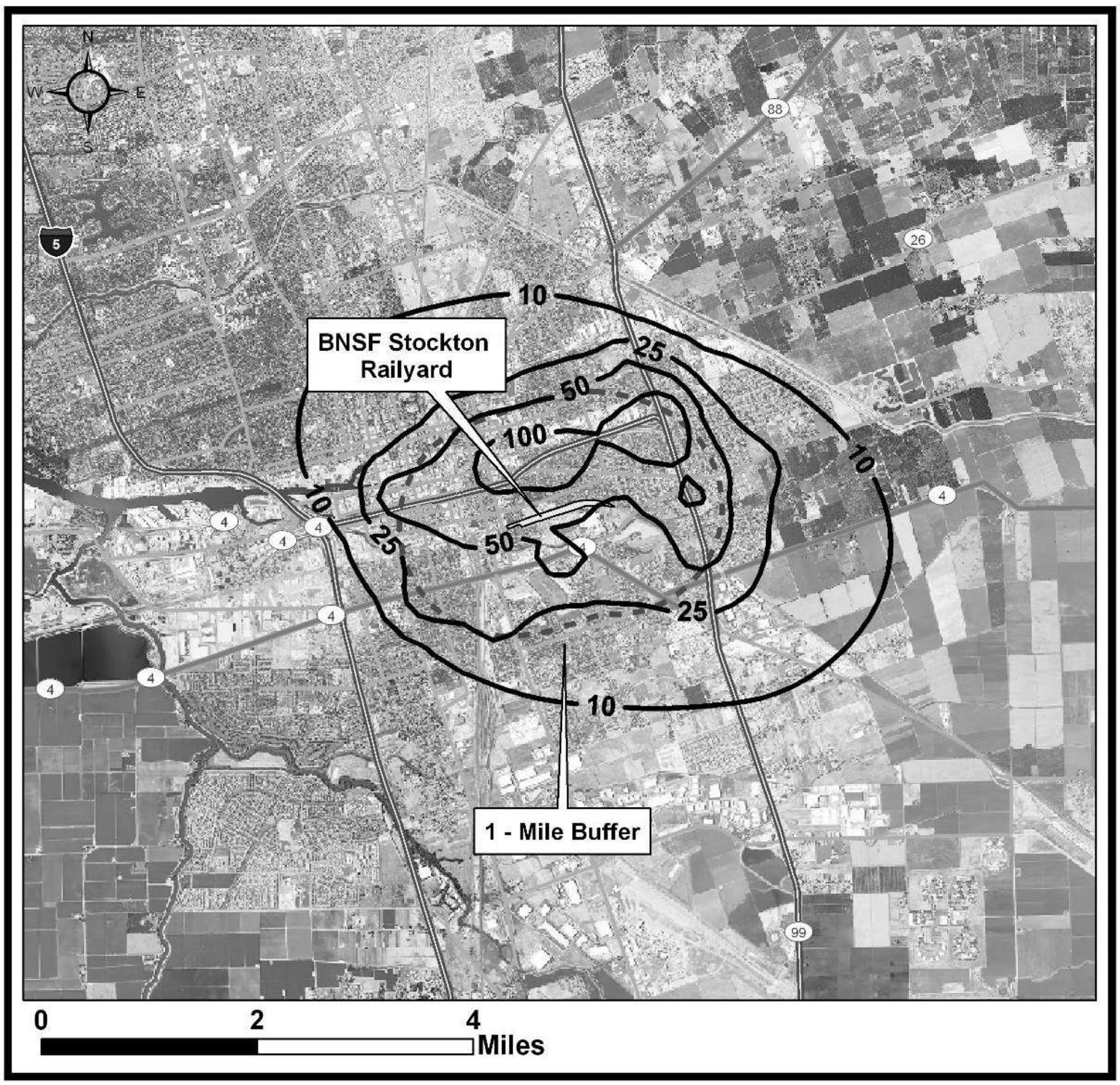
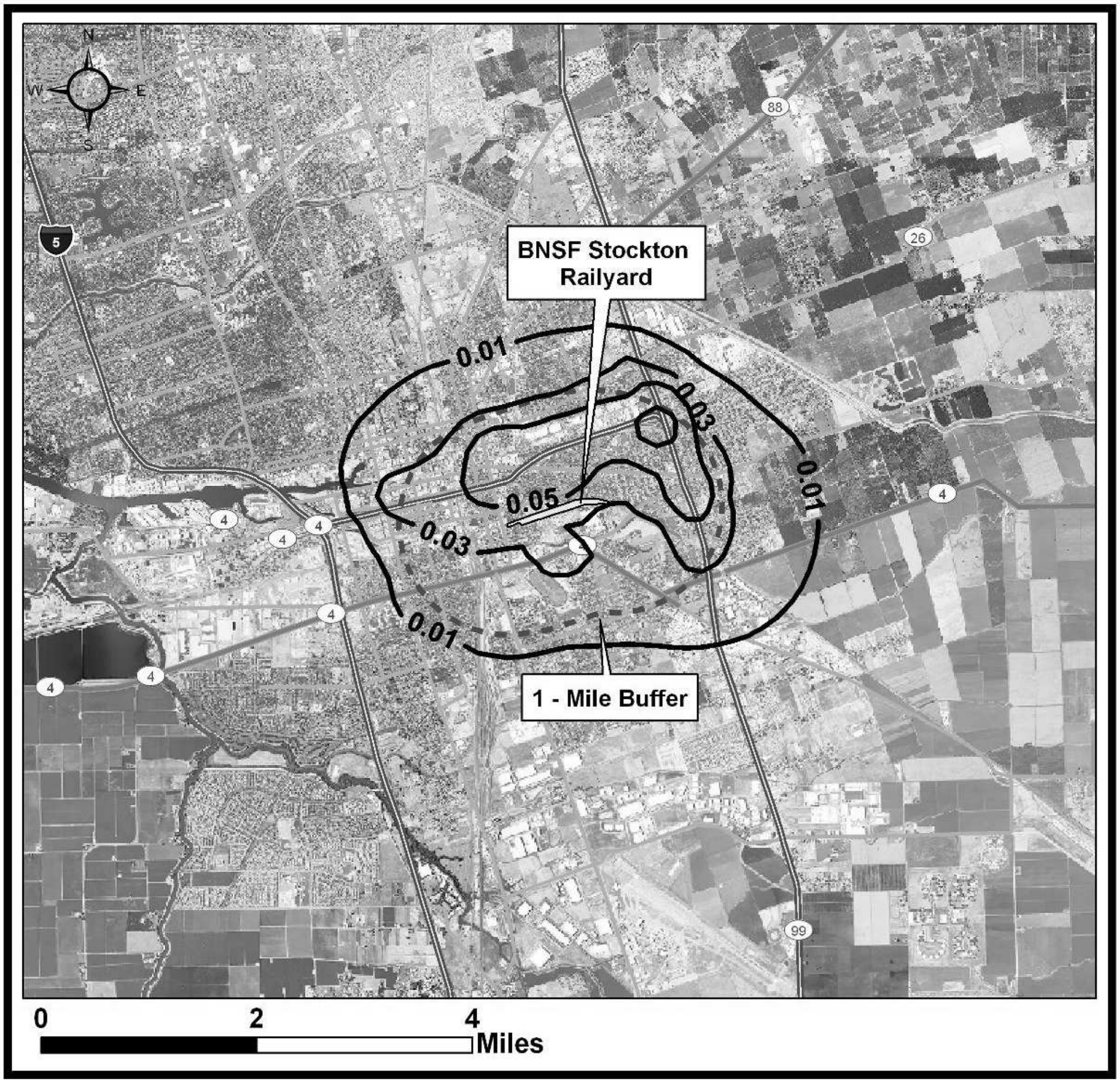


