California Environmental Protection Agency

Air Resources Board

Health Risk Assessment for the BNSF Railway Barstow Railyard

Stationary Source Division
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I. INTRODUCTION

The California Air Resources Board (ARB or Board) conducted a health risk assessment study to evaluate the health impacts associated with toxic air contaminants emitted in and around the BNSF Railway's (BNSF) Barstow Railyard located in the city of Barstow, California. The BNSF Barstow Railyard is located at 200 Avenue H in Barstow. The study focused on the railyard property emissions from locomotives, on-road trucks, and off-road vehicles and equipment used to move bulk cargo such as forklifts. 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 health risks associated with diesel particulate matter emissions to those living nearby the railyard.

A. Why ARB is 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 contaminants in and around a railyard facility. Statewide, diesel PM accounts for about 70% of the estimated potential ambient air toxic cancer risks based on an analysis conducted by ARB staff in 2000 (ARB, 2000). These findings are consistent with the preliminary findings reported in a recently released draft report entitled the *Multiple Air Toxics Exposure Study in the South Coast Air Basin (SCAQMD, 2008).* Based on scientific research findings and the dominance of diesel PM emissions, the health impacts in this railyard health risk assessment study primarily focus on the risks from the diesel PM emissions.

[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.

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

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

The Agreement requires that health risk assessments (HRAs) be prepared for each of the 17 major or designated railyards in the State. The Agreement also 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 Guidelines for Railyard and Intermodal Facilities* developed by the ARB in 2006 (See http://www.arb.ca.gov/railyard/hra/hra.htm) (ARB, 2006d). The BNSF Barstow Railyard is one of the designated railyards subject to the Agreement and the HRA requirements.

C. What are Health Risk Assessments (HRAs)?

An exposure assessment is an analysis of the amount (i.e., concentration in the air) of a pollutant that a person is exposed to in a specific time period. This information is used in a risk assessment to evaluate the potential for an air pollutant to contribute to cancer or other health effects. A health risk assessment uses mathematical models to evaluate the health impacts from exposure to certain chemical or toxic air contaminants released from a facility or found in the air. Health risk assessments provide information to estimate potential long-term cancer and non-cancer health risks. Health risk assessments do not gather information or health data on specific individuals, but are estimates for the potential health impacts on a population at large.

A health risk assessment consists of three major components: (1) the air pollution emission inventory, (2) the air dispersion modeling, and (3) an assessment of associated risks. The air pollution emission inventory provides an estimate of how air pollutants are generated from different emission sources. The air dispersion modeling incorporates the estimated emission inventory and meteorological data as inputs, and then uses a computer model to predict the distributions of air toxics in the air. Based on the modeling results, an assessment of the potential health risks from the air toxics to exposed population is performed. The results are expressed in a number of ways as summarized below.

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

- For non-cancer health effects, a reference exposure level (REL)[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 reference exposure level is compared to the concentration that a person is exposed to and a "hazard index" (HI) is calculated. Typically, the greater the hazard index is above 1.0, the greater the potential for possible adverse health effects. If the hazard index is less than 1.0, then it is an indicator that adverse effects are less likely to occur.

- For premature deaths linked to diesel PM emissions in the Mojave Desert Air Basin (MDAB), ARB staff estimated about 22 premature deaths per year due to diesel exhaust exposure in 2000 (ARB Research Division, and Lloyd and Cackette, 2001). The total diesel PM emissions from all sources in the Mojave Desert Air Basin are about 1,070 tons per year in 2005 (ARB, 2006a). Diesel PM emissions in 2005 from the BNSF Barstow Railyard are estimated at about 28 tons per year, which is about 2.6% of the total Mojave Desert Air Basin emissions. For comparison with another major source of diesel PM emissions, in South Coast Air Basin, the combined diesel PM emissions from the Port of Los Angeles/Port of Long Beach were estimated at about 1,760 tons per year, which resulted in an estimated twenty nine (29) premature deaths per year in the basin (ARB 2006b).

[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.

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

The HRA is a complex process that is based on current knowledge and a number of assumptions. However, there is a certain amount 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 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. 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.

D. Who prepared the BNSF Barstow Railyard HRA?

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

Using the guidelines, BNSF and their consultant (i.e., ENVIRON International Corporation) were responsible for the preparation of the emission inventories and performing the air dispersion modeling for operations that occur within the BNSF Barstow Railyard. The base year of the analysis was 2005.
ARB staff is responsible for reviewing and approving the railroads' submittals, identifying significant sources of emissions near the railyards, modeling the impacts of those sources, and preparing the railyard health risk assessments (HRAs). 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 help identify the most effective mitigation measures that could be implemented to further reduce railyard emissions and public health risks.

E. How is this report structured?

The next chapter provides a summary of the BNSF Barstow Railyard operations, emissions, air dispersion modeling, and health risk assessment results. Following the summary, the third chapter presents the details of the BNSF Barstow Railyard emission inventories. After that, the fourth chapter explains how the air dispersion modeling was conducted, and the fifth chapter provides the detailed health risk assessment for the BNSF Barstow 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 Barstow Railyard operations, emissions, air dispersion modeling, and health risk assessment results. The study estimates are based on the 2005 base-year diesel PM emissions generated from the BNSF Barstow Railyard, and off-site non-railyard emission sources.

A. General Description of the BNSF Barstow Railyard

The BNSF Barstow Railyard is located at 200 Avenue H in Barstow, California (see Figure II-1). The BNSF Barstow Railyard is located on the northern edge of the City of Barstow in a commercial and residential area. The railyard is approximately 5 miles in length, oriented in an east-west direction and covers an area of about 600 acres. The BNSF Barstow Railyard is situated in a valley that runs from east to west, and has mountains with elevation of several hundred feet and is located within 3 miles to the north and south sides of the railyard. The railyard is bordered by a rail "wye" near Highway 58 on the west side, and the City of Barstow with West Main Street and Historic Route 66 or National Trails Highway to the south side. Interstate 15 is located to the east of the BNSF Barstow Railyard, and the Mojave River and residential streets are located to the north and northeast of the railyard.

Barstow is the major BNSF maintenance hub for California. Nearly all of the trains leaving or arriving in California pass through the BNSF Barstow Railyard. Trains are reconfigured in the BNSF Barstow Railyard and all trains receive a crew change. Furthermore, Barstow is the major California location for services to trains and locomotives, including engine refueling and technical services.

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

The BNSF Barstow Railyard is predominantly a classification yard. The function of a classification railyard is to "break" arriving trains into sections based on their final destinations, and to build new trains that then depart for the desired destinations. The other key operation of the BNSF Barstow Railyard is to perform locomotive maintenance services.

The BNSF Barstow Railyard facility can generally be divided into six operational areas:

- **Locomotive Maintenance Area.**
- **Arrival Tracks.**
- **Departure Tracks.**
- **Hump Yard.**
- **Classification Yard.**
- **Adjacent Main Line**.

Primary activities at the BNSF Barstow Railyard include train reconfiguration (classification) operations and locomotive inspections and maintenance. Many trains arriving in BNSF Barstow Railyard are scheduled for inspections and maintenance. Depending on the scheduled inspection, locomotives may enter full or partial circles through the inspection yard before being pulled to the ready tracks for departure. Furthermore, depending on the inspection cycle, trains undergo different engine tests at the BNSF Barstow Railyard. A number of other activities occur at the BNSF Barstow Railyard in support of or as a result of the primary railyard activities. These include material handling equipment operations near the arrival tracks and the track maintenance equipment operations (use to repair and maintain tracks) throughout the BNSF Barstow Railyard.

Trains arriving in BNSF from the west enter the Railyard directly onto the arrival tracks at the west end of the BNSF Barstow Railyard. The trains arriving from the east follow a specific set of tracks west through the railyard to the arrival tracks. Locomotives enter the maintenance areas from the west portion of the arrival tracks at the west end of the railyard where a variety of maintenance activities may be performed (e.g., sanding and refueling, engine inspections, and engine load and opacity testing).

After receiving service in the maintenance area the locomotives proceed east to the departure tracks located in the north central portion of the BNSF Barstow Railyard. Once the locomotives are detached from the arriving trains, switcher locomotives push individual rail cars or sets of rail cars from the trains to the top of the hump in the hump yard. New trains are configured by rolling the rail cars eastward down the hump and switching them onto specific tracks in the western classification yard.

Once a new train has been created in the western part of the classification yard, switcher engines pull the newly configured train into the eastern classification yard, and then push the train back onto the departure tracks. The locomotive consist (multiple line-haul locomotives), is added to the train, and the trains then departs either to the east or west by moving onto the adjacent main line which, runs along the northern boundary of the BNSF Barstow Railyard.

Figure II-1: BNSF Barstow Railyard and Surrounding Area

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

In 2005, the combined diesel PM emissions from the BNSF Barstow Railyard (on-site emissions) and other significant emission sources within a one-mile distance from the boundary of the BNSF Barstow Railyard (off-site emissions) are estimated at about 54 tons per year (see Figure II-2). Estimated off-site diesel PM emissions from mobile sources (not generally related to activities at the railyard) are about 26 tons per year, or about 48% of the total combined on-site and off-site diesel PM emissions. Off-site stationary sources diesel PM emissions are less than 0.1 tons per year so they are considered to be below de-minimis levels. The BNSF Barstow Railyard diesel PM emissions are estimated at about 28 tons per year, which accounts for about 52% of the total combined on-site and off-site diesel PM emissions.

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

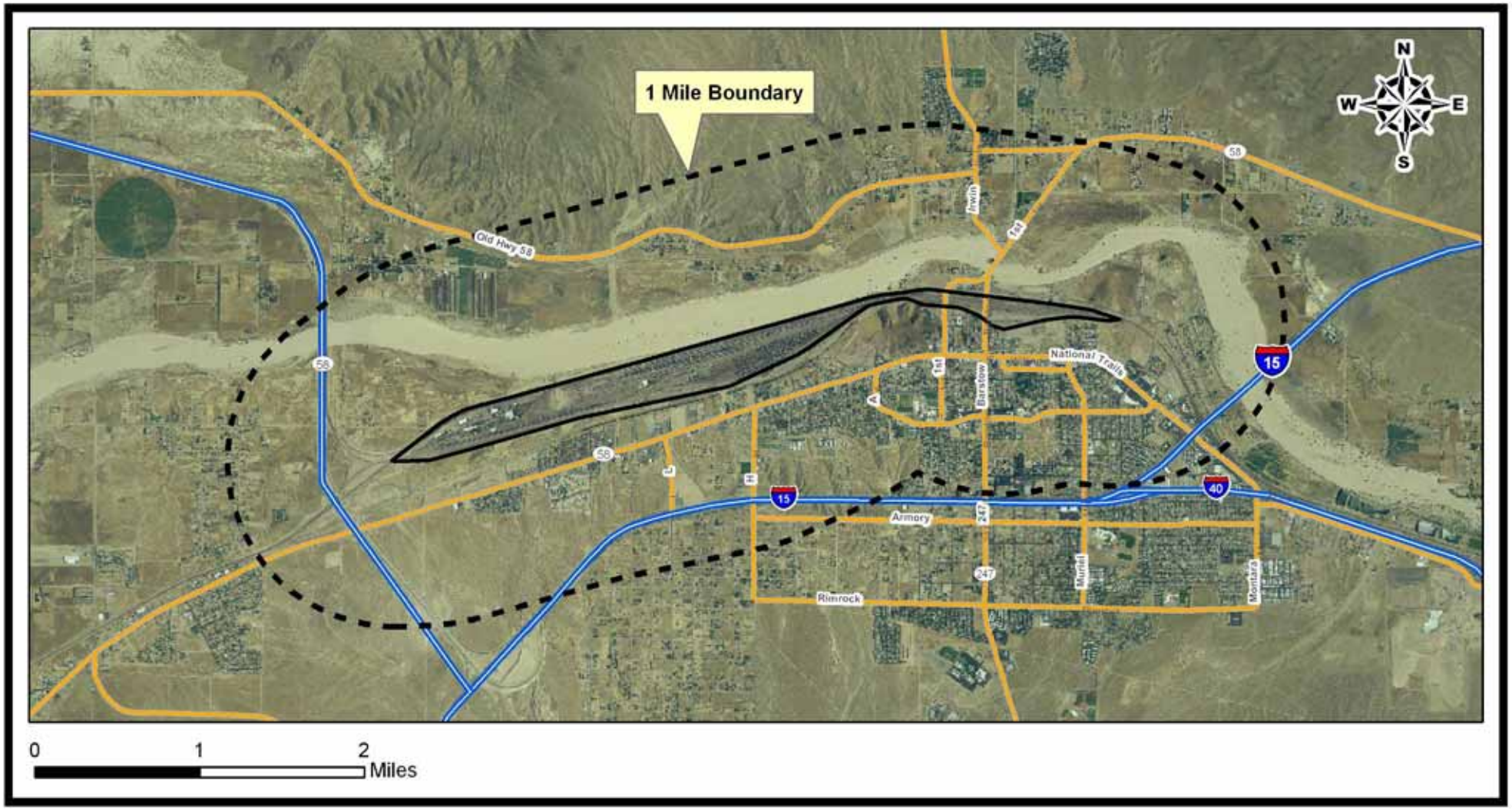
Table II-1: Comparison of Diesel PM Emissions (tons per year) from Four Major Source Categories within Eighteen Railyards

Railyard	Locomotive	Cargo Handling Equipment	On-Road Trucks	Others (Off-Road Equipment, TRUs, Stationary Sources, etc.)	Total§
BNSF Barstow	27.1	0.03	0.04	0.75	27.9
BNSF San Bernardino	10.6	3.7	4.4	3.4	22.0
BNSF San Diego	1.6	N/A	0.007	0.04	1.7
UP ICTF/Dolores	9.8	4.4	7.5	2.0	23.7
UP Colton	16.3	N/A	0.2	0.05	16.5
UP Oakland	3.9	2.0	1.9	3.4	11.2
UP City of Industry	5.9	2.8	2.0	0.3	10.9
UP Roseville*	25.1*	N/A	N/A	N/A	25.1
BNSF Hobart	5.9	4.2	10.1	3.7	23.9
UP Commerce	4.9	4.8	2.0	0.4	12.1
UP LATC	3.2	2.7	1.0	0.5	7.3
UP Stockton	6.5	N/A	0.2	0.2	6.9
UP Mira Loma	4.4	N/A	0.2	0.2	4.9
BNSF Richmond	3.3	0.3	0.5	0.6	4.7
BNSF Stockton	3.6	N/A	N/A	0.02	3.6
BNSF Commerce Eastern	0.6	0.4	1.1	1.0	3.1
BNSF Sheila	2.2	N/A	N/A	0.4	2.7
BNSF Watson	1.9	N/A	<0.01	0.04	1.9
STATEWIDE RY TOTAL	136.8	25.33	31.15	17.0	210.1§
Statewide RY Percent	*65%*	*12%*	*15%*	*8%*	*100%*

* The UP Roseville Health Risk Assessment (ARB, 2004a) was based on 1999-2000 emission estimate, only locomotive diesel PM emissions were reported in that study. The actual emissions were estimated at a range of 22.1 to 25.1 tons per year.

§ Numbers may not add precisely due to rounding.

Figure II-2: One-mile Boundary for the BNSF Barstow Railyard.



1. Railyard

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

As indicated by Table II-2, locomotive operations within the railyard are responsible for an estimated 27 tons per year of diesel PM emissions (about 97% of the total on-site emissions). Line-haul locomotives contribute most of the locomotive diesel PM emissions, at about 19 tons per year. Yard operations (primarily switch locomotives moving rail cars within the facility) contribute about 4.7 tons per year, and are the second largest source of diesel PM emissions. Service and testing activities account for about 3.4 tons per year of locomotive diesel PM emissions. Off-road TRUs and maintenance equipment contribute about 0.64 tons per year, or about 2% of the total on-site diesel PM emissions. On-site stationary sources, on-road trucks, and cargo handling equipment contribute about 0.2 tons per year or about 1% of the total on-site diesel PM emissions.

Approximately 156,516 locomotives arrived or passed through the BNSF Barstow Railyard between May 1, 2005 and April 30, 2006. Of those numbers, 32,256 were foreign locomotives; the foreign locomotives counts also include 728 Amtrak transcontinental trains, which are not considered as a part of the freight movements. The number of BNSF freight locomotives that pass through the railyard is 70,159, of which, 54,101 BNSF locomotives were counted as true arrivals and departures from the BNSF Barstow Railyard. This equates to about 13,500 trains per year or 37 trains per day, assuming 4 locomotives per train.

Diesel PM is not the only toxic air contaminant (TAC) emitted in the BNSF Barstow Railyard. Relatively small amounts of gasoline TACs are also emitted from some of the gasoline fleet vehicles, the two track maintenance forklifts, two on-site gasoline storage and dispensing units, and from four on-site generators. These TACs emissions include 1-3 butadiene, benzene, and other TACs. The detailed emission inventories for these TACs are presented in *the Air Dispersion Modeling Assessment of Air Toxic Emissions from BNSF Barstow Railyard* and *BNSF Barstow Railyard TAC Emission Inventory Reports (ENVIRON International Corporation)*.

The total amount of these TACs emissions is about 180 pounds per year, as compared to 28 tons per year of the BNSF Barstow facility-related diesel PM emissions. Furthermore, using cancer potency weighted factor adjustments, shows that these toxic air contaminant emissions are about a factor of 300 times less than the cancer potency weighted emissions of diesel PM, (i.e., 0.09 vs. 28 tons per year). Therefore, only

diesel PM emissions, the predominant emissions at the BNSF Barstow Railyard, are presented in the on-site emission analysis and health impact evaluation.

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

DIESEL PM EMISSIONSOURCES	BNSF Barstow Railyard		Off-site Emissions**	
	Tons/Year	Percentage	Tons/Year	Percentage
LOCOMOTIVES	**27.1**	**97%**	-	-
Line Haul Locomotives	***19.1***	***68%***	-	-
Arriving and Departing Trains	*14.8*	*53%*	-	-
Freight Movement on Adjacent Line	*4.3*	*15%*	-	-
Adjacent Line Commuter Rail Operations	*0.03*	*<1%*	-	-
Switch Locomotives	***4.7***	***17%***	-	-
Service/Testing/Refueling	***3.4***	***12%***	-	-
OFF-ROAD EQUIPMENT/VEHICLES	**0.64**	**2%**	-	-
STATIONARY SOURCES	**0.11**	**<1%**	-	-
ON-ROAD TRUCKS	**0.04**	**<1%**	-	-
CARGO HANDLING EQUIPMENT	**0.03**	**<0.1**	-	-
OFF-SITE MOBILE SOURCES	-	-	**26.0**	**100%**
OFF-SITE STATIONARY SOURCES	-	-	**0**	**0%**
TOTAL	**27.9***	**100%**	**26.0**	**100%**

*Numbers may not add precisely due to rounding.
**Emissions within the one-mile boundary. (Railyard emissions not included)

2. Surrounding Sources

ARB staff evaluated significant off-site mobile and stationary sources of diesel PM emissions within a one-mile distance of the BNSF Barstow Railyard. A one-mile distance was chosen because the Health Risk Assessment study for the UP Roseville Railyard (ARB, 2004a) indicated that cancer risks associated with on-site diesel PM emissions are substantially reduced beyond a one-mile distance from the railyard. Therefore, for the BNSF Barstow Railyard, 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 sources of diesel PM emissions 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 Barstow 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, and off-road equipment outside the railyards. Individual sources such as local truck distribution centers and warehouses were not evaluated due to insufficient activity data, but truck traffic related to these facilities is reflected in the roadway link traffic activities. Because the off-site mobile sources have only focused on the on-road diesel emissions, the exclusion of extended idling and off-road equipment may result in an underestimation of off-site mobile sources emissions.

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

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

Within a one-mile distance from the boundary of the BNSF Barstow Railyard, off-site diesel PM emissions are predominantly generated by mobile sources, which emit around 26 tons per year, as indicated by Table II-2. The majority of the off-site diesel PM emissions are from diesel-fueled heavy duty trucks traveling on freeway I-15, at about 24 tons per year or about 92% of the total mobile sources emissions. Hwy 58 and major local streets contribute about 2 tons per year, or 8% of the total mobile source diesel PM emissions. Although Interstate 40 falls outside the one-mile radius

from the railyard and was not considered as part of ARB's off-site analysis, its emissions are likely to impact risk levels in the vicinity of the BNSF Barstow Railyard. There is only one stationary source within a one mile distance from the railyard boundary and the diesel PM emissions are considered at levels below de-minimis. Diesel PM emissions from sources in the BNSF Barstow Railyard and the sources within a one-mile distance from the boundary of the BNSF Barstow Railyard are summarized in Table II-2.

ARB staff also evaluated other toxic air contaminant (TACs) emissions around the BNSF Barstow Railyard. According to ARB's *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (ARB, 2000), diesel PM, 1-3 butadiene, benzene, carbon tetrachloride, and formaldehyde are defined as the top five 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% 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 total emissions are estimated at about 0.26 tons per year, which is substantially less than the diesel PM emissions. Therefore, the potential cancer risk levels caused by non-diesel PM TACs 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.

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

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

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

ENVIRON selected meteorological data for air dispersion modeling based upon their spatial and temporal representativeness of conditions in the immediate vicinity of the BNSF Barstow Railyard. Therefore, Barstow station operated by the California Air Resources Board was selected for the wind speed, wind direction, and temperature data for the BNSF Barstow Railyard. Five year data from 2001-2002 and 2004 through 2006 was selected as the most representative wind speed, wind direction, and temperature data for use in the air dispersion analysis for the BNSF Barstow Railyard.

ENVIRON used cloud cover, temperature, and pressure data from the Barstow-Daggett Airport operated by National Weather Services (NWS). Upper air data from the Desert Rock, Nevada station was used in AERMET processing for the BNSF Barstow Railyard (ENVIRON 2007a).

The potential cancer risk levels associated with the estimated diesel PM emissions at the BNSF Barstow Railyard are displayed by using isopleths. In this study, ARB staff elected to present the cancer risk isopleths focusing on risk levels of 10, 25, 50, 100, and 250 in a million, presented in Figure II-3 and Figure II-4. Figure II-3 focuses on the near source risk levels and Figure II-4 focuses on the more regional impacts. In each figure, the risk isopleths are overlaid onto a satellite image of the Barstow area surrounding the BNSF Barstow Railyard, to illustrate the land use (residential, commercial, industrial, or mixed use) within the impacted areas.

> 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 OEHHA Guidelines specify that, for health risk assessments, the cancer risk for the maximum exposure at the point of maximum impact be reported. The point of maximum impact (PMI), which is defined as a location or the receptor point with the highest cancer risk level outside of the facility boundary, with or without residential exposure, is predicted to be located at the southeast side of the railyard fence line (see Figure II-3). This is directly downwind of high emission density areas for the prevailing westerly wind, where locomotive activities (i.e. line haul locomotives, switchers, and locomotive service shop) generates about 75% of the facility-wide diesel PM emissions (see the emission allocation in Appendix E).

The cancer risk at the PMI is estimated to be about 1,000 chances in a million. The land use in the vicinity of the PMI is primarily zoned as open land and industrial use. However, there is always a potential for 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 450 chances in a million.

As indicated by the Roseville Railyard Study (ARB, 2004a), the location of the PMI may vary depending upon the settings of the model inputs and parameters, such as a meteorological data sets 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). In addition, the estimated levels and the location of the PMI and MICR may not be replicated by air monitoring because there is no approved specific measurement technique for directly monitoring diesel PM emissions in the ambient air. Therefore, the indications of PMI and MICR should not be interpreted as a literal prediction of disease incidence but rather as a tool for risk comparison.

A0RB 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-3 at the BNSF Barstow Railyard, the area with the greatest impact has an estimated potential cancer risk of over 250 chances in a million, occurring in an area, 200 yards north and south of the railyard fence line. The majority of the BNSF Barstow Railyard activities take place in the western part of the railyard, and emissions allocations for this railyard is presented in Appendix E. At about 400 yards, outside of the BNSF Barstow Railyard boundary, the estimated cancer risks are lowered to about 150 chances in a million. At about a half mile from the BNSF Barstow Railyard boundaries, the estimated cancer risk is about 100 in a million, and within a mile of the railyard boundary the estimated cancer risks are lowered further to about 50 in a million. At about 1.5 miles from the BNSF Barstow Railyard, the estimated cancer risks are lowered to about 10 in a million.

The OEHHA Guidelines recommend 70-year lifetime exposure duration to evaluate the potential cancer risks for residents. Shorter exposure duration of 30 years and 9 years may also be evaluated 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 (OEHHA, 2003).

To evaluate the potential cancer risks for off-site workers, the OEHHA Guidelines recommend that a 40-year exposure duration to be used, assuming workers have different rates of exposure for an 8-hour workday, with adjustments of five days a week and 245 days a year.

Figure II-3: Estimated Near-Source Cancer Risks (chances per million people) from the BNSF Barstow Railyard

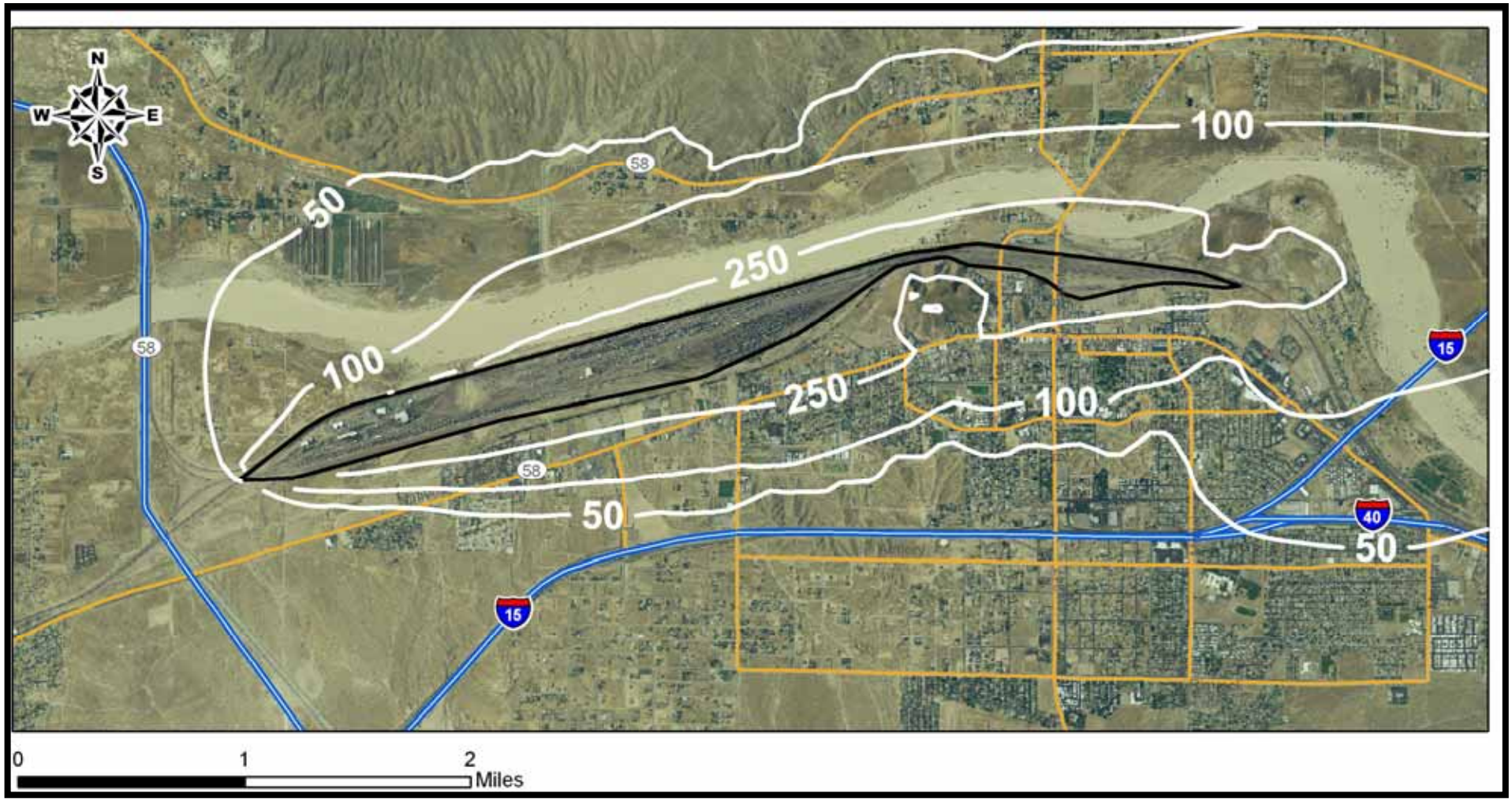


Figure II-4: Estimated Regional Cancer Risks (chances per million people) from the BNSF Barstow Railyard.

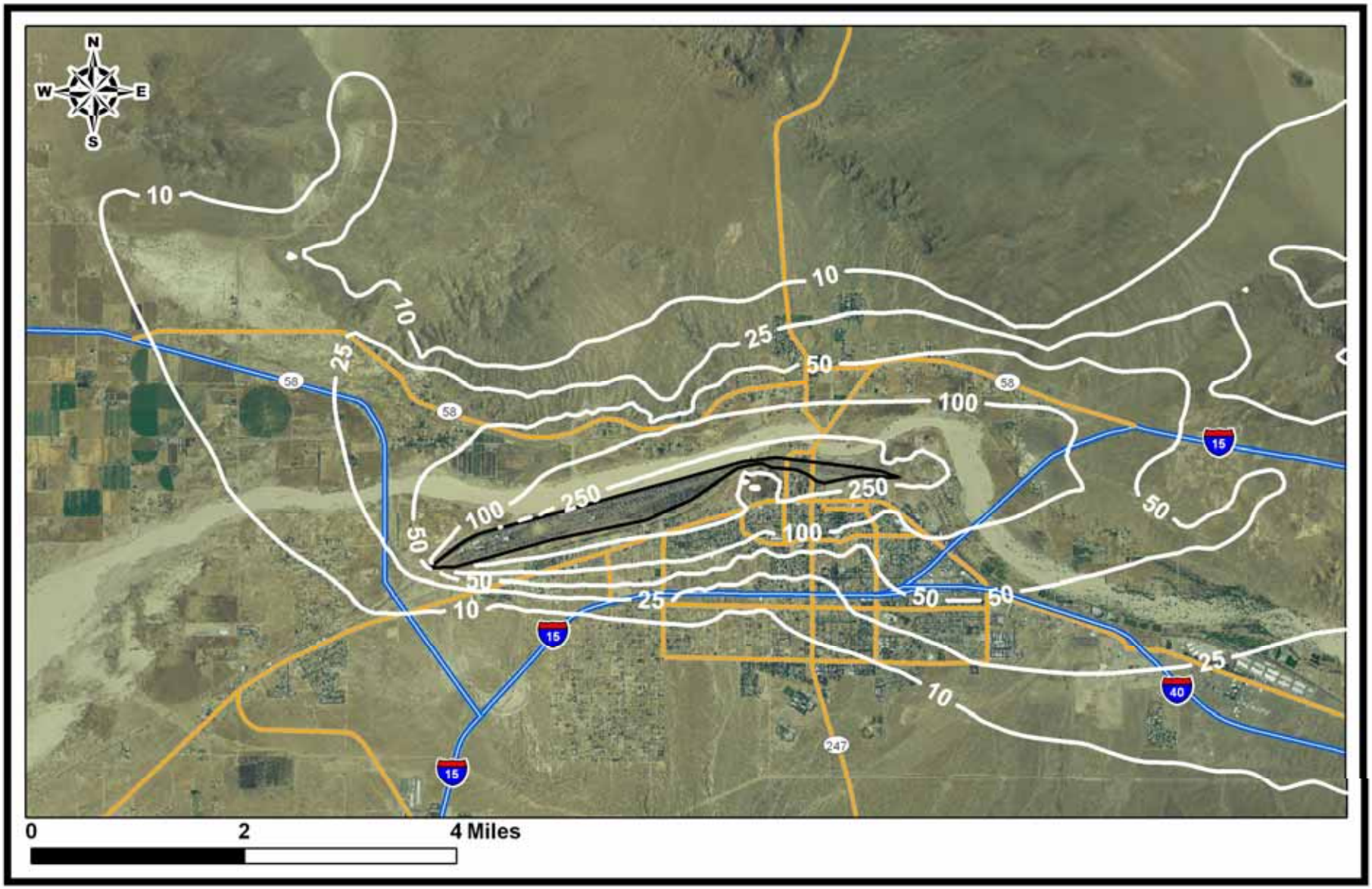


Table II-3 shows the equivalent risk levels of 70-, and 30-year exposure durations for exposed residents, 40, and 9-year exposure durations for workers and school-aged children, respectively. Using Table II-3, the 10 in a million isopleth line in Figures II-4 would become 4 in a million for exposed population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

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

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

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

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

The residential areas near the BNSF Barstow Railyard are located primarily to the north and south east of the railyard. Areas located to the west are predominately open desert land or industrial areas. Based on the 2000 U. S. Census Bureau's data, the zone of impact with the estimated cancer risk over 10 chances in a million encompasses approximately 25,500 acres and about 22,060 residents. Table II-4 presents the exposed population and area coverage for various impacted zones of cancer risks. The prevailing wind patterns around the BNSF Barstow Railyard move from the west to east, where much of the downwind areas are industrial lands.

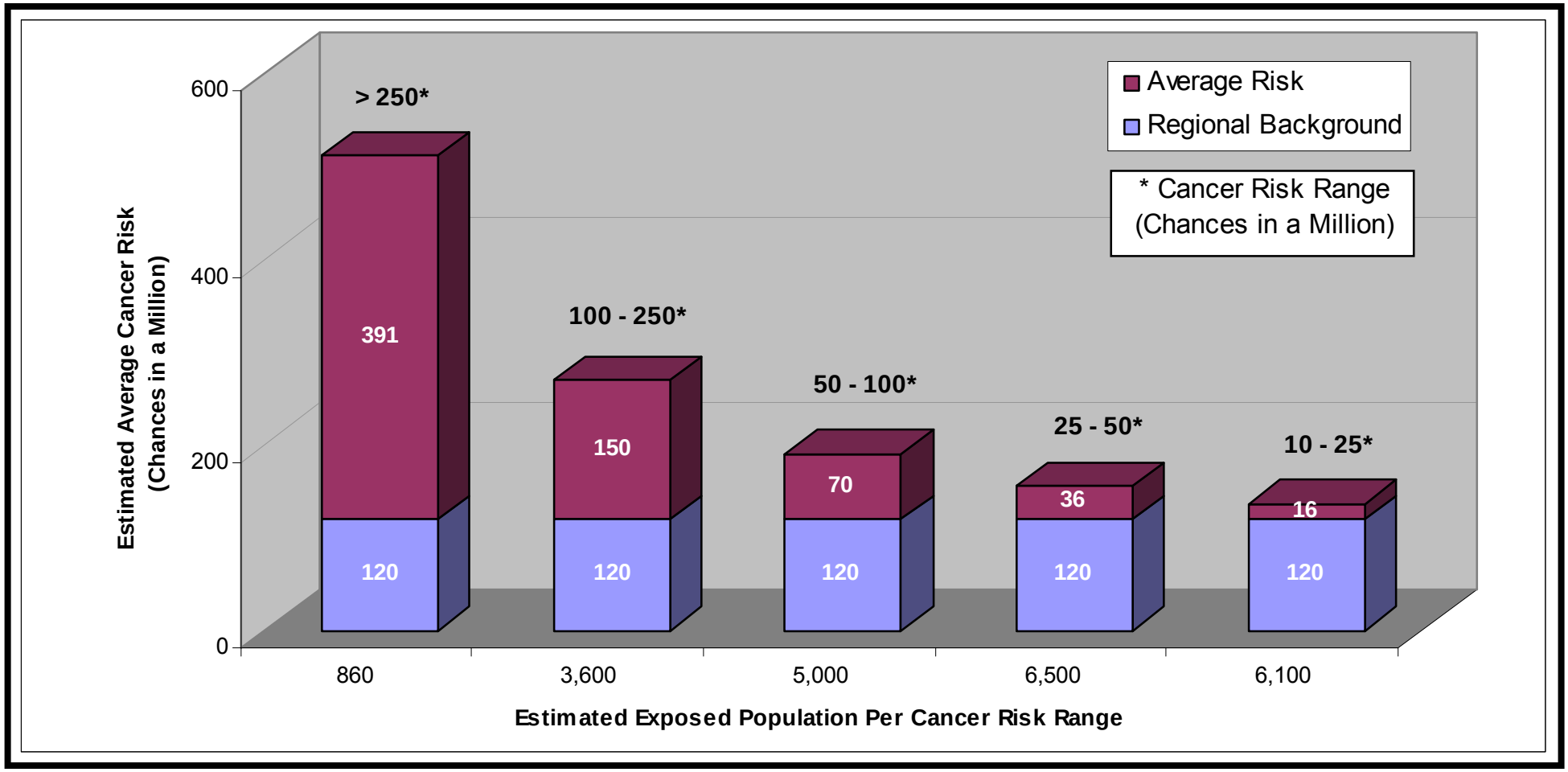
Table II-4: Estimated Impacted Areas and Exposed Population Associated with Different Cancer Risk Levels Caused by BNSF Barstow Railyard Diesel PM Emissions

Estimated Risk (chances per million)	Impacted Area* (Acres)	Estimated Population Exposed*
> 250	650	860
100 - 250	2,650	3,600
50 - 100	4,300	5,000
25 - 50	6,900	6,500
10 - 25	11,000	6,100
>10	25,500**	22,060**

*Based on 2000 Census Data
**Numbers may not add due to rounding

It is important to understand that these risk levels represent the predicted risks (due to the BNSF Barstow Railyard diesel PM emissions) above the existing background risk levels. For the broader Mojave Desert Air Basin, the estimated regional background risk level is estimated to be 120 in a million caused by diesel PM only in 2000 (ARB, 2006a). The ARB does not currently have estimates for other TACs. Figure II-5 provides a comparison of the predicted average potential cancer risks in various isopleths to the regional background risk level and estimated exposed population. For example, in the risk range greater than 100, the average potential cancer risk above the regional background is 150 chances per million. Therefore, residents living in that area would have a potential cancer risk of about 270 chances in a million.

Figure II-5: Comparison of Estimated Potential Cancer Risks from the BNSF Barstow Railyard to the Regional Diesel PM Background Risk Levels.



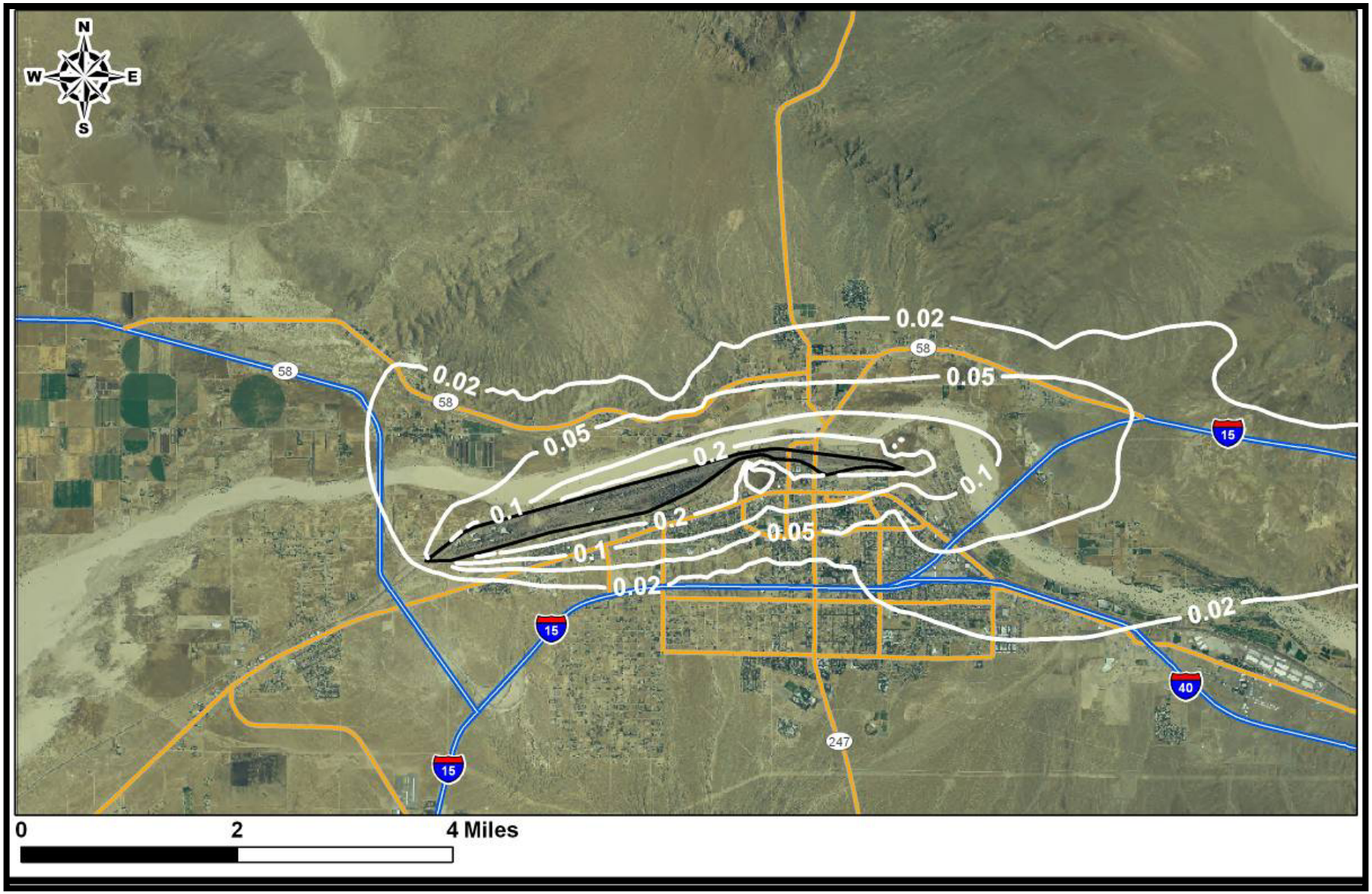
**No toxics monitoring in the Mojave Desert Air Basin,
**Regional background risk is only from diesel PM, because we don't have data available for other TACs for Mojave Desert Air basin.

E. What are the estimated non-cancer chronic risks from the BNSF Barstow Railyard?

The potential non-cancer chronic health HI from the estimated diesel PM emissions at the BNSF Barstow Railyard is estimated to range from 0.02 to 0.20 as shown in Figure II-6. According to Office of Environmental Health Hazard Assessment (OEHHA) Guidelines (OEHHA, 2003) these levels indicate that exposure to DPM from the BNSF Barstow Railyard is less likely to result in adverse non-cancer health effects.

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

Figure II-6: Estimated non-cancer chronic risks (indicated as Hazard Indices) Associated with the diesel PM emissions from the BNSF Barstow Railyards.



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 Barstow 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 Barstow Railyard was included. Off-site diesel PM emissions used in the off-site modeling runs consisted of about 26 tons per year from roadways in 2005. The diesel PM emissions from the BNSF Barstow Railyard is not analyzed in the off-site air dispersion modeling. The estimated potential cancer risks associated with off-site diesel PM emissions are illustrated in Figure II-7.

Based on the 2000 U.S. Census Bureau's data, the zone of impact of the estimated potential cancer risks above 100 chances in a million associated with off-site diesel PM emissions encompass approximately 6,200 acres where about 15,700 residents live. For comparison with the BNSF Barstow Railyard health risks, the same level of potential cancer risks (100 chances in a million) associated with railyard diesel PM emissions covers about 3,300 acres where approximately 4,500 residents live.