Figure V-4: Non-cancer Risk Levels Associated with Off-Site Diesel PM Emissions Sources Surrounding the BNSF Stockton Railyard in 2005



3. Risks to Sensitive Receptors

Individuals who may be more sensitive to toxic exposures than the general population are distributed thorough the total population. These sensitive populations are identified as school-age children and seniors. Typical sensitive receptors are schools, hospitals, day-care centers and elder care facilities. There are 22 such sensitive receptors around the BNSF Stockton Railyard within the distance of one mile (18 schools and day care centers, 2 hospital and 2 group homes). Table V-6 also shows the number of sensitive receptors in various levels of cancer risks associated with diesel PM emission from the BNSF Stockton Railyard, based on 70-year residential exposure duration.

Table V-6: Numbers of Schools and Hospitals within the isopleths at the BNSF Stockton Railyard

Estimated Risk (per million)	Distance (miles)	Sensitive Receptors
10 – 25	0.5-1	17
25 – 50	0.3-0.5	5
50 – 100	0.3	0

D. Uncertainty and Limitations

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

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

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

1. Emission Inventory

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

The uncertainties of emission estimates may be attributed to many factors such as a lack of information for variability of locomotive engine type, throttle setting, level of maintenance, operation time, and emission factor estimates. Quantifying individual uncertainties is a complex process and may in itself introduce unpredictable uncertainties[5].

For locomotive sources at the BNSF Stockton Railyard, the activity rates include primarily the number of engines 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 could not distinguish when engine is on or off during periods when locomotive is in the idle notch. As a result, a professional judgment is applied to distinguish between these two modes. While the current operations may not be precisely known, control measures already being implemented are expected to result in reduced activity levels and lower emissions than are estimated here for future years.

As discussed previously, emission factors are often used for emission estimates according to different operating cycles. The Roseville Railyard Study (ARB, 2004) developed representative diesel PM emission factors for locomotives in different duty cycles. To reduce the possible variability of locomotive population and the uncertainty from assumptions, the emission factors were updated in the study to cover a wide range of locomotive fleet in the State (see Appendix D). The fuel usage in the locomotives in 2005 was calculated from the UP's annual fuel consumption database. These critical updates for locomotive emission inventory have established the most representative locomotive emission factors for the study.

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[5] The railyard HRAs have been performed using a methodology according to the ARB's and OEHHA Guidelines, and consistent with previous health risk analyses conducted by ARB. Similar to any model with estimations, the primary barriers of an HRA to determine objective probabilities are lack of adequate scientific understanding and more precise levels of data. Subjective probabilities are also not always available.