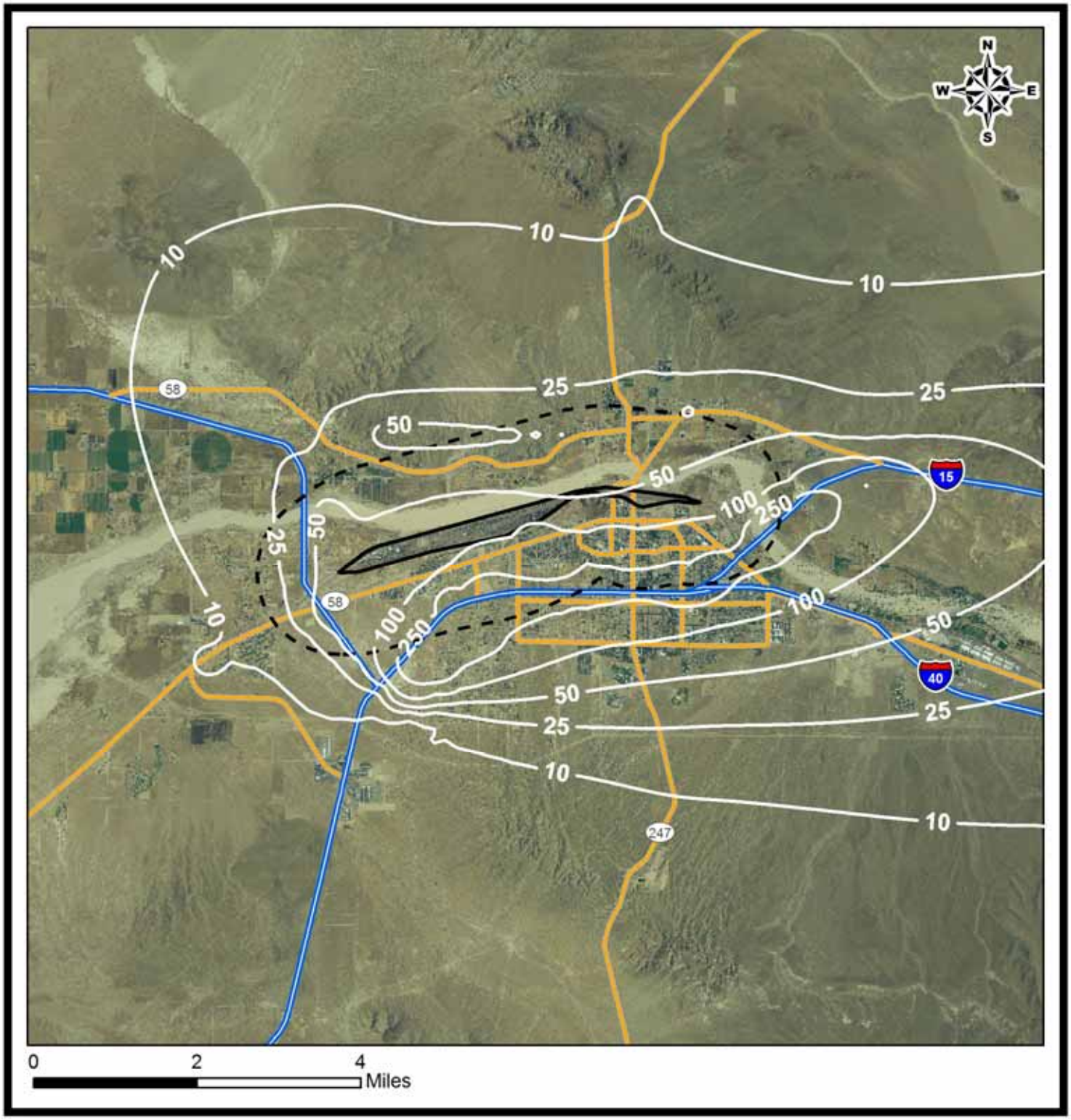
Table II-5 presents the exposed population and area coverage size for various impacted zones of cancer risks associated with off-site diesel PM emissions.

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

Estimated Cancer Risk (chances per million)	Estimated Impacted Area* (Acres)	Estimated Exposed Population*
>250	2,100	3,500
100-250	4,100	12,200
50-100	7,000	6,600
25-50	9,600	4,500
10-25	20,500	3,350
>10	43,300**	30,150**

*Approximate estimates because partially these isopleths exceed the air dispersion model domain.
**Numbers may not add due to rounding.

Figure II-7 Estimated Cancer Risk from 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 Air Resources Board (ARB) has developed a comprehensive approach to reduce locomotive and railyard emissions through a combination of voluntary agreements, ARB and United States Environmental Protection Agency (U.S. EPA) regulations, funding programs, and early replacement of California's line haul and yard locomotive fleets. The information presented below summarizes California's key locomotive and rail yard air pollution control measures and strategies.

South Coast Locomotive NOx Fleet Average Agreement (1998): Signed in 1998 between ARB and both Union Pacific Railroad (UP) and BNSF Railway (BNSF), it requires the locomotive fleets that operate in the South Coast Air Quality Management District (SCAQMD) to meet, on average, U.S. EPA's Tier 2 locomotive emissions standards by 2010. Tier 2 locomotives became commercially available in 2005 and provide a 65 percent reduction in oxides of nitrogen (NOx) and 50 percent reduction in diesel particulate matter (PM) emissions in South Coast Air Basin. This Agreement will provide locomotive fleet benefits in southern California 20 years earlier than the rest of the country. 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 Mojave Desert 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 which does not change any federal, state, or local authorities to regulate railroads. The Agreement has resulted in measures that have achieved a 20 percent reduction in locomotive diesel PM emissions in and around rail yards since its adoption in June 2005. The measures in the Agreement include:

- Phasing-out of non-essential idling on all locomotives without idle reduction devices (60 minute limit – fully implemented);
- Installing idling reduction devices on 99% of the 450 California-based locomotives by June 30, 2008 (15 minute limit – 95 percent implemented);
- Identify and expeditiously repair locomotives with excessive smoke and ensure that at least 99 percent of the locomotives operating in California pass smoke inspections (fully implemented); and

- Requiring all locomotives that fuel in the state use at least 80 percent federal or California ultra low sulfur (15 parts per million) diesel fuel by January 1, 2007, (six years prior to federal requirement) (fully implemented);
- Preparing new health risk assessments for 16 major railyards, based on the UP Roseville Railyard health risk assessment (completed in 2004) and Office of Environmental Health Hazard Assessment (OEHHA) guidelines; (nine of 16 finalized in November 2007); and
- Identifying and implementing future feasible mitigation measures based on the results of the railyard health risk assessments.

ARB Diesel Fuel Regulations Extended to Intrastate Locomotives (2007): This regulation, approved in 2004, requires intrastate locomotives that operate 90 percent of the time in the state to use only California ultra low sulfur (15 parts per million) diesel fuel. CARB diesel's lower aromatics provide on average a six percent reduction in NOx and 14 percent reduction in diesel PM emissions as compared to U.S. EPA ultra low sulfur on-road diesel fuel. 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, such as yard trucks and forklifts that operate at ports and intermodal rail yards. Implementation of this regulation will reduce diesel PM by approximately 40% in 2010 and 65% in 2015, and NOx emissions by approximately 25% in 2010 and 50% in 2015. This regulation is expected to reduce diesel PM and NOx emissions by up to 80 percent by 2020. The regulation took effect on January 1, 2007.

Heavy Duty Diesel New Trucks Regulations: ARB and the U.S. EPA both have adopted emission standards for 2007 and subsequent model year heavy-duty diesel engines. These standards represent a 90 percent reduction of NOx emissions, 72 percent reduction of non-methane hydrocarbon emissions, and a 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.

On-Road In-Use Truck Measure: The ARB is developing a regulation to reduce diesel PM, NO_x and green house gas emissions from on-road heavy-duty diesel-fueled vehicles. This measure will cover long and short haul truck-tractors, construction related trucks, wholesale and retail goods transport trucks, tanker trucks, package and household goods transport trucks, and most other diesel-powered trucks and buses with a gross vehicle weight rating of 14,000 pounds or greater (shuttle buses of all sizes will also be included). The goals of this effort are: (a) by 2014, emissions are to be no higher than a 2007 model year engine with a diesel particulate filter, and (b) by 2021, emissions are to be no higher than a 2010 model year engine. With the implementation

of the proposed measure, California's diesel PM emissions from this sector could be reduced by about 70 percent and NOx emissions by up to 35 percent in 2014. This measure is scheduled for ARB Board consideration in October-2008.

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

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

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

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

after-treatment devices are expected to provide up to a 90 percent reduction in NOx and PM emissions beginning in 2015. The final U.S. EPA locomotive regulations were released on March 14 2008.

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

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

III. BNSF BARSTOW RAILYARD DIESEL PM EMISSIONS

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

For the year 2005, the combined diesel PM emissions from the BNSF Barstow Railyard (on-site emissions) and significant non railyard emission sources within a one-mile distance from the boundary of the BNSF Barstow railyard (off-site emissions) are estimated at about 54 tons per year. Estimated off-site diesel PM emissions from mobile sources (generally not related to the activities at the railyard) are about 26 tons per year, or about 48% of the total combined on-site and off-site diesel PM emissions. There are no significant off-site stationary sources within a one mile radius. Only one facility, Verizon Barstow C.O. lies within that radius and the emissions from that facility are considered at levels below de-minimis. The BNSF Barstow Railyard diesel PM emissions are estimated at about 28 tons per year, which accounts for about 52% of the total combined on-site and off-site diesel PM emissions.

A. BNSF Barstow Railyard Diesel PM Emissions Summary

The BNSF Barstow Railyard activity data and emission inventories were provided by the BNSF Railways and its consultant, ENVIRON International Corporation. The methodology used to calculate the diesel PM and other toxic air contaminant (TAC) emissions is based on ARB Guidelines for Railyard Emission Inventory (ARB, 2006c). Detailed calculation methodologies and resulting emission factors are included in the *Toxic Air Contaminant Emissions Inventory and Air Dispersion Modeling Assessment Air Toxic Emissions Report for the BNSF Barstow Railyard, Los Angeles, California* (ENVIRON International Corporation, 2007) submitted by ENVIRON International Corporation (ENVIRON Report).

The BNSF Barstow Railyard is a classification yard with a focus on locomotive maintenance. This facility can generally be divided into six operational areas:

- **Locomotive Maintenance Area.**
- **Arrival Tracks.**
- **Departure Tracks.**
- **Hump Yard.**
- **Classification Yard.**
- **Adjacent Main Line**.

The trains that arrive and depart in Barstow are representative of the population of BNSF line haul locomotives that service California. Most of the locomotives entering or leaving California stops in or passes through BNSF Barstow Railyard.

Arrival Tracks

The area designated as the arrival tracks is located to the south of the locomotive maintenance area in the southwest portion of the BNSF Barstow Railyard. The arrival tracks area consists of approximately ten tracks that run in parallel for approximately one mile and converge at the east and west ends.

Departure Tracks

The area designated as the departure tracks is located to the east of the locomotive maintenance area and in the north-central portion of the BNSF Barstow Railyard. The departure tracks area consists of approximately fifteen tracks that run in parallel for approximately one mile and then converge at the east and west ends.

Hump Yard

The hump yard is located in the south central portion of the railyard to the east of the arrival tracks. At its widest point at the east end, the hump yard consists of approximately 45 tracks that converge into one track that spans to the east end of the arrival tracks.

Classification Yard

The classification yard is located to the south of the departure tracks and adjacent main line and extends from the east edge of the hump yard to the east boundary of the BNSF Barstow railyard and consists of an east and west yard. At its widest point at the west end, the classification yard consists of approximately 45 tracks that run in parallel for nearly 4.5 miles before they converge at the east end of the west classification yard. The east classification yard consists of approximately 10 tracks that run in parallel and converge at both the east and west end.

Adjacent Main Line

The adjacent main line consists of two parallel tracks and runs immediately north of the northern boundary of the BNSF Barstow Railyard facility. The adjacent main line is approximately 5 miles in length and runs east-west along the BNSF Barstow facility boundary. The operations at the adjacent main line includes locomotive DTL (direct to locomotive) refueling, boxcar/freight and container TRUs, track maintenance equipment, passing line-haul, and passenger locomotive activities. Locomotive idling during DTL refueling occurs at two locations on the adjacent main line at the east and west ends of the departure tracks. In addition to BNSF operations, there are some limited non-BNSF freight trains as well as passenger trains that use BNSF or adjacent main line tracks. However, the only passenger activity on the adjacent main line is a daily train in both directions with destinations between Los Angeles and Chicago.

Locomotive Maintenance Area

One key element of the BNSF Barstow Railyard is the locomotive maintenance and inspections. Many trains arriving in BNSF Barstow are scheduled for inspection. The inspection area is located on the west end of the railyard and the locomotive maintenance area is situated in the northwest portion of the railyard. The locomotive maintenance area, consists of the diesel, fueling, sanding, service (DSFS) area, diesel engine repair facility, rail car repair building, storage areas(diesel fuel storage tanks), equipment service areas, and an administration building. The locomotive maintenance area includes basic locomotive services, locomotive engine test services, and full locomotive service inspections. The path taken depends on the scheduled inspection; locomotives may enter full or partial circles through the inspection yard. Furthermore, depending on the inspection cycle, trains undergo different engine tests.

Locomotives enter the maintenance area from the arrival tracks at the west end and are washed at the locomotive wash area. All locomotives then proceed to the diesel, sand, fueling (DSFS) area for sanding and refueling. After leaving the DSFS area, locomotives may take a number of different paths within the maintenance area to reach the various service locations (e.g., inspection areas, engine test areas), depending on the level of service required, the order of the maintenance activities, and the locations of other locomotives already in the maintenance area.

Activities at the BNSF Barstow Railyard

Activities at the BNSF Barstow Railyard include locomotive maintenance (e.g., sanding, refueling, and inspections), switching operations, line-haul locomotive operations, and passenger locomotive operations. A number of activities occur at the BNSF Barstow railyard in support of or as a result of the primary railyard activities (i.e., locomotive maintenance and train reconfiguration operations). These include material handling equipment operations near the arrival tracks, track maintenance equipment operations (to repair and maintain tracks) throughout the railyard.

Other activities in BNSF Barstow Railyard are crew changes and refueling of the locomotives. All of the passing by trains on the mainline stop at BNSF Barstow Railyard for crew changes. Some will be refueled as well. Crew and administrative buildings are located near the inspection area. Crews are brought to the trains by on-road vehicles. Two fixed fueling stations utilize pipeline to deliver fuel to locomotives. Furthermore, several direct to locomotive (truck to locomotive) fueling sites are located throughout the railyard. On-site sources were separated into six operational areas based on specific activities to better characterize diesel PM emissions. These areas are summarized in Table III-1 and shown in Figure III-1. The detailed schematic and descriptions of the areas and activities are presented in the Environ Air Dispersion Modeling Assessment of Air Toxic Emissions from BNSF Barstow Railyard. Report (Environ, 2007).

Figure: III-1: Emission Source Locations at BNSF Barstow Railyard

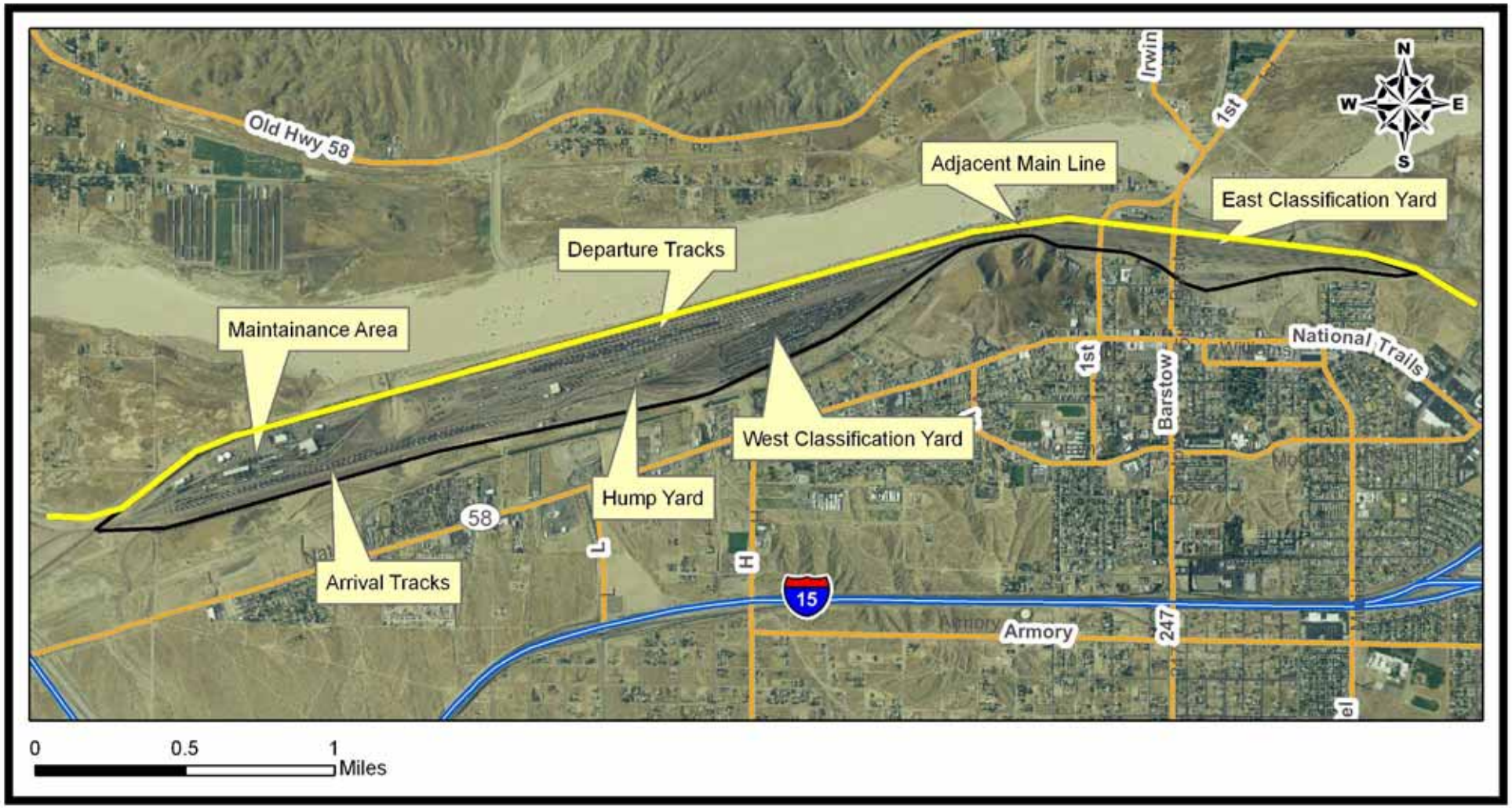


Table III-1: BNSF Barstow Railyard Activities

Area	Description
Locomotive Maintenance	Basic Locomotive Services, Engine Test Inspection, Full Service Inspection, Refueling Truck, On-Road Fleet, Permitted Stationary Sources
Arrival Tracks	Arriving Line-Haul, Material Handling Equipment, Boxcar/Freight and Container TRUs, Track Maintenance
Departure Tracks	Departing Line-Haul, Refueling Truck, Boxcar/Freight and Container TRUs, Track Maintenance
Hump Yard	Switching, Arriving Line-Haul, On-Road Fleet, Boxcar/Freight and Container TRUs, Track Maintenance, Permitted Stationary Sources
Classification Yard	Switching, Arriving Line-Haul, On-Road Fleet, Boxcar/Freight and Container TRUs, Track Maintenance
Adjacent Main Line	DTL Refueling, Passing Line-Haul, Passenger Locomotives, Boxcar/Freight and Container TRUs, Track Maintenance

Using the data provided by BNSF and the methodology described in the emission inventory report by ENVIRON International Corporation, the diesel PM emissions calculated for railyard sources are estimated to be approximately 28 tons per year. The diesel PM emissions from each on-site activity are provided in Table III-2.

Table III-2: Summary of the Diesel PM Emissions from the BNSF Barstow Railyard

Sources	Diesel PM Emissions (tons per year)	
	Total Diesel PM Emissions*	Percent of Total
LOCOMOTIVES	**27.10**	**97%**
Line Hauls Locomotives	*19.1*	*68%*
Switch Locomotives	*4.7*	*17%*
Refueling, Service and Maintenance	*3.4*	*12%*
OFF-ROAD EQUIPMENT/ VEHICLES	**0.64**	**2%**
STATIONARY SOURCES	**0.11**	**<1%**
ON-ROAD TRUCKS	**0.04**	**<1%**
CARGO HANDLING EQUIPMENT	**0.03**	**<0.1%**
TOTAL	**27.91**	**100%**

*The difference in total is due to rounding off.

Diesel PM is not the only toxic air contaminant (TAC) emitted in the BNSF Barstow Railyard. Relatively small amounts of gasoline TACs are also emitted from some of the gasoline fleet vehicles, track maintenance forklifts (2), two on-site gasoline storage and dispensing units, and from four on-site generators. These TACs emission include 1-3 butadiene, benzene and other TACs. The detailed emission inventories for these TACs are presented in the *Air Dispersion Modeling Assessment of Air Toxic Emissions*

from BNSF Barstow Railyard and TAC Emission Inventory report for BNSF Barstow Railyard (ENVIRON International Corporation). The total amount of these TACs emissions is about 180 pounds per year, as compared to 28 tons per year of facility related diesel PM emissions. However, using cancer potency weighted factor adjustment, these toxic air contaminant emissions are about a factor of 300 times less than the cancer potency weighted emissions of diesel PM, (i.e., 0.09 vs. 28 tons per year). Therefore, only diesel PM emissions, the predominant emissions at the BNSF Barstow Railyard are presented in the on-site emission analysis and health impact evaluation.

1. Locomotives

Locomotives are the largest diesel PM emission source at the BNSF Barstow Railyard. Locomotives contribute about 27 tons per year, or about 97% of the total railyard diesel PM emissions.

The locomotive operations at the BNSF Barstow Railyard are divided into three major categories: switching (i.e., moving rail cars within the yard and hump and bowl and trim operations), locomotive services (i.e., maintenance, testing, refueling etc.), and passing and arriving-departing line haul locomotives. The locomotive operations are further divided into activity subcategories to describe the emission modes and spatial allocation, such as locomotive movements, idling, etc. As shown in Table III-3 line haul locomotive operations are the largest source of diesel PM emissions at the BNSF Barstow railyard and account for about 19 tons per year or 70% of the locomotive diesel PM emissions and 68% of the total railyard diesel PM emissions. Arriving and departing trains account for about 14.8 tons per year or 55% of the locomotive diesel PM. Freight movement on the adjacent main line accounts for about 4.3 tons per year or 16%. Commuter rail operations account for about 0.03 tons per year or less than 1 % of the locomotive diesel PM emissions. Train classification operations account for about 3.7 tons per year, or 13%, and hump operations accounts for about one ton per year or 4% of the locomotive diesel PM emissions. Maintenance, service, and refueling accounts for about 3.4 tons per year or 13% of the locomotive diesel PM emissions.

According to BNSF, many of the BNSF interstate locomotives are fueled out of state before they enter 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 *BNSF Barstow Railyard TAC Emission Inventory*, ENVIRON, 2008). 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 benefit of the diesel fuel regulations is presented in detail in Section B. Table III-3 presents the summary of diesel PM emissions from locomotive operation activities.