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

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

2. Air Dispersion Modeling

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

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

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

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

3. Risk Assessment

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

Human exposures to diesel PM are often based on limited availability of data and are mostly derived based on estimates of emissions and duration of exposure. Different epidemiological studies also suggest somewhat different levels of risk. When the Scientific Review Panel (SRP) identified diesel PM as a toxic air contaminant (ARB, 1998), the panel members endorsed a range of inhalation cancer potency factors (1.3×10^{-4} to 2.4×10^{-3} $(\mu g/m^3)^{-1}$) and a risk factor of 3×10^{-4} $(\mu g/m^3)^{-1}$, as a reasonable estimate of the unit risk. From the unit risk factor an inhalation cancer potency factor of 1.1 $(mg/kg\text{-}day)^{-1}$ can be calculated, which is used in the study. 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 OEHHA for exposure and risk assessment. The Tier 1 approach is an end-point estimate methodology without the consideration of site-specific data distributions. The OEHHA recommends the lifetime 70-year exposure duration be used for determining residential cancer risks. This will ensure a person residing in the vicinity of a facility for a lifetime will be included in the evaluation of risk posed by the facility. Lifetime 70-year exposure is a conservative estimate, but it is a historical benchmark for comparing facility impacts on receptors and for evaluating the effectiveness of air pollution control measures. Although it is not likely that most people will reside at a single residence for 70 years, it is common that people will spend their entire lives in a major urban area. While residing in urban areas, it is very possible to be exposed to the emissions of another facility at the next residence. In order to help ensure that people do not accumulate an excess unacceptable cancer risk from cumulative exposure to stationary facilities at multiple residences, the 70-year exposure duration is used for risk management decisions. However, if a facility is notifying the public regarding health risk, it is a useful indication for a person who has resided in his or her current residence less than 70 years to know that the calculated estimate of his or her cancer risk is less than that calculated for a 70-year risk (OEHHA, 2003). It is important that the risk estimates generated in this study not be interpreted as the expected rates of disease in the exposed population, but rather as estimates of potential risk.

Moreover, since the Tier-1 methodology is used in the study for the health risk assessment, the results have been limited to deterministic estimates based on conservative inputs. For example, an 80 percentile breathing rate approach is used to represent a mid-point inhalation for the general group of population. Although this approach may ensure the risk assessment is not under- or overestimated by the variability of breath intake, it cannot rule out the possible uncertainties from other sources due to limited data availability from experimental exposure studies. Because of these limitations, it should be noted that the results 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, ARB staff estimated emissions based on roadway specific vehicle activity data and allocated them to individual roadway links. All roadway links within a 2-mile buffer of the combined Commerce yards and all links within a 1-mile buffer of all other yards were included in this assessment. This inventory does not include emissions generated by idling of heavy duty trucks or any off-road equipment outside the rail yards.

As more work has been done to understand transportation modeling and forecasting, access to local scale vehicle activity data has increased. For example, the various Metropolitan Planning Organizations (MPOs) are mandated by the Federal government to maintain a regional transportation plan and a regional transportation improvement plan. These reports assess the impact the travel growth and assess various transportation improvement plans[6]. 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

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 1) where speed-specific VMT is then matched to an emission factor from EMFAC to estimate total emissions from each vehicle type for each hour of the day. The working draft of EMFAC, rather than EMFAC2007, was used for this assessment because at the time this project was underway EMFAC2007 was not completed. The working draft of

[6] SCAG Transportation Modeling, http://www.scag.ca.gov/modeling/ (Accessed January 2007).

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

Table 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 railyard study are covered by the Integrated Transportation Network (ITN) developed by Alpine Geophysics[7]. 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 are then compiled into an activity matrix (Table 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)

[7] 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

VMT, medium heavy duty diesel truck (MHDDT) VMT, and heavy heavy duty diesel truck (HHDDT) VMT.

Table 2: Activity Matrix Example

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

Step 2: Derive Gram per Mile Emission Factors

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

Table 3: Emission Factor Matrix Example

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

Step 3: Calculate Emissions

Diesel particulate matter (DPM) 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:

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

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

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

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

where

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

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

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

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

LIMITATIONS AND CAVEATS

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

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

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

APPENDIX B

METHODOLOGY FOR ESTIMATING OFF-SITE DIESEL PM STATIONARY SOURCE EMISSIONS

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

Geographic information system (GIS) mapping tools were used to create a one-mile buffer zone outside the property boundary footprint reported for each railyard. The CEIDARS facilities whose latitude/longitude coordinates fell within the one-mile buffer zone were selected. Because of the close proximity of railyards in the Commerce area, the four railyards (Commerce-BNSF, Commerce-UP-Main, Commerce-UP-Eastern, and Commerce-UP-Mechanical/Sheila) were enclosed in a combined polygon outline, and a two-mile buffer zone was then used around the combined polygon footprint.

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 (IC) 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 PM10) 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 PM10 reported at diesel IC 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.

APPENDIX C

METHODOLOGY FOR THE AIR DISPERSION MODELING OF OFF-SITE DIESEL PM EMISSIONS

Impacts from off-site pollution sources near the BNSF Stockton rail yard facility were modeled using the USEPA-approved AERMOD dispersion model. 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 Stockton rail yard were included. Other emission sources that were located immediately beyond the one mile zone from the facility, such as a high-volume freeway, have the potential to impact receptors in the modeling grid, but were not considered.

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

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

Type of Data	Description	Data Source
Emission Estimates	Off-site DPM emissions for 2005 Mobile Sources: 10.0 TPY DPM Stationary Sources: 0.05 TPY DPM	PTSD/MSAB
Receptor Grid	45x42 Cartesian grid covering 451 km^2 with uniform spacing of 500 meters. Grid origin: (641900, 4191400) in UTM Zone 10.	ENVIRON
Meteorological Data	AERMET-Processed data for 2000, 2002-2005 *Surface*: Stockton Municipal Airport *Upper Air*: Oakland Metro. Airport	ENVIRON
Surface Data	Albedo: 0.14 to 0.20 Bowen Ratio: 0.24 to 2.74 Surface Roughness: 0.13 to 0.54	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 1: Region surrounding the BNSF Stockton rail facility with the modeling domain indicated by the black outline.

Figure 1 illustrates the region surrounding the BNSF Stockton modeling domain. The domain has dimensions 22 km x 20.5 km and contains a grid of 1890 receptors with a 500 meter uniform grid spacing.

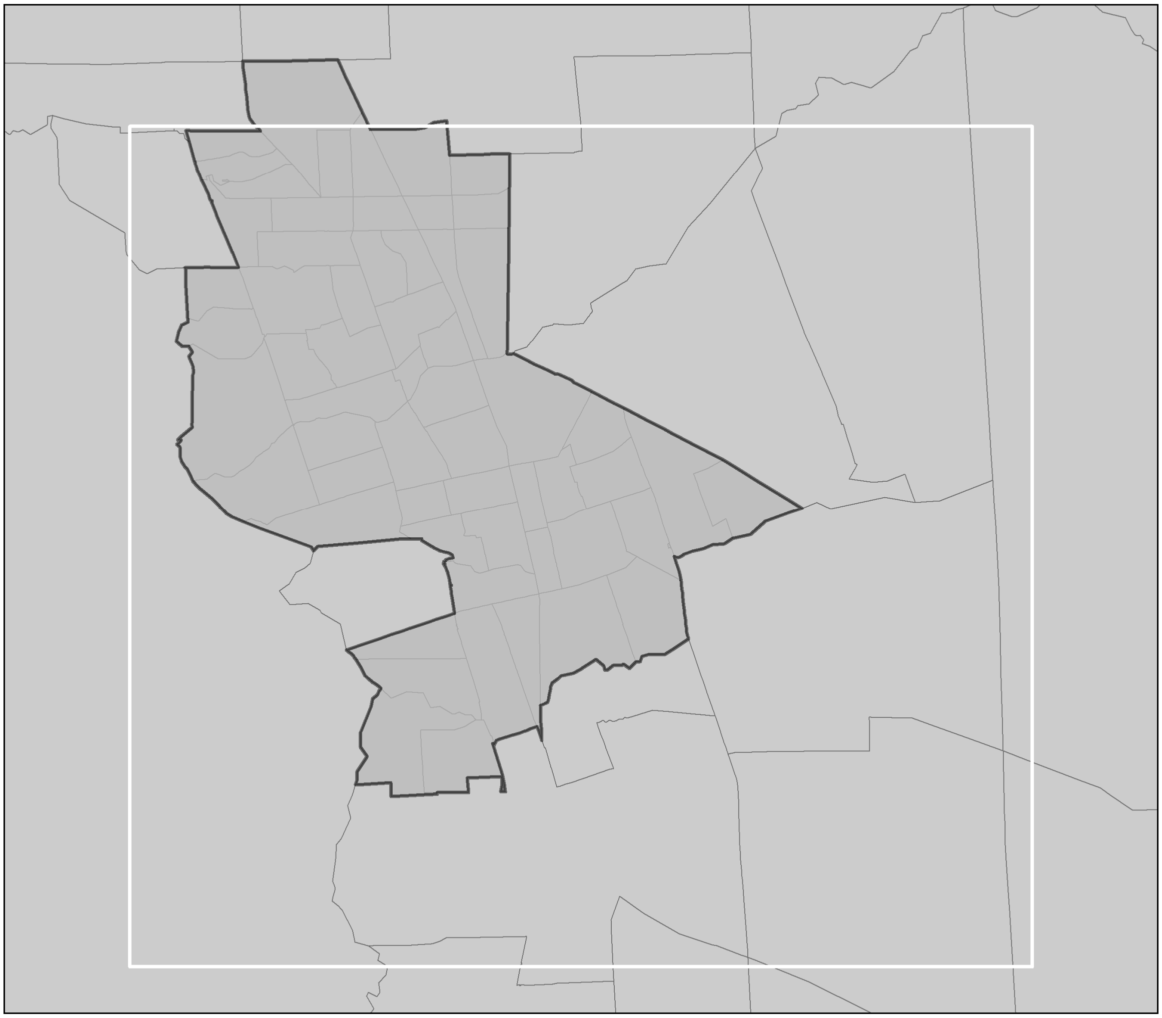


Figure 2: BNSF Stockton Urban Population: Orange denotes areas with at least 750 people/km^2. The highlighted region is the contiguous urban area used for modeling purposes.

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 continuous urban area selected can be seen in Figure 2. The population in this selected area is 282,462.