The ARB has developed an integrated approach to reduce statewide locomotive emissions through a combination of voluntary agreements, ARB and U.S. EPA regulations, incentive funding programs, and early replacement of California's line haul and yard locomotive fleets. The detailed approach has been discussed in Chapter 2. Therefore in the future, the BNSF Barstow Railyard will benefit from these mitigation measures as diesel PM emissions from locomotives are gradually reduced as the locomotive fleet turnovers.

Table III-3: Locomotive Diesel PM Emissions for the BNSF Barstow Railyard

Activity	Diesel PM Emissions in 2005	
	Tons Per Year	**Percent of Total**
Line Haul Locomotives	**19.1***	**70%**
Arriving and Departing Trains	14.8	55%
Freight Movement on Adjacent Main Line	4.3	16%
Commuter Rail Operations on Adjacent Line	<0.1	<1%
Switch Locomotives (Conducting yard Operations)	**4.7**	**17%**
Classification Yard	3.7	13%
Hump Yard	1.0	4%
Service/Maintenance	**3.4**	**13%**
Basic Services	1.9	7%
Full Engine Service/Inspection	1.0	4%
Basic Engine Inspection	0.3	1%
DTL Fueling Idling emissions	0.1	<1%
TOTAL	**27.1***	**100*%**

*Numbers may not add up due to rounding off.

2. Off-Road Equipment/Vehicles

Diesel PM emissions from off-road equipment are shown in Table III.4. Off-road equipment at the BNSF Barstow Railyard was categorized into two main types of equipment: Transportation Refrigeration Units (TRUs)/boxcars and track maintenance equipment. TRUs are used to regulate temperatures (i.e., refrigerate) during the transport of perishable products with temperature requirements. Container TRUs are responsible for almost 82% of the total off-road diesel PM emissions, at 0.52 tons per year. Track maintenance equipment includes equipment used to service tracks anywhere in California, though it may be housed at any given facility. This equipment category includes large and small engines and equipment and they contribute about 0.11 tons per year or 18% of diesel PM emissions from off-road equipment.

Table III-4: Diesel PM Emissions from Off-Road Equipment

Equipment Type	Diesel PM Emissions Tons Per Year	Percent of Total Emissions
Container TRUs/Boxcars	**0.52***	**82%**
Off-Road Track Maintenance	**0.11***	**18%**
TOTAL	**0.64***	**100%**

*Numbers may not add precisely due to rounding-off**.**

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 on December 31, 2008 for engine model years 2001 or older. ARB staff estimates that diesel PM emissions from TRUs and TRU generator set engines will be reduced by approximately 65% by 2010 and 92% by 2020. Therefore, starting in 2009, the BNSF Barstow Railyard will benefit from these mitigation measures as diesel PM emissions from TRUs are gradually reduced as their fleets turnover.

3. Stationary Sources

Permitted stationary sources at the BNSF Barstow Railyard facility included two gasoline dispensing and storage facilities, three emergency generators, and one emergency internal combustion engine. The gasoline storage and dispensing units includes two 1,000 gallon tanks with a hose and nozzle. The tanks are located near the east and west ends of the ready tracks. The diesel PM emissions from the stationary sources are estimated at about 0.11 tons per year, or less than one percent of the total diesel PM emissions at the BNSF Barstow Railyard.

4. On-Road Trucks/Fleet Vehicles

On-road truck activity is limited to a few service operations. The BNSF Barstow railyard does not have cargo handling operations. Thus, the only on-road trucks operating at the site are fuel trucks. The fueling trucks stay entirely within the Barstow railyard. BNSF operates approximately 90 on-road licensed vehicles out of its Barstow facility. On-road fleet vehicles included BNSF-owned employee vehicles and road-legal vehicles (i.e., passenger vehicles and small trucks) used for both on-site and off-site travel. The vehicles provide service to BNSF trains, tracks, and other assets. There are several facilities within the yard, where those vehicles may have business or may be stationed. Diesel PM emissions due to BNSF on-road trucks and fleet vehicle activities were estimated using the emission factors from the draft EMFAC2005 model provided by ARB (2006c) and an average on-site travel distance. As shown in Table III-5 on-road trucks/vehicles contribute about 0.04 tons per year of 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. Therefore, starting in 2007, the BNSF Barstow Railyard will benefit from these mitigation measures, with diesel PM emissions from heavy-duty diesel-fueled trucks being gradually reduced as the truck fleets turn over.

An ARB regulation to modernize port and intermodal railyard drayage trucks will reduce diesel PM by nearly 86 percent by 2010, and NOx by nearly 56 percent by 2014, as compared to 2007 baseline. There are an estimated 20,000 drayage trucks operating at California's ports and intermodal railyards. These trucks are a significant source of air pollution, with about 3 tons per day of diesel PM and 61 tons per day of NOx in 2007. Drayage trucks also often operate in close proximity to communities. This regulation will result in significant reductions in exposure and potential cancer risks to residents that live near ports, railyards, and the major roadways. The ARB Board approved the regulation in December 2007.

The ARB is developing a regulation to reduce diesel PM, NO_x and green house gas emissions from on-road heavy-duty diesel-fueled vehicles. This measure will cover long and short haul truck-tractors, construction related trucks, wholesale and retail goods

transport trucks, tanker trucks, package and household goods transport trucks, and most other diesel-powered trucks and buses with a gross vehicle weight rating of 14,000 pounds or greater (shuttle buses of all sizes will also be included). The goals of this effort are: (a) by 2014, emissions are to be no higher than a 2007 model year engine with a diesel particulate filter, and (b) by 2021, emissions are to be no higher than a 2010 model year engine. With the implementation of the proposed measure, California's diesel PM emissions from this sector could be reduced by about 70 percent and NOx emissions by up to 35 percent in 2014. This measure is scheduled for ARB Board consideration in October-2008.

Table III-5: BNSF Barstow Railyard On-Road Truck/Vehicles Diesel PM Emissions

Source	Diesel PM Emissions (tons per year)	
	Diesel PM Emissions Tons Per Year*	Percent of Total Emissions
On-Road Fleet Vehicles	0.03	75%
On-Road Trucks	0.01	25%
Total On-Road Truck Emissions	0.04	100%

*Numbers may not add precisely due to rounding.

5. Cargo Handling Equipment

The BNSF Barstow Railyard has no cargo handling operations, except for emergency operations. Only one piece of equipment operates at the BNSF Barstow Railyard. The annual hours of operation are 240 hours according to data from BNSF.

The diesel PM emissions due to cargo handling equipment activities at the BNSF Barstow Railyard were estimated using the latest version of ARB cargo handling equipment model (ARB, 2006d). The total diesel PM emissions from cargo handling equipment was estimated at about 0.03 tons per year. As indicated in Table III-6, diesel PM emissions from cargo handling equipment were due to the only one piece of material handling equipment which contributes about less than 1% of the total diesel PM emissions at the BNSF Barstow Railyard.

In December 2005, ARB adopted a new regulation for cargo handling equipment to reduce diesel PM and NOx emissions beginning in 2007. Implementation of this regulation will reduce diesel PM emissions by approximately 40% in 2010 and 65% in 2015, and NO_x emissions by approximately 25% in 2010 and 50% in 2015. The regulation, when fully implemented, is expected to cumulatively reduce diesel PM and NO_x emissions from all cargo handling equipment in the State by up to 80 percent by 2020. Therefore, the BNSF Barstow Railyard should benefit from this mitigation measure in the near future.

Table III-6: Diesel PM Emissions by Cargo Handling Equipment

Cargo Handling Equipment	Diesel PM Emissions	
	Tons Per Year	Percent of Total
Material Handling Equipment	0.03	100%
Total	0.03†	100%

B. Off-Site Diesel PM Emissions Summary

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

1. Mobile Sources

For the off-site mobile sources, the analysis focused on on-road heavy duty diesel trucks, as they are the primary source of diesel PM from the on-road vehicle fleet. ARB staff estimated mobile emissions based on roadway specific vehicle activity data and allocated them to individual roadway links. All roadway links within a one-mile distance from the boundary of the BNSF Barstow Railyard are included in the analysis. The estimates do not include the diesel PM emissions generated from other modes such as extended idling, starts, 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.

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, and major arterial, minor arterial, collector, or centroid connector.

Within a one-mile distance from the boundary of the BNSF Barstow Railyard, off-site diesel PM emissions are predominantly generated by mobile sources which emit around 26 tons per year. The majority of the off-site diesel PM emissions are from diesel-fueled heavy duty trucks traveling on freeway I-15 and major local streets.

As shown in Table III-8, the freeway I-15 contribute approximately 24 tons per year of diesel PM emissions, which account for over 92% of total mobile sources diesel PM emissions. The remaining 2.0 tons of off-site diesel PM emissions, or 8% of the total diesel PM emissions are diesel-fueled trucks traveling on Hwy 58 and major local streets local streets. Although Interstate 40 falls outside the one-mile radius from the railyard and was not considered as part of ARB's off-site analysis, its emissions are likely to impact risk levels in the vicinity of the BNSF Barstow Railyard. The methodology for mobile diesel PM emission estimation is presented in Appendix A.

The diesel PM off-site mobile source emissions were estimated based on the local traffic flow, and calculated by different classifications of truck gross vehicle weights, as shown in Table III-7. For the year 2005, the total diesel PM emissions from mobile sources are estimated at about 26 tons per year with 18.8 tons per year or 72% from heavy-heavy duty trucks. Medium – heavy duty trucks account for about 3.8 tons per year or 15%. Light-heavy duty trucks accounts for about 3.4 tons per year or 13% respectively. Although Interstate 40 falls outside the one mile radius from the

BNSF Barstow Railyard and was not considered as part of ARB's off-site analysis, its emissions are likely to impact risk levels in the vicinity of the BNSF Barstow Railyard. Off-site mobile source diesel PM emissions by vehicle type are shown in Table III-10.

Table III-7: Off-site Mobile Source Diesel PM Emissions by Vehicle Type

Vehicle Types of Off-Site Mobile Diesel PM Sources	Gross Vehicle Weight (pounds)	Diesel PM Emissions	
		Tons per year	Percent of Total
Light-Heavy Duty Diesel Trucks	8,501-14,000	3.4	13%
Medium-Heavy Duty Diesel Trucks	14,001-33,000	3.8	15%
Heavy-Heavy Duty Diesel Trucks	> 33,000	18.8	72%
Total	-	26.0*	100%

*Numbers may not add up due to rounding

Table III-8: Off-site Mobile Source Diesel PM Emissions by Freeways

Sources	Diesel PM Emissions	
	Tons per year	Percent of Total Off-site Mobile Sources
I-15 Freeway	24.0	92%
HWY 58 and Local Streets	2.0	8%
TOTAL	26.0	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 whose locations fell within the one-mile distance from the boundary of the BNSF Barstow Railyard are selected. Diesel PM emissions are estimated from stationary internal combustion (IC) engines burning diesel fuel, operating at stationary sources reported in CEIDARS.

There are no significant off-site stationary sources with in a one mile radius. Only one facility, Verizon Barstow C.O. lies within that radius. Therefore, within a one-mile distance from the boundary of the BNSF Barstow railyard, the diesel PM emissions from stationary sources are estimated at about less than 0.1% which are considered below levels of de-minimis.

ARB staff also evaluated other toxic air contaminant (TACs) emissions around the BNSF Barstow Railyard. According to ARB's *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (ARB, 2000), diesel PM, 1-3.butadiene, benzene, carbon tetrachloride, and formaldehyde are defined as the top five 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% 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 total emissions are estimated at about 0.26 tons per year, which is substantially less than the diesel PM emissions. Therefore, the potential cancer risk levels caused by non-diesel PM TACs 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.

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

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

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

- A limit of 500 parts per million by weight (ppmw) on sulfur content to reduce emissions of both sulfur dioxide and directly emitted PM.
- A limit on aromatic hydrocarbon content of 10 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 ppm/w beginning in June 2006. Thus, ARB's specifications for sulfur and aromatic hydrocarbons are shown in Table III-9.

Table III-9: 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. %). All on-road motor-vehicle diesel fuel sold or supplied in the United States, except in Alaska, must comply with these requirements. Diesel fuel, not intended for on-road motor-vehicle use, must contain dye solvent red 164.

On January 18, 2001, the U.S. EPA published a final rule which specified that, beginning June 1, 2006, refiners must begin producing highway diesel fuel that meets a maximum sulfur standard of 15 ppmw for all diesel fueled vehicles. The current U.S. EPA on-road diesel fuel standard is shown in Table III-10.

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-10.

Table III-10: U.S. EPA Diesel Fuel Standards

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

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

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

Table III-11 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 levels have been recorded as about 3,000 ppmw in-use and similar levels as U.S. EPA on-road diesel fuel for aromatics at about 35 percent by volume in-use.

Table III-11: Average 1999 Properties of Reformulated Diesel Fuel

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

1 U.S. EPA, December 2000
2 Based on margin to comply with 15 ppmw sulfur standards in June 2006
3 Poly-nuclear aromatic

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 fueling. 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. When these out-of-state line haul locomotives arrive in California they typically have about 10 percent remaining volume of diesel fuel relative to their tank capacity.

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 dropped from 5,000 ppmw to 500 ppmw on June 1, 2007. In 2012, the non-road diesel fuel limits for use in locomotives and 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%, 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.

IV. AIR DISPERSION MODELING FOR THE BNSF BARSTOW 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 Barstow 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 Barstow 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 stands 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 simple to implement.

B. Source Characterization and Parameters

The emission sources from the locomotives and other diesel PM sources at the BNSF Barstow Railyard are characterized as one of the following source types, required by the ARB Guidelines (ARB, 2006c):

- Point source (a source with emissions emanating from a known point, with buoyancy due to either thermal or mechanical momentum). A point source is characterized by a height, diameter, temperature, and exit velocity.

- Volume source (a source with emissions that have no buoyancy and are emanated from a diffuse area). A volume source is characterized by an initial lateral and vertical dimension (initial dispersion) and a release height.

- Area source (a source with emissions that have no buoyancy and are emanated from a diffuse plane or box). An initial vertical dimension and release height may also be specified for an area source.

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. When a mobile source is traveling, the emissions are simulated as a series of volume sources to mimic the effects of initial dispersion due to plume downwash. Key model parameters for volume sources include emission rate (or strength), source release height, and initial lateral and vertical dimensions of volumes.

The emission rates for individual locomotives are a function of locomotive makes, notch setting, activity time, duration, and operating location. Emission source parameters for locomotive model classifications at the yard, including emission source height, diameter, exhaust temperature, and exhaust velocity. While BNSF assumed more specific temperatures and stack heights from their switchers and line haul locomotives fleets, UP used data from the *Roseville Railyard Study* (ARB, 2004a) based on the most prevalent locomotive model of switchers and line hauls to parameterize locomotive emission settings. In total, the assumptions on the locomotive emission parameters are slightly different between UP and BNSF; however, both are within reasonable ranges according to their activities, and the slight differences in stack height have an insignificant impact on predicted air concentrations, within 2%, based on a sensitivity analysis conducted by ARB staff.

For the stationary locomotives, they 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. 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.

C. Meteorological Data

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

These meteorological variables are important to describe the air dispersion in the atmosphere. The wind speed determines how rapidly the pollutant emissions are diluted and influences the rise of emission plume in the air, thus affecting downwind concentrations of pollutants. Wind direction determines where pollutants will be

transported. The difference of ambient temperature and the emission releasing temperature from sources determines the initial buoyancy of emissions. In general, the greater the temperature difference, the higher the plume rise. The opaque cloud cover and upper air sounding data are used in calculations to determine other important dispersion parameters. These include atmospheric stability (a measure of turbulence and the rate at which pollutants disperse laterally and vertically) and mixing height (the vertical depth of the atmosphere within which dispersion occurs). The greater the mixing height is, the larger the volume of atmosphere is available to dilute the pollutant concentration.

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

In this study, meteorological data for air dispersion modeling was selected based upon the spatial and temporal representativeness of conditions in the immediate vicinity of the railyard. (ENVIRON 2007b). ENVIRON evaluated the meteorological stations and identified that, based on ARB criteria for representativeness (ARB, 2006d). Barstow station operated by the California Air Resources Board (CARB) was the most representative meteorological station for the BNSF Barstow Railyard.

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

ENVIRON selected the wind speed, wind direction, and temperature data from the Barstow station operated by CARB for five years (2001-2002 and 2004 through 2006) as the most representative available data for use in the air dispersion analysis of the BNSF Barstow Railyard. ENVIRON used cloud cover, temperature, and pressure data (as Barstow did not have a record of complete temperature measurements for 2005 and 2006 or complete pressure measurements for 2001, 2005, and 2006) from the Barstow-Daggett Airport. Upper air data from the Desert Rock, Nevada station was used in AERMET processing for the BNSF Barstow railyard (ENVIRON 2007a). Detailed meteorological data selection is discussed in *Meteorological Data Selection and Processing Methodology for 2007 BNSF Designated Rail Yards* (ENVIRON, 2007a).

AERMET: A meteorological preprocessing program for AERMOD.

According to *ARB Railyard Health Risk Assessment Guidelines* (ARB, 2006d), five years of meteorological data are recommended to be used in the air toxic health risk assessment. Surface parameters supplied to the model were specified for the area surrounding the surface meteorological monitoring site as recommended by AERMOD and the ARB *Health Risk Assessment Guidance for Railyard and Intermodal Facilities*

(ARB, 2006d). For this study, five years (2001-2002 and 2004 through 2006) of meteorological data from CARB Barstow station and Barstow Daggett stations were processed (ENVIRON, 2007) with AERMET to assure that an adequate number of years of acceptable data completeness and quality would be available for AERMOD modeling. The detailed procedures of meteorological data preparation and the quality control procedures are documented in the modeling report by ENVIRON. Surface parameters supplied to the model were specified for the area surrounding the surface meteorological monitoring site as recommended by AERMOD and ARB Guidelines (ARB, 2006d).

According to the sensitivity analyses conducted by BNSF, the impacts on the diesel PM air concentration spatial patterns, locations of highest concentrations, and absolute concentrations by using the long-term (i.e., five-year) vs. short-term (i.e., one-year) are found to be similar. This is consistent with the findings from a sensitivity analysis from one of UP Railyard conducted by ARB staff (see Appendix F). Therefore, whether five-year or one-year meteorological data are used, the modeling results show similar estimated exposures and potential cancer risks surrounding the railyard facility.

Figure IV-1 presents the wind rose and Figure IV-2 provides the wind class frequency distributions for the meteorological data used in the BNSF Barstow Railyard air dispersion modeling. The yearly average wind speed is 3.3 meters per second. The prevailing wind over the modeling domain blows from west to east.

Figure IV-1: Wind-rose Plot for BNSF Barstow Railyard from Barstow Station In 2005

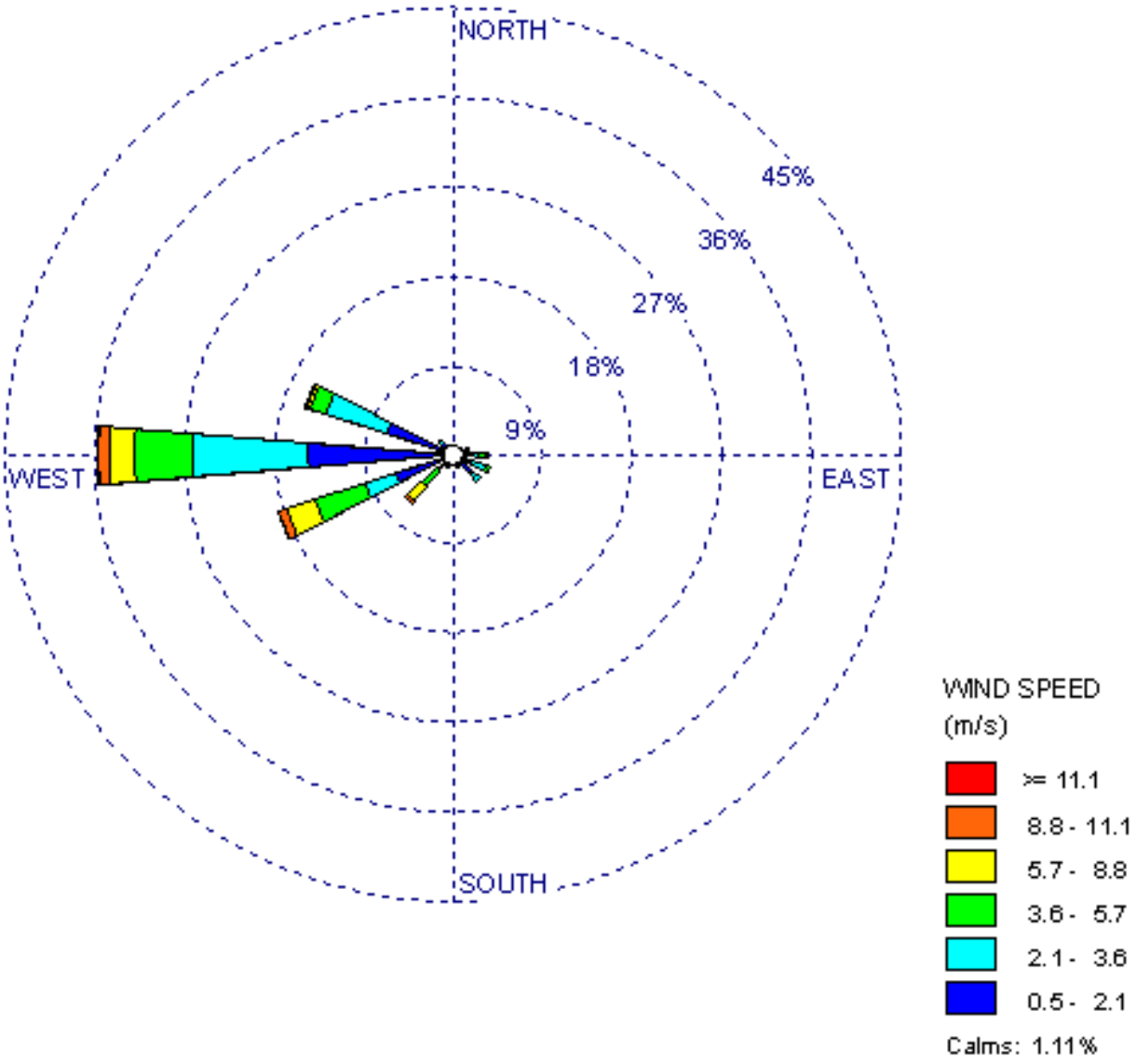
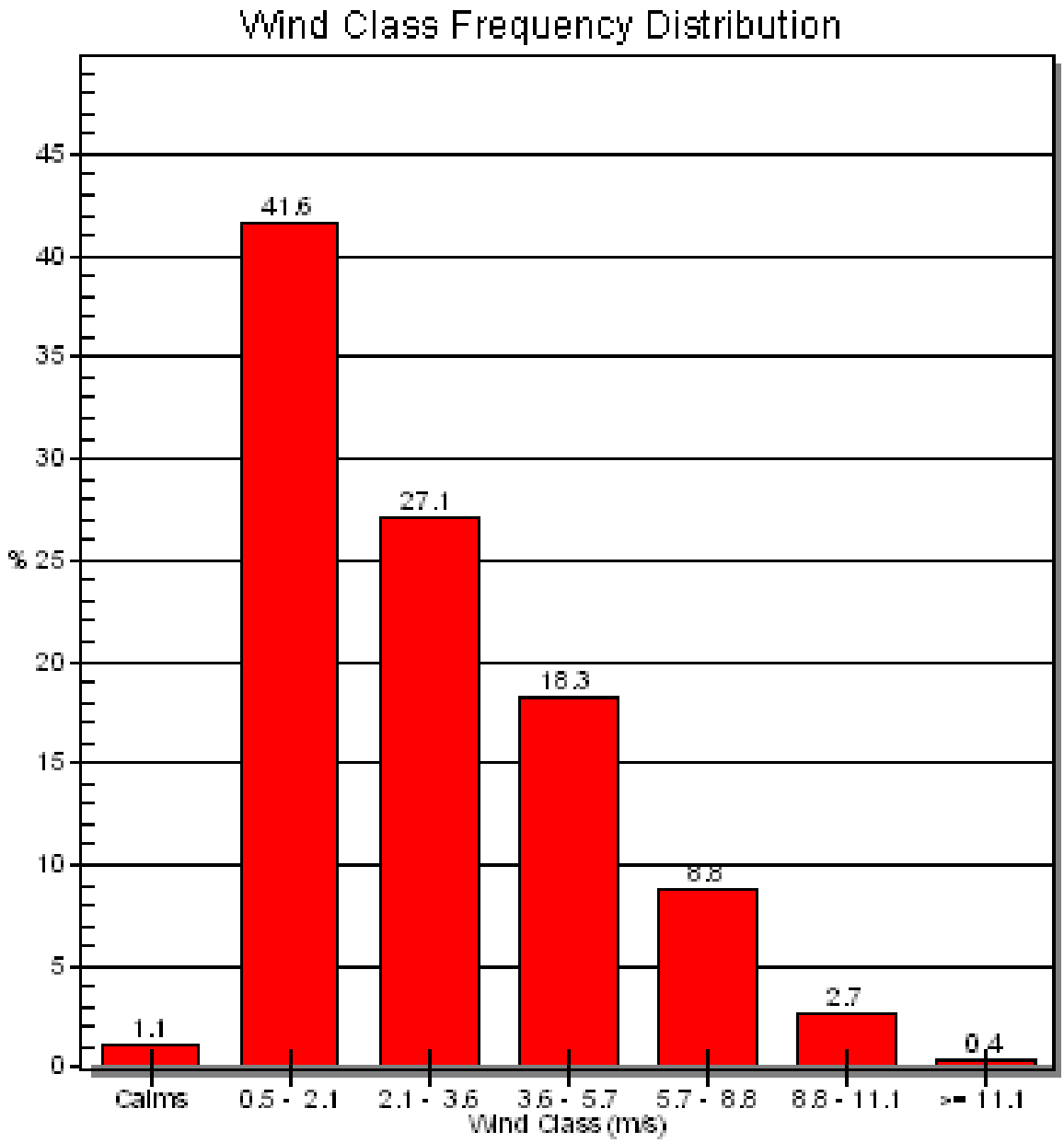