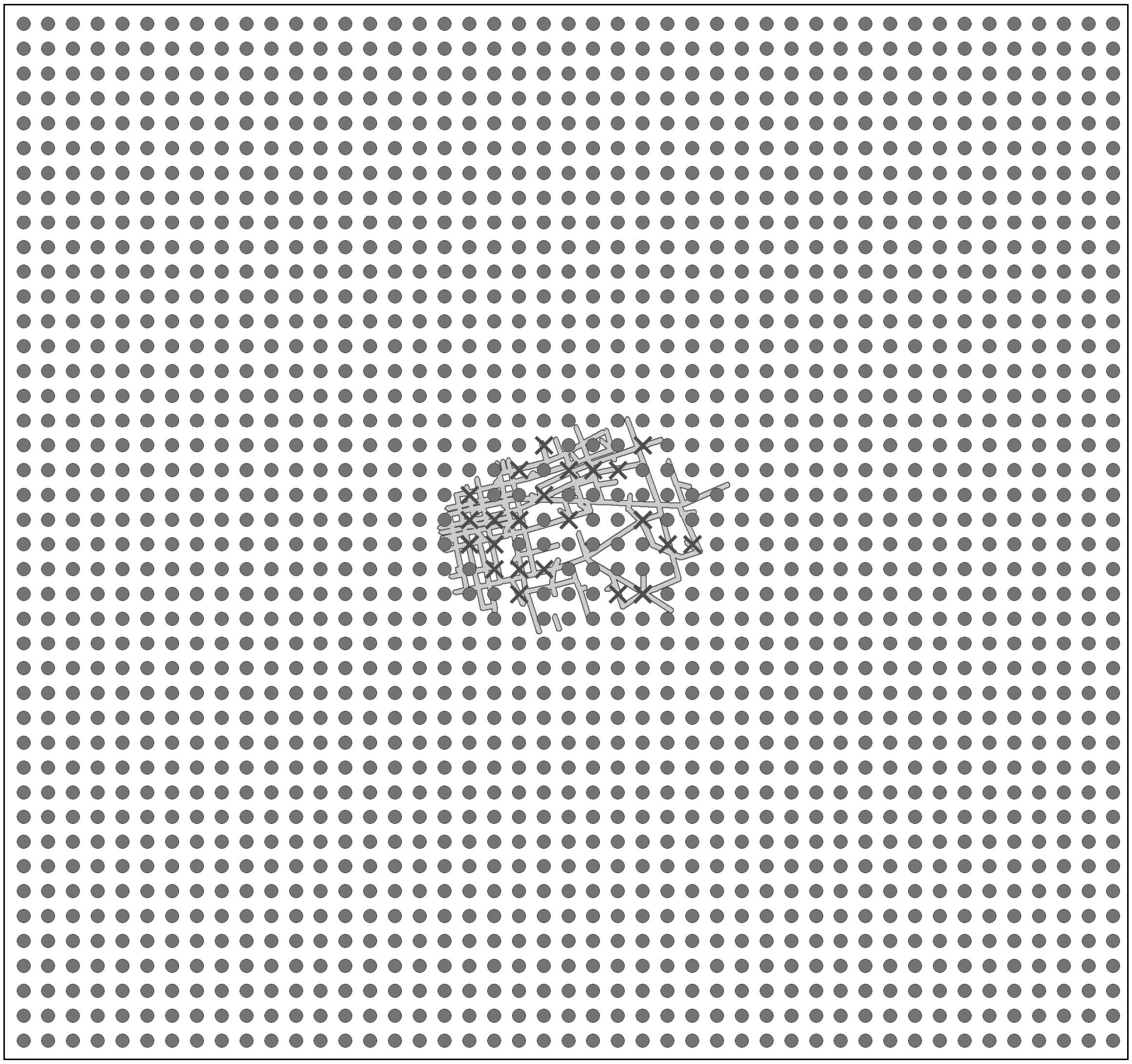


Figure 3: BNSF Stockton receptor network including off-site sources and rail facility

The off-site stationary and on-road emission sources used in the BNSF Stockton model runs are plotted along with the receptor network in Figure 3. These sources do not represent all stationary and roadway sources within the domain, but rather a subset made up of those roadways and facilities within one mile of the perimeter of the rail yard facility. Diesel PM off-site emissions used in the off-site modeling runs consisted of 10.0 tons per year from roadways and 0.05 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 22 km x 20.5 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 3. After removal, 1867 of the original 1890 receptors remained.

The same meteorological data used by ENVIRON was used for the off-site modeling runs. The data were compiled by ENVIRON from the nearby Stockton Municipal Airport (37.90°N, 121.23°W). Upper air data for the same time period was obtained from the Oakland Metropolitan Airport upper air station (37.717°N, 122.217°W). The model runs used five year of meteorological data from 2000 and 2002 through 2005.

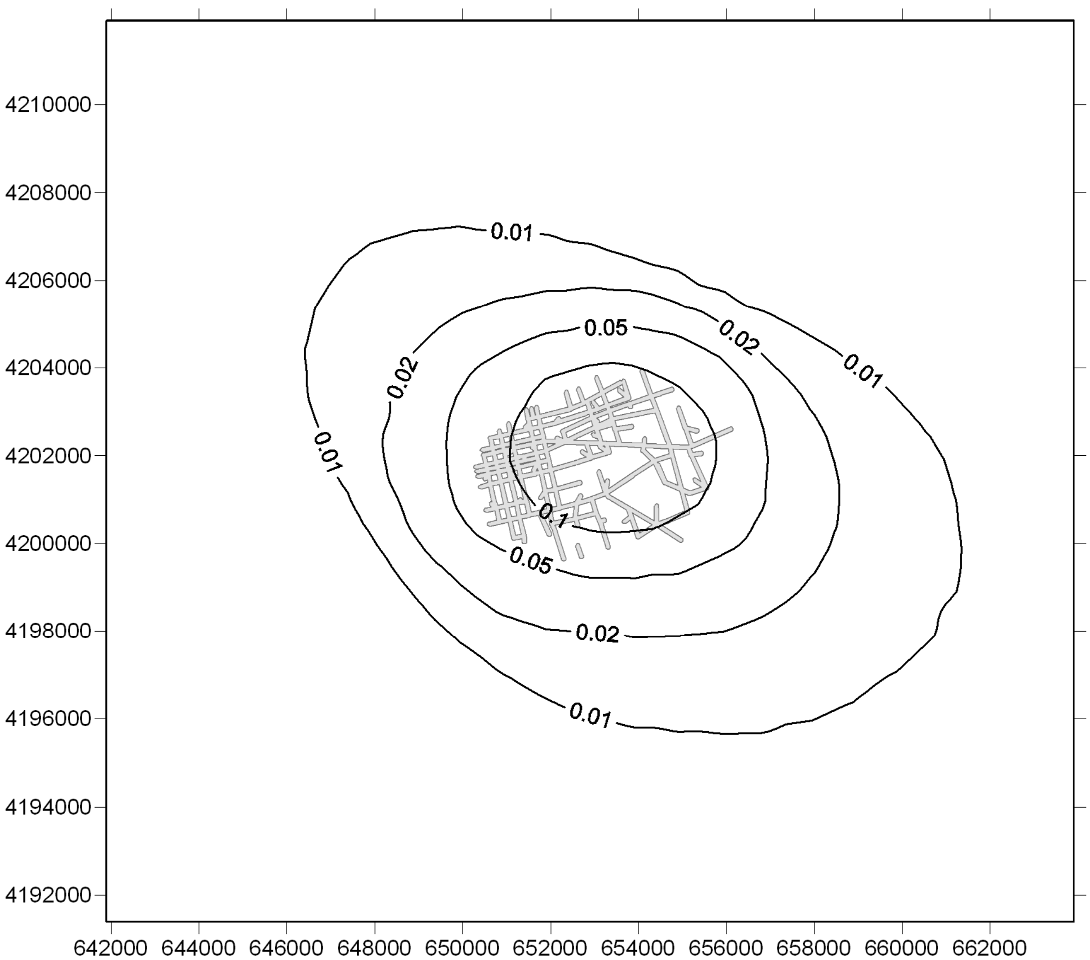


Figure 4: BNSF Stockton off-site sources and rail yard with modeled annual average concentrations from off-site sources in ug/m^3

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

Table 2: BNSF Stockton maximum annual concentrations in ug/m^3

X	Y	Mobile	Stationary	Total (Off-site)
654400	4202900	0.828	0.0001	0.828
652900	4202400	0.477	0.0003	0.477
651900	4202400	0.457	0.0003	0.457
654900	4201900	0.387	0.0002	0.387
653400	4202400	0.279	0.0002	0.279

APPENDIX D
TABLE OF LOCOMOTIVE DIESEL PM EMISSION FACTORS

Table D-1: Locomotive Diesel PM Emission Factors (g/hr)

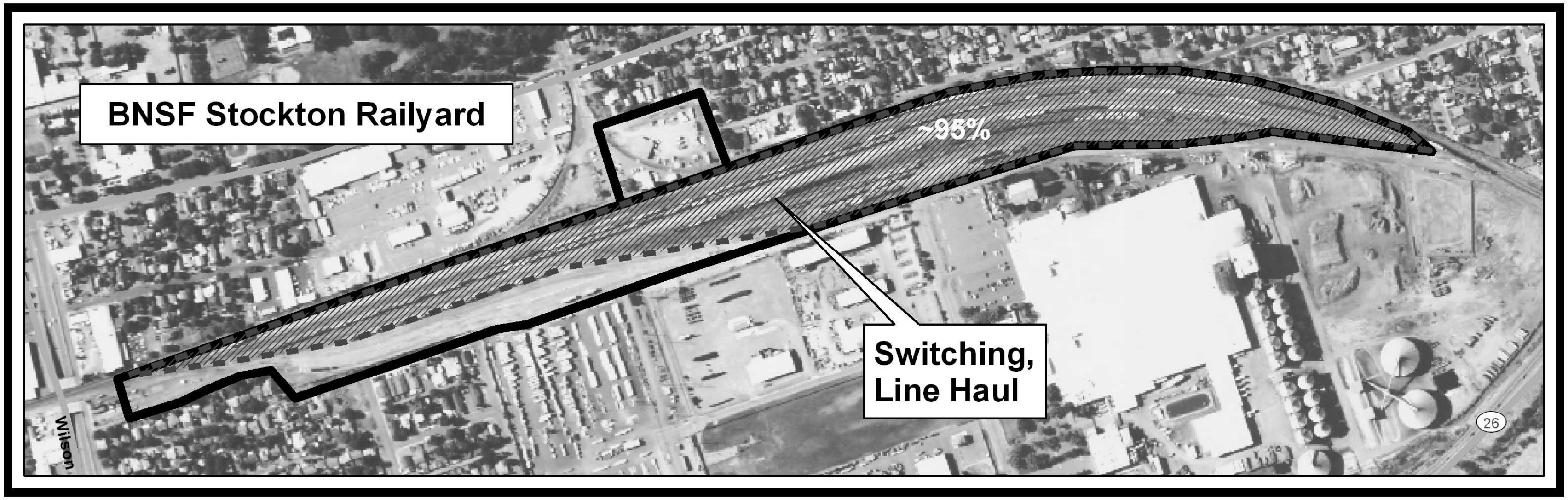
Model Group	Tier	Throttle Setting										Source[1]
		Idle	DB	N1	N2	N3	N4	N5	N6	N7	N8	
Switcher	N	31.0	56.0	23.0	76.0	131.8	146.1	181.5	283.2	324.4	420.7	ARB and ENVIRON
GP-3x	N	38.0	72.0	31.0	110.0	177.7	194.8	241.2	383.4	435.3	570.9	ARB and ENVIRON
GP-4x	N	47.9	80.0	35.7	134.3	216.2	237.5	303.5	507.4	600.4	771.2	ARB and ENVIRON
GP-50	N	26.0	64.1	51.3	142.5	288.0	285.9	355.8	610.4	681.9	871.2	ARB and ENVIRON
GP-60	N	48.6	98.5	48.7	131.7	271.7	275.1	338.9	593.7	699.1	884.2	ARB and ENVIRON
GP-60	0	21.1	25.4	37.6	75.5	228.7	323.6	467.7	666.4	1058.5	1239.3	KCS7332
SD-7x	N	24.0	4.8	41.0	65.7	149.8	223.4	290.0	344.6	446.8	553.3	ARB and ENVIRON
SD-7x	0	14.8	15.1	36.8	61.1	220.1	349.0	407.1	796.5	958.1	1038.3	ARB and ENVIRON
SD-7x	1	29.2	31.8	37.1	66.2	219.3	295.9	436.7	713.2	783.2	847.7	NS2630[3]
SD-7x	2	55.4	59.5	38.3	134.2	271.7	300.4	335.2	551.5	672.0	704.2	UP8353[3]
SD-90	0	61.1	108.5	50.1	99.1	255.9	423.7	561.6	329.3	258.2	933.6	EMD 16V265H
Dash 7	N	65.0	180.5	108.2	121.2	322.6	302.9	307.7	268.4	275.2	341.2	ARB and ENVIRON
Dash 8	0	37.0	147.5	86.0	133.1	261.5	271.0	304.1	334.9	383.6	499.7	ARB and ENVIRON
Dash 9	N	32.1	53.9	54.2	108.1	197.3	267.3	343.9	392.4	397.3	573.3	SWRI 2000
Dash 9	0	33.8	50.7	56.1	117.4	205.7	243.9	571.5	514.6	496.9	460.3	average of ARB & CN2508[1]
Dash 9	1	16.9	88.4	62.1	140.2	272.8	354.5	393.4	466.4	445.1	632.1	CSXT595[2]
Dash 9	2	7.7	42.0	69.3	145.8	273.0	337.4	376.0	375.1	419.6	493.5	BNSF 7736[2]
C60-A	0	71.0	83.9	68.6	78.6	277.9	234.1	276.0	311.4	228.0	362.7	ARB and ENVIRON