Figure IV-2: Wind Class Frequency Distribution for the BNSF Barstow Railyard from the Barstow Meteorological Station.



The detailed procedures of meteorological data preparation and quality control are described in the ENVIRON report (ENVIRON, 2007).

D. Model Receptors

Model receptors are the defined discrete locations where concentrations are estimated by the dispersion model. A Cartesian UTM grid receptor network is used in this study where an array of points are identified by their x and y coordinates. This receptor

network is capable of identifying the emission sources within the railyard with respect to the receptors in the nearby residential areas.

ARB Railyard Health Risk Assessment Guidance for Railyard and Intermodal Facilities (ARB, 2006b), the modeling domain is defined as a 20 x 20 kilometer region, which covers the railyard in the center of domain and extends to the surrounding areas. To better capture the different concentration gradients surrounding the railyard area, four sets of receptor grids fine, medium, intermediate and coarse were used:

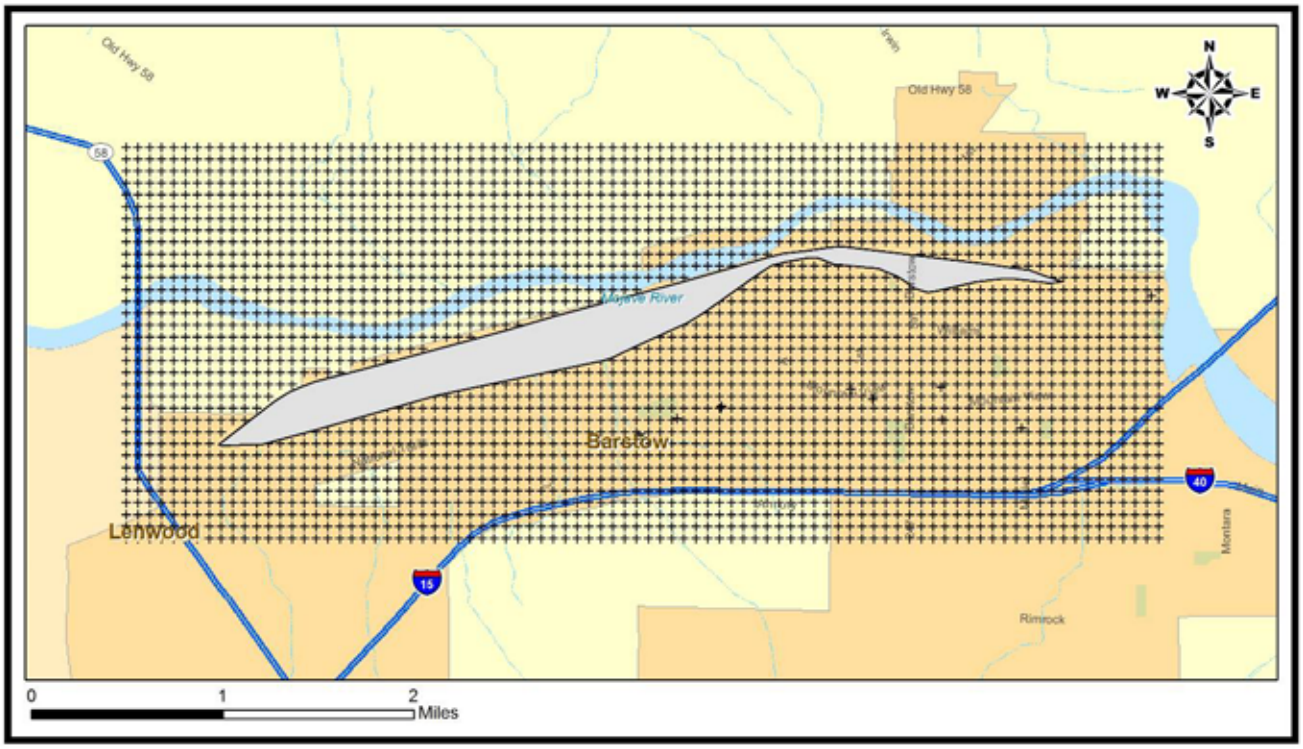
- A fine grid receptor network within 150 meters from the facility boundary with receptor spacing of 50 m apart.
- An intermediate receptor network within 750 meters from the facility boundary with receptor spacing of 100 meters.
- A medium grid receptor network between 1500 meters with receptor spacing of 250m apart.
- A coarse receptor network between 20km by 20km with receptor spacing of 500 m apart.

Fine, medium, Intermediate and coarse receptor grid networks are presented in Figures IV-3a, IV-3b, IV-3c and IV-3d, respectively.

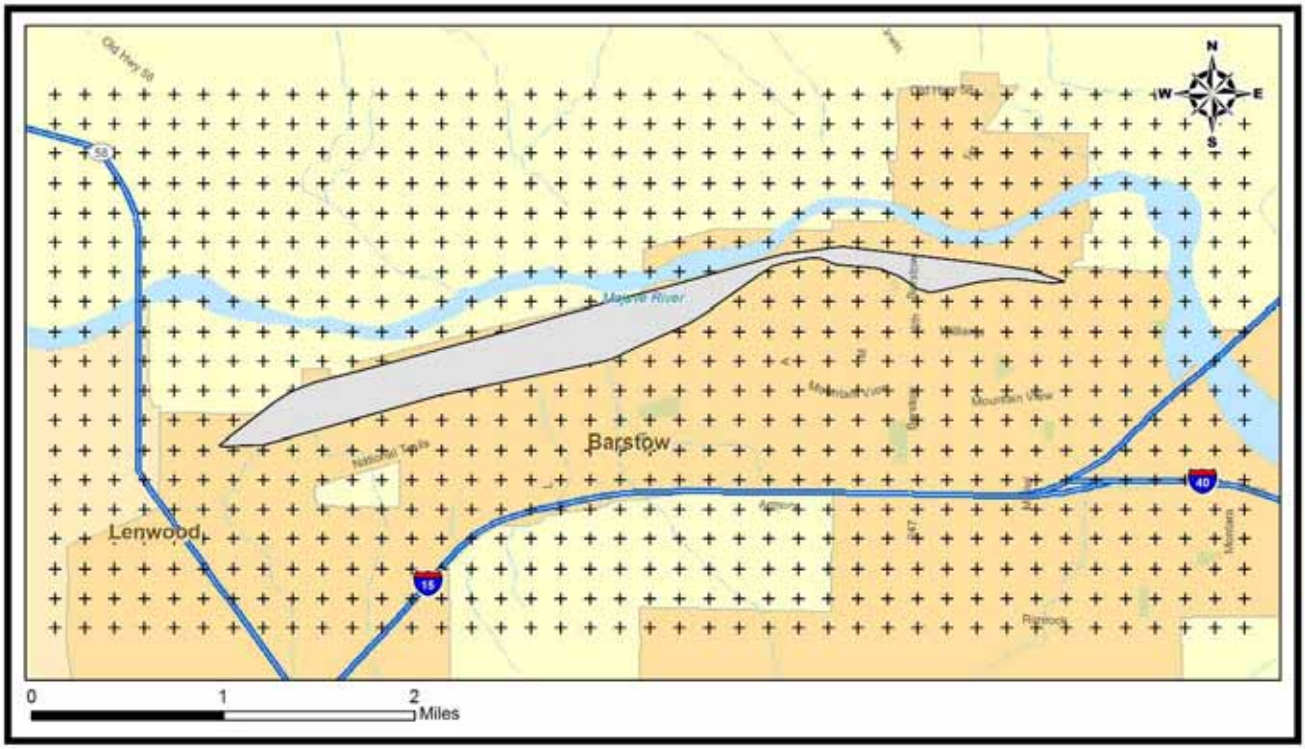
Figure IV-3: The Receptor Grid Networks of Air Dispersion Modeling at the BNSF Barstow Railyard

A: Fine Grid

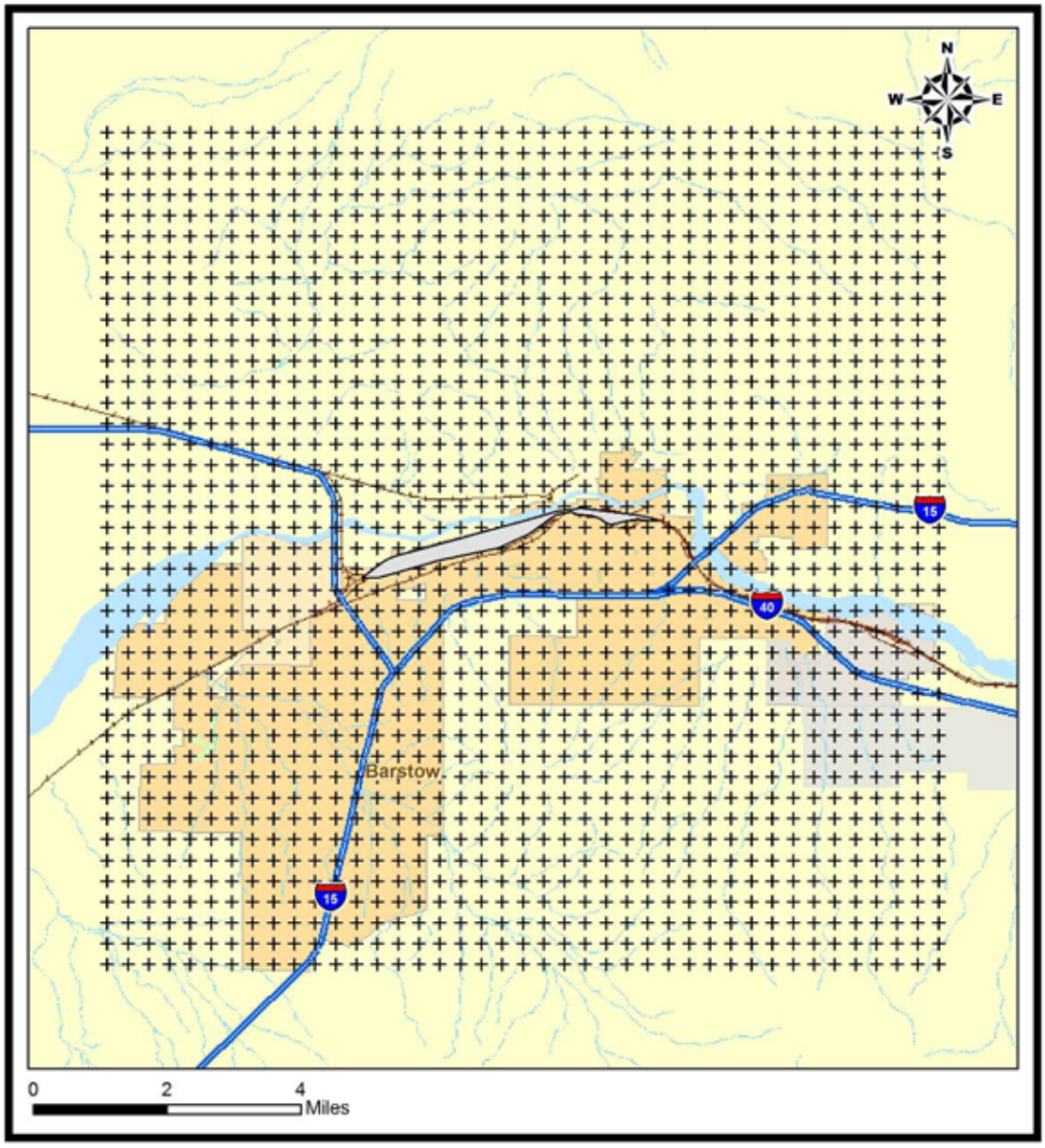
B: Intermediate Grid



C: Medium Grid



D: Coarse Grid



E. Building Wake Effects

One of characterizations in the air dispersion model is mixing process of air pollutants due to the air flow cause by surrounding environment. The spacing and placement of emission sources relative to surrounding building or structures can have such an effect on the pollutant plume in the air. If pollutant emissions are released at or below the Good Engineering Practice (GEP) height as defined by U.S. EPA Guidance (US 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 to simulate the effects of building downwash. To do so, “direction-specific” building dimensions for each emission point need to be input. The direction-specific building dimensions represent the building width perpendicular to the wind direction along with the building height, and are estimated by a model built-in module, the Building Profile Input Program – 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, 2007b). Detailed treatments of building downwash effects can be found from ENVIRON International Corporation Report (ENVIRON, 2007b).

F. Model Implementation Inputs

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

Source inputs require source identification and source type. Each source type requires specific parameters to define the source. For example, the required details for a point source are emission rate, release height, emission source diameter, exhaust exit temperature, and exhaust exit velocity. Meteorological and receptor inputs have been discussed in Sections IV-C and IV-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 are provided in ENVIRON International Corporation Report (ENVIRON, 2007b).

V. HEALTH RISK ASSESSMENT OF THE BNSF BARSTOW RAILYARD

This chapter discusses the characterization of potential cancer and non-cancer risks associated with exposure to toxic air contaminants (TACs), especially diesel PM, emitted in and around the BNSF Barstow 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

This 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 method used with ARB's UP Roseville Railyard Study. The Office of Environmental Health Hazard Assessment (OEHHA) guidelines outline a tiered approach to risk assessment, providing risk assessors with flexibility and allowing for consideration of site-specific differences:

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

The Health Risk Assessment is based on the railyard specific emission inventory and air dispersion modeling predictions. The Office of Environmental Health Hazard Assessment (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 Office of Environmental Health Hazard Assessment (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.

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

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 play key roles in determining potential risk. In general, 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 potentially greater risk than adults because they have greater exposure on a per unit body weight basis and also because of other physiological factors.

Diesel PM is not the only toxic air contaminant (TAC) emitted in the BNSF Barstow Railyard. Relatively small amounts of gasoline TACs are also emitted from some of the gasoline fleet vehicles, track maintenance forklifts (2), two on-site gasoline storage and dispensing units and from four on-site generators, including 1-3 butadiene, benzene etc. The detailed emission inventories for these TACs are presented in *the Air Dispersion Modeling Assessment of Air Toxic Emissions from BNSF Barstow Railyard* and *Barstow Railyard TAC Emission Inventory reports (ENVIRON 2008)*. The total amount of these TACs emissions is about 180 pounds per year, as compared to 28 tons per year of the BNSF Barstow facility-related diesel PM emissions. However, using cancer potency weighted factor adjustment, these toxic air contaminant emissions are about a factor of 300 times less than the cancer potency weighted emissions of diesel PM, (i.e., 0.09 vs. 28 tons per year). Therefore, only diesel PM emissions, the predominant emissions at the BNSF Barstow Railyard are presented in the on-site emission analysis and health impact evaluation.

ARB staff also evaluated other toxic air contaminant (TACs) emissions around the BNSF Barstow Railyard. According to ARB's *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (ARB, 2000), diesel PM, 1-3 butadiene, benzene, carbon tetrachloride, and formaldehyde are defined as the top five 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% 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 total emissions are estimated at about 0.26 tons per year, which is substantially less than the diesel PM emissions. Therefore, the potential cancer risk levels caused by non-diesel PM TACs 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.

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 potency factor) to estimate potential cancer or non-cancer health effects associated with air contaminant exposure.

Pollutants that were originally emitted into the air can result in exposures as a result of breathing, dermal contact, ingestion of contaminated produce, and ingestion of fish that have taken up contaminants from water bodies. These exposures can all contribute to an individual's health risk. However, diesel PM risk is evaluated by the inhalation pathway only in this study because the risk contributions by other pathways of exposure are insignificant relative to the inhalation pathway. It should be noted that the background or ambient diesel PM concentrations are not incorporated into the risk quantification in this study. Therefore, the estimated potential health risk in the study should be viewed as risk level above 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 risk levels associated with the estimated diesel PM emissions at the BNSF Barstow Railyard are displayed by using isopleths. In this study, ARB staff elected to present the cancer risk isopleths focusing on risk levels of 10, 25, 50, 100, and 250 in a million, presented in Figure II-3 and Figure II-4. Figure II-3 focuses on the near source risk levels and Figure II-4 focuses on the more regional impacts. In each figure, the risk isopleths are overlaid onto a satellite

image of the Barstow area surrounding the BNSF Barstow Railyard, to illustrate the land use (residential, commercial, industrial, or mixed use) within the impacted areas.

The OEHHA Guidelines specify that, for health risk assessments, the cancer risk for the maximum exposure at the point of maximum impact be reported. The point of maximum impact (PMI), which is defined as a location or the receptor point with the highest cancer risk level outside of the facility boundary, with or without residential exposure, is predicted to be located at the southeast side of the railyard fence line (see Figure V-1). This is directly downwind of high emission density areas for the prevailing westerly wind, where locomotive activities (i.e. line haul locomotives, switchers, and locomotive service shop) generates about 75% of the facility-wide diesel PM emissions (see the emission allocation in Appendix E).

The cancer risk at the PMI is estimated to be about 1,000 chances in a million. The land use in the vicinity of the PMI is primarily zoned as open land and industrial use. However, there is always the potential for 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 450 chances in a million.

As indicated by the Roseville Railyard Study (ARB, 2004a), the location of the PMI may vary depending upon the settings of the model inputs and parameters, such as a meteorological data sets 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 incidences but more as a tool for comparison. In addition, the estimated point of maximum impact location and maximum individual cancer risk value may not be replicated by air monitoring.

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

As shown in Figure II-3 at the BNSF Barstow Railyard, the area with the greatest impact has an estimated potential cancer risk of over 250 chances in a million, occurring in an area, 200 yards north and south of the railyard fence line. The majority of the BNSF Barstow Railyard activities take place in the western part of the railyard, and emissions allocations for this railyard are presented in Appendix E. At about 400 yards, outside of the BNSF Barstow Railyard boundary, the estimated cancer risks are lowered to about 150 chances in a million. At about a half mile from the BNSF Barstow Railyard boundary, the estimated cancer risk is about 100 in a million, and within a mile of the railyard boundary the estimated cancer risks are lowered further to about 50 chances in

a million. At about 1.5 miles from the BNSF Barstow Railyard, the estimated cancer risks are lowered to about 10 in a million.

The OEHHA Guidelines recommend 70-year lifetime exposure duration to evaluate the potential cancer risks for residents. Shorter exposure duration of 30 years and 9 years may also be evaluated for residents and school-aged children respectively, as a supplement. These three exposure durations all assume exposure occur 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, may have higher rates of exposure than adults, on a per unit body weight basis. (OEHHA, 2003).

To evaluate the potential cancer risks for off-site workers, the OEHHA Guidelines recommend that a 40-year exposure duration to be used, assuming workers have different rates of exposure for an 8-hour workday, with adjustments of five days a week and 245 days a year.