Notes:

1. Except as noted below, these emission rates were originally developed for the ARB Roseville Rail Yard Study (October 2004), and were subsequently adjusted based on an average fuel sulfur content of 0.11% by ENVIRON as part of the BNSF efforts for their analyses for the Railyard MOU (Personal communication from Chris Lindhjem to R. Ireson, 2006).
2. Emission rates added by ENVIRON based on data produced in the AAR/SwRI Exhaust Plume Study (Personal communication from Steve Fritz to C. Lindhjem, 2006)
3. SD-70 emission rates taken from data produced in the AAR/SwRI Exhaust Plume Study (Personal communication from Steve Fritz to R. Ireson, 2006)

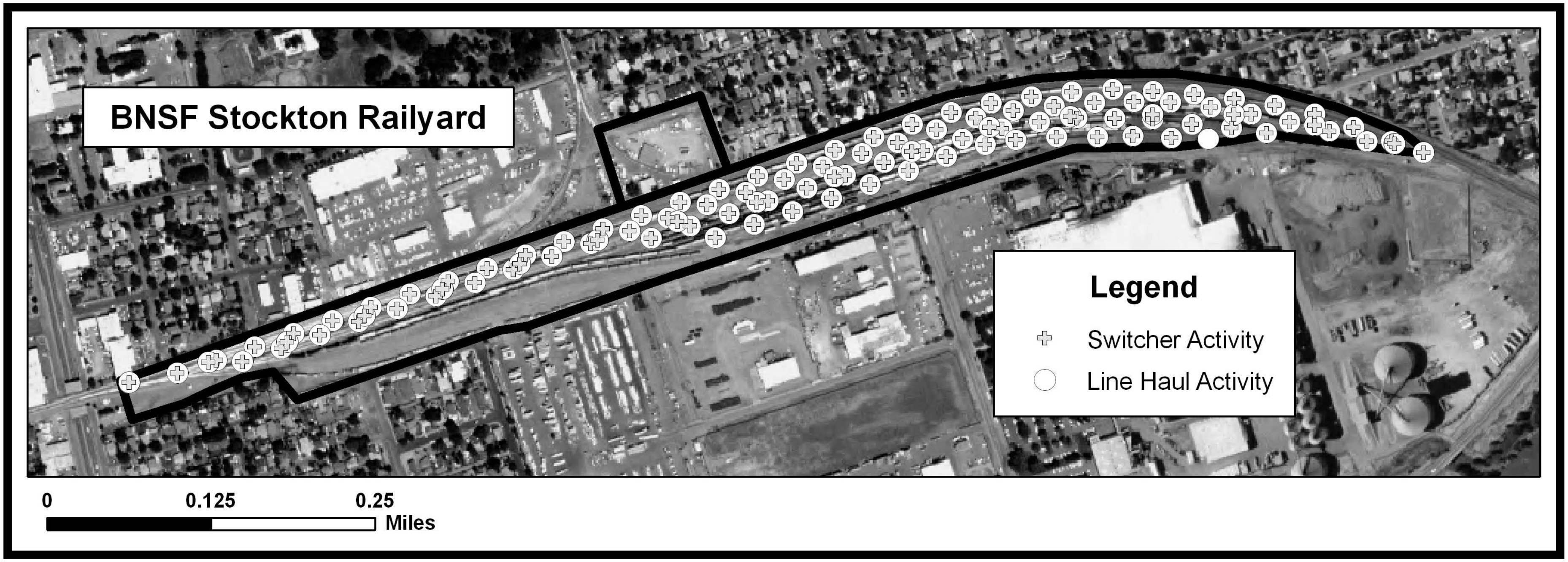
APPENDIX E
SPATIAL ALLOCATIONS OF MAJOR DIESEL PM EMISSION SOURCES AT BNSF STOCKTON RAILYARD