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

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

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

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

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

The residential areas near the BNSF Barstow Railyard are located primarily to the north and south east of the railyard. Areas located to the west are predominately open desert land or industrial areas. Based on the 2000 U. S. Census Bureau's data, the zone of impact with the estimated cancer risk over 10 chances in a million encompasses approximately 25,500 acres and about 22,060 residents. Table V-2 presents the exposed population and area coverage for various impacted zones of cancer risks. The prevailing wind patterns around the BNSF Barstow Railyard move from the west to east, where much of the downwind areas are industrial lands.

Table V-2: Estimated Impacted Areas and Exposed Population associated with Different Cancer Risk Levels Caused by BNSF Barstow Railyard Diesel PM Emissions

Estimated Risk (chances per million)	Impacted Area (Acres)	Estimated Population Exposed*
> 250	650	860
100 - 250	2,650	3,600
50 - 100	4,300	5,000
25 -50	6,900	6,500
10 - 25	11,000	6,100
>10	25,500**	22,060**

***** Based on 2000 Census Data
** Numbers may not add due to rounding

Figure V-1: Estimated Near-Source cancer Risks (case per million people) From the BNSF Barstow Railyard

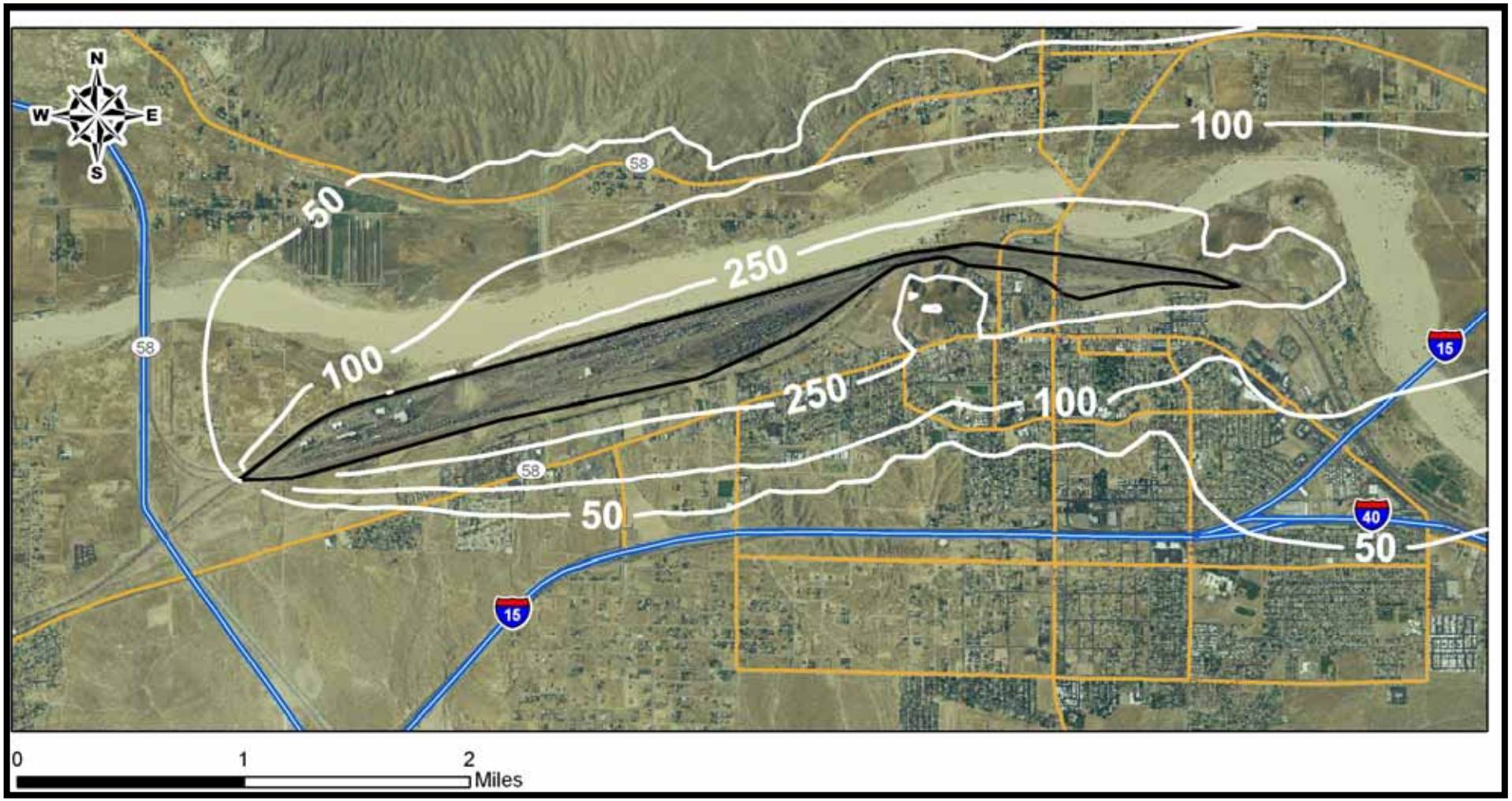
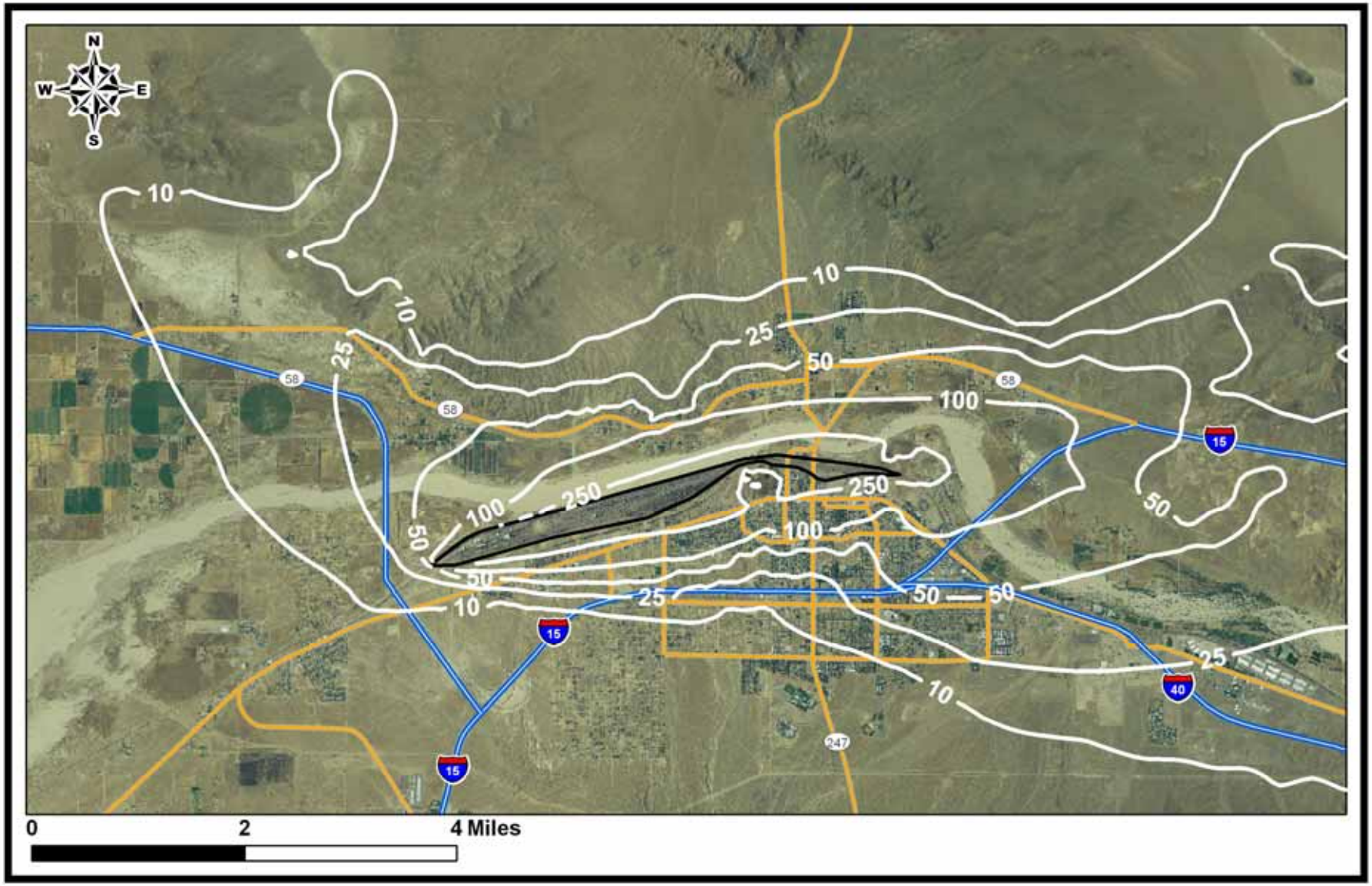


Figure V-2: Estimated Regional Cancer Risks (chances per million) from the BNSF Barstow Railyard.



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

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

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

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

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

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

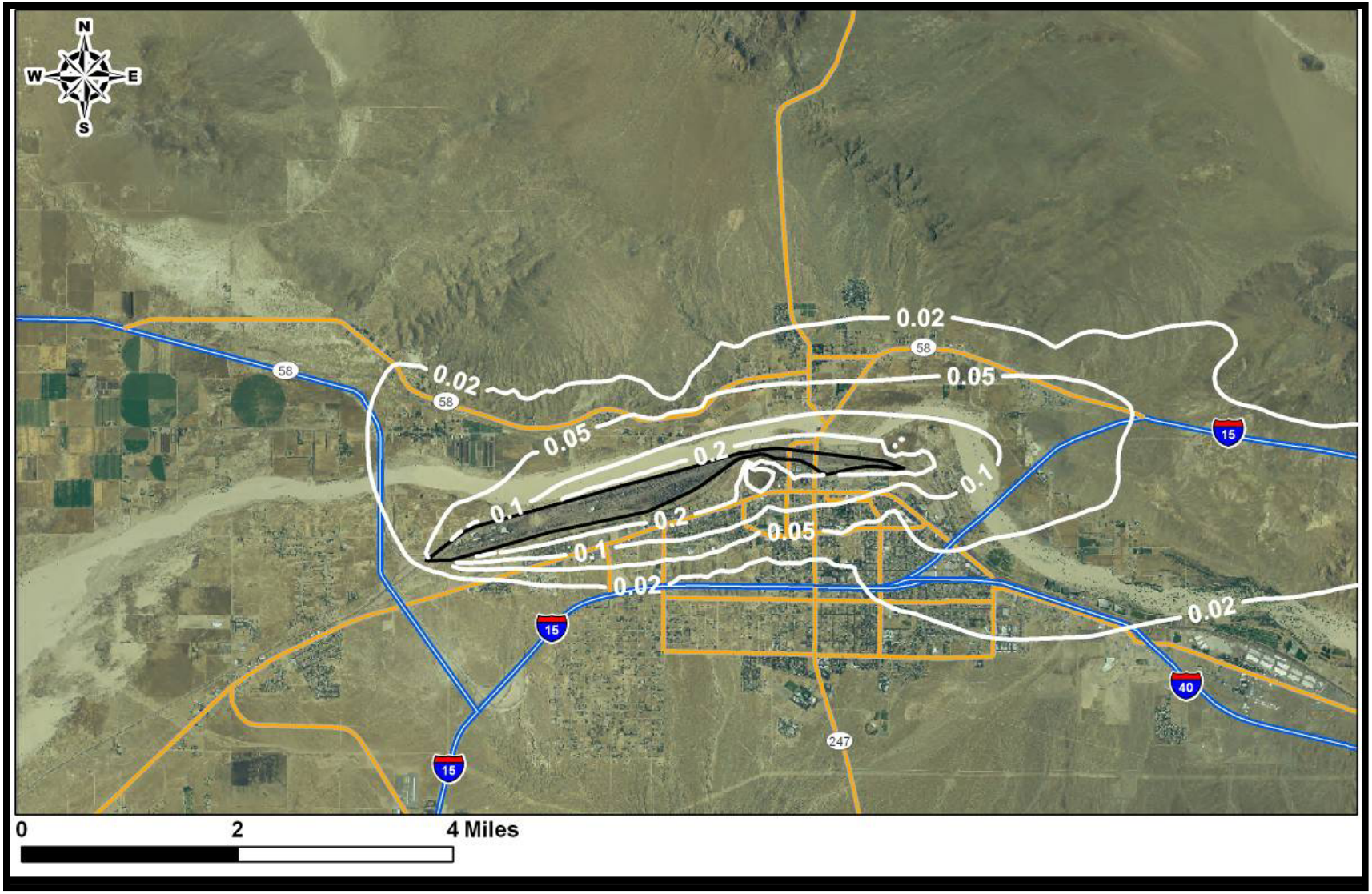
particulate matter on cardiovascular and respiratory disease and deaths, exacerbation of asthma, and enhancement of allergic response.

The hazard index (HI) is then calculated by taking the annual average diesel PM concentration, and dividing by the chronic REL of 5 $\mu g/m^3$. 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 chronic health impacts associated with exposures to the model-predicted levels of directly emitted diesel PM from on-site sources. The HI values were calculated, and then plotted as a series of isopleths in Figure V-3. As can be seen, the potential non-cancer chronic health hazard index from diesel PM emissions at the BNSF Barstow Railyard are estimated to be less than 0.3. According to OEHHA Guidelines (OEHHA, 2003), these levels indicate that the potential non-cancer chronic public health risks are less likely to occur. The zone of impact where non-cancer chronic health hazard indexes are over 0.02 covers an estimated area of 12,100 acres.

Figure V-3 presents the spatial distribution of non-cancer chronic health hazard index isopleths that range from 0.2 to 0.02 around the BNSF Barstow Railyard facility.

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



c) Non-Cancer Acute Risk

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

Due to the uncertainties in the toxicological and epidemiological studies, diesel PM as a whole was not assigned a short-term acute REL. It is only specific compounds of diesel exhaust (e.g., acrolein) that independently have potential acute effects (such as irritation of the eyes and respiratory tract), and an assigned acute REL. However, acrolein is primarily used as a chemical intermediate in the manufacture of adhesives and paper. It has also been found as a byproduct of any burning process, such as fire, and tobacco smoke. Acrolein is a chemically reactive and unstable compound, and easily reacts with a variety of chemical compounds in the atmosphere. Compared to the other compounds in the diesel exhaust, the concentration of acrolein has a much lower chance of reaching a distant off-site receptor. More importantly, given the multitude of activities ongoing at facilities as complex as railyards, there are much higher levels of uncertainties associated with hourly-specific emission data and 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 Barstow 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 Barstow Railyard was included. Diesel PM off-site emissions used in the off-site modeling runs consisted of about 26 tons per year from roadways or mobile sources, there is only one stationary source within a one mile radius and the emissions from that one facility are below levels of de-minimis representing emissions for the year 2005. The diesel PM emissions from BNSF Barstow Railyard is not analyzed in the off-site air dispersion modeling. The same meteorological data and coarse receptor grid system used for on-site air dispersion modeling was used for the off-site modeling runs.

The estimated potential cancer risks and non-cancer chronic health hazard index associated with off-site diesel PM emissions are illustrated in Figure V-4 and Figure V-5.

Figure V-4: Estimated Cancer Risk Levels from Off-site Diesel PM Emissions

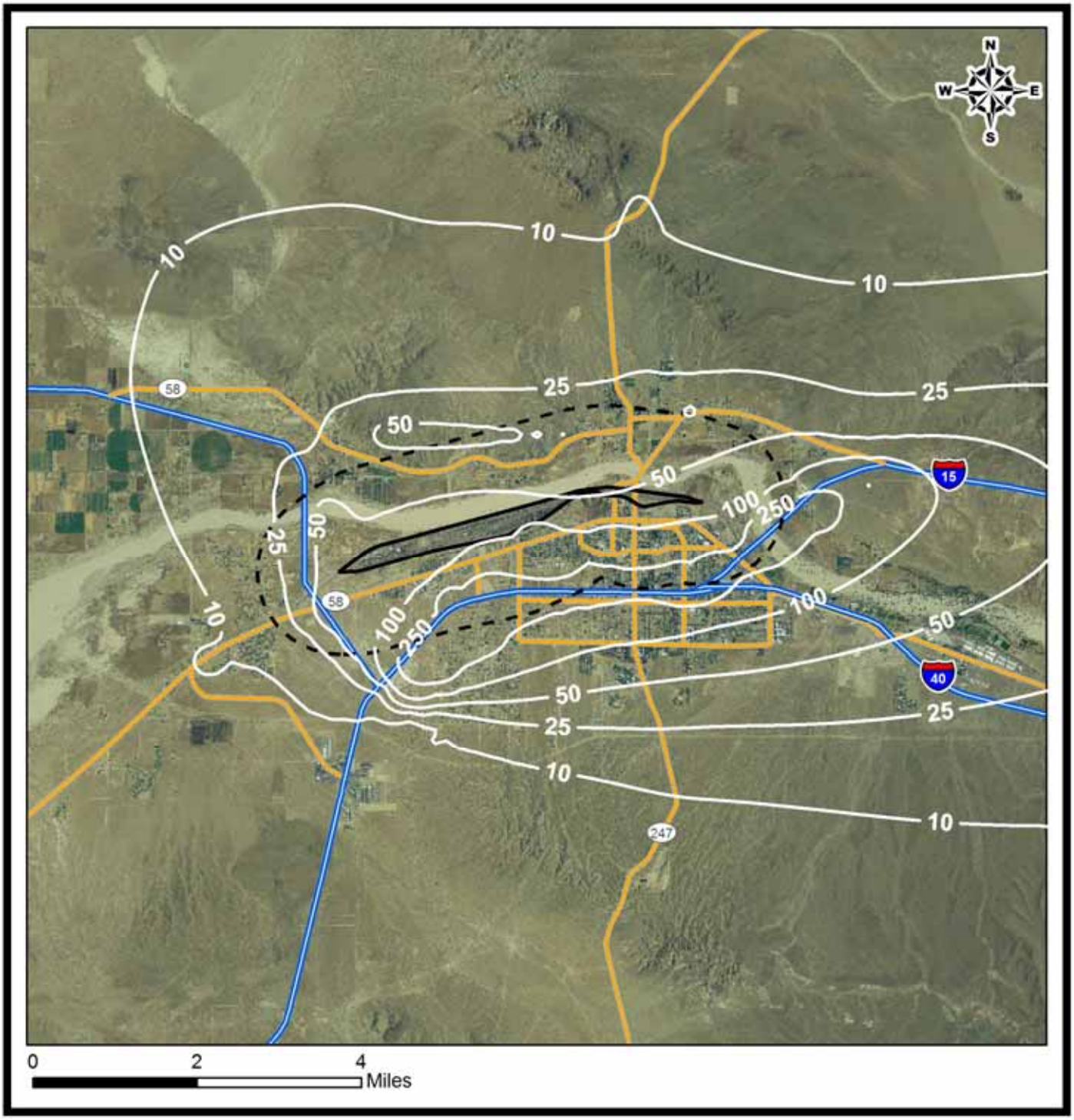
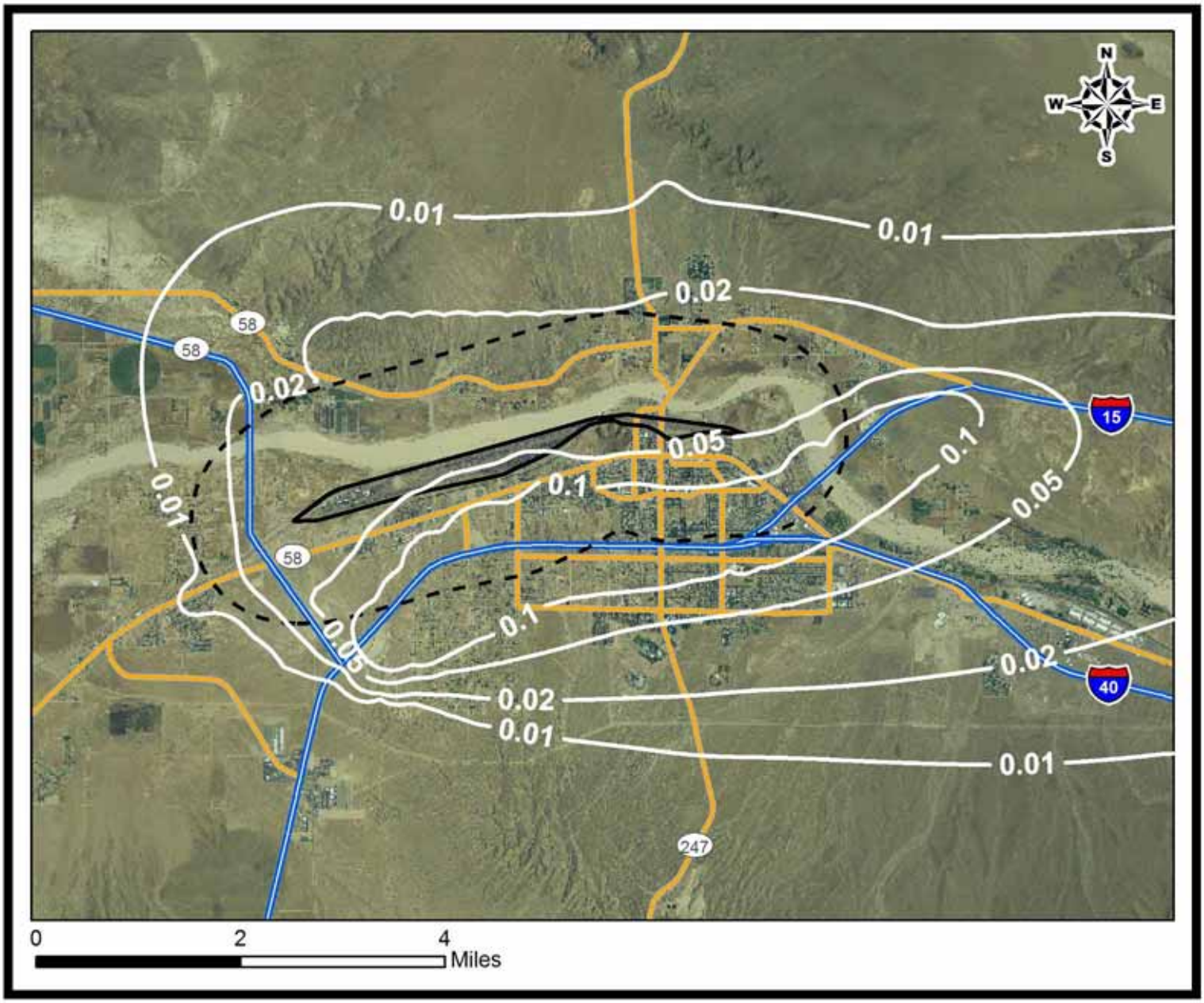


Figure V-5: Estimated Non-Cancer Chronic Health Hazard Index from Off-site Diesel PM Emissions



Based on the 2000 U.S. Census Bureau's data, the zone of impact of the estimated potential cancer risks >100 chances in a million associated with off-site diesel PM emissions encompass approximately 6,200 acres where about 15,700 residents live. For comparison with the BNSF Barstow Railyard health risks, the same level of potential cancer risks (>100 chances in a million) associated with railyard diesel PM emissions covers about 3,300 acres where approximately 4,500 residents live. Detailed calculations and methodologies used in off-site air dispersion modeling are presented in Appendix C.