Figure E-1 The BNSF Stockton Railyard shown with the shaded area accounting for about 95 percent of facility-wide diesel PM emissions.



At the BNSF Stockton Railyard, Line Haul activity (arriving, departing, and idling) and switching (movement and idling) both occur with in the highlighted area. Of the 3.9 TPY of diesel PM at this yard, line haul and switch operations account for 1.7 TPY and 1.5 TPY respectively.

Figure E-2 Spatial allocation of locomotive emissions at BNSF Stockton Railyard.



APPENDIX F

AERMOD MODEL SENSITIVITY ANALYSIS OF METEOROLOGICAL DATA (ONE- 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.

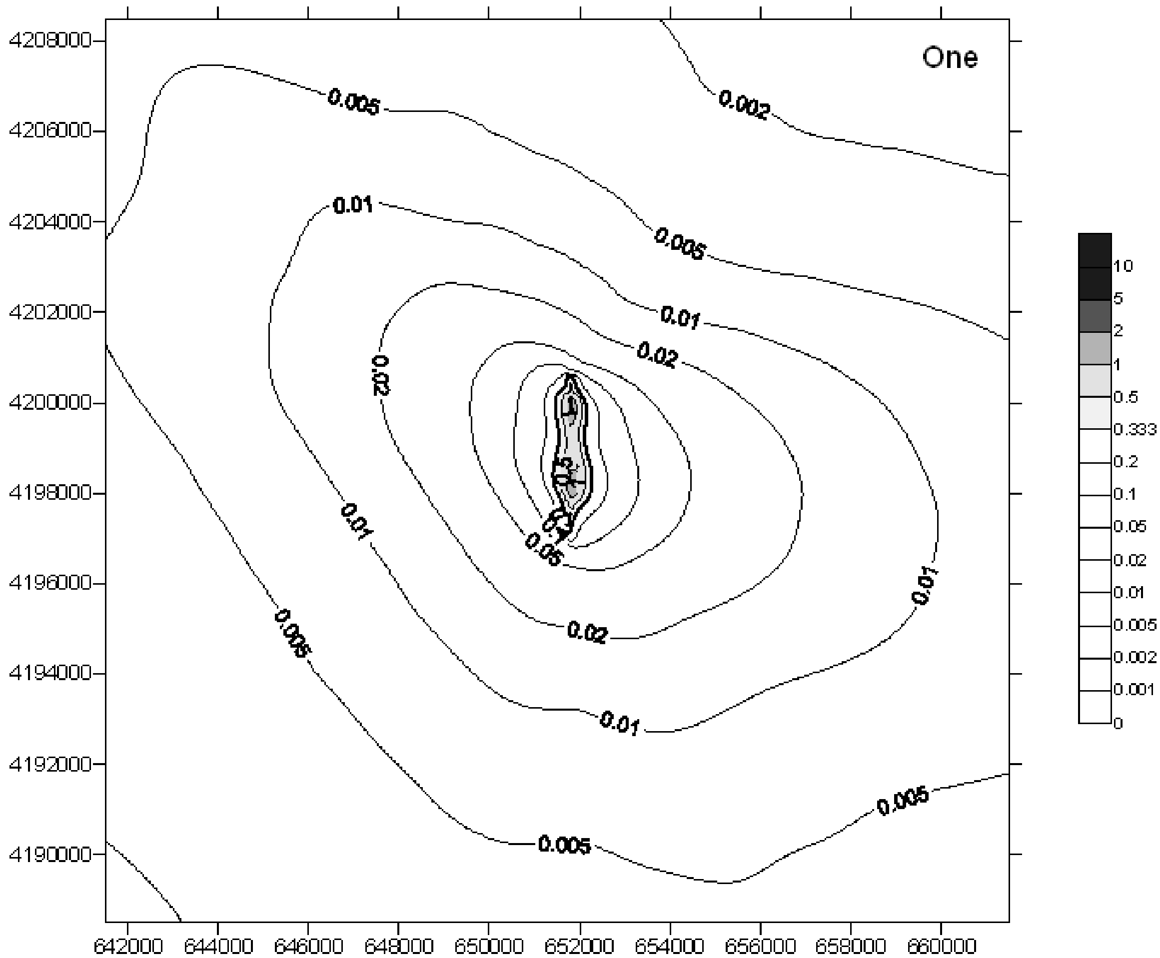


Figure F-2 AERMOD's Simulated Diesel PM Concentrations (due to On-site and Off-site Diesel PM Emissions) around UP Stockton.