Table V-3 presents the exposed population and area coverage size for various impacted zones of cancer risks associated with off-site diesel PM emissions.

Table V-3: Estimated Impacted Areas and Exposed Population associated with Different Cancer Risk Levels Associated with Off-Site Diesel PM Emissions

Estimated Cancer Risk (chances per million)	Estimated Impacted Area (Acres)	Estimated Population Exposed
>250	2,100	3,500
100-250	4,100	12,200
50-100	7,000	6,600
25-50	9,600	4,500
10-25	20,500	3,350
>10	43,300**	30,150**

*Approximate estimates because partially these isopleths exceed the air dispersion model domain.
** Numbers may not add due to rounding.

3. Risks to Sensitive Receptors

Certain individuals may be more sensitive to toxic exposures than the general population. These sensitive populations include school-age children and seniors. The sensitive receptor locations include schools, hospitals, day-care centers and elder care facilities. There are 14 sensitive receptors within one-mile of the BNSF Barstow Railyard, including 7 schools, 4 child care centers and 3 health facilities or hospitals. Table V-4 shows the number of sensitive receptors in various levels of cancer risks associated with diesel PM emission from the BNSF Barstow Railyard, based on 70-year residential exposure duration.

Table V-4: Estimated Number of Sensitive Receptors in Various Levels of Cancer Risks associated with On-Site Diesel PM Emissions

Estimated Cancer Risk (chances per million)	Number of Sensitive Receptors
10 – 25	1
25 – 50	0
50 – 100	7
100 – 250	6
>10	14

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 individuals are not underestimated.

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

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

1. Emission Inventory

Emissions are usually estimated by consideration of the operational activities and fuel consumption associated with emission factors based on source tests. There are some uncertainties with the emission estimates. These uncertainties of emission estimates may be attributed to many factors such as a lack of information for variability of locomotive engine type, throttle setting, level of maintenance, operation time, and emission factor estimates. Quantifying individual uncertainties is a complex process and may in itself introduce unpredictable uncertainties[3].

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

As discussed previously, emission factors are often used for emission estimates according to different operating cycles. The Roseville Railyard Study (ARB, 2004a) developed representative diesel PM emission factors for locomotives in different duty cycles. To reduce the possible variability of 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 BNSF'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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[3] 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, 2004a)" 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 variant whose true value could be established if a perfect measurement is available. The structure of mathematical models employed to represent scenarios and phenomena of interest is often a key source of model uncertainty, due to the fact that models are often only a simplified representation of a real-world system, such as the limitation of model formulation, the parameterization of complex processes, and the approximation of numerical calculations. These uncertainties are inherent and exclusively caused by the model's inability to represent a complex aerodynamic process. An air dispersion model usually uses simplified atmospheric conditions to simulate pollutant transport in the air, and these conditions become inputs to the models (e.g., the use of non site-specific meteorological data, uniform wind speed over the simulating domain, use of surface parameters for the meteorological station as opposed to the railyard, substitution of missing meteorological data, and simplified emission source representation). There are also other physical dynamics in the transport process, such as the small-scale turbulent flow in the air, which are not characterized by the air dispersion models. As a result of the simplified representation of real-world physics, deviations in pollutant concentrations predicted by the models may occur due to the introduced uncertainty sources.

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

complex. Many updated formulations have been incorporated into the model structure from its predecessor, ISCST3, for better predictions from the air dispersion process. Nevertheless, quantifying overall uncertainty of model predictions is infeasible due to the associated uncertainties described above, and is beyond the scope of this study.

3. Risk Assessment

The toxicity of toxic air contaminants is often established by available epidemiological studies or use of data from animal studies where data from humans are not available. The diesel PM cancer potency factor is based on long term studies of railyard workers exposed to diesel exhaust at concentrations approximately ten times greater than typical ambient exposures. The differences within human populations usually cannot be easily quantified and incorporated into risk assessments. Factors including metabolism, target site sensitivity, diet, immunological responses, and genetics may influence the response to toxicants. In addition, the human population is much more diverse both genetically and culturally (e.g., lifestyle, diet) than inbred experimental animals. The variability among humans is expected to be much greater than in laboratory animals. Adjustment for tumors at multiple sites induced by some carcinogens could result in a higher potency. Other uncertainties arise (1) in the assumptions underlying the dose-response model used, and (2) in extrapolating from large experimental doses, where, for example, other toxic effects may compromise the assessment of carcinogenic potential due to much smaller environmental doses. Also, only single tumor sites induced by a substance are usually considered. When epidemiological data are used to generate a carcinogenic potency, less uncertainty is involved in the extrapolation from workplace exposures to environmental exposures. However, children, a subpopulation whose hematological, nervous, endocrine, and immune systems are still developing and who may be more sensitive to the effects of carcinogens on their developing systems, are not included in the worker population and risk estimates based on occupational epidemiological data are more uncertain for children than adults.
Human exposures to diesel PM are often based on limited data and are mostly derived based on estimates of emissions and duration of exposure. Different epidemiological studies also suggest somewhat different levels of risk. When the Scientific Review Panel (SRP) identified diesel PM as a toxic air contaminant (ARB, 1998), the panel members endorsed a range of inhalation cancer potency factors (1.3×10^{-4} to 2.4×10^{-3} $(\mu g/m^3)^{-1}$) and a risk factor of 3×10^{-4} $(\mu g/m^3)^{-1}$, as a reasonable estimate of the unit risk. From the unit risk factor an inhalation cancer potency factor of 1.1 $(mg/kg\text{-}day)^{-1}$ can be calculated, which is used in the study. There are many epidemiological studies that support the finding that diesel exhaust exposure elevates relative risk for lung cancer. However, the quantification of each uncertainty applied in the estimate of cancer potency is very difficult and can be itself uncertain.

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

exposure duration with a 24-hour per day exposure be used for determining residential cancer risks. This will ensure a person residing in the vicinity of a facility for a lifetime will be included in the evaluation of risk posed by the facility. Lifetime 70-year exposure is a conservative estimate, but it is a historical benchmark for comparing facility impacts on receptors and for evaluating the effectiveness of air pollution control measures. Although it is not likely that most people will reside at a single residence for 70 years, it is common that people will spend their entire lives in a major urban area. While residing in urban areas, it is very possible to be exposed to the emissions of another facility at the next residence. In order to help ensure that people do not accumulate an excess unacceptable cancer risk from cumulative exposure to stationary facilities at multiple residences, the 70-year exposure duration is used for risk management decisions. However, if a facility is notifying the public regarding health risk, it is a useful indication for a person who has resided in his or her current residence less than 70 years to know that the calculated estimate of his or her cancer risk is less than that calculated for a 70-year risk (OEHHA, 2003). It is important that the risk estimates generated in this study not be interpreted as the expected rates of disease in the exposed population, but rather as estimates of potential risk. Risk assessment is best viewed as a comparative tool rather than a literal prediction of diesel incidence in a community.

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

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APPENDIX A

METHODOLOGY FOR ESTIMATING OFF-SITE MOBILE SOURCES DIESEL PM EMISSIONS

INTRODUCTION

This assessment includes on-road mobile emissions from all heavy duty diesel truck running exhaust as it is the primary source of diesel particulate emissions within the on-road vehicle fleet. Traditionally, on-road mobile emission inventories are generated at the county scale using California's emission factor model EMFAC and then allocated to large grid cells using the Direct Travel Impact Model (DTIM). To enhance the spatial resolution we have estimated emissions based on roadway specific vehicle activity data and allocated them to individual roadway links. All roadway links within a mile buffer of the combined Commerce yards and all links within a 1-mile buffer of all other yards were included in this assessment.

As more and more work has been done to understand transportation modeling and forecasting, access to local scale vehicle activity data has increased. For example, the various Metropolitan Planning Organizations (MPOs) are mandated by the Federal government to maintain a regional transportation plan and regional transportation improvement plan. These reports assess the impact the travel growth and assess various transportation improvement plans[1]. 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 (version V2.3), rather than EMFAC2007, was used for this assessment because at the time this project was underway EMFAC2007 was not completed. The working draft of EMFAC (version V2.3), 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 rail yard study are covered by the Integrated Transportation Network (ITN) developed by Alpine Geophysics[2]. 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[2] and is based on the fraction of trucks within each county as it is estimated in EMFAC.

The product of truck volume and link length is referred to as vehicle miles traveled (VMT) and has units of miles. Transportation demand models provide total VMT for each link without further classification into the various heavy duty truck weight and fuel type classifications. Therefore, in order to assess the emissions only from heavy duty diesel trucks the total heavy duty truck VMT is multiplied by the fraction of trucks that are diesel. Once the total diesel VMT is calculated the heavy duty truck diesel VMT is multiplied by the fraction of trucks that make up the four weight classifications. The fuel and weight fractions are specific to each county and are derived from total VMT for each weight and fuel class in EMFAC for each county. The data is then compiled into an activity matrix (Table 2) composed of a link identification code, hour of the day, speed, light heavy duty diesel 1 truck (LHDDT1) VMT, light heavy duty diesel 2 truck (LHDDT2) VMT, medium heavy duty diesel truck (MHDDT) VMT, and heavy-heavy duty diesel truck (HHDDT) VMT.

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

Finally, a matrix of emission factors by speed and vehicle type was assembled for each county for light heavy-duty diesel trucks 1 and 2 (LHDDT1 and LHDDT2), medium heavy-duty diesel trucks (MHDDT) and heavy heavy-duty diesel trucks (HHDDT). The following is an example of such a matrix (Table 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

We have made several important assumptions in developing this inventory. While these assumptions are appropriate at the county level they may be less appropriate for the particular areas modeled in this assessment. For example, the county specific default model year distribution within EMFAC and vehicle type VMT fractions were assumed to be applicable for all links within the domain modeled. In the vicinity of significant heavy heavy-duty truck trip generators, it is reasonable to expect that surrounding links will also have higher heavy heavy-duty truck fractions. In these cases, using EMFAC county vehicle mix fractions may underestimate the total diesel particulate emissions from on-road heavy duty trucks. In this inventory, EMFAC county defaults were employed as there is insufficient data available to assess the vehicle mix fractions surrounding the railyards.

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

The emissions inventory developed for this study only included diesel particulate matter emissions from running exhaust as it is the primary diesel source from on-road mobile sources. Emissions from other modes such as extended idling, starts, and off-road equipment outside the rail yards were excluded. Vehicle activity from distribution centers, rail yards and ports, however, are included as they are captured on the roadway network by the travel demand models.

REFERENCES

[1]. "SCAG Transportation Modeling", http://www.scag.ca.gov/modeling/ [Accessed January 2007].

[2]. 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

APPENDIX B

METHODOLOGY FOR ESTIMATING OFF-SITE SATIONARY SOURCES DIESEL PM EMISSIONS

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

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

The reported criteria pollutants in CEIDARS include carbon monoxide, nitrogen oxides, sulfur oxides, total organic gases, and particulate matter (PM). The reported toxic pollutants include the substances and facilities covered by the Air Toxics "Hot Spots" (AB 2588) program. Diesel exhaust particulate matter (diesel PM) was estimated from stationary internal combustion (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 micro-scale 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 US EPA stack defaults from the Emissions Modeling System for Hazardous Air Pollutants (EMS-HAP) program were assigned. The U.S. E.P.A stack defaults are assigned based on the Source Classification Code (SCC) or Standard Industrial Classification (SIC) code of the operation. If an applicable US EPA default was not available, then a final generic

default was applied. To ensure that the micro scale 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 micro scale modeling input files.

APPENDIX C

METHADOLOGY FOR THE AIR DISPERSIONMODELING OF OFF-SITE DIESEL PM EMISSIONS

Off-site Diesel PM (DPM) Sources
For the BNSF Barstow Railyard, Barstow, CA

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

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: 26.1 TPY DPM Stationary Sources: <0.01 TPY DPM**	**PTSD/MSAB**
Receptor Grid	**41x41 Cartesian grid covering 400 km^2 with uniform spacing of 500 meters. Grid origin: (486000, 3851500) in UTM Zone 11.**	**ENVIRON**
Meteorological Data	**AERMET-Processed data for 2001-2005 *Surface*: Barstow station and Barstow-Daggett Airport station *Upper Air*: Desert Rock, NV**	**ENVIRON**
Surface Data	**Albedo: 0.19 - 0.27 Bowen Ratio: 1.21 – 8.69 Surface Roughness: 0.45 – 0.80**	**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 Barstow Railyard facility with the modeling domain indicated by the black outline.

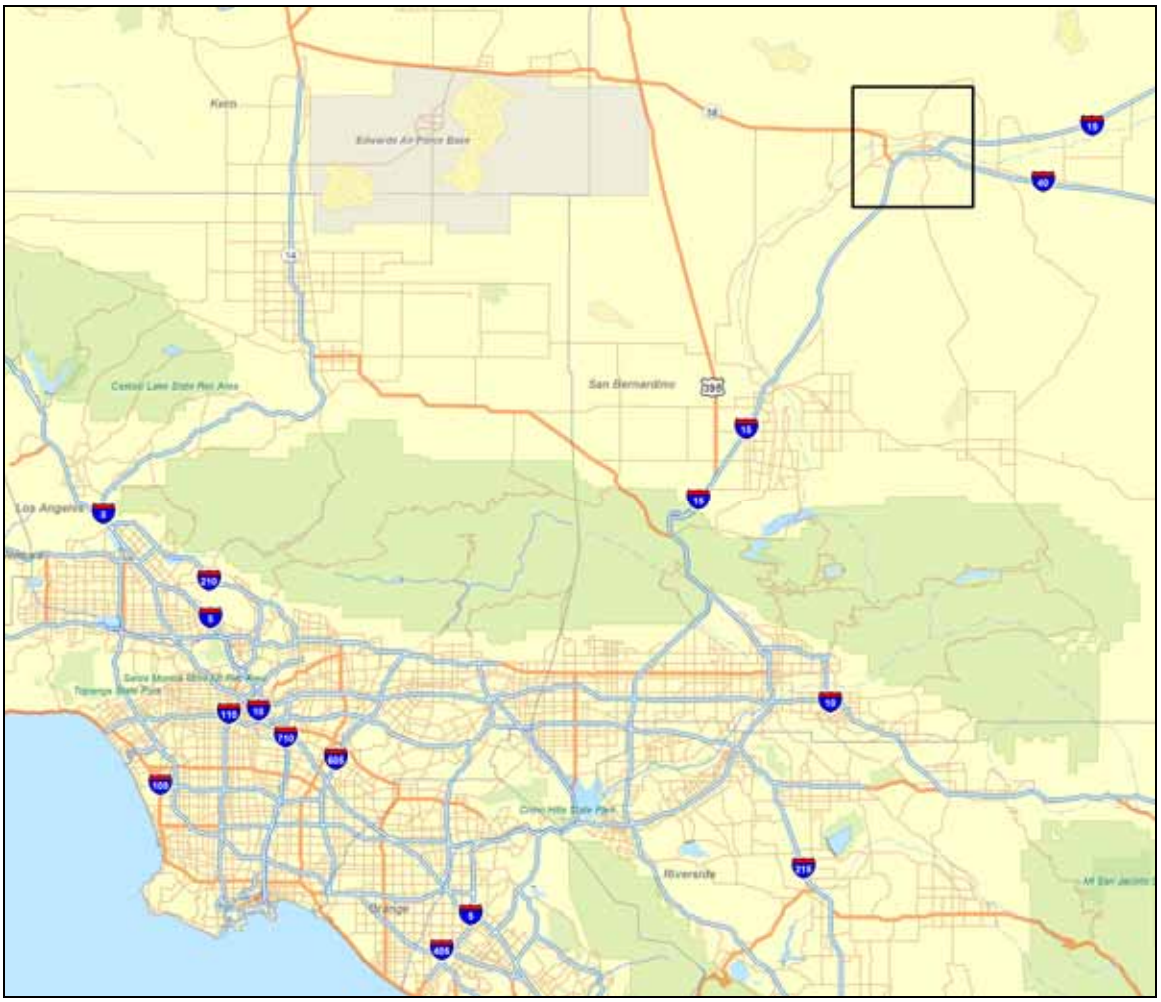
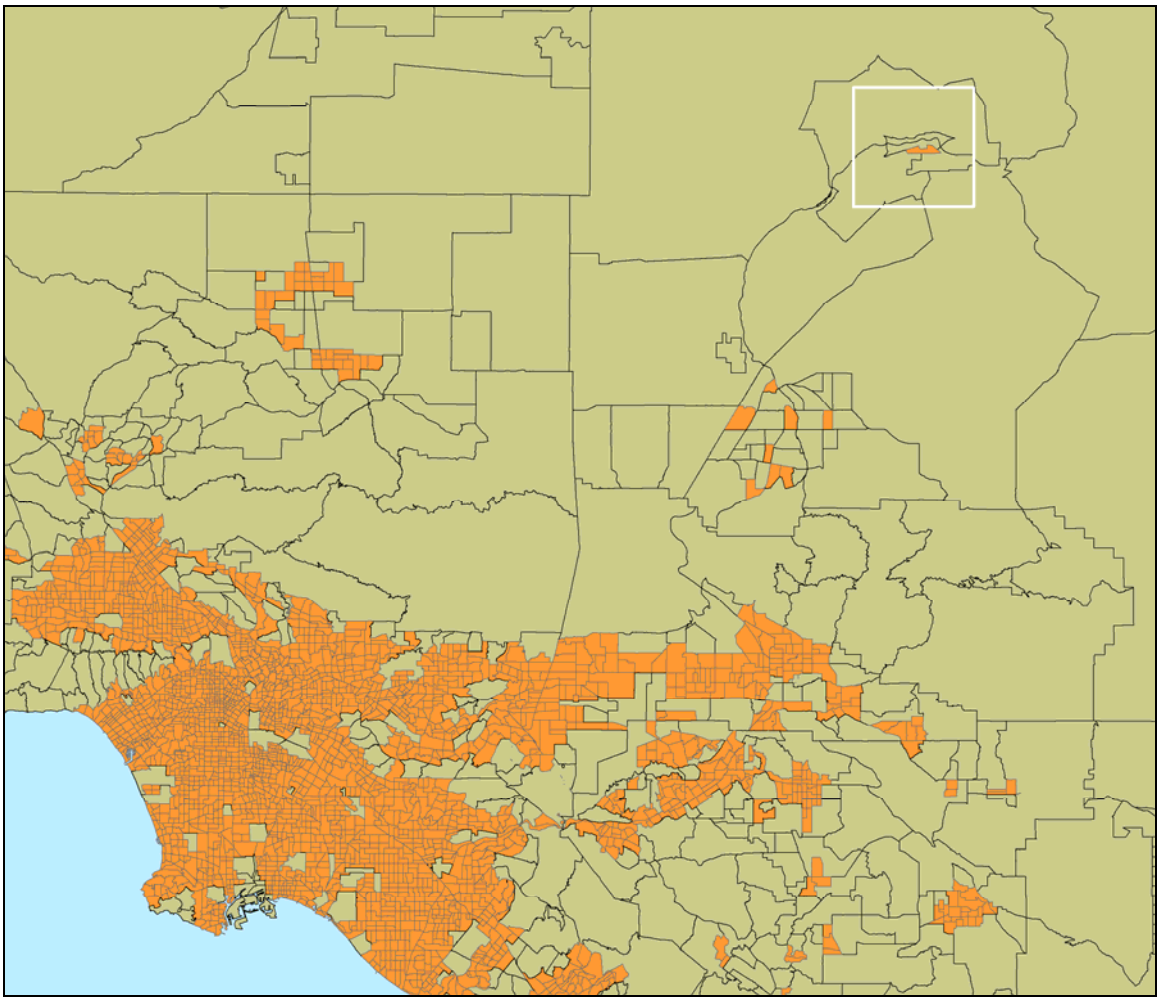


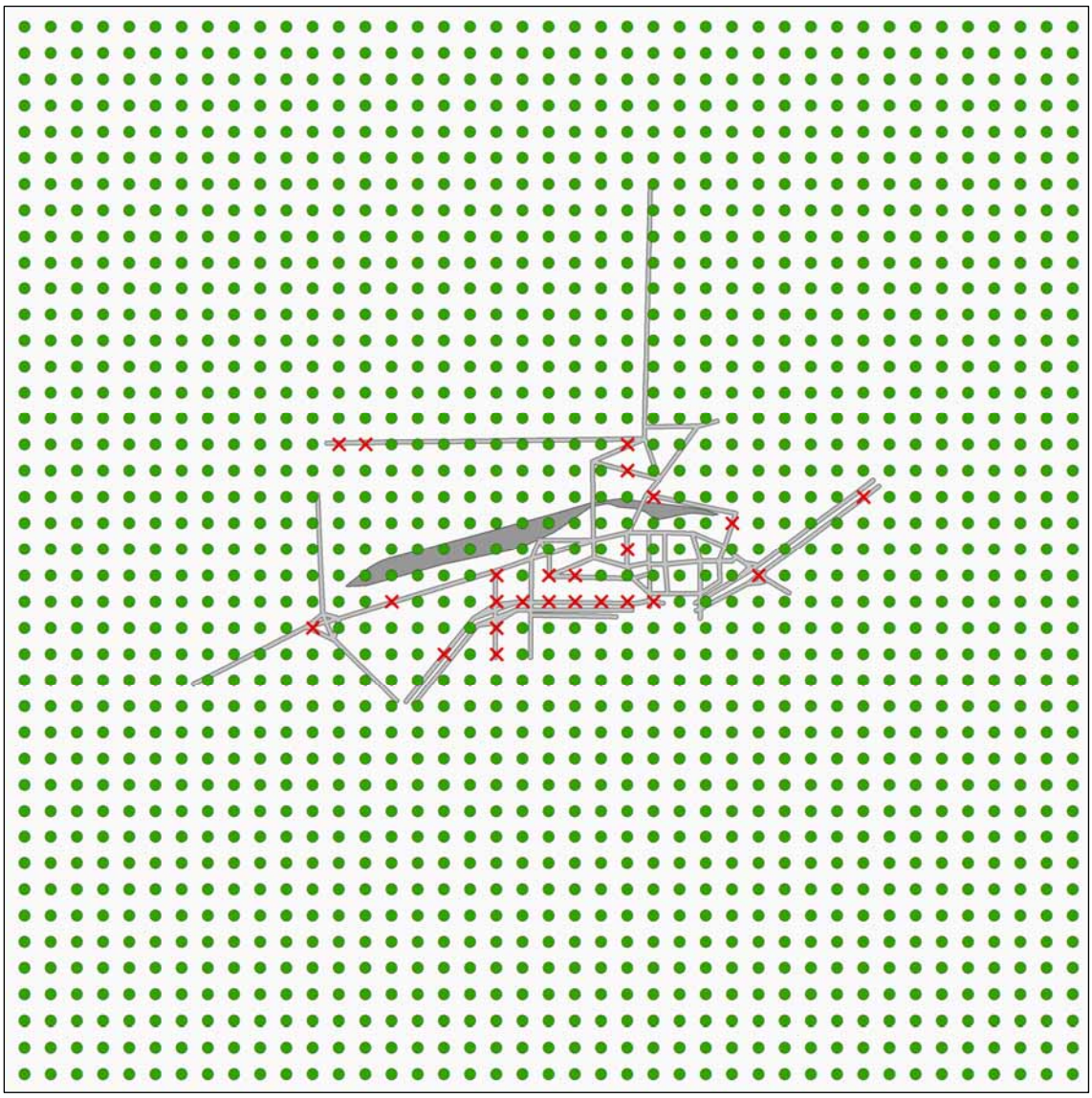
Figure 1 illustrates the region surrounding the BNSF Barstow modeling domain. The domain has dimensions 20 km x 20 km and contains a grid of 1681 receptors with a 500 meter uniform grid spacing.

Figure 2: BNSF Barstow Urban Population: Orange (dark) denotes areas with at least 750 people/km^2. The study area is not located in an area considered urban by guidance standards and therefore was not modeled with the urban dispersion coefficients.



AERMOD requires an estimate of the urban population for urban source modeling. The urban population parameter can be 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. Though the BNSF Barstow model domain contains a small urban area, the majority of the domain is not urban, nor is it near any large urban complex. Therefore, AERMOD's urban options and parameters were not used in modeling either on- or off-site sources for the Barstow Railyard.

Figure 3: BNSF Barstow receptor network including off-site sources and railyard facility



The off-site stationary and on-road emission sources used in the BNSF Barstow 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 26.1 tons per year from roadways and less than 0.01 tons per year from stationary facilities, representing emissions for 2005. Roadway emissions were simulated as AERMOD area sources with an aspect ratio of no greater than 100 to 1, with a width of 7.3 meters and a release height of 4.15 meters.

As indicated above, Figure 3 illustrates a 20 km x 20 km gridded receptor field with uniform 500 meter spacing of receptors that are plotted as "●". Because a uniform grid

sometimes places receptors on a roadway, those within 35 meters of a roadway were omitted. The basis for this is that these receptors are likely to fall on the roadway surface, versus a dwelling or workplace, and have high model-estimated concentrations, which could skew average concentration isopleths. Locations where receptors were removed are displayed as an "**x**" in Figure 3. After removal, 1657 of the original 1681 receptors remained.

The same meteorological data used by ENVIRON were used for the off-site modeling runs. The data were compiled by Environ from the ARB Barstow station (34.89°N, 117.04°W) and NCDC/NWS Barstow-Daggett Airport station (34.87°N, W 116.77°W). Upper air data for the same time period were obtained from the NWS Desert Rock, NV upper air station (36.62°N, 116.02°W). The model runs used five years of meteorological data from 2001 through 2005.

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

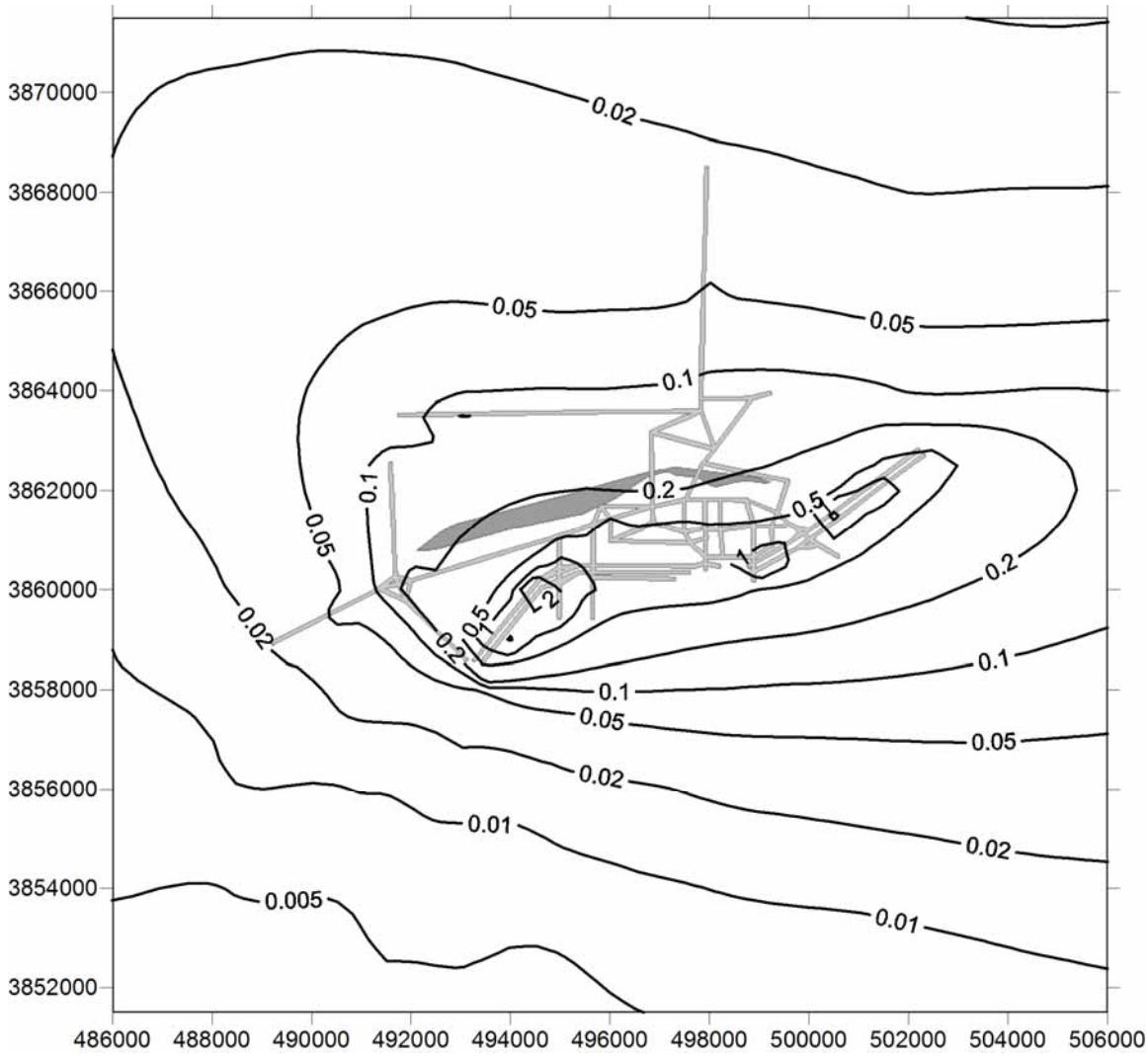


Figure 4 shows annual average diesel PM concentrations from the off-site emissions. Highest values occur near major freeways; the five highest concentrations at a receptor and their locations are provided in Table 2.

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

X	Y	Mobile	Stationary	Total Off-site
494500	3860000	3.835	0.000	3.835
500500	3861500	2.236	0.000	2.236
494000	3859000	2.080	0.000	2.080
494500	3859500	1.781	0.000	1.781
499000	3860500	1.736	0.000	1.736

APPDENDIX 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)

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

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

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

APPENDIX E

SPATIAL ALLOCATIONS OF MAJOR DIESEL PM EMISSION SOURCES AT THE BNSF BARSTOW RAILYARD

This Appendix is provided as a visual aid to understand where significant sources of diesel PM are generated within the BNSF Barstow Railyard. This visual layout indicates that about 75% of the emissions occur in the middle and western part of the BNSF Barstow Railyard.

Figure 1. The BNSF Barstow Railyard shown with the Shaded Area accounting for about 75 Percent of Facility-Wide Diesel PM Emissions.

According to the emissions inventory for the BNSF Barstow Railyard about 75% percent of DPM emissions occur in the western section of the yard, as there is significant switcher and line haul activity in this area. The maintenance facility also lies in this area.

Figure 2. Spatial Allocation of Line Haul Locomotive Emissions at BNSF Barstow Railyard

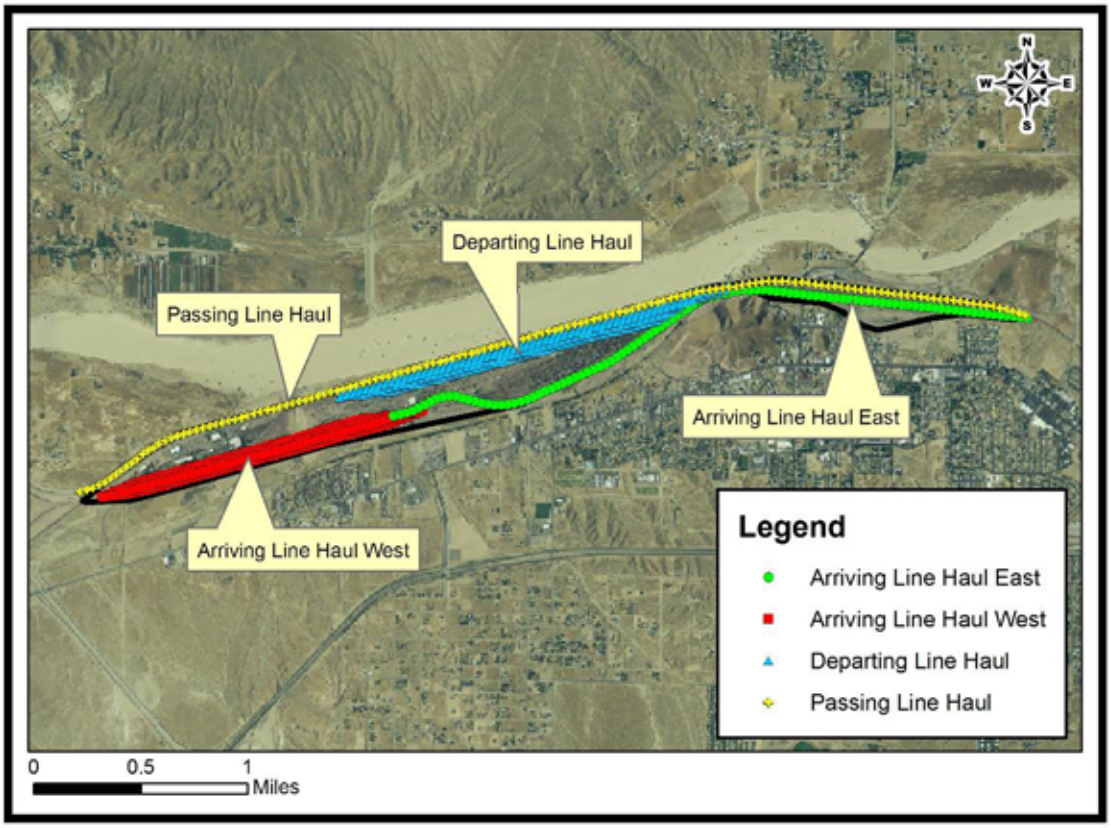
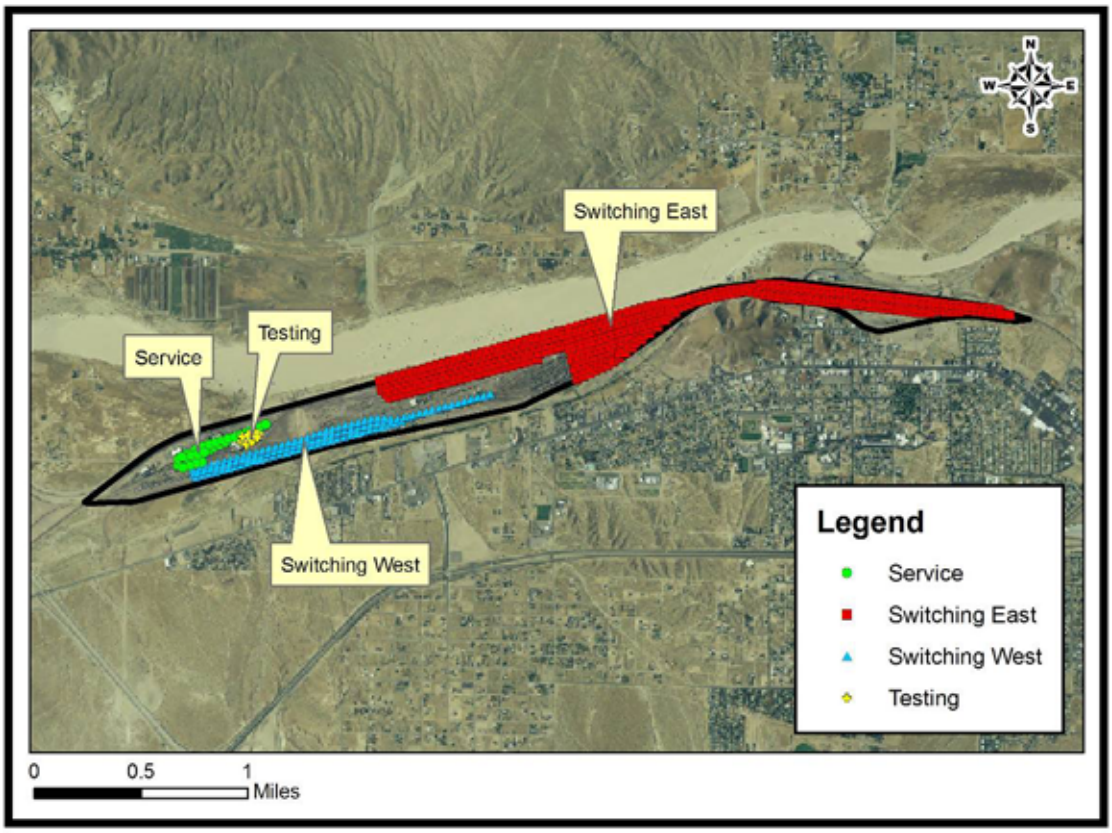


Figure 3. Spatial Allocation of Diesel PM Emissions from Switch Locomotives and testing and service at BNSF Barstow Railyard.



APPENDIX F

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

Figure 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.

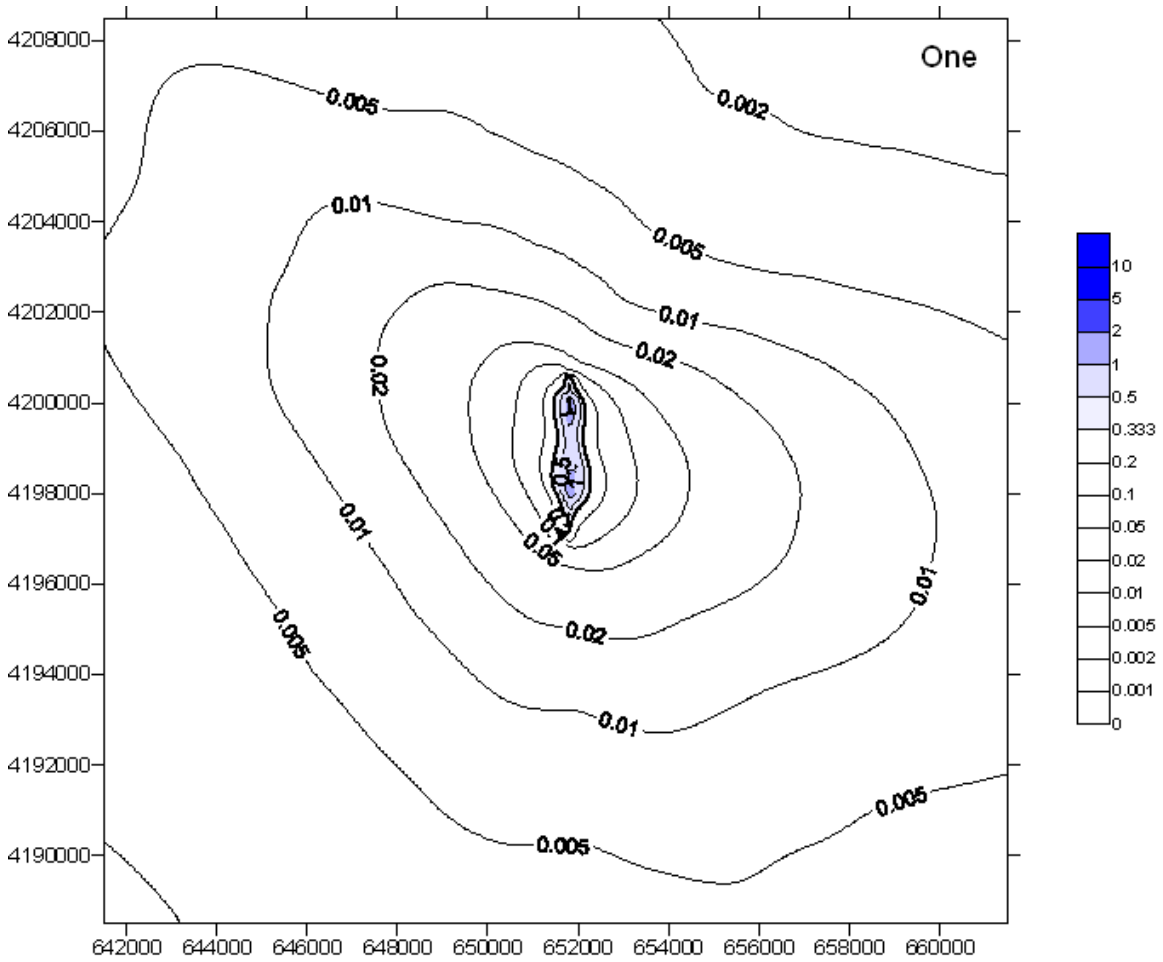
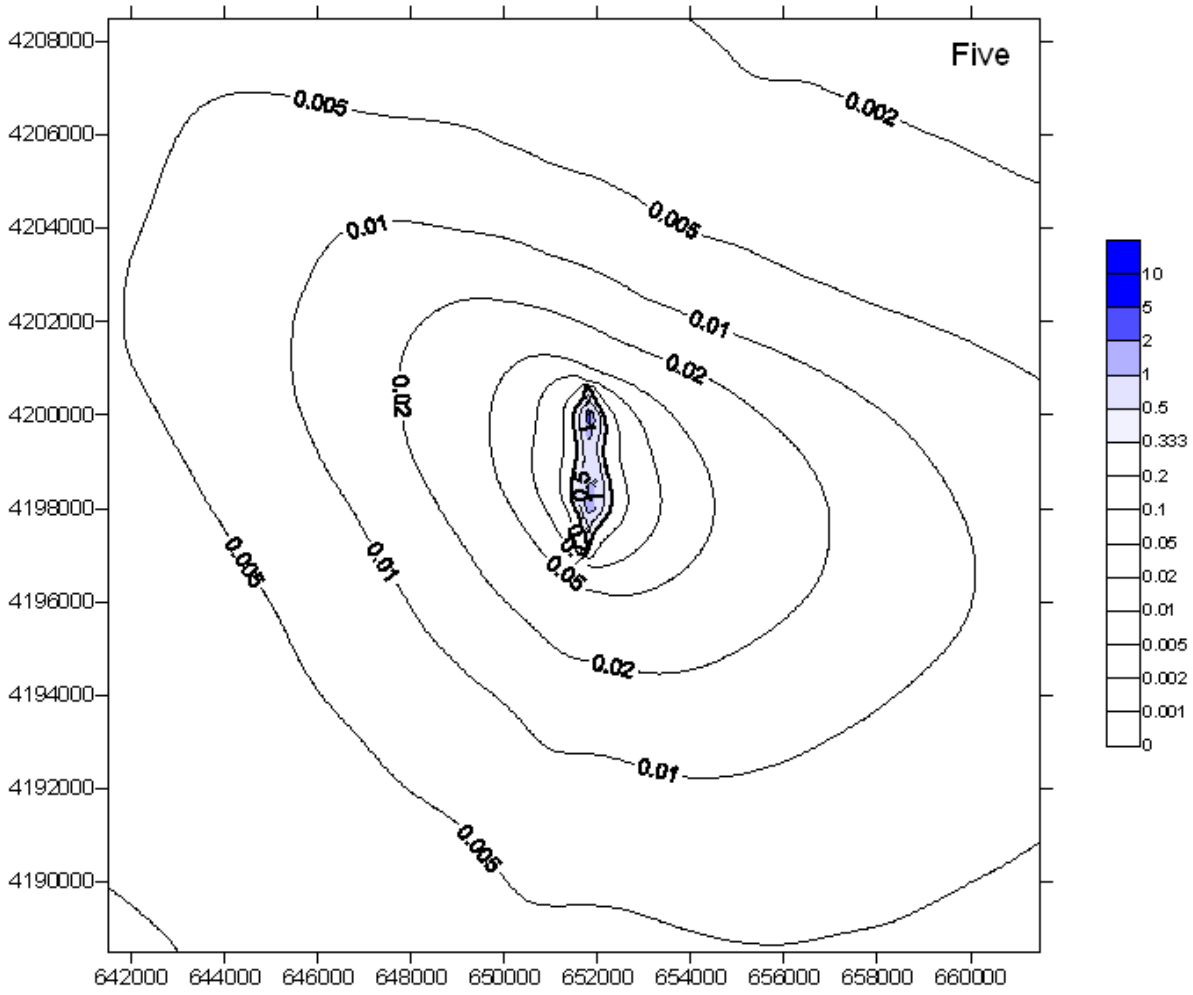



Figure 2 AERMOD's Simulated Diesel PM Concentrations (due to On-site and Off-site Diesel PM Emissions) around UP Stockton Railyard Using Five-year Meteorological Data